Electric Energy, LLC
1500 Eastport Plaza Dr.
Collinsville, IL 62234

July 28, 2022

Illinois Environmental Protection Agency
DWPC – Permits MC #15
Attn: Part 845 Coal Combustion Residual Rule Submittal
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

Re: Joppa Power Plant East Ash Pond; IEPA ID # W1270100004-02

Dear Mr. LeCrone:

In accordance with 35 I.A.C. § 845.200, Electric Energy, LLC (EEI) is submitting a construction permit application for the Joppa Power Plant East Ash Pond (IEPA ID # W1270100004-02). One hardcopy is provided with this submittal.

The permit application was prepared in accordance with 35 I.A.C. § 845.220 (a) and (d). This submittal includes the completed permit forms as required by § 845.210.

Sincerely,

Cynthia Vodopivec
SVP-Environmental Health and Safety

Enclosures

Form CCR 1	Illinois Environmental Protection Agency CCR Surface Impoundment Permit Application Form CCR 1 – General Provisions

Bureau of Water ID Number:
W1270100004-02

CCR Permit Number:
N/A

Facility Name:
Joppa Power Plant

For IEPA Use Only

SECTION 1: FACILITY, OPERATOR, AND OWNER INFORMATION (35 Ill. Adm. Code 845.210(b))

Facility, Operator, and Owner Information

1.1	Facility Name		
	Electric Energy, Inc. - Joppa Power Plant		
1.2	Illinois EPA CCR Permit Number (if applicable)		
	Initial Permit		
1.3	Facility Contact Information		
	Name (first and last) Phil Morris	Title Senior Director - Environmental	Phone Number 618-343-7794
	Email address phil.morris@vistracorp.com		
1.4	Facility Mailing Address		
	Street or P.O. box 1500 Eastport Plaza Dr		
	City or town Collinsville	State IL	Zip Code 62234
1.5	Facility Location		
	Street, route number, or other specific identifier 2100 Portland Road		
	County name Massac	County code (if known)	
	City or town Joppa	State IL	Zip Code 62953
1.6	Name of Owner/Operator		
	Electric Energy, Inc.		

Facility, Operator, and Owner Info

1.7 Owner/Operator Contact Information

Name (first and last)	Title	Phone Number
Phil Morris	Senior Director - Environmental	618-343-7794

Email address: phil.morris@vistracorp.com

1.8 Owner/Operator Mailing Address

Street or P.O. box: 1500 Eastport Plaza Dr

City or town	State	Zip Code
Collinsville	IL	62234

SECTION 2: LEGAL DESCRIPTION (35 Ill. Adm. Code 845.210(c))

Legal Description

2.1 Legal Description of the facility boundary

See Attachment A.

SECTION 3: PUBLICLY ACCESSIBLE INTERNET SITE REQUIREMENTS (35 Ill. Adm. Code 845.810)

Internet Site

3.1 Web Address(es) to publicly accessible internet site(s) (CCR website)

www.luminant.com/ccr

3.2 Is/are the website(s) titled "Illinois CCR Rule Compliance Data and Information"

☑	Yes	☐	No

SECTION 4: IMPOUNDMENT IDENTIFICATION

Impoundment Identification

4.1 List all the impoundment identification numbers for your facility and check the corresponding box to indicate that you have attached a written description for each impoundment.

W1270100004-02 (See Attachment A.)	☑	Attached written description
	☐	Attached written description
	☐	Attached written description
	☐	Attached written description
	☐	Attached written description
	☐	Attached written description

			☐	Attached written description
			☐	Attached written description
			☐	Attached written description
			☐	Attached written description

SECTION 5: CHECKLIST AND CERTIFICATION STATEMENT

Checklist and Certification Statement

5.1 In Column 1 below, mark the sections of Form 1 that you have completed and are submitting with your application. For each section, specify in Column 2 any attachments that you are enclosing.

Column 1		Column 2	
Section 1: Facility, Operator, and Owner Information	☑	w/attachments	☐
Section 2: Legal Description	☑	w/attachments	☑
Section 3: Publicly Accessible Internet Site Requirement	☑	w/attachments	☐
Section 4: Impoundment Identification	☑	w/attachments	☑

5.2 **Certification Statement**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name (print or type first and last name) of Owner/Operator	Official Title
Cynthia Vodopivec	SVP - Environmental
Signature: Cynthia S. Vodopivec	Date Signed: 7-18-2022

Form 2CC	Illinois Environmental Protection Agency CCR Surface Impoundment Permit Application Form CCR 2CC – Closure Construction

Bureau of Water ID Number:
W1270100004-02

CCR Permit Number:
N/A

Facility Name:
Joppa Power Plant

For IEPA Use Only

SECTION 1: DESIGN AND CONSTRUCTION PLANS (35 Ill. Adm. Code 845.220)

Design and Construction Plans (Construction History)

1.1	CCR surface impoundment name.
	East Ash Pond
1.2	Identification number of the CCR surface impoundment (if one has been assigned by the Agency).
	N/A
1.3	Describe the boundaries of the CCR surface impoundment (35 Ill. Adm. Code 845.210 (c)).
	Attachment A
1.4	State the purpose for which the CCR surface impoundment is being used.
	Attachment C
1.5	How long has the CCR surface impoundment been in operation?
	Attachment C
1.6	List the types of CCR that have been placed in the CCR surface impoundment.
	Attachment D

Design and Construction Plans (Continued)

1.7	List the name of the watershed within which the CCR surface impoundment is located.	
	Attachment F	
1.8	What is the size in acres of the watershed within which the CCR surface impoundment is located?	
	Attachment C	
1.9	Check the corresponding boxes to indicate that you have attached the following:	
	☑	A description of the physical and engineering properties of the foundation and abutment materials on which the CCR surface impoundment is constructed.
	☑	A statement of the type, size, range, and physical and engineering properties of the materials used in constructing each zone or stage of the CCR surface impoundment.
	☑	A statement of the method of site preparation and construction of each zone of the CCR surface impoundment.
	☑	A statement of the approximate dates of construction of each successive stage of construction of the CCR surface impoundment.
	☑	Drawings satisfying the requirements of 35 Ill. Adm. Code 845.220(a)(1)(F).
	☑	A description of the type, purpose, and location of existing instrumentation.
	☑	Area capacity curves for the CCR impoundment.
	☑	A description of each spillway and diversion design features and capacities and provide the calculations used in their determination.
	☑	The construction specifications and provisions for surveillance, maintenance, and repair of the CCR surface impoundment.
1.10.1	Is there any record or knowledge of structural instability of the CCR surface impoundment?	
	☑ Yes	☐ No
1.10.2	If you answered yes to Item 1.10.1, provide detailed explanation of the structural instability.	
	See Attachment C and Attachment G, and Operating Permit Attachment P	

SECTION 2: NARRATIVE DESCRIPTION OF THE FACILITY (35 Ill. Adm. Code 845.220)

Narrative Description

2.1	List the types of CCR expected in the CCR surface impoundments.			
	Attachment D			
2.2	Have you attached a chemical analysis of each type of expected CCR?			
	☑	Yes		
2.3	Estimate of the maximum capacity of the surface impoundment in gallons or cubic yards.			
	Attachment C			
2.4	The rate at which CCR and non-CCR waste streams currently enter the CCR impoundment in gallons per day and dry tons.			
	Attachment C	GPD	Attachment C	dTn
2.5	Estimate length of time the CCR surface impoundment will receive CCR and non-CCR waste streams.			
	Attachment C			
2.6	Have you attached an on-site transportation plan that includes all existing and planned roads in the facility that will be used during the operation of the CCR surface impoundment?			
	☑	Yes		

SECTION 3: MAPS (35 Ill. Adm. Code 845.220)

Maps

3.1	Check the corresponding boxes to indicate that you have attached the following maps:	
	☑	A site location map on the most recent United Sates Geological Survey (USGS) quadrangle of the area from the 7 ½ minute series (topographic) or on another map whose scale clearly shows the information required in 35 Ill. Adm. Code 845.220(a)(3).
	☑	Site plans maps satisfying the requirements of 35 Ill. Adm. Code 845.220(a)(4).

SECTION 4: ATTACHMENTS

Attachments

4.1	Check the corresponding boxes to indicate that you have attached the following:	
	☑	A narrative description of the proposed construction of, or modification to, a CCR surface impoundment and any projected changes in the volume or nature of the CCR or non-CCR waste streams.
	☑	Plans and specifications fully describing the design, nature, function, and interrelationship of each individual component of the facility.
	☑	The signature and seal of a qualified professional engineer.
	☑	Certification that the owner or operator of the CCR surface impoundment completed the public notification and public meetings required under 35 Ill. Adm. Code 845.240.

Attachments (Continued)		☑	A summary of the issues raised by the public during the public notification and public meetings.
		☑	A summary of any revisions, determinations, or other considerations made in response to those issues raised by the public during the public notification and public meetings.
		☑	A list of interested persons in attendance who would like to be added to the Agency's listserv for the facility.
		☑	Certification that all contractors, subcontractors, and installers utilized to construct, install, modify, or close a CCR surface impoundment are participants in a training program that is approved by and registered with the U.S. Department of Labor's Employment and Training Administration and that includes instruction in erosion control and environmental remediation.
		☑	Certification that all contractors, subcontractors, and installers utilized to construct, install, modify, or close a CCR surface impoundment are participants in a training program that is approved by and registered with the U.S. Department of Labor's Employment and Training Administration and that includes instruction in the operation of heavy equipment and excavation.
SECTION 5: GROUNDWATER MONITORING PROGRAM			
Groundwater Monitoring	5.1	Indicate that you have attached the following components of a new groundwater monitoring program or any modifications to an existing groundwater monitoring program by checking the corresponding boxes:	
		☑	A hydrogeologic site investigation meeting the requirements of 35 Ill. Adm. Code 845.620, if applicable.
		☑	Design and construction plans of a groundwater monitoring system meeting the requirements of 35 Ill. Adm. Code 845.630.
		☑	A proposed groundwater sampling and analysis program that includes selection of the statistical procedures to be used for evaluating groundwater monitoring data as required by 35 Ill. Adm. Code 845.640 and 845.650.
SECTION 6: CLOSURE (35 Ill. Adm. Code 845.220(d))			
Closure	6.1	What is the closure prioritization category under 35 Ill. Adm. Code 845.700(g), if applicable?	
		Attachment I	
	6.2	Indicate that you have attached the following by checking the corresponding boxes:	
		☑	The final closure plan, as specified in 35 Ill. Adm. Code 845.720(b), which includes the closure alternatives analysis required by 35 Ill. Adm. Code 845.710.
		☑	Proposed schedule to complete closure.
		☑	Post-closure care plan as specified in 35 Ill. Adm. Code 845.780(d).
SECTION 7: GROUNDWATER MODELING (35 Ill. Adm. Code 845.220(d)(3))			
Groundwater	7.1	Indicate that you have attached the following by checking the corresponding boxes:	
		☑	The results of groundwater contaminant transport modeling and calculations showing how the closure will achieve compliance with the applicable groundwater standards.
		☑	All modeling inputs and assumptions.
		☑	Description of the fate and transport of contaminants with the selected corrective action over time.

		☑	Capture zone modeling, if applicable.
		☑	Any necessary licenses and software needed to review and access both the model and the data contained within the model.

Prepared for

Electric Energy, Inc.
2100 Portland Road
Joppa, Illinois 62953

CONSTRUCTION PERMITAPPLICATION

JOPPA POWER PLANT
EAST ASH POND
(IEPA ID W1270100004-02)
Joppa, Illinois

Prepared by

Geosyntec consultants
engineers | scientists | innovators

600 Roselane Court
Farmington, Missouri 63640

Project Number GLP8025

Revision 0

July 28, 2022

Geosyntec consultants

TABLE OF CONTENTS

1. Introduction 1
   1.1. Legal Description 1
   1.2. Previous Assessments 1

2. Construction Permit 3
   2.1. History of Construction 3
   2.2. Narrative Description of Facility 3
   2.3. Site Maps 5
   2.4. Narrative Description of Proposed Construction 7
   2.5. Plans and Specifications 10
   2.6. Groundwater Monitoring Program 10
   2.7. Certification 12
   2.8. Public Meeting Information 13
      2.8.2. Interim Measures 13
   2.9. Closure Construction 13

3. Additional Information 15

4. References 16

TABLES

Table 1 CCR Surface Impoundments at Joppa Power Plant

TABLE OF CONTENTS

ATTACHMENTS

Attachment A	Legal Description (845.210(c))
Attachment B	Groundwater Information (845.210(d)(1), 845.220(a)(7)(A-C), 845.220(c)(2), and 845.220(d)(3))
Attachment C	History of Construction Report (845.220(a)(1))
Attachment D	Types of CCR and Chemical Constituents (845.220(a)(2)(A))
Attachment E	Site Plan Map and On-Site Transportation Plan ((845.220(a)(4) and 845.220(a)(2)(E))
Attachment F	Site Location Maps (845.220(a)(3))
Attachment G	Final Closure Plan and Proposed Closure Schedule (including Closure Alternatives Analysis/Preliminary Corrective Measures Assessment, 845.210, 845.220(a)(5-6), 845.720(b), 845.220(d)(2))
Attachment H	Public Notification and Public Meeting Certification (845.220(a)(9))
Attachment I	Closure Prioritization Category Letter (845.220(d)(1))
Attachment J	Post-Closure Care Plan (845.220(d)(5))
Attachment K	Contractor Training Certification (45 ILCS 5/22.59(b)(4))

1. INTRODUCTION

Electric Energy, Incorporated (EEI) is the owner of the coal-fired Joppa Power Plant (JPP), also referred to as Joppa Power Station (JOP), in Joppa, Illinois. According to the Illinois Environmental Protection Agency (IEPA), this power plant has two CCR surface impoundments, as listed in **Table 1**. This construction permit application is for the East Ash Pond (EAP) only. As of the date of this report, the JPP is an active power plant, as electricity is being produced, and the EAP is an active CCR surface impoundment, as CCR is actively being placed in the EAP and it has not initiated closure. EEI intends to cease the burning of coal and generation of electricity of JPP on September 1, 2022, after which the EAP will no longer receive CCR.

Table 1 – CCR Surface Impoundments at Joppa Power Plant

Impoundment Name	Status	Acronym	IEPA ID Number	Dynegy CCR Unit ID	National Inventory of Dams Number
East Ash Pond	**Active**	**EAP**	**W1270100004-02**	**401**	**IL50714**
Joppa West Former Surface Impoundment (Joppa West)	Removed from Service	Joppa West	W127010004-01	403	None

This construction permit application was developed in accordance with 35 Ill. Admin. Code 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845) [1].

1.1. Legal Description

Section 845.210(c): All permit applications must contain a legal description of the facility boundary and a description of the boundaries of all units included in the facility.

A legal description of the facility is provided in **Attachment A**.

1.2. Previous Assessments

Section 845.210(d): Previous Assessments, Investigations Plans, and Programs

The EAP is also regulated by 40 C.F.R. Part 257, herein referred to as the CCR Rule [2] and subsequently became regulated by Part 845 [1]. Multiple previous initial and periodic assessments, investigation plans, and programs were completed for the EAP to satisfy the requirements of both the CCR Rule and Part 845; some of which are referred to within this report.

Section 845.210(d)(1): The Agency may approve the use of any hydrogeologic site investigation or characterization, groundwater monitoring well or system, or groundwater monitoring plan,

bearing the seal and signature of an Illinois Licensed Professional Geologist or Licensed Professional Engineer, completed before April 21, 2021 to satisfy the requirements of this Part.

The hydrogeologic site investigation and characterization, groundwater monitoring well system, and groundwater monitoring plan are provided for the EAP in **Attachment B**.

Section 845.210(d)(2): For existing CCR surface impoundments, the owner or operator of the CCR surface impoundment may use a previously completed location restriction demonstration required by Section 845.300 (Placement Above the Uppermost Aquifer), Section 845.310 (Wetlands), Section 845.320 (Fault Areas), Section 845.330 (Seismic Impact Zones), and Section 845.340 (Unstable Areas) provided that the previously completed assessments meet the applicable requirements of those Sections.

Previous assessments for Placement Above the Uppermost Aquifer, Wetlands, Fault Areas, Seismic Impact Zones, and Unstable Areas were included in the Part 845 Initial Operating Permit Application for the EAP [3]. The Initial Operating Permit Application was submitted to IEPA in October 2021.

Section 845.210(d)(3): For existing CCR surface impoundments, the owner or operator of the CCR surface impoundment may use a previously completed assessment to serve as the initial assessment required by Section 845.440 (Hazard Potential Classification Assessment), Section 845.450 (Structural Stability Assessment) and Section 845.460 (Safety Factor Assessment) provided that the previously completed assessment: A) Was not completed more than five years ago; and B) Meets the applicable requirements of those Sections.

Previous assessments for the Hazard Potential Classification, Structural Stability, and Safety Factors were included in the Part 845 Initial Operating Permit Application for the EAP [3]. The Initial Operating Permit Application was submitted to IEPA in October 2021.

Section 845.210(d)(4): For inactive closed CCR surface impoundments, the owner or operator of the CCR surface impoundment may use a post-closure care plan previously approved by the Agency.

No post-closure care plan for the EAP was previously approved by the Agency.

2. CONSTRUCTION PERMIT

2.1. History of Construction

Section 845.220(a)(1): Design and Construction Plans (Construction History)

The History of Construction report for the EAP and subsequent update letter are provided in **Attachment C**.

2.2. Narrative Description of Facility

Section 845.220(a)(2): Narrative Description of the Facility. The permit application must contain a written description of the facility with supporting documentation describing the procedures and plans that will be used at the facility to comply with the requirements of this Part. The descriptions must include, but are not limited to, the following information:

The Facility Narrative Description details are described in the following sections.

Section 845.220(a)(2)(A): The types of CCR expected in the CCR surface impoundment, including a chemical analysis of each type of expected CCR;

The types of CCR expected in EAP and analysis of the chemical constituents found within the CCR in the EAP is provided in **Attachment D.**

Section 845.220(a)(2)(B): An estimate of the maximum capacity of each surface impoundment in gallons or cubic yards;

The EAP currently is estimated to contain approximately 5,870,000 cubic yards (CY) of CCR. The JPP is expected to cease the burning of coal and production of electricity on September 1, 2022. CCR that is being placed in the EAP is currently being excavated for beneficial use at a similar rate as it is being placed, therefore the total volume of CCR within the EAP is not expected to significantly change prior to cessation of operation of JPP and the EAP.

Approximately 530,000 CY of CCR is estimated to be located outside of the limits of the EAP embankments. All of this exterior CCR and up to one foot of underlying subgrade materials will be excavated and consolidated in the EAP as part of closure (see **Section 2.4**), resulting in a maximum CCR capacity at under post-closure conditions of approximately 6,500,000 CY.

<u>Section 845.220(a)(2)(C):</u> The rate at which CCR and non-CCR waste streams currently enter the CCR surface impoundment in gallons per day and dry tons;

The EAP currently receives multiple CCR and non-CCR waste streams at an approximate total average rate of 1.8 dry tons per day and 4.6 million gallons per day[1] [4]. These waste streams, and the approximate daily volumes, are described below.

- CCR Waste Streams
    - Boiler Cleanout CCR
        - Approximately 240 dry tons per year is placed in the EAP during outages. However, this material is not placed continuously.
        - The average placement rate would 0.5 dry tons per day, if the material was assumed to be placed continuously.
    - Fly ash
        - Fly ash was placed in 2020 and 2021 at a rate of 2,300 and 6,400 dry tons per year (12 dry tons per day on average).
        - No fly ash is expected to be placed in 2022, as essentially all fly ash produced at JPP is sold for beneficial use and not placed in the EAP.
    - Bottom ash
        - Bottom ash is placed at a rate of approximately 128,000 dry tons per year (350 dry tons per day on average) [5].
        - However, bottom ash is removed for beneficial use at a rate approximately equal to the placement rate. Therefore, the amount of bottom ash within the EAP does not significantly change from year to year.
- Non-CCR Waste Streams
    - Ohio River clamshell dipping materials

[1] Estimated using the average daily discharge rate of 5 million gallons per day and considering an average daily rainfall of 420,000 gallons, without including an allowance for evaporation.

- Approximately 480 dry tons per year of sediment collected from the Ohio River is placed in the EAP, during periodic maintenance of the dock system.

- The average placement rate would be 1.3 dry tons per day, if the material was assumed to be placed continuously.

- Bottom ash sluice water, demineralization water plant wastewater, and regeneration water.

    - These liquid waste streams constitute the estimated average process flows of 4.6 million gallons per day[1].

Section 845.220(a)(2)(D): The estimated length of time the CCR surface impoundment will receive CCR and non-CCR waste streams; and

The EAP is expected to receive CCR waste streams until the JPP ceases the burning of coal and generation of electricity on September 1, 2022. After September 1, 2022, the EAP will not receive any production CCR waste streams.

The EAP is expected to continue to receive some of the existing non-CCR waste streams until closure of the EAP begins. The specific non-CCR waste streams and estimated length of time over which the EAP will receive them is still being evaluated.

Section 845.220(a)(2)(E): An on-site transportation plan that includes all existing and planned roads in the facility that will be used during the operation of the CCR surface impoundment.

An On-Site Transportation Plan was developed as required by Section 845.220(a)(2)(E) and is provided for the EAP in **Attachment E** that includes all on-site access roads and the surrounding roadways.

2.3. Site Maps

Section 845.220(a)(3): Site Location Map. All permit applications must contain a site location map on the most recent United States Geological Survey (USGS) quadrangle of the area from the 7½ minute series (topographic), or on another map whose scale clearly shows the following information:

A. The facility boundaries and all adjacent property, extending at least 1000 meters (3280 feet) beyond the boundary of the facility;
B. All surface waters;
C. The prevailing wind direction;
D. The limits of all 100-year floodplains;

E. *All-natural areas designated as a Dedicated Illinois Nature Preserve under the Illinois Natural Areas Preservation Act [525 ILCS 30];*
F. *All historic and archaeological sites designated by the National Historic Preservation Act (16 USC 470 et seq.) and the Illinois Historic Sites Advisory Council Act [20 ILCS 3410]; and*
G. *All areas identified as critical habitat under the Endangered Species Act of 1973 (16 USC 1531 et seq.) and the Illinois Endangered Species Protection Act [520 ILCS 10].*

A Site Location Map showing the information required in Section 845.220(a)(3) is provided for the EAP in **Attachment F**. The Site Location Map consists of the most recent USGS topographic map (2021) which contains the facility and at least 1,000 meters of the surrounding area. Information included on the site location map meets the requirements for a Flood Hazard Map, Topographic Vicinity Map, Designated Nature Map, Designated Historic and Archeological Site Map, and Identified Critical Habitat Map.

The data in the Site Location Map was collected by performing a comprehensive search of the Illinois Department of Natural Resources (IDNR) natural heritage database [6] for natural and protected areas within 1,000 meters of the EAP. Within Massac County, a total of 14 of these sites were identified from the Illinois Natural Areas Inventory and 5 were identified from the Illinois Nature Preserves list. None of the natural areas or preserves fall within 1,000 meters of the EAP. The nearest area is the Mermet Swamp Nature Preserve, located approximately 1,900 meters to the north of the EAP.

The IDNR natural heritage database also includes a list of endangered species by county [7] and notes that a total of 63 threatened and endangered species as located within Massac County, including 42 endangered and 21 threatened species. A review of the U.S. Fish and Wildlife Service (USFWS) Threatened & Endangered Species Active Critical Habitat Report [8] identified critical habitat for the threatened rabbitsfoot mussel (quadrula cylindrica cylindrica) within the Ohio River, located within 1,000 meters of the EAP.

A search of the IDNR Historic and Architectural Resources Geographic Information System (HARGIS database) [9] for historical sites within the 1,000 meters of the Site located no results.

The 100-year flood plain limits were obtained from the Federal Emergency Management Area (FEMA) Flood Map Service Center [10]. Portions of the JPP site are within the 100-year flood plain of the Ohio River, although the EAP is outside of the 100-year floodplain limits.

<u>Section 845.220(a)(4):</u> Site Plan Map. The application must contain maps, including cross-sectional maps of the site boundaries, showing the location of the facility. The following information must be shown:

A. *The entire facility, including any proposed and all existing CCR surface impoundment locations;*
B. *The boundaries, both above and below ground level, of the facility and all CCR surface impoundments or landfills containing CCR included in the facility;*
C. *All existing and proposed groundwater monitoring wells; and*
D. *All main service corridors, transportation routes, and access roads to the facility.*

The Site Plan Map showing the information required in Section 845.220(a)(4) is provided for the EAP in **Attachment F**.

2.4. Narrative Description of Proposed Construction

Section 845.220(a)(5): A narrative description of the proposed construction of, or modification to, a CCR surface impoundment and any projected changes in the volume or nature of the CCR or non-CCR waste streams.

The proposed modification to the EAP will include closing the EAP through a hybrid consolidate-and-cap approach with a final cover system. The consolidate-and-cap approach will involve reducing the footprint of the EAP from approximately 128 acres to approximately 74 acres. This will include removing all CCR from a closure-by-removal area inside the EAP into a consolidated footprint within the existing EAP. The consolidated footprint will then be covered with a final cover system.

During the closure process, EEI will continue to assess off-site CCR beneficial use opportunities. Ash consolidation and closure-in-place with a combination of offsite beneficial use may result in a smaller footprint for the ultimate cap design along with a reduced construction schedule.

Specific areas and volumes that will be relocated into the closure-in-place area are described below.

- All CCR and up to one foot of underlying subgrade soils, totaling approximately 1.2 million CY, will be removed from a 54-acre area inside the EAP (the closure-by-removal area).

- All CCR and up to one foot of underlying subgrade soils, totaling approximately 580,000 CY, will be removed from a 32-acre area outside of the EAP, to the south and southeast (the southeast area).

- Approximately 3,000 ft of the existing perimeter dikes will be removed from the closure-by-removal areas, as the dikes will no longer be retaining CCR during post closure conditions.

- This will include removing approximately 120,000 CY of dike soils, all CCR beneath the dike soils (where present), and, where the CCR is present, up to one foot of underlying subgrade soils.

CCR removal will include excavating all of the CCR and approximately of one foot of native underlying subgrade materials beneath the CCR. The excavation of CCR will be verified via visual observations performed during construction, and excavation depths will be adjusted, as needed to remove all of the CCR. The removed CCR and subgrade soils will be placed within the closure-in-place area, on top of existing impounded CCR that will remain in-place, as compacted fill to achieve final cover system subgrades. Dike soils that are observed as not containing CCR may be utilized as cover soil for the final cover system. Dike soils that contain CCR will be utilized as subgrade fill beneath the final cover system.

As part of consolidation, a new soil containment berm and final cover system will be constructed within the closure-in-place area, as described below.

- Approximately 380,000 CY of onsite clay borrow soils will be utilized to construct a new compacted clay soil containment berm to separate the closure-by-removal portion of the EAP from the consolidate-and-cap portion.
    - The soil containment berm will be founded on native foundation soils where all CCR has been removed.
    - The berm will have an approximate length of 2,700 ft and a maximum height of approximately 55-ft with 3H:1V (horizontal to vertical) exterior slopes.
- An approximately 74-acre final cover system will be installed completely over the extents of consolidated CCR in plan.
    - The final cover system will consist of a geomembrane, protective cover soil, and vegetated topsoil. The final cover system will be keyed into the perimeter dikes and berms with an anchor trench.

CCR in the consolidated closure-in-place footprint will be physically separated from the underlying uppermost aquifer by the low-permeability clay upper confining unit, which underlies the CCR and overlies the uppermost aquifer. Prior to installation of the final cover, free liquids will be removed from the CCR. Additionally, CCR in the consolidated footprint will be physically separated from the estimated normal groundwater table in the upper confining unit post-closure. The provided separation between CCR and the uppermost aquifer and groundwater tables is described below:

- Uppermost Aquifer Vertical Separation

    - The upper confining unit (UCU), which is a native clay foundation soil with an estimated permeability on the order of 5×10^{-7} to 6×10^{-8} cm/sec [11], directly underlies the CCR, overlies the uppermost aquifer, and provides physical separation between the CCR and uppermost aquifer.

    - The UCU will provide 15 to 50 ft, and approximately 30 ft on average, of vertical separation between the base of CCR and the top of the uppermost aquifer [11].

- Normal Groundwater Table Vertical Separation

    - A minimum of 10 feet of separation will be present between the base of CCR and the estimated normal groundwater table within the UCU under post-closure conditions [12].

The CCR will be laterally separated from surrounding areas by compacted clay soil containment dikes and berms, including both the new soil containment berm and the existing soil dikes, all of which are or will be constructed on native clay foundation soils. Therefore, consolidate-and-cap closure of the EAP with a final cover system will result in the CCR retained within the EAP being encapsulated within a continuous earthen barrier on the sides (e.g., the dikes and berms) and bottom (e.g., the upper confining unit), and top by a geosynthetic and soil barrier (e.g., the final cover system). This separation, along with the removal of free liquids from the CCR prior to final cover installation, will reduce the potential for groundwater liquids, and/or leachate to migrate into or out of the EAP under post-closure conditions due to low-permeability barriers being present on all sides. Furthermore, the geomembrane will reduce post-closure infiltration into the CCR.

A post-closure stormwater management system including channels, diversion berms, culverts, and riprap energy dissipation will direct non-contact stormwater off of the EAP final cover system and into surrounding areas. Stormwater will then be routed to other areas of the site and ultimately to the Ohio River using both new and existing site stormwater channels.

The closure-by-removal areas, including the area inside the current EAP footprint and the southeast area outside of the EAP, will be restored to approximate conditions that existed prior to construction of the EAP. This will include re-establishing the approximate pre-construction stream and drainage channels and establishing suitable vegetation on native soils within the restored area. Stormwater detention basis may also be used, as and if necessary, and based on site post-closure topography. Suitable vegetation will include upland species (i.e., grasses), where appropriate. Trees and/or wetland species will be planted along stormwater channels and within low areas near the Ohio River, as appropriate.

The CCR volume within the EAP will increase by approximately 580,000 CY as part of closure. This will include excavating all CCR known to be present outside the limits of the EAP. The CCR was generated onsite and will be placed in the EAP as compacted subgrade fill.

Changes in waste streams will include the cessation of CCR placement on or around September 1, 2022, when coal burning is ceased at the JPP. Other non-CCR waste streams may continue for some time after JPP retirement but will cease by the time the early stages of closure construction begin.

All areas affected by releases of CCR from the CCR surface impoundment, including, but not limited to, CCR known to be present beneath, east, and, south of the EAP perimeter dikes, will be decontaminated in accordance with 845.740(a). This will include removing all of the CCR and up to one foot of underlying subgrade materials beneath the CCR. All structures and conveyances used to manage CCR will be demolished and placed beneath the final cover system of the EAP or decontaminated and sent to a licensed landfill.

A photovoltaic (PV) solar array will be installed on the final cover system of the consolidated-and-capped EAP, after closure construction is complete. Additional information on the proposed construction and modification to the EAP is included within the Closure Plan provided in **Attachment G**, including additional information on the PV solar array.

2.5. Plans and Specifications

Section 845.220(a)(6): Plans and specifications fully describing the design, nature, function and interrelationship of each individual component of the facility.

Permit-level design plans and specifications for key construction materials are included within the Closure Plan provided for the EAP in **Attachment G** and were prepared in accordance with Section 845.220(a)(6). The permit-level design plans are consistent with the narrative description provided in Section 845.220(a)(5).

2.6. Groundwater Monitoring Program

Section 845.220(a)(7): A new groundwater monitoring program or any modification to an existing groundwater monitoring program that includes but is not limited to the following information:

The Groundwater Monitoring Program details are described within this section and the referenced attachments.

Section 845.220(a)(7)(A): A hydrogeologic site investigation meeting the requirements of Section 845.620, if applicable;

Hydrogeologic site investigations for EAP are provided in **Attachment B**.

Section 845.220(a)(7)(B): Design and construction plans of a groundwater monitoring system meeting the requirements of Section 845.630; and

Design and construction plans of a groundwater monitoring system as required by Section 845.630 are provided in **Attachment B**.

Section 845.220(a)(7)(C): A proposed groundwater sampling and analysis program that includes selection of the statistical procedures to be used for evaluating groundwater monitoring data (see Sections 845.640 and 845.650).

A groundwater sampling and analysis program that meets the requirements of Section 845.640 and 845.650 is provided in **Attachment B**.

2.7. Certification

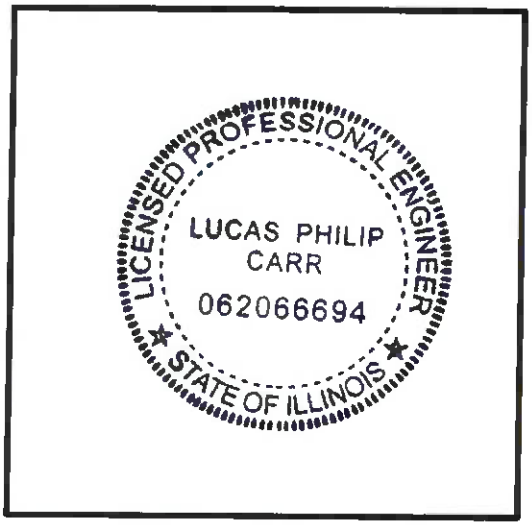
Section 845.220(a)(8): The signature and seal of a qualified professional engineer.

I, Lucas P. Carr, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this construction permit application has been prepared in accordance with the accepted practice of engineering.

Lucas P Carr
Printed Name

7/28/2022
Signature Date

062-066694 IL 11/30/2023
Registration Number State Expiration Date



Affix Seal

2.8. Public Meeting Information

Section 845.220(a)(9): Certification that the owner or operator of the CCR surface impoundment completed the public notification and public meetings required under Section 845.240, a summary of the issues raised by the public, a summary of any revisions, determinations, or other considerations made in response to those issues, and a list of interested persons in attendance who would like to be added to the Agency's listserv for the facility.

Certification that the public notification and public meetings have been completed as required by Section 845.240 is provided in **Attachment H**.

2.8.2. Interim Measures

Section 845.220(c)(5): Any interim measures necessary to reduce the contaminants leaching from the CCR surface impoundment, and/or potential exposures to human or ecological receptors, including an analysis of the factors specified in Section 845.680(a)(3).

Interim measures to reduce contaminations leaching and potential exposure to human and/or ecological receptors are included within the CMA provided in **Attachment G**.

2.9. Closure Construction

Section 845.220(d): Closure Construction. In addition to the requirements in subsection (a), all construction permit applications for closure of the CCR surface impoundment under Subpart G must contain the following information and documents:

The Closure Construction details are described in the following sections.

Section 845.220(d)(1): Closure prioritization category, if applicable (see Section 845.700(g));

A CCR Surface Impoundment Category Designation and Justification letter was submitted to IEPA on May 19, 2021. The EAP was designated as Category 5 CCR surface impoundment due to groundwater protection standards exceedances, per Section 845.600. This letter is provided in **Attachment I**. A corrective measures assessment is underway.

Section 845.220(d)(2): Final closure plan (see Section 845.720(b)), including the closure alternatives analysis required by Section 845.710;

The Final Closure Plan as required by Section 845.720(b) and the Alternatives Analysis as required by Section 845.210 are provided in **Attachment G**.

Section 845.220(d)(3): Groundwater modeling, including:

A. *The results of groundwater contaminant transport modeling and calculations showing how the closure will achieve compliance with the applicable groundwater standards;*
B. *All modeling inputs and assumptions;*
C. *Description of the fate and transport of contaminants, with the selected closure over time;*
D. *Capture zone modeling, if applicable; and*
E. *Any necessary licenses and software needed to review and access both the model and the data contained within the model.*

Groundwater modeling as required by Section 845.220(d)(3) is provided in **Attachment B**.

Section 845.220(d)(4): Proposed schedule to complete closure; and

The proposed schedule to completed closure is included within the Final Closure Plan, provided in **Attachment G.**

Section 845.220(d)(5): Post-closure care plan specified in Section 845.780(d), if applicable.

The Post Closure Care Plan required by Section 845.220(d)(5) is provided in **Attachment J**.

3. ADDITIONAL INFORMATION

Certification that EEI will utilize contractors, subcontractors, and installers who are participants in an approved training program, in accordance with 415 Illinois Complied Statutes (ILCS) 5/22.59(b)(4), is provided in **Attachment K**.

4. REFERENCES

[1] Illinois Environmental Protection Agency, "35 Ill. Adm. Code Part 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments," Springfield, IL, 2021.

[2] United Stated Environmental Protection Agency, "40 CFR Parts 257 and 261, Hazardous and Solid Waste Management System, Disposal of Coal Combustion Residuals from Electric Utilities, Final Rule, 2015," 2015.

[3] Burns & McDonnell, "Initial Operating Permit Application, Joppa East Ash Pond," St. Louis, MO, October 25, 2021.

[4] Electric Energy, Incorporated, *Email: RE: Information on CCR in EAP,* April 13, 2022.

[5] Electric Energy, Inc., "Joppa Power Plant, Illinois 12-Month Coal Combustion Byproducts Report," 2021.

[6] Illinois Department of Natural Resrouces, "IDNR Natural Heritage Database," [Online]. Available: https://www2.illinois.gov/sites/naturalheritage/DataResearch/Pages/Access-Our-Data.aspx. [Accessed March 2022].

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[8] U.S. Fish & Wildlife Service, "USFWS Threatened & Endangered Species Active Critical Habitat Report," [Online]. Available: https://ecos.fws.gov/ecp/report/table/critical-habitat.html. [Accessed March 2022].

[9] Illinois Department of Natural Resources, "IDNR Historic Preservation Devision HARGIS," [Online]. Available: https://www2.illinois.gov/dnrhistoric/Preserve/Pages/HARGIS.aspx. [Accessed March 2022].

[10] Federal Emergency Management Agency, "FEMA Flood Map Service Center: Welcome!," [Online]. Available: https://msc.fema.gov/portal/home. [Accessed March 2022].

[11] Ramboll, "Hydrogeologic Site Characterization Report, East Ash Pond, Joppa Power Plant, Joppa, Illinois," October 25, 2021.

[12] Ramboll, "Groundwater Model Report, East Ash Pond, Joppa Power Plant, Joppa, Illinois," July 2022.

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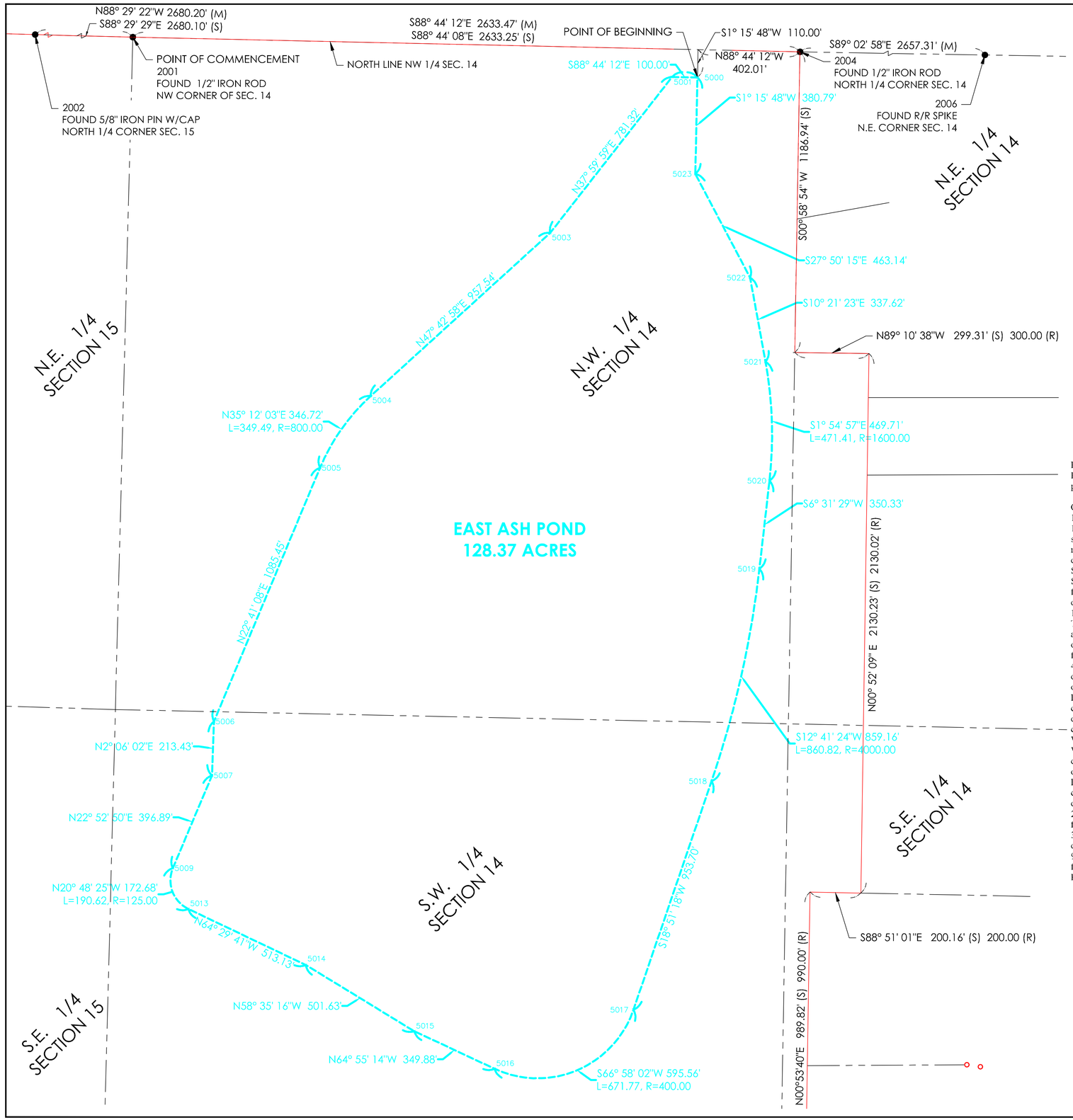
ATTACHMENT A

Legal Description

845.210(c)

July 2022



Luminant

ELECTRIC ENERGY, INC.
JOPPA POWER PLANT

N

0' 200' 400'

LEGEND

- CCR FACILITY BOUNDARY
- QUARTER SECTION LINES
- APPROXIMATE PROPERTY LINE BY OTHERS
- ● FOUND SURVEY MARKER AS NOTED
- M DENOTES MEASURED DIMENSION
- R DENOTES RECORD (DEED) DIMENSION
- S DENOTES DIMENSIONS PER SHAWNEE SURVEY

SURVEY NOTE:
THIS DRAWING AND THE INFORMATION SHOWN HERE ON WAS OBTAINED FROM DATA COLLECTED FROM A FIELD SURVEY MADE BY INGENAE, LLC BETWEEN FEBRUARY 12 THROUGH SEPTEMBER 7, 2021. SURVEY COORDINATES, BEARINGS & DISTANCES ARE REFERENCED TO ILLINOIS EAST 1201 STATE PLANE COORDINATE SYSTEM NAD 1983.

CONTROL MONUMENTATION				
POINT NO.	NORTHING	EASTING	ELEVATION	DESCRIPTION
2001	202315.91'	831502.87'	352.32	FOUND 1/2" IRON ROD - N.W. CORNER OF SEC. 14
2002	202386.57'	828823.60'	358.72	FOUND 5/8" IRON PIN W/CAP - NORTH 1/4 CORNER SEC. 15
2004	202257.85'	834135.70'	362.15	FOUND 1/2" IRON ROD - NORTH 1/4 CORNER SEC. 14
2006	202213.73'	836792.64'	381.28	FOUND R/R SPIKE - N.E. CORNER SEC. 14

Land Description of the Joppa Power Plant
East Ash Pond Facility Boundary
128.37 Acres

Part of the Northwest Quarter and Southwest Quarter of Section 14, Township 15 South, Range 3 East of the Third Principal Meridian, Massac County, Illinois being more particularly described as follows:

Commencing at the found Iron Rod in the pavement at the Northwest Corner of Section 14, from which bears an Iron Pin in the pavement at the North Quarter Corner of Section 15 North 88 degree 29 minutes 22 seconds West a distance of 2680.20 feet; thence from said commencement point at the Northwest Corner of Section 14, South 88 degrees 44 minutes 12 seconds East, along the North line of the Northwest Quarter of Section 14, a distance of 2633.47 feet to the Iron Rod in the pavement at the North Quarter Corner of Section 14, from which bears a Railroad Spike in the pavement at the Northeast Corner of Section 14 South 89 degree 02 minutes 58 seconds East a distance of 2657.31 feet; thence from said Iron Rod in the pavement at the North Quarter Corner of Section 14 North 88 degrees 44 minutes 12 seconds West a distance of 402.01 feet; thence South 01 degrees 15 minutes 48 seconds West a distance of 110.00 feet to the Point of Beginning of the Tract described herein; thence continuing South 01 degrees 15 minutes 48 seconds West a distance of 380.79 feet; thence South 27 degrees 50 minutes 15 seconds East a distance of 463.14 feet; thence South 10 degrees 21 minutes 23 seconds East a distance of 337.62 feet; thence along a curve to the right having a radius of 1600.00 feet a curve length of 471.41 feet a chord bearing South 01 degrees 54 minutes 57 seconds East a chord distance of 469.71 feet; thence South 06 degrees 31 minutes 29 seconds West a distance of 350.33 feet; thence along a curve to the right having a radius of 4000.00 feet a curve length of 860.82 feet a chord bearing South 12 degrees 41 minutes 24 seconds West a chord distance of 859.16 feet; thence South 18 degrees 51 minutes 18 seconds West a distance of 953.70 feet; thence along a curve to the right having a radius of 400.00 feet a curve length of 671.77 feet a chord bearing South 66 degrees 58 minutes 02 seconds West a chord distance of 595.56 feet; thence North 64 degrees 55 minutes 14 seconds West a distance of 349.88 feet; Thence North 58 degrees 35 minutes 16 seconds West a distance of 501.63 feet; thence North 64 degrees 29 minutes 41 seconds West a distance of 513.13 feet; thence along a curve to the right having a radius of 125.00 feet a curve length of 190.62 feet a chord bearing North 20 degrees 48 minutes 25 seconds West a chord distance of 172.68 feet; thence North 22 degrees 52 minutes 50 seconds East a distance of 396.89 feet; thence North 02 degrees 06 minutes 02 seconds East a distance of 213.43 feet; thence North 22 degrees 41 minutes 08 seconds East a distance of 1085.45 feet; thence along a curve to the right having a radius of 800.00 feet a curve length of 349.49 feet a chord bearing North 35 degrees 12 minutes 03 seconds East a chord distance of 346.72 feet; thence North 47 degrees 42 minutes 58 seconds East a distance of 957.54 feet; thence North 37 degrees 59 minutes 59 seconds East a distance of 781.32 feet; thence South 88 degrees 44 minutes 12 seconds East a distance of 100.00 feet to the Point of Beginning and containing 128.37 Acres.

CCR FACILITY BOUNDARY CORNERS		
POINT NO.	NORTHING	EASTING
5000	202156.75	833731.09
5001	202158.95	833631.12
5003	201543.27	833150.09
5004	200899.03	832441.69
5005	200615.71	832241.82
5006	199614.24	831823.20
5007	199400.95	831815.37
5009	199035.29	831661.06
5013	198873.87	831722.40
5014	198652.92	832185.52
5015	198391.47	832613.63
5016	198243.17	832930.52
5017	198476.19	833478.61
5018	199378.71	833786.82
5019	200216.88	833975.55
5020	200564.94	834015.36
5021	201034.38	833999.66
5022	2010366.5	833938.97
5023	201776.05	833722.70

SURVEYOR CERTIFICATE:
THIS IS TO CERTIFY THAT WE, INGENAE, LLC, HAVE AT THE REQUEST OF AND FOR THE EXCLUSIVE USE OF THE OWNERS, PERFORMED A SURVEY OF THE TRACT AS SHOWN HEREON AND THAT THIS IS A TRUE REPRESENTATION OF THAT SURVEY. THIS PLAT AND THE SURVEY FROM WHICH IT IS BASED WERE DONE IN ACCORDANCE WITH THE "MINIMUM STANDARDS OF PRACTICE" FOR LAND SURVEYING IN THE STATE OF ILLINOIS.

INGENAE, LLC
PROFESSIONAL DESIGN FIRM
LICENSE NO. 184.007588-0010

STATE OF ILLINOIS
MICHAEL J. GRAMINSKI
035-2901
LAND SURVEYOR
Sept 20, 2021

MICHAEL J. GRAMINSKI — DATE
I.P.L.S. NO. 035.002901
EXPIRES: 11/30/2022

IngenAE
502 Earth City Plaza, Suite 120
Earth City, MO 63045
www.ingenae.com

Submissions / Revisions:		Date:
1		
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Luminant

Project Name & Location:

JOPPA
POWER PLANT

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JOPPA, IL 62953

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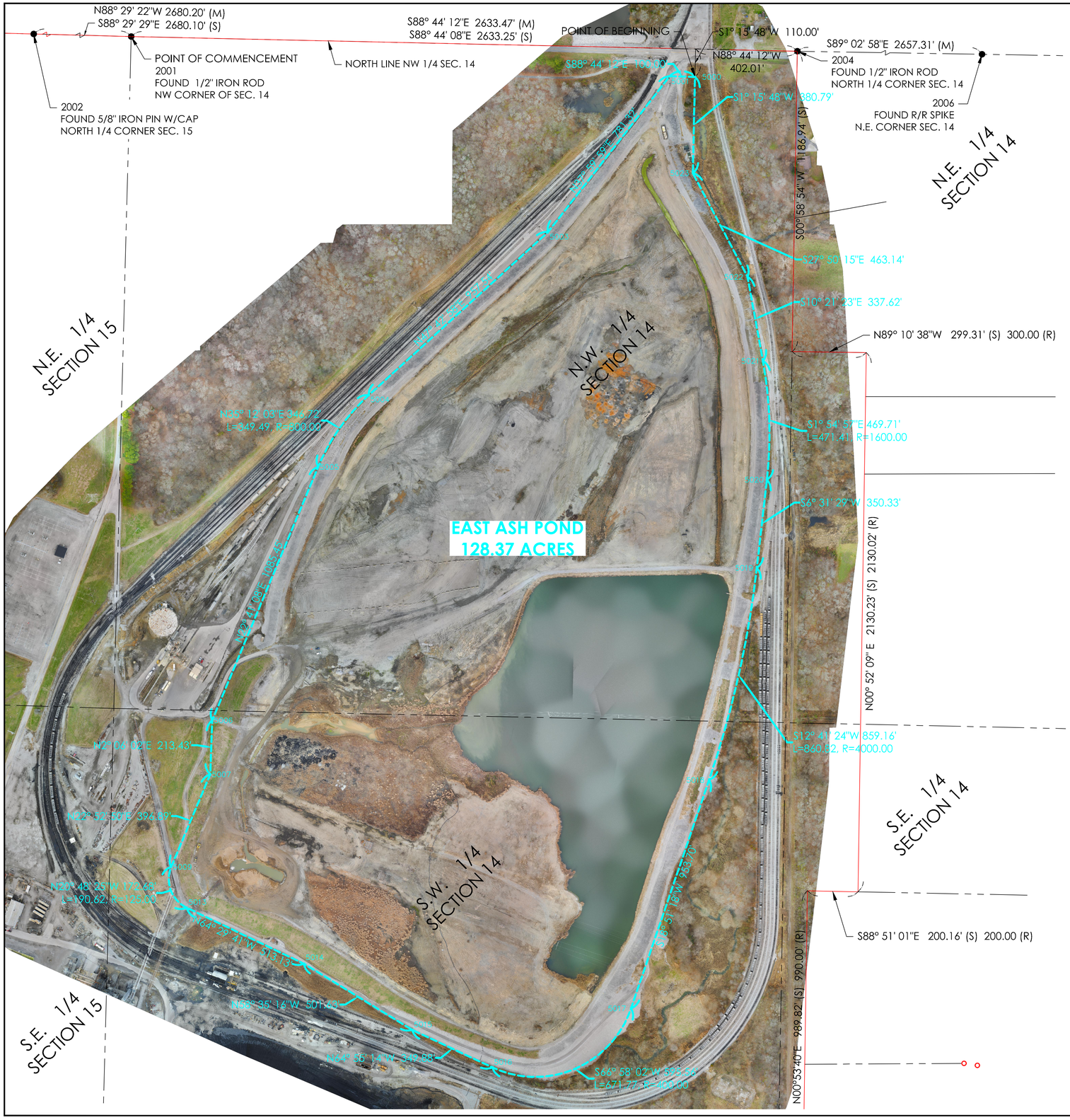
09/07/2021	
Type: SITE	Drawing No. 1
Drawn By: CB	
Approved By: BH	
Scale: AS NOTED	



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JOPPA POWER PLANT

0' 200' 400'

LEGEND

- CCR FACILITY BOUNDARY
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Project Name & Location:

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Approved By: BH	
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ATTACHMENT B

Groundwater Information

845.210(d)(1), 845.220(a)(7)(A-C), 845.220(c)(2), and 845.220(d)(3)

July 2022

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Attachment B.1

Groundwater Modeling Report

July 2022

Intended for
Electric Energy, Inc.

Date
July 28, 2022

Project No.
1940101010-012

GROUNDWATER MODELING REPORT

EAST ASH POND

JOPPA POWER PLANT

JOPPA, ILLINOIS

GROUNDWATER MODELING REPORT
JOPPA POWER PLANT EAST ASH POND

Project Name	**Joppa Power Plant East Ash Pond**
Project No.	**1940101010-012**
Recipient	**Electric Energy, Inc.**
Document Type	**Groundwater Modeling Report**
Revision	**FINAL**
Date	**July 28, 2022**

Ramboll
234 W. Florida Street
Fifth Floor
Milwaukee, WI 53204
USA

T 414-837-3607
F 414-837-3608
https://ramboll.com

Katie Moran
Senior Hydrogeologist

Brian G. Hennings, PG
Senior Managing Hydrogeologist

CONTENTS

Executive Summary		**7**
1.	**Introduction**	**10**
1.1	Overview	10
1.2	Site Location and Background	10
1.3	Site History and Unit Description	10
1.4	Status of Site Investigations	11
2.	**Site Geology and Hydrogeology**	**12**
2.1	Site Topography	12
2.2	Site Geology	12
2.3	Site Hydrogeology	13
2.3.1	Hydraulic Parameters and Characteristics	14
2.3.2	Pumping Wells	14
2.3.3	Ohio River	14
2.3.4	Conceptual Site Model for Flow	15
3.	**Groundwater Quality**	**17**
4.	**Model Approach**	**18**
4.1	Overview	18
4.2	Description of Site-Specific Groundwater Models	18
4.3	Conceptual Site Model for Transport	19
4.4	Model Code Descriptions	20
5.	**Model Setup and Calibration**	**22**
5.1	Current Conditions Flow Model	22
5.1.1	Model Domain and Discretization	22
5.1.2	Boundary Conditions and Hydraulic Parameters	23
5.1.2.1	No-Flow Boundaries	23
5.1.2.2	River	24
5.1.2.3	General Head Boundaries	24
5.1.2.4	Pumping wells	24
5.1.2.5	Recharge	25
5.1.2.6	Hydraulic Conductivity	26
5.1.3	Flow Model Calibration	27
5.1.3.1	Flow Model Targets and Model Calibration Statistics	27
5.1.3.2	Model Calibration Results and Statistics	28
5.2	Historical Transport Model	29
5.2.1	Transient Model Setup and Changes from the Steady-State Flow Model	29
5.2.1.1	Storage Parameters and Porosity	29
5.2.2	Transport Model Construction	30
5.2.2.1	Sources of Boron	30
5.2.2.2	Transport Parameters	31
5.2.3	Transport Model Calibration and Targets	32
5.2.3.1	Transport Model Calibration Results and Statistics	32
5.3	River Flood Evaluation	33
5.3.1	Flood Model Construction	33
5.3.2	Flood Model Results	34
5.4	Flow and Transport Model Assumptions and Limitations	34
6.	**Simulation of Closure Scenario**	**36**
6.1	Overview and Prediction Model Development	36
6.2	HELP Model Setup	36
6.3	Simulation of Closure Scenarios	37
6.3.1	Closure Scenario 1 (CIP)	37
6.3.1.1	Model Setup	37
6.3.1.2	Model Results	39
6.3.2	Closure Scenario 2 (CBR)	40
6.3.2.1	Model Setup	40

6.3.2.2 Model Results 41
7. Conclusions 43
8. References 44

TABLES (IN TEXT)

Table A Flow Model Layer Description
Table B Pumping Well Summary
Table C Model Recharge (Current Conditions Flow Model)
Table D Time Discretization and Model Timeline (Historic Transport Calibration)
Table E Transient Model Storage Parameters
Table F Boron Recharge Concentrations, Historic Transport Calibration, SP2 and SP3

TABLES (ATTACHED)

Table 5-1 Current Conditions Flow Model Hydraulic Conductivity Assignments
Table 5-2 Current Conditions Flow Model Calibration Targets and Statistics
Table 5-3 Historical Transport Model Calibration Targets and Statistics
Table 5-4 Observed and Simulated Flood Event Groundwater Elevations
Table 6-1 HELP Model Input and Output Values
Table 6-2 Predicted Boron Concentrations at EAP Monitoring Wells, CIP and CBR

FIGURES (IN TEXT)

Figure A Daily Gauge Height (feet) and Daily Precipitation (inches) January 1, 2021 to March 30, 2022 for Joppa Power Plant Gaging Station at the Ohio River at Joppa, Illinois
Figure B Correlation of Observed Sulfate and Boron Concentrations in Downgradient UA Wells

FIGURES (ATTACHED)

Figure 1-1 Site Location Map
Figure 1-2 Site Map
Figure 2-1 Site Topographic Map
Figure 2-2 Potentiometric Surface Map, February 1, 2022
Figure 2-3 Ohio River Stage and Observed Groundwater Elevations
Figure 4-1 Closure Scenario Calibration and Prediction Model Timeline
Figure 5-1 Model Grid
Figure 5-2 Boundary Conditions, Model Layer 1
Figure 5-3 Boundary Conditions, Model Layers 2 and 3
Figure 5-4 Boundary Conditions, Model Layer 4
Figure 5-5 Boundary Conditions, Model Layers 6 and 7
Figure 5-6 Model Recharge, Steady-State Flow Model
Figure 5-7 Assigned Hydraulic Conductivities, Model Layer 1
Figure 5-8 Assigned Hydraulic Conductivities, Model Layer 2
Figure 5-9 Assigned Hydraulic Conductivities, Model Layer 3
Figure 5-10 Assigned Hydraulic Conductivities, Model Layer 4
Figure 5-11 Assigned Hydraulic Conductivities, Model Layers 5, 6, 7
Figure 5-12 Simulated Groundwater Elevations and Residuals, Flow Model, Model Layer 1
Figure 5-13 Simulated Groundwater Elevations and Residuals, Flow Model, Model Layer 2
Figure 5-14 Simulated Groundwater Elevations and Residuals, Flow Model, Model Layer 3
Figure 5-15 Simulated Groundwater Elevations and Residuals, Flow Model, Model Layer 4
Figure 5-16 Flow Model Calibration Plots, Observed vs Simulated GWE and Residuals
Figure 5-17 Boron Recharge, Historic Transport Model, SP1
Figure 5-18 Boron Recharge, Historic Transport Model, SP2 and SP3
Figure 5-19 Simulated Dispersivity, Transport Model Layers 2 through 4

Figure 5-20 Historic Transport Model Simulated Boron Concentrations, Model Layer 2
Figure 5-21 Historic Transport Model Simulated Boron Concentrations, Model Layer 3
Figure 5-22 Historic Transport Model Simulated Boron Concentrations, Model Layer 4
Figure 5-23 Simulated Flood Event Groundwater Elevations in Model Layer 4
Figure 5-24 Simulated River Stage and Flood Event Groundwater Elevations
Figure 6-1 CIP Recharge Distribution and Boundary Conditions, Model Layer 1
Figure 6-2 Predicted Boron Concentrations at EAP Monitoring Wells, CIP and CBR
Figure 6-3 Boron Concentrations in Model Layer 2, 24 years Elapsed Time (CIP and CBR)
Figure 6-4 Boron Concentrations in Model Layer 3, 24 years Elapsed Time (CIP and CBR)
Figure 6-5 CIP – Hydraulic Steady State Reductions in Total Flux In and Out of Fill Unit (CCR)
Figure 6-6 CIP – Model Predicted Flux Reduction Over Time
Figure 6-7 Potential Ash Saturation Simulated Closure In Place Groundwater Surface
Figure 6-8 CBR Recharge Distribution and Boundary Conditions, Model Layer 1

APPENDICES

Appendix A Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond, CCR Unit 401 (Ramboll, 2022)
Appendix B Hydrogeologic Updates for Construction Permit
Appendix C MODFLOW, MT3DMS, HELP Model, and Flux Evaluation Data Export Files (Electronic Only)
Appendix D Evaluation of Partition Coefficient Results (Geosyntec, 2022b)
Appendix E HELP Model Output Files
Appendix F Flux Evaluation Data

ACRONYMS AND ABBREVIATIONS

§	Section
35 I.A.C.	Title 35 of the Illinois Administrative Code
40 C.F.R.	Title 40 of the Code of Federal Regulations
bgs	below ground surface
CBR	closure by removal
CCR	coal combustion residuals
CIP	closure in place
cm/s	centimeters per second
CSM	conceptual site model
CY	cubic yards
DMM	deep mixing method
EAP	East Ash Pond
EPRI	Electric Power Research Institute
Federal CCR Rule	40 C.F.R. § 257 Subpart D
ft/d	feet/foot per day
ft^2/d	square feet per day
Geosyntec	Geosyntec Consultants, Inc.
GHB	general head boundary
GMP	Groundwater Monitoring Plan
GMR	Groundwater Modeling Report
gpm	gallons per minute
GWPS	Groundwater Protection Standard
HCR	Hydrogeologic Site Characterization Report
HELP	Hydrologic Evaluation of Landfill Performance
HSU	hydrostratigraphic unit
ID	identification
IEPA	Illinois Environmental Protection Agency
in/yr	inches per year
ISGS	Illinois State Geological Survey
JPP	Joppa Power Plant
Kd	soil adsorption coefficient
LAU	lower aquifer unit
LCU	lower confining unit
LLDPE	linear low-density polyethylene
mg/L	milligrams per liter
mL/g	milliliters per gram
NAVD88	North American Vertical Datum of 1988
NGVD27	National Geodetic Vertical Datum of 1927
NID	National Inventory of Dams
No.	number
NPDES	National Pollutant Discharge Elimination System
NRT	Natural Resource Technology, Inc.
Part 845	35 I.A.C. § 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments
R^2	correlation coefficient

Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
Silt Unit	Peoria Silt/Roxana Silt/Loveland Silt
SP	stress period
TVD	total-variation-diminishing
UA	uppermost aquifer
UCU	upper confining unit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WAP	West Ash Pond

EXECUTIVE SUMMARY

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Modeling Report (GMR) on behalf of the Joppa Power Plant (JPP), operated by Electric Energy, Inc., in accordance with requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845) (Illinois Environmental Protection Agency [IEPA], 2021). This document presents the results of predictive groundwater modeling simulations for proposed closure scenarios for the East Ash Pond (EAP). The two coal combustion residuals (CCR) Units present on the JPP property are the EAP (Vistra identification [ID] number [No.] 401, Illinois Environmental Protection Agency [IEPA] ID No. W1270100004-02, and National Inventory of Dams [NID] No. IL50714), and Landfill (Vistra ID No. 402). In addition, there is a former CCR disposal area, Joppa West, (Vistra ID No. 403, IEPA ID No. W1270100004-01) located west of the EAP. The EAP is the subject of this report and is located at the JPP which is located in Joppa, Illinois (**Figure 1-1**). The JPP property is situated in an agricultural/industrial area, bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south (**Figure 1-2**).

A detailed summary of site conditions was provided in the Hydrogeologic Site Characterization Report (HCR; Ramboll, 2021a). Five distinct water-bearing units have been identified in the vicinity of the EAP based on stratigraphic relationships and common hydrogeologic characteristics. The units are described as follows from the surface downward:

- **CCR:** CCR consisting of fly ash and bottom ash. Water elevations measured in early March 2021 within the EAP indicate the phreatic surface is approximately 370 to 374 feet North American Vertical Datum of 1988 (NAVD88). A maximum thickness of saturated fill and CCR of approximately 42 feet was observed at location XPW01 in April 2021. The amount of saturated fill and CCR in the EAP is generally consistent, ranging from 35 to 45 feet from March through August 2021, based on an estimated base of ash from 425 to 435 feet NAVD88 and the measured phreatic surface.
- **Upper Confining Unit (UCU):** Low permeability silt and clay of the Equality Formation, silts of the Peoria/Roxana/Loveland, and clay and silt of the Metropolis Formation are considered the UCU. This unit was encountered in all borings advanced on site and limits the vertical migration of CCR impacts into the uppermost aquifer (UA). These deposits are approximately 50 feet thick and extend down to the McNairy Formation. The geometric mean hydraulic conductivity of this unit is 5.9×10^{-6} centimeters per second (cm/s) (Natural Resource Technology, Inc. [NRT], 2013).
- **Uppermost Aquifer (UA):** High permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation. The UA was encountered at elevations ranging from 222.6 to 318.6 feet NAVD88 and is between 50 and 100 feet thick near the EAP. This aquifer is classified as a Class I groundwater as defined by 35 I.A.C. § 620.110.
- **Lower Confining Unit (LCU):** Clay and silt of the Lower McNairy Formation that was encountered in site borings advanced to bedrock, with thicknesses of 12 to 14 feet. Based on material description, continuous lateral extent, and observed vertical gradients between the lower aquifer unit (LAU) and the UA, this is identified as a confining unit.

- **Lower Aquifer Unit (LAU):** Lowermost unit identified at the site and underlies all unlithified deposits. This unit is comprised of the Salem Limestone, which is the uppermost lithified unit at the site, and used as a potable and non-potable water supply in the vicinity of the JPP. This aquifer is classified as a Class I groundwater as defined by 35 I.A.C. § 620.110.

In general, the Upper McNairy Formation consists of permeable sands and gravels with isolated lenses of finer grained material. The Upper McNairy Formation is more permeable than the overlying Equality and Metropolis Formations and is encountered at its shallowest elevation on the east/southeast edge of the EAP. The Lower McNairy Formation acts as a confining unit, comprised of clay and silt which overlies the Mississippian Aged Salem Limestone. The clay and silt of this unit appears to be laterally continuous in the vicinity of the EAP.

The underlying Salem Limestone Bedrock is interpreted as the LAU. The LAU is present at an elevation of approximately 200 feet NAVD88 below the EAP, and slopes downward toward the east. The LAU is assumed to be continuous in the vicinity of the EAP, and an upward gradient within the LAU supports the conceptual model that the Ohio River is the regional receiving body of water.

The elevation of free liquids (phreatic surface) within the EAP are higher than groundwater elevations in the surrounding area. In general, groundwater flow beneath the EAP is from northwest to southeast in the northern half of the EAP, and flows southwest to southeast in the southern half of the EAP. Groundwater elevations may fluctuate by up to 20 feet. Some variations in groundwater flow directions in the southern part of the EAP have been observed; however, the major component of groundwater flow direction is consistently south toward the Ohio River which is the primary receiving body of water in the vicinity of the JPP (Ramboll, 2021a). Flood events in the Ohio River have the potential to increase groundwater elevations in the UA near the EAP.

A review and summary of data collected from 2015 through 2021 for parameters with groundwater protection standards (GWPS) listed in 35 I.A.C. § 845.600 is provided in the HCR (Ramboll, 2021a). Concentration results presented in the HCR are considered potential exceedances because the methodology used to determine them is proposed in the Statistical Analysis Plan (Appendix A to the Groundwater Monitoring Plant [GMP], Ramboll 2021b), which has not been reviewed or approved by IEPA at the time of submittal of the Part 845 operating and construction permit application. The following constituents with potential exceedances of the GWPS listed in 35 I.A.C. § 845.600 were identified in the HCR: boron, chloride, lithium, cobalt, pH, radium 226 and 228 combined, sulfate, and thallium (Ramboll, 2021a).

The History of Potential Exceedances (Ramboll, 2021c) attached to the operating permit application were based on an evaluation of background groundwater quality and the statistical methodologies proposed in the groundwater monitoring plan (GMP; Ramboll, 2021b). This evaluation identified the following potential exceedances: boron, pH, and sulfate. The *Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond [CCR Unit 401]* (**Appendix A**) report was prepared to further evaluate potential GWPS exceedances. The results of the evaluation indicate that two of the well locations are not exceeding following more rigorous statistical analysis. At the remaining well locations, pH exceedances are not related to the EAP because porewater in the EAP does not exhibit low pH, and there is a significant downward trend in background wells indicates changing aquifer consditions outside the EAP. As a result, boron

and sulfate are the two remaining potential exceedances of the GWPS. Boron was selected for modeling the closure scenarios.

A statistically significant correlation is present between concentrations of boron and sulfate identified as potential exceedances of the GWPS which indicate boron is an acceptable surrogate for sulfate in the groundwater model. Concentrations of these parameters are expected to change along with model predicted boron concentrations.

For modeling purposes, it was assumed that boron would not significantly sorb or chemically react with aquifer solids (soil adsorption coefficient [Kd] was set to 0 milliliters per gram [mL/g]) which is a conservative estimate for predicting contaminant transport times in the model. Boron and sulfate transport is likely to be affected by both chemical and physical attenuation mechanisms (*i.e.,* adsorption and/or precipitation reactions as well as dilution and dispersion).

Data collected from previous field investigations, as well as the 2021 and 2022 field investigations, were used to develop and calibrate site-specific groundwater flow and transport models for the EAP. The MODFLOW and MT3DMS models were then used to evaluate two closure scenarios, including CCR consolidation and closure in place (CIP), and closure by removal (CBR) scenarios, using information provided in the *CCR Surface Impoundment Final Closure Plan* (Geosyntec Consultants, Inc. [Geosyntec], 2022a):

- **Scenario 1:** CIP (CCR removal from the southeast areas of the EAP, consolidation to the north and west areas of the EAP, and construction of a cover system over the remaining CCR).
- **Scenario 2:** CBR (CCR removal from the EAP).

Prior to the simulation of these scenarios, a dewatering simulation was included which simulated the removal of free liquids from the EAP prior to the implementation of the two scenarios.

CIP was predicted to reduce total flux in and out of the Fill Unit (CCR) by approximately 99.99% within 1 year of unit closure. Additionally, the base of consolidated CCR was compared to the simulated steady-state groundwater elevations which indicate a minimum of 10 feet of separation will be present between the base of CCR and groundwater.

Results of predictive simulations for the CIP and CBR construction show near-equivalent timeframes for groundwater in the UA to reach GWPS. Simulated concentrations at UA groundwater wells with average boron concentrations that exceed GWPS from 2015 to 2022 decrease to GWPS within 14.2 years of closure for both CIP and CBR. Boron concentrations at all locations within the UA decrease to the GWPS of 2 milligrams per liter (mg/L) within 24 years of closure for both CIP and CBR. The decrease in infiltration rates at the EAP after cessation of sluicing, and following construction (capping and/or excavation) limits the flushing of residual boron concentration within fine-grained UCU materials beneath the EAP; however, the predicted slow migration of the residual boron within the UCU after closure does not result in impacts to the UA above the GWPS after 24 years.

1. INTRODUCTION

1.1 Overview

In accordance with requirements of Part 845 (IEPA, 2021), Ramboll has prepared this GMR on behalf of JPP, operated by Electric Energy, Inc. This report will apply specifically to the CCR unit referred to as the EAP (**Figure 1-1**).

The EAP is a 111-acre unlined CCR surface impoundment (SI) used to manage CCR and non-CCR waste streams prior to discharge in accordance with the plant's National Pollutant Discharge Elimination System (NPDES) permit (IL0001970) at the JPP. This GMR presents and evaluates the results of predictive groundwater modeling simulations for two proposed closure scenarios, including CCR consolidation and CIP, and CBR scenarios:

- **Scenario 1:** CIP (CCR removal from the southeast areas of the EAP, consolidation to the north and western areas of the EAP, and construction of a cover system over the remaining CCR).
- **Scenario 2:** CBR (CCR removal from the EAP).

This document and associated groundwater flow and transport modeling was developed to simulate and evaluate conditions at the EAP. Due to their proximity, Joppa West and the Joppa Landfill are also incorporated into the groundwater model domain. However, given the objectives for this modeling effort, groundwater model construction and simulation results at other units and other non-focus areas should be considered approximate and/or coarse. Evaluation of conditions at Joppa West or the Joppa Landfill should not be performed with the model presented in this document without further refinement and calibration.

1.2 Site Location and Background

The JPP is west of the Village of Joppa in Massac County, Illinois, northeast of the Ohio River in Section 14, Township 15 South, Range 3 East (**Figure 1-1**). The JPP property is bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south. The EAP is located in the west half of Section 14 directly north of the JPP, and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa.

Figure 1-1 shows the location of the plant; **Figure 1-2** is a site map showing the location of the EAP and other CCR units.

The EAP was investigated in 2013 (NRT, 2013) and exceedances of Class I Groundwater Standards were reported for boron, cobalt, pH, radium, sulfate, and thallium. Additional wells were installed in 2015 to comply with Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257 Subpart D (the Federal CCR Rule), and again in 2021 to collect additional data to meet the requirements of 35 I.A.C. § 845.620.

1.3 Site History and Unit Description

The JPP is a coal-fired power plant that was removed from service in 2019. It began operation in 1953 and is located on the north bank of the Ohio River, approximately 2 miles west of the town of Joppa, Illinois. Three CCR units are associated with the JPP:

- **Joppa East (*i.e.,* EAP):** A 111-acre existing unlined CCR SI which is used to manage both fly ash and bottom ash. The EAP is currently operating to receive sluiced ash; a portion of the footprint is an open water pond, the remainder of the area consists of ash to current ground surface.
- **Joppa West (*i.e.,* West Ash Pond [WAP]):** An 103.5-acre existing closed impoundment located in the western portion of the JPP property. The WAP was used from the early 1950's through the 1970's. The WAP consists of two areas, the primary ash impoundment area and a smaller former settlement pond area in the southern portion (settlement area). Currently, Joppa West is capped by a layer of topsoil and clay ranging from 1 to 2 inches (in the forested areas) to several feet along the utility corridors. Natural vegetation was allowed to grow on the surface of Joppa West, which is now covered with dense vegetation, shrubs, and mature trees.
- **Joppa Landfill:** An existing permitted inactive landfill present in the northwestern portion of the JPP property.

The JPP currently operates the EAP for management of CCR waste streams. The EAP is classified as an existing unlined CCR SI which is used to manage both fly ash and bottom ash. The EAP was built in two phases. The northern portion (Phase I) was placed into service in late 1973, while the southern portion (Phase II) was permitted in May 1985, with completion of construction occurring in late 1985. These two sections are separated by a dividing dike (*i.e.,* Central Dike) and were referred to as the Northern and Southern Ponds. The pond embankment has not been raised since its construction in 1973, but material has been added in some areas to increase the width. The Northern Pond is diked over the length of its perimeter and the height of the dike varies from approximately 15 to 45 feet above the outboard toe of slope. The crest is at an approximate elevation of 380 feet NAVD88. The Southern Pond is also a diked earthen embankment structure with a height that varies from approximately 15 to 45 feet above its outboard toe. As with the Northern Pond, the crest is at an approximate elevation of 380 feet NAVD88 (O'Brien and Gere Engineers, Inc. [OBG], 2010).

Ground improvement along the southeastern portion of the EAP was performed in 2016, consisting of wet soil cement deep mixing method (DMM) to an elevation of approximately 305 feet NAVD88. The purpose of the DMM barrier installation was to provide structual stability along this portion of the embankment, with an added benefit of reduction in permeability between the CCR and native material.

1.4 Status of Site Investigations

A report summarizing the geologic and hydrogeologic conditions at the EAP was submitted to IEPA in 2013 (NRT, 2013). Since that submittal, multiple site characterization activities have been performed at the EAP including monitoring network installation in 2015, geotechnical investigations in 2016 (AECOM, 2016), hydraulic conductivity testing in April 2017, and hydrogeologic investigation in 2021 (Ramboll, 2021a). Site investigations are ongoing to delineate and characterize conditions and boron concentrations downgradient of the EAP. A summary of relevant information collected since submittal of the HCR (Ramboll, 2021a) is provided in **Appendix B.**

2. SITE GEOLOGY AND HYDROGEOLOGY

2.1 Site Topography

Topography in the vicinity of the EAP varies from approximately 370 feet NAVD88 along the north end of the site to 330 feet NAVD88 towards the south and east sloping toward the Ohio River (**Figure 2-1**). The embankments are at an elevation of approximately 370 feet NAVD88, while CCR material within the Phase I area of the impoundment ranges from approximately 372 to 380 feet NAVD88, and in the Phase II it ranges from approximately 351 to 363 feet NAVD88. The height of the EAP is approximately 55 feet relative to surrounding grade.

The EAP also contains ponded water in the southeastern portion of the unit which is connected to the CCR material. According to staff gage XSG01 the surface of the pond is at an elevation of approximately 368 feet NAVD88.

Pre-development ground surface contours indicate that a former drainage feature was present in the central portion of the EAP. Elevation contours indicate that the ground surface was approximately 320 feet North American Vertical Datum of 1927 (NAVD27) in the southeast corner of the pond prior to filling with CCR. **Appendix B** presents information used to develop the base of ash surface.

2.2 Site Geology

Four geologic units are present in the vicinity of the EAP, these include the following in descending order: fill material and CCR, silts and clays of multiple formations, the McNairy Formation, and the Salem Limestone (bedrock). The units are described as follows, with further details in the HCR (Ramboll, 2021a):

- **Fill and CCR:** Both CCR and non-CCR fill material are present within and near the EAP. Non-CCR fill material is present at the EAP at depths of up to 5 feet below ground surface (bgs), and is present in the vicinity of the JPPand near the EAP. Non-CCR fill varies in composition and is present in the constructed berms, railroad embankments, and areas near the plant. Soil borings performed within the EAP (XPW01, XPW02, and XPW03) indicate that CCR material consists of both fly and bottom ash and it varies in thickness up to approximately 50 feet. Ash is encountered within the footprint of the EAP, at the WAP, at the landfill, and two areas exterior to the EAP to the south and southeast of the EAP berm, which are described in **Appendix B**.
- **Silts and Clays:** The uppermost native material at the site consists of predominantly silt and clay with some sand and gravel, of the Equality Formation, windblown silts, and the Metropolis Formation. The Equality Formation is the uppermost unlithified material encountered at the EAP, consisting of silt and clay with minor amounts of sand and gravel. Borings advanced at the site indicated formation thicknesses of 14 to 28 feet. The Peoria Silt, Roxana Silt, and Loveland Silt (Silt Units) are primarily loess, and are generally classified in boring logs as silt with limited occurrences of sandy silt. These Silt Units are not encountered at all locations near the EAP and are limited in extent. The Metropolis Formation is composed of clay, sandy clay, and sandy silt with limited occurrences of silty sand and gravel. This unit is encountered across the site, and varies in thickness from approximately 4 to 40 feet. Contacts between these units are typically gradational and they are grouped together for evaluation of site conditions.

- **McNairy Formation:** The McNairy Formation underlies the superficial silt and clay units and consists of sands, silts, and clay. At the site, the McNairy Formation is primarily sand and gravels, with occasional lenses of silt and clay, with a total thickness of approximately 50 to 100 feet. The McNairy Formation is continuous through the region and outcrops at ground surface upgradient of the site (Nelson and Masters, 2008).

  Site borings penetrating the full thickness of the McNairy Formation have identified a layer of lean clay immediately above the bedrock surface. This material is more generally characterized as clay, silt, or chert gravel residuum in on-site wells (Nelson, 1997), and has been interpreted and characterized as part of the Lower McNairy Formation, Post Creek (Tuscaloosa) Formation, or weathered limestone residuum. Site borings advanced to bedrock identified unit thicknesses of 14 and 12 feet at G09M and G14D, respectively (Ramboll, 2021a; **Appendix B**). This layer is assumed to be continuous atop the bedrock surface and is referred to in the HCR as the Lower McNairy Formation.

- **Salem Limestone Bedrock**: Bedrock at the site consists of Mississippian-age limestone with some shales present in shallower zones. The bedrock dips gently northward toward the center of the Illinois Basin. The top-of-rock elevation is 162 to 236 feet NAVD88 based on site borings and regional geologic information (Nelson and Masters, 2008); the total thickness of Mississipian limestone in the region is greater than 3,200 feet (Ramboll, 2021a).

2.3 Site Hydrogeology

Five hydrostratigraphic units (HSUs) are present at the site and surrounding areas. HSU is defined as a body of rock or unlithified materials that forms a distinct hydrologic unit with respect to the flow of groundwater. The HSUs at the EAP are discussed in detail in the HCR, and consist of the following in descending order:

- **CCR:** CCR consisting of fly ash and bottom ash. Water elevations measured in early March 2021 within the EAP indicate the phreatic surface is approximately 370 to 374 feet NAVD88. The saturated thickness within the CCR varies based upon the base elevation of the ash material and varies from 0 to 45 feet.

- **UCU:** This unit is comprised of the Equality Formation, the Silt Unit, and Metropolis Formation deposits, which are similar in composition and consist primarily of fine-grained silts and clays. The average thickness of this unit is 40 feet with a range of 8 to 58 feet at the site. The UCU underlies the CCR fill and is thinnest beneath the southeast corner of the EAP. This unit is not an aquifer; it is characterized as a confining unit based upon composition, and flow directions with this unit are predominantly vertical.

- **UA:** This unit is composed of the high-permeability sands and gravels of the McNairy Formation, with isolated lenses of finer-grained material. At the site, the UA is 50 to 100 feet thick.

- **LCU:** The LCU consists of the 12- to 14-foot thick clay material encountered between the McNairy Formation and bedrock. This unit is expected to be low permeability with predominantly vertical flow directions between the two high-permeability aquifers above and below.

- **LAU:** This unit, composed of the Salem Limestone Bedrock, is the lowermost HSU identified. The limestone is high permeability and is used as a regional water supply. The LAU has an

upward gradient where monitored near the southern portion of the site, and discharges into the Ohio River.

2.3.1 Hydraulic Parameters and Characteristics

Estimates of hydraulic conductivity and other hydraulic parameters for site HSUs are available from the results of field testing (*i.e.,* slug testing), laboratory testing, and regional or published information.

Field hydraulic conductivity tests were performed on the UA at the EAP as part of the 2021 field investigation (Ramboll, 2021a). Horizontal hydraulic conductivities for the Upper McNairy Formation (*i.e.,* UA) ranged from 4.8×10^{-4} to 1.2×10^{-2} cm/s with a geometric mean of 3.1×10^{-3} cm/s. Field hydraulic conductivity tests were performed at wells completed into the CCR material in 2021 and ranged from 4.5×10^{-3} to 1.7×10^{-1} cm/s, with a geometric mean of 1.3×10^{-2} cm/s. Results of field testing performed in 2010 by Geotechnology and reported by NRT (2013) yield an estimate of 5.9×10^{-6} cm/s for the UCU at Joppa West and Joppa East (geometric mean).

Laboratory falling head permeability tests were conducted on samples collected in CCR material during the 2021 field investigation resulting in a geometric mean vertical hydraulic conductivity of 1.0×10^{-6} cm/s. Additionally, four samples were collected from UCU material for laboratory falling head permeability tests, which resulted in a geometric mean vertical hydraulic conductivity of 1.7×10^{-7} cm/s (Ramboll, 2021a).

A regional geologic study (Brahana and Mesko, 1988) reports a range of estimated hydraulic conductivities for the Salem Limestone of 10 to 75 feet per day (ft/d), and storativity of 0.007 to 0.0008; well yields for this HSU are high. Slug testing performed at well G09M (completed in shallow bedrock) yielded an estimated average hydraulic conductivity of 4.0×10^{-4} cm/s.

2.3.2 Pumping Wells

The bedrock aquifer (*i.e.,* LAU) is a regional source of groundwater for public supply and private wells. There are four currently-operating supply wells completed into the LAU near the EAP, three at JPP and the community water supply (CWS) for the Village of Joppa. The McNairy Formation (*i.e.,* UA) may also be a source of water for private wells. A site visit/windshield survey was conducted in February 2022 for visual identification of potential pumping wells on private property near the site, however no clear link between database records for well locations and observed potential wellheads was identified (Ramboll, 2022a). No active private water supply wells have been identified off property east or south of the EAP near the Village of Joppa, and no known pumping wells in the area utilize the Equality and Metropolis Formations for groundwater.

2.3.3 Ohio River

The Ohio River is the primary receiving body of water for the region. It is a large navigable waterway, approximately 3,500 feet across at the site, with stage managed by several dams including Olmsted, which is 12 miles downgradient from the site. A gauging station is maintained by JPP personnel adjacent to the site. Daily gauge heights and precipitation from January 1, 2021 through March 2022 are shown in **Figure A** below.

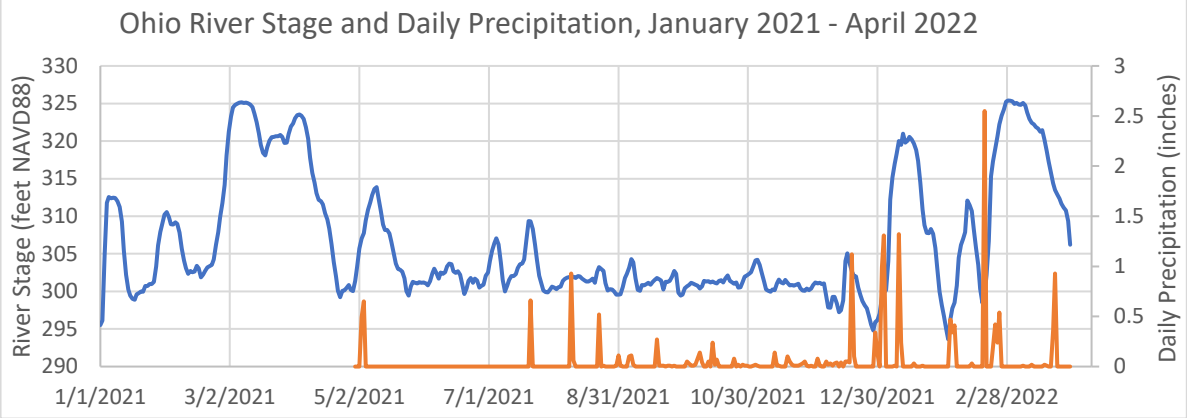

Figure A. Daily Gauge Height (feet) and Daily Precipitation (inches) January 1, 2021 to March 30, 2022 for Joppa Power Plant Gaging Station at the Ohio River at Joppa, Illinois.

Review of available data from the Olmsted gauge and on-site gauge data indicates the following:

- River stage maintains a relatively constant level for most of the time, which represents baseflow conditions in the river and the groundwater system which flows toward the river. This baseflow condition occurs with a site river elevation of approximately 300 feet and represents quasi-equilibrium conditions for the watershed.
- Periodic flood events occur during which the stage in the Ohio River increases by up to 25 feet above baseflow. As shown in **Figure A**, flood events occurred in early 2021 and early 2022.
- Flood events vary with respect to timing/periodicity, the observed pattern of water level changes, severity (*i.e.,* maximum sustained stage), and length. This is unsuprising considering that flooding in the Ohio River is caused by patterns of precipitation and snowmelt, and controlled by multiple dams along its length, which are not constant year-to-year. Review of the longer series of water levels from the Olmsted gauge indicates that the timing of the annual flood varies and should not be characterized as strictly an annualized phenomena.

2.3.4 Conceptual Site Model for Flow

The HCR (Ramboll, 2021a) is the foundation of the site setting and conceptual site model (CSM) that describes groundwater flow at the site. In general, groundwater is recharged from surficial precipitation and from upgradient areas, flowing from north to south within the UA and LAU (bedrock) towards the regional sink of the Ohio River. Groundwater flow is predominantly vertical in the confining units (*i.e.,* UCU and LCU). Groundwater flow in the UA is south towards the river, with an easterly flow component along the east portion of the pond towards the eastern property boundary. Vertical gradients between the bedrock and the UA are upward near the Ohio River.

Discussion of Groundwater Elevations and River Stage

Review of available groundwater elevations from site monitoring wells screened within the UA indicates some variability in groundwater elevations over time. The degree of variability in the groundwater elevation record at each well is not consistent, and varies by location. Evaluation of recent data collected in 2021 and 2022 suggested that the source for variation of groundwater elevations in the UA may be changes in river stage.

A number of site wells were installed in 2021 near the eastern edge of the EAP and along the property boundary to the east. Boring logs, groundwater elevation data, and boron concentrations collected in 2021 and 2022 for these wells are presented in the HCR and **Appendix B**. Data collected from these monitoring wells in early 2022, during flood stage of the Ohio River (**Figure A**), indicate that groundwater elevations within the UA are influenced by stage in the Ohio River.

Generally, evaluation of synoptic (*i.e.*, site-wide) groundwater elevations within the UA indicates that the direction of groundwater flow near the EAP is towards the river from upgradient areas, with some easterly component of flow direction noted near the eastern boundary of the EAP and the site. This is evident in **Figure 2-2**, which presents groundwater elevations measured in the UA on February 1, 2022. The conditions observed in this figure are consistent with the conceptual site model for baseflow conditions at the site, in which the Ohio River has the lowest elevation within the hydrologic watershed and is the receiving body of water for the groundwater system.

Figure 2-3 presents river stage and groundwater elevations collected at site monitoring wells in late 2021 and early 2022, during 2022 flood stages of the Ohio River. This plot shows a clear increase in groundwater elevation during the flooding period, culminating in early March when the flood is at its peak. Elevations at wells for which a pre-flood baseline and March 2, 2022 measurement were collected increased by up to 20 feet during the flood event.

3. GROUNDWATER QUALITY

Per 35 I.A.C. § 620.210, groundwater within the UA and the LAU at the EAP meet the definition of a Class I – Potable Resource Groundwater based on the following criteria:

- Groundwater in the UA extends 10 feet or more below the land surface.
- Hydraulic conductivity exceeds the 1 x 10^{-4} cm/s criterion (Table 3-3 of the HCR [Ramboll, 2021a]).

Field hydraulic conductivity tests performed on the unlithified geologic materials that include high permeability sands of the Upper McNairy Formation (silts, clays, and gravel layers within the unit), and lithified materials (limestone of the Salem Formation) at the JPP had geometric mean hydraulic conductivities exceeding 1 x 10^{-4} cm/s. Based on this information, groundwater is classified as Class I – Potable Resource Groundwater.

A review and summary of data collected from 2015 through 2021 for parameters with GWPSs listed in 35 I.A.C. § 845.600 is provided in the HCR (Ramboll, 2021a). Concentration results presented in the HCR were compared directly to 35 I.A.C. § 845.600 GWPSs to determine potential exceedances. The results indicate the following parameters were greater than the applicable 35 I.A.C. § 845.600 GWPS and are considered potential exceedances: boron, cobalt, pH, radium, sulfate, and thallium. They are considered potential exceedances because the results were compared directly to the standard and did not include an evaluation of background groundwater quality or utilize the statistical methodologies proposed in the GMP (Ramboll, 2021b) attached to the operating permit application.

The History of Potential Exceedances (Ramboll, 2021c) attached to the operating permit application are based on an evaluation of background groundwater quality and the statistical methodologies proposed in the groundwater monitoring plan (GMP; Ramboll, 2021b). This evaluation identified the following potential exceedances: boron, pH, and sulfate. Boron, sulfate, and pH are defined as potential exceedances because the methodology used to determine them is proposed in the Statistical Analysis Plan (Appendix A to GMP), which has not been reviewed or approved by IEPA at the time of submittal of the 35 I.A.C. § 845 operating permit application.

An *Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond [CCR Unit 401]* (**Appendix A**) evaluates the potential GWPS exceedances included in the History of Potential Exceedances (Ramboll, 2021c). The results of the evaluation demonstrated that the potential GWPS exceedances of pH in monitoring wells G06S, G07, G11, G51D, and G151 are not related to the EAP based on several lines of evidence presented in the document. Since potential GWPS exceedances pH are not related to the Ash Pond, this parameter will not be discussed further in this GMR.

Potential exceedances of the GWPS for boron and sulfate are limited to the UA and have not been observed in the lower aquifer unit (LAU, *i.e.,* bedrock aquifer). There is currently one monitoring well present in the LAU (G09M) and no exceedances for boron were observed in the five monitoring events conducted in 2021.

4. MODEL APPROACH

4.1 Overview

Data collected from previous field investigations and those performed in 2021 and early 2022 (Ramboll, 2022a and **Appendix B**) were used to develop groundwater flow and transport models for the EAP (**Section 5**). The MODFLOW and MT3DMS models were then used to evaluate two closure scenarios, including CCR consolidation and CIP, and CBR scenarios, using information provided in the *CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a). The results of the CIP and CBR closure scenarios are summarized and evaluated in **Section 6**. Associated model files are included as **Appendix C.**

As discussed in previous sections, investigation of offsite impacts of boron concentrations resulting from the EAP are currently ongoing. Information obtained after April 2022 was not incorporated into the model, and may impact the final closure and/or corrective measures for the site. As such, it is expected that the groundwater models developed and described in this report may be modified as more information becomes available, and for use in simulation of corrective measures in the future.

The groundwater modeling activities documented in this report utilized the following software and model codes:

- Groundwater flow was simulated in three dimensions using MODFLOW
- Contaminant transport was simulated in three dimensions using MT3DMS
- Hydrologic Evaluation of Landfill Performance (HELP) modeling to simulate infiltration
- Use of Groundwater Vistas as a MODFLOW/MT3DMS processing tool

4.2 Description of Site-Specific Groundwater Models

Four specific groundwater flow and transport models were developed to simulate conditions at the EAP consistent with the CSM presented in **Section 2.3.4**, consisting of the following:

- **Current Conditions Flow Model**: A steady-state flow model was developed and calibrated to represent current conditions for groundwater flow at the EAP. This flow model provided the base model for modifications for other phases of modeling and is documented in **Section 5.1**.
- **Historical Transport Calibration:** A transient flow model was developed by modifying the current conditions model to simulate groundwater flow conditions throughout operation of the EAP to the present time. A solute transport model was developed to simulate boron concentrations in groundwater throughout EAP operation to enable comparison of simulated concentrations to observed concentrations (transport calibration) and provide a stable distribution of current boron concentrations as a baseline for predictive modeling. The historical transport model is documented in **Section 5.2**.
- **River Flood Evaluation:** Identification of the potential for transient groundwater flow direction reversals near the Ohio River during periods of river flooding underscored the need for further evaluation of river flooding. The current conditions model was used as a base to construct a transient model to simulate effects of river flooding on groundwater flow directions. The river flood model is documented in **Section 5.3**.

- **Predictive Simulations:** Modifications to the site flow and transport models were made to simulate closure alternatives for the EAP. Simulated groundwater flow and boron concentrations from the historical transport calibration and current conditions models were used to provide baseline conditions for predictive simulations. Predictive simulations are documented in **Section 6.3**.

A visual representation of the number of years simulated for the calibration and predictive simulations is presented on **Figure 4-1**.

4.3 Conceptual Site Model for Transport

As discussed in previous sections, investigation of impacts to offsite groundwater from the EAP are ongoing. Although potential exceedances of GWPS have been identified for several COCs, the prevalence of these exceedances (degree and spatial extent) is limited, with the exception of boron, which has been identified in a number of wells within the UA. Concentrations of compounds in leachate potentially migrated downward from the EAP through the silts and clays of the UCU into the sands and gravels of the UA. Groundwater in the UA flows south and southeast (**Figure 2-2**), and boron concentrations have been detected in monitoring wells downgradient of the EAP.

Boron is commonly used as an indicator parameter for contaminant transport of CCR because: (i) it is commonly present at elevated concentrations in coal ash leachate; (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater; and (iii) it is less likely than other constituents to be present at elevated concentrations in background groundwater from natural or other anthropogenic sources.

Comparisons of observed sulfate to boron concentrations (**Figure B** below) indicate a statistically significant correlation between these parameters in downgradient UA wells. Observed concentrations were transformed into Log10 concentrations for evaluation. The correlation coefficient (R^2) and p values (indicator of statistical significance) are also provided on **Figure B**. Higher R^2 values (*i.e.,* closer to 1) indicate stronger correlation between parameters. A correlation is considered statistically significant when the p value is lower than 0.05. The p value is less than the target of 0.05, indicating correlations are statistically significant. The statistically significant correlation between sulfate and boron indicates boron is an acceptable surrogate for sulfate in the groundwater model, and concentrations of sulfate are expected to change along with model predicted boron concentrations. Accordingly, transport modeling was performed for boron and no other constituents at the site at this time.

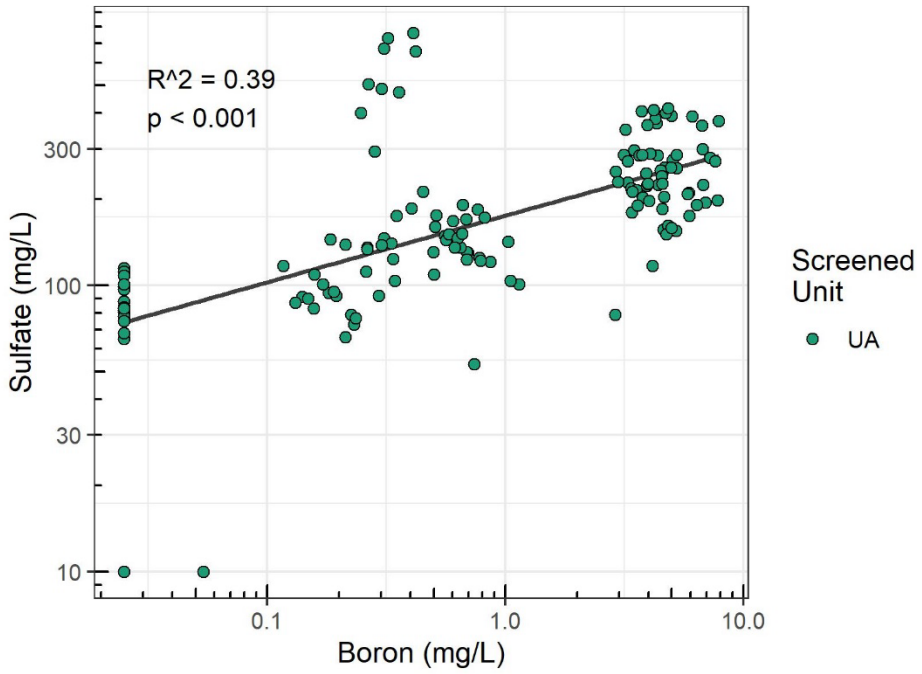

Figure B. Correlation of Observed Sulfate and Boron Concentrations in Downgradient UA Wells.

4.4 Model Code Descriptions

For the construction and calibration of the numerical groundwater flow model for the site, Ramboll selected the model code MODFLOW, a publicly-available groundwater flow simulation program developed by United States Geological Survey (USGS) (McDonald and Harbaugh, 1988). MODFLOW is thoroughly documented, widely used by consultants, government agencies and researchers, and is consistently accepted in regulatory and litigation proceedings. MODFLOW uses a finite difference approximation to solve a three-dimensional head distribution in a transient, multi-layer, heterogeneous, anisotropic, variable-gradient, variable-thickness, confined or unconfined flow system—given user-supplied inputs of hydraulic conductivity, aquifer/layer thickness, recharge, wells, and boundary conditions. The program also calculates water balance at wells, rivers, and drains.

MODFLOW was developed by USGS (McDonald and Harbaugh, 1988) and has been updated several times. Major assumptions of the code are: (i) groundwater flow is governed by Darcy's law; (ii) the formation behaves as a continuous porous medium; (iii) flow is not affected by chemical, temperature, or density gradients; and (iv) hydraulic properties are constant within a grid cell. Other assumptions concerning the finite difference equation can be found in McDonald and Harbaugh (1988). MODFLOW 1996 was used for these simulations with Groundwater Vistas 7 software for model pre- and post-processing tasks (Environmental Simulations, Inc., 2017).

MT3DMS (Zheng and Wang, 1998) is an update of MT3D. It calculates concentration distribution for a single dissolved solute as a function of time and space. Concentration is distributed over a three-dimensional, non-uniform, transient flow field. Solute mass may be input at discrete points

(wells, drains, river nodes, constant head cells), or distributed evenly or unevenly over the land surface (recharge).

MT3DMS accounts for advection, dispersion, diffusion, first-order decay, and sorption. Sorption can be calculated using linear, Freundlich, or Langmuir isotherms. First-order decay terms may be differentiated for the adsorbed and dissolved phases.

The program uses the standard finite difference method, the particle-tracking-based Eulerian-Lagrangian methods and the higher-order finite-volume total-variation-diminishing (TVD) method for the solution schemes. The finite difference solution has numerical dispersion for low-dispersivity transport scenarios but conserves good mass balance. The particle-tracking method avoids numerical dispersion but was not accurate in conserving mass. The TVD solution is not subject to significant numerical distribution and adequately conserves mass, but is numerically intensive, particularly for long-term models such as developed for the EAP. The finite difference solution was used for this simulation.

Major assumptions of MT3DMS are: (i) changes in the concentration field do not affect the flow field; (ii) changes in the concentration of one solute do not affect the concentration of another solute; (iii) chemical and hydraulic properties are constant within a grid cell; and (iv) sorption is instantaneous and fully reversible, while decay is not reversible.

The HELP model was developed by the United States Environmental Protection Agency (USEPA). HELP is a one-dimensional hydrologic model of water movement across, into, through and out of a landfill or soil column based on precipitation, evapotranspiration, runoff, and the geometry and hydrogeologic properties of a layered soil and waste profile. For this modeling, results of the HELP model, HELP Version 4.0 (Tolaymat and Krause, 2020), were used to estimate the hydraulic conditions beneath removal and consolidation areas.

5. MODEL SETUP AND CALIBRATION

This section describes three models which were developed to represent conditions at the site, which consist of the current conditions flow model, the historical calibration transport model, and the river flood evaluation model.

5.1 Current Conditions Flow Model

A steady-state flow model was developed and calibrated to represent current conditions for groundwater flow at the EAP. This flow model provided the base model for flow at the EAP and for modifications for other phases of modeling. Model Files are provided in **Appendix C**.

The development process for a numerical groundwater flow model consists of construction of a finite-difference grid for the model area, specification of model structure, assignment of boundary conditions, specification of hydraulic parameter values and zones, and selection of appropriate water-level measurements for calibration of the model. These features represent elements of the conceptual site model, which provides the basis for the construction and calibration of the numerical model to observed groundwater flow conditions at the site.

Evaluation of available groundwater elevation data for monitoring wells within the model domain indicated that a steady-state current conditions flow calibration was appropriate for this site:

- Groundwater elevation data are generally limited to measurements from the last several years. The dataset that is available for older measurements (wells with longer records) does not indicate the existence of long term water level trends that may require a transient, historical calibration.
- Groundwater elevations for the UA are affected by flooding of the Ohio River, with head increases of up to 20 feet in monitoring wells during periods of flooding (**Section 2.3.3**). However, water levels are generally stable during long periods of baseflow river conditions (stage of approximately 300 feet NAVD88) at the site. The conceptual model for the steady-state flow model is to simulate the stable groundwater elevations and flow directions present during these periods of baseflow (*i.e.,* minimum controlled stage) in the Ohio River to provide a basis for evaluation of long-term, steady-state conditions.

5.1.1 Model Domain and Discretization

The model domain consists of an area 20,000 feet by 15,000 feet (approximately 7,000 acres). The grid was rotated -23.5 degrees to align the southern edge of the model grid with the bank of the Ohio River near the EAP. The model domain is divided into 578 columns (x) and 408 rows (y), with variable grid spacing of 20 feet in areas of interest increasing to 150 feet at the edges of the model domain. **Figure 5-1** presents the model grid.

Seven model layers were assigned to represent subsurface materials. Model layers 1 and 2 were set to represent unconfined flow conditions, with layers 3 through 7 confined. Ground surface elevation within the model domain varies from approximately 300 feet NAVD88 at the Ohio River, to 500 feet NAVD88 in upland areas. Model layer boundaries were interpreted based upon site-specific data (boring logs) and publicly-available information for the area (Nelson and Masters, 2008; Illinois State Geological Survey [ISGS], 2022).

Table A. Flow Model Layer Description

Model Layer	Approximate Layer Bottom Elevation (feet NAVD88)	Layer Description
1	308-surface	CCR material; fill or native materials
2	305-322	UCU – silts and clays
3	273-319	UCU – silts and clays
4	176-250	UA (McNairy formation)
5	162-236 (14 feet uniform thickness)	LCU
6	132-206 (30 feet uniform thickness)	Bedrock
7	-100	Bedrock

Model layer 1 was developed to explicitly represent CCR material, including CCR within the unit boundaries of the EAP and in areas to the southeast of the EAP where ash has been recently identified (and is currently under investigation). Bottom elevations for model layer 1 were set to the base of ash elevation in these areas, with a high base elevation of 375 feet NAVD88 set in areas where no ash is located to ensure these areas would remain dry (inactive) for model simulations. Details regarding ash external to the EAP unit boundaries and elevations of the ash are presented in **Appendix B**.

Model layers 2 and 3 both represent the UCU; two layers were used to represent this HSU to enable greater flexibility in model calibration given the parameter sensivity associated with vertical flow through the thick package of low-permeability material. The base of model layer 3 was set to the top of the McNairy Formation. Model Layer 4 represents the McNairy Formation which comprises the UA. Model layer 5 represents the LCU, and model layers 6 and 7 represent the bedrock. The thickness of the LCU was set to a uniform thickness of 14 feet based upon site data. Simulation of the bedrock as two model layers was selected to enable flexibility in representation of vertical flow through the bedrock. The top of bedrock elevation was set using a handful of data points from site boring logs which penetrated bedrock, well logs for nearby pumping wells, and from the USGS Joppa Geologic Quadrangle Map (Nelson and Masters, 2008).

5.1.2 Boundary Conditions and Hydraulic Parameters

Boundary conditions define the spatial boundaries of the model on the top, bottom, and all sides of the model grid. Additional boundary conditions within the model domain can be specified to represent groundwater sources or sinks, or flow-specified or limiting conditions. This flow model includes five types of boundary conditions: no-flow, recharge (specified flux), and river (head-dependent flux), general head (head-dependent flux), and pumping wells (specified flux). **Figures 5-2 through 5-5** (layer 1, layers 2 and 3, layer 4, layers 6 and 7, respectively) present boundary conditions for the flow model.

Boundary condition parameters and model parameters, chiefly hydraulic conductivity, were varied within appropriate ranges for the site during the model construction and calibration process. Sensitivity testing was performed as necessary to evaluate model construction and adequacy of selected parameters and is documented below where relevant.

5.1.2.1 No-Flow Boundaries

No-flow boundary cells were used to define the edges of the active model area where they do not coincide with the edges of the model grid.

- Model Layer 1 (**Figure 5-2**): Model layer 1 was set as inactive surrounding the EAP extent, since the bottom elevations for model layer 1 represent the base of ash, where present, and are artificially high in other areas to produce dry (unsaturated) model conditions.
- Model Layers 2 and 3 (**Figure 5-3**): No-flow boundaries were defined at the approximate upgradient extends of the local watershed boundaries for the shallow surface units (natural physiographic boundaries). No-flow boundaries were also incorporated above the southern portion of the river as inactive areas.
- No-flow boundaries are not present in model layers 4, 5, 6, and 7; flow in these layers extends to the full model grid extent.

5.1.2.2 River

The Ohio River provides the southern boundary for the model domain. River stage varies based on rainfall/runoff and is also controlled by managing pool level at downstream dams. River elevation data are collected onsite at the JPP and also recorded at the USGS gauging station in Olmsted, Illinois (approximately 12 miles downstream). As shown in **Figure A** in **Section 2.3.3**, plant data indicate that baseflow conditions occur (*i.e.,* consistent minimum elevation) at approximately 300 feet NAVD88, with occasional short-term stage increases of 5 to 10 feet, and periodic (0 to 2 times per year) river flood events of 20 or 25 feet above baseflow conditions. Bathymetry information for the Ohio River near the site indicates a base elevation for the river bottom of approximately 260 feet.

The Ohio River was simulated using river boundary cells in model layer 4 (**Figure 5-4**). A river stage of 300 feet NAVD88 was simulated in the steady-state flow model, with a base of 260 feet. Conductance was increased during sensitivity testing to be sufficiently high to avoid limiting flow into the Ohio River (1.2×10^5 square feet per day [ft^2/d]), as is appropriate per the conceptual model and the function of the river as the primary receiving body of water for the model domain.

5.1.2.3 General Head Boundaries

General head boundaries (GHB) were used to simulate inflow into the upgradient (northern) edge of the model domain in model layers 4, 6, and 7. GHB elevations and conductances were adjusted during calibration to provide an appropriate gradient through the model domain. GHB elevations were simulated at 329 feet NAVD88 in model layer 4, and 332 feet NAVD88 in model layers 6 and 7.

5.1.2.4 Pumping wells

No active private water supply wells have been identified off property east or south of the EAP near the Village of Joppa. Groundwater is pumped for water supply from four bedrock wells located within the model domain. This consists of three supply wells for the plant (JPP1, JPP2, JPP3), and one public water supply well for the town of Joppa (Joppa CWS2). These pumping wells were simulated in the groundwater flow model, within model layer 7 (bedrock) and shown on **Figure 5-5**.

Table B. Pumping Well Summary

Well	Rate (gpm)
Joppa CWS 2	15
JPP1	80
JPP2	410
JPP3	475

Notes:
gpm = gallons per minute

5.1.2.5 Recharge

Recharge is applied as a source of water to the uppermost (top) active layer of the model and represents infiltration of precipitation from the surface to the groundwater table. Recharge can also be used to represent anthropogenic sources of water to groundwater, which in this case consists of sluicing of ash and water into the EAP.

The recharge zones and values specified in the groundwater flow model are identified below and shown in **Figure 5-6**. The model recharge values assigned for each zone described below were selected according to typical recharge values for the site setting, ground cover, and conditions within each zone, and adjusted during model calibration. Sensitivity of model calibration parameters and groundwater elevations in model layers 2 and 3 (flow and transport, described in **Section 5.2**) to changes in recharge values in the EAP and external ash areas was high, due to the large head difference observed between water elevations in the EAP (model layer 1) and the UCU beneath and adjacent to the EAP (model layer 2).

Background recharge of 6.6 inches per year (in/yr) was applied to most of the model domain, which is consistent with typical recharge values for humid temperate climates of the eastern United States. High recharge values were specified for the open water area of the EAP, which receives sluiced ash. . A portion of the ash exterior to the EAP was also specified with high recharge due to identification of minimal ground cover and sandy surface fill materials; higher recharge in this location was also consistent with boron concentrations at wells adjacent to this area (Zone 6).

Model settings were applied in MODFLOW for recharge to enter the highest active (saturated) cell; since the area outside of the EAP is inactive (dry or no-flow) in model layer 1, much of the recharge assigned to the model was applied to model layer 2.

Table C. Model Recharge (Current Conditions Flow Model)

Zone	Assigned Recharge (ft/d)	Assigned Recharge (in/yr)	Zone Description
1	0.0015	6.6	Background recharge
2	0.0027	11.8	Ash
3	0.016	70.1	open water ash pond
5	0.0015	6.6	EAP external ash
6	0.007	30.7	EAP external ash, high recharge (limited ground cover)

5.1.2.6 Hydraulic Conductivity

In constructing the model for the site, representative values for horizontal and vertical hydraulic conductivity of hydrogeologic units were selected based on the results of hydraulic testing conducted at the site as well as regional information and literature values for geologic materials where site specific information was not available. **Table 5-1** presents the hydraulic conductivities assigned for the current-conditions flow model, as described below. The hydraulic conductivities specified were selected from site data presented in the HCR and other site reports, and were carefully adjusted during calibration and sensitivity testing.

- **Model Layer 1 (Figure 5-7)**: Given the limited spatial extent of the active area in model layer 1, three conductivity zones were simulated. Zone 1 represents the ash material; hydraulic conductivities for this material were selected from the range of available slug test data for the ash (HCR) and adjusted during calibration. Zone 2 represents the open water area of the EAP and has an artificially high conductivity to produce uniform head across this area. Simulated model layer 1 water elevations were very sensitive to vertical conductivity, and these values were adjusted carefully to produce an adequate calibration. The DMM was represented by a narrow zone with very low hydraulic conductivity (1×10^{-4} ft/d).
- **Model Layer 2 (Figure 5-8):** Model layer 2 chiefly represents the silts and clays of the UCU (Zone 2), with calibrated conductivity of 0.2 ft/d, consistent with slug test data for the UCU wells. As presented in Nelson and Masters (2008), the McNairy Formation outcrops at ground surface some distance north of the river. This transition was approximated with Zone 18 in model layers 2 and 3, with a horizontal conductivity of 20 ft/d. A higher conductivity zone was placed above the Ohio River (simulated in model layer 4) to ensure that these cells remained inactive (dry) in model layer 2, consistent with the elevations of each model layer and the CSM. A zone of slightly lower conductivity (zone 13) was assigned south of the EAP and west to the WAP, based upon calibration; and a zone of slightly higher conductivity (zone 11) was assigned along the eastern edge of the EAP during calibration. Since the UCU is a surficial confining unit, flow is predominantly vertical within the unit, and simulated groundwater elevations had high sensitivity to changes in vertical hydraulic conductivity. The DMM was also specified in model layer 2, with a base elevation of 305 feet (specified in the model layer 2 bottom elevation) consistent with its construction.
- **Model Layer 3 (Figure 5-9):** The hydraulic conductivities in model layer 3 were mostly equivalent to those in model layer 2. The vertical hydraulic conductivity of the UCU was adjusted slightly following sensitivity testing, and the zone of elevated permeability to the east of the EAP (zone 11) was removed from model layer 3. The DMM was not simulated for model layer 3 according to its base elevation.
- **Model Layer 4 (Figure 5-10):** The sandy McNairy Formation which comprises the UA was simulated with hydraulic conductivities of 10 ft/d to 100 ft/d. The background hydraulic condcutivity specified for most of the model domain was 40 ft/d, with high and low zones (10 and 100 ft/d) assigned during calibration to reproduce the observed groundwater flow directions and elevations observed in this unit.
- **Model Layers 5, 6 and 7 (Figure 5-11):** Model layers 5, 6, and 7 were simulated with two zones within each layer, one zone representing uniform background hydraulic conductivities for each material, and one zone was placed under the southern portion of the river to provide flexibility for calibration of vertical flow. The alignment of these zones is equivalent in each of the three layers. Background horizontal hydraulic conductivities were specified in model layers

5, 6, and 7 as 0.1, 40, and 70 ft/d, respectively. Site-specific hydraulic conductivities were not available for the LCU (model layer 5), so the value of 0.1 ft/d was selected to represent fine-grained materials. Sensitivity to the horizontal conductivity for model layer 5 is low due to its function as a confining unit with the predominantly vertical flow directions; the vertical hydraulic conductivity of the background zone in model layer 5 was adjusted to 0.008 ft/d during model calibration due to sensitivity of vertical gradients between the LAU and the UC to this value. The hydraulic conductivities for the bedrock layers 6 and 7 were initially identified from regional data cited in the HCR, and adjusted during calibration.

5.1.3 Flow Model Calibration

Calibration of a groundwater flow model refers to the iterative process of adjusting model parameters and boundary conditions to obtain a reasonable match between observed conditions and simulation results. The calibration of a groundwater model should rely on discrete measurements of groundwater elevation to avoid the potential for interpretive bias that may result from attempting to match a contoured potentiometric surface (Konikow, 1978; Anderson and Woessner, 1992).

5.1.3.1 Flow Model Targets and Model Calibration Statistics

The primary criterion for evaluating the calibration of a groundwater flow model is the difference between observed and simulated water levels at a set of calibration targets. Calibration targets are a set of field measurements, typically groundwater elevations. For the calibration of a steady-state (time-invariant) model, the goal in selecting calibration targets is to define a set of water-level measurements that represent the average elevation of the water table or potentiometric surface at locations throughout the site.

To match the conceptual model for development of the flow model, which is simulation of relatively low-elevation conditions in the UA which match periods of lower river stage of approximately 300 feet, available groundwater elevations at each monitoring well were evaluated to identify elevations which represented these baseline conditions, and combined to provide a comprehensive baseline/low-elevation dataset for the model domain. Where feasible, groundwater elevation records were compared to river stage to identify appropriate measurements (*i.e.,* groundwater elevations were selected during periods when river stage was at baseflow). However, in other wells (such as those with an older dataset), generally the minimum values were selected. Insufficient temporal data were available across the model domain to provide a synoptic set of water-level targets. Most of the groundwater monitoring data used for target selection were collected between 2015 and 2022.

Groundwater measurements and elevations have been collected during previous hydrogeologic investigations and characterization to meet requirements of regulatory programs. Water elevations used for calibration were compiled from the HCR (Ramboll, 2021) and supplemented with additional data collected during installation and monitoring of wells installed in September 2021 to delineate the extent of potential impacts (**Appendix B**).

A total of 36 flow model targets were selected from available groundwater level data within the model domain, which includes the Joppa Landfill (3 targets) and the EAP (33 targets). Targets were present in model layers 1 through 4 and 6, with the majority (24) in the UA (model layer 4). Water levels used for targets include the new wells installed along the eastern property boundary in late 2021. Target water levels from these wells were selected from initial well

development water levels collected in late 2021 because the synoptic measurements at these locations were collected in early 2022 during a period of high river stage, thus elevated above the levels required for calibration to baseflow (*i.e.,* minimum) conditions.

A number of qualitative, or semi-quantitative, model outputs and results were evaluated and used to adjust calibration as needed to ensure an adequate match to the CSM.

- A calibration target was not defined to represent the level of the open water area within the EAP, however simulation of an elevation close to the observed 368 feet NAVD88 was evaluated during calibration. Use of boundary cells to specify this elevation was considered and discarded in favor of calibration of vertical conductivity and recharge for the ash ponds. The simulated steady-state elevation for this area is 366.7 feet NAVD88.
- The flow balance for the steady-state model was assessed during calibration to ensure that inflow/outflow rates for the model and various boundaries (river and GHBs versus recharge) were reasonable. The flow balance error for the steady-state model was 0.1 percent.
- Vertical gradients upgradient from the site (recharge area) and near the river were assessed during calibration to confirm that vertical flow was reasonably consistent with the CSM and observed vertical gradients at nested wells.
- Flow directions in the UA were carefully evaluated during calibration. Flow directions in the UA from the EAP towards the property boundary to the east show an easterly component of groundwater flow, which is not completely consistent with the expected flow directions directly towards the Ohio River which should be producedby a uniform flow field (hydraulic conductivity/thickness) and linear discharge boundary. Representation of observed flow directions in this area is important for accurate simulation of groundwater flow paths and boron transport from the EAP. The mechanism for the easterly flow component in this area of the UA is the subject of ongoing investigation; flow directions and gradient for the UA were obtained primarily through assignment of hydraulic conductivity zones within model layer 4 during calibration.

5.1.3.2 Model Calibration Results and Statistics

Calibration of the groundwater flow model required numerous individual simulations in an iterative process. During calibration, hydraulic conductivity values, river and GHB boundary components, and recharge were adjusted by trial-and-error and parameter estimation techniques until a reasonable solution was achieved. Calibration targets were used to evaluate the model calibration by analyzing the simulated hydraulic head distributions at the site and the residual statistics.

A model residual is defined as the calculated difference between the observed and simulated hydraulic head at a specific location (observed – simulated). A positive residual indicates that the model is under-predicting observed water levels. Accordingly, a negative residual indicates over-prediction of observed conditions. Residual statistics are used to quantify and evaluate the relative fit of a model simulation to measured water level targets. The mean of model residuals is a representation of overall model bias; a value near zero is desired. The mean residual for this calibration is 0.30. The residual standard deviation indicates the magnitude and spread of the residuals. A residual standard deviation of less than 10 percent of the total range of water level targets is desireable. The residual standard deviation for this calibration is 2.1, which is less than 10 percent of the observation range (67.5).

The residual statistics and simulated hydraulic head distributions indicate a high degree of model calibration and a satisfactory model match to observed groundwater flow conditions. Calibration targets with simulated groundwater elevations, model residuals, and calibration statistics are presented in **Table 5-2**. Simulated groundwater elevations and target residuals are presented on **Figure 5-12 through 5-15**, for model layers 1 through 4.

Another goal of flow model calibration is that residuals are evenly distributed such that there is no bias affecting simulated groundwater elevations across the range of observed values. The observed heads are plotted versus the simulated heads in **Figure 5-16**. The near-linear relationship between observed and simulated values indicates that the model adequately represents the calibration dataset.

5.2 Historical Transport Model

A transient flow model was developed to simulate groundwater flow conditions throughout operation of the EAP to the present time. The current conditions flow model documented in **Section 5.1** was modified to simulate transient, historical flow conditions, and a solute transport model was developed to simulate boron concentrations in groundwater throughout EAP operation. The objective of the historical transport model was to enable comparison of simulated concentrations to observed concentrations (transport calibration) and provide a stable distribution of current boron concentrations as a baseline for predictive modeling.

5.2.1 Transient Model Setup and Changes from the Steady-State Flow Model

A transient flow model was developed to represent conditions of groundwater flow throughout the history of EAP operation and provide the groundwater flow basis for simulation of boron concentrations over time and to the present day. A total of three stress periods (SP) were simulated, to represent 49 years of ash pond operation, as summarized in **Table D** below.

Table D. Time Discretization and Model Timeline (Historic Transport Calibration)

	Years	Description
SP1	1973-1985 (12)	Initial operation of EAP; northern portion only
SP2	1985-2016 (31)	Operation of northern and southern portions
SP3	2016-2022 (6)	Installation of the DMM barrier

Modifications to the steady-state flow model to represent historical conditions of ash pond operation were minimal. One change was to eliminate the DMM barrier from SP1 and SP2 to simulate placement during SP3. The hydraulic conductivities for this thin (1 cell thick) barrier were changed to match the surrounding hydraulic conductivity values in model layers 1 and 2 in SP1 and SP2.

Modifications to recharge zones from the steady-state flow model to reflect changes in ash pond operation are discussed below in **Section 5.2.2.1**.

5.2.1.1 Storage Parameters and Porosity

Simulation of transient flow conditions requires assignment of storage parameters to active model cells, specifically values of storativity, specific yield, and porosity. Limited information was available to define these parameters using site specific values, therefore values were selected based on ranges from literature and assessed during transport model calibration. Uniform storage parameters were specified for each model layer as designated in **Table E** below.

Table E. Transient Model Storage Parameters

Model Layer	Storativity	Specific Yield	Porosity	HSU
1.0	0.003	0.1	0.2	CCR
2.0	0.003	0.1	0.3	UCU
3.0	0.003	0.1	0.3	UCU
4.0	0.003	0.2	0.25	UA
5.0	0.003	0.1	0.3	LCU
6.0	0.001	0.05	0.05	Bedrock
7.0	0.001	0.05	0.1	Bedrock

Note: the storage parameters in the table above do not have units (dimensionless).

5.2.2 Transport Model Construction

The development process for an MT3DMS transport model consists of construction of a finite-difference grid for the model area, specification of model structure, assignment of boundary conditions, specification of hydraulic parameter values and zones, specification of chemical transport parameter values and zones, and selection of appropriate chemical concentrations for calibration of the model. These features represent elements of the conceptual site model, which provides the basis for the construction and calibration of the numerical model to observed groundwater concentration data.

5.2.2.1 Sources of Boron

Migration of boron from the EAP into groundwater was simulated by assigning concentrations of boron to the recharge input. SP1 incorporated boron recharge in the northern portion of the EAP active at that time only, at a concentration of 12 mg/L; SP2 and SP3 incorporated boron recharge consistent with the full area of the EAP (**Table F** below). No initial concentrations were incorporated into the historical transport model prior to construction of the EAP. **Figures 5-17 and 5-18** present the simulated recharge distributions for SP1 and SP2/SP3.

Recharge input of 12 mg/L was selected based upon sample results from monitoring wells completed within the ash (porewater boron concentrations, presented in the HCR). A concentration of 7 mg/L was assigned during calibration to represent dilution of influent within the open water ash pond. Concentrations of 10 and 12 mg/L were assigned for the ash external to the EAP.

Table F. Boron Recharge Concentrations, Historic Transport Calibration, SP2 and SP3

Zone	Recharge	Boron Concentration (mg/L)	Zone Description
1	0.0015	0	Background
2	0.0027	12	Ash
3	0.016	7	open water ash pond
5	0.0015	10	EAP external ash
6	0.007	12	EAP external ash, high recharge (limited ground cover)

5.2.2.2 Transport Parameters

Physical attenuation (dilution and dispersion) of contaminants is simulated in MT3DMS. Dispersion in porous media refers to the spreading of contaminants over a greater region than would be predicted solely from the average groundwater velocity vectors (Anderson, 1979; Anderson, 1984). Dispersion is caused by both mechanical dispersion, a result of deviations of actual velocity at a microscale from the average groundwater velocity, and molecular diffusion driven by concentration gradients. Molecular diffusion is generally secondary and negligible compared to the effects of mechanical dispersion and only becomes important when groundwater velocity is very low. The sum of mechanical dispersion and molecular diffusion is termed hydrodynamic dispersion, or simply dispersion (Zheng and Wang, 1998).

Dispersivity was applied to the groundwater model domain with values identified during calibration. A background dispersivity of 1/0.1 feet (longitudinal/transverse) was applied with increased dispersivity of 30/10 feet (longitudinal/transverse) within the observed boron plume location in model layers 2, 3, and 4. Sensitivity of the background dispersivity was high – increases in this value produced overestimation of concentrations of boron to the west and south of the EAP. The increased dispersivity used in the location of the observed plume showed lower sensitivity. **Figure 5-19** presents the dispersivity zonation specified in model layers 2 through 4.

It was assumed that boron would not significantly sorb or chemically react with aquifer solids (Kd was set to 0 mL/g) which is a conservative estimate for estimating contaminant transport times. Boron and sulfate transport is likely to be affected by both chemical and physical attenuation mechanisms (*i.e.,* adsorption and/or precipitation reactions as well as dilution and dispersion). Batch adsorption testing was conducted to generate site specific partition coefficient results for boron (Geosyntec, 2022b; **Appendix D**) for location G07. Results of the testing are summarized below:

- **Boron:** All boron partition coefficients for G07 were calculated using four of the five datapoints provided by batch attenuation testing. The results for the 1:27.3 soil:solution ratio were excluded because they consistently reduced the goodness-of-fit of each isotherm, and resulted in unrealistic values for both the partition coefficients (*i.e.,* negative values) and isotherm fitting parameters (*i.e.,* 1/n). Removal of the 1:27.3 soil:solution ratio also resulted in a more conservative linear partition coefficient. The linear boron partition coefficient of 2.4 L/Kg, calculated using the four-point isotherm, was chosen for G07 based on its goodness-of-fit (R^2 >0.99) and comparability to other values reported in the literature which range from 0.19 to 1.3 L/kg depending on pH conditions and the amount of sorbent present (Electric Power Research Institute [EPRI], 2005; Strenge and Peterson, 1989). Despite their high goodness-of-fit, both the linearized Langmuir and Freundlich isotherms yielded partition coefficients orders of magnitude higher than anticipated relative to values reported in literature.

The results from site specific samples indicate the potential for retardation of boron using a linear isotherm. The potential exceedances identified in groundwater (boron and sulfate) are affected by natural attenuation processes in multiple ways and to varying degrees. Further assessment of these processes and how they may be applied as a potential groundwater remedy will be completed as part of future remedy selection evaluations, as necessary. For the purposes of this GMR, and as mentioned at the beginning of this section, no retardation was applied to boron transport in the model (*i.e.,* Kd was set to 0 mL/g). Sensitivity tests were not run for retardation.

5.2.3 Transport Model Calibration and Targets

Calibration of a transport model is a similar process to calibration of a flow model, in that it consists of the iterative process of adjusting model parameters and boundary conditions to obtain a reasonable match between observed conditions and simulation results.

For the historic transport model, observed boron concentrations at site monitoring wells were used as targets to evaluate adequacy of model simulated boron concentrations. Boron concentrations at site monitoring wells were available from 2016 to 2021, with between 1 and 11 sample results available for each monitoring well. Due to variable numbers of sample results, differences in date of sample results, and interest in capturing average conditions, the average boron concentrations from recent (2016 to 2022) sample results were used to provide targets representing current conditions (2022) for the transport model. Wells with a larger number of observed concentrations were assessed to identify the presence of concentration trends (up or down) which may affect use of average concentrations over a 5-year period to represent current conditions, however no clear trends were identified which would make use of averages inappropriate for model calibration. Boron concentrations and sample results used for calculation of per-well averages are documented in the HCR and **Appendix B**.

A total of 30 boron concentration targets were selected for the EAP, four in the UCU (1 in model layer 2, 3 in model layer 3), one in the bedrock (layer 6) and the remainder within the UA. Five sets of monitoring wells installed in 2021 (G12S/D, G13S/D, G14S/D, G15S/D, G16S/D) are nested pairs within the UA, with one well near the top of the UA and the other completed at a deeper interval. The ”duplicate” target locations were preserved for model calibration to facilitate appropriate averaging of concentrations in the UA, and presented individually for clarity in predicted concentration results; however, simulated boron concentrations for targets in the same model cell are equivalent.

5.2.3.1 Transport Model Calibration Results and Statistics

Calibration of the historical transport model required numerous individual simulations in an iterative process to produce a reasonable solution. Much of the transport calibration process and iterations were performed in tandem with flow model calibration given the sensitivity of simulated boron concentration distributions to flow directions in the UA.

Table 5-3 presents transport model targets and residuals (observed-simulated) for the final transport model calibration. Simulated boron concentrations and transport model target residuals for 2022 (year 49 of the model simulation) are presented on **Figures 5-20 through 5-22**, for model layers 2, 3, and 4. The overall distribution (extent) of simulated boron concentrations in the UA and magnitude are appropriate for observed concentrations, and target locations with concentrations of boron which exceed the GWPS of 2 mg/L are simulated with concentrations above 2 mg/L. Concentrations at G12S/D and G13S/D, along the eastern property boundary, are underpredicted by 1-4 mg/L; underprediction in this portion of the plume is due to slight underrepresentation of easterly flow directions which are observed in this area. Investigations to further characterize the flow directions in this area are ongoing. Simulation of the lower observed concentrations to the west and south of the EAP is consistent with observed concentrations, except for concentrations at G09 which are overpredicted by 2.4 mg/L.

5.3 River Flood Evaluation

Identification of the potential for transient groundwater flow direction reversals near the Ohio River during periods of river flooding highlighted the need for further evaluation of river flooding. As discussed in **Section 2.3.3**, variable stage in the Ohio River, specifically short-term flood events, impacts groundwater elevations measured in the UA. This effect was initially identified in review of groundwater elevation data collected in early 2022, during a flood in the Ohio River with stage of up to 325 feet NAVD88.

As shown in **Figure 2-3**, the early 2022 flood event occured between approximately January 1, 2022, until the end of the record obtained for this report on March 30, 2022. The flood event began with baseline conditions, characterized by an average stage of approximately 300 feet NAVD88 in late December 2021. An initial flood period was characterized by an increase in stage to 321 feet on January, then a return to below baseline conditions of 293 feet NAVD88 on February 1 (stage reduced below baseline likely due to management of pool conditions at the Olmsted Dam to provide capacity for expected future flooding). The greatest flood elevations occured in February and March, reaching an elevation of 325 feet NAVD88 by February 28. Groundwater elevations are grouped by period of the flood event in which they were obtained. The "Baseline" elevations are aggregated as needed from data extending back in time to June 2021, during which river stage was at baseflow. Elevations shown for 2022 were collected within one day of the assigned date.

Table 5-4 presents a groundwater elevation measurements collected in early 2022 for site monitoring wells. The observed change in groundwater elevations between baseline and the flood elevation (date of maximum flood stage for this event, on 3/1/2022) was calculated for each monitoring well. As shown, elevations at each monitoring well within the UA with sufficient data for this evaluation increased from baseline conditions during the flood event, varying between 0.5 feet at G10 and 18.7 feet at G15D. The average increase in head was 10.9 feet, and the magnitude of head change decreased with distance from the river.

The calibrated groundwater flow model was used as a base to construct a transient groundwater flow model to simulate the observed 2022 flood event. The objectives of this simulation were to evaluate the adequacy of the groundwater model in reproducing observed conditions (qualitative calibration) and evaluate the effects of river flooding at the site on groundwater flow.

5.3.1 Flood Model Construction

A few modifications were made to the current conditions flow model to simulate the 2022 flood event. The model was converted to transient conditions. A total of 60 SPs were specified – 59 of these SPs were 1 day long, to represent daily river stage during the course of the flood event through the end of observed data, from January 3 (stage of 300 feet) to March 2 (stage of 325 feet). The final SP was 300 days in length to simulate conditions following the end of the flood. River stage was specified at the river boundary cells in Layer 4 for each SP according to the stage observed on each day (**Figure 2-3**).

The calibrated steady-state groundwater elevations were used as the initial conditions for the start of the transient model simulation.

5.3.2 Flood Model Results

Figure 5-23 presents simulated groundwater elevations for model layer 4 for the end of the flood period at 59 days elapsed time, which corresponds to the highest river stage (325 feet NAVD88). As shown, groundwater elevations near the river are high, and then decrease moving inland for approximately 2000 feet, where elevations reach a ”saddle” and begin increasing with distance from the river similar to normal conditions. The simulated gradient reversal near the river indicates inflow of water from the river into model layer 4.

Table 5-4 presents the observed and simulated groundwater elevations for each of the flood event monitoring wells, and **Figure 5-24** presents a time-series plot of simulated elevations at a select subset of monitoring wells, and a comparison of observed versus simulated change in groundwater elevation from baseline to flood elevations on March 2, 2022. As shown, the flood model simulation does mimic the changes in groundwater elevation observed in the UA in early 2022. **Figure 5-24** illustrates that groundwater elevations respond to changes in the river stage throughout the flood period, with fluctuations between flood peaks. It is also apparent that the flood model underpredicts the total amount of groundwater elevation increase observed at the monitoring wells onsite –the simulated elevation changes are underpredicted by 25 percent compared to the observed changes, on average. A potential explanation for the underprediction may be the limitations associated with the assignment of hydraulic properties in model layers 2 and 3; specifically, model layers 2 and 3 were simulated with material properties consistent with the UCU through the entire domain, near the river. Under normal flow conditions, application of these properties to materials which are known to be higher in hydraulic conductivity (open space / above ground surface for layer 2, and alluvium for the strip of material closest to the river in layer 3) is not important for accurate representation of flow directions and boron transport near the EAP, since this portion of model layer 2 is typically dry, and both model layers 2 and 3 represent confining units with typically low hydraulic conductivity. Revision of hydraulic properties in this area may be considered for future phases of modeling, as necessary, when additional site investigation activites are completed; however, for the purposes of reviewing the predicted effects of a river flood event, and qualitative assessment of ability to represent observed changes in elevation, this model simulation is adequate for reproduction of flood events.

5.4 Flow and Transport Model Assumptions and Limitations

Simplifying assumptions were made while developing these models:

- Simulation of the groundwater flow system as steady-state is representative of current conditions.
- The approximate base of ash surface in the EAP was developed from information presented in the HCR (Ramboll, 2021a) and in **Appendix B**.
- Observed concentrations of boron in groundwater do not indicate the presence of a trend in concentrations over time.
- Source concentrations are assumed to remain constant over time.
- Boron is not adsorbed and does not decay, and mixing and dispersion are the only attenuation mechanisms.

The model is limited by the data used for calibration, which adequately define the local groundwater flow system and the source and extent of the plume. Since data used for calibration are near the EAP, model predictions of transport distant spatially and temporally from the calibrated conditions at the CCR units will not be as reliable as predictions closer to the CCR units and concentrations observed between 2015 and 2021.

6. SIMULATION OF CLOSURE SCENARIO

6.1 Overview and Prediction Model Development

Prediction simulations were performed to evaluate the effects of closure (source control) measures (CCR consolidation and CIP, and CBR scenarios) for the EAP on groundwater quality.

Modifications were made to the calibrated historical flow and transport model as needed to simulate closure action moving forward from 2022, and are described in detail below. Other parameters and conditions simulated in the calibrated historical flow and transport models were retained for the predictive simulations. Simulations for CIP and CBR consisted of extending the historic transport calibration model to simulate conditions at the beginning of remedy construction (February 1, 2025), simulation of a 2-year construction period consisting of dewatering to remove free liquids from CCR material and construction of the remedy, and a predictive simulation of boron concentrations and groundwater elevations for 50 years following closure.

Model specifications to simulate site closure were selected to be consistent with CIP and CBR remedial designs provided in the *CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a), consistent with methodologies used for simulation of site closure at similar units in 2021 and 2022. Model simulations assume all closure or remedial activities specified below were performed instantaneously at the beginning of each model SP.

6.2 HELP Model Setup

HELP (Version 4.0; Tolaymat and Krause, 2020) was used to estimate percolation through the EAP areas for two ash fill closure scenarios and three area types, including CBR removal areas, CIP removal areas, and CIP consolidation and cover system areas. HELP input and output files are included electronically and attached to this report.

HELP input data and results are provided in **Table 6-1**. All scenarios were modeled for a period of 30 years. Climatic inputs were synthetically generated using default equations developed for Peducah Barkley Regional Airport in Kentucky (the closest weather station included in the HELP database). Precipitation, temperature, and solar radiation was simulated based on the latitude of the EAP. Thickness and type of the geosynthetic drainage layer, geomembrane liner, soil, and soil runoff input parameters were developed for the ash fill removal and consolidation scenarios using data provided the *CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a).

Two additional HELP model simulations were completed to support the *Proposed Alternative Final Protective Layer Equivalency Demonstration*, (Geosyntec, 2022c) which is an appendix to the Construction Permit Application to which this report is also attached. Results of these two HELP simulations were not incorporated in the MODFLOW simulations for closure. Simulation inputs and output results are presented in **Appendix E**.

HELP model simulations were performed for the CIP and CBR remedial actions described in the following sections.

6.3 Simulation of Closure Scenarios

6.3.1 Closure Scenario 1 (CIP)

The design for Closure Scenario 1 is presented in the *CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a). This EAP closure consists of a consolidation and cap approach, where ash is removed from a portion of the EAP (CBR area) and moved to the portion of the EAP where ash will remain with a protective cover (CIP area). Phases of construction of this remedy consist of a preliminary pre-construction phase for permitting and planning, a dewatering phase in which free liquids will be removed from the ash material, a construction and consolidation phase, and then post-closure care.

The CCR will be consolidated from an area of approximately 128 acres to approximately 74 acres. Approximately 1.5 million cubic yards (CY) of CCR material will be relocated from an approximately 54-acre CBR area in the southeastern portion of the EAP, to the 74-acre CIP area in the north and western portion of the EAP. Approximately 3,000 feet (120,000 CY) of perimeter dikes will be relocated from around the removal area, as it will not be needed after closure, and non-CCR material will be utilized for protective cover soil. Additionally, 230,000 CY of CCR material will be relocated from a 32-acrea area outside of the EAP to the 74-acre CIP area. Approximately 1 foot of native material underlying the CCR material will also be excavated during relocation. Backfill of the CBR area following removal of CCR will not be performed. The footprint of the CIP scenario including final grades are included in the *CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a).

After consolidation of the CCR material to the CIP area, a 2,700 feet long, 55-foot high compacted clay soil containment berm will be constructed between the CIP and CBR areas. The CIP area will have a final cover system consisting of the following materials from bottom to top:

- A 40-mil linear low-density polyethylene (LLDPE) geomembrane
- A 10 ounce nonwoven geotextile liner
- A 1.5-foot thick protective layer, utilized from the destruction of the perimeter dikes
- A 0.5-foot thick vegetative topsoil layer

A stormwater detention pond will be constructed in the southeast corner of the EAP with a maintained outfall elevation of 320 feet NAVD88.

6.3.1.1 Model Setup

Closure Scenario 1 (CIP) was simulated using the calibrated historical flow and transport model for the EAP as a base, to be consistent with the specifications and timelines expressed in the *CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a). The model was developed to simulate three explicit periods of closure, as described below.

Period 1 – Current Conditions (Extended)

The first period of closure consists of closure plan submittal, approval, and design and bid activities. This period was simulated by using the transport calibration model with no modifications to current model specifications, extended in time to simulate groundwater elevations and boron concentrations from August 1, 2022 (end of historical calibration model) to the anticipated beginning of remedy construction on February 1, 2025 (30 months).

Period 2 – Dewatering and Construction

The second period of closure consists of construction of the CIP remedy and dewatering of free liquids from the CCR in the EAP. Dewatering and construction activities were simulated to occur during a 2 year period; while this is truncated from the expected timeline for CIP, this shorter timeframe is consistent with remedial scenarios simulated for similar sites as part of site closure predictive modeling.

The flow and transport model was modified to represent conditions during dewatering and construction as described below:

- A 2-year period was simulated for dewatering and closure construction, using simulated conditions for February 1, 2025 as initial conditions.
- Dewatering was simulated by adding drain boundary cells within the model cells representing CCR materials within the footprint of the EAP (model layer 1). The drain elevations were set 0.5 feet above the base of each model layer 1 cell where the base of ash elevation was higher than simulated groundwater elevations in model layer 2 (UCU) from the steady-state current conditions flow model. Drain elevations near the southeastern corner of the EAP were set to 315 feet NAVD88, which approximates the expected UCU groundwater elevation level in this area. Drain cells were not simulated in the CBR areas located outside of the EAP unit boundary. The simulated vertical hydraulic conductivity of the CCR materials was increased from the calibrated value of 0.0013 ft/d to 0.03 ft/d to increase draining of the CCR in model layer 1, with the understanding that dewatering of ash materials will incorporate dewatering techniques such as trenching or sumps as necessary to achieve construction timelines.
- Recharge concentrations of boron were eliminated from the EAP to reflect dewatering conditions. Infiltration within the footprint of the EAP was set to be equivalent with background recharge at 6.6 in/yr.

Period 3 – Post-Closure

A fifty-year period was simulated to represent post-closure conditions, with the following changes from the previous SP:

- Drain cells used to dewater free liquids from the ash were removed. Hydraulic conductivities in CBR areas in model layer 1 were set to 1 ft/d (isotropic) with the assumption that most of the CBR area would be open (*i.e.,* above grade). Existing hydraulic conductivities used to represent the CCR material in model layer 1 were retained for the CIP area, with the increased vertical hydraulic conductivity noted above.
- River cells were used to simulate the stormwater detention pond. The stormwater detention pond was simulated with a base of 318 feet NAVD88, stage of 320 feet NAVD88, and no liner. A conductance of value of 40 ft^2/d was used for these cells.
- Boron concentrations remaining after dewatering and construction activities (*i.e.,* simulated at the end of the period 2) were removed from the CBR areas of model layer 1, representing the removal of ash from model layer 1. Boron concentrations present in the groundwater system (model layers 2 through 7) at the end of the dewatering/construction period provided starting concentrations for the post-closure period simulation.

- Recharge concentrations of boron were retained (12 mg/L) within the CIP area to simulate continued leaching from the ash. Recharge concentrations in the CBR areas were eliminated to reflect removal of ash.
- Infiltration rates within the CIP and CBR areas (which included the removal areas outside of the EAP unit footprint) were set to values calculated using HELP model simulations. The HELP model was used to develop two percolation rates for the Closure Scenario 1 (CIP). HELP model results were 1.18 inches of percolation per year for the EAP CIP removal areas, and 0.0044 inches of percolation per year for the EAP consolidation and cover system areas. The differences in HELP model runs for each area included the following parameters: area, layer construction, soil thickness, and soil runoff slope length; all other HELP model input parameters were the same for each simulated area. HELP input data and results are provided in **Appendix C**.

Figure 6-1 presents model layer 1 recharge and boundary conditions for the CIP predictive remedy, which shows the CBR and CIP areas as well as the simulated stormwater detention pond.

6.3.1.2 Model Results

Simulated groundwater elevations and boron concentrations at the end of the current conditions (Period 1) are consistent with conditions presented for 2022 (**Section 5.2**). At the end of the dewatering and construction phase (Period 2), groundwater elevations within the EAP footprint are decreased to the simulated drain elevations, 0.5 feet above the base of model layer 1, or below the base of model layer 1 (dry cells).

Boron concentrations begin to decrease in Period 2, with the removal of boron recharge to the model, and accelerates in Period 3 following completion of closure activities. **Figure 6-2** presents concentrations of boron following closure at 12 of the 30 EAP monitoring wells which have average concentrations exceeding the GWPS of 2 mg/L. As shown, predicted concentrations of boron fall below the GWPS at these locations within 14.2 years of completion of the CIP remedy. Concentrations of most of the monitoring wells are predicted to fall below 2 mg/L within 5 to 10 years, with the exception of concentrations at G09, which was overpredicted in the calibration model (5.5 mg/L versus the target value of 3.1 mg/L). **Table 6-2** presents a summary of observed and simulated boron concentrations at EAP monitoring wells, with predicted time to meet GWPS at each location following closure. Groundwater elevations in each of the model layers reach a new equilibrium (*i.e.,* new steady-state groundwater elevations) within one year of closure.

By year 24, no concentrations exceeding 2 mg/L are simulated within the UA (model layer 4). Residual mass remains in the UCU (model layers 2 and 3) after concentrations have decreased in the UA due to the lower permeability (slower transport) of these materials and the decrease in infiltration at the EAP after unit closure. **Figures 6-3 and 6-4** depict concentrations of boron in model layers 2 and 3, respectively, after 24 years. The residual concentrations simulated in these layers remain in close proximity to the EAP as the plume recedes over time. Despite these residual concentrations within the UCU, boron concentrations in the UA remain below 2 mg/L, which indicates continued migration of boron into the UA from the UCU does not adversely impact groundwater quality in the UA. The maximum predicted boron concentration at a site monitoring well 50-years post-closure is 0.03 mg/L.

Evaluation of post-construction water flux through the consolidated and covered Fill Unit (CCR) was completed using data obtained from the CIP prediction model. This evaluation compared water flux through the CCR material at the end of the calibration period (49 years elapsed time) to water flux through the consolidated CCR material following completion of the CIP. Calculated fluxes are summarized in **Appendix F** and discussed below. Model output used for flux evaluations are found along with model files in **Appendix C**.

The CIP scenario was predicted to reduce total flux in and out of the Fill Unit (CCR) by approximately 99.99% within 1 year of unit closure, as illustrated in **Figure 6-5**. **Figure 6-6** is a plot showing the changes in flux (shown as inverse percentage of flux reduction) over time following completion of CIP. As shown, hydraulic flux into and out of the remaining CCR material after CIP is minuscule compared to current conditions. No portion of the CCR material is saturated after the first year following site closure; therefore, the only source of flux into the material is from the limited areal recharge through the cover system.

Further, the base of consolidated CCR was compared to the simulated steady-state groundwater elevations which indicate a minimum of 10 feet of separation will be present between the base of CCR and groundwater (**Figure 6-7**).

6.3.2 Closure Scenario 2 (CBR)

This EAP closure scenario consists of approximately 128-acres of CCR material being removed from within the EAP footprint and transported off-site. Additionally, 230,000 CY of CCR material will be relocated from the 32-acrea area south of the EAP and transported to either an on-site or off-site storage facility. Approximately 1 foot of native material underlying the CCR material will also be excavated during relocation of both areas. Backfill following the CCR material removal is not anticipated.

Phases of construction of this remedy consist of a preliminary pre-construction phase for permitting and planning, a dewatering phase in which free liquids will be removed from the ash material, a construction and consolidation phase, and then post-closure care.

Two stormwater detention ponds of maintained elevation will be constructed in the CBR area. The pond in the southeast corner of the EAP is consistent with the pond specified for the CIP remedy, with a maintained outfall elevation of 320 feet NAVD88. A second pond will be located in the northern portion of the CBR area, with a maintained elevation of 332 feet NAVD88.

6.3.2.1 Model Setup

Closure Scenario 1 (CBR) was simulated using the calibrated historical flow and transport model for the EAP as a base, to be consistent with the specifications and timelines expressed in the *CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a). The model was developed to simulate three explicit periods of closure, as described below. Periods 1 and 2 are identical to those simulated for the CIP remedy, described above.

Period 1 – Current Conditions (Extended)

The first period of closure consists of closure plan submittal, approval, and design and bid activities. This period was simulated by using the transport calibration model with no modifications to current model specifications, extended in time to simulate groundwater

elevations and boron concentrations from August 1, 2022 (end of historical calibration model) to the anticipated beginning of remedy construction on February 1, 2025 (30 months).

Period 2 – Dewatering and Construction

The second period of closure consists of construction of the remedy and dewatering of free liquids from the CCR in the EAP. Dewatering and construction activities were simulated to occur during a 2 year period. The flow and transport model was modified to represent conditions during dewatering and construction as described above, for CIP.

Period 3 – Post-Closure

A fifty-year period was simulated to represent post-closure conditions, with the following changes from the previous SP:

- Drain cells used to dewater free liquids from the ash were removed. Hydraulic conductivities in model layer 1 were set to 1 ft/d (isotropic) with the assumption that the CBR area would be above grade, or open water in the stormwater detention ponds.
- Two stormwater detention ponds were simulated using river cells. The stormwater detention pond in the southeastern portion of the EAP was simulated in the same manner as for the CIP, with a stage of 320 feet and base of 318 feet. The northern stormwater pond was simulated with a stage of 332 feet NAVD88 and a base of 330 feet (conductance of 40 ft^2/d).
- Boron concentrations remaining after dewatering and construction activities (*i.e.,* simluated at the end of the period 2) were removed from the CBR areas of model layer 1, representing the removal of ash from model layer 1. Boron concentrations present in the groundwater system (model layers 2 through 7) at the end of the dewatering/construction period provided starting concentrations for the post-closure period simulation.
- Infiltration rates within the CBR areas (which include the removal areas outside of the EAP unit footprint) were set to values calculated using HELP model simulations. The HELP model was used to develop a percolation rate for the Closure Scenario 2 (CBR). HELP model results indicated 0.962 inches of percolation per year for the EAP CBR area. HELP input data and results are provided in **Appendix C**.

Figure 6-8 presents model layer 1 recharge and boundary conditions for the CBR predictive remedy, which shows the CBR areas and the 2 simulated stormwater detention ponds.

6.3.2.2 Model Results

Simulated groundwater elevations and boron concentrations at the end of the current conditions (Period 1) are consistent with conditions presented for 2022 (**Section 5.2**). At the end of the dewatering and construction phase (Period 2), groundwater elevations within the EAP footprint are decreased to the simulated drain elevations, 0.5 feet above the base of model layer 1, or below the base of model layer 1 (dry cells).

Boron concentrations begin to decrease in Period 2, with the removal of boron recharge to the model, and accelerates in Period 3 following completion of closure activities. **Figure 6-2** presents concentrations of boron following closure at the 12 of 30 EAP monitoring wells which have average concentrations exceeding the GWPS of 2 mg/L. with current average concentrations over time following closure. As shown, predicted concentrations of boron fall below the GWPS at these locations within 14.2 years of completion of the CBR remedy. Concentrations of most of the

monitoring wells are predicted to fall below 2 mg/L with 5 to 10 years, with the exception of concentrations at G09, which was overpredicted in the calibration model (5.5 mg/L versus the target value of 3.1 mg/L in 2022). Groundwater elevations in each of the model layers reach a new equilibrium (*i.e.,* new steady-state groundwater elevations) within one year of closure.

By year 24, no concentrations exceeding 2 mg/L are simulated within the UA (model layer 4). As shown for the CIP simulation, residual mass remains in the UCU (model layers 2 and 3) after this time, but migration of boron into the UA does not adversely impact groundwater quality (*i.e.,* groundwater concentrations remain below the GWPS of 2 mg/L. **Figures 6-3 and 6-4** present boron concentrations in model layers 2 and 3 at 24 years, with CIP concentrations shown for comparison. These figures indicate minimal differences in the magnitude of residual mass after 24 years between the two remedies.

7. CONCLUSIONS

This GMR was prepared to evaluate how proposed CIP and CBR closure scenarios will achieve compliance with the applicable groundwater standards at the EAP. Data collected from sampling events between December 2015 and July 2021 were used to develop site-specific groundwater flow and transport models for the JPP EAP. The calibrated MODFLOW and MT3DMS models were then used to evaluate CIP and CBR closure scenarios using information provided in the *CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a):

- **Scenario 1:** CIP (CCR removal from the southeast areas of the EAP, consolidation to the north and west areas of the EAP, and construction of a cover system over the remaining CCR)
- **Scenario 2:** CBR (CCR removal from the EAP)

Scenario 1 (CIP) was predicted to reduce total flux in and out of the Fill Unit (CCR) by approximately 99.99% within one year of completion of CIP. Additionally, the base of consolidated CCR was compared to the simulated steady-state groundwater elevations which indicate a minimum of 10 feet of separation will be present between the base of CCR and groundwater.

Boron and sulfate were identified as potential exceedances of the GWPS in groundwater. Boron was selected for modeling the closure scenarios. A statistically significant correlation is present between concentrations of boron and sulfate identified as potential exceedances of the GWPS which indicate boron is an acceptable surrogate for sulfate in the groundwater model. Concentrations of these parameters are expected to change along with model predicted boron concentrations.

It was assumed that boron would not significantly sorb or chemically react with aquifer solids (soil adsorption coefficient [Kd] was set to 0 milliliters per gram [mL/g]) which is a conservative estimate for predicting contaminant transport times in the model. Boron and sulfate transport is likely to be affected by both chemical and physical attenuation mechanisms (*i.e.,* adsorption and/or precipitation reactions as well as dilution and dispersion).

Results of predictive simulations for the CIP and CBR construction show near-equivalent timeframes for groundwater in the UA to reach GWPS. Simulated concentrations at UA groundwater wells with average boron concentrations that exceed GWPS from 2015 to 2022 decrease to GWPS within 14.2 years of closure for both CIP and CBR. Boron concentrations at all locations within the UA decrease to the GWPS of 2 milligrams per liter (mg/L) within 24 years of closure for both CIP and CBR. The decrease in infiltration rates at the EAP after cessation of sluicing, and following construction (capping and/or excavation) limits the flushing of residual boron concentration within fine-grained UCU materials beneath the EAP; however, the predicted slow migration of the residual boron within the UCU after closure does not result in impacts to the UA above the GWPS after 24 years.

8. REFERENCES

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TABLES

TABLE 5-1. CURRENT CONDITIONS FLOW MODEL HYDRAULIC CONDUCTIVITY ASSIGNMENTS
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Zone	Kx/Ky (ft/d) [1]	Kz (ft/d) [1]	Model Layer	Zone Description	Reference / Support
1	0.3	0.0013	1	Ash	within site-specific data range
2	0.2	0.045	2	UCU - silt and clay	within site-specific data range; vertical conductivity adjusted during calibration (high sensitivity)
3	0.2	0.05	3	UCU - silt and clay	within site-specific data range; vertical conductivity adjusted during calibration (high sensitivity)
4	40	4	4	McNairy formation - sand	regional information and literature values
5	0.1	0.002	5	LCU - silt/clay or saprolite	adjusted during calibration
6	40	0.5	6	Shallow bedrock	regional information and literature values
7	70	3.5	7	Limestone bedrock	regional information and literature values
8	0.0001	0.0001	1,2	DMM	insensitive; within literature range for in-situ stabilization
10	100	5	4	Interpreted gravel zone within McNairy formation	regional information and literature values
11	2	0.06	2	higher-permeability zone within UCU	regional information and literature values
12	200	0.01	1	Standing water in EAP (open water)	vertical conductivity adjusted during calibration
13	0.1	0.008	2,3	interpreted less permeable zone within UCU	regional information and literature values
14	10	1	4	interpreted less permeable zone within UA	regional information and literature values
15	50	5	5	vertical communication area under Ohio River	vertical conductivity adjusted during calibration
16	1	0.1	6,7	vertical communication area under Ohio River	vertical conductivity adjusted during calibration
18	20	2	2,3	McNairy formation upgradient surface outcrop	regional information and literature values
19	8	1	2,3	"drain" area above Ohio River in shallow layers	adjusted during calibration; does not represent subsurface material (inactive cells)

[O: KM 05/16/22; C: EGP 5/19/22]

Notes
[1] Isotropic horizontal conductivity was assumed (*i.e.,* Kx=Ky)
ft/d = feet/foot per day
DMM = deep mixing method
EAP = East Ash Pond
Kx = horizontal hydraulic conductivity
Ky = horizontal hydraulic conductivity
Kz = vertical hydraulic conductivity
LCU = lower confining unit
UA = uppermost aquifer
UCU = upper confining unit

TABLE 5-2. CURRENT CONDITIONS FLOW MODEL CALIBRATION TARGETS AND STATISTICS
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	Unit	X	Y	Layer	Observed GWE (feet NAVD88)	Simulated GWE (feet NAVD88)	Residual (observed-simulated, feet)
XPW01	Joppa East	833197	200767	1	368.5	372.0	-3.5
XPW02	Joppa East	832343	200371	1	371.2	371.2	0.0
XPW03	Joppa East	832213	199021	1	372.3	371.6	0.7
G151	Joppa East	832154	200439	2	321.4	317.6	3.8
G109	Joppa Landfill	826650	204021	2	321.8	321.8	0.0
G102	Joppa Landfill	826535	205073	2	328.9	323.9	5.0
G105	Joppa Landfill	826290	204659	2	323.5	322.9	0.6
G54S	Joppa East	831609	199074	3	312.7	316.4	-3.7
G153	Joppa East	833979	200068	3	314.7	315.8	-1.1
G101JE	Joppa East	831717	202049	3	318.9	320.5	-1.6
G06S	Joppa East	834117	199303	3	315.1	314.0	1.1
G04	Joppa East	834001	201154	4	319.0	317.5	1.5
G05	Joppa East	834089	200844	4	319.0	316.9	2.1
G54D	Joppa East	831610	199067	4	314.7	314.6	0.1
G01D	Joppa East	831716	202039	4	321.0	320.4	0.6
G11	Joppa East	831953	199843	4	319.7	316.7	3.0
G02D	Joppa East	832843	202137	4	320.6	319.9	0.7
G03	Joppa East	833699	202118	4	320.2	319.6	0.6
G51D	Joppa East	832152	200430	4	320.1	317.5	2.6
G07	Joppa East	834089	198591	4	315.2	312.3	2.9
G10	Joppa East	832089	198700	4	313.5	313.6	-0.1
G09	Joppa East	832589	198357	4	310.4	311.1	-0.7
G06	Joppa East	834115	199293	4	312.4	312.6	-0.2
G08	Joppa East	833493	198423	4	318.7	315.7	3.0
G53D	Joppa East	833980	200075	4	311.8	312.3	-0.5
G12S	Joppa East	834634	198795	4	308.6	307.6	1.0
G12D	Joppa East	834639	198793	4	304.8	307.8	-3.0

TABLE 5-2. CURRENT CONDITIONS FLOW MODEL CALIBRATION TARGETS AND STATISTICS

GROUNDWATER MODELING REPORT

JOPPA POWER PLANT

EAST ASH POND

JOPPA, ILLINOIS

Well ID	Unit	X	Y	Layer	Observed GWE (feet NAVD88)	Simulated GWE (feet NAVD88)	Residual (observed-simulated, feet)
G13S	Joppa East	834598	198270	4	305.2	308.2	-3.0
G13D	Joppa East	834599	198275	4	311.8	312.3	-0.5
G14S	Joppa East	834653	197097	4	316.8	313.9	2.9
G14D	Joppa East	834653	197104	4	313.7	312.5	1.2
G15S	Joppa East	834108	197189	4	310.8	311.1	-0.3
G15D	Joppa East	834112	197189	4	304.9	308.2	-3.3
G16S	Joppa East	833582	197190	4	306.2	307.6	-1.4
G16D	Joppa East	833584	197196	4	306.8	307.8	-1.0
G09M	Joppa East	832585	198359	6	317.3	316.1	1.2

[O: KM 5/17/22; C: EGP 5/19/22; U: KM 5/24/22]

NOTES:
GWE = groundwater elevation

Calibration Statistics	
Residual Mean	0.30
Absolute Residual Mean	1.63
Residual Std. Deviation	2.07
Sum of Squares	157.8
RMS Error	2.1
Min. Residual	-3.7
Max. Residual	5.0
Number of Observations	36.0
Range in Observations	67.5
10% of Range	6.75

TABLE 5-3. HISTORICAL TRANSPORT MODEL CALIBRATION TARGETS AND STATISTICS
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	X	Y	Screen Depth (feet bgs)	Model Layer	Boron Concentration (mg/L)		Residual (Observed - Simulated)
					Observed	Simulated	
G54S	831609	199074	(35-45)	3	0.06	0.00	0.1
G54D	831610	199067	(70-80)	4	0.48	0.00	0.5
G53D	833980	200075	(47-57)	4	0.36	3.08	-2.7
G51D	832152	200430	(50-59)	4	0.44	0.00	0.4
G16S	833582	197190	(50-60)	4	7.20	5.15	2.0
G16D	833584	197196	(98-108)	4	4.95	5.15	-0.2
G15S	834108	197189	(50-60)	4	0.98	4.86	-3.9
G15D	834112	197189	(83-93)	4	6.89	4.86	2.0
G153	833979	200068	(30-40)	3	0.02	1.19	-1.2
G151	832154	200439	(32-42)	2	0.12	0.00	1.1
G14S	834653	197097	(53-63)	4	0.03	3.42	-3.4
G14D	834653	197104	(120-130)	4	3.67	3.42	0.3
G13S	834598	198270	(50-60)	4	4.98	3.41	1.6
G13D	834599	198275	(80-90)	4	4.66	3.40	1.3
G12S	834634	198795	(60-70)	4	5.88	2.75	3.1
G12D	834639	198793	(80-90)	4	6.70	2.73	4.0
G11	831953	199843	(56-66)	4	0.33	0.00	0.3
G10	832089	198700	(60-70)	4	4.37	3.48	0.9
G09M	832585	198359	(145-155)	6	0.04	0.00	0.0
G09	832589	198357	(60-70)	4	3.10	5.52	-2.4
G08	833493	198423	(75-85)	4	4.39	5.80	-1.4
G07	834089	198591	(50-60)	4	4.65	5.05	-0.4
G06S	834117	199303	(30-40)	3	0.25	0.61	-0.4
G06	834115	199293	(75-85)	4	3.35	4.21	-0.9
G05	834089	200844	(50-60)	4	0.16	1.52	-1.4
G04	834001	201154	(50-60)	4	0.02	1.02	-1.0
G03	833699	202118	(55-65)	4	0.30	0.00	0.3
G02D	832843	202137	(62-72)	4	0.04	0.00	0.0
G01D	831716	202039	(54-64)	4	0.03	0.00	0.0
Well3	832373	196799	(40-50)	4	0.60	1.79	-1.2

[O: KM 05/16/22; C: EGP 05/20/22]

Notes
Target time is 49 years elapsed time from beginning of simulation, corresponding to early 2022.
Boron concentrations were averaged from available data for 2015-2022
bgs = below ground surface
mg/L = milligrams per Liter
X = latitude
Y = longitude

TABLE 5-4. OBSERVED AND SIMULATED FLOOD EVENT GROUNDWATER ELEVATIONS
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

	Observed GWE (feet NAVD88)			Simulated GWE (feet NAVD88)		
Well ID	Baseline 12/1/2021	Flood Elevation 3/2/2022	Change in Elevation (feet)	Simulated Baseline Elevation 0 days	Simulated Flood Elevation 59 days	Simulated Change (feet)
G03	320.2	323.4	3.2	319.5	320.1	0.6
G05	318.6	322.9	4.2	316.9	318.0	1.1
G06	315.4	322.3	6.9	314.0	316.2	2.2
G07	313.6	321.7	8.0	312.3	315.6	3.2
G08	312.5	322.5	10.0	312.5	315.9	3.4
G09	312.3	323.6	11.2	312.6	316.8	4.2
G10	313.5	314.1	0.5	313.7	317.4	3.7
G11	319.2	325.0	5.8	316.8	318.1	1.3
G12D	311.8	321.7	9.9	312.3	315.4	3.0
G12S	311.8	321.7	9.9	312.4	315.4	3.0
G13D	310.8	321.4	10.7	311.1	315.1	4.0
G13S	310.4	321.5	11.1	311.1	315.1	4.0
G14D	306.8	319.9	13.1	307.8	315.8	8.0
G14S	304.8	320.2	15.4	307.8	315.8	8.0
G15D	304.9	323.6	18.7	308.2	316.1	7.9
G15S	305.2	323.7	18.6	308.2	316.1	7.9
G16D	306.2	326.9	20.6	307.6	316.9	9.3
G16S	308.6	327.1	18.5	307.5	316.9	9.4

[O: KM 05/23/22; C: EGP 05/23/22]

Notes
Elevations recorded as "baseline" were collected between June 30, 2021 and January 1, 2022
Elevations are in feet, referenced to North American vertical Datum of 1988 (NAVD88)
GWE = groundwater elevatoin
Change in GWE was calculated by subtracting the Flood Elevation from the Baseline Elevation at each location

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Closure Scenario - Area Description	EAP CIP - Consolidation Area	EAP CIP - Removal Area	EAP CBR - Removal Area	Notes
Input Parameter				
Climate-General				
City	Joppa, Illinois	Joppa, Illinois	Joppa, Illinois	Nearby city to the Site within HELP database
Latitude	37.21	37.21	37.21	Site latitude
Evaporative Zone Depth	18	18	18	Estimated based on geographic location (Illinois) and uppermost soil type (Tolaymat, T. and Krause, M, 2020)
Maximum Leaf Area Index	4.5	4.5	4.5	Maximum for geographic location (Illinois) (Tolaymat, T. and Krause, M, 2020)
Growing Season Period, Average Wind Speed, and Quarterly Relative Humidity	Paducah Barkley Regional Airport, KY	Paducah Barkley Regional Airport, KY	Paducah Barkley Regional Airport, KY	Nearby city to the Joppa East Ash Pond within HELP database
Number of Years for Synthetic Data Generation	30	30	30	
Temperature, Evapotranspiration, and Precipitation	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 37.21/-88.85	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 37.21/-88.85	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 37.21/-88.85	
Soils-General				
% where runoff possible	100	100	100	
Area (acres)	74	54	128	CBR - Removal Area based on HCR (Ramboll, 2021); CIP - Consolidation and Cover System Area based on construction drawing for Joppa East Ash Pond; CIP -Removal Area equals the difference
Specify Initial Moisture Content	No	No	No	
Surface Water/Snow	Model Calculated	Model Calculated	Model Calculated	
Soils-Layers				
1	Vegetative Soil Layer (HELP Final Cover Soil [topmost layer])	Unsaturated UCU Material (HELP Final Cover Soil)	Unsaturated UCU Material (HELP Final Cover Soil)	Layers details for CBR and CIP areas based on grading plans, construction drawings, and cover system design for Joppa East Ash Pond
2	Protective Soil Layer (HELP Vertical Percolation Layer)	--	--	
3	Geotextile Protective Layer (Custom)	--	--	
4	Geomembrane Liner	--	--	
5	Unsaturated CCR Material (HELP Waste)	--	--	
6	Unsaturated UCU Material (HELP Vertical Percolation Layer)	--	--	

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Closure Scenario - Area Description	EAP CIP - Consolidation Area	EAP CIP - Removal Area	EAP CBR - Removal Area	Notes
Soil Parameters--Layer 1, Vegetative Soil Layer (HELP Final Cover Soil [topmost layer]) or Unsaturated UCU Material (HELP Final Cover Soil)				
Type	1	1	1	Vertical Percolation Layer (Cover Soil)
Thickness (in)	6	120	180	For CBR and CIP removal areas, layer 1 thickness is the average thickness of unsaturated material after removal
Texture	10	43	43	Default used for CIP Consolidation area, Custom used for CBR areas (UCU Material)
Description	Sandy Clay Loam	Clay	Clay	
Saturated Hydraulic Conductivity (cm/s)	1.20E-04	1.70E-07	1.70E-07	Default used for CIP Consolidation area, Custom used for CBR areas from HCR
Soil Parameters--Layer 2, Protective Soil Layer (HELP Vertical Percolation Layer)				
Type	1	--	--	Vertical Percolation Layer (EAP)
Thickness (in)	18	--	--	design thickness
Texture	15	--	--	Defaults used
Description	Clay (Low Density)	--	--	
Saturated Hydraulic Conductivity (cm/s)	1.70E-05	--	--	Defaults used
Soil Parameters--Layer 3, Geotextile Protective Layer (Custom)				
Type	2	--	--	Geotextile Protective Layer (Custom)
Thickness (in)	0.11	--	--	design thickness
Texture	123	--	--	Defaults used
Description	10 oz Nonwoven Geotextile	--	--	
Saturated Hydraulic Conductivity (cm/s)	3.00E-01	--	--	Defaults used
Soil Parameters--Layer 4, Geomembrane Liner				
Type	4	--	--	Flexible Membrane Liner
Thickness (in)	0.04	--	--	design thickness
Texture	36	--	--	Defaults used
Description	LDPE Membrane	--	--	
Saturated Hydraulic Conductivity (cm/s)	4.00E -13	--	--	Defaults used

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Closure Scenario - Area Description	EAP CIP - Consolidation Area	EAP CIP - Removal Area	EAP CBR - Removal Area	Notes
Soil Parameters--Layer 5, Unsaturated CCR Material (HELP Waste)				
Type	1	--	--	Vertical Percolation Layer (Waste)
Thickness (in)	600	--	--	design thickness
Texture	83	--	--	Custom used for CCR material
Description	Unsaturated CCR Material (HELP Waste)	--	--	
Saturated Hydraulic Conductivity (cm/s)	1.00E-06	--	--	Custom used for CCR material from HCR
Soil Parameters--Layer 6, Unsaturated UCU Material (HELP Vertical Percolation Layer)				
Type	1	--	--	Vertical Percolation Layer (UCU Material)
Thickness (in)	252	--	--	Unsaturated UCU Thickness
Texture	43	--	--	Custom used
Description	Clay	--	--	
Saturated Hydraulic Conductivity (cm/s)	1.70E-07	--	--	Custom used or UCU material from HCR
Soils--Runoff				
Runoff Curve Number	85.5	89.7	89.6	HELP-computed curve number
Slope	4.67%	3.50%	3.00%	Estimated from construction design drawings
Length (ft)	600	1000	1000	estimated maximum flow path
Texture	10	43	43	uppermost layer texture
Vegetation	fair	fair	fair	fair indicating fair stand of grass on surface of soil backfill
Execution Parameters				
Years	30	30	30	
Report Daily	No	No	No	
Report Monthly	No	No	No	
Report Annual	Yes	Yes	Yes	
Output Parameter				
Percolation Rate (in/yr)	**0.004401**	**1.18**	**0.962**	

Notes:
% = percent
CBR = closure by removal
CIP = closure in place
cm/s = centimeters per second
EAP = East Ash Pond
ft = feet
HCR = Hydrogeologic Site Characterization Report
HELP = Hydrologic Evaluation of Landfill Performance
in = inches
in/yr = inches per year
Lat = latitude
Long = longitude

[O: EGP 5/20/22, C: JJW 5/19/22]

References:
Tolaymat, T. and Krause, M, 2020. *Hydrologic Evaluation of Landfill Performance: HELP 4.0 User Manual*. United States Environmental Protection Agency, Washington, DC, EPA/600/B 20/219.
Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021. Hydrogeologic Site Characterization Report. Newton Primary Ash Pond. Newton Power Plant. Newton, Illinois.

TABLE 6-2. PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP AND CBR
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	2022 Simulated Boron Concentration (mg/L)	Target Value (Average Boron Concentration [mg/L])	Year 0 Predicted Boron Concentration (mg/L)	CIP Years to Meet GWPS	CBR Years to Meet GWPS
G01D	0.00	0.03	0.00		
G02D	0.00	0.04	0.00		
G03	0.00	0.30	0.00		
G04	1.02	0.02	0.60		
G05	1.52	0.16	0.98		
G06	4.21	3.35	3.61	3.8	3.7
G06S	0.61	0.25	0.62		
G07	5.05	4.65	5.19	5.9	5.6
G08	5.80	4.39	5.33	1.9	2.0
G09	5.52	3.10	5.36	14.2	14.2
G09M	0.00	0.04	0.00		
G10	3.48	4.37	3.47	5.2	5.3
G11	0.00	0.33	0.00		
G12D	2.73	6.70	2.43	3.4	3.5
G12S	2.75	5.88	2.43	3.4	3.5
G13D	3.40	4.66	3.20	6.1	6.0
G13S	3.41	4.98	3.20	6.1	6.0
G14D	3.42	3.67	3.33	8.5	8.3
G14S	3.42	0.03	3.25		
G151	0.00	0.12	0.00		
G153	1.19	0.02	1.02		
G15D	4.86	6.89	4.75	9.8	9.3
G15S	4.86	0.98	4.75		
G16D	5.15	4.95	5.02	7.3	7.4
G16S	5.15	7.20	5.02	7.3	7.4
G51D	0.00	0.44	0.00		
G53D	3.08	0.36	2.47		
G54D	0.00	0.48	0.00		
G54S	0.00	0.06	0.00		
Well3	1.79	0.60	2.12		

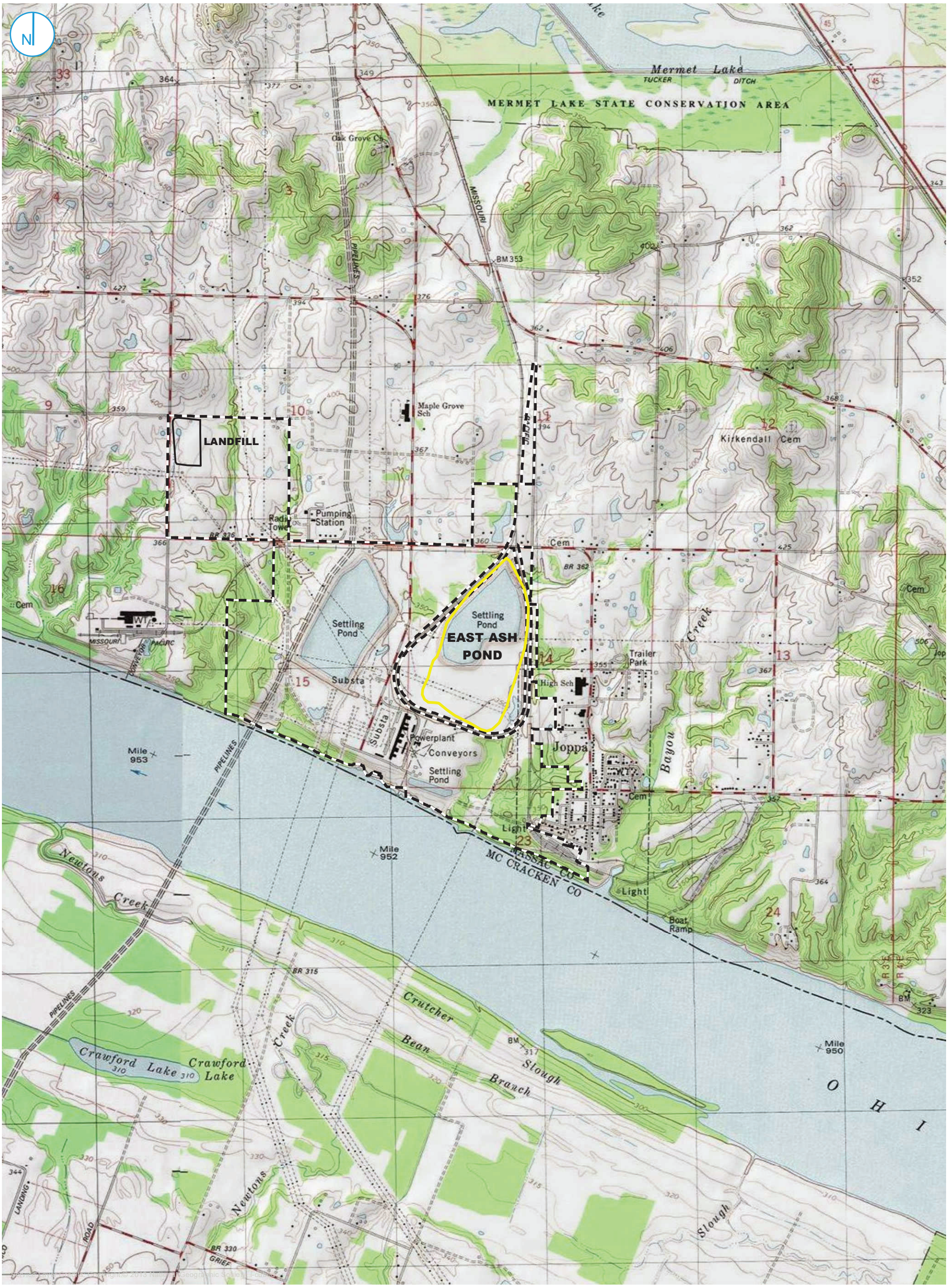
[O: KM 5/17/22, C: EGP 5/20/22]

Notes:
CBR = closure by removal
CIP = closure in place
GWPS = groundwater protection standard
mg/L = milligrams per liter

FIGURES

PROJECT: 169000XXXX | DATED: 5/18/2022 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Joppa\Figure 1-1_Site Location Map.mxd



PART 845 REGULATED UNIT (SUBJECT UNIT)

OTHER UNIT

PROPERTY BOUNDARY

0 1,000 2,000 Feet

SITE LOCATION MAP

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 1-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\221285\MXD\Model_Figures\Joppa\Figure 1-2_Site Map.mxd
PROJECT: 169000XXXX | DATED: 5/18/2022 | DESIGNER: galammc

PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
CENTRAL DIKE
PROPERTY BOUNDARY

0 500 1,000 Feet

SITE MAP

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

10FT TOPOGRAPHIC CONTOUR
2FT TOPOGRAPHIC CONTOUR
PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY

Note:
Elevation contours shown in feet, North American Vertical Datum of 1988 (NAVD88)

0 250 500
Feet

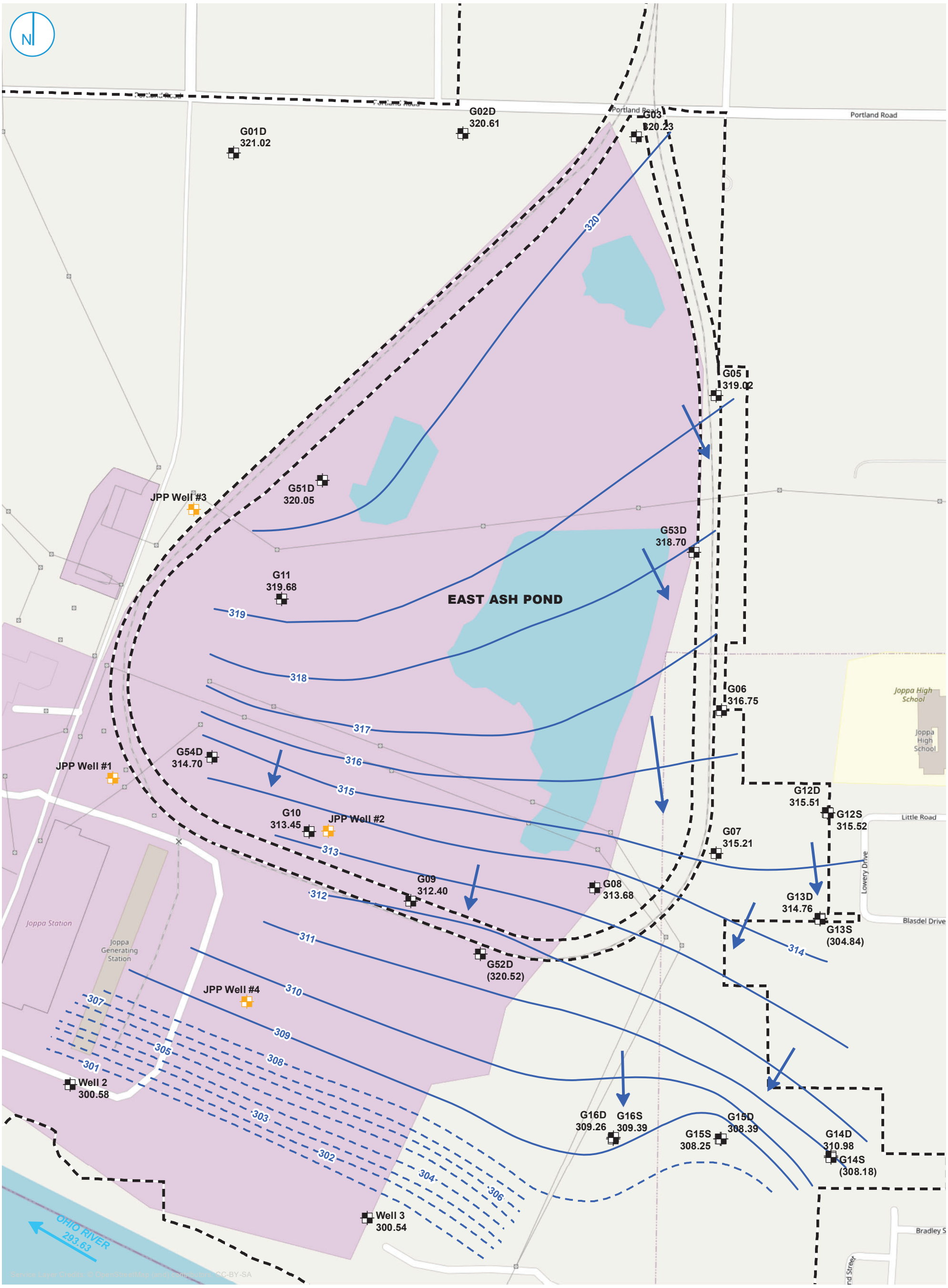
SITE TOPOGRAPHIC MAP

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



MONITORING WELL

JOPPA POWER PLANT NON-POTABLE WELLS

PROPERTY BOUNDARY

GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

NOTE:
ELEVATIONS IN PARENTHESIS NOT USED FOR CONTOURING

0 225 450 Feet

POTENTIOMETRIC SURFACE MAP FEBRUARY 1, 2022

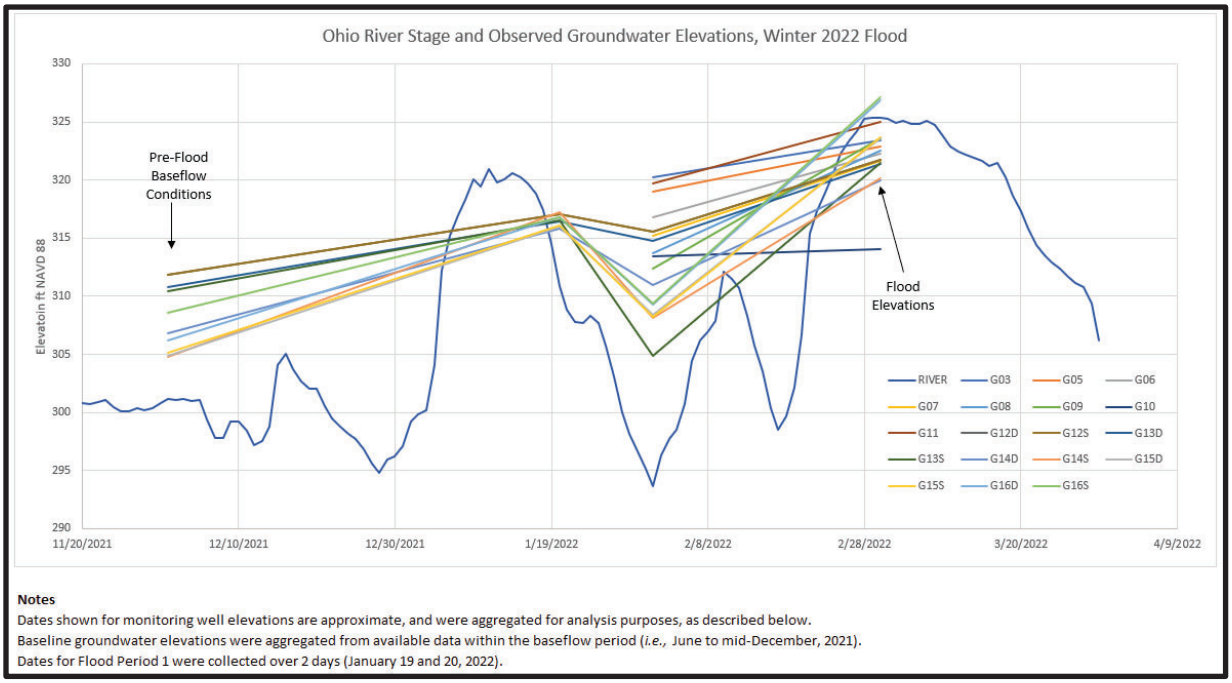
FIGURE 2-2

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

FIGURE 2-3



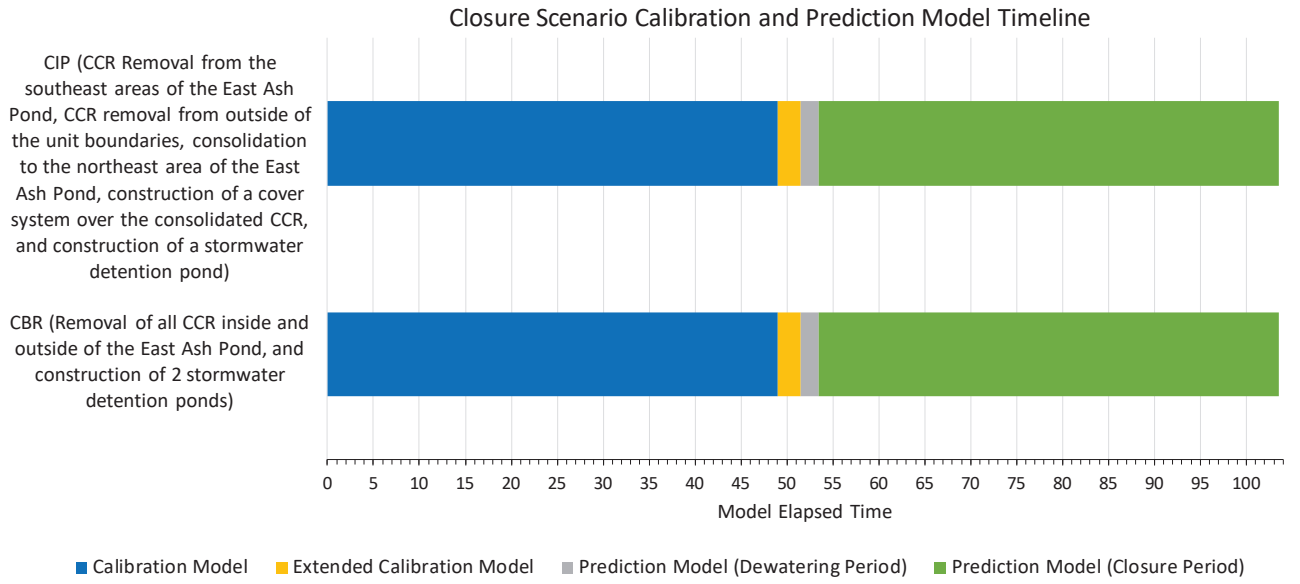
Notes
Dates shown for monitoring well elevations are approximate, and were aggregated for analysis purposes, as described below.
Baseline groundwater elevations were aggregated from available data within the baseflow period (*i.e.,* June to mid-December, 2021).
Dates for Flood Period 1 were collected over 2 days (January 19 and 20, 2022).

OHIO RIVER STAGE AND OBSERVED GROUNDWATER ELEVATIONS

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

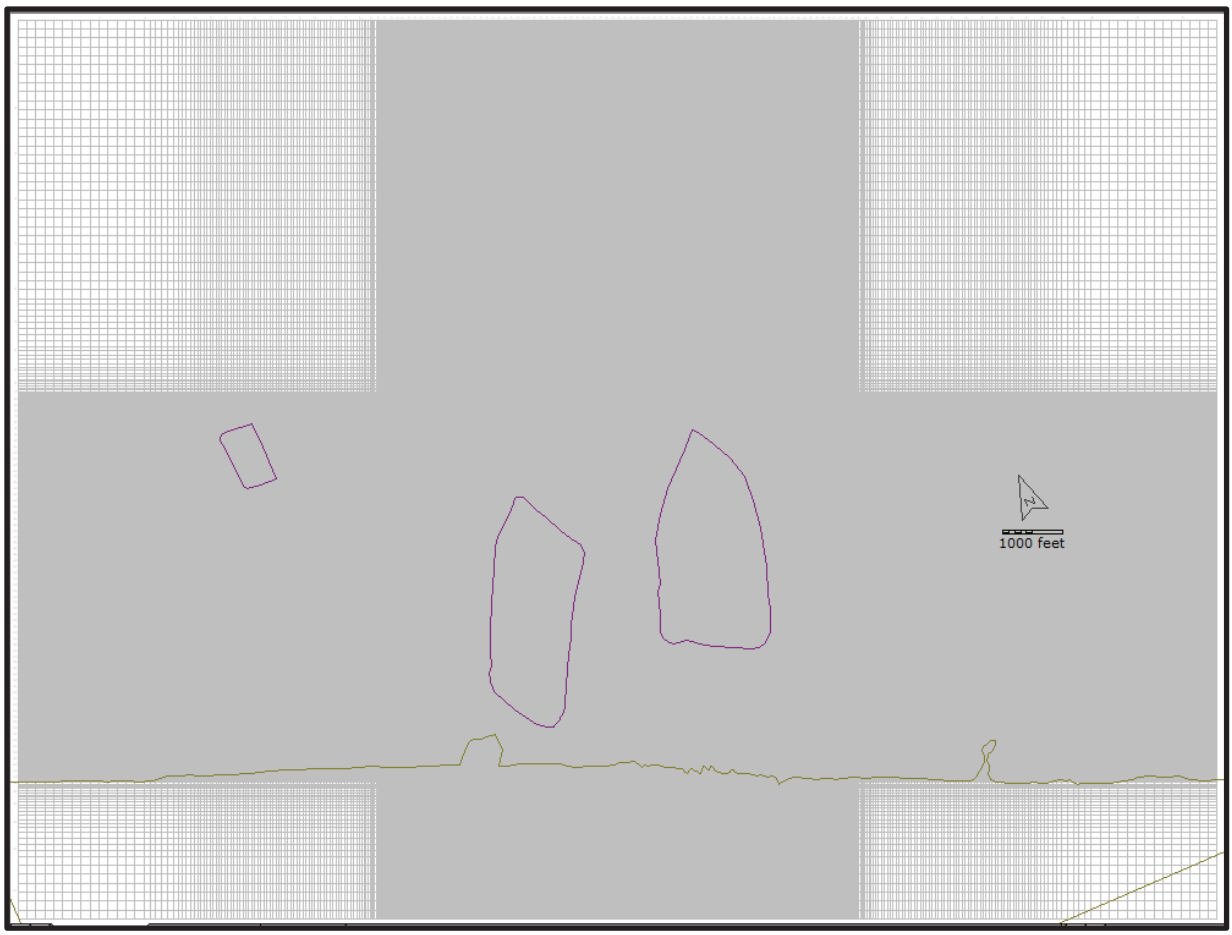
FIGURE 4-1



CLOSURE SCENARIO CALIBRATION AND PREDICTION MODEL TIMELINE

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL



MODEL GRID

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-2

BOUNDARY CONDITIONS, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

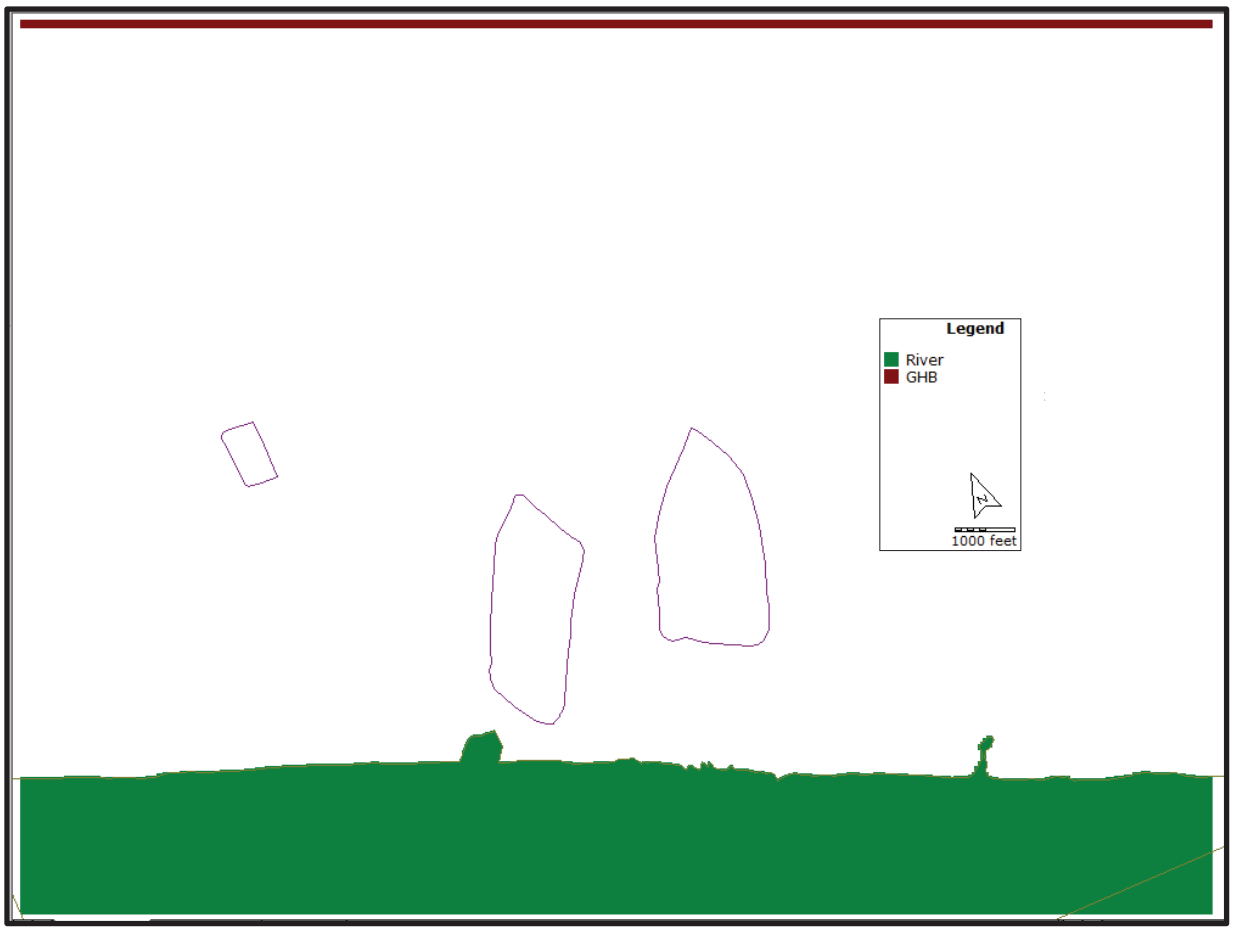
RAMBOLL

FIGURE 5-3

BOUNDARY CONDITIONS, MODEL LAYERS 2 AND 3

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

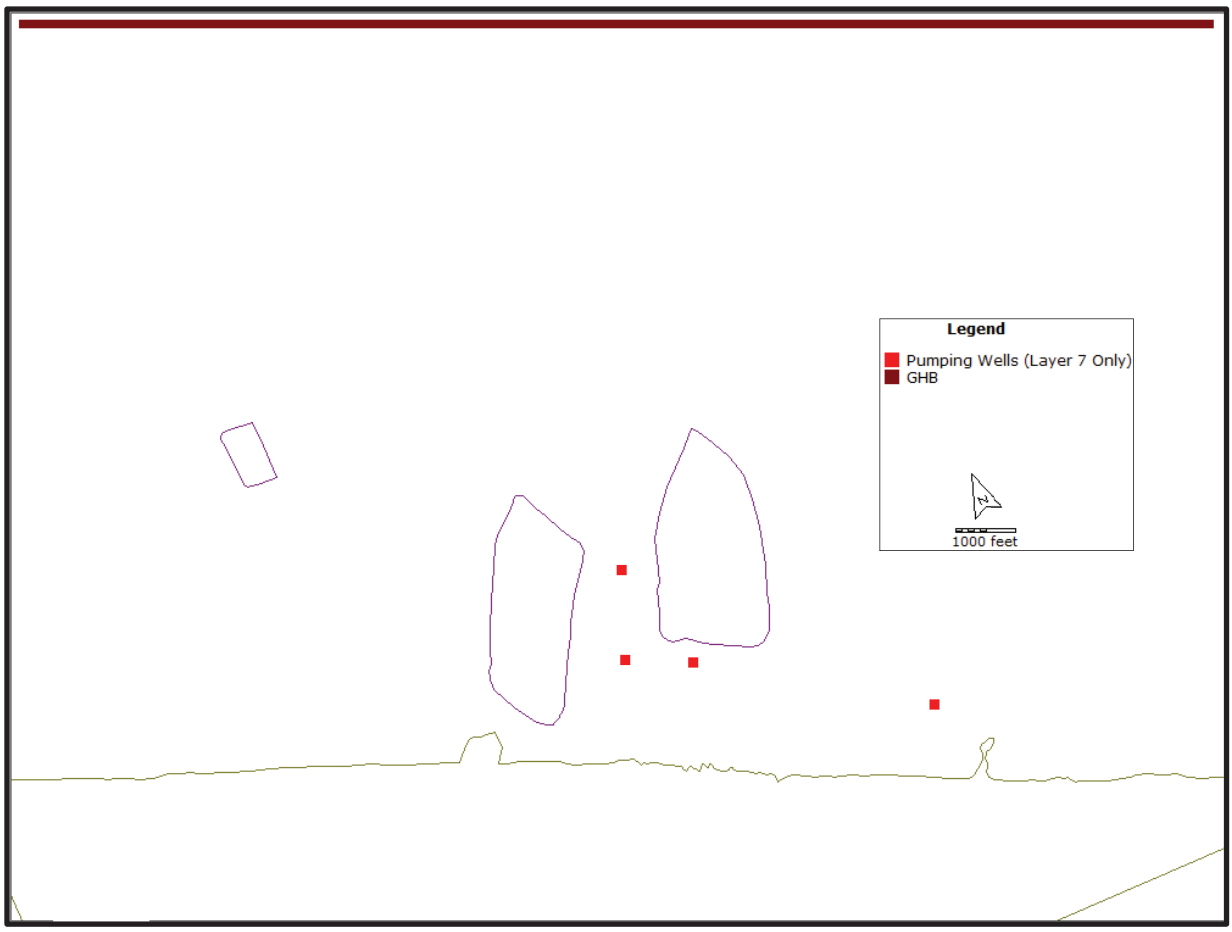


BOUNDARY CONDITIONS, MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-5

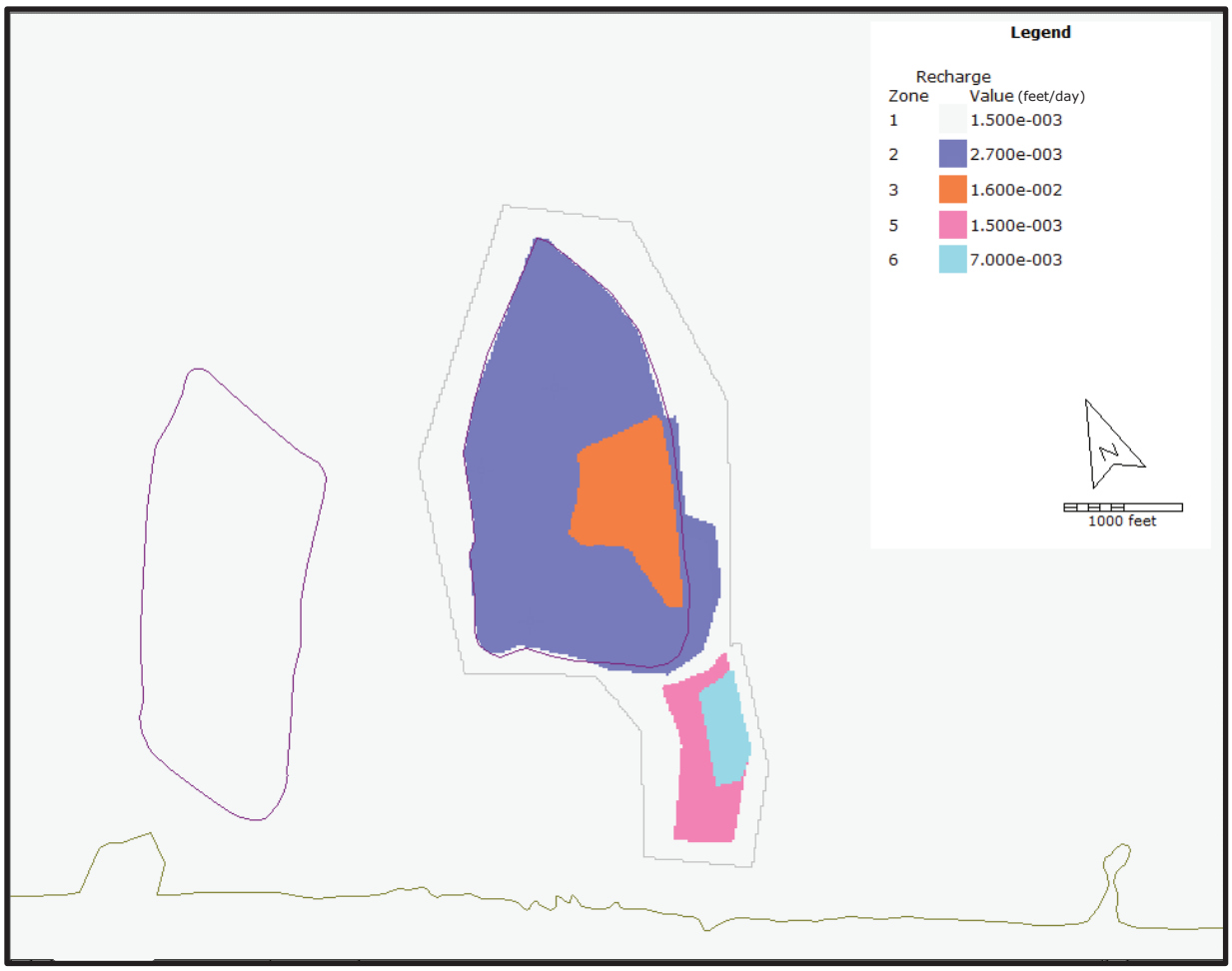


BOUNDARY CONDITIONS, MODEL LAYERS 6 AND 7

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-6

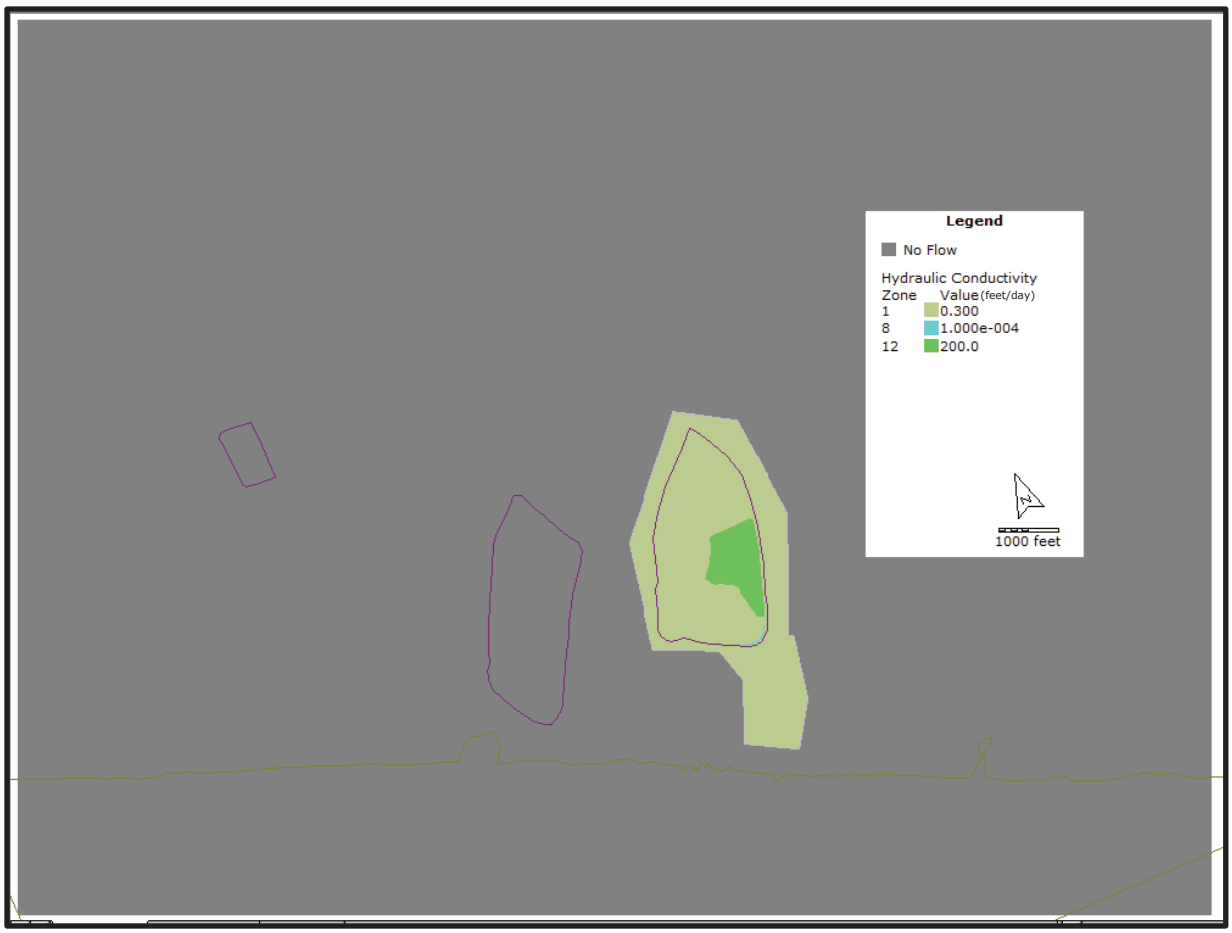


MODEL RECHARGE, STEADY-STATE FLOW MODEL

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-7

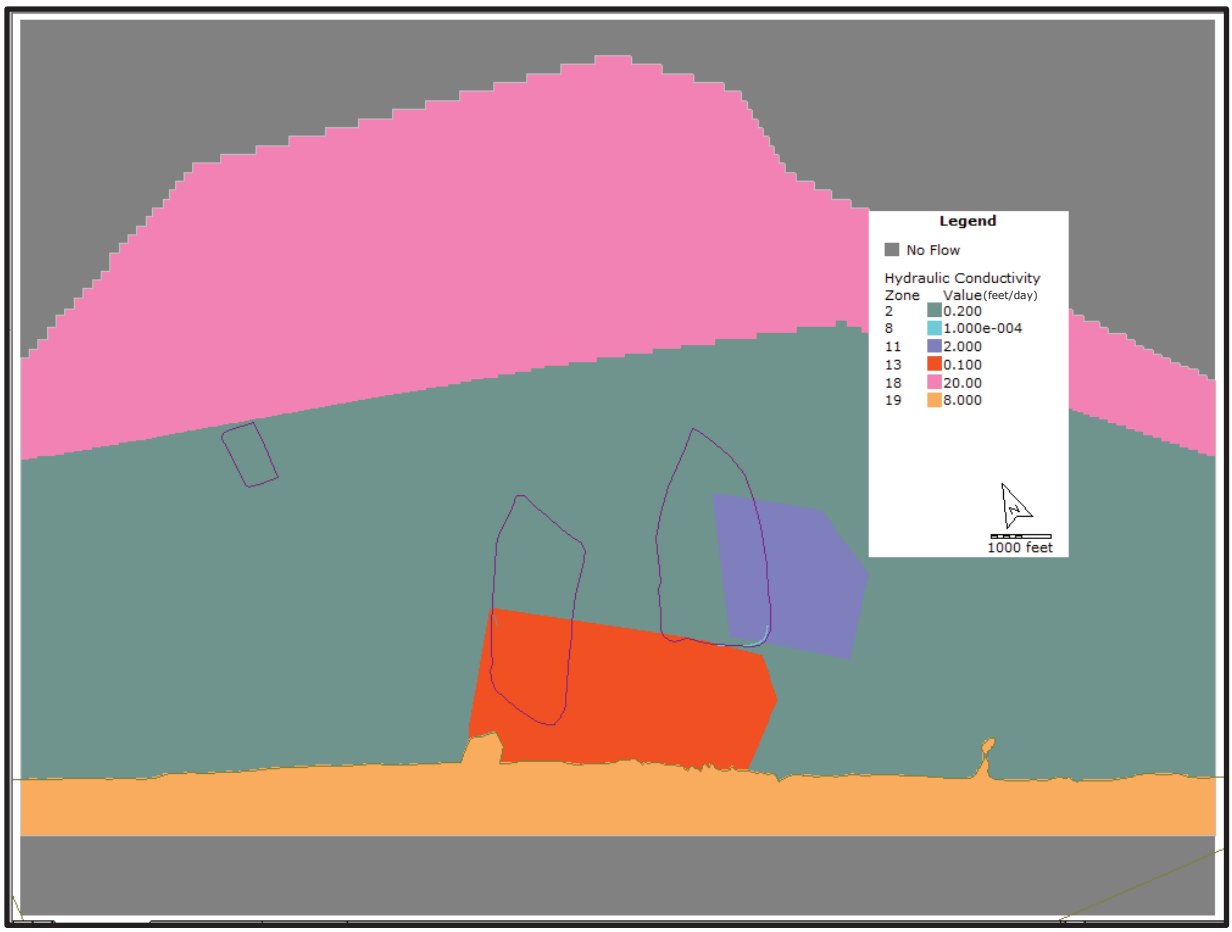


ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-8

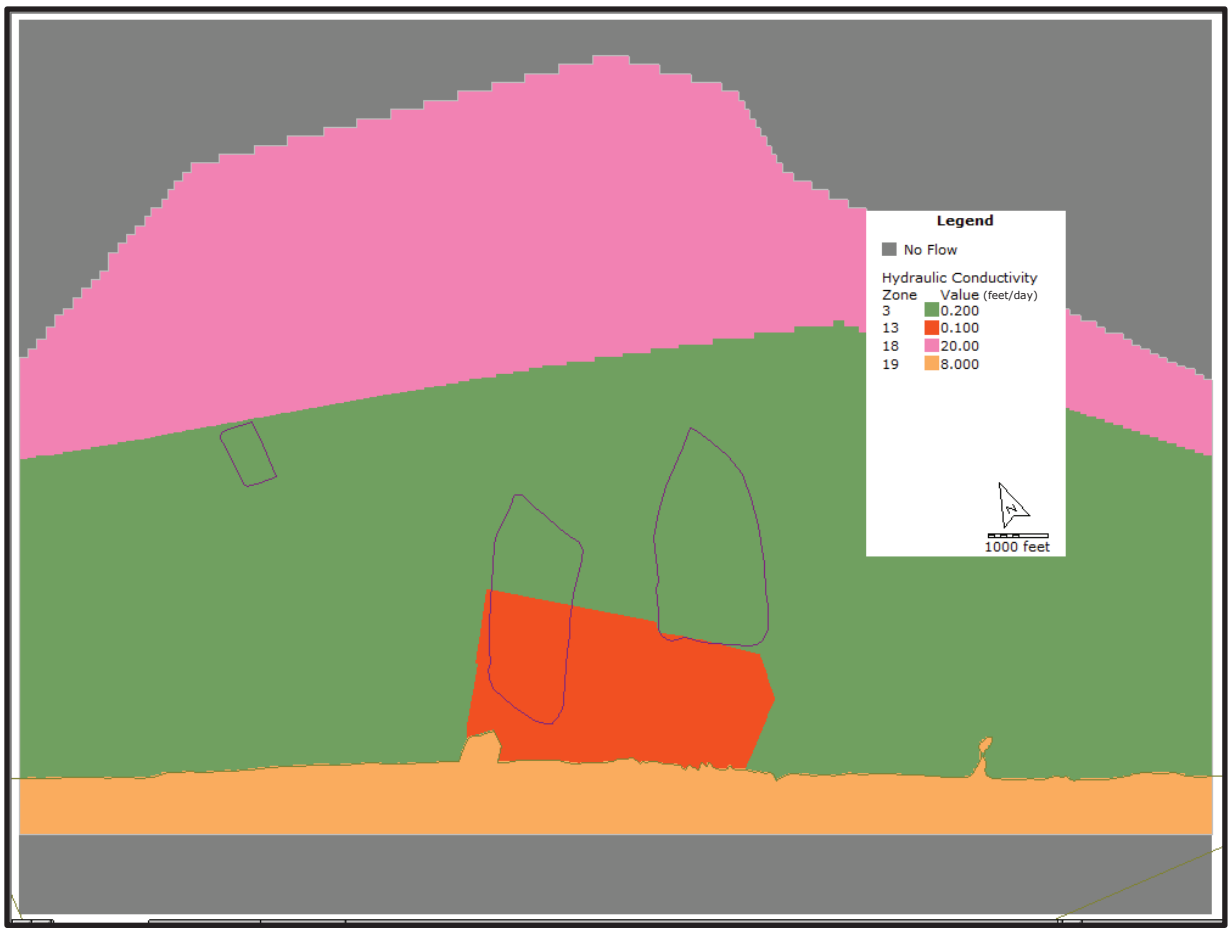


ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 2

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

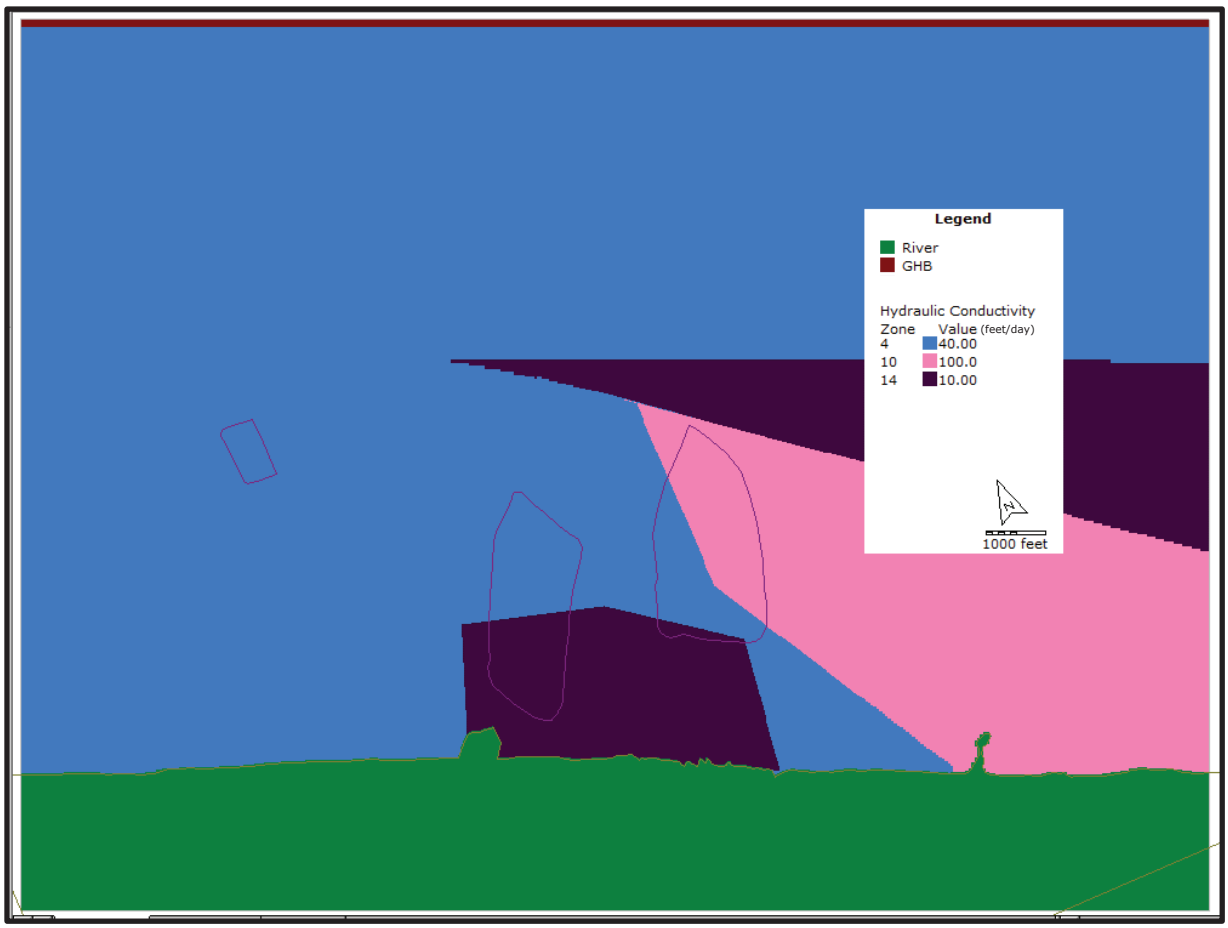
FIGURE 5-9



ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 3

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

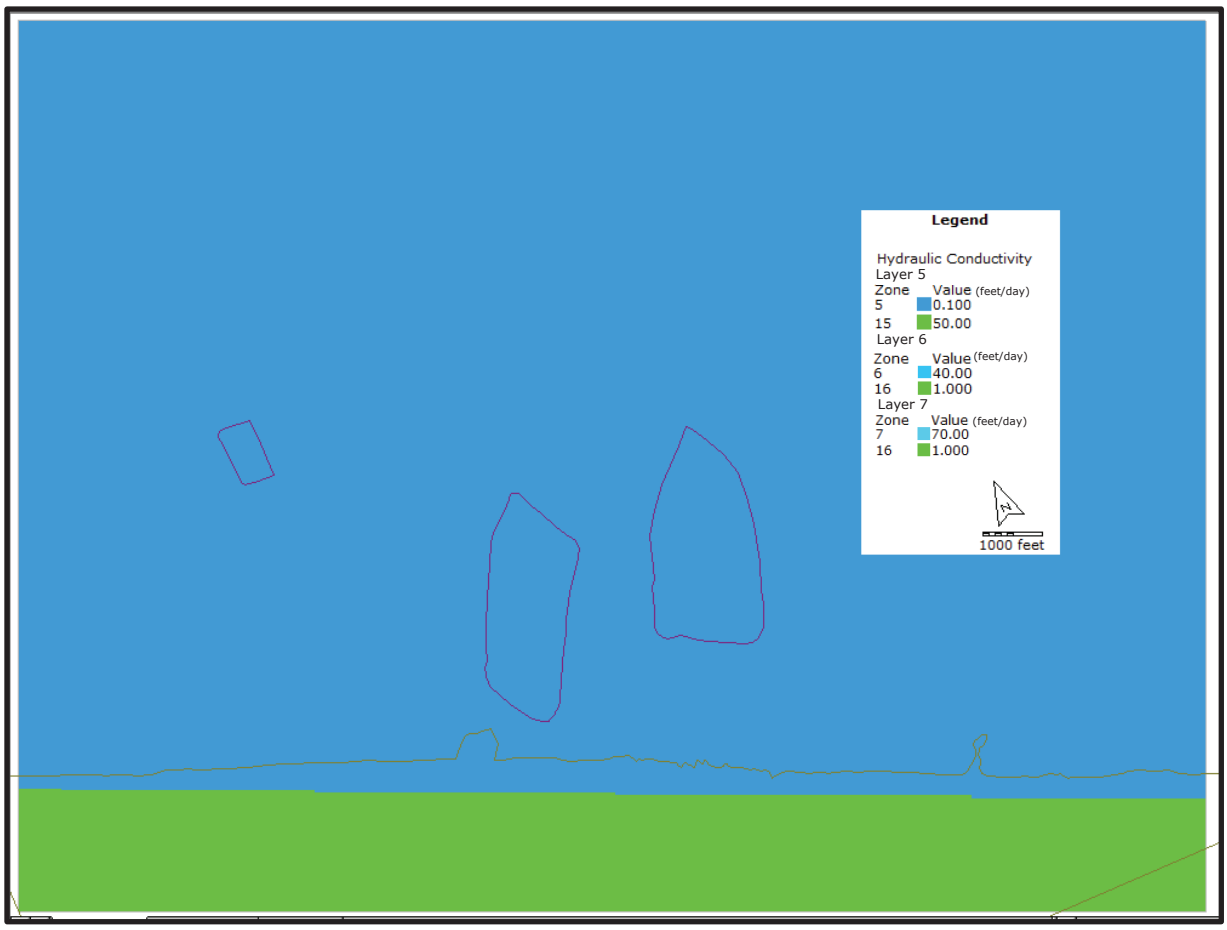


ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-11



ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYERS 5, 6, 7

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

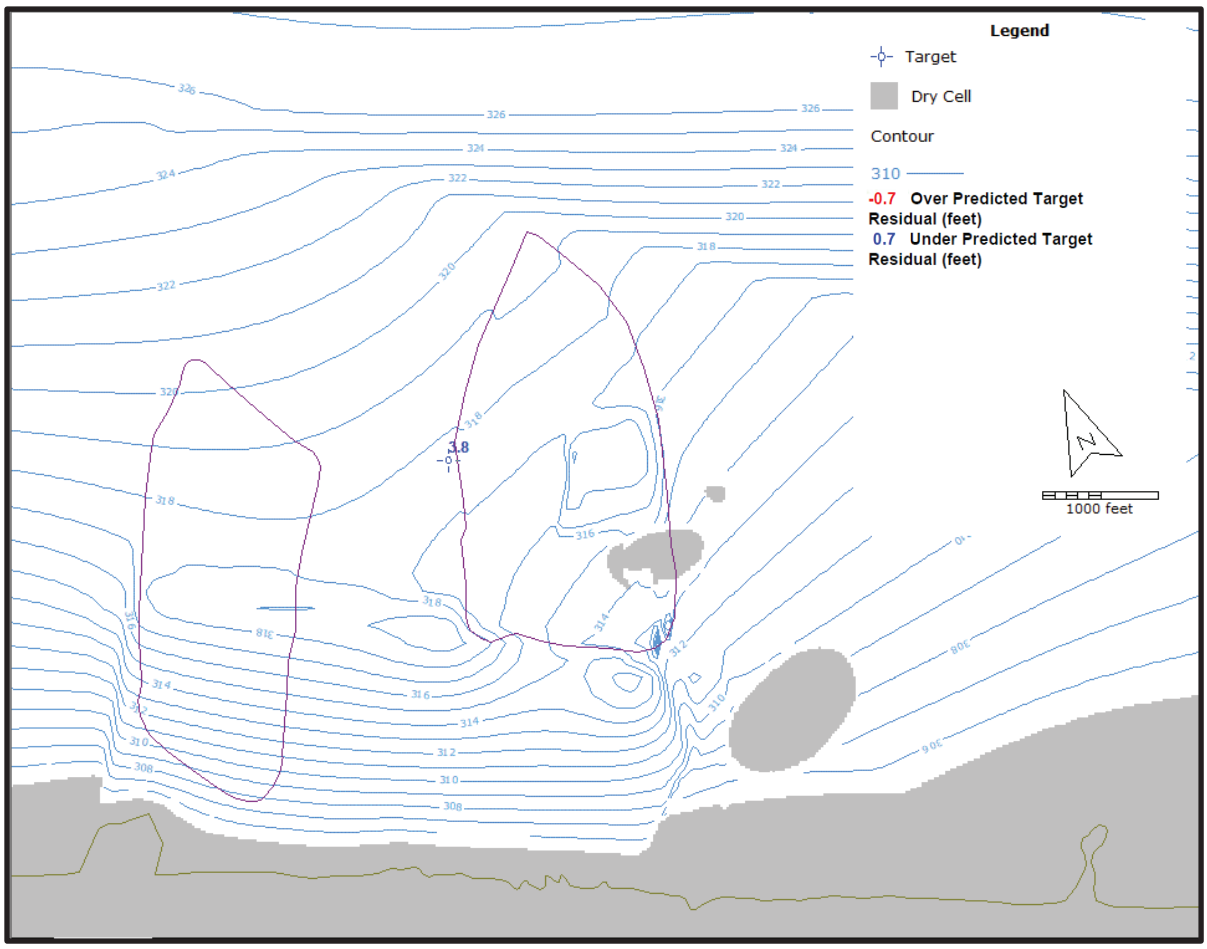
FIGURE 5-12

SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-13

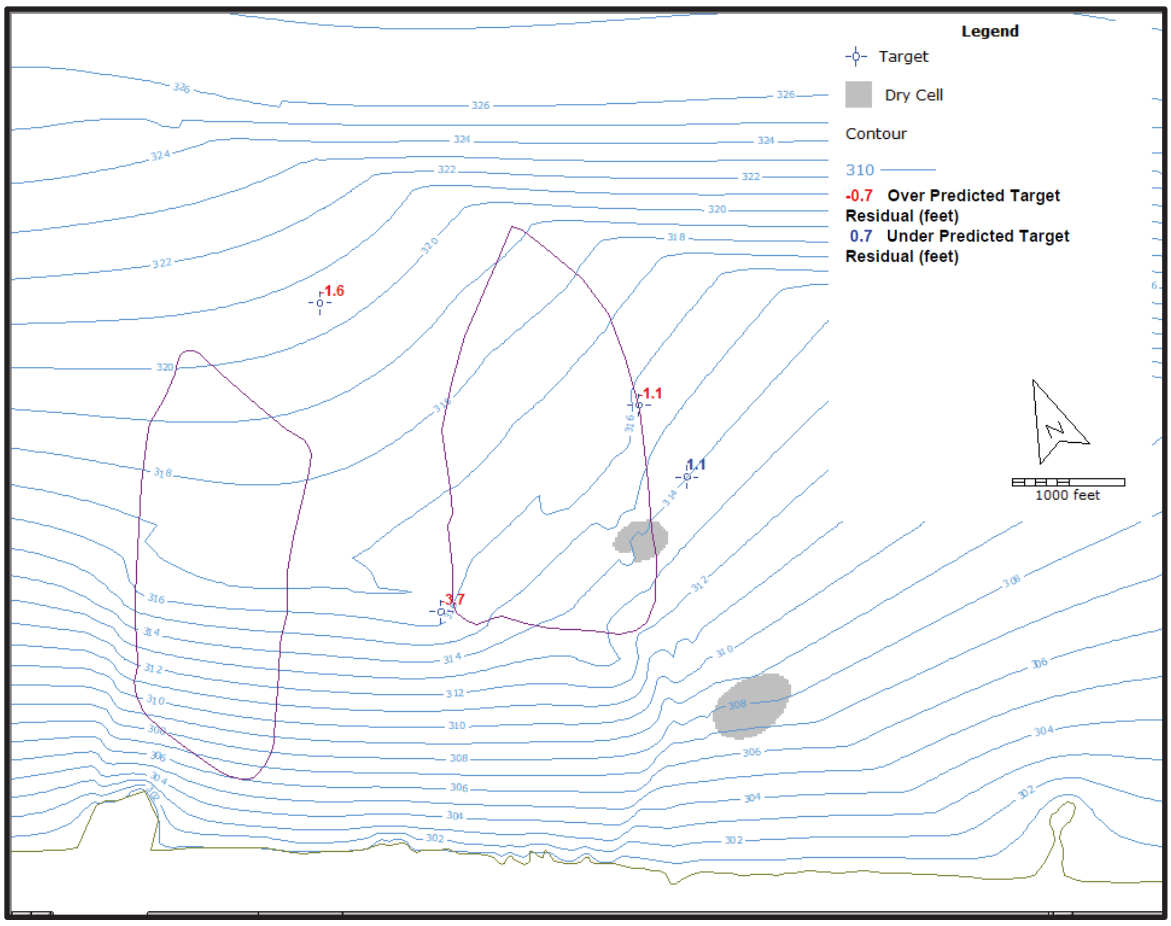


SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 2

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-14

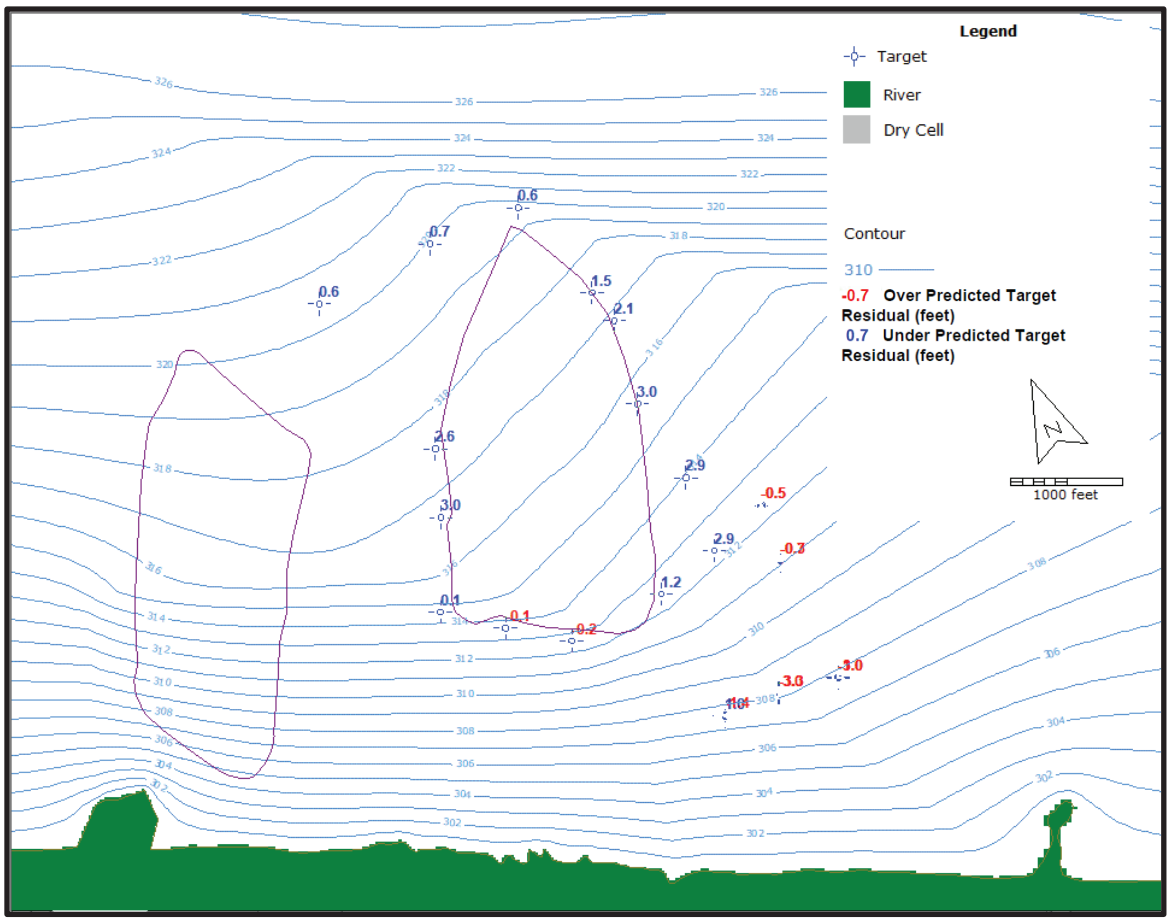


SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 3

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

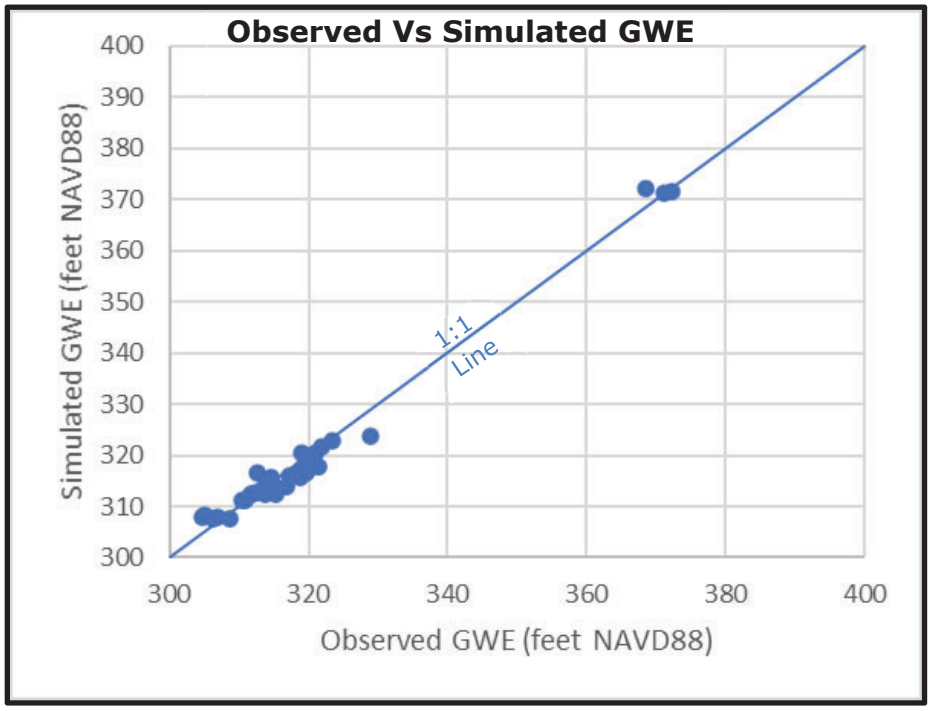
FIGURE 5-15

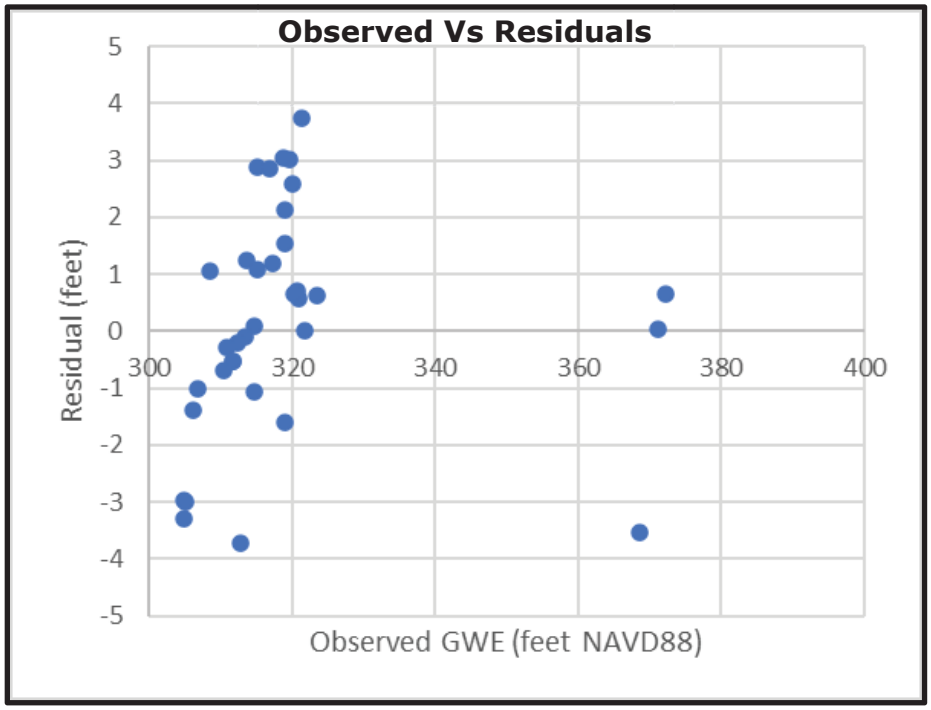


SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

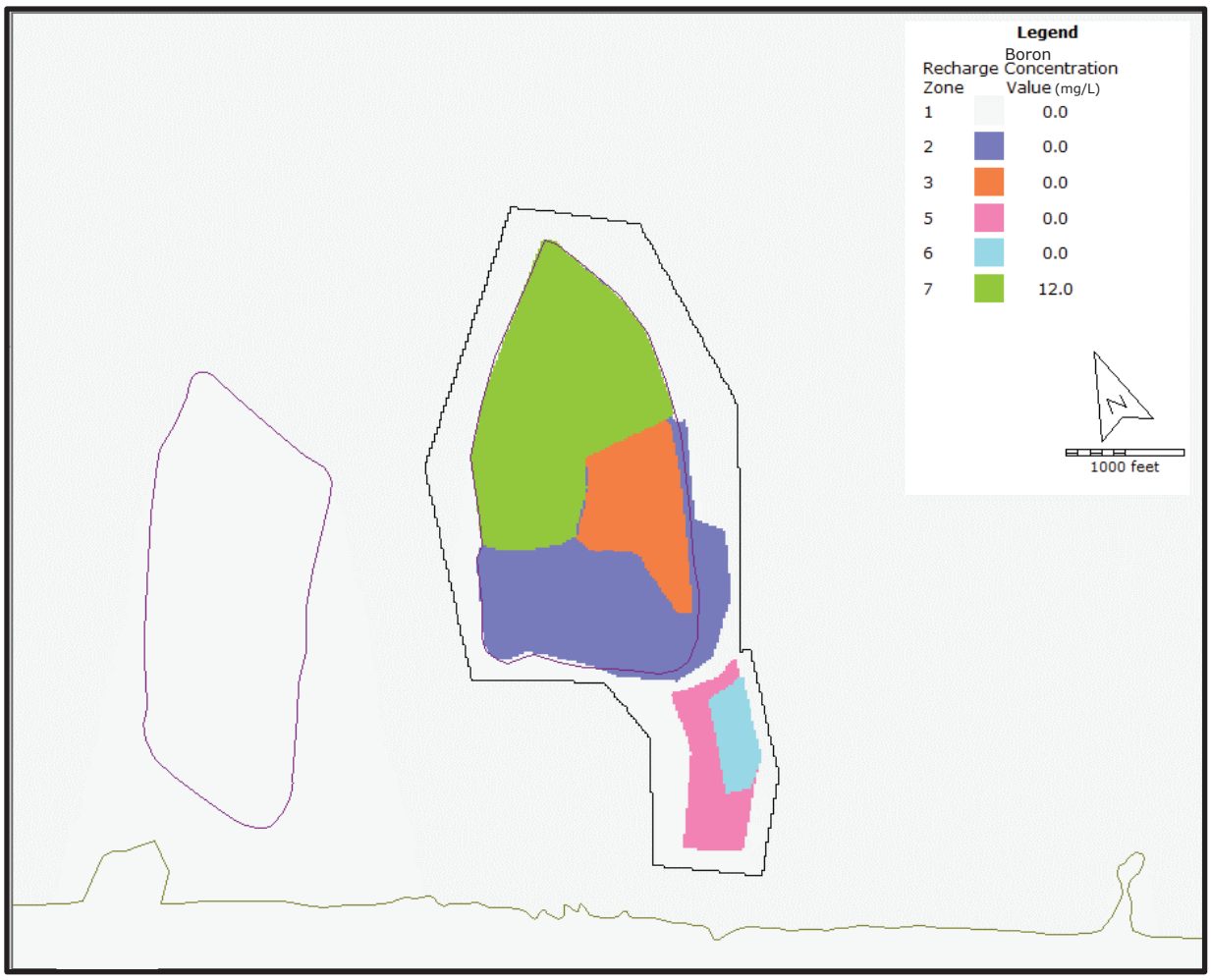




FLOW MODEL CALIBRATION PLOTS, OBSERVED VS SIMULATED GWE AND RESIDUALS

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

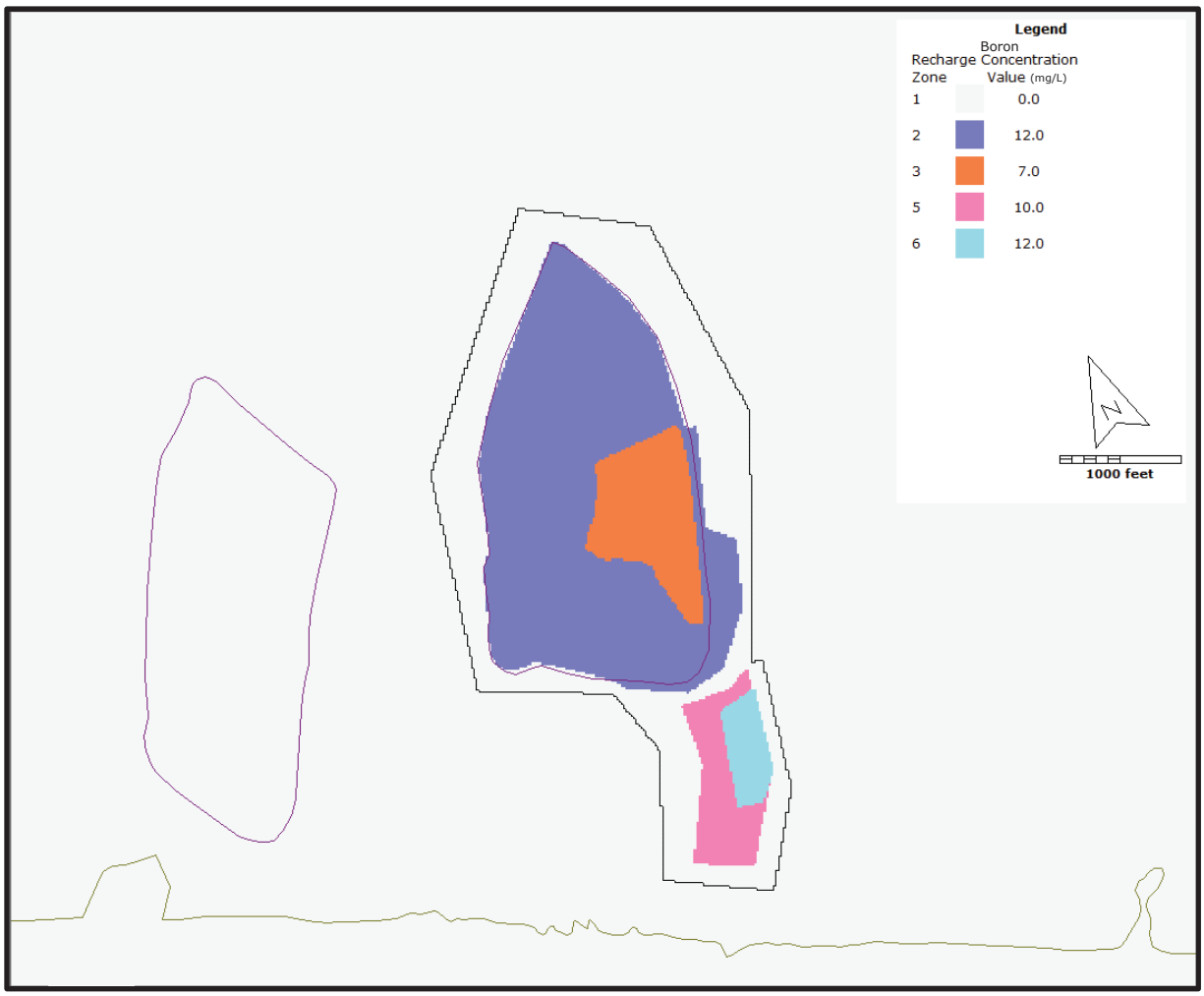


BORON RECHARGE, HISTORIC TRANSPORT MODEL, SP1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-18



BORON RECHARGE, HISTORIC TRANSPORT MODEL, SP2 AND SP3

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

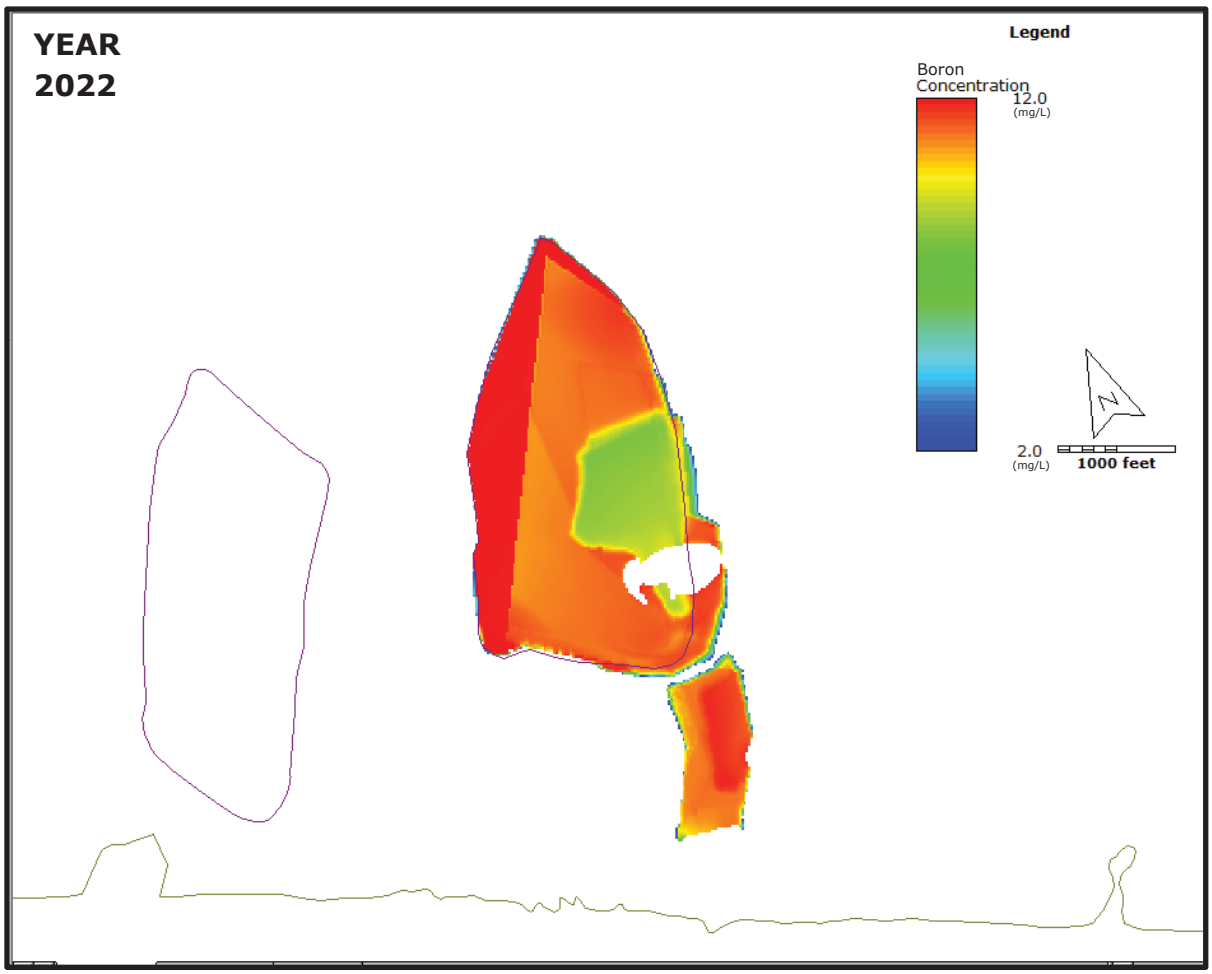
RAMBOLL

FIGURE 5-19

SIMULATED DISPERSIVITY, TRANSPORT MODEL LAYERS 2 THROUGH 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

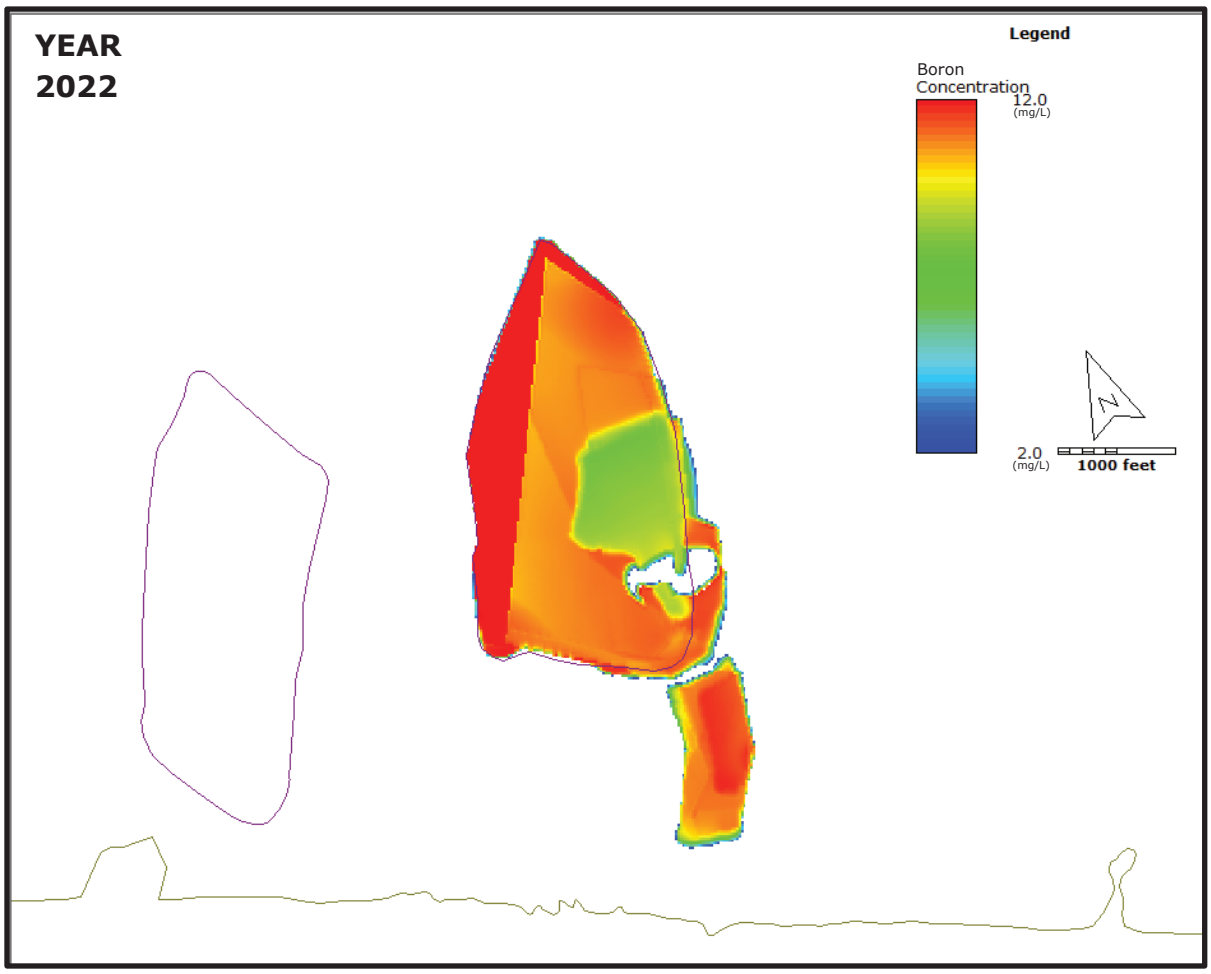
RAMBOLL



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 2

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

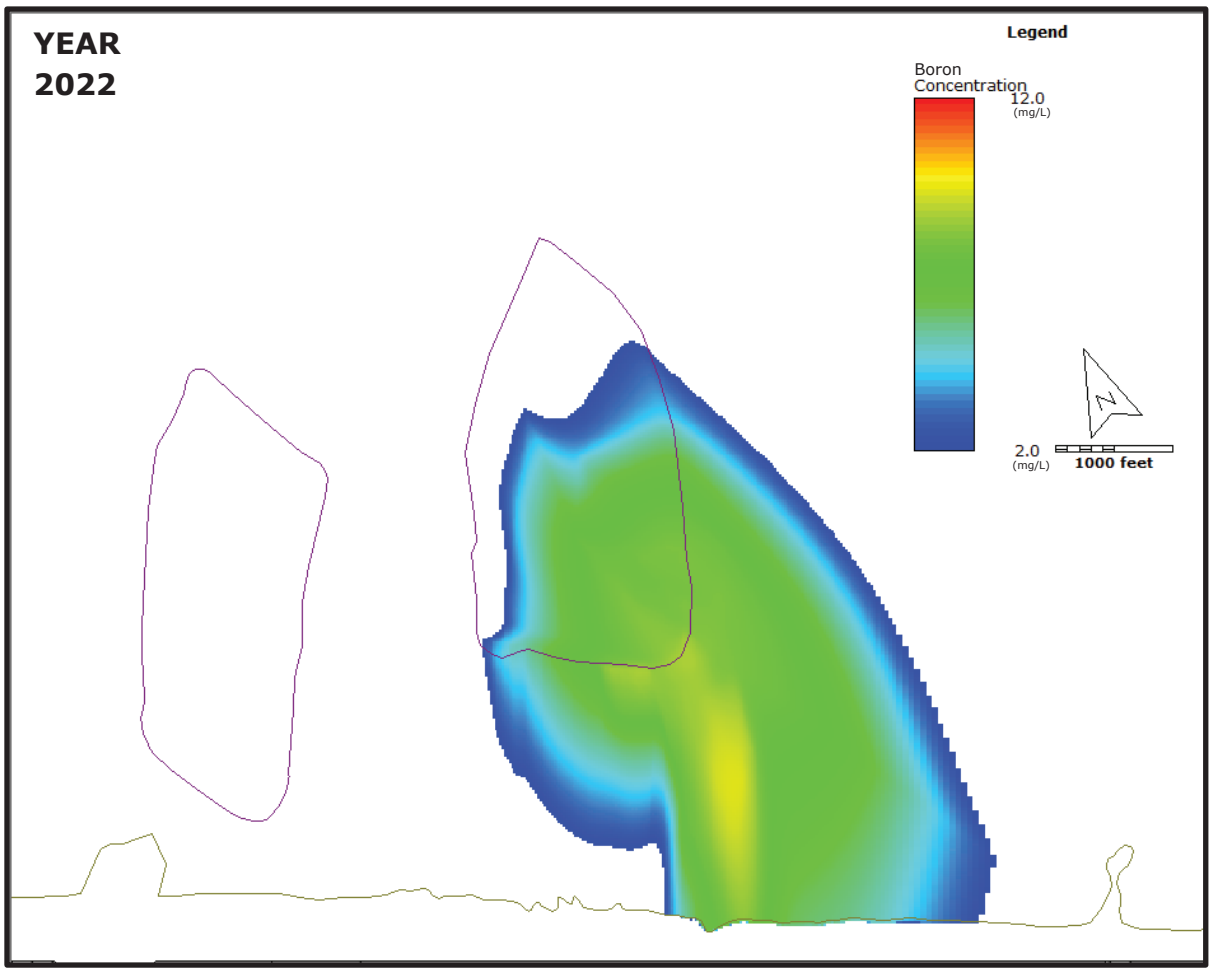
RAMBOLL



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 3

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

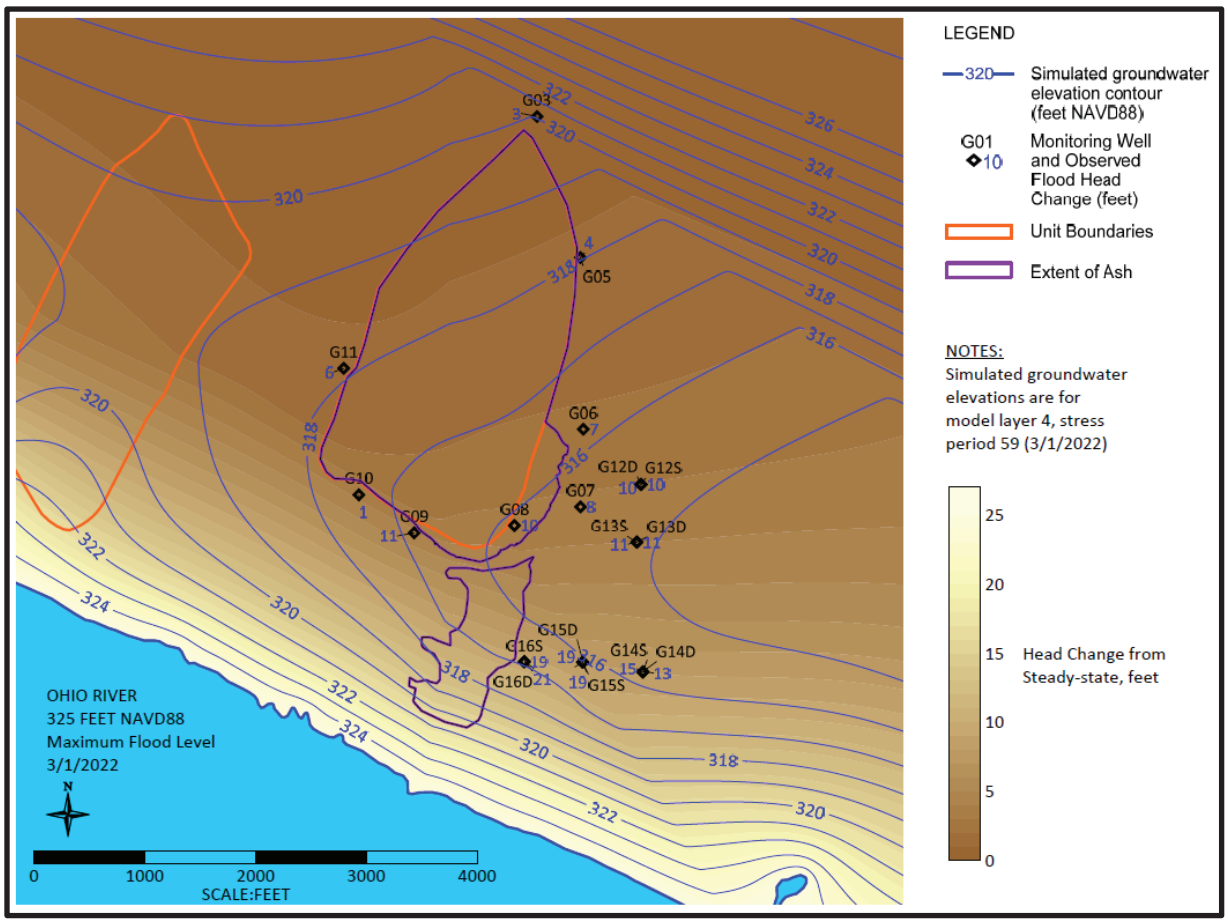


HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

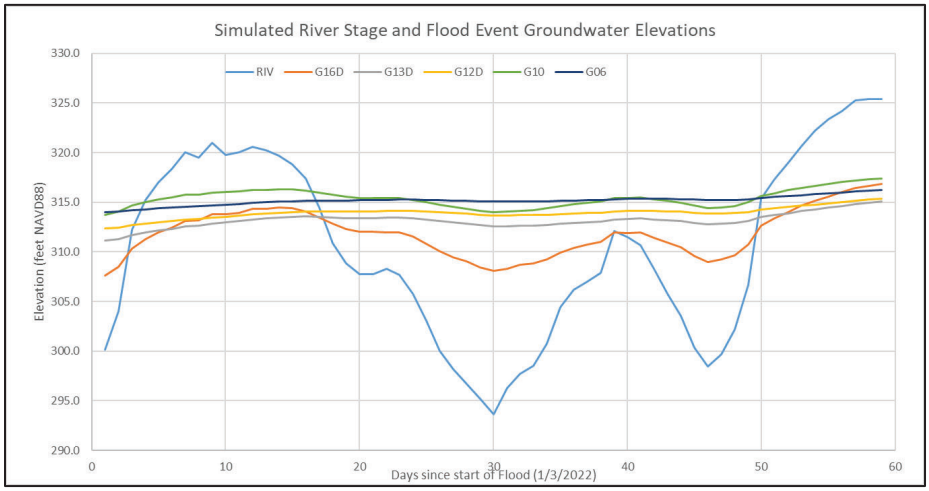
FIGURE 5-23

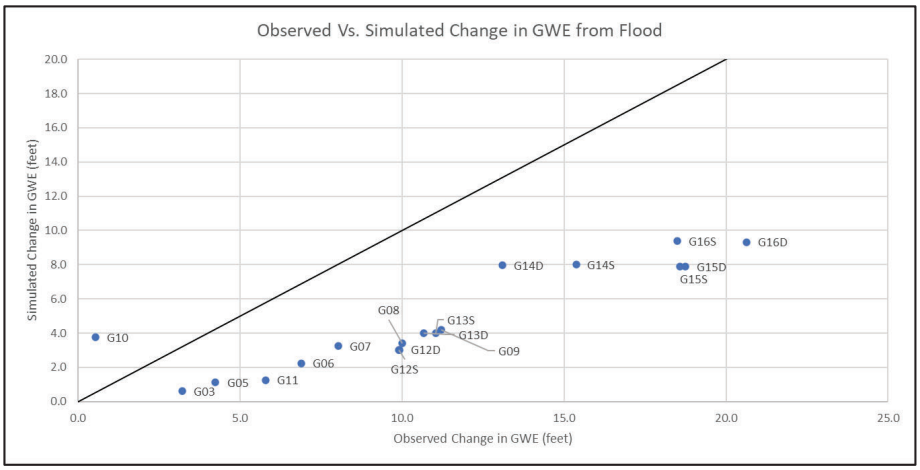


SIMULATED FLOOD EVENT GROUNDWATER ELEVATIONS IN MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

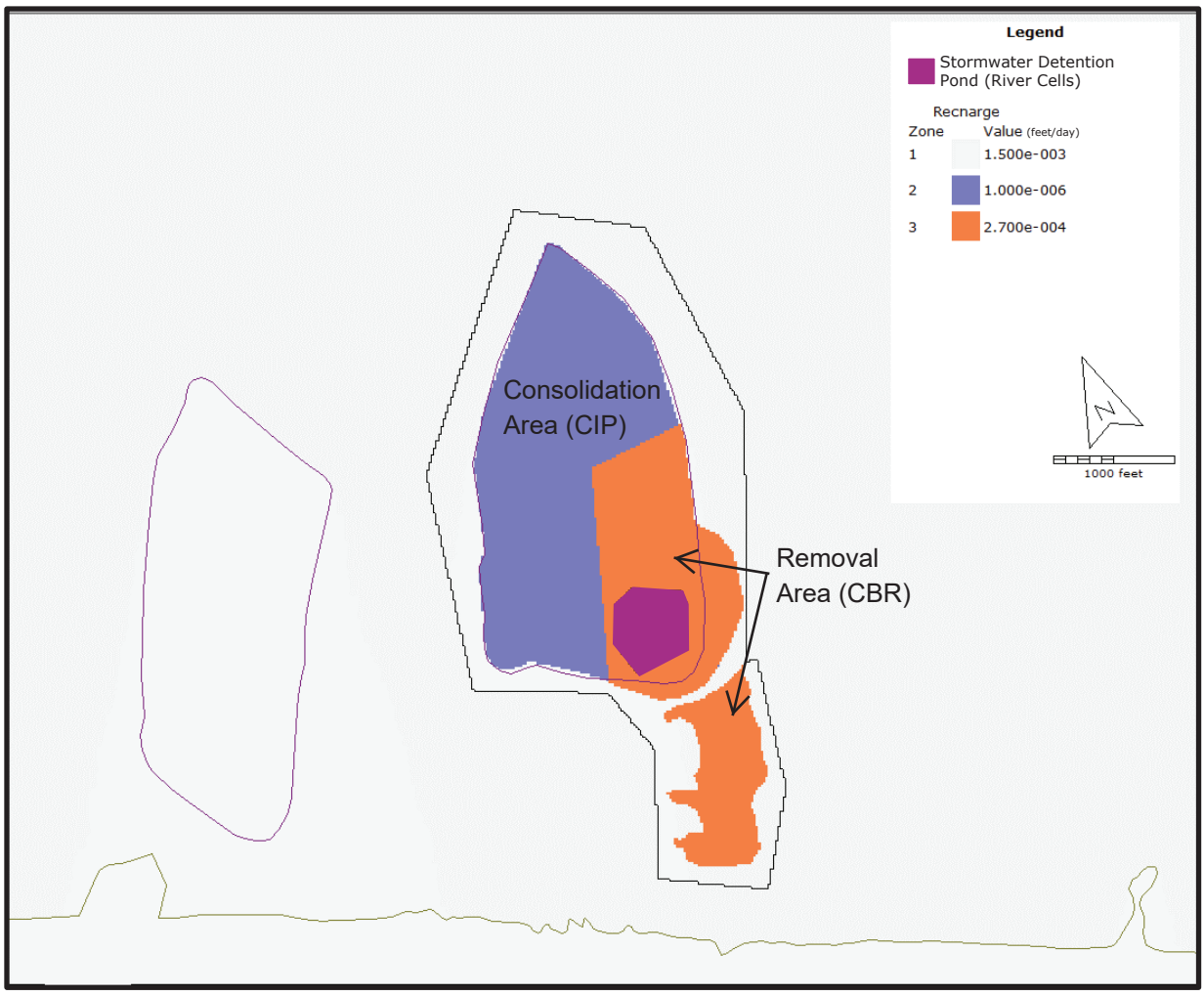




SIMULATED RIVER STAGE AND FLOOD EVENT GROUNDWATER ELEVATIONS

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

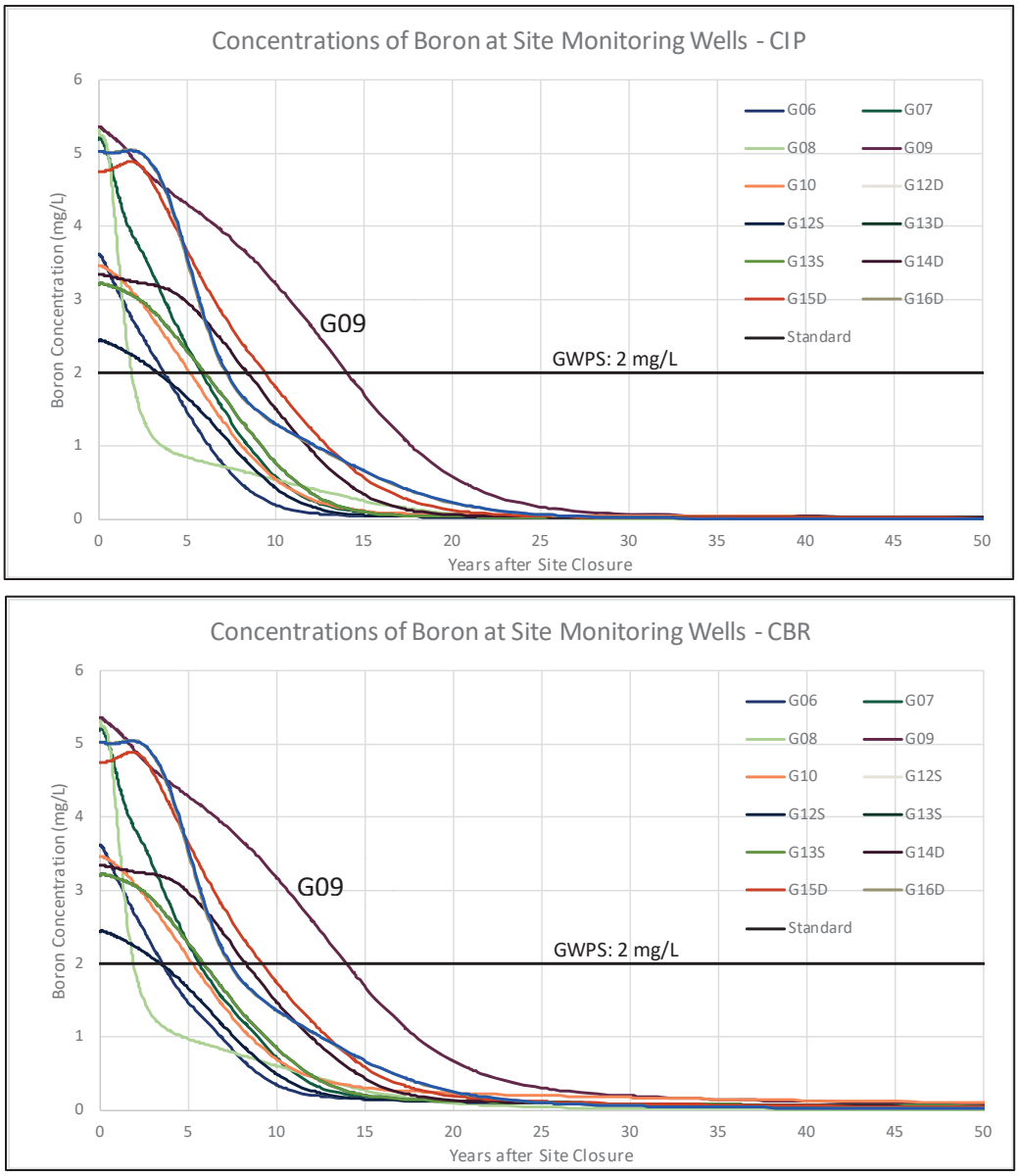
RAMBOLL



CIP RECHARGE DISTRIBUTION AND BOUNDARY CONDITIONS, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

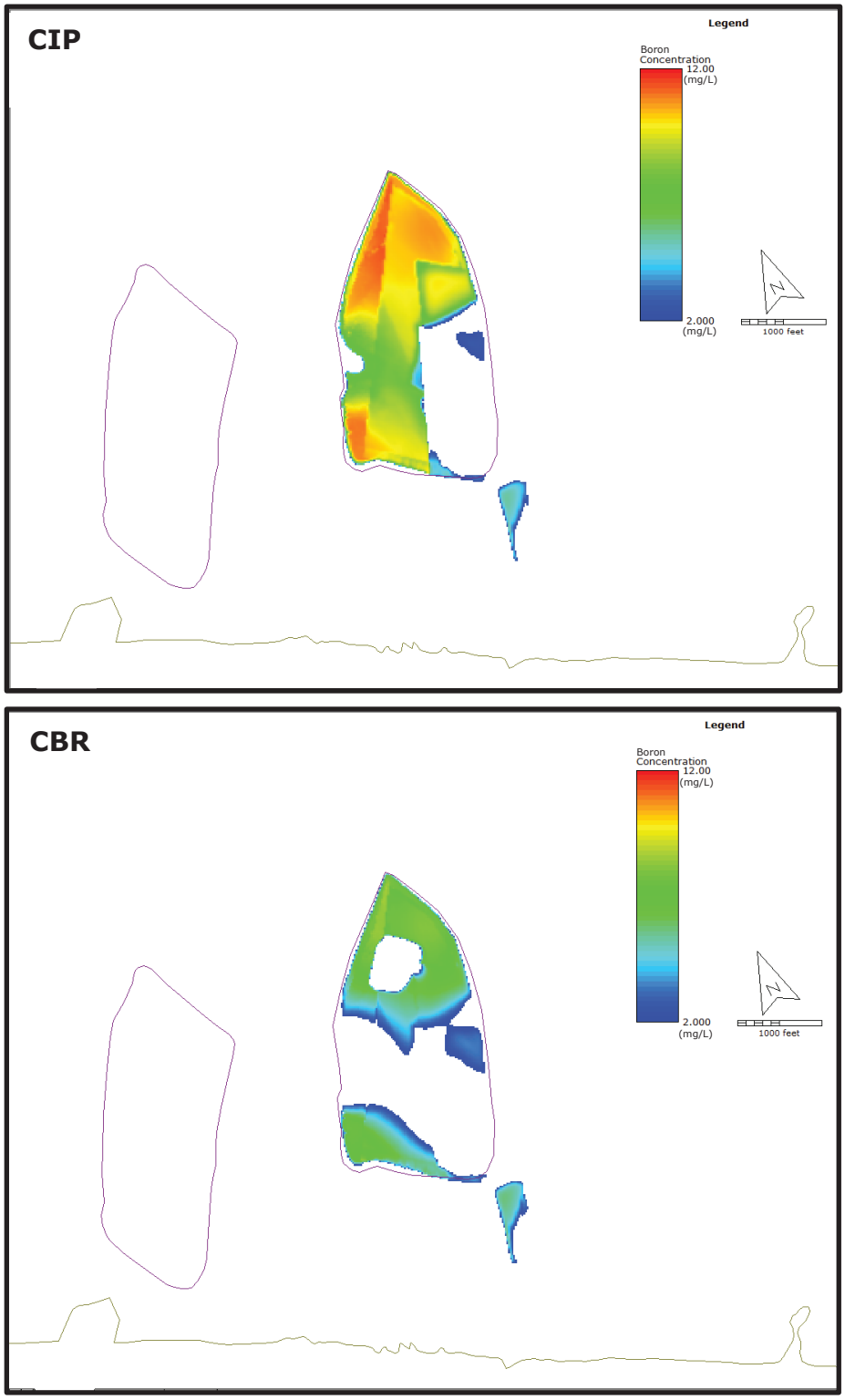
RAMBOLL



PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP AND CBR

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

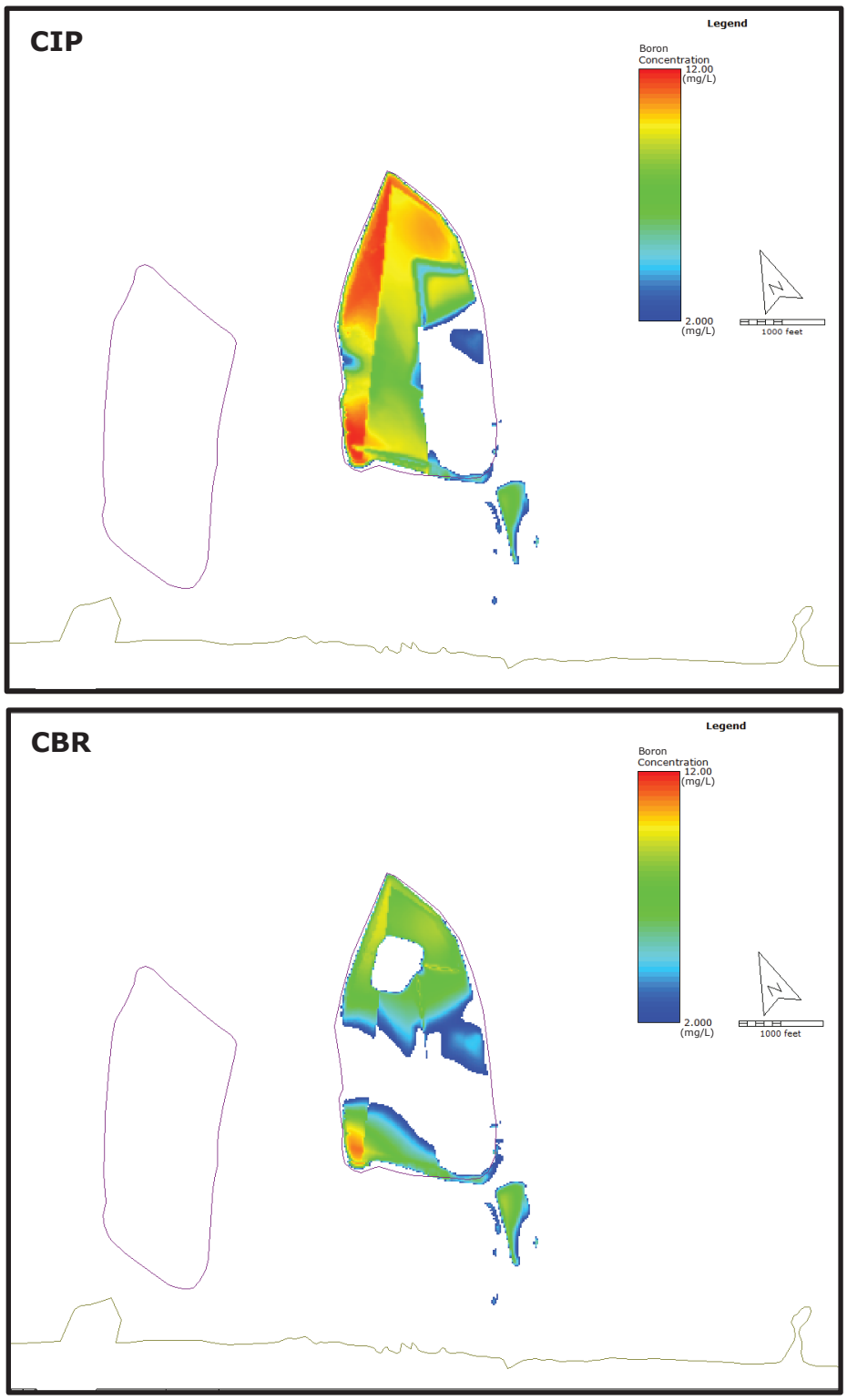
RAMBOLL



BORON CONCENTRATIONS IN MODEL LAYER 2, 24 YEARS ELAPSED TIME (CIP AND CBR)

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

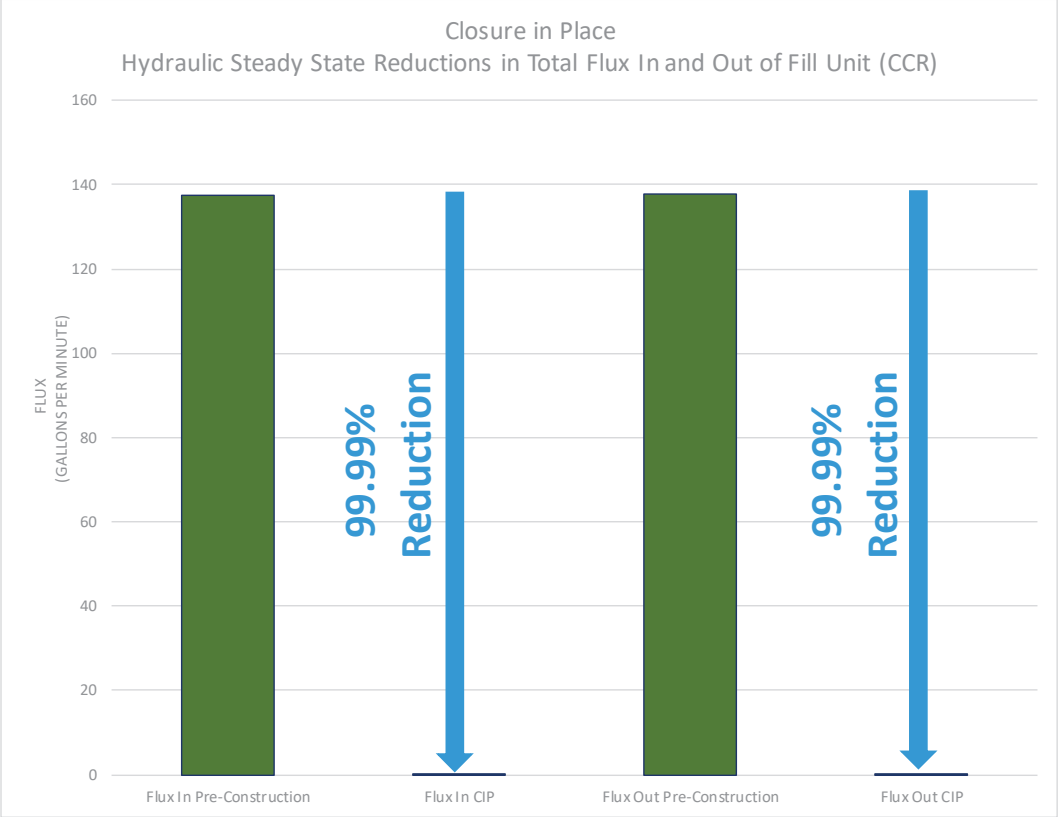


BORON CONCENTRATIONS IN MODEL LAYER 3, 24 YEARS ELAPSED TIME (CIP AND CBR)

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 6-5



CIP-
HYDRAULIC STEADY STATE REDUCTIONS IN TOTAL FLUX IN AND OUT OF FILL UNIT (CCR)

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

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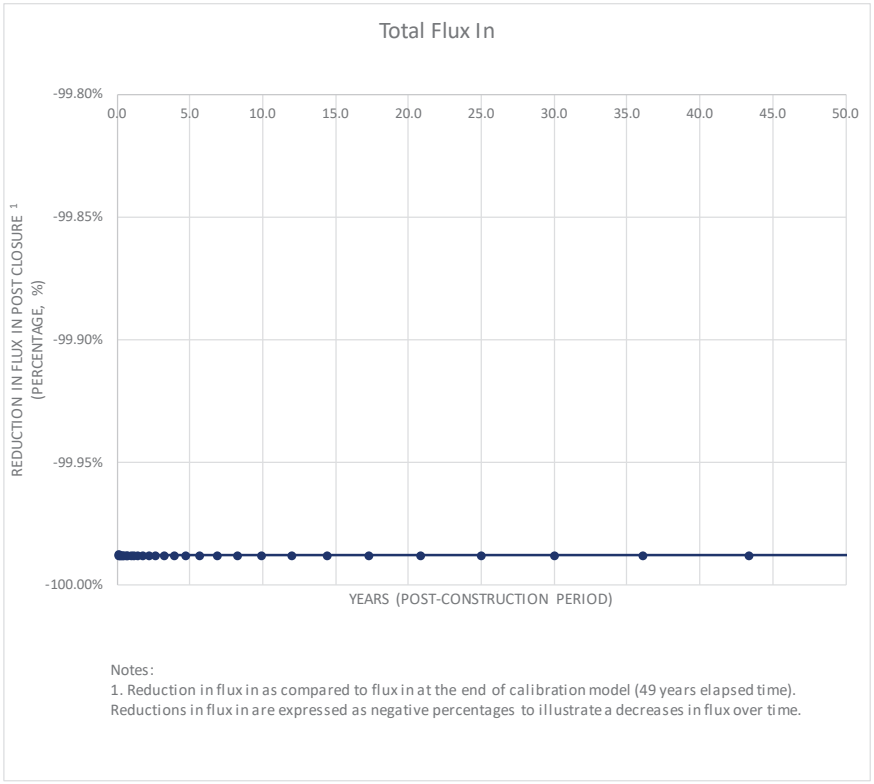

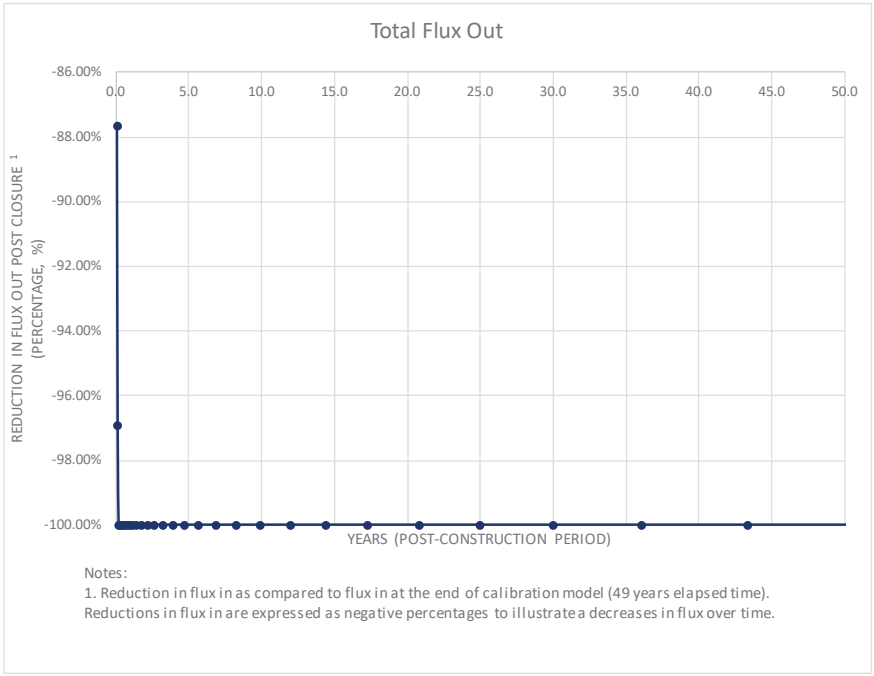

CIP – MODEL PREDICTED FLUX REDUCTION OVER TIME

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

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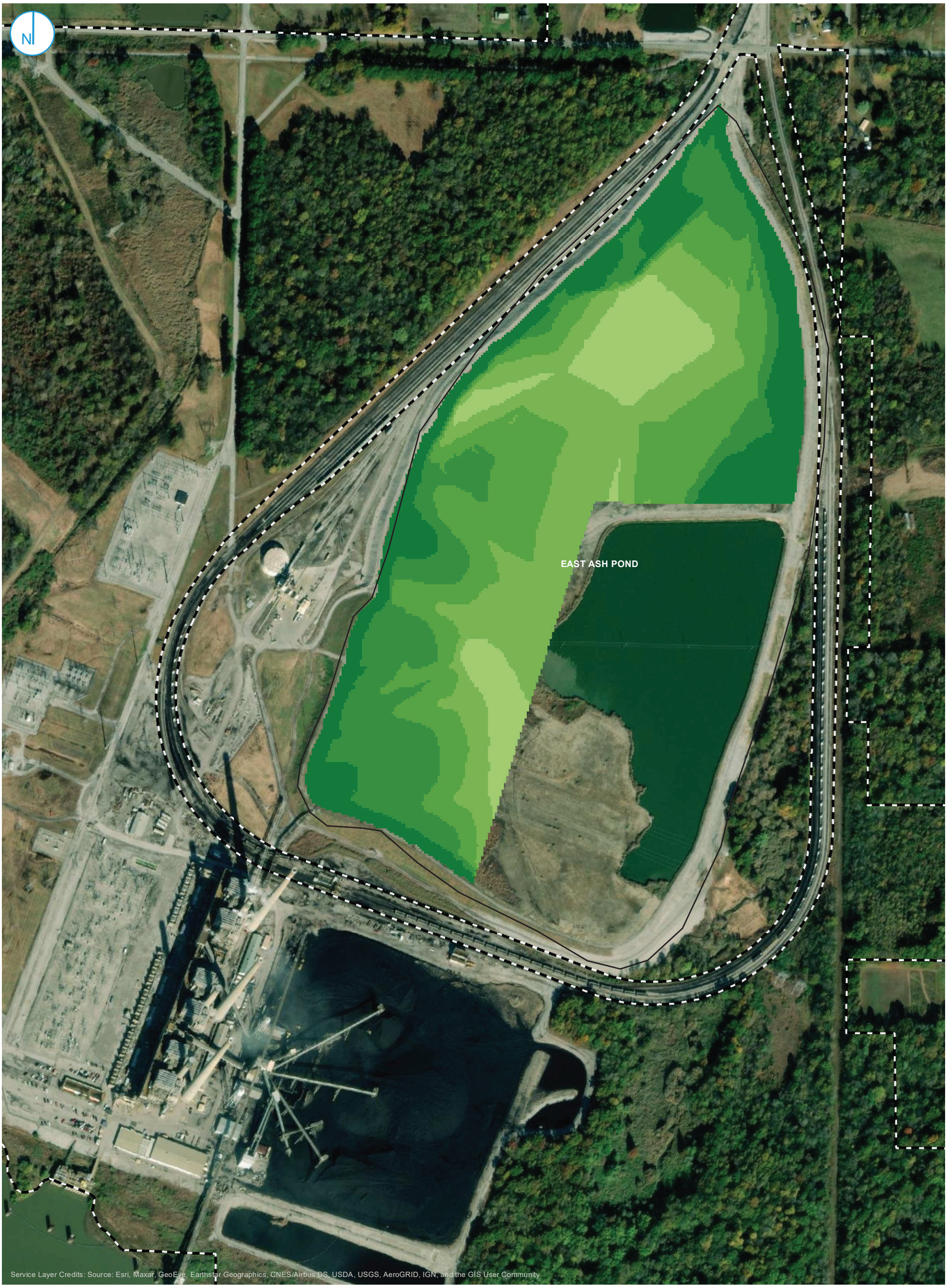
PROJECT: 169000XXXX | DATED: 7/1/2022 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\IntersectingGW_2022\JOP East BOA Saturation CIP.mxd



SITE FEATURE

PROPERTY BOUNDARY

DIFFERENCE BETWEEN BOTTOM OF CCR AND SIMULATED GROUNDWATER SURFACE*
(FEET, POSITIVE VALUES INDICATE SEPARATION)

10.1 - 15 | 15.1 - 20 | 20.1 - 25 | 25.1 - 30 | >30

0 200 400 Feet

*GROUNDWATER SURFACE BASED ON SIMULATED CLOSURE IN PLACE SCENARIO AT HYDRAULIC STABILIZATION.

POTENTIAL ASH SATURATION SIMULATED CLOSURE IN PLACE GROUNDWATER SURFACE

JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 6-7

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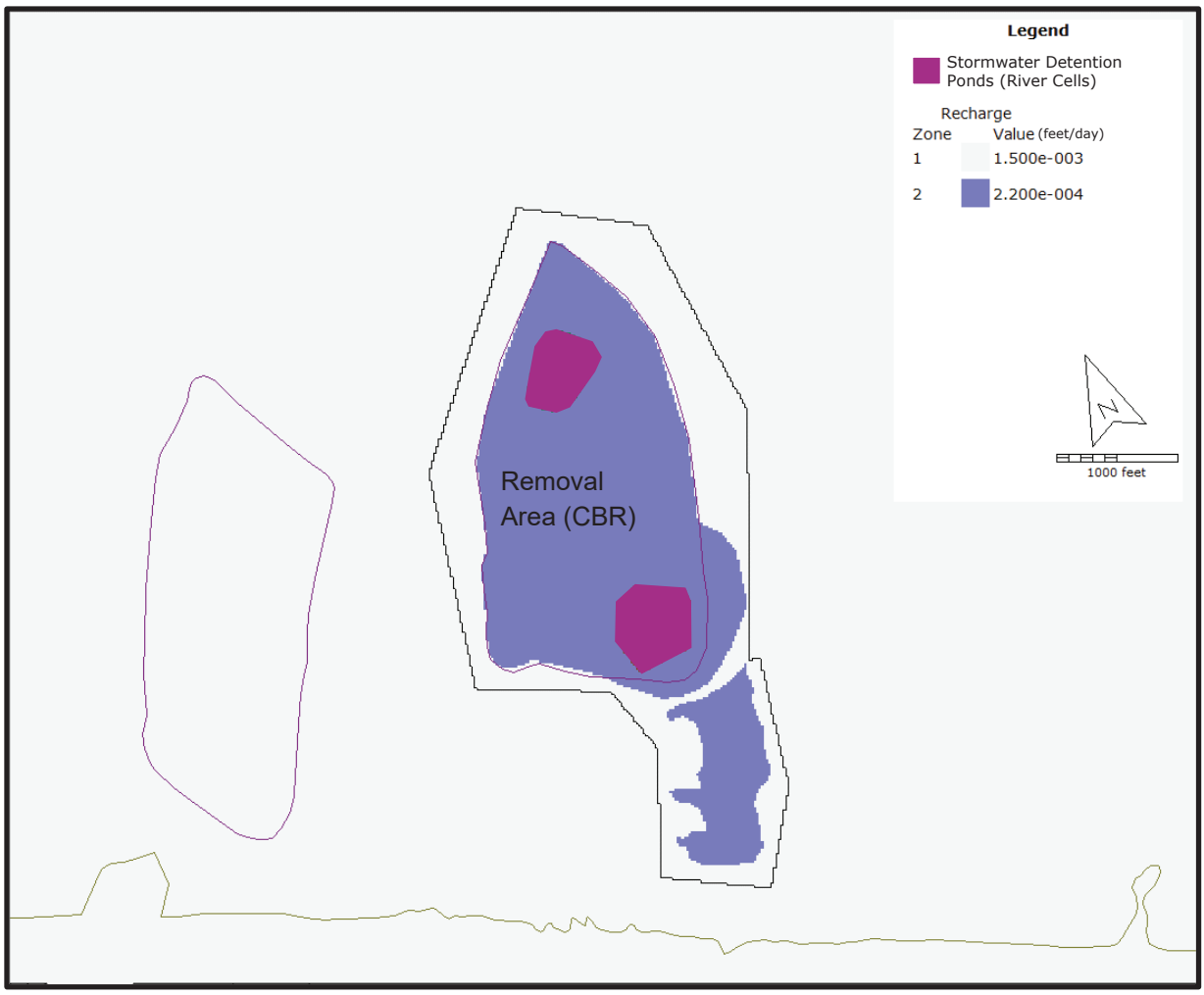
ENGINEERING SOLUTIONS, INC.

RAMBOLL

FIGURE 6-8



CBR RECHARGE DISTRIBUTION AND BOUNDARY CONDITIONS, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

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APPENDICES

APPENDIX A
EVALUATION OF POTENTIAL GWPS EXCEEDANCES

Intended for
Electric Energy, Inc.

Date
May 23, 2022

Project No.
1940102417

EVALUATION OF POTENTIAL GWPS EXCEEDANCES

JOPPA POWER PLANT
EAST ASH POND
CCR UNIT 401

RAMBOLL Bright ideas. Sustainable change.

CONTENTS

1.	**Introduction**	**3**
2.	**Site Information**	**4**
3.	**Potential GWPS Exceedances**	**5**
4.	**Evidence that Potential GWPS Exceedances are not Related to the EAP**	**6**
4.1	The pH Exceedances at Wells G06S and G07 Are Not Statistically Significant	6
4.2	The EAP Porewater is Not a Source of Low pH	6
4.3	Background pH Is Trending Downward	7
5.	**Conclusions**	**9**
6.	**References**	**10**

FIGURES (IN TEXT)

Figure A	pH Ranges Measured in CCR Porewater and Monitoring Wells from 2015 to 2021.
Figure B	2021 Sampling Data and Mann-Kendall Trend Test Results for pH in Background Wells.

FIGURES (ATTACHED)

Figure 2-1	Uppermost Aquifer Potentiometric Surface Map, May 11 and 12, 2021

TABLES (IN TEXT)

Table A	Potential pH exceedances of the GWPS

ACRONYMS AND ABBREVIATIONS

§	section
35 I.A.C.	Title 35 of the Illinois Administrative Code
40 C.F.R.	Title 40 of the Code of Federal Regulations
CCR	coal combustion residuals
GWPS	groundwater protection standard
EAP	East Ash Pond
EEI	Electric Energy, Inc.
ID	identification
IEPA	Illinois Environmental Protection Agency
IQR	interquartile range
JPP	Joppa Power Plant
LAU	lower aquifer unit
LCL	lower confidence limit
LCU	lower confining unit
NAVD88	North American Vertical Datum of 1988
NID	National Inventory of Dams
No.	number
Part 257	40 C.F.R. § 257 Subpart D
Part 845	35 I.A.C. § 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments
PMP	potential migration pathway
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
UA	uppermost aquifer
UCL	upper confidence limit
UCU	upper confining unit
USEPA	United States Environmental Protection Agency

1. INTRODUCTION

Electric Energy, Inc. (EEI) currently operates the Joppa Power Plant (JPP) East Ash Pond (EAP), located in Joppa, Illinois. The EAP is a 111-acre-foot existing unlined coal combustion residuals (CCR) surface impoundment (SI) used to manage CCR and non-CCR waste streams at the JPP. The EAP is regulated under Title 35 of the Illinois Administrative Code (35 I.A.C.) section (§) 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845). The EAP is identified by Vistra identification (ID) number (No.) 401, Illinois Environmental Protection Agency (IEPA) ID No. W1270100004-02, and National Inventory of Dams (NID) No. IL50714.

EEI is preparing a construction permit application for the EAP as required under Part 845. This application includes groundwater modeling to be completed for the known potential exceedances of groundwater protection standards (GWPS) unless an alternate source can be demonstrated. In October 2021, Ramboll Americas Engineering Solutions, Inc. (Ramboll) identified potential GWPS exceedances for pH in certain monitoring wells in the vicinity of the EAP (Ramboll, 2021a). This document evaluates the source of these potential GWPS exceedances.

2. SITE INFORMATION

The site information has been summarized from the Hydrogeological Site Characterization Report (Ramboll, 2021b). The EAP lies adjacent to and north to northeast of the Ohio River at the southern boundary of the Illinois Basin and the northern edge of the Mississippi Embayment, a relatively low-lying area that is part of the Coastal Plain Physiographic Province. Regionally, the unlithified materials consist of diamictons and lacustrine/alluvial deposits. These deposits may exceed 100 feet in thickness. In addition to CCR material, four principal unlithified deposits exist in the vicinity of the EAP, in descending order: (1) the Equality Formation; (2) Peoria Silt / Roxana Silt / Loveland Silt; (3) Metropolis Formation; and (4) McNairy Formation. The unlithified materials rest on Mississippian-age bedrock. Five water-bearing units have been identified in the vicinity of the EAP based on stratigraphic relationships and common hydrogeologic characteristics. The units are described as follows:

- **CCR:** CCR consisting of fly ash and bottom ash. The amount of saturated fill and CCR in the EAP is generally consistent, ranging from 35 to 45 feet, and the estimated base of ash range from 425 to 435 feet North American Vertical Datum of 1988 (NAVD88).
- **Upper Confining Unit (UCU):** The uppermost hydrostratigraphic unit is comprised of the fine-grained materials from the Equality Formation, the Silt Unit, and Metropolis Formation deposits. The average thickness of this unit is 40.7 feet with a range of 8 to 58 feet. The UCU underlies the CCR fill in all locations and limits the vertical migration of CCR impacts into the uppermost aquifer.
- **Uppermost Aquifer (UA):** This unit consists of the Upper McNairy Formation which is composed of permeable sands and gravels with isolated lenses of finer grained material. This hydrostratigraphic unit at the site was 58 feet thick and is underlain by the LCU.
- **Lower Confining Unit (LCU):** This unit consists of the Lower McNairy Formation which in the vicinity of the EAP is composed of clay and silt overlying the Salem Limestone. Based on material description, continuous lateral extent, and observed vertical gradients, this unit is identified as the LCU.
- **Lower Aquifer Unit (LAU):** This unit is composed of the Salem Limestone bedrock and underlies all unlithified deposits. It is the lowermost hydrostratigraphic unit identified and is considered a potential migration pathway (PMP). The Salem Limestone is used as a potable and non-potable water supply in the vicinity of the JPP.

Groundwater elevations within the EAP are elevated relative to the surrounding area. In general, groundwater flow beneath the EAP is northwest to southeast in the northern half of the EAP, and from southwest and southeast in the southern half of the EAP (Figure 2-1). Groundwater elevations vary seasonally. Slight seasonal variation in groundwater flow directions in the southern part of the EAP have been observed; however, the major component of groundwater flow direction is consistently south toward the Ohio River which is the primary receiving body of water in the vicinity of the JPP (Ramboll, 2021b).

3. POTENTIAL GWPS EXCEEDANCES

As required by Part 845, an evaluation of the history of potential GWPS exceedances was completed for the operating permit application. Data collected since 2015 from the EAP monitoring well network were evaluated using statistical methods described in the Statistical Analysis Plan included in Appendix I of the operating permit application (Ramboll, 2021c). The following monitoring wells and potential exceedances are evaluated in this document:

- pH at wells G06S, G07, G11, and G51D. These wells are screened in the UA. Well G51D was installed in 2015; G06S, G07, and G11 were installed in January 2021.
- pH at well G151. This well is screened in the UCU and was installed in 2010.

The potential exceedances are summarized in Table A below.

Table A. Potential pH exceedances of the GWPS.

Well	Lower Confidence Limit (SU)	Upper Confidence Limit (SU)	Lower GWPS		Upper GWPS	
			Value (SU)	Source	Upper GWPS	Source
G06S	5.5	6.2	6.0	Background	9	Standard
G07	5.9	6.2	6.0	Background	9	Standard
G11	5.8	5.9	6.0	Background	9	Standard
G51D	5.6	5.9	6.2	Background	9	Standard
G151	5.4	5.9	6.0	Background	9	Standard

Monitoring well G51D has been historically monitored in accordance with Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257 Subpart D (Part 257), from 2015 through 2021. The lower confidence limit (LCL) for this well was determined using this data and was compared to the background used in Part 257 compliance monitoring (calculated from data collected between 2015 and 2017). For the other monitoring wells (either newly constructed or not monitored under Part 257), background was determined using data collected from the eight sampling events in 2021 required by Part 845 (Ramboll, 2021a).

4. EVIDENCE THAT POTENTIAL GWPS EXCEEDANCES ARE NOT RELATED TO THE EAP

This document demonstrates that sources other than the EAP (CCR unit) caused the potential GWPS exceedances. Evidence supporting this include the following:

1. The pH exceedances at wells G06S and G07 are not statistically significant.
2. The EAP porewater is not a source of low pH.
3. Background pH is trending downward.

These are described and supported in greater detail below.

4.1 The pH Exceedances at Wells G06S and G07 Are Not Statistically Significant

The preliminary history of potential GWPS exceedances calculation compared the LCL to the lower GWPS for all compounds of concern. However, pH is unique in that it has both a high and a low limit, creating a range of acceptable concentrations. For a pH "exceedance" to occur, the full range of the observed data (characterized by both the LCL and the upper confidence limit [UCL]) would need to fall outside of the GWPS range. Practically, this means that for a pH exceedance to occur, the UCL would fall below the lower GWPS, or the LCL would fall above the upper GWPS. Although the pH LCLs at wells G06S and G07 fall below the lower GWPS (Table A), the UCL remains above the lower GWPS. Therefore, the previously determined pH exceedances at G06S and G07 are not significant.

4.2 The EAP Porewater is Not a Source of Low pH

Box-and-whisker plots graphically represent the range of values of a given dataset using lines to construct a box where the lower line, midline, and upper line of the box represent the values of the first quartile, median, and third quartile values, respectively. The minimum and maximum values of the dataset (excluding outliers) are illustrated by whisker lines extending beyond the first and third quartiles of (*i.e.*, below and above the box). The interquartile range (IQR) is the distance between the first and third quartiles. Outliers (values that are at least 1.5 times the IQR away from the edges of the box) are represented by single points plotted outside of the range of the whiskers. The number in parentheses below each plot is the number of observations (*i.e.,* samples) represented in that dataset.

Figure A below provides a box-and-whisker plot of the pH data collected between 2015 and 2021 at the wells with potential exceedances. The range of pH observed in the CCR porewater is consistently higher than the pH observed in the potential exceedance wells. If the EAP were the source of low pH, the pH would have to be equal to or lower than the pH in the potential exceedance wells. Therefore, the EAP is not the source of the low pH exceedances.

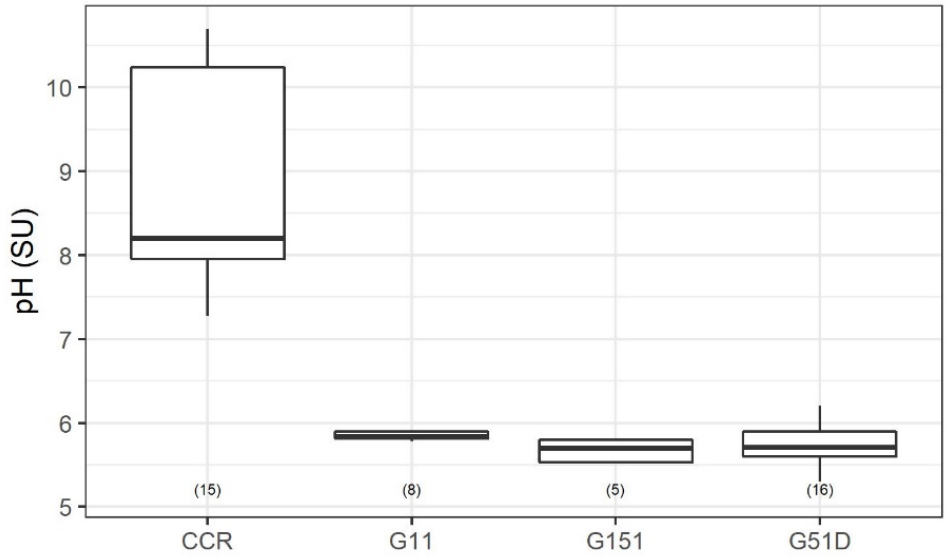


Figure A. pH Ranges Measured in CCR Porewater and Monitoring Wells from 2015 to 2021. The number in parentheses below each box plot represents the sample count.

4.3 Background pH Is Trending Downward

The GWPS used to determine the exceedances at G11 and G151 was based on background data collected during eight sampling events in 2021 conducted for the purpose of establishing a monitoring program compliant with Part 845. Background data was collected from locations G01D and G02D located upgradient from the EAP. The pH at both wells during this sampling period had significant downward trends, determined using a Mann-Kendall trend test with a significance level of 0.05 (Figure B below). As described in the United States Environmental Protection Agency's (USEPA) *Unified Guidance* document, a trend in background data can cause inappropriate determination of background values because the mean of the data is changing over time (USEPA 2009, Section 5.2). In this case, the background would be inappropriately high due to the decreasing mean of the data.

The *Unified Guidance* suggests several possibilities that could cause trends in background data, including contamination of the background or site-wide changes in the aquifer composition. Groundwater flow at the site is generally from the north and west. The site property is bordered by a cement plant to the west and a compressor station to the west and north (Ramboll, 2021c). Therefore, there is a possibility that the decrease in pH is driven by off-site activities. The pH of both background wells decreasing at the same rate (shown by the equivalent slopes of the trend lines) indicates that the change may also indicate a site-wide change in aquifer conditions. In either case, the upgradient decline in pH could influence the determination of exceedances by causing an inappropriately high determination of background.

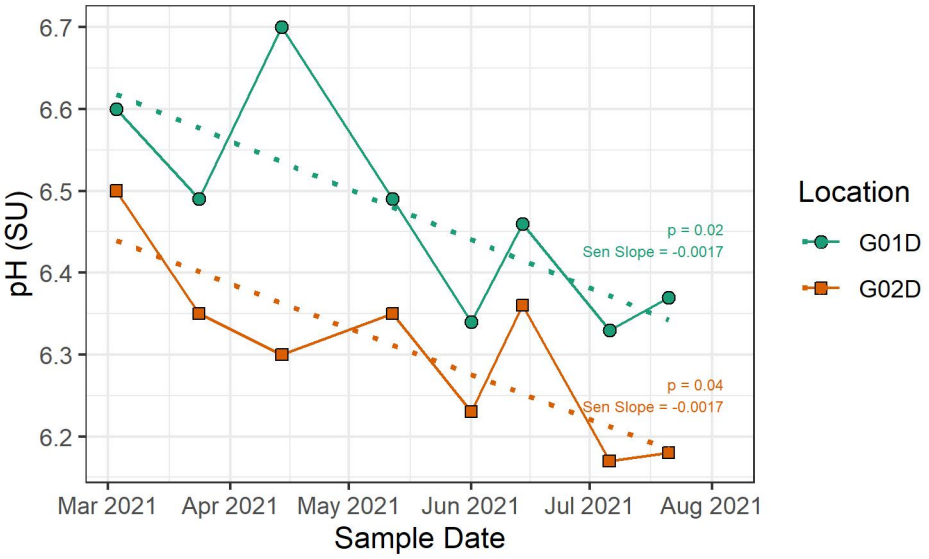


Figure B. 2021 Sampling Data and Mann-Kendall Trend Test Results for pH in Background Wells.

5. CONCLUSIONS

Several lines of evidence indicate that the potential pH exceedances identified are not caused by the EAP. When more rigorous statistical comparison of the data to the GWPS is made, two wells are found to not have a potential pH exceedance. Additionally, the EAP porewater does not have low pH comparable to the potentially affected wells. Finally, the background used for several of the GWPS comparisons has a significant downward trend indicative of changing aquifer conditions outside the influence of the EAP. It is therefore unlikely that the EAP is the cause of the low pH GWPS exceedances.

6. REFERENCES

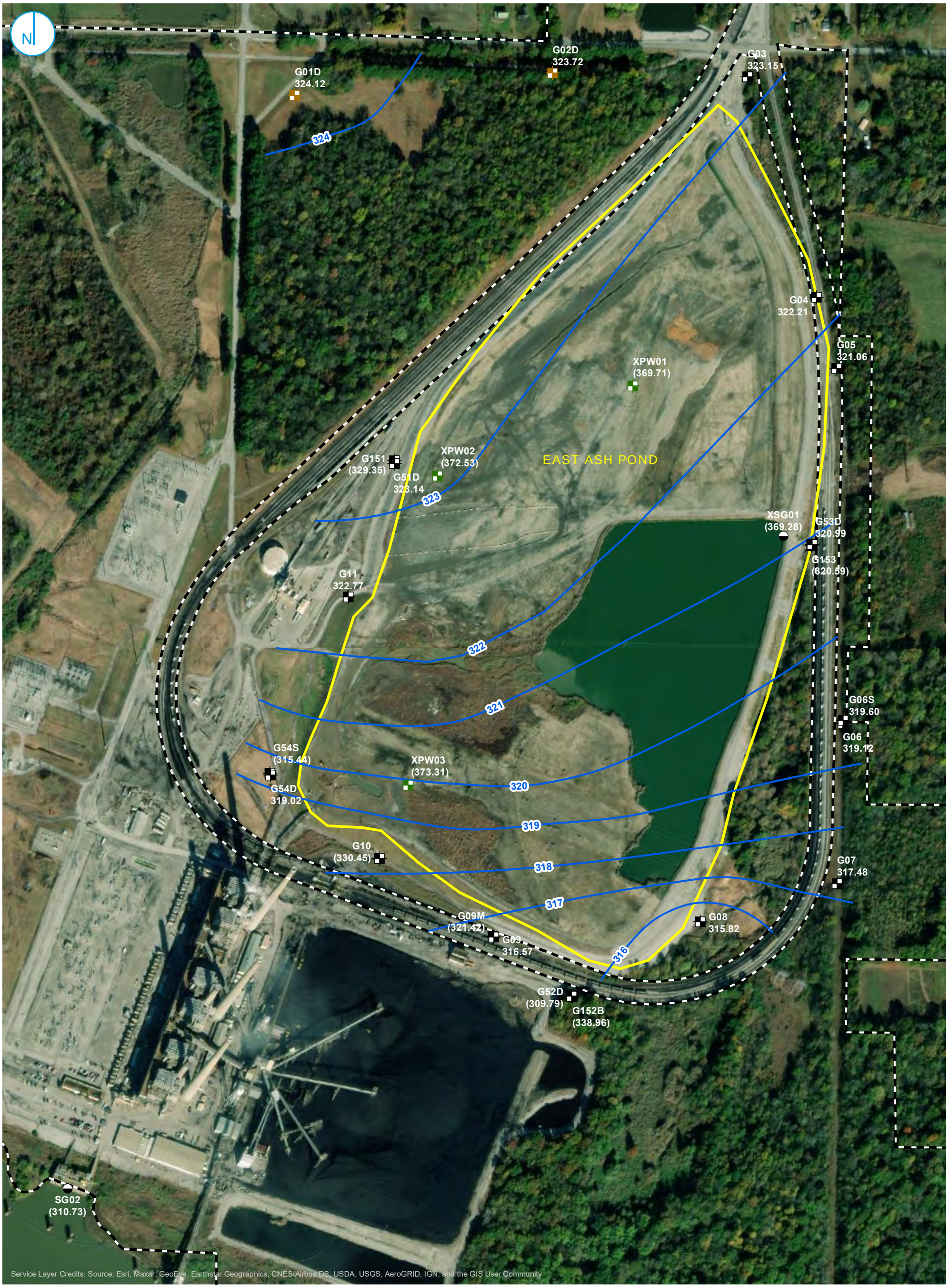
Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021a. *History of Potential Exceedances, Joppa East Ash Pond, Joppa Power Plant*. October 25, 2021.

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021b. *Hydrogeologic Site Characterization Report, Joppa East Ash Pond, Joppa Power Plant*. October 25, 2021.

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021c. *Statistical Analysis Plan, Joppa East Ash Pond, Joppa Power Plant*. October 25, 2021.

United States Environmental Protection Agency (USEPA), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*. EPA 530-R-09-007.

FIGURES



BACKGROUND WELL
MONITORING WELL
SOURCE SAMPLE LOCATION
STAFF GAGE
GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 200 400 Feet

NOTES:
1.ELEVATIONS IN PARENTHESIS WERE NOT USED FOR CONTOURING.
2. ELEVATIONS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988

UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP MAY 11 AND 12, 2021

EVALUATION OF POTENTIAL GWPS EXCEEDANCES

JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-1

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APPENDIX B
HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT

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ENVIRONMENT
& HEALTH

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, IL

Project name	**Joppa East Construction Permit**
Project no.	**1940102417**
Version	**DRAFT**
Date	**May 31, 2022**
Prepared by	**Nathaniel Keller**
Checked by	
Approved by	
Description	**Evaluation and documentation of recently installed monitoring wells, the base of CCR, the top of the uppermost aquifer and the average water table for use in the Closure Plan and Groundwater Modeling Reports**

CONTENTS

1.	**Introduction**	**2**
1.1	Background	2
1.2	Site Location	2
2.	**Hydrogeologic Investigation and Additional Evaluations**	**2**
2.1	Hydrogeologic Investigation	2
2.2	Base of CCR	3
2.3	Top of Uppermost Aquifer	4
2.4	Water Table Evaluation	4
3.	**Conclusions**	**4**
4.	**References**	**5**

Tables

Table 2-1	Groundwater Analytical Results
Table 2-2	Groundwater Elevations
Table 2-3	Upper Confining Unit Groundwater Elevations

Figures

Figure 1-1	Site Location Map
Figure 1-2	Site Map
Figure 2-1	Geologic Cross Section X-X’
Figure 2-2	Base of CCR (Inside EAP)
Figure 2-3	Base of CCR (Outside EAP)
Figure 2-4	Top of Uppermost Aquifer
Figure 2-5	Upper Confining Unit Average Water Table Elevations 2021
Figure 3-1	Base of CCR – Top of Uppermost Aquifer Separation

Appendices

Appendix A	Soil Boring Logs and Well Construction Forms

1. Introduction

1.1 Background

In October 2021, Ramboll Americas Engineering Solutions, Inc. (Ramboll) completed a Hydrogeologic Site Characterization Report (HCR; Ramboll, 2021) for the East Ash Pond (EAP) at Joppa Power Plant (JPP). The report was included in the Operating Permit Application (Burns & McDonnell, 2021) that was submitted to the Illinois Environmental Protection Agency (IEPA). The report was assembled to meet the information and analysis requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845.620 and included hydrogeologic and groundwater quality data specific to the EAP, which had been collected between 2015 and 2021.

Additional monitoring wells (G12S, G12D, G13S, G13D, G14S, G14D, G15S, G15D, G16S, and G16D) were installed in the fall of 2021 between the EAP and the JPP property boundary to further evaluate groundwater quality consistent with 35 I.A.C. § 845.600(a)(1). Groundwater samples were collected from the expanded well network in January and February 2022, and confirmed on March 7, 2022. During preparation of the Closure Plan (Geosyntec Consultants, Inc. [Geosyntec], 2022) and groundwater model to evaluate closure scenarios, the conceptual model was updated to include the recent hydrogeologic information, as well as additional evaluations completed to define the bottom/base elevation of the CCR material in the EAP, the top elevation of the uppermost aquifer (UA), and the average water table elevation in the upper confining unit (UCU). This report includes the recent (2022) hydrogeologic information as well as summarizes and documents the results of the additional evaluations.

1.2 Site Location

The JPP is west of the Village of Joppa in Massac County, Illinois, northeast of the Ohio River in Section 14, Township 15 South, Range 3 East (**Figure 1-1**). The JPP property is bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south. The EAP is located in the west half of Section 14 directly north of the JPP and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa. **Figure 1-1** shows the location of the plant; **Figure 1-2** is a site map showing the location of the EAP.

2. Hydrogeologic Investigation and Additional Evaluations

2.1 Hydrogeologic Investigation

Ten wells were installed at the JPP property boundary in fall of 2021 to further evaluate groundwater quality consistent with 35 I.A.C. § 845.600(a)(1). Soil boring logs and well construction forms are included in **Appendix A**. Consistent with the HCR (Ramboll, 2021), the additional borings encountered the following hydrostratigraphic units (from ground surface down, **Figure 2-1**):

- **Upper Confining Unit (UCU):** Low permeability silt and clay of the Equality Formation, silts of the Peoria/Roxana/Loveland, and clay and silt of the Metropolis Formation are considered the UCU. This unit was encountered in all borings advanced downgradient of the EAP.
- **Uppermost Aquifer (UA):** High permeability sands with gravel, silt, and clay lenses of the McNairy Formation. The UA was encountered in the downgradient wells at elevations ranging from 226.06 to 312.06 feet North American Vertical Datum of 1988 (NAVD88).

- **Lower Confining Unit (LCU):** Clay, silt, or chert gravel residuum in on-site wells (Nelson, 1997) has been interpreted and characterized as part of the Lower McNairy Formation, Post Creek (Tuscaloosa) Formation, or weathered limestone residuum. This material was encountered in two borings that penetrated the entire thickness of sand (G14D and G15D) at elevations of 214.81 and 233.97 feet NAVD88, respectively. Based on material descriptions (high clay and/or silt content, and partial cementation), continuous lateral extent, and vertical gradients observed between the UA and the LAU, this unit is identified as the LCU.
- **Lower Aquifer Unit (LAU):** Lowermost unit identified at the site and underlies all unlithified deposits. This unit is comprised of the Salem Limestone (bedrock), which is the uppermost lithified unit at the site, and used as a potable and non-potable water supply in the vicinity of the JPP. The LAU was encountered in G14D at approximately 208.31 feet NAVD88.

Following well installation and development, groundwater elevations were measured, and the wells were sampled for 35 I.A.C. § 845.600 parameters during three events (January, February, and March 2022). Results of the groundwater sampling are summarized in **Table 2-1**, groundwater elevations are included in **Table 2-2**. Results from monitoring wells screened within the UA downgradient of the EAP indicate potential exceedances primarily for boron. Boron concentrations above the GWPS of 2 milligrams per liter (mg/L) have been observed in monitoring wells adjacent to the EAP (G06, G07, G08, G09, G10) and downgradient (G12S, G12D, G13S, G13D, G14D, G15S, G15D, G16S, and G16D). Porewater samples collected from within the EAP indicate boron concentrations range from 9.42 to 12.2 mg/L, while boron concentrations in the downgradient wells with potential exceedances range from 2.89 to 7.88 mg/L (**Table 2-1**).

2.2 Base of CCR

Information in the HCR indicated that the base of the CCR material within the EAP extends to an elevation of 327.7 feet NAVD88 (Ramboll, 2021). This elevation provided in the report was the most conservative (lowest) elevation where CCR was observed in the limited number of borings advanced within the footprint of the EAP. To assess closure options, a detailed base of ash surface was required to estimate CCR volumes (for removal or consolidation) and define the geologic layers in the groundwater model.

Geosyntec (2022) evaluated the base of CCR within the EAP using existing soil borings, cone penetrometer data, and the preconstruction historical topographic map and developed a base of CCR surface (**Figure 2-2**) for use in groundwater modeling and evaluation of closure scenarios. Boring logs and cone penetrometer testing results were used in the EAP where available, and the historic topographic contours were used in areas without any investigation to develop a comprehensive base of ash surface. The results are summarized as follows:

- The base of ash ranges in elevation from approximately 310 to 350 feet NAVD88
- CCR is at the lowest elevation (approximately 309 feet NAVD88) in the southeast corner of the EAP and is generally located within the former drainage feature identified on historic topographic maps
- Based on surface elevations, the average thickness of CCR material in the EAP is approximately 50 feet

Review of historic boring logs also indicated the presence of additional CCR material outside the berms and near the southeast corner of the EAP. The extent and base elevations of this CCR material outside the EAP are currently being defined, but preliminary base elevations are illustrated on **Figure 2-3**. Based on preliminary information the elevation of the base of ash in the southeast area ranges from 316 to 334 feet NAVD88, with the lowest elevations occurring in locations within or near the historic drainage feature.

2.3 Top of Uppermost Aquifer

As discussed in the HCR, the UA is comprised of sand and gravel, and was classified as the McNairy Formation. The unit was encountered at its shallowest elevation (approximately 319 feet NAVD88) at C004 located on the east/southeast edge of the EAP. The elevation of G06 that was included in the HCR (Ramboll, 2021) was revised (from approximately 319 to 313 feet NAVD88) following additional evaluation of the boring logs. Descriptions of soil that were dry, cohesive, tight, and/or had elevated fines were not included in the UA definition, as a result the elevation at this location was lowered. The top of the UA (Figure 3-2 in the HCR; Ramboll, 2021) was based on wells installed in 2015 and didn't include information from the 35 I.A.C. § 845 well installation.

Review of boring logs and the cone penetrometer test results was completed to refine the top of UA to construct layers for the groundwater modeling. In areas where there were multiple sources of information for the top of aquifer elevation, data was evaluated for potential errors and uncertainty and a representative elevation was selected. In general, the variability between adjacent points was less than 2 feet. Based on this analysis the top of the UA was refined and contoured (**Figure 2-4**). As illustrated in **Figure 2-4**, the UA is highest (C004, approximately 319 feet NAVD88) along the boundary of the EAP near the southeast corner and generally elevated in an east-west trending ridge across the center of the EAP. The lowest elevation (approximately 278 feet NAVD88) occurs at G52D which is located on the south/southeast corner of the EAP.

2.4 Water Table Evaluation

As presented in the HCR (Ramboll, 2021), the groundwater elevation in wells within the UCU (G101, G151, G152B, G153, and G54S) from March to July 2021 averaged 322.75 feet NAVD88, with a range from 310.25 feet NAVD88 in G54S (southwest corner of the EAP) to 338.96 feet NAVD88 in G152B (southern edge of EAP). Well G152B, located south of the EAP, consistently recorded the highest groundwater elevation, with an average groundwater elevation of 335.58 feet NAVD88. The elevated groundwater here is assumed to be a result of well G152B screen being situated in low conductivity materials. Groundwater elevations at well G151 (along the western edge of the EAP) were also consistently higher than the remaining UCU wells, with an average groundwater elevation of 326.97 feet NAVD88.

A summary of groundwater elevations and averages from the UCU wells during 2021 is provided in **Table 2-3** and the average groundwater elevation at each well is contoured in **Figure 2-5**. The average water table elevation measured in 2021 ranges from 314.1 to 335.9 feet NAVD88 and the flow direction is generally from the west to the east and south, around a groundwater mound that is consistently measured in G152B (as discussed above).

3. Conclusions

The results described above were used to evaluate the proposed closure options and determine separation distances between the base of the CCR and the top of the UA. Evaluation of the water table and CCR was not completed because water elevations measured in the UCU may be influenced by the hydraulic head inside the EAP since the wells are screened in low permeability materials directly adjacent to the EAP. These conditions indicate measurements may not represent the water table following closure of the unit.

The separation distance between the base of CCR and the top of the UA is illustrated on **Figure 3-1**. Separation distance ranges from 0.5 ft to 89 feet with an average of approximately 31 feet. The

separation distances are smallest in the southeast corner of the EAP within the former drainage feature where the top of the UA is shallowest.

4. References

Burns & McDonnell, 2021. *Initial Operating Permit Application*, Joppa East Ash Pond. October 25, 2021.

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Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021a. *Hydrogeologic Site Characterization Report*. East Ash Pond. Joppa Power Plant, Joppa, Illinois. October 25, 2021.

TABLES

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 + Radium 228 (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G01D	03/14/2022	<0.001	<0.001	0.128	<0.001	<0.025	<0.001	26.1	8	0.0026	<0.001	0.22	<0.001	<0.003	<0.0002	<0.0015	**6.4**	1.1	0.0012	22	<0.002	318
G02D	03/14/2022	<0.001	<0.001	0.148	<0.001	0.0283	<0.001	38.2	22	<0.0015	<0.001	0.23	<0.001	<0.003	<0.0002	<0.0015	6.5	0.905	0.0012	11	<0.002	260
G12S	01/20/2022	<0.001	<0.001	0.0367	<0.001	**5.91**	<0.001	83.7	19	<0.0015	<0.001	0.28	<0.001	<0.003	<0.0002	<0.0015	**6.3**	0.228	<0.001	175	<0.002	470
G12S	02/10/2022	<0.001	<0.001	0.0343	<0.001	**5.89**	<0.001	78.8	19	<0.0015	<0.001	0.28	<0.001	<0.003	<0.0002	<0.0015	6.6	0.672	<0.001	211	<0.002	432
G12S	03/16/2022	<0.001	<0.001	0.0287	<0.001	**5.83**	<0.001	80.8	19	<0.0015	<0.001	0.27	<0.001	<0.003	<0.0002	<0.0015	6.5	0.329	<0.001	209	<0.002	456
G12D	01/20/2022	<0.001	<0.001	0.0449	<0.001	**6.94**	<0.001	88.4	18	<0.0015	0.0014	0.27	<0.001	<0.003	<0.0002	<0.0015	6.5	1.09	<0.001	195	<0.002	492
G12D	02/10/2022	<0.001	<0.001	0.0361	<0.001	**6.38**	<0.001	85.8	19	<0.0015	<0.001	0.27	<0.001	<0.003	<0.0002	<0.0015	6.7	0.212	<0.001	191	<0.002	458
G12D	03/16/2022	<0.001	<0.001	0.0282	<0.001	**6.79**	<0.001	88.1	19	<0.0015	<0.001	0.26	<0.001	<0.003	<0.0002	<0.0015	6.6	0.33	<0.001	225	<0.002	482
G13S	01/20/2022	<0.001	<0.001	0.0341	<0.001	**5.22**	<0.001	82.2	19	<0.0015	<0.001	0.29	<0.001	<0.003	<0.0002	<0.0015	6.5	0.501	<0.001	155	<0.002	456
G13S	02/10/2022	<0.001	<0.001	0.0297	<0.001	**4.74**	<0.001	79.5	19	<0.0015	<0.001	0.29	<0.001	<0.003	<0.0002	<0.0015	6.5	0.743	<0.001	151	<0.002	428
G13S	03/16/2022	<0.001	<0.001	0.0259	<0.001	**4.99**	<0.001	80.4	20	<0.0015	<0.001	0.28	<0.001	<0.003	<0.0002	<0.0015	**6.3**	0.335	<0.001	159	<0.002	440
G13D	01/20/2022	<0.001	<0.001	0.0376	<0.001	**4.62**	<0.001	84.5	19	<0.0015	<0.001	0.27	<0.001	<0.003	<0.0002	<0.0015	6.6	0.0852	<0.001	157	<0.002	444
G13D	02/10/2022	<0.001	<0.001	0.0346	<0.001	**4.55**	<0.001	83	19	<0.0015	<0.001	0.27	<0.001	<0.003	<0.0002	<0.0015	6.5	0.582	<0.001	185	<0.002	398
G13D	03/16/2022	<0.001	<0.001	0.0302	<0.001	**4.82**	<0.001	81.5	19	<0.0015	<0.001	0.26	<0.001	<0.003	<0.0002	<0.0015	**6.4**	0.438	<0.001	162	<0.002	436
G14S	01/19/2022	<0.001	0.0024	0.106	<0.001	0.054	<0.001	75.9	4	<0.0015	<0.001	0.32	<0.001	0.0086	<0.0002	0.002	7.0	0.53	<0.001	10	<0.002	278
G14S	02/10/2022	<0.001	0.0031	0.0992	<0.001	<0.025	<0.001	77.7	3	<0.0015	<0.001	1.03	<0.001	0.0066	<0.0002	0.0019	7.1	0.835	<0.001	10	<0.002	244
G14S	03/15/2022	<0.001	0.003	0.103	<0.001	<0.025	<0.001	72.1	<4	<0.0015	<0.001	0.3	<0.001	0.0063	<0.0002	0.002	7.1	0.173	<0.001	10	<0.002	278
G14D	01/19/2022	<0.001	<0.001	0.0381	<0.001	**3.4**	<0.001	88	21	<0.0015	<0.001	0.35	<0.001	<0.003	<0.0002	<0.0015	6.6	0.0148	<0.001	180	<0.002	498
G14D	02/10/2022	<0.001	<0.001	0.0348	<0.001	**3.6**	<0.001	85	20	<0.0015	<0.001	0.98	<0.001	<0.003	<0.0002	<0.0015	6.5	0.444	<0.001	190	<0.002	456
G14D	03/15/2022	<0.001	<0.001	0.0314	<0.001	**4.02**	<0.001	85.8	20	<0.0015	<0.001	0.33	<0.001	<0.003	<0.0002	<0.0015	6.5	0.102	<0.001	197	<0.002	472
G15S	01/19/2022	<0.001	<0.001	0.0914	<0.001	1.14	<0.001	55.7	6	<0.0015	**0.0069**	0.25	<0.001	0.0034	<0.0002	<0.0015	**6.2**	0.22	<0.001	101	<0.002	320
G15S	02/10/2022	<0.001	<0.001	0.101	<0.001	1.05	<0.001	56.6	7	<0.0015	0.0042	0.24	<0.001	<0.003	<0.0002	<0.0015	**6.2**	1.07	<0.001	104	<0.002	290
G15S	03/15/2022	<0.001	<0.001	0.0895	<0.001	0.74	<0.001	45.5	3	<0.0015	0.0026	0.25	<0.001	0.0031	<0.0002	<0.0015	**6.2**	0.568	<0.001	53	<0.002	230

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 + Radium 228 (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G15D	01/19/2022	<0.001	0.0014	0.0506	<0.001	**6.69**	<0.001	134	19	<0.0015	**0.0238**	0.33	<0.001	0.0063	<0.0002	0.0017	6.8	0.726	<0.001	362	<0.002	762
G15D	02/11/2022	<0.001	0.0023	0.0444	<0.001	**6.1**	<0.001	126	19	0.0038	**0.0178**	0.87	<0.001	0.0064	<0.0002	0.0016	6.7	0.00598	<0.001	389	<0.002	726
G15D	03/15/2022	<0.001	0.0023	0.0365	<0.001	**7.88**	<0.001	134	20	0.0017	**0.0217**	0.31	<0.001	0.0082	<0.0002	<0.0015	6.8	0.12	<0.001	375	<0.002	770
G16S	01/19/2022	<0.001	<0.001	0.0421	<0.001	**7.24**	<0.001	147	17	<0.0015	0.0054	0.56	<0.001	<0.003	<0.0002	<0.0015	6.7	0.0657	<0.001	279	<0.002	720
G16S	02/10/2022	<0.001	<0.001	0.0407	<0.001	**7.63**	<0.001	142	17	<0.0015	0.0049	0.64	<0.001	<0.003	<0.0002	<0.0015	6.7	1.45	<0.001	271	<0.002	684
G16S	03/15/2022	<0.001	<0.001	0.0372	<0.001	**6.74**	<0.001	128	17	<0.0015	0.0045	0.54	<0.001	<0.003	<0.0002	<0.0015	6.7	0.99	<0.001	300	<0.002	742
G16D	01/19/2022	<0.001	0.0016	0.0908	<0.001	**2.89**	<0.001	81.8	12	<0.0015	<0.001	0.34	<0.001	0.0053	<0.0002	0.0062	7.1	1.1	<0.001	79	<0.002	400
G16D	02/10/2022	<0.001	<0.001	0.0582	<0.001	**7.79**	<0.001	104	18	<0.0015	<0.001	0.24	<0.001	<0.003	<0.0002	0.0026	6.8	1.12	<0.001	198	<0.002	488
G16D	03/15/2022	<0.001	0.0012	0.0607	<0.001	**4.16**	<0.001	92.3	15	<0.0015	<0.001	0.3	<0.001	<0.003	<0.0002	0.0035	7.0	0.53	<0.001	117	<0.002	430
G51D	03/15/2022	<0.001	<0.001	0.0433	<0.001	0.689	<0.001	31	5	0.0017	0.0016	<0.1	<0.001	0.0055	<0.0002	<0.0015	**5.6**	1.21	0.0049	123	<0.002	324
G52D	03/15/2022	<0.001	0.0018	0.208	<0.001	<0.025	<0.001	48.3	12	<0.0015	**0.0063**	0.29	<0.001	<0.003	<0.0002	<0.0015	**6.2**	0.975	<0.001	68	<0.002	350
G53D	03/15/2022	<0.001	<0.001	0.0922	<0.001	0.332	<0.001	38.1	18	<0.0015	0.0022	0.71	<0.001	<0.003	<0.0002	<0.0015	6.5	0.285	<0.001	74	<0.002	342
G54D	03/15/2022	<0.001	<0.001	0.064	<0.001	0.451	<0.001	83.4	21	<0.0015	**0.011**	0.31	<0.001	<0.003	<0.0002	<0.0015	6.6	0.843	<0.001	213	<0.002	524
Well 3	02/10/2022	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.878	--	--	--	--
Well 3	03/15/2022	<0.001	<0.001	0.0435	<0.001	0.588	<0.001	143	20	<0.0015	<0.001	0.45	<0.001	0.0031	<0.0002	0.0016	6.5	1.14	<0.001	233	<0.002	712
XPW01	03/15/2022	<0.001	**0.0529**	0.113	<0.001	**10.4**	<0.001	159	5	<0.0015	<0.001	0.25	<0.001	<0.003	<0.0002	**0.333**	8.3	--	<0.001	360	<0.002	698
XPW02	03/15/2022	<0.001	**0.051**	0.023	<0.001	**16**	<0.001	483	115	<0.0015	<0.001	0.48	<0.004	**0.0841**	<0.0002	**1.06**	7.7	--	<0.001	**2590**	**<0.008**	**4050**
XPW03	03/15/2022	**0.0124**	**0.533**	0.0095	<0.001	**11.1**	<0.001	12.9	25	<0.0015	<0.001	0.27	<0.001	**0.185**	<0.0002	**0.346**	**10.5**	--	0.0266	152	<0.002	414

Notes:
Boron concentrations detected at concentration greater than the GWPS
Exceedance of parameters other than boron
Detected at concentration greater than the GWPS
GWPS = Groundwater protection standard
mg/L = milligrams per liter
pCi/L = picocuries per liter
SU = standard units

RAMBOLL

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 + Radium 228 (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200

< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method. Estimated concentrations below the reporting limit and associated qualifiers are not provided since they are not utilized in statistics to determine exceedances above Part 845 standards.
35 I.A.C. 845.600 = Residuals in Surface Impoundments: Title 35 of the Illinois Administrative Code § 845

TABLE 2-2. GROUNDWATER ELEVATIONS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G01D	02/01/2022	321.02
G01D	03/02/2022	324.74
G01D	03/14/2022	325.94
G02D	02/01/2022	320.61
G02D	03/02/2022	323.79
G02D	03/14/2022	325.46
G03	02/01/2022	320.23
G03	03/02/2022	323.42
G05	02/01/2022	319.02
G05	03/02/2022	322.85
G06	02/01/2022	316.75
G06	03/02/2022	322.31
G06S	03/02/2022	322.95
G07	02/01/2022	315.21
G07	03/02/2022	321.66
G08	02/01/2022	313.68
G08	03/02/2022	322.50
G09	02/01/2022	312.40
G09	03/02/2022	323.55
G09M	03/02/2022	324.61
G10	02/01/2022	313.45
G10	03/02/2022	314.07
G11	01/19/2022	321.44
G11	02/01/2022	319.68
G11	03/02/2022	324.98
G12S	01/20/2022	317.06
G12S	02/01/2022	315.52
G12S	03/02/2022	321.74
G12S	03/14/2022	324.04
G12D	01/20/2022	317.05
G12D	02/01/2022	315.51
G12D	03/02/2022	321.73
G12D	03/14/2022	324.04
G13S	01/20/2022	316.50
G13S	02/01/2022	304.84
G13S	03/02/2022	321.49
G13S	03/14/2022	323.78
G13D	01/20/2022	316.44
G13D	02/01/2022	314.76
G13D	03/02/2022	321.42
G13D	03/14/2022	323.81
G14S	01/19/2022	317.23
G14S	02/01/2022	308.18
G14S	03/02/2022	320.19
G14S	03/14/2022	323.55
G14D	01/19/2022	315.81
G14D	02/01/2022	310.98

TABLE 2-2. GROUNDWATER ELEVATIONS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G14D	03/02/2022	319.94
G14D	03/14/2022	322.44
G15S	01/19/2022	316.13
G15S	02/01/2022	308.25
G15S	03/02/2022	323.72
G15S	03/14/2022	322.82
G15D	01/19/2022	316.00
G15D	02/01/2022	308.39
G15D	03/02/2022	323.62
G15D	03/14/2022	322.62
G16S	01/19/2022	316.82
G16S	02/01/2022	309.39
G16S	03/02/2022	327.12
G16S	03/14/2022	323.50
G16D	01/19/2022	316.75
G16D	02/01/2022	309.26
G16D	03/02/2022	326.86
G16D	03/14/2022	323.49
G51D	02/01/2022	320.05
G51D	03/02/2022	314.10
G51D	03/14/2022	326.13
G52D	02/01/2022	320.52
G52D	03/02/2022	321.80
G52D	03/14/2022	323.13
G53D	02/01/2022	318.70
G53D	03/02/2022	307.79
G53D	03/14/2022	324.84
G54S	03/02/2022	346.60
G54D	02/01/2022	314.70
G54D	03/02/2022	323.70
G54D	03/14/2022	325.19
G151	03/02/2022	329.40
G152B	03/02/2022	337.08
G153	03/02/2022	322.83
Well 3	02/01/2022	300.54
Well 3	03/02/2022	325.64
Well 3	03/14/2022	322.03
XPW01	03/02/2022	370.61
XPW01	03/14/2022	369.57
XPW02	03/02/2022	373.71
XPW02	03/14/2022	372.56
XPW03	03/02/2022	375.05
XPW03	03/14/2022	373.73
XSG01	03/14/2022	367.28

Notes:
ft NAVD88 = feet relative to the North American Vertical Datum 1988, GEOID 12A
generated 05/23/2022, 8:28:24 PM CDT

TABLE 2-3. UPPER CONFINING UNIT GROUNDWATER ELEVATIONS

HYDROGEOLOGIC UPDATE FOR CONSTRUCTION PERMIT

EAST ASH POND

JOPPA POWER PLANT

JOPPA, ILLINOIS

G151		G152B		G153		G54S	
Date	GWE [1]	Date	GWE [1]	Date	GWE [1]	Date	GWE [1]
03/03/21	326.64	03/03/21	338.25	03/03/21	319.04	03/03/21	310.25
03/24/21	330.47	03/25/21	338.38	03/25/21	324.74	03/24/21	311.48
04/14/21	329.35	04/14/21	336.25	04/13/21	324.60	04/14/21	312.84
05/11/21	329.35	05/12/21	338.96	05/11/21	320.59	05/12/21	315.44
06/01/21	325.68	06/01/21	334.71	06/01/21	319.71	06/01/21	312.65
06/14/21	326.03	06/15/21	335.06	06/14/21	320.19	06/14/21	314.30
07/06/21	324.48	07/06/21	332.91	07/06/21	318.17	07/06/21	316.75
07/20/21	324.77	07/20/21	332.91	07/20/21	317.91	07/20/21	318.87
Average GWE [1]	**327.10**		**335.93**		**320.62**		**314.07**

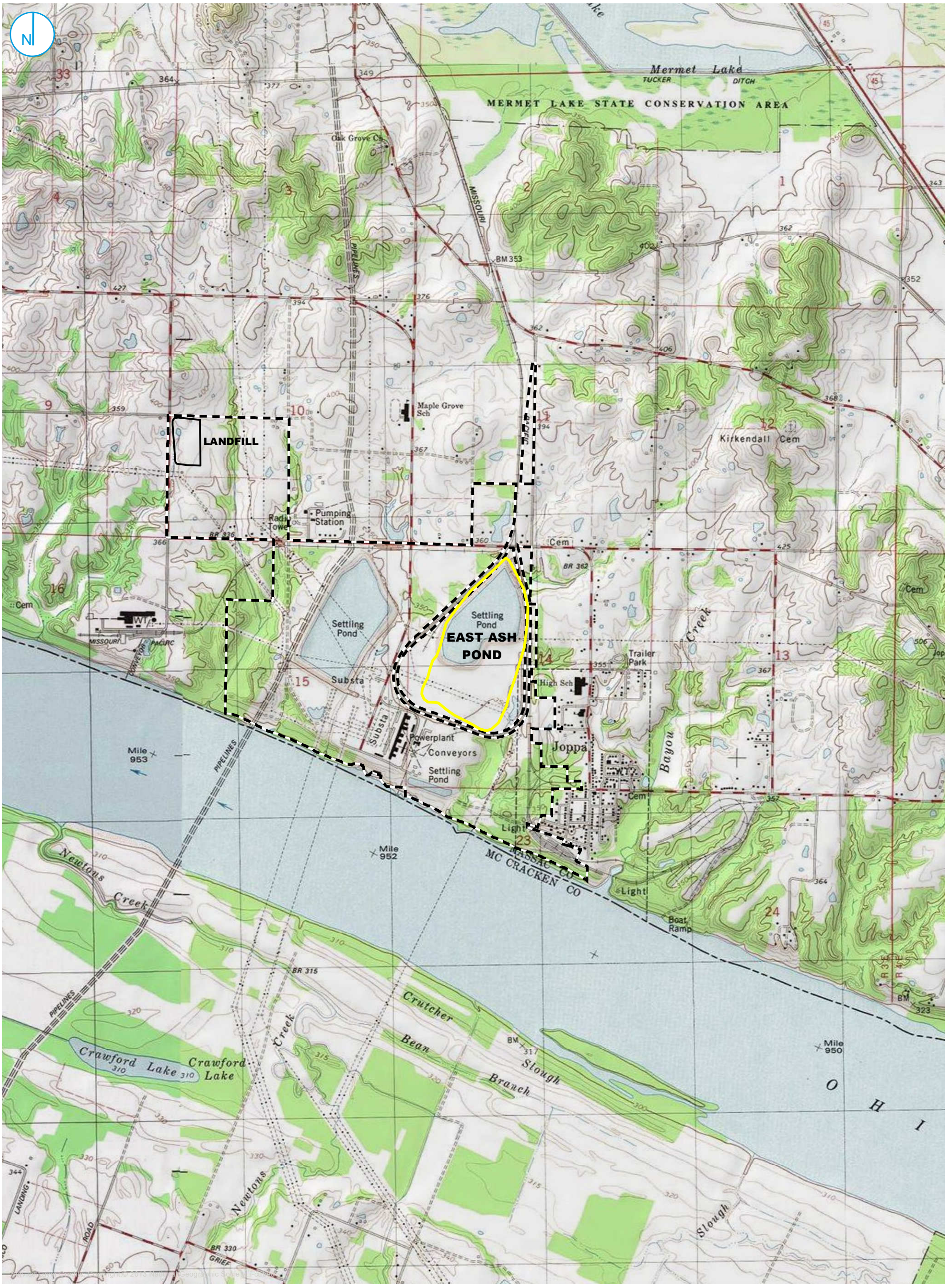
[O: NRK 05/23/22, C: CJC 05/25/22]

Notes:

[1] GWE is in feet referenced to North American Vertical Datum of 1988 (NAVD88)

GWE = groundwater elevation

FIGURES



PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY

0 1,000 2,000 Feet

SITE LOCATION MAP

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 1-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
CENTRAL DIKE
PROPERTY BOUNDARY

0 500 1,000 Feet

SITE MAP

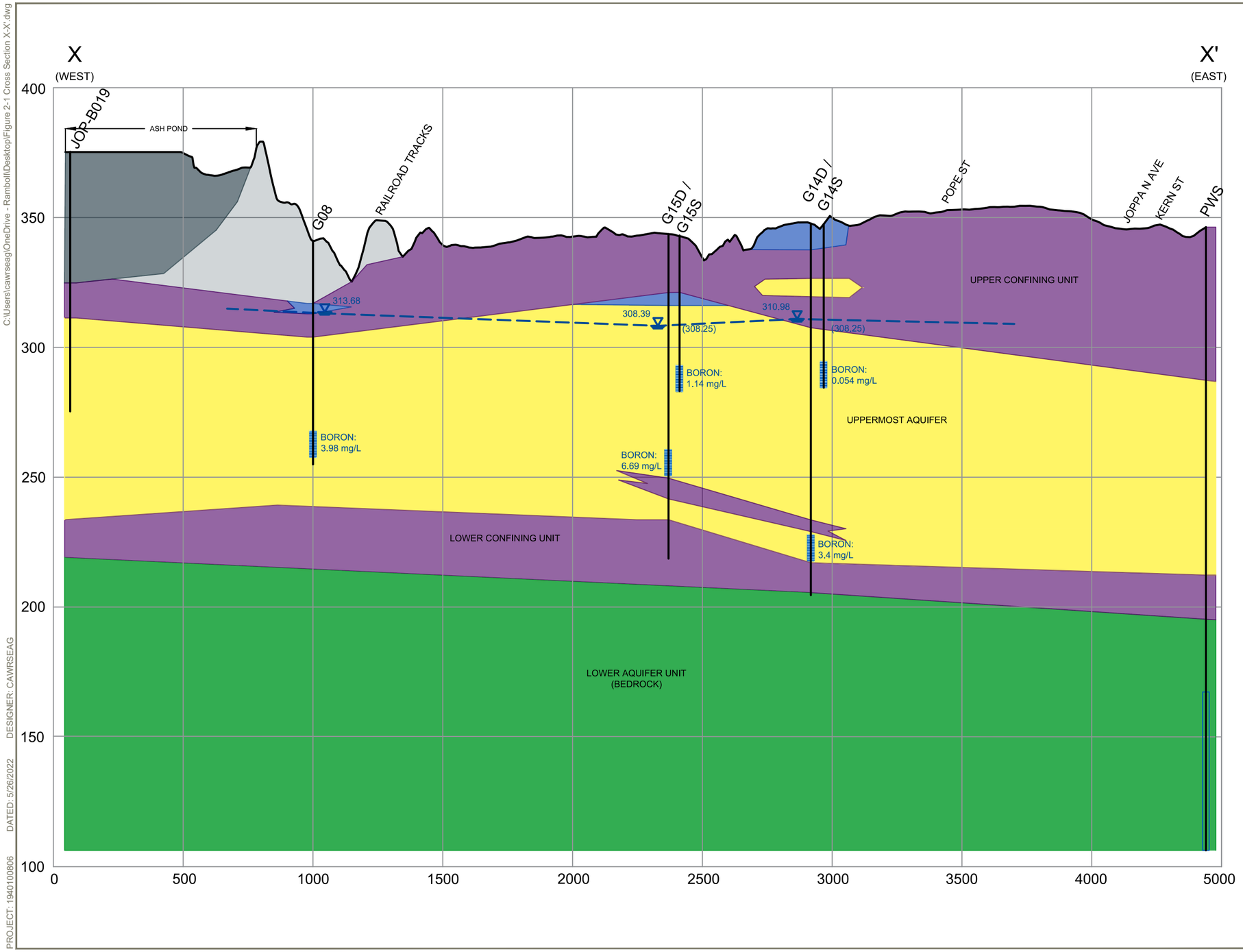
HYDROGEOLOGIC UPDATES
FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

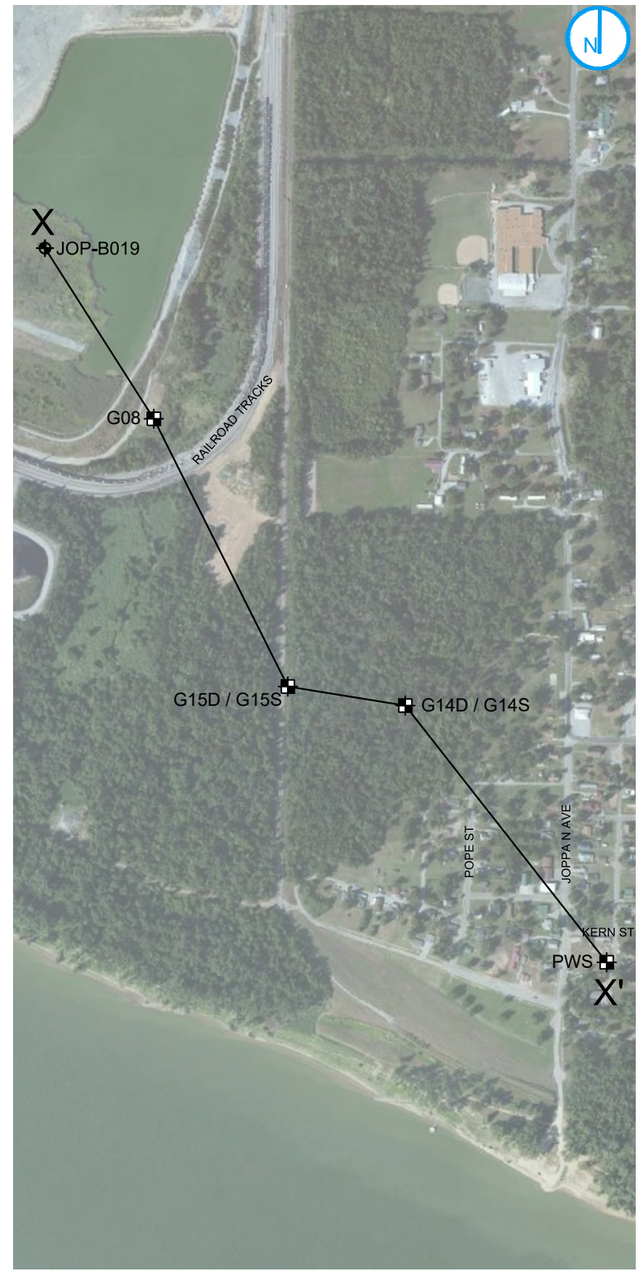
FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\Plume_Delineation\Joppa\JOP_INV_2022\Part845_Construction_Permit\Figure 1-2_Site Map.mxd
PROJECT: 169000XXXX | DATED: 5/25/2022 | DESIGNER: galarmmc





C:\Users\cawrseag\OneDrive - Ramboll\Desktop\Figure 2-1 Cross Section X-X'.dwg

DESIGNER: CAWRSEAG

DATED: 5/26/2022

PROJECT: 1940100806

LEGEND

- COAL COMBUSTION RESIDUALS (CCR)
- FILL
- SILT
- CLAY
- SAND
- BEDROCK
- WELL SCREEN INTERVAL
- UPPERMOST AQUIFER POTENTIOMETRIC SURFACE
- UPPERMOST AQUIFER GROUNDWATER ELEVATION

NOTES

1. This profile was developed by interpolation between widely spaced boreholes. Only at the borehole location should it be considered as an approximately accurate representation and then only to the degree implied by the notes on the borehole logs.
2. Scale is approximate.
3. Vertical scale is exaggerated 10X.
4. Groundwater elevations measured on February 1, 2022.

40' 0 400'

GEOLOGIC CROSS SECTIONS
X-X'

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

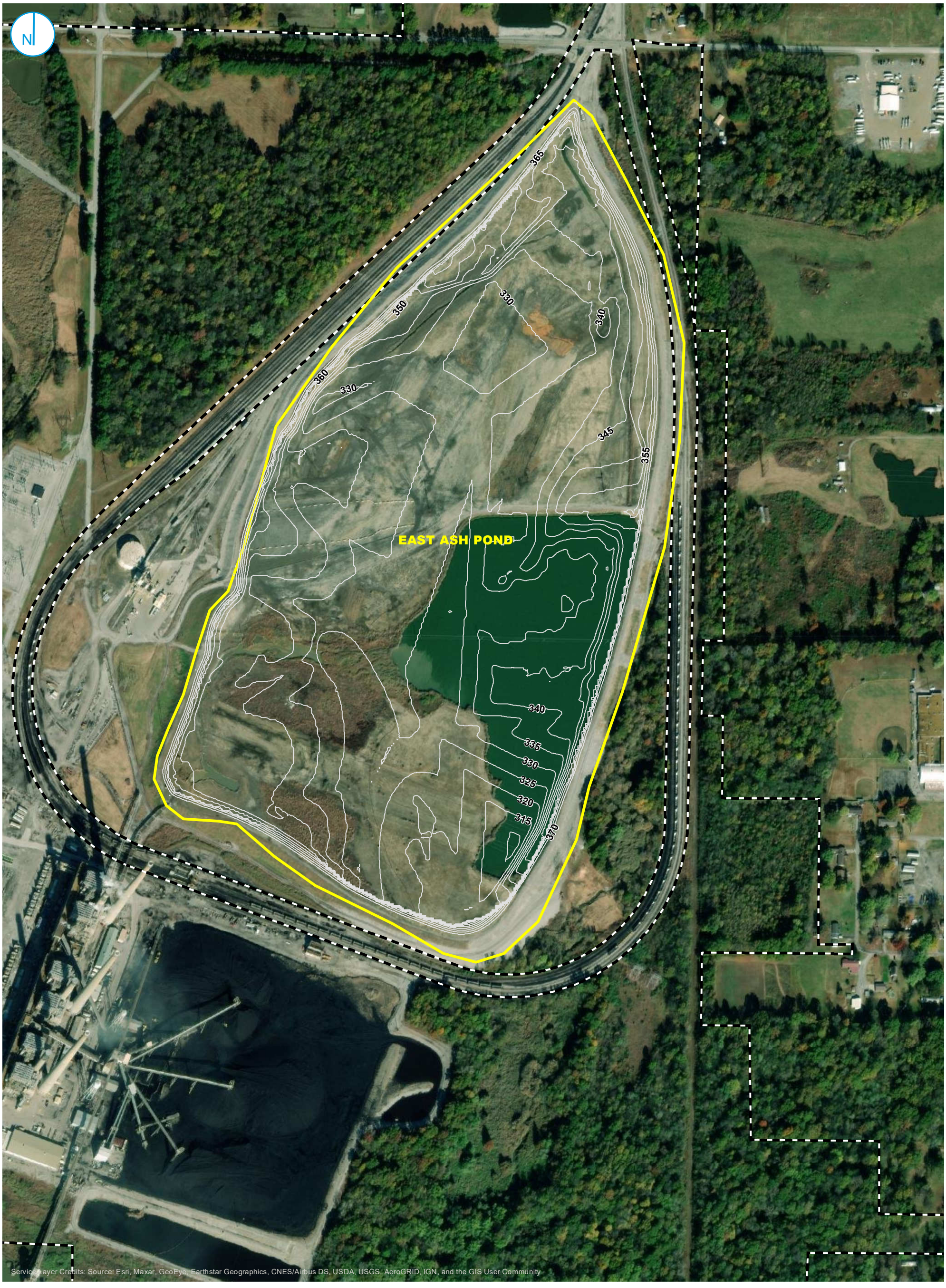
FIGURE 2-1

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/26/2022 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\Plume_Delineation\Joppa\JOP_INV_2022\Part845_Construction_Permit\Figure 2-2_Base of CCR.mxd



BOTTOM OF ASH CONTOUR (5-FT INTERVAL)

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

0 200 400 Feet

BASE OF CCR (INSIDE EAP)

FIGURE 2-2

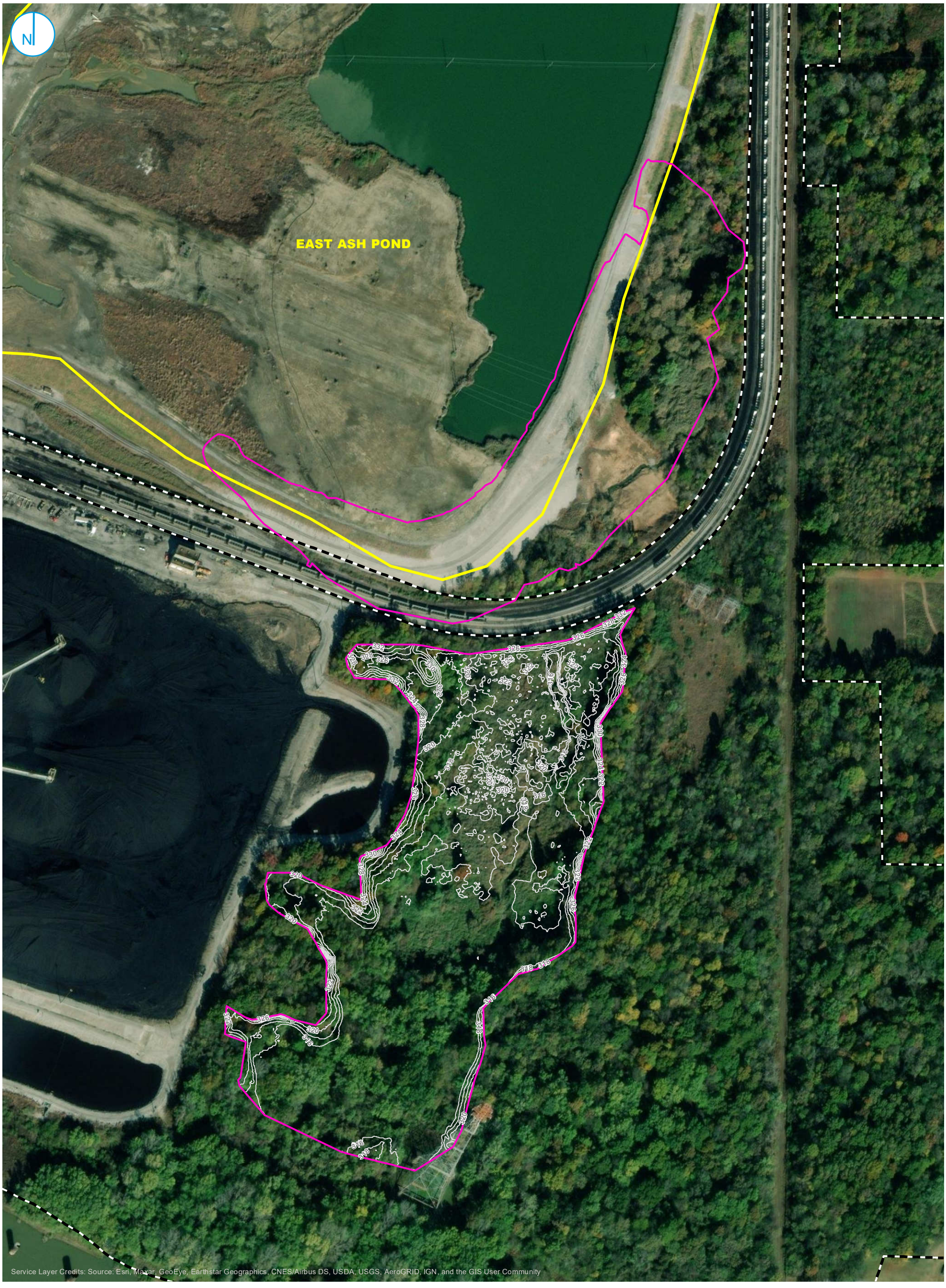
HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/26/2022 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\Plume_Delineation\Joppa\JOP_INV_2022\Part845_Construction_Permit\Figure 2-3_Ash outside EAP.mxd



ASH EXTERIOR BOUNDARY

BOTTOM OF ASH CONTOUR (2-FT INTERVAL)

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

0 125 250 Feet

BASE OF CCR (OUTSIDE EAP)

FIGURE 2-3

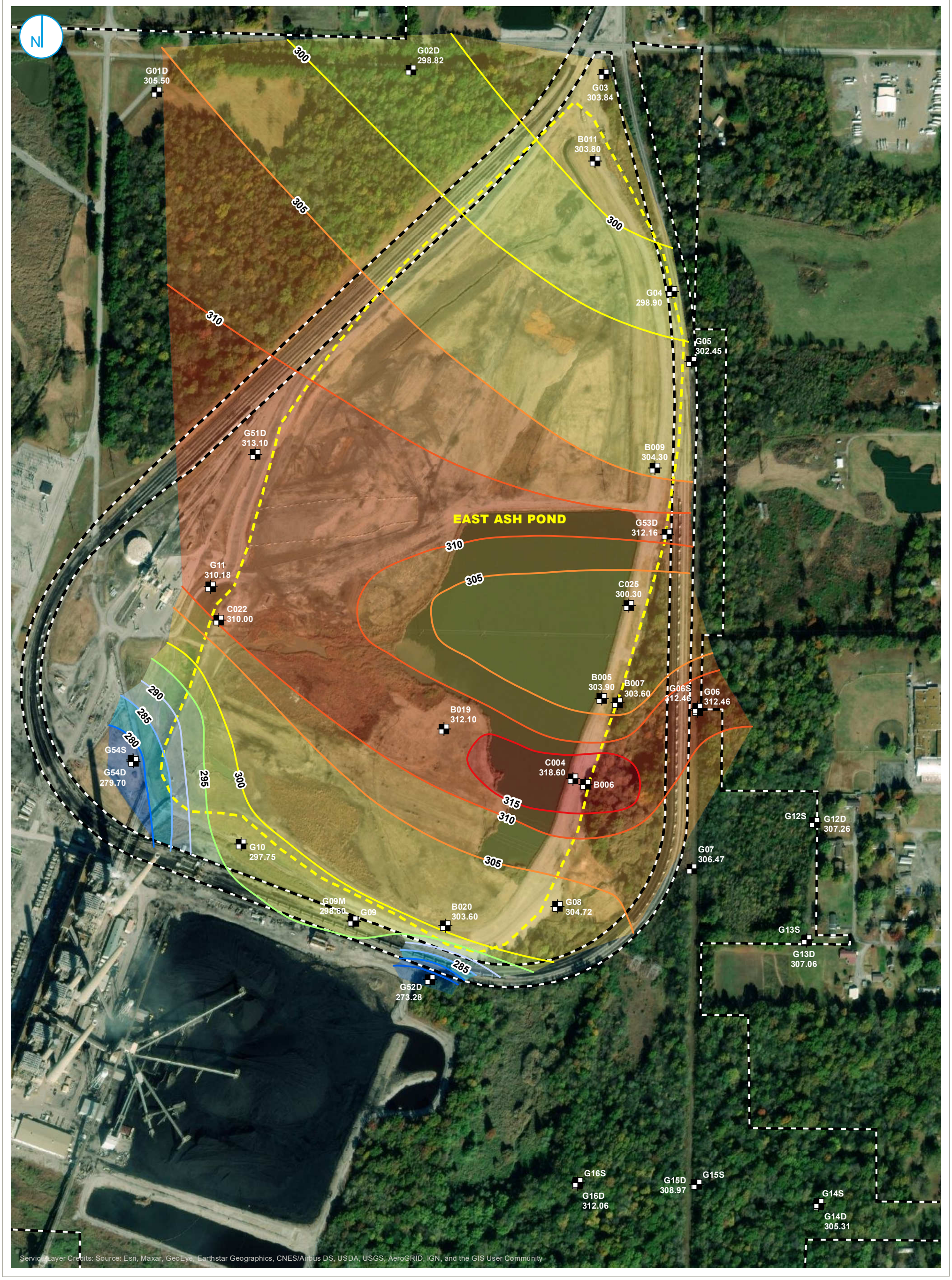
HYDROGEOLOGIC UPDATES
FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/26/2022 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\Plume_Delineation\Joppa\JOP_INV_2022\Part845_Construction_Permit\Figure 2-4_Wells and TOA_rev2022.mxd



WELL LOCATION

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

TOP OF UPPER AQUIFER CONTOURS (5-FT CONTOUR INTERVAL)

- 275
- 280
- 285
- 290
- 295
- 300
- 305
- 310
- 315

0 200 400 Feet

TOP OF UPPERMOST AQUIFER

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT EAST ASH POND

JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-4

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/26/2022 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\Plume_Delineation\Joppa\JOP_INV_2022\Part845_Construction_Permit\Figure 2-5_UCU Contours.mxd

WELL LOCATION

AVERAGE UCU WATER TABLE ELEVATION CONTOUR 2021

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

0 200 400 Feet

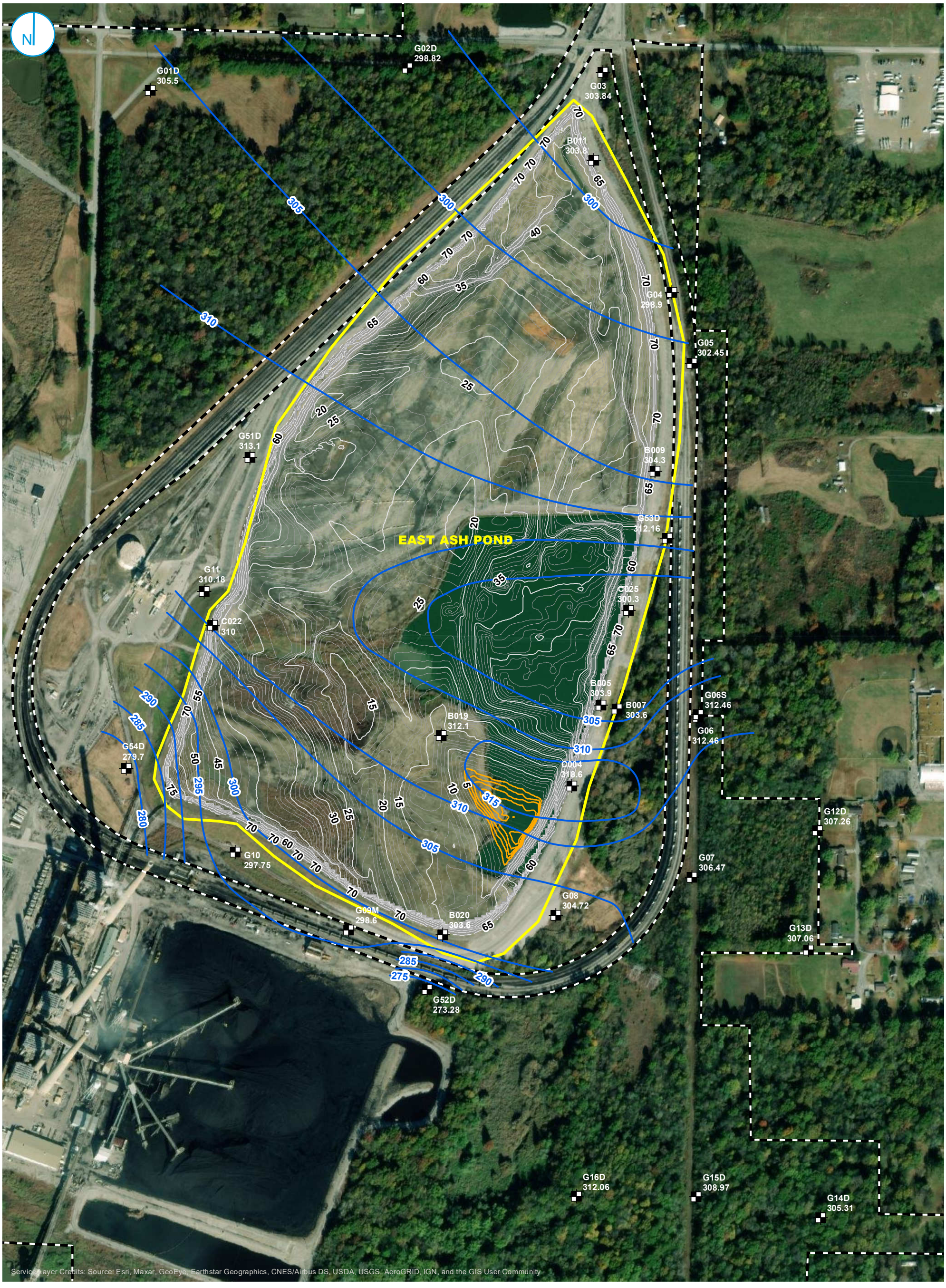
UPPER CONFINING UNIT AVERAGE WATER TABLE ELEVATIONS 2021

FIGURE 2-5

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL



WELL LOCATION

INTERPRETED TOP OF UPPERMOST AQUIFER (95TH PERCENTILE GROUNDWATER ELEVATION CONTOURS, 2022)

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER LESS THAN 5FT

SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER (5FT CONTOUR INTERVAL)

SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER (1FT CONTOUR INTERVAL)

0 200 400 Feet

BASE OF CCR - TOP OF UPPERMOST AQUIFER SEPARATION

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT EAST ASH POND

JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 3-1

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

APPENDIX A
SOIL BORING LOGS AND WELL CONSTRUCTION FORMS

Geosyntec consultants
engineers | scientists | innovators

Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12D
Page: 1 of 5

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**100**	Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.22**	Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.26**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') SILT (ML); light brown, fine grained, loose, moist.		0
10								(10') As above: gray with light brown mottling.		10
15								(14.5') As above: light gray with orange mottling, trace clay, cohesive.		15
								(16.5') Clayey SILT (ML); light gray and orange, cohesive, dry.		
20										20

NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12D
Page: 2 of 5

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**100**	Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.22**	Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.26**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') CLAY (CL); light gray with trace orange mottling, little silt, medium stiff, high plasticity, moist.		20
25										25
30								(30') Clayey SAND (SC); light gray and orange throughout, fine grained, cohesive, moist.		30
35										35
40										40

NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12D
Page: 3 of 5

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**100**	Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.22**	Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.26**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') Silty SAND (SM); reddish orange, fine grained, cohesive, moist.		40
								(42.5') As above: light brown.		
45								(44.5') As above: light gray.		45
50								(50') SAND (SP); light brown, fine grained, semi cohesive, saturated.		50
								(51') As above: light gray.		
55								(55.5') As above: light brown to gray, trace gravel.		55
60								(59') Gravelly SAND (SP); light brown, poorly graded and small gravel, loose, saturated.		60

NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12D
Page: 4 of 5

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**100**	Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.22**	Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.26**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60') GRAVEL (GP); various colors, well-graded, loose, saturated.		60
								(62') Gravelly SAND (SP); brown, coarse grained, well-graded gravel, loose, saturated.		
								(64') As above: orange.		
65										65
								(67.75') As above.		
70								(70') As above.		70
75								(76.25') 3" seam of dark brown.		75
								(79') As above: fine grained sand.		
80										80

NOTES:

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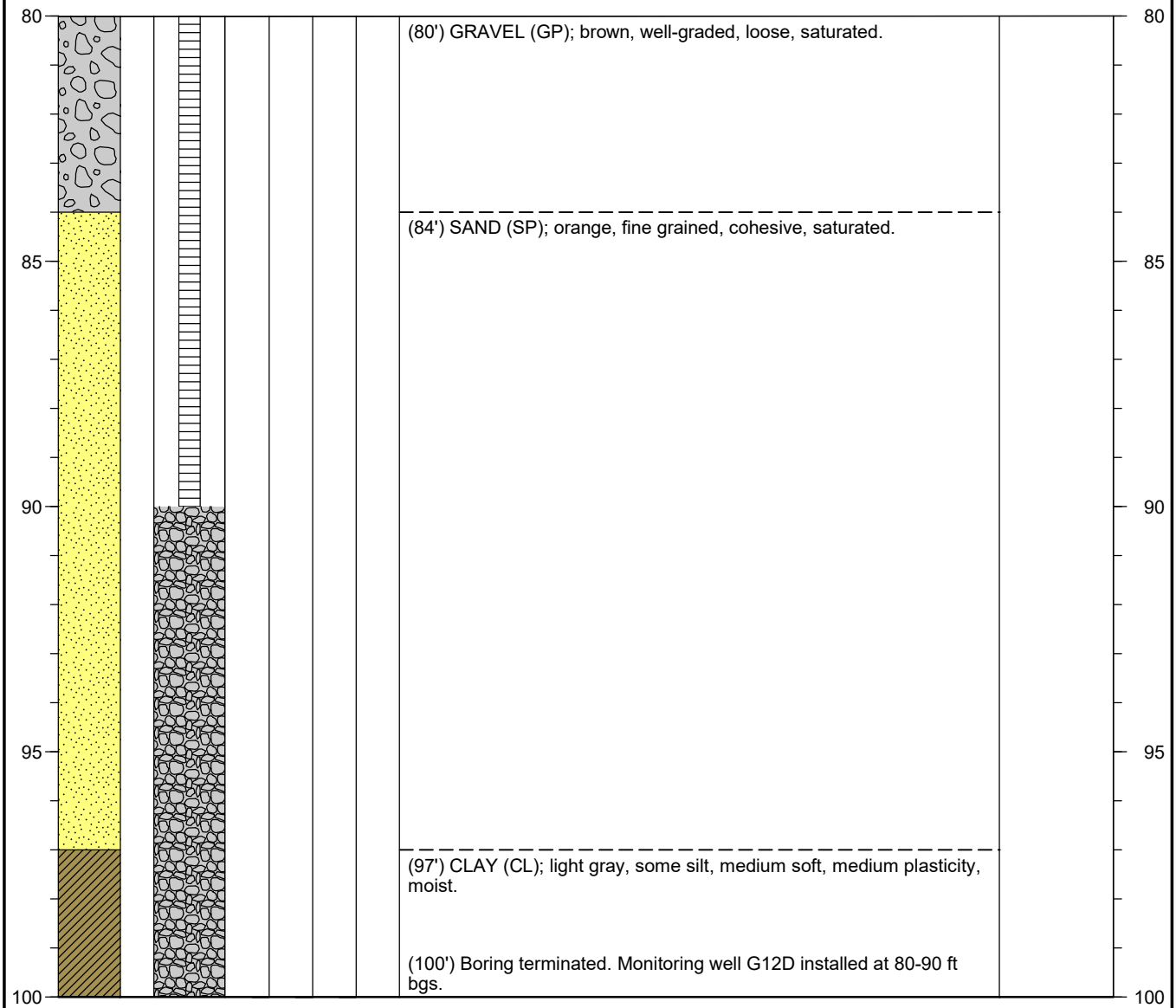
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12D
Page: 5 of 5

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**100**	Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.22**	Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.26**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12S
Page: 1 of 4

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**70**	Well Depth (ft):	**70**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.34**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12S
Page: 2 of 4

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**70**	Well Depth (ft):	**70**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.34**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

NOTES:

Geosyntec consultants
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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12S
Page: 3 of 4

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**70**	Well Depth (ft):	**70**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.34**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') Blind drill.		40
50								(50') SAND (SP); light gray, trace gravel, fine grained, moist.		50
								(52') Gravelly SAND (SP); reddish brown, coarse grained, saturated, 10 inch sand lense at 53 ft bgs.		
60										60

NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G12S
Page: 4 of 4

Drilling Start Date:	09/23/2021	Boring Depth (ft):	70	Well Depth (ft):	70
Drilling End Date:	09/23/2021	Boring Diameter (in):	4	Well Diameter (in):	2
Drilling Company:	Cascade	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Drilling Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	360.34	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	357.56	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60.5') As above: dark brown lense.		60
65								(64.5') As above: dark brown lense.		65
70								(60') Boring terminated. Monitoring well G12S installed at 60-70 ft bgs.		70
75										75

NOTES:

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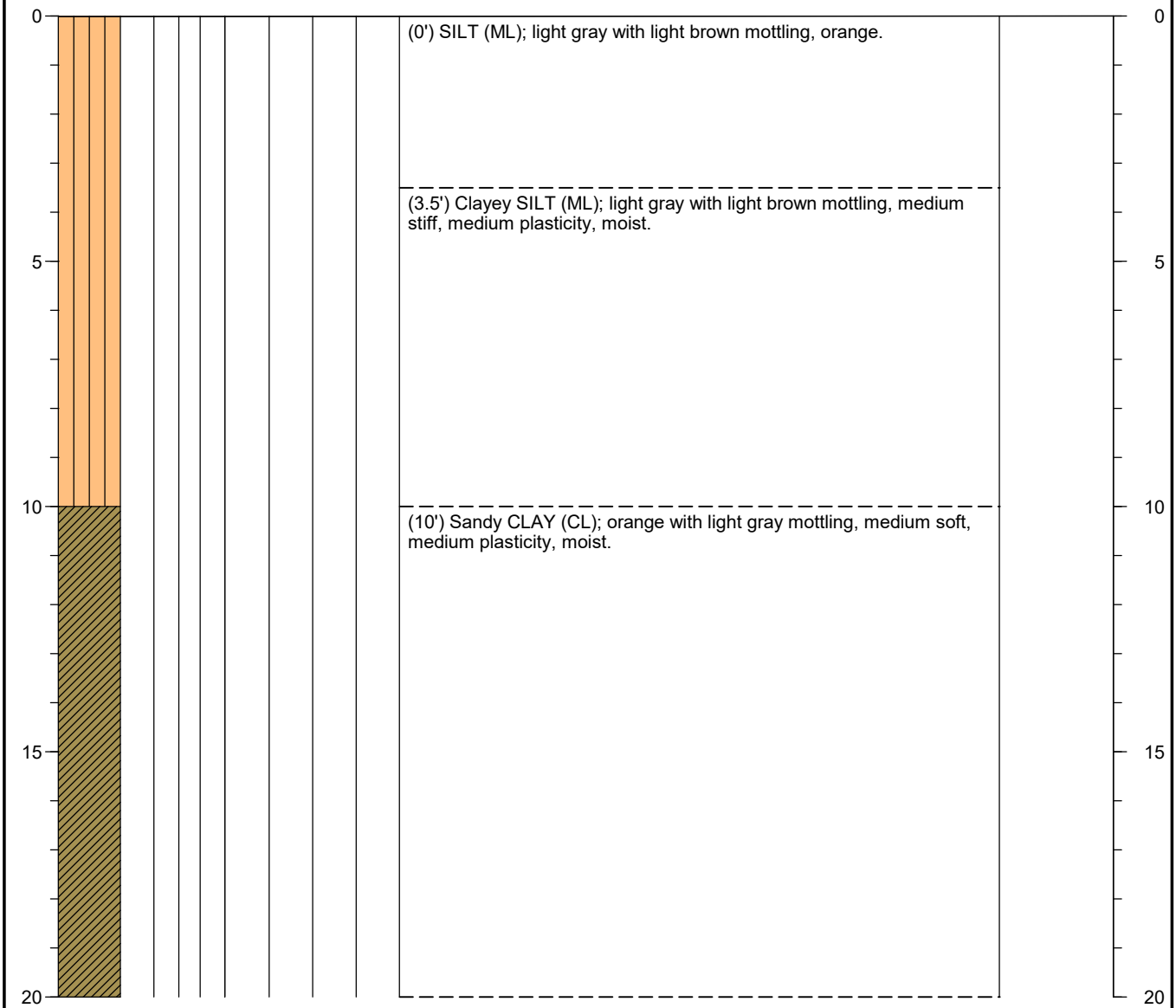
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13D
Page: 1 of 6

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft): **354.11**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **351.31**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13D
Page: 2 of 6

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft): **354.11**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **351.31**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Clayey SAND (SC); red with some orange, soft, fine grained, medium to high plasticity, moist.		20
25										25
30								(33') As above: light grayish brown, coarse grained sand.		30
35										35
40										40

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13D
Page: 3 of 6

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft): **354.11**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **351.31**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); red, trace clay, fine grained, cohesive, moist.		40
								(42.75') As above: no clay.		
								(44.25') As above: no clay, loose.		
45								(44.75') Gravelly SAND (SP); tan, fine grained, loose, saturated.		45
50								(50') As above: fine grained sand lens at 50.75 ft bgs, 56 ft bg, gravel lense at 52 ft bgs, saturated.		50
55										55
60										60

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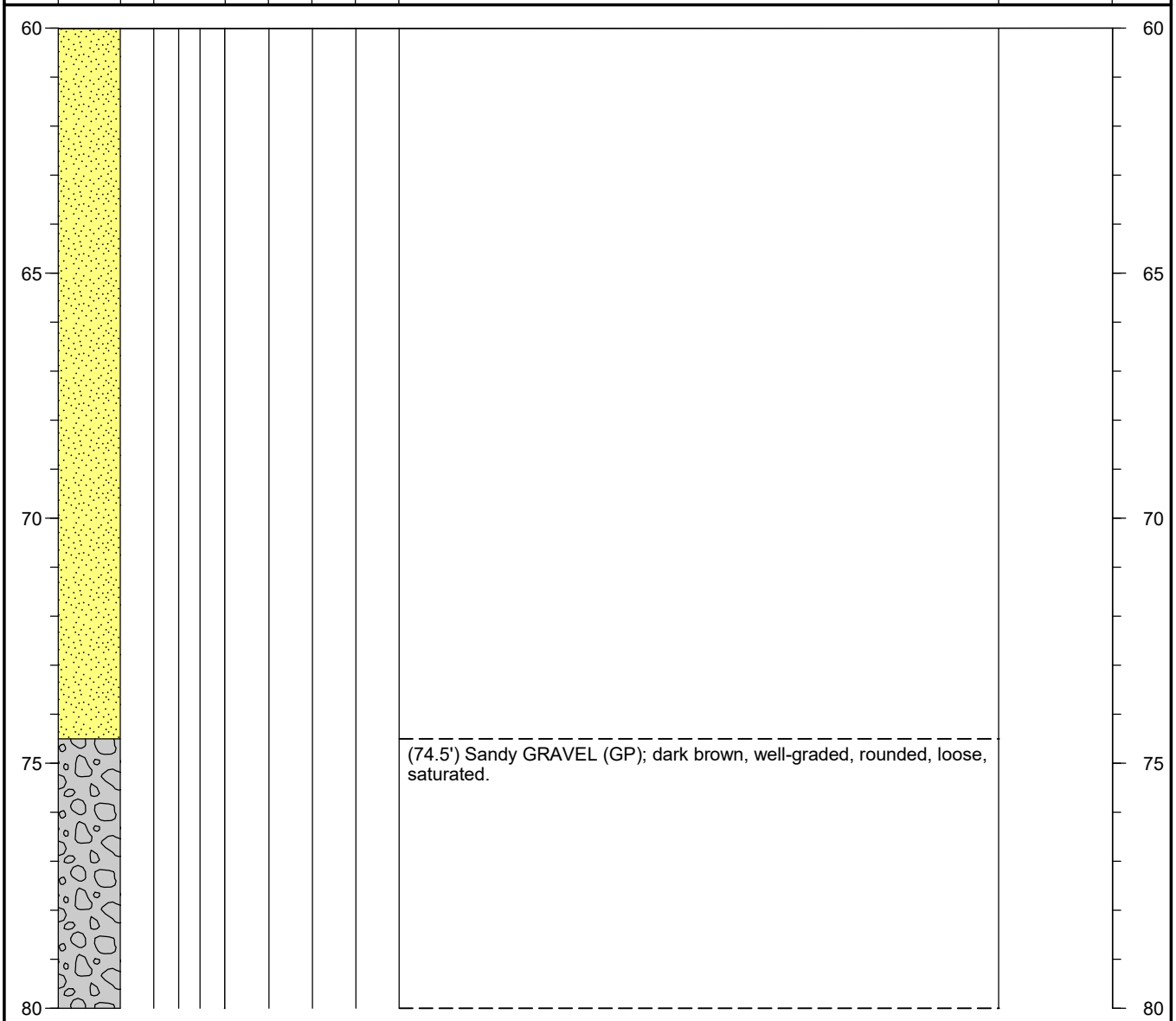
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13D
Page: 4 of 6

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft):	**354.11**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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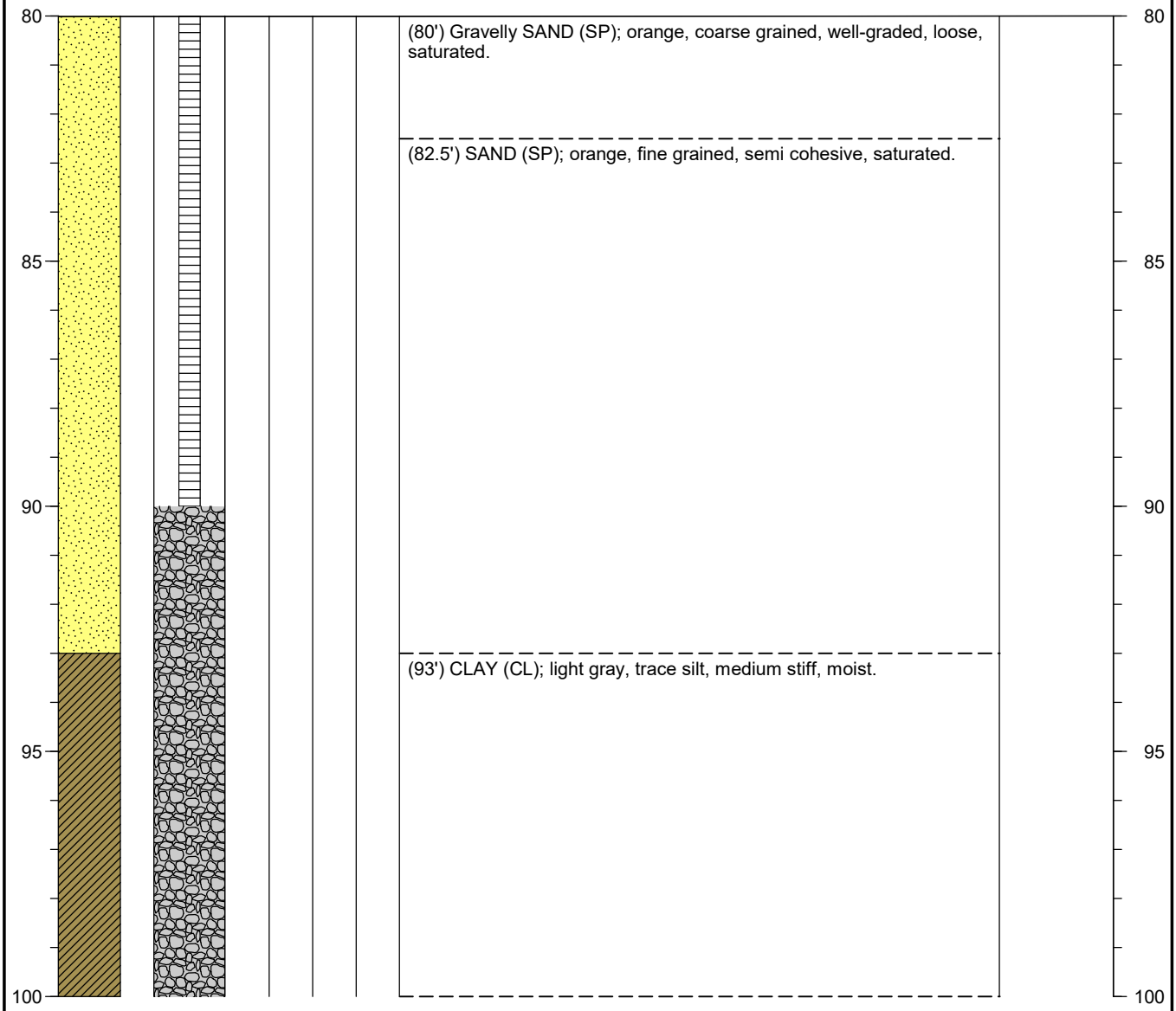
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13D
Page: 5 of 6

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft): **354.11**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **351.31**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13D
Page: 6 of 6

Drilling Start Date:	09/24/2021	Boring Depth (ft):	110	Well Depth (ft):	90
Drilling End Date:	09/24/2021	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft): Top		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	of Casing Elev. (ft):	354.11	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	351.31	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100								(100') SAND (SP); light gray, fine grained, very cohesive, moist.		100
105										105
110								(110') Boring terminated. Monitoring well G-13D installed at 80-90 ft bgs.		110
115										115

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13S
Page: 1 of 3

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft): **354.28**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **351.72**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13S
Page: 2 of 3

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft):	**354.28**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.72**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13S
Page: 3 of 3

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft): **354.28**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **351.72**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); red, trace clay, fine grained, cohesive, moist.		40
								(43') As above: no clay.		
								(44') As above: no clay, loose.		
45								(45') Gravelly SAND (SP); tan, fine grained, loose, saturated.		45
50								(50') As above: fine grained sand lense at 51 ft bgs, 56 ft bgs, gravel lense at 52 ft bgs, saturated.		50
55										55
60								(60') Boring terminated. Monitoring well G-13S installed at 50-60 ft bgs.		60

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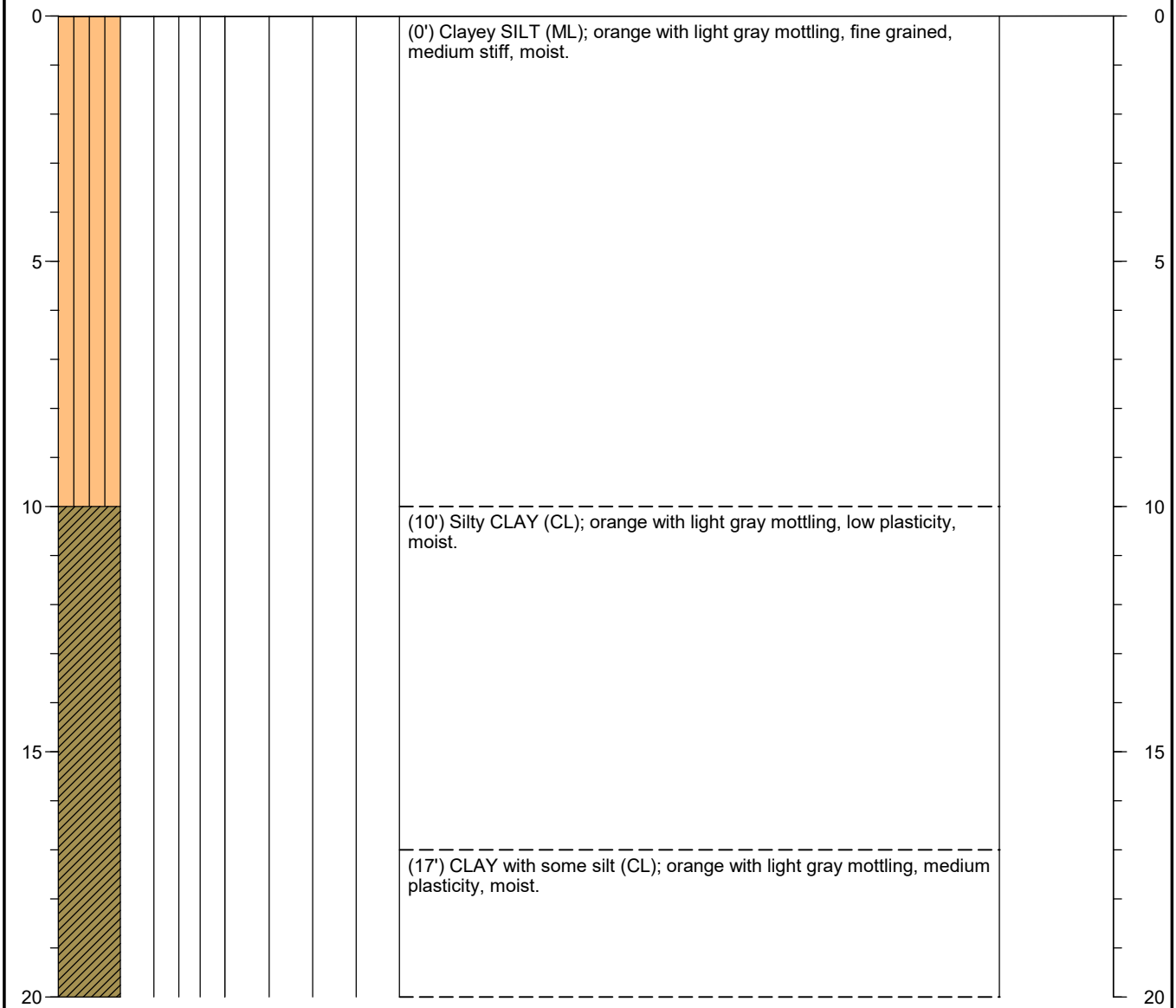
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14D
Page: 1 of 8

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14D
Page: 2 of 8

Drilling Start Date:	09/16/2021	Boring Depth (ft):	143	Well Depth (ft):	130
Drilling End Date:	09/16/2021	Boring Diameter (in):	4	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	348.09	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	345.31	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Clayey SILT (ML); light gray with orange mottling, fine grained, cohesive, low plasticity, moist.		20
								(21') Clayey SAND (SC); burnt orange, some gravel, fine grained sand, well-graded gravel, cohesive, moist.		
25										25
								(27') Gravelly SAND (SP); light gray with orange mottling, fine grained sand, well-graded gravel, loose, moist.		
								(28') No Recovery.		
30								(30') SILT with some clay (ML); light brown, very soft, fine grained, saturated but cant be influenced by rig.		30
								(31.5') Silty CLAY (CL); light brown, trace sand and gravel, medium plasticity, moist.		
35								(34.5') Gravelly sandy CLAY (CL); light brown, well-graded, fine grained, medium plasticity, 3" coal seam at 39 ft bgs, moist.		35
40										40

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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14D
Page: 3 of 8

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); dark to light orange, little to some well-graded gravel, fine grained, cohesive, moist.		40
45								(48.25') As above: increased gravel content.		45
50								(50') Sandy GRAVEL (GP); orange, well-graded, loose, saturated.		50
55										55
60										60

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14D
Page: 4 of 8

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60') SAND with gravel (SP); orange, fine grained, well-graded, saturated.		60
65								(64') As above: dark brown. (65.5') As above: orange.		65
70								(70') Sandy GRAVEL (GP); orange, well-graded, loose, saturated, 6" clay lense at 28".		70
75								(73') SAND (SP); light gray to light orange, little silt, fine grained, cohesive, saturated.		75
80										80

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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14D
Page: 5 of 8

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80								(80') SAND (SP); orange with light orange and dark gray throughout, fine grained, semi loose, saturated.		80
85										85
90								(90') As above: little to some silt.		90
95										95
100										100

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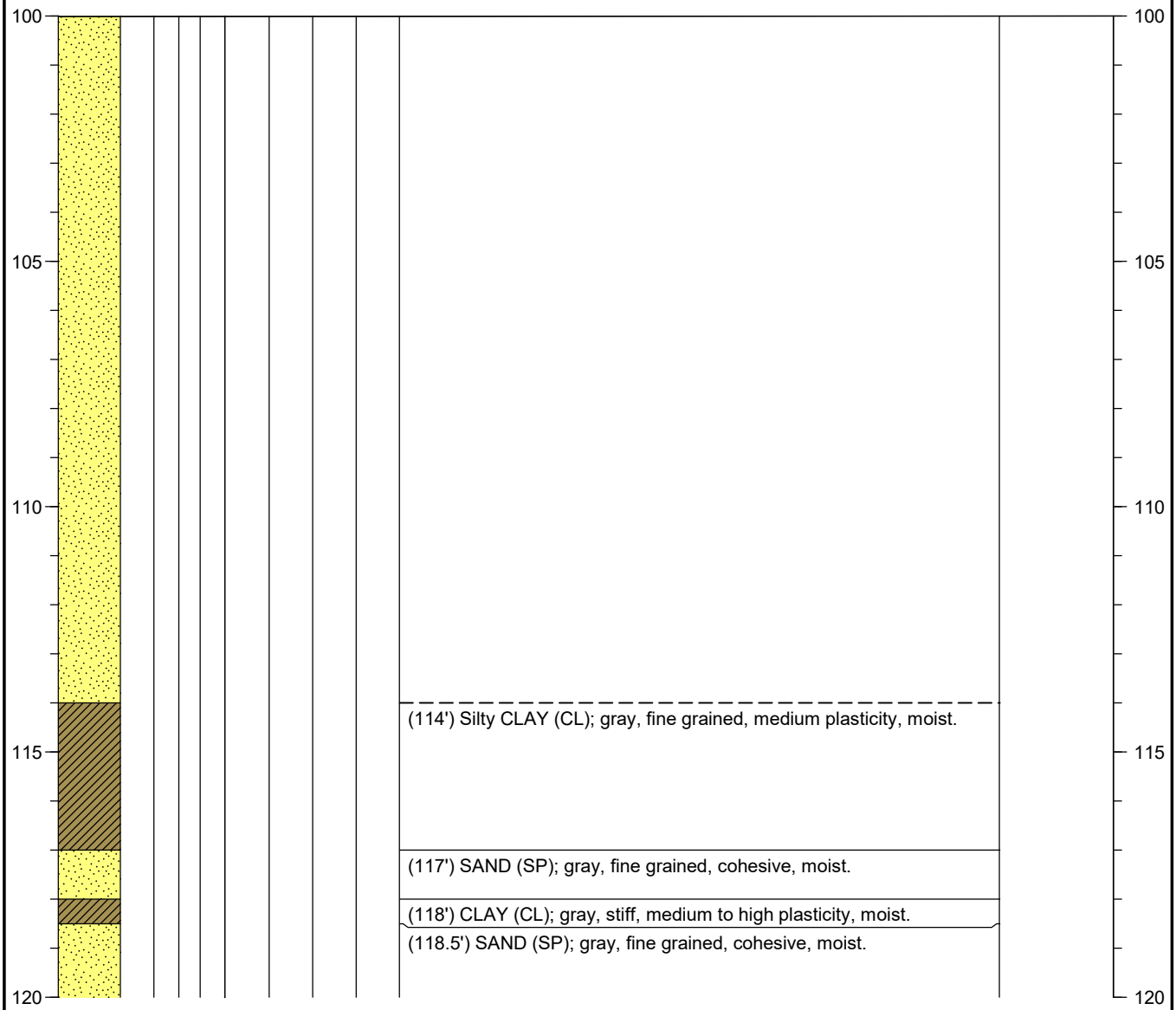
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14D
Page: 6 of 8

Drilling Start Date:	09/16/2021	Boring Depth (ft):	143	Well Depth (ft):	130
Drilling End Date:	09/16/2021	Boring Diameter (in):	4	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	348.09	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	345.31	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA



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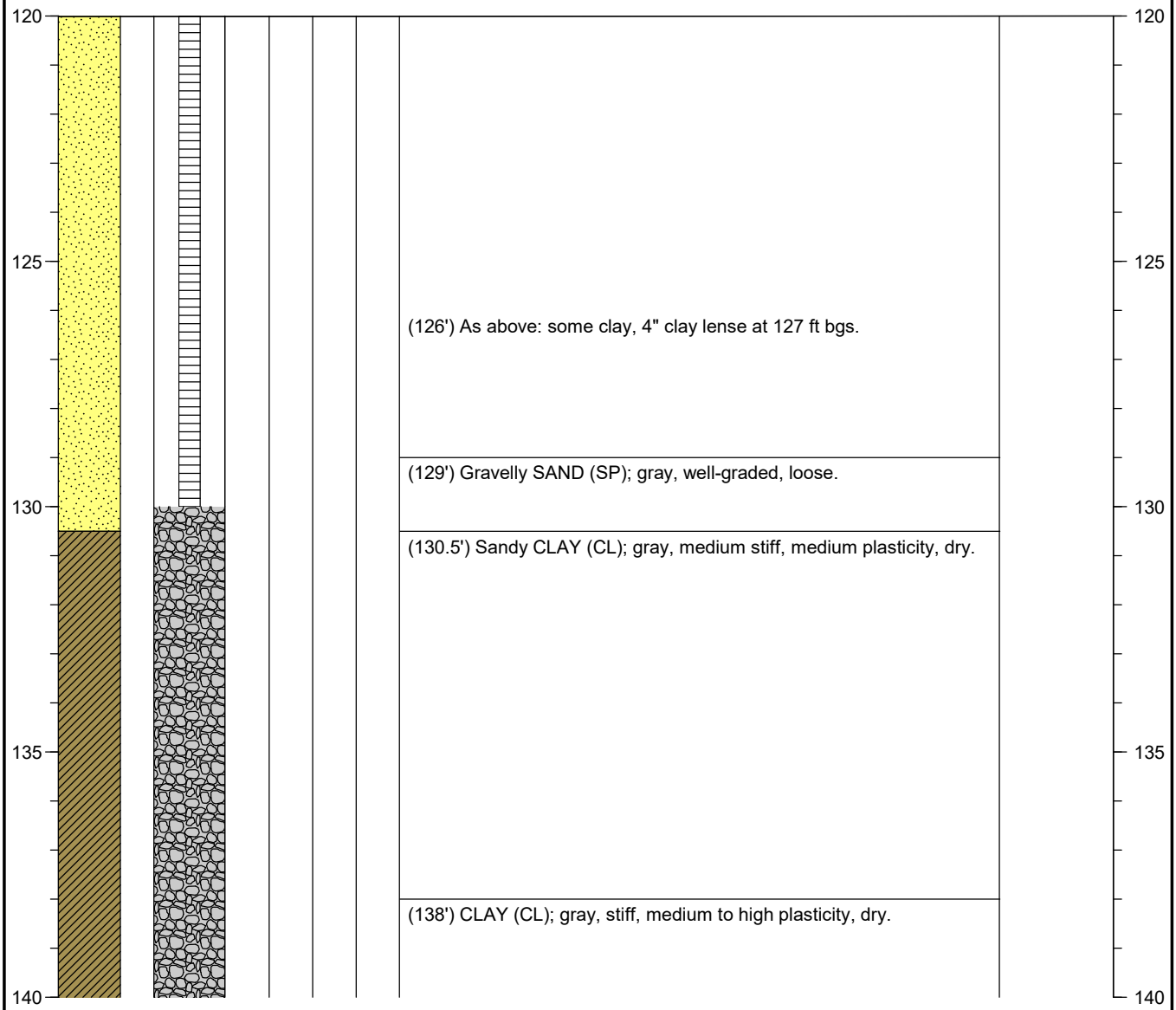
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14D
Page: 7 of 8

Drilling Start Date:	09/16/2021	Boring Depth (ft):	143	Well Depth (ft):	130
Drilling End Date:	09/16/2021	Boring Diameter (in):	4	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	348.09	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	345.31	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA



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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14D
Page: 8 of 8

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
140										140
								(142') 1' of bedrock, limestone.		
								(143') Boring terminated. Monitoring well G-14D installed at 120-130 ft bgs.		
145										145

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14S
Page: 1 of 4

Drilling Start Date:	**9/16/2021**	Boring Depth (ft):	**63**	Well Depth (ft):	**63**
Drilling End Date:	**9/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.26**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.46**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14S
Page: 2 of 4

Drilling Start Date: **9/16/2021**	Boring Depth (ft): **63**	Well Depth (ft): **63**
Drilling End Date: **9/16/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **348.26**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **345.46**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

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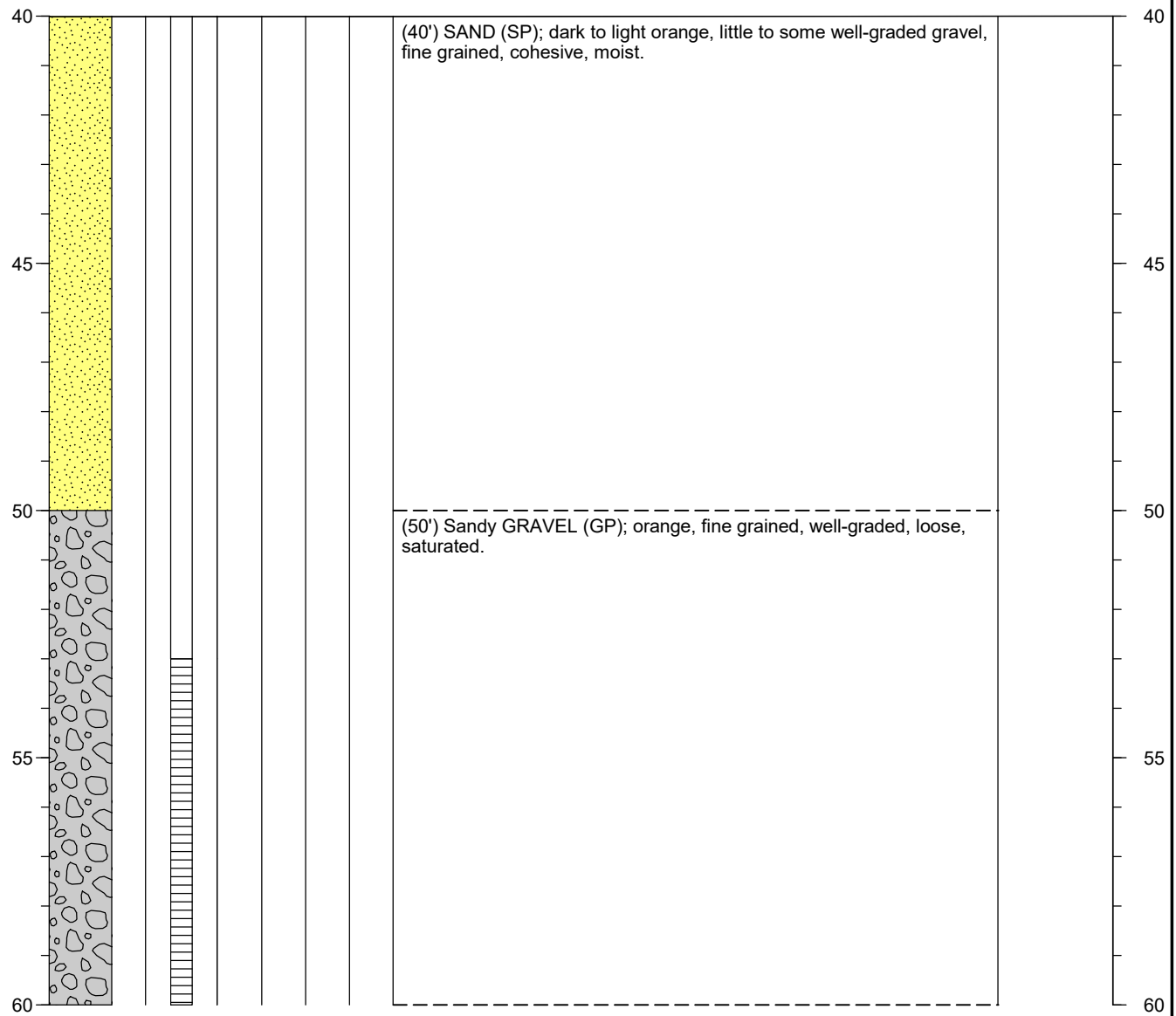
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14S
Page: 3 of 4

Drilling Start Date:	**9/16/2021**	Boring Depth (ft):	**63**	Well Depth (ft):	**63**
Drilling End Date:	**9/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.26**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.46**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); dark to light orange, little to some well-graded gravel, fine grained, cohesive, moist.		40
45										45
50								(50') Sandy GRAVEL (GP); orange, fine grained, well-graded, loose, saturated.		50
55										55
60										60



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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G14S
Page: 4 of 4

Drilling Start Date:	**9/16/2021**	Boring Depth (ft):	**63**	Well Depth (ft):	**63**
Drilling End Date:	**9/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.26**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.46**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60') SAND with gravel (SP); orange, fine grained, well-graded, saturated.		60
								(60') Boring terminated. Monitoring well G-15S installed at 53-63 ft bgs.		
65										65

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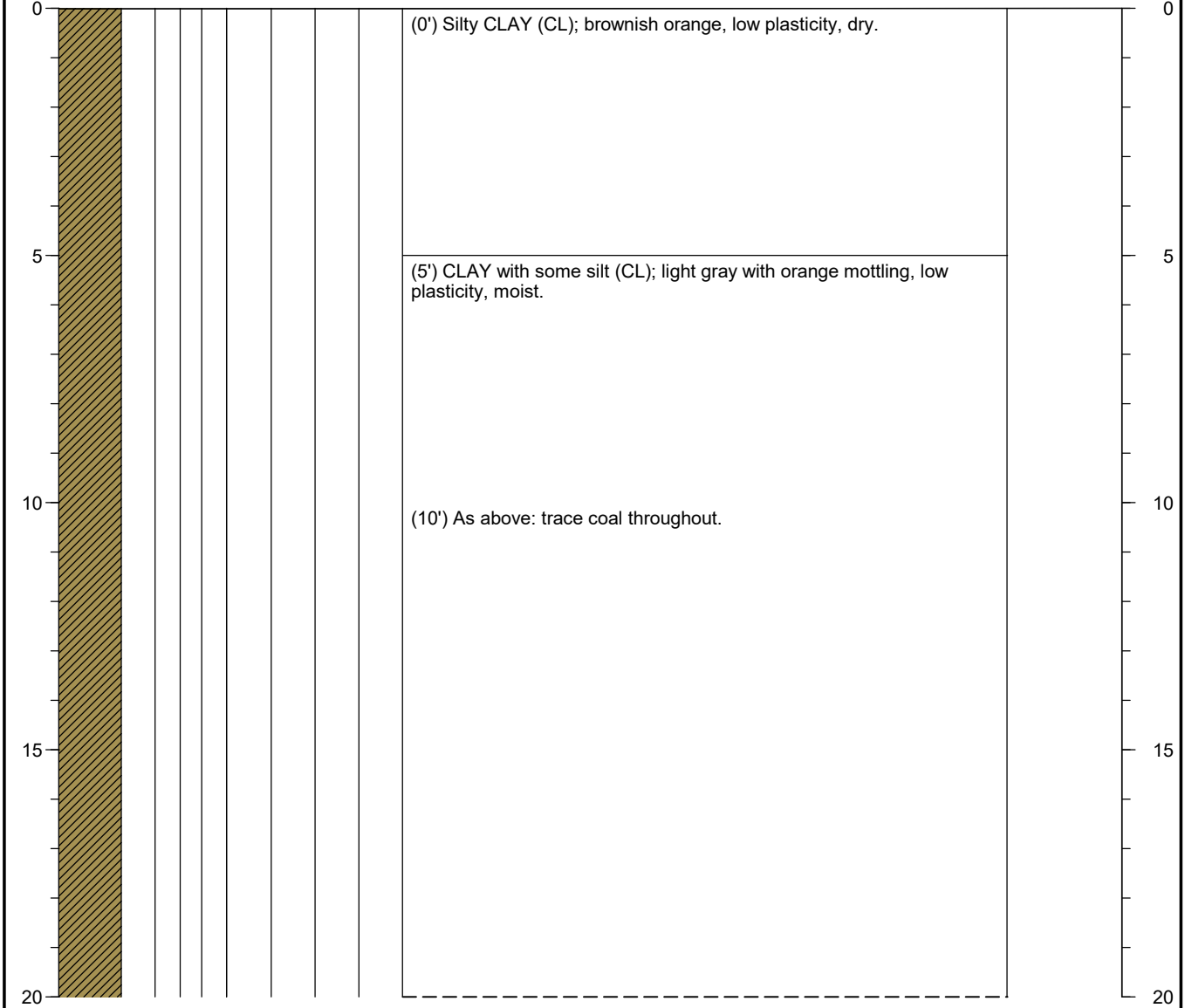
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15D
Page: 1 of 7

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15D
Page: 2 of 7

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Silty CLAY (CL); light gray with orange mottling, trace gravel, fine grained, medium plasticity, moist.		20
								(22.5') Clayey SILT (ML); light gray with orange mottling, trace gravel, low plasticity, moist.		
25								(26') As above.		25
								(27.5') SAND (SP); light gray with orange mottling, trace gravel, fine grained, moist, silt lense at 28.5 ft bgs.		
30								(30') As above.		30
								(32.5') Clayey SAND with gravel (SC); light gray with orange mottling, fine to coarse grained, moist.		
35								(35') SAND with gravel (SP); burnt orange and light gray throughout, fine to coarse grained, cohesive, moist.		35
40										40

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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15D
Page: 3 of 7

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') As above: saturated, loose.		40
45										45
50								(50') GRAVEL (GP); burnt orange, well-graded, loose, moist.		50
								(51') SAND with gravel (SP); burnt orange, fine to coarse grained, increasing cohesiveness with depth, loose, saturated.		
55								(54') SAND (SP); burnt orange, trace gravel, fine grained, cohesive, moist.		55
								(57.5') Gravelly SAND (SP); brownish orange, coarse grained, loose, moist.		
60										60

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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15D
Page: 4 of 7

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60') As above.		60
65								(65') SAND (SP); light orange, trace gravel, fine grained, cohesive, moist.		65
								(67.5') Sandy GRAVEL (GP); dark orange, well-graded, loose, saturated.		
70								(70') GRAVEL (GP); dark orange, well-graded, loose, saturated.		70
75								(75') Sandy gravelly CLAY (CL); light gray with orange mottling, medium to high plasticity, moist.		75
								(76') Clayey sandy GRAVEL (GP); orange, well-graded, cohesive, saturated.		
								(77') Clayey GRAVEL (GP); orange, well-graded, saturated.		
80										80

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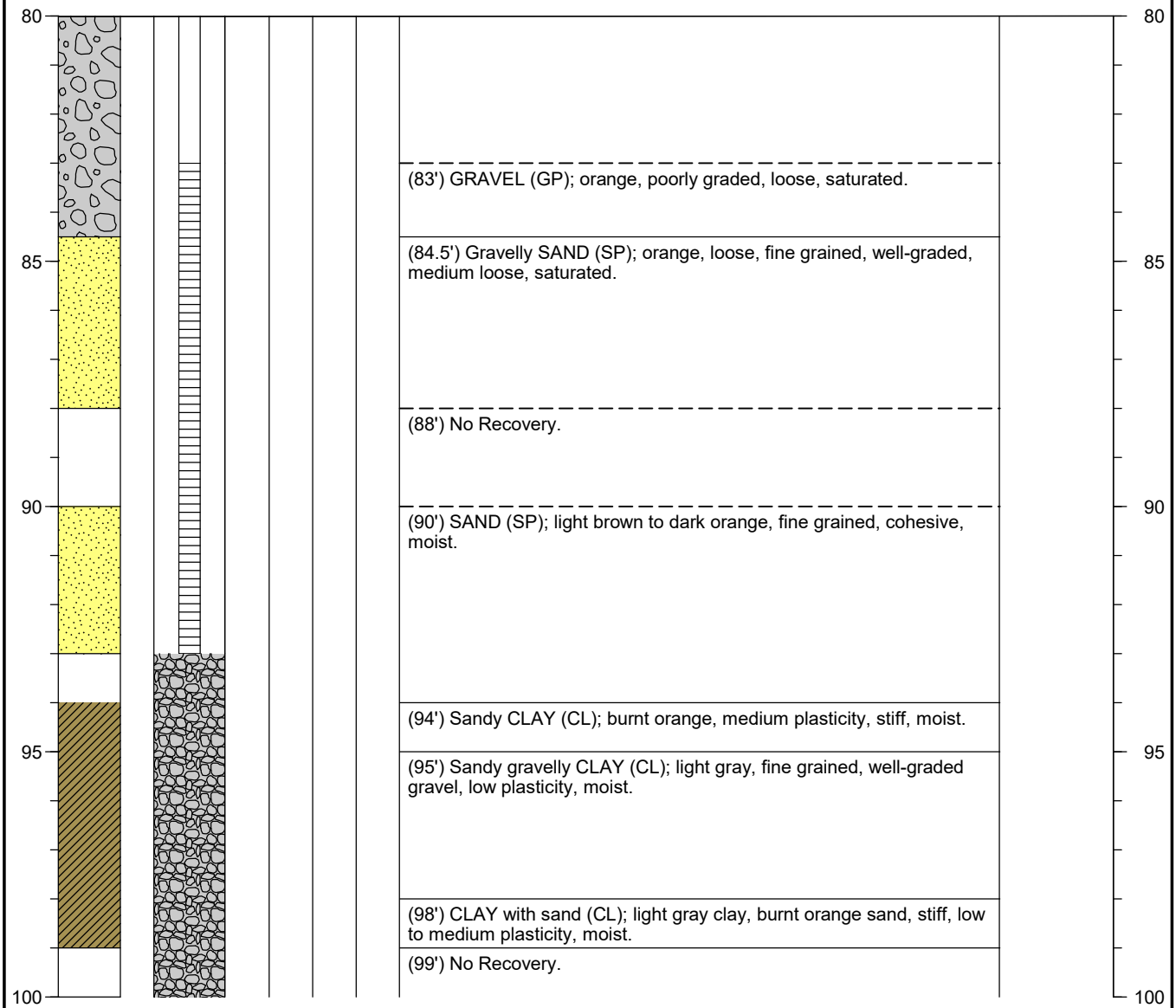
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15D
Page: 5 of 7

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15D
Page: 6 of 7

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100								(100') As above.		100
								(101') CLAY (CL); light gray with orange mottling, stiff, medium to high plasticity, moist.		
								(102') SAND (SP); light gray with orange mottling, fine grained, cohesive, saturated.		
105								(105') As above: clay inclusions throughout.		105
								(106') 8" Gravel lense at 106 ft bgs.		
110								(110') CLAY (CL); gray to light orange, medium stiff, medium plasticity, dry.		110
								(111.5') Silty clayey SAND (SC); gray, fine grained, cohesive, moist.		
								(113') CLAY (CL); gray, stiff, medium plasticity, dry.		
115								(115') CLAY (CL); black, stiff, low plasticity, moist.		115
120										120

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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15D
Page: 7 of 7

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	Dave Gordon	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
120										120
125								(125') Boring terminated. Monitoring well G-15D installed at 83-93 ft bgs.		125
130										130

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Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15S
Page: 1 of 3

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.81**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.76**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15S
Page: 2 of 3

Drilling Start Date: **9/15/2021**	Boring Depth (ft): **60**	Well Depth (ft): **60**
Drilling End Date: **9/15/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **346.81**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **343.76**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30								(30') SAND (SP); tan to burnt orange, fine to medium grained, moist, loose, trace clay, trace gravel.		30
35								(35') Gravelly SAND (SP); burnt orange, medium to large grains, moist, stiff to hard. (37') As above: tan.		35
40										40

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WELL LOG
Well No. G15S
Page: 3 of 3

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.81**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.76**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') As above: tan to burnt orange.		40
50								(50') Gravelly SAND (SP); burnt orange, medium to large grained, saturated to moist, loose, trace fine sand.		50
55								(54') SAND (SP); burnt orange, fine to medium grained, moist, loose. (55') Gravelly SAND (SP); burnt orange, medium to large grained, saturated to moist, loose, trace fine sand.		55
60								(60') Boring terminated. Monitoring well G-15S installed at 50-60 ft bgs.		60

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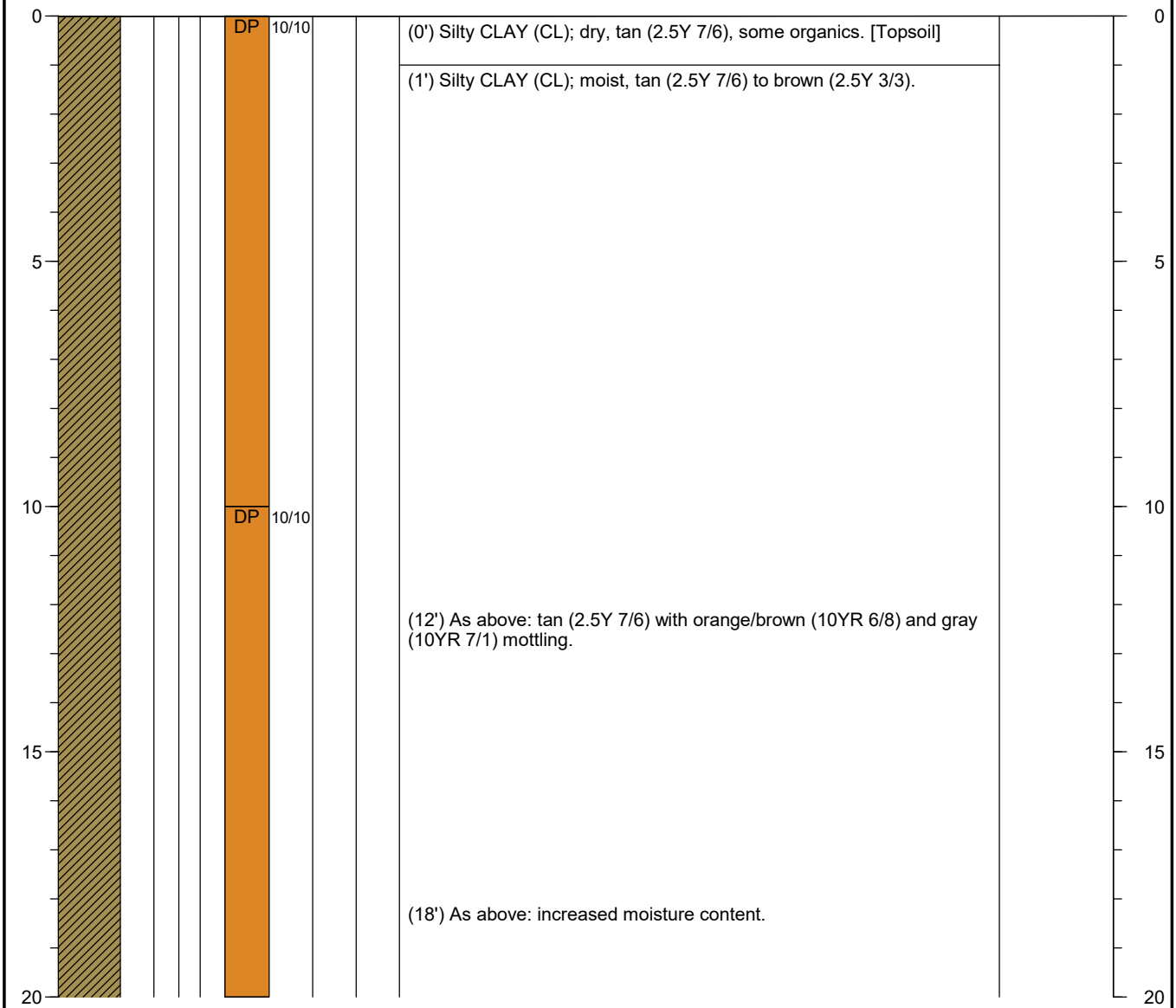
WELL LOG
Well No. G16D
Page: 1 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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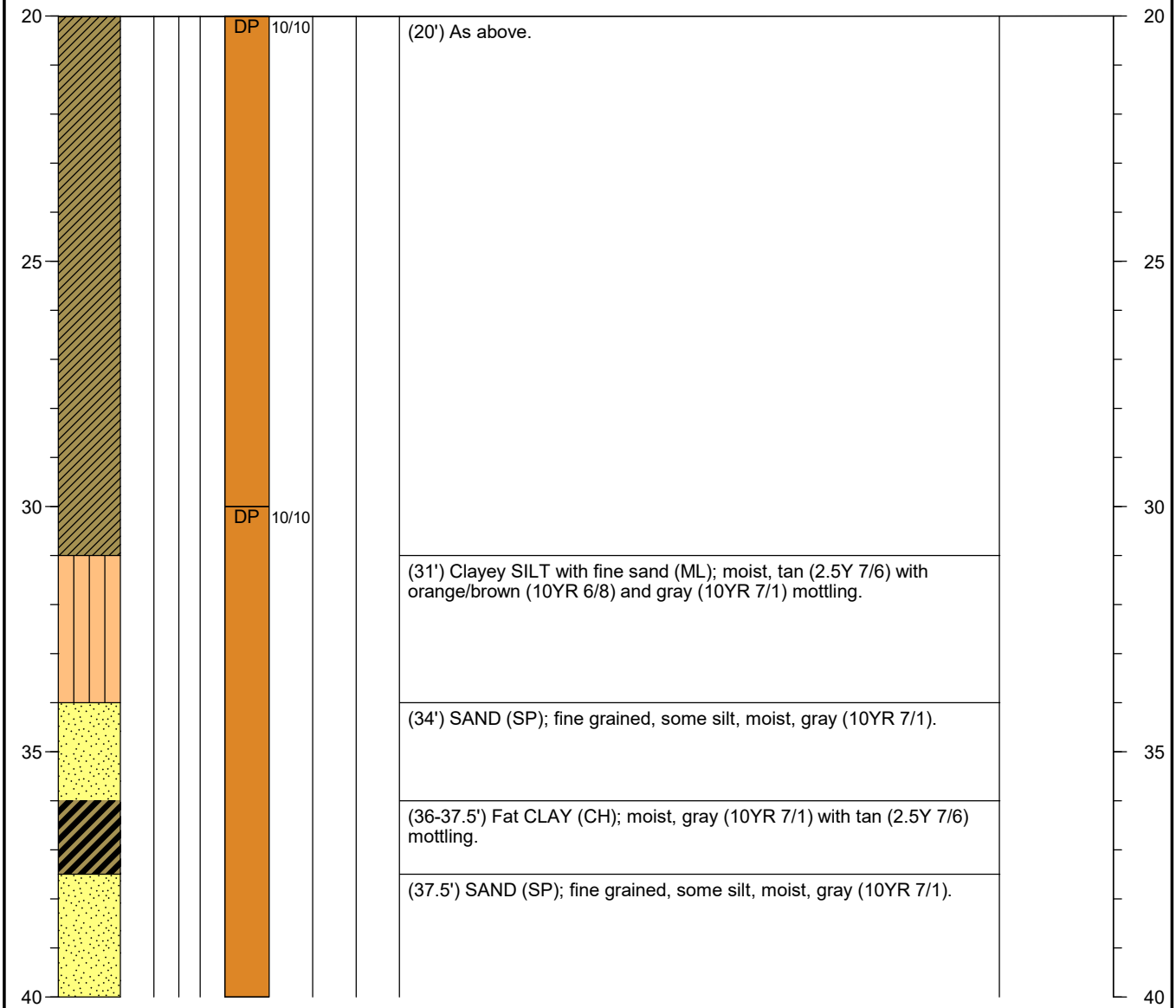
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16D
Page: 2 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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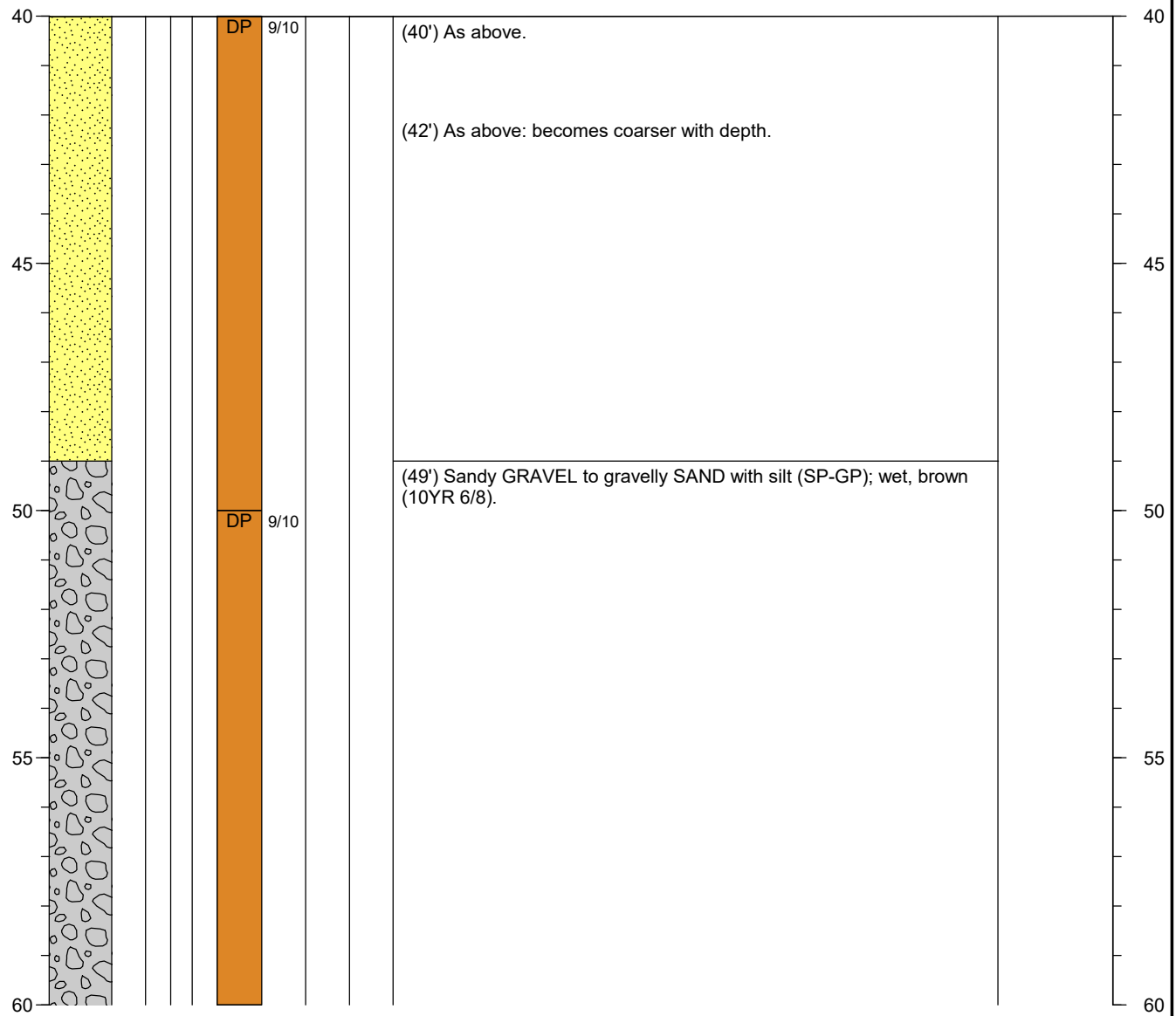
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16D
Page: 3 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16D
Page: 4 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				DP	9/10			(60') As above.		60
65								(67') ~1 ft layer brown (10YR 4/6).		65
70				DP	10/10			(70') As above.		70
75								(78') ~8" layer of Gravelly CLAY, orange, moist, stiff, moderate to high plasticity.		75
80										80

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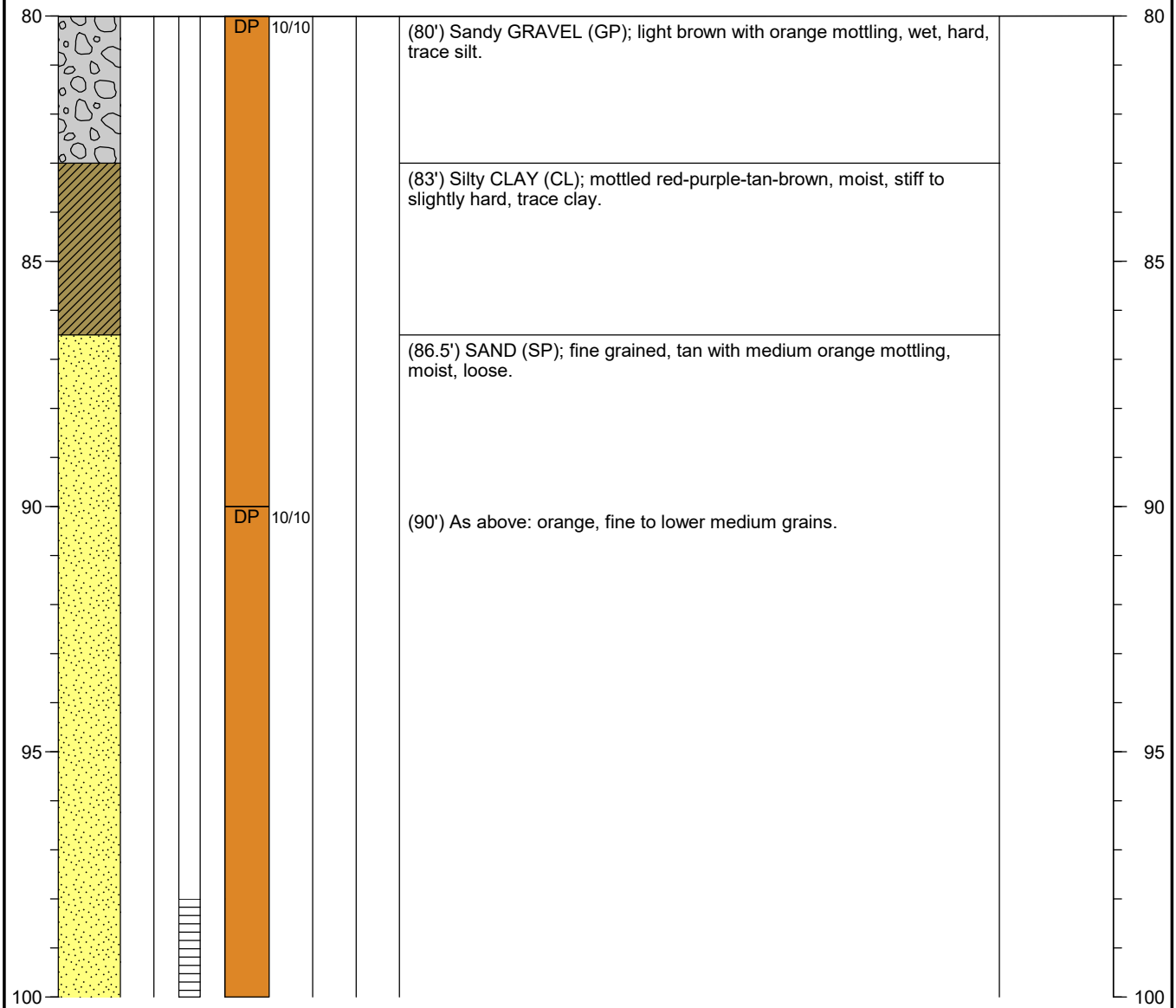
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16D
Page: 5 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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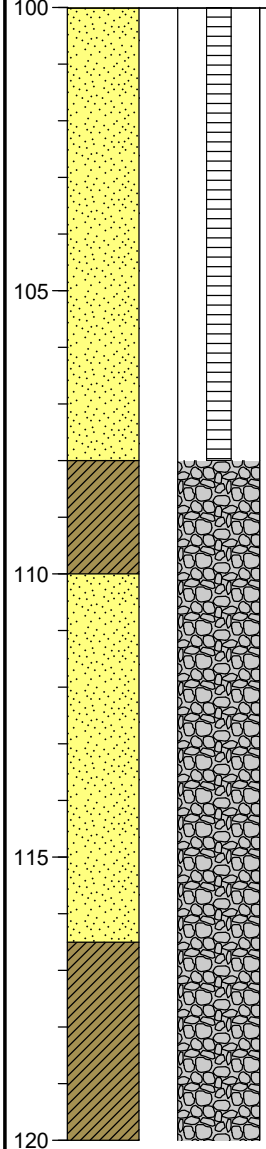
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16D
Page: 6 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100								(100') As above: SAND, orange to tan with red staining at 106', fine to lower medium grains, moist, loose.		100
105								(107') 1 ft Silty SAND, tan, moist, loose, fine grained.		105
								(108') Silty CLAY (CL); reddish brown to purple brown, moist, hard to very stiff, low plasticity.		
110								(110') SAND (SP); tan to orange, fine grained, moist, loose, trace large sand grains and small gravel.		110
115								(116.5') Sandy silty CLAY (CL); burnt orange with mottled gray and purple, moist, stiff to slightly hard, moderate to high plasticity.		115
120										120

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16D
Page: 7 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
120								(120') SAND (SP); black, fine grained, moist, loose, trace medium sand grains.		120
								~4" CLAY layer, black, moderate plasticity.		
								(123.5') CLAY (CL); black, very stiff to slightly hard, low plasticity.		
125										125
130								(130') Boring terminated. Monitoring well G-16D installed at 98-108 ft bgs.		130
135										135

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Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16S
Page: 1 of 3

Drilling Start Date:	**09/14/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/14/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.32**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.60**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16S
Page: 2 of 3

Drilling Start Date:	**09/14/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/14/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.32**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.60**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16S
Page: 3 of 3

Drilling Start Date:	**09/14/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/14/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.32**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.60**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); light gray with orange mottling, fine grained, moist.		40
45										45
50								(50') Gravelly SAND (SP); orange, fine to coarse grained, moist.		50
55										55
60								(60') Boring terminated. Monitoring well G-16S installed at 50-60 ft bgs.		60

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Client: Vistra
Project: GLP8030, Joppa
Address: 2100 Portland Rd, Joppa, IL

WELL LOG

Well No. Well 3
Page: 1 of 3

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**50**	Well Depth (ft):	**50**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:		Top of Casing Elev. (ft)		Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Silty CLAY (CL); brown with light gray mottling, medium stiff, low palsticity, moist.		0
5										5
10								(10') As above: brown, soft, medium plasticity, moist.		10
15										15
20										20

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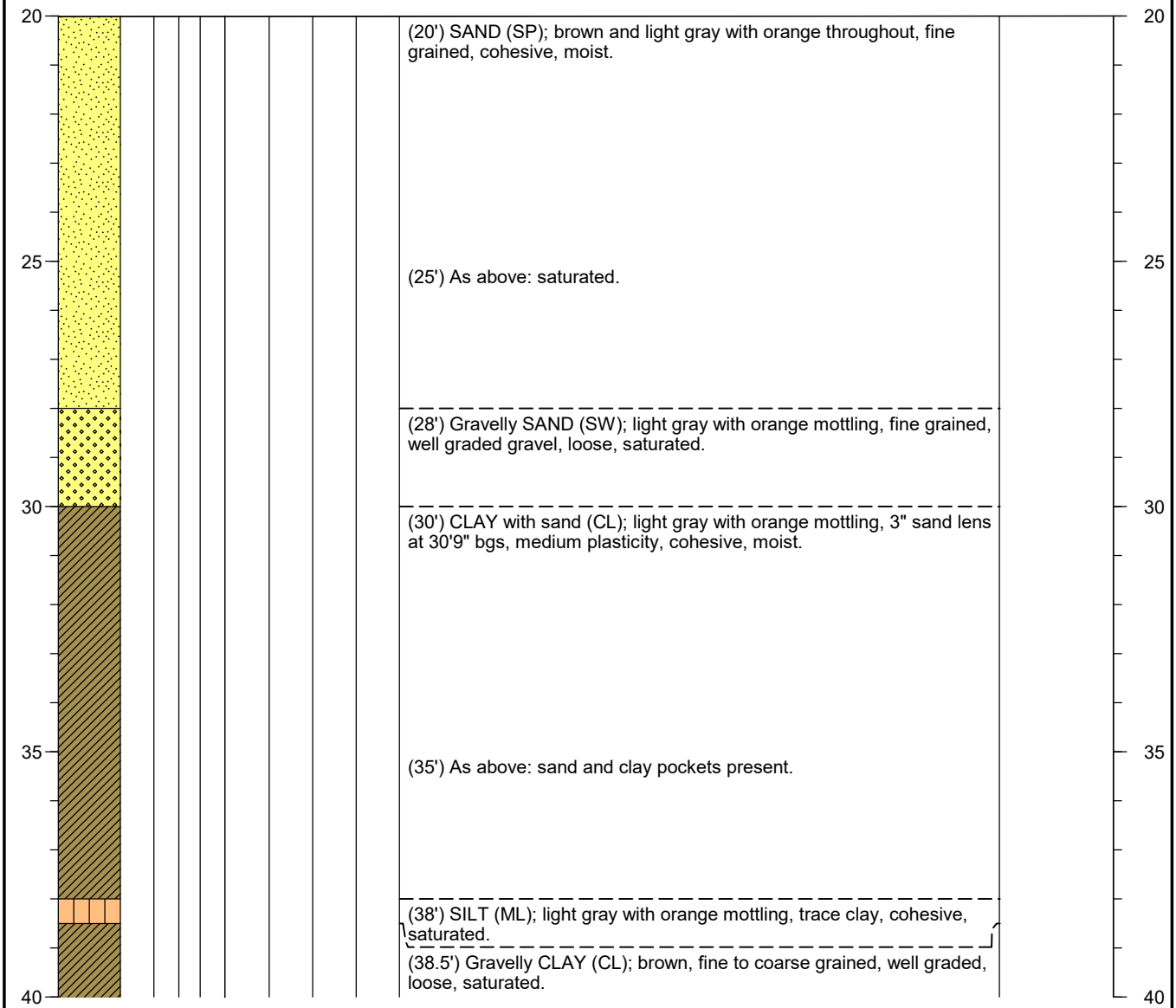
Client: Vistra
Project: GLP8030, Joppa
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. Well 3
Page: 2 of 3

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**50**	Well Depth (ft):	**50**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:		Top of Casing Elev. (ft)		Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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Client: Vistra
Project: GLP8030, Joppa
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. Well 3
Page: 3 of 3

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**50**	Well Depth (ft):	**50**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:		Top of Casing Elev. (ft)		Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

NOTES:

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G12D
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/23/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 700 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

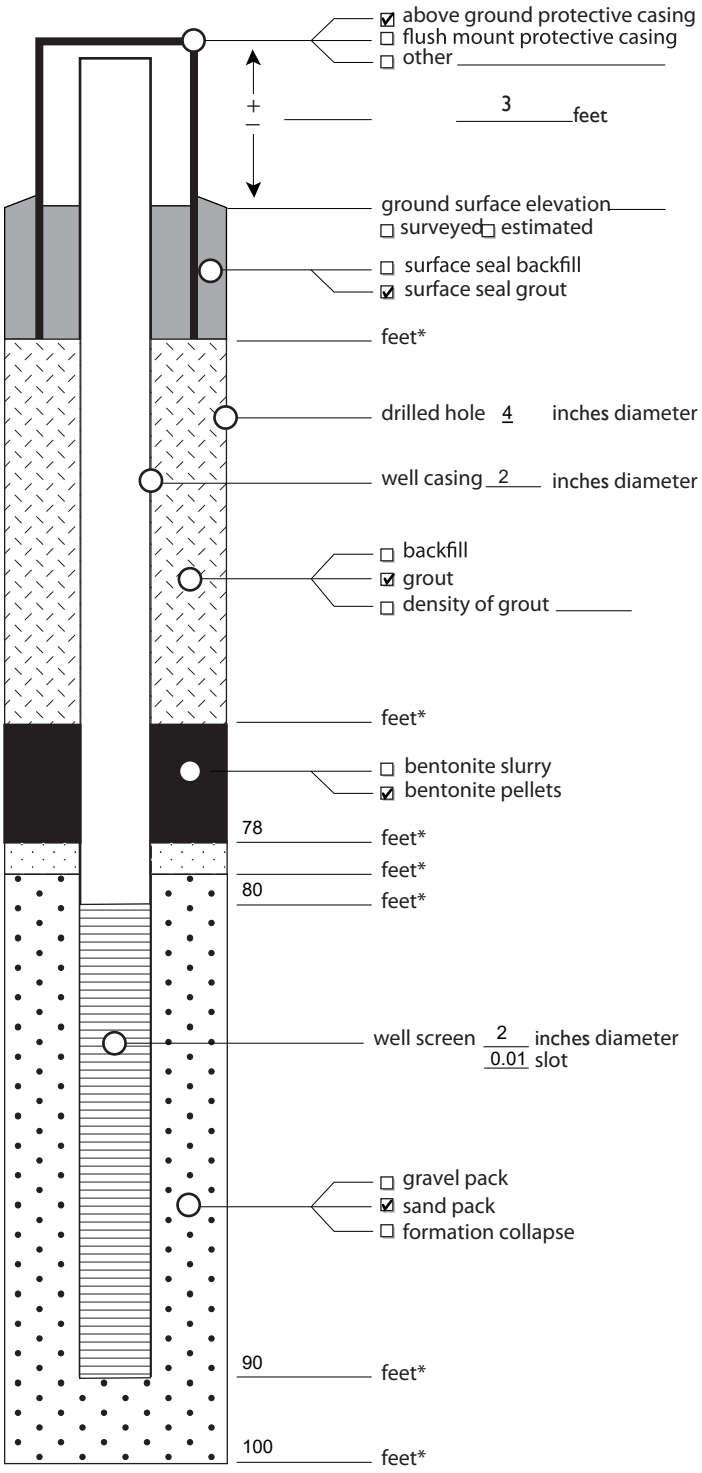
Protective Casing: Length feet
Diameter inches
Construction
- ☐ Cast Aluminum
- ☑ Cast Steel
- ☐ Other

Casing Installation: Length 90 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: bags of lb per bag Size
Fine Sand: 10 bags of 50 lb per bag Size

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: bags of lb per bag Type



Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G12S
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/23/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

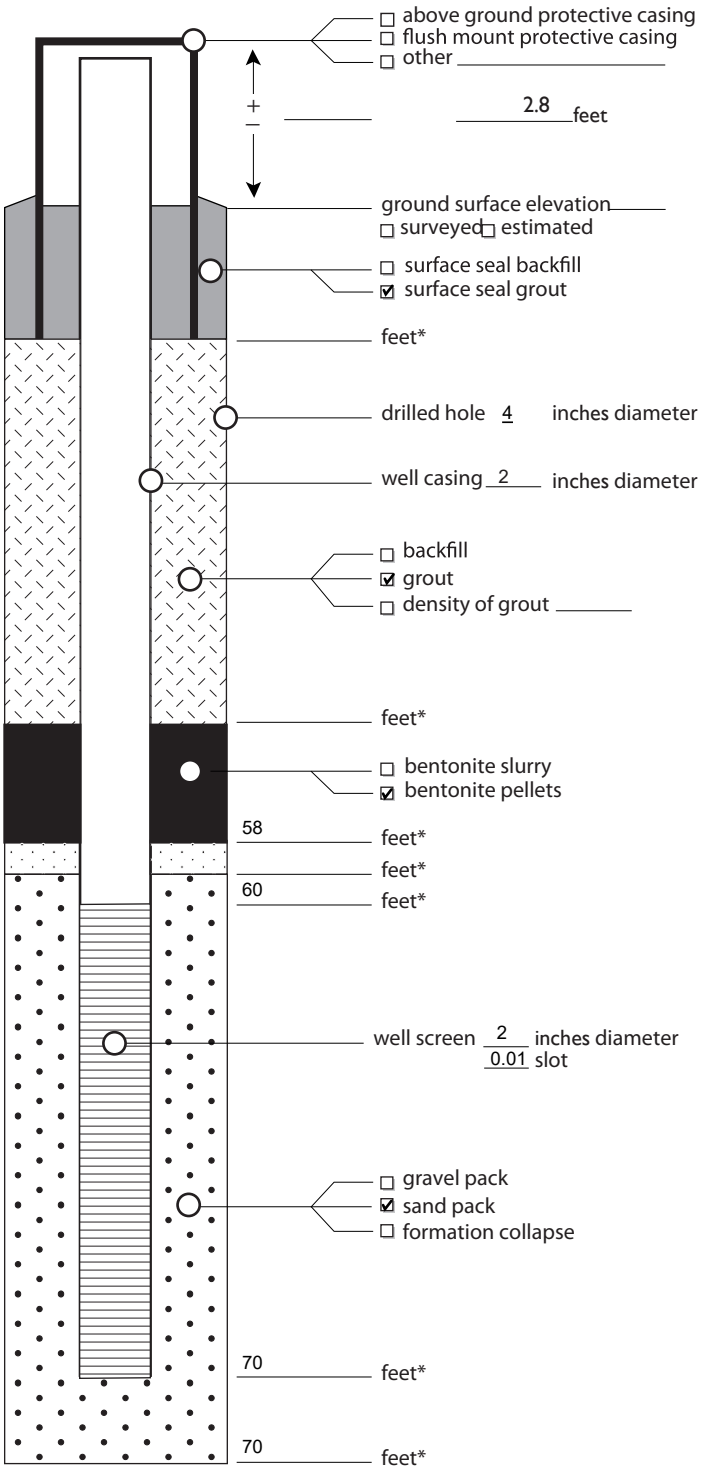
Protective Casing: Length ____ feet
Diameter ____ inches
Construction
- ☐ Cast Aluminum
- ☑ Cast Steel
- ☐ Other

Casing Installation: Length 70 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag ___ Size
Fine Sand: 10 bags of 50 lb per bag ___ Size

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ___

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: ___ bags of ___ lb per bag Type ___



Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G13D
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/23/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 700 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap:
- ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap:
- ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

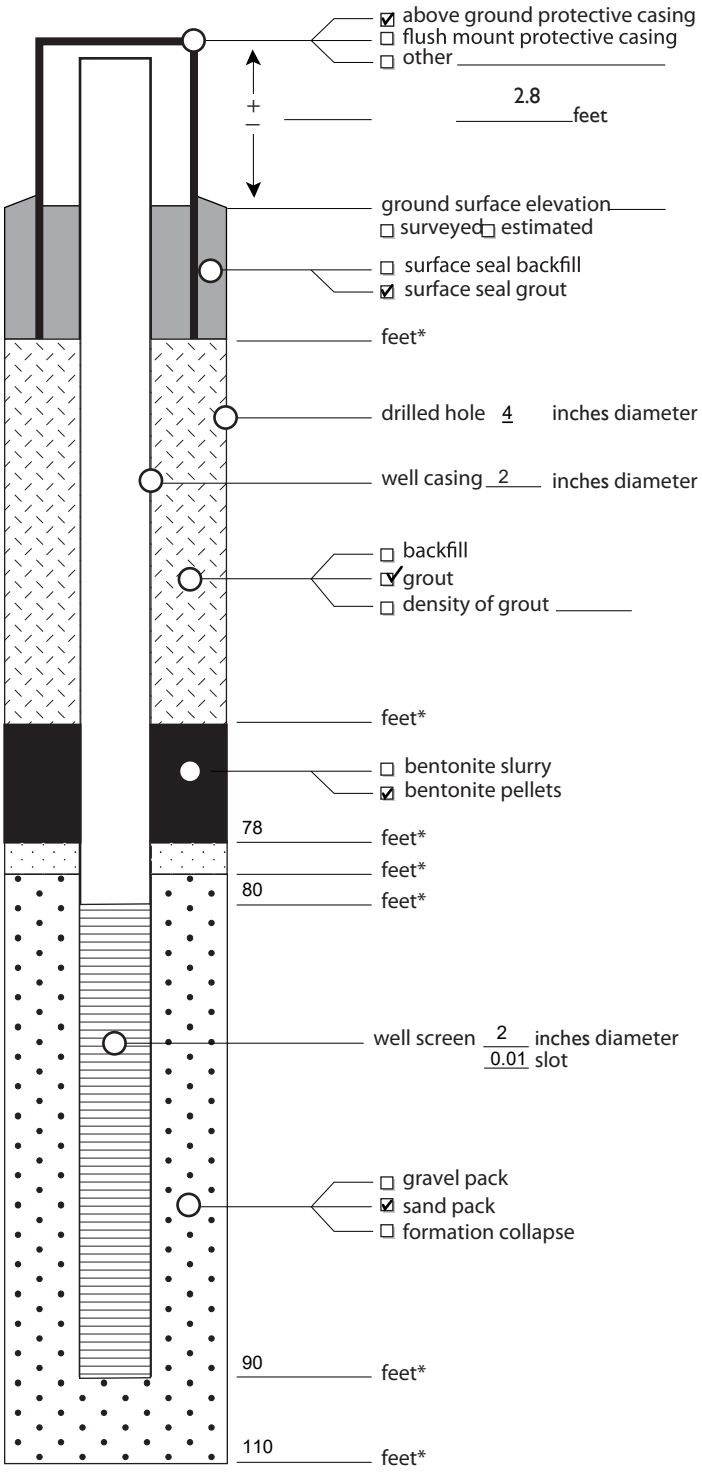
Protective Casing: Length feet
Diameter inches
Construction
- ☐ Cast Aluminum
- ☑ Cast Steel
- ☐ Other

Casing Installation: Length 90 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: bags of lb per bag Size
Fine Sand: 10 bags of 50 lb per bag Size

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: bags of lb per bag Type



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G13S
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/23/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

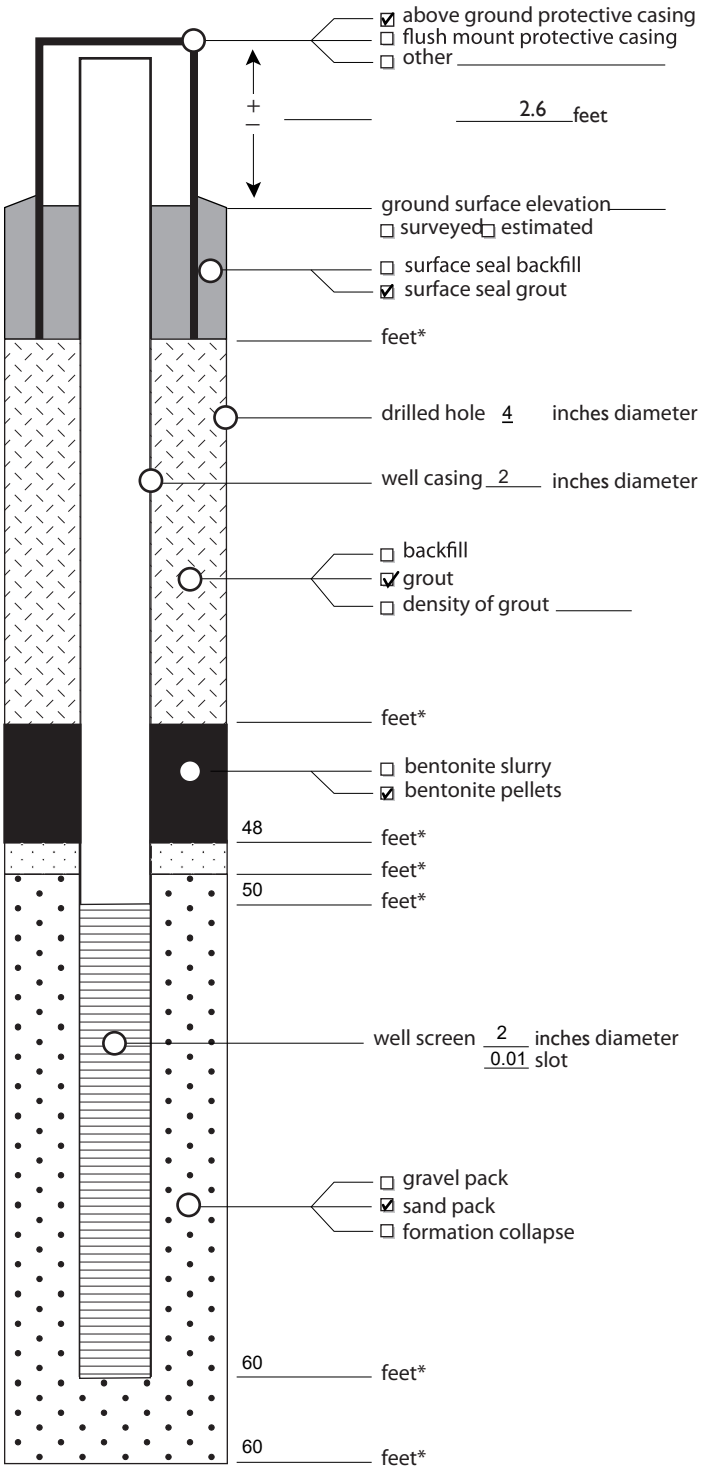
Protective Casing: Length feet
Diameter inches
Construction
- ☐ Cast Aluminum
- ☑ Cast Steel
- ☐ Other

Casing Installation: Length 60 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: bags of lb per bag Size
Fine Sand: 10 bags of 50 lb per bag Size

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: bags of lb per bag Type



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G14D
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye & Michael Jury
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/16/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 700 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

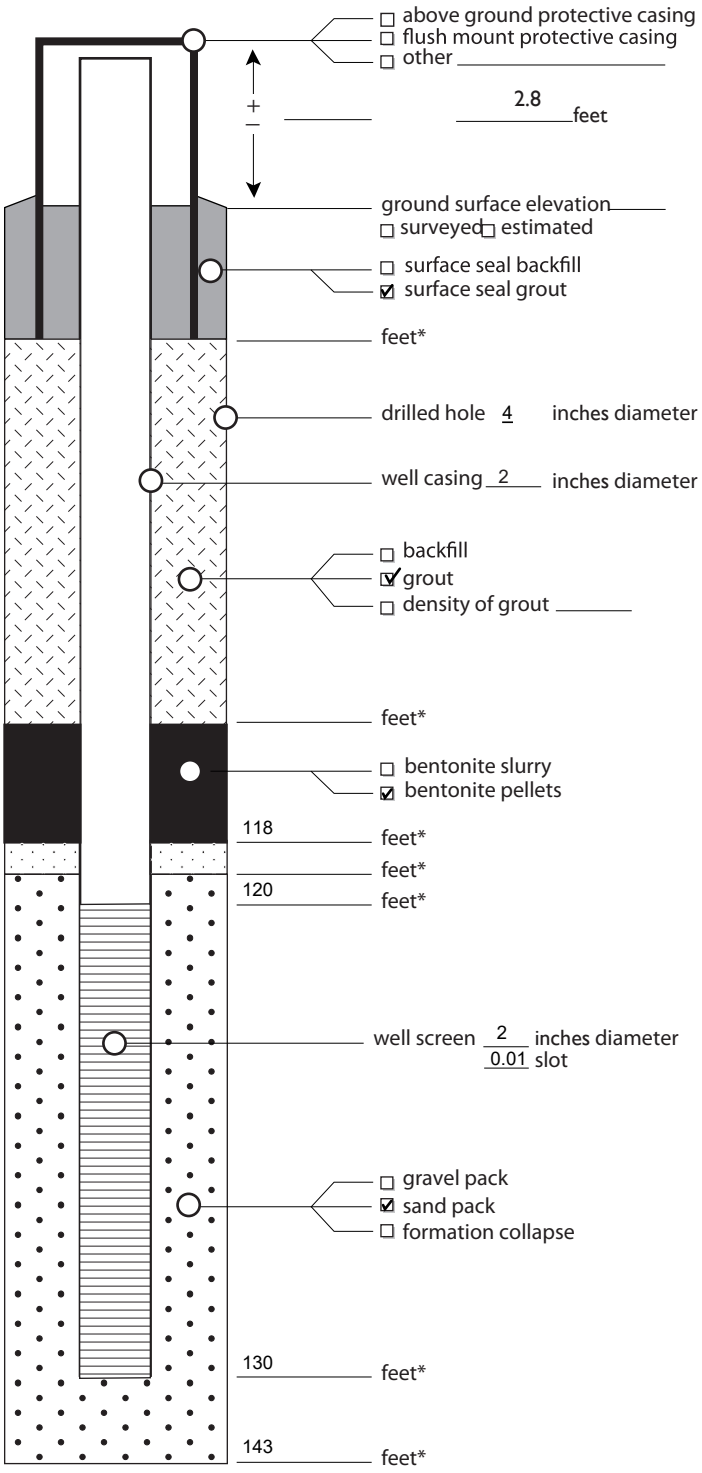
Protective Casing: Length feet
Diameter inches
Construction
- ☐ Cast Aluminum
- ☑ Cast Steel
- ☐ Other

Casing Installation: Length 130 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: bags of lb per bag Size
Fine Sand: 5 bags of 50 lb per bag Size

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 7 bags of 50 lb per bag Type Quickcrete cement
Bentonite: bags of lb per bag Type



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G14S
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye & MJ
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/16/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 500 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

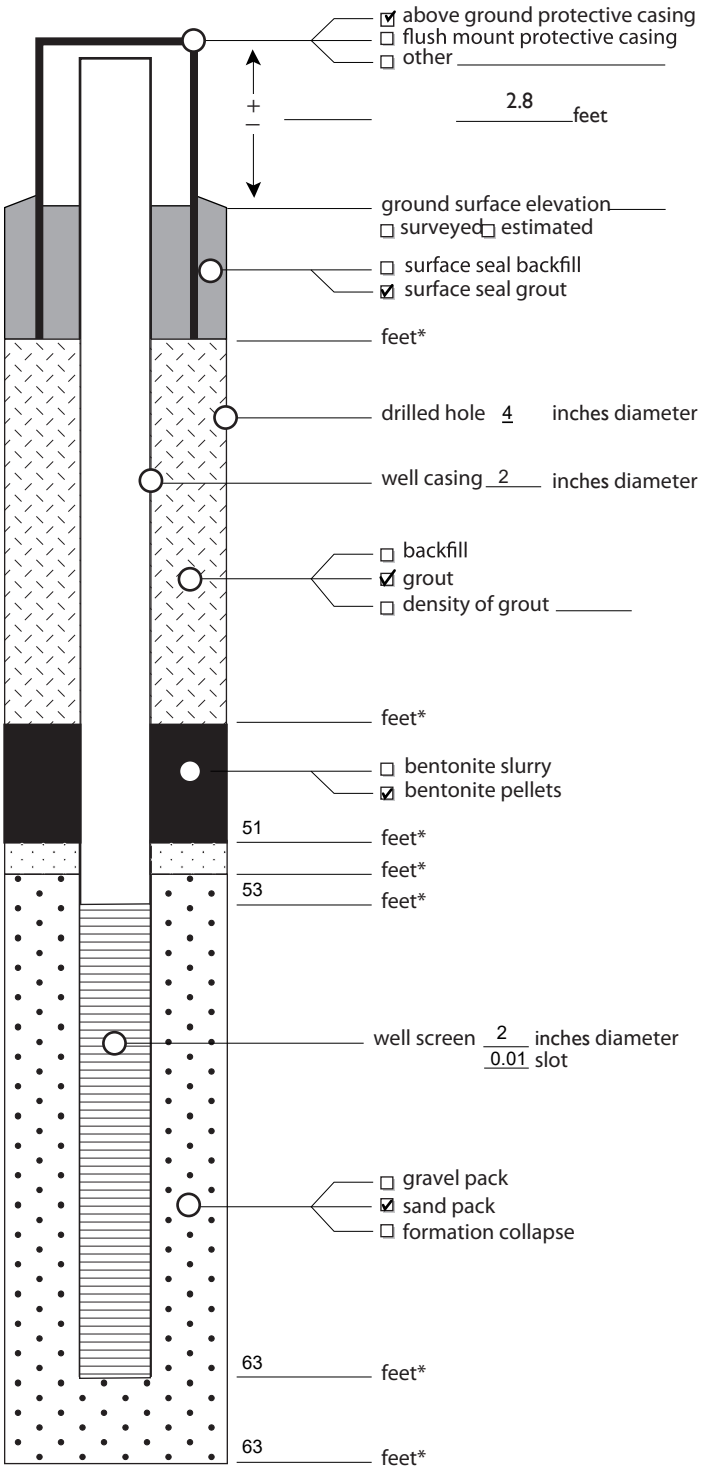
Protective Casing: Length feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length 63 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: bags of lb per bag Size
Fine Sand: 10 bags of 50 lb per bag Size

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: bags of lb per bag Type
Bentonite: 5 bags of 50 lb per bag Type dry mix



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G15D
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye & Michael Jury
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/15/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 600 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap:
- ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap:
- ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

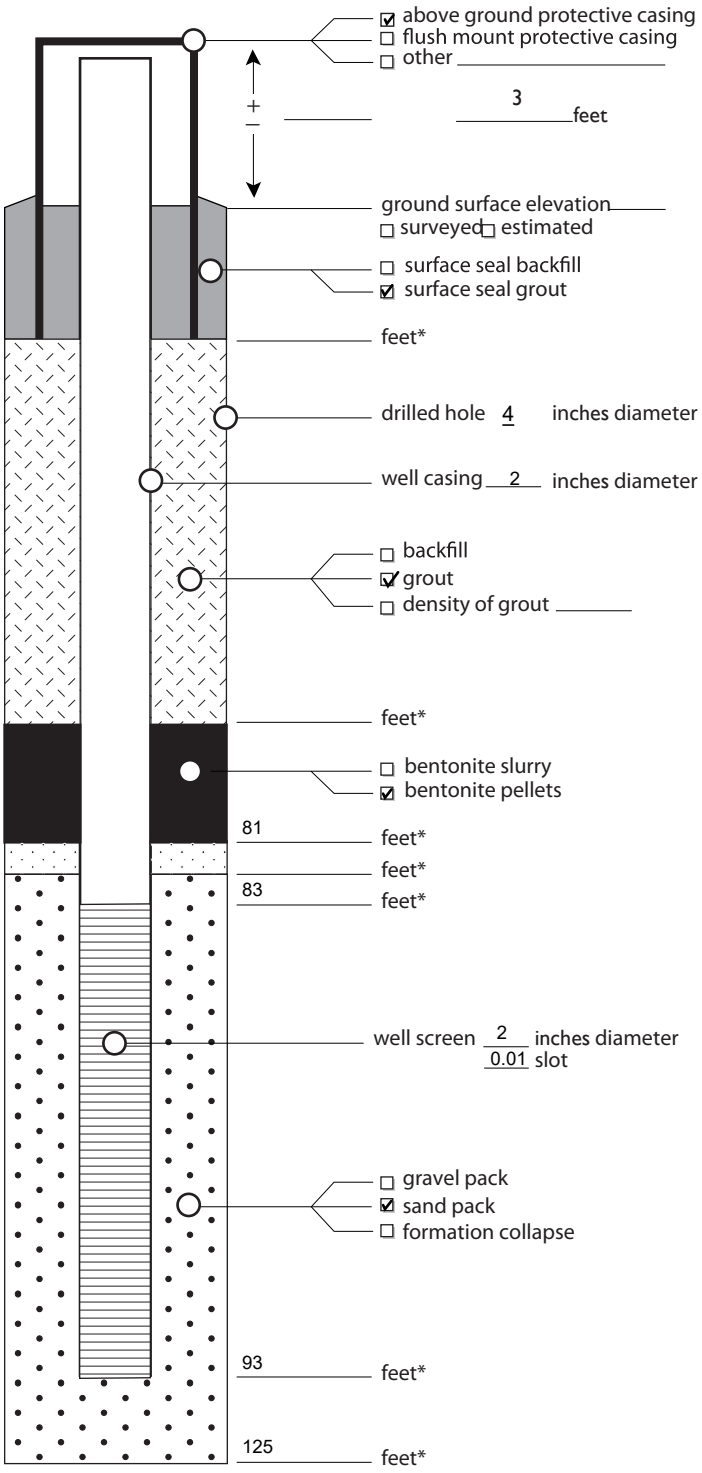
Protective Casing: Length 93 feet
Diameter inches
Construction
- ☐ Cast Aluminum
- ☑ Cast Steel
- ☐ Other

Casing Installation: Length 108 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: 9 bags of 80 lb per bag Size
Fine Sand: 10 bags of 50 lb per bag Size

Seal:
Bentonite Pellets: 5 bags of 80 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: ___ bags of ___ lb per bag Type



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G15S
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye & Michael Jury
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/15/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

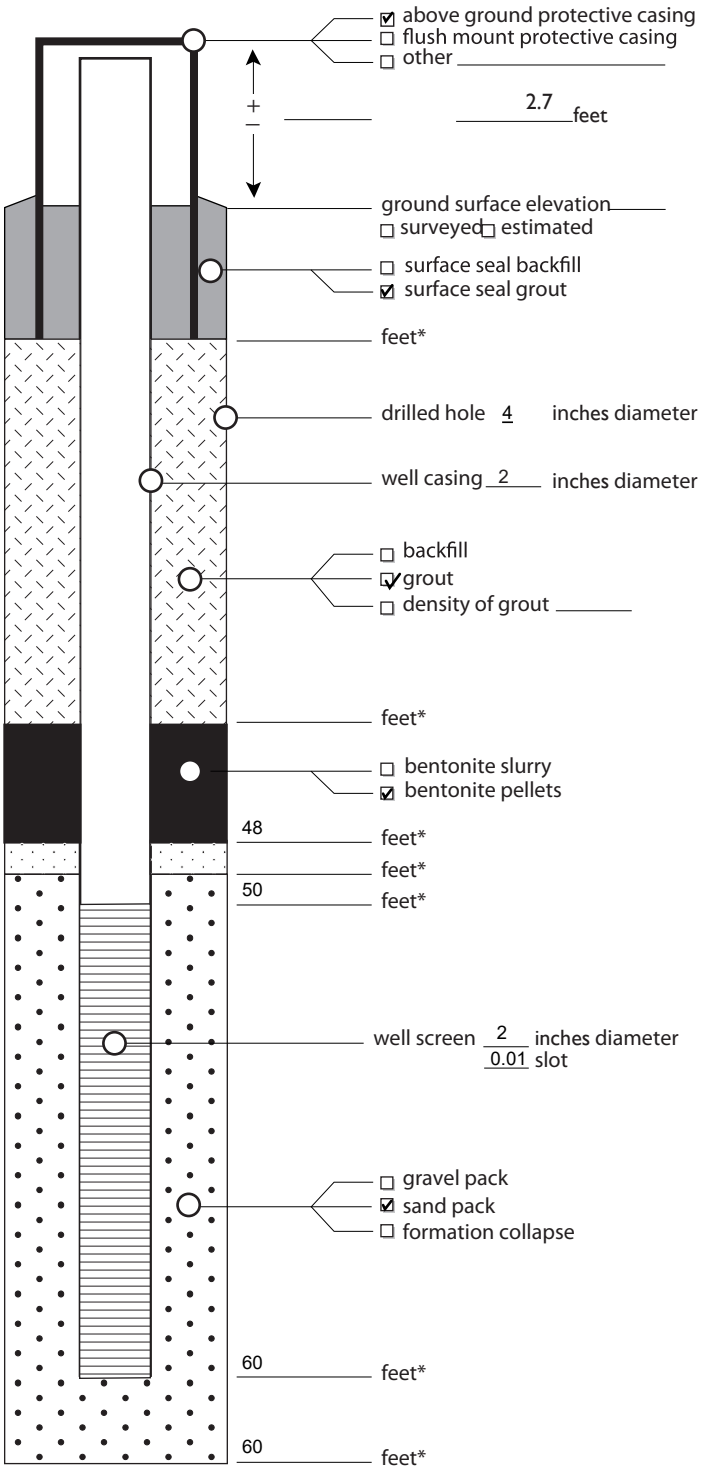
Protective Casing: Length feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length 60 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: bags of lb per bag Size
Fine Sand: 5 bags of 50 lb per bag Size

Seal:
Bentonite Pellets: 2 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 5 bags of 50 lb per bag Type Quickcrete cement
Bentonite: bags of lb per bag Type



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* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G16D
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye & Michael Jury
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/14/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 600 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap:
- ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap:
- ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

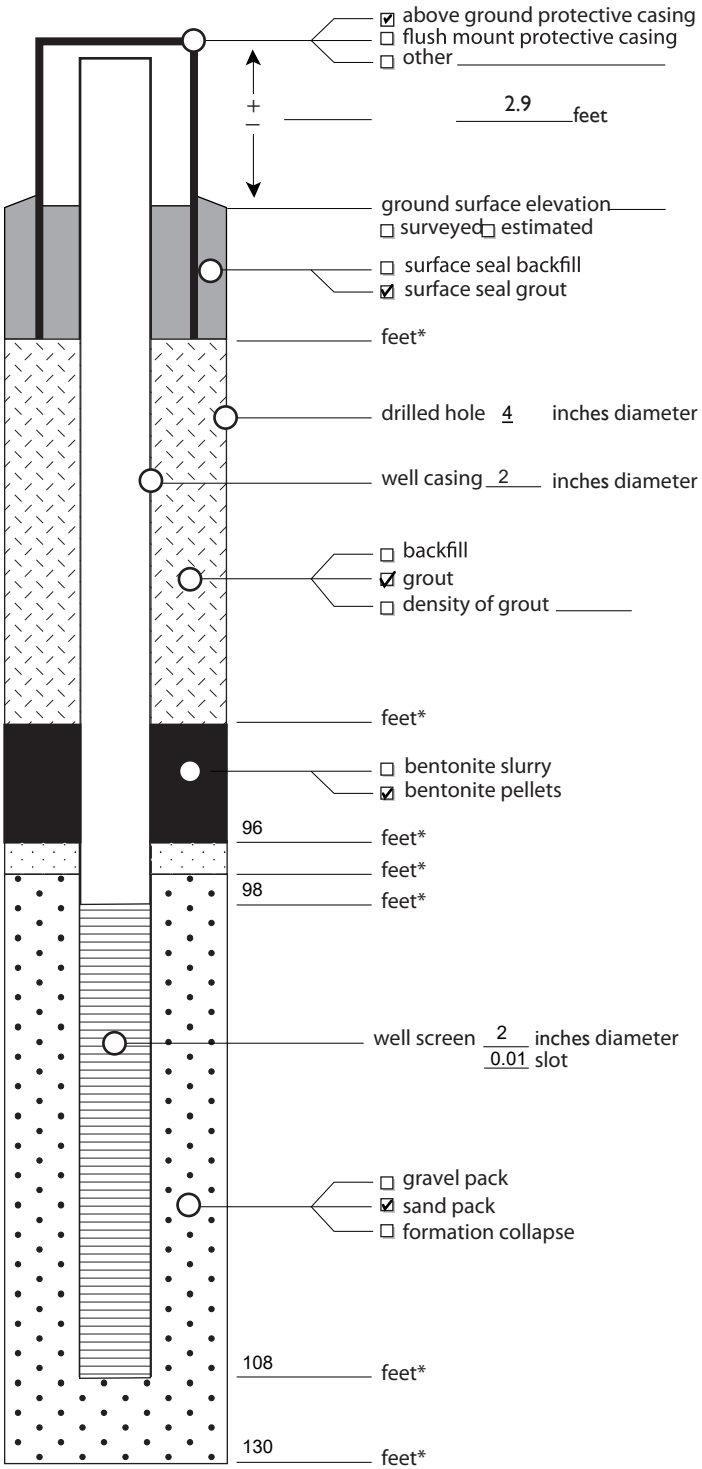
Protective Casing: Length 108 feet
Diameter 2 inches
Construction
- ☐ Cast Aluminum
- ☑ Cast Steel
- ☐ Other

Casing Installation: Length 108 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: bags of lb per bag Size
Fine Sand: 4 bags of 50 lb per bag Size

Seal:
Bentonite Pellets: 6 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 5 bags of 50 lb per bag Type Quickcrete cement
Bentonite: bags of lb per bag Type



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G16S
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Amanda Toye & Michael Jury
Project Number: GLP8030
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/14/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: _____ Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

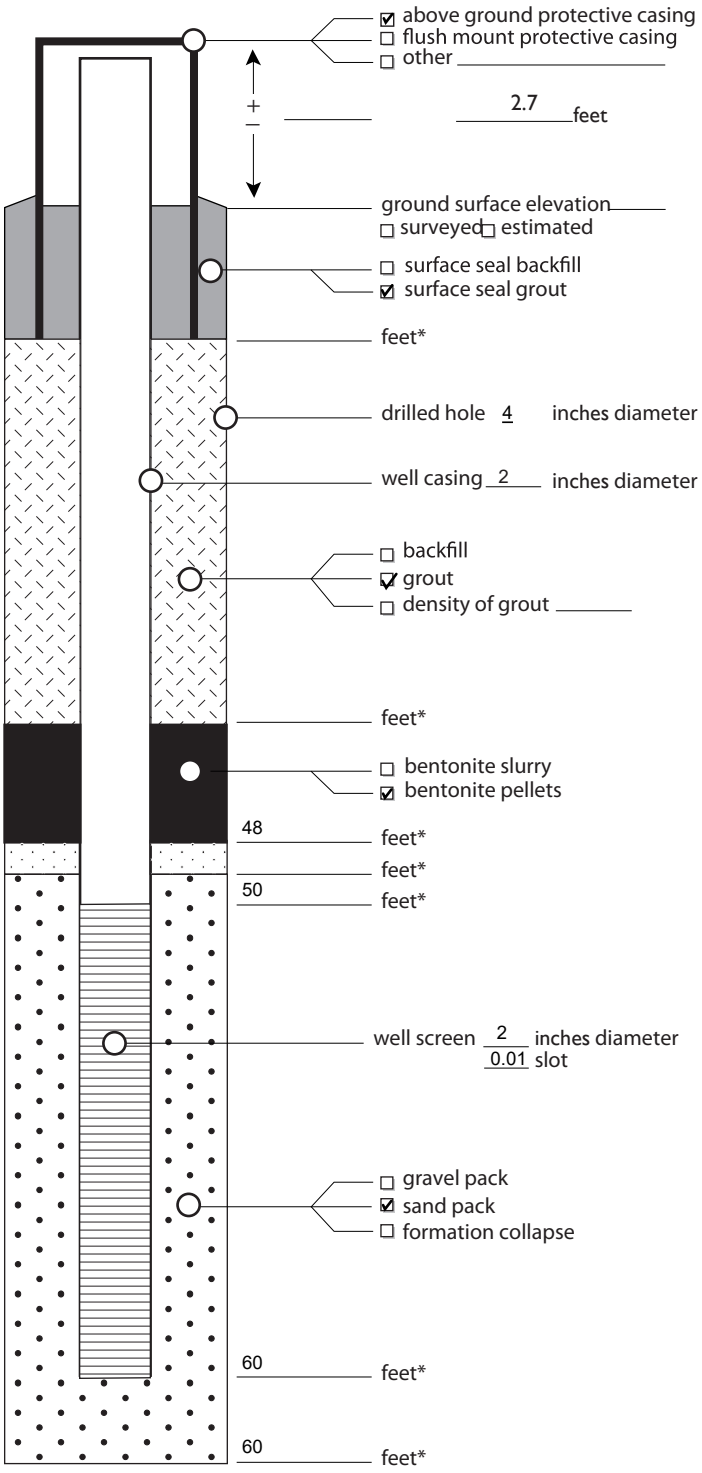
Protective Casing: Length _____ feet
Diameter _____ inches
Construction
- ☐ Cast Aluminum
- ☑ Cast Steel
- ☐ Other

Casing Installation: Length 60 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: __ bags of ____ lb per bag Size ____
Fine Sand: 4 bags of 50 lb per bag Size ____

Seal:
Bentonite Pellets: 6 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: __ bags of __ lb per bag Type ____

Grout:
Cement: 5 bags of 50 lb per bag Type Quickcrete cement
Bentonite: __ bags of __ lb per bag Type ____



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

MONITORING WELL CONSTRUCTION DETAIL

Well ID: Well 3
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: AT, GA
Project Number:
Recorded By: AT

Permit Number:
Installation Date(s): 9/22/2021
Drilling Method: Sonic
Borehole Diameter: 6
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.010 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap:
- ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap:
- ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

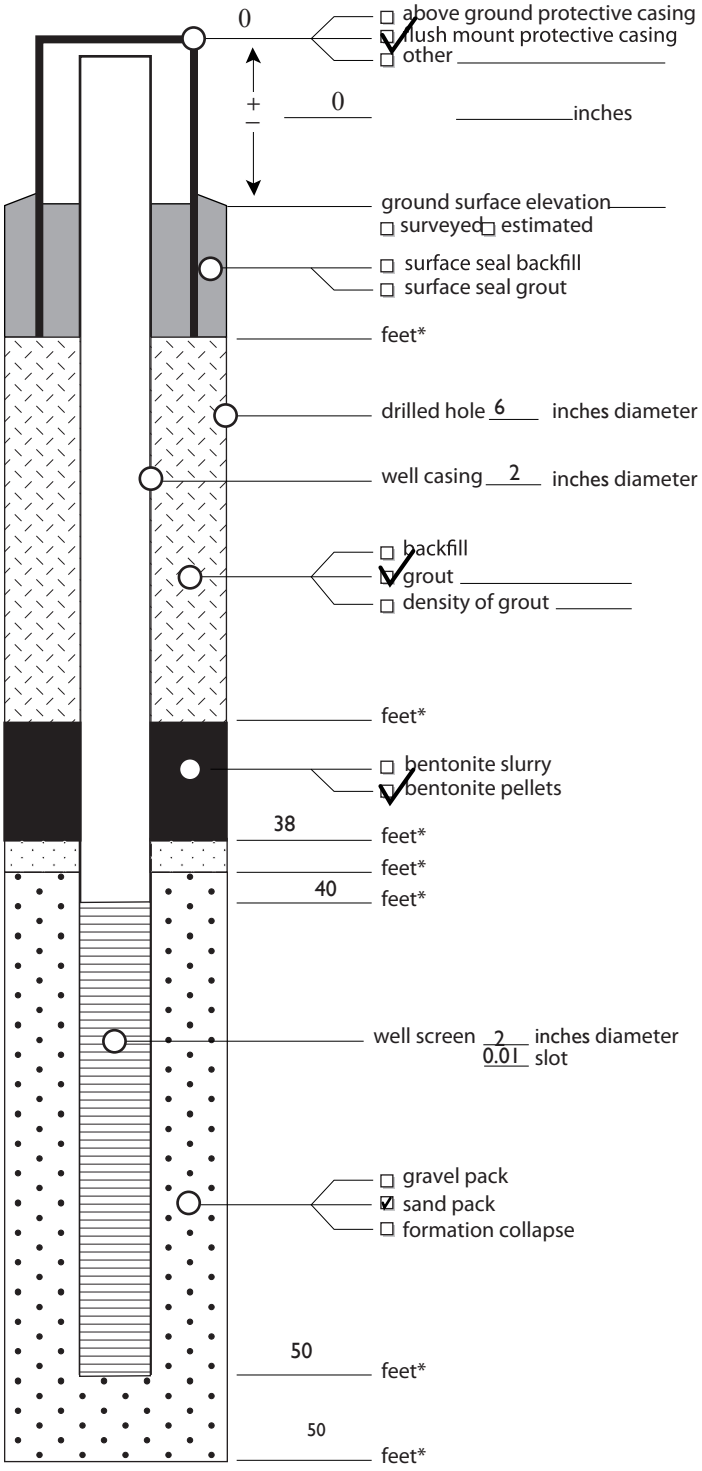
Protective Casing: Length feet
Diameter inches
Construction
- ☐ Cast Aluminum
- ☐ Cast Steel
- ☐ Other

Casing Installation: Length 68 feet
Diameter 2 inches
Material PVC

Sandpack: Filter sil
Coarse Sand: bags of lb per bag Size
Fine Sand: 7 bags of 50 lb per bag Size

Seal: Holeplug
Bentonite Pellets: 5 bags of 50 lb per bag Type 5/8
Bentonite Slurry: bags of lb per bag Type

Grout: Quikcrete
Cement: 5 bags of 50 lb per bag Type
Bentonite: bags of lb per bag Type



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

APPENDIX C
MODFLOW, MT3DMS, HELP MODEL, AND FLUX EVALUATION DATA EXPORT FILES (ELECTRONIC ONLY)

APPENDIX D
EVALUATION OF PARTITION COEFFICIENT RESULTS

Geosyntec consultants

1 McBride and Son Center Drive, Suite 202
Chesterfield, MO 63005
www.geosyntec.com

Memorandum

Date:	July 5, 2022
To:	David Mitchell, Stu Cravens, Vic Modeer Electric Energy Inc.
Copies to:	Brian Hennings - Ramboll
From:	Allison Kreinberg, Ryan Fimmen – Geosyntec Consultants, Inc.
Subject:	Evaluation of Partition Coefficient Results – Joppa East Ash Pond CCR Unit 401, Joppa Power Plant, Joppa, Illinois

INTRODUCTION

Electric Energy, Inc. currently operates the Joppa Power Plant (JPP) and its associated ash ponds located in Joppa, Illinois. The East Ash Pond (EAP) (Vistra identification [ID] No. 401; Illinois Environmental Protection Agency [IEPA] ID No. W1270100004-02; National Inventory of Dams [NID] No. IL50714) is an active 111-acre unlined surface impoundment used to manage CCR and non-CCR waste streams at the JPP. Geosyntec Consultants (Geosyntec) is assisting Electric Energy, Inc. with Part 845 compliance at the Site.

Electric Energy, Inc. is currently preparing a Construction Permit application for the EAP as required under Section 845.220. As part of the Construction Permit application, groundwater modeling is being completed for known potential exceedances of groundwater protection standards (GWPS) identified in the Operating Permit (Burns & McDonnell, 2021). In the Operating Permit (October 2021), Burns & McDonnell identified potential GWPS exceedances for several constituents potentially associated with the EAP, including boron, pH (field), and sulfate. An evaluation of potential exceedances of applicable GWPS found that the pH potential exceedances are not related to the EAP (Ramboll, 2022). Batch adsorption testing was conducted for boron to generate site-specific partition coefficients. This technical memorandum summarizes the results of the batch adsorption testing and calculation of partition coefficients.

BATCH ATTENUATION TESTING

In 2021, Geosyntec conducted a field investigation at the EAP which included completion of three (3) soil/rock borings ranging in depth from 50 to 80 feet below ground surface. As part of that investigation, soil and groundwater samples were submitted to SiREM Laboratories (Guelph, ON) for batch solid/liquid partitioning testing.

One groundwater sample (G07) and one soil sample (SB-03) were used for batch attenuation testing at five (5) soil:solution ratios (**Table 1**), each ran in duplicate. For each treatment, 0.1 L of groundwater was brought into contact with varying amounts of soil (0.004 to 0.2 kg) and equilibrated over a seven-day period. Each microcosm was amended (i.e., spiked) with boric acid (H_3BO_3) to achieve the desired initial concentration (5 mg/L) of boron (**Table 2**).

An initial sample of the stock solution for each experimental design was collected on Day 0, and a control sample (i.e., only amended G07 groundwater with no aquifer solids) was collected on Day 7 after tumbling in polypropylene bottleware to evaluate any loss due to interactions with the bottleware or changes in ambient conditions. Duplicates were constructed for each microcosm, including the control samples. After seven days of contact time, an aliquot of the free liquid was collected and filtered through a 0.45-micron (µm) filter prior to analysis for dissolved concentrations of boron. The oxidation/reduction potential (redox) and pH were measured for each batch test at the beginning and end of the contact period and in the control samples.

Data obtained from the test (**Table 3**) were used to construct isotherms for boron; 5-point isotherms were constructed by averaging duplicate results for each soil:solution ratio. Mathematical fitting was used to calculate the attenuation distribution coefficients (K_d), assuming linear adsorption. The linear adsorption equation was used:

$$q_e = K_d \times C_e \qquad \text{Eq. 1}$$

where q_e is the mass of constituent adsorbed to the solid phase at equilibrium, C_e is the remaining aqueous constituent concentration at equilibrium, and K_d is the linear sorption coefficient (reported in liters per kilogram [L/kg]). The data showed a deviation from a linear trend, and so were also fitted using non-linear isotherms. The non-linear Langmuir isotherm was used:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \qquad \text{Eq. 2}$$

where q_m is the inverse of the slope and K_L is the Langmuir distribution coefficient. The adsorption data were linearized according to:

$$\frac{C_e}{q_e} = \frac{1}{(K_L \times q_m)} + \frac{C_e}{q_m} \qquad \text{Eq. 3}$$

A common non-linear Freundlich equation was also used:

$$q_e = K_F(C_e)^{1/n} \quad \text{Eq. 4}$$

where q_e is the mass of constituent adsorbed to the solid phase at equilibrium, C_e is the remaining aqueous constituent concentration at equilibrium, K_F is the Freundlich distribution coefficient, and *1/n* is a non-linearity constant. The adsorption data were plotted as log-transformed values to perform the non-linear isotherm fitting using the linearized Freundlich equation:

$$log(q_e) = \log(K_F) + (1/n)\log(C_e) \quad \text{Eq. 5}$$

The calculated linear, Langmuir, and Freundlich distribution coefficients (K_d, K_L, and K_F, respectively) and 1/*n* values are shown in **Table 4**.

SUMMARY OF RESULTS

The partition coefficient values for G07 are presented in **Table 4**. A figure which shows the linear, Langmuir, and Freundlich isotherms for boron is provided in **Appendix A**.

All boron partition coefficients for G07 were calculated using four of the five datapoints provided by batch attenuation testing. The results for the 1:27.3 soil:solution ratio were excluded because they consistently reduced the goodness-of-fit of each isotherm, and resulted in unrealistic values for both the partition coefficients (i.e., negative values) and isotherm fitting parameters (i.e., 1/n). Removal of the 1:27.3 soil:solution ratio also resulted in a more conservative linear partition coefficient. The linear boron partition coefficient of 2.4 L/kg, calculated using the four-point isotherm, was chosen for G07 based on its goodness-of-fit ($R^2 > 0.99$) and comparability to other values reported in the literature, which range from 0.19 to 1.3 L/kg depending on pH conditions and the amount of sorbent present (EPRI, 2005; Strenge & Peterson, 1989). Despite their high goodness-of-fit, both the linearized Langmuir and Freundlich isotherms yielded partition coefficients orders of magnitude higher than anticipated relative to values reported in the literature.

REFERENCES

Burns & McDonnell. 2021. Initial Operating Permit Joppa East Ash Pond. October

EPRI, 2005. *Chemical Constituents In Coal Combustion Product Leachate: Boron. Final Report 1005258.*

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2022. *Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond, CCR Unit 401, May 2022*.

Strenge, D. and Peterson, S. 1989. Chemical Data Bases for the Multimedia Environmental Pollutant Assessment System (MEPAS) (No. PNL-7145). Pacific Northwest National Laboratory, Richland, WA (USA).

TABLES

Table 1 - Batch Attenuation Testing Data Summary
Joppa EAP

Geosyntec Consultants

Groundwater Sample ID	Soil Sample ID	Soil: Water Ratio
G07	SB-03 (57.5-62.5, 63.5-70.0 ft bgs)	2:1.3
		1:1.2
		1:5.6
		1:11.0
		1:27.3

Notes:

ft bgs = feet below ground surface

Table 2 - Microcosm Amendment and Target Concentration
Joppa EAP

Geosyntec Consultants

Groundwater Sample ID	Soil Sample ID	Compound	Amendment	Target Concentration (mg/L)
G07	SB-03 (57.5-62, 63.5-70.0 ft bgs)	Boron	7.89 mL of a 2 g/L H_3BO_3	5

Notes:

ft bgs - feet below ground surface

mg/L - milligrams per liter

mL - milliliters

H_3BO_3 - boric acid

Table 3 - Batch Attenuation Testing Results, G07
Joppa EAP

Geosyntec Consultants

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	pH	ORP
						mg/L	SU	mV
G07	--	Water Control Only	23-Dec-21	0	G07-1a	5.8	7.23	81
					G07-2a	5.4	7.3	73
					Average Concentration (mg/L)	**5.6**	**7.3**	**77**
			30-Dec-21	7	G07-1	4.1	7.14	193
					G07-2	4.3	7.09	168
					Average Concentration (mg/L)	**4.2**	**7.1**	**181**
	SB-03	2:1.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 2:1-1	2.5	6.85	148
					SB-03: G07 2:1-2	3.1	6.75	132
					Average Concentration (mg/L)	**2.8**	**6.8**	**140**
		1:1.2 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:1-1	3.1	6.84	146
					SB-03: G07 1:1-2	3.1	6.95	142
					Average Concentration (mg/L)	**3.1**	**6.9**	**144**
		1:5.6 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:5-1	3.8	6.96	134
					SB-03: G07 1:5-2	4.3	6.91	135
					Average Concentration (mg/L)	**4.1**	**6.9**	**135**
		1:11 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:10-1	4.4	6.98	136
					SB-03: G07 1:10-2	4.4	6.89	131
					Average Concentration (mg/L)	**4.4**	**6.9**	**134**
		1:27.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:20-1	4.5	7.08	146
					SB-03: G07 1:20-2	4.4	6.92	150
					Average Concentration (mg/L)	**4.5**	**7.0**	**148**

Notes:

mg/L - milligrams per liter

mV - millivolts

SU - Standard Units

ORP - oxidation/reduction potential

Table 4 - Partition Coefficient Results, G07
Joppa EAP

Geosyntec Consultants

Materials	Analyte	Isotherm	Variable	Value
G07/SB-03	Boron	Linear	R^2	0.998
			K_D (L/kg)	2.40
		Langmuir	R^2	0.982
			q_m (mg/g)	0.06
			K_L (L/kg)	5.66E+04
		Freundlich	R^2	0.999
			1/n	0.83
			K_F (L/kg)	86.4

Notes:

K_D - linear partition coefficient

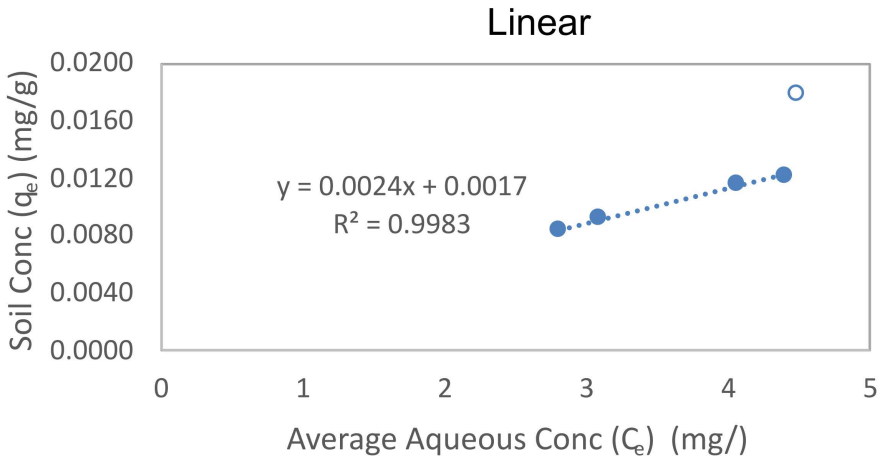
K_L - Langmuir partition coefficient

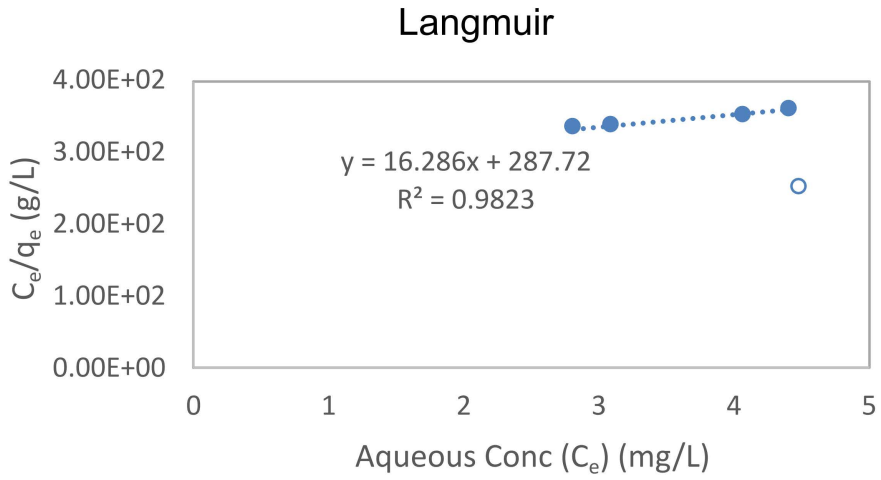
K_F - Freundlich partition coefficient

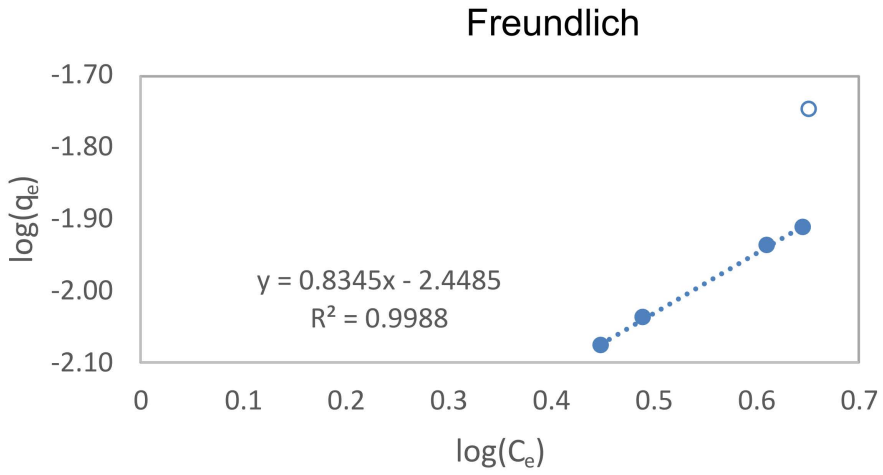
q_m - inverse of the slope of the linearized Langmuir isotherm

n - non-linearity constant of the Freundlich isotherm

APPENDIX A
BATCH TESTING ISOTHERM PLOTS







Notes:
q_e - mass of constituent adsorbed to the solid phase
C_e - remaining aqueous constituent concentration
mg/L - milligrams per liter
mg/g - milligrams per gram
g/L - grams per liter

The results from the 1:27.3 soil:solution ratio, shown as hollow symbols, were not used to calculate the partition coefficients.

G07 Boron Partitioning Coefficients
Joppa Power Plant EAP
Joppa, Illinois

Geosyntec consultants

Columbus, OH | May 2022

Figure 1

APPENDIX E
HELP MODEL OUTPUT FILES

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Joppa EAP CIP Default Earth **Simulated On:** 6/24/2022 16:51

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SCL - Sandy Clay Loam
Material Texture Number 10

Thickness	=	6	inches
Porosity	=	0.398	vol/vol
Field Capacity	=	0.244	vol/vol
Wilting Point	=	0.136	vol/vol
Initial Soil Water Content	=	0.398	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
C - Clay (Low Density)
Material Texture Number 15

Thickness	=	30	inches
Porosity	=	0.475	vol/vol
Field Capacity	=	0.378	vol/vol
Wilting Point	=	0.265	vol/vol
Initial Soil Water Content	=	0.475	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-05	cm/sec

Layer 3

Type 3 - Barrier Soil Liner
Liner Soil (High)
Material Texture Number 16

Thickness	=	36	inches
Porosity	=	0.427	vol/vol
Field Capacity	=	0.418	vol/vol
Wilting Point	=	0.367	vol/vol
Initial Soil Water Content	=	0.427	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-07	cm/sec

Layer 4

Type 1 - Vertical Percolation Layer (Waste)

CCR Material

Material Texture Number 83

Thickness	=	312	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1933	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-06	cm/sec

Layer 5

Type 1 - Vertical Percolation Layer

Clay

Material Texture Number 43

Thickness	=	252	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.371	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	85.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	74	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.088	inches
Upper Limit of Evaporative Storage	=	8.088	inches
Lower Limit of Evaporative Storage	=	3.996	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	185.811	inches
Total Initial Water	=	185.811	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	37.21	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	95	days
End of Growing Season (Julian Date)	=	297	days
Average Wind Speed	=	7	mph
Average 1st Quarter Relative Humidity	=	71	%
Average 2nd Quarter Relative Humidity	=	70	%
Average 3rd Quarter Relative Humidity	=	76	%
Average 4th Quarter Relative Humidity	=	75	%

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Default Earth
Simulated on: 6/24/2022 16:52

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	12.078	[5.327]	3,244,351.3	25.07
Evapotranspiration	34.049	[3.576]	9,146,287.4	70.68
Subprofile1				
Percolation/leakage through Layer 3	2.050194	[0.070975]	550,723.0	4.26
Average Head on Top of Layer 3	23.4090	[2.0491]	---	---
Subprofile2				
Percolation/leakage through Layer 5	0.000793	[0.002101]	213.0	0.00
Water storage				
Change in water storage	2.0443	[1.766]	549,145.3	4.24

* Note: Average inches are converted to volume based on the user-specified area.

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Joppa EAP CIP Cons **Simulated On:** 6/24/2022 16:36

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SCL - Sandy Clay Loam
Material Texture Number 10

Thickness	=	6	inches
Porosity	=	0.398	vol/vol
Field Capacity	=	0.244	vol/vol
Wilting Point	=	0.136	vol/vol
Initial Soil Water Content	=	0.398	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
C - Clay (Low Density)
Material Texture Number 15

Thickness	=	18	inches
Porosity	=	0.475	vol/vol
Field Capacity	=	0.378	vol/vol
Wilting Point	=	0.265	vol/vol
Initial Soil Water Content	=	0.475	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-05	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
10 oz Nonwoven Geotextile
Material Texture Number 123

Thickness	=	0.11	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.85	vol/vol
Effective Sat. Hyd. Conductivity	=	3.00E-01	cm/sec
Slope	=	4.67	%
Drainage Length	=	600	ft

Layer 4

Type 4 - Flexible Membrane Liner

LDPE Membrane

Material Texture Number 36

Thickness	=	0.04	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	1	Holes/Acre
FML Installation Defects	=	1	Holes/Acre
FML Placement Quality	=	3	Good

Layer 5

Type 1 - Vertical Percolation Layer (Waste)

CCR Material

Material Texture Number 83

Thickness	=	312	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1871	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-06	cm/sec

Layer 6

Type 1 - Vertical Percolation Layer

Clay

Material Texture Number 43

Thickness	=	252	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.371	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	85.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	74	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.088	inches
Upper Limit of Evaporative Storage	=	8.088	inches
Lower Limit of Evaporative Storage	=	3.996	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	162.884	inches
Total Initial Water	=	162.884	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	37.21	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	95	days
End of Growing Season (Julian Date)	=	297	days
Average Wind Speed	=	7	mph
Average 1st Quarter Relative Humidity	=	71	%
Average 2nd Quarter Relative Humidity	=	70	%
Average 3rd Quarter Relative Humidity	=	76	%
Average 4th Quarter Relative Humidity	=	75	%

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Cons
Simulated on: 6/24/2022 16:37

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	10.613	[5.037]	2,850,768.6	22.03
Evapotranspiration	33.583	[3.577]	9,021,032.4	69.71
Subprofile1				
Lateral drainage collected from Layer 3	3.9684	[0.5199]	1,066,001.8	8.24
Percolation/leakage through Layer 4	0.016120	[0.003456]	4,330.0	0.03
Average Head on Top of Layer 4	9.5123	[2.0558]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.004411	[0.000998]	1,185.0	0.01
Water storage				
Change in water storage	0.0038	[1.6278]	1,009.3	0.01

* Note: Average inches are converted to volume based on the user-specified area.

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Joppa EAP CIP Default Cover **Simulated On:** 6/24/2022 16:46

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SCL - Sandy Clay Loam
Material Texture Number 10

Thickness	=	6	inches
Porosity	=	0.398	vol/vol
Field Capacity	=	0.244	vol/vol
Wilting Point	=	0.136	vol/vol
Initial Soil Water Content	=	0.398	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
C - Clay (Low Density)
Material Texture Number 15

Thickness	=	30	inches
Porosity	=	0.475	vol/vol
Field Capacity	=	0.378	vol/vol
Wilting Point	=	0.265	vol/vol
Initial Soil Water Content	=	0.475	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-05	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
10 oz Nonwoven Geotextile
Material Texture Number 123

Thickness	=	0.11	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.85	vol/vol
Effective Sat. Hyd. Conductivity	=	3.00E-01	cm/sec
Slope	=	4.67	%
Drainage Length	=	600	ft

Layer 4

Type 4 - Flexible Membrane Liner

LDPE Membrane

Material Texture Number 36

Thickness	=	0.04	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	1	Holes/Acre
FML Installation Defects	=	1	Holes/Acre
FML Placement Quality	=	3	Good

Layer 5

Type 1 - Vertical Percolation Layer (Waste)

CCR Material

Material Texture Number 83

Thickness	=	312	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1871	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-06	cm/sec

Layer 6

Type 1 - Vertical Percolation Layer

Clay

Material Texture Number 43

Thickness	=	252	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.371	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	85.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	74	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.088	inches
Upper Limit of Evaporative Storage	=	8.088	inches
Lower Limit of Evaporative Storage	=	3.996	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	168.594	inches
Total Initial Water	=	168.594	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	37.21	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	95	days
End of Growing Season (Julian Date)	=	297	days
Average Wind Speed	=	7	mph
Average 1st Quarter Relative Humidity	=	71	%
Average 2nd Quarter Relative Humidity	=	70	%
Average 3rd Quarter Relative Humidity	=	76	%
Average 4th Quarter Relative Humidity	=	75	%

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Default Cover
Simulated on: 6/24/2022 16:47

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	9.606	[5.013]	2,580,252.8	19.94
Evapotranspiration	33.574	[3.579]	9,018,602.4	69.70
Subprofile1				
Lateral drainage collected from Layer 3	4.9822	[0.4157]	1,338,319.0	10.34
Percolation/leakage through Layer 4	0.030562	[0.005081]	8,209.6	0.06
Average Head on Top of Layer 4	17.9539	[2.9669]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.003474	[0.001644]	933.3	0.01
Water storage				
Change in water storage	0.0070	[2.1225]	1,889.5	0.01

* Note: Average inches are converted to volume based on the user-specified area.

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: JOP EAP CIP Rem **Simulated On:** 4/26/2022 16:50

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)

Clay

Material Texture Number 43

Thickness	=	120	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.3927	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	89.7	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	36	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.221	inches
Upper Limit of Evaporative Storage	=	8.622	inches
Lower Limit of Evaporative Storage	=	4.518	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	47.126	inches
Total Initial Water	=	47.126	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	37.21	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	95	days
End of Growing Season (Julian Date)	=	297	days
Average Wind Speed	=	7	mph
Average 1st Quarter Relative Humidity	=	71	%
Average 2nd Quarter Relative Humidity	=	70	%
Average 3rd Quarter Relative Humidity	=	76	%
Average 4th Quarter Relative Humidity	=	75	%

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: JOP EAP CIP Rem
Simulated on: 4/26/2022 16:51

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	6,295,133.7	100.00
Runoff	17.495	[5.179]	2,286,282.6	36.32
Evapotranspiration	29.229	[3.315]	3,819,647.2	60.68
Subprofile1				
Percolation/leakage through Layer 1	1.162109	[0.592091]	151,864.4	2.41
Water storage				
Change in water storage	0.2857	[1.449]	37,339.4	0.59

* Note: Average inches are converted to volume based on the user-specified area.

APPENDIX F
FLUX EVALUATION DATA

APPENDIX F. FLUX EVALUATION DATA
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Calibration Model					
Model	**Years (Model Elapsed Time)**	**HSU**	**Total Flux In[1] (ft^3/d)**	**Total Flux In (gpm)**	
Calibration Model	49	Fill Unit (CCR)	29802	155	
Model	**Years (Model Elapsed Time)**	**HSU**	**Total Flux Out[1] (ft^3/d)**	**Total Flux Out (gpm)**	
Calibration Model	49	Fill Unit (CCR)	-29845	-155	
CIP (CCR Removal from the southeast areas of the East Ash Pond, CCR removal from outside of the unit boundaries, consolidation to the northwest area of the East Ash Pond, construction of a cover system over the consolidated CCR, and construction of a stormwater detention pond)					
Prediction Model	**Years (Post-Construction Period)**	**HSU**	**Total Flux In[1] (ft^3/d)**	**Total Flux In (gpm)**	**Reduction in Flux In Post Closure[2] (Percentage, %)**
CIP	25	Fill Unit (CCR)	3.66	0.02	99.99%
Prediction Model	**Years (Post-Construction Period)**	**HSU**	**Total Flux Out[1] (ft^3/d)**	**Total Flux Out (gpm)**	**Reduction in Flux Out Post Closure[2] (Percentage, %)**
CIP	25	Fill Unit (CCR)	3.66	-0.02	99.99%

[O: KEM 6/29/22; C: BGH 6/30/22]

Notes:
1. Reduction in flux as compared to flux at the end of calibration model (model elapsed time of 49 years).
2. Total flux in and out source data provided in flux calculation data files included in Appendix C.

CCR = coal combustion residuals
CIP = closure in place
HSU = Hydrostratigraphic Unit
% = percentage
ft^3/d = cubic feet per day
gpm = gallons per minute

Geosyntec
consultants

Attachment B.2

Groundwater Monitoring Plan

July 2022

Intended for
Electric Energy, Inc.

Date
October 25, 2021

Project No.
1940100806-006

GROUNDWATER MONITORING PLAN
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL Bright ideas. Sustainable change.

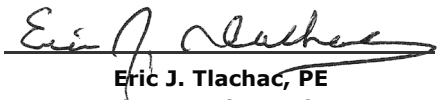
GROUNDWATER MONITORING PLAN
JOPPA POWER PLANT EAST ASH POND

Project Name	**Joppa Power Plant East Ash Pond**
Project No.	**1940100806-006**
Recipient	**Electric Energy, Inc.**
Document Type	**Groundwater Monitoring Plan**
Revision	**FINAL**
Date	**October 25, 2021**

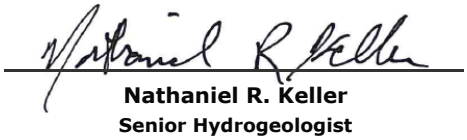
Ramboll
234 W. Florida Street
Fifth Floor
Milwaukee, WI 53204
USA

T 414-837-3607
F 414-837-3608
https://ramboll.com

Brian G. Hennings, PG
Senior Managing Hydrogeologist



Eric J. Tlachac, PE
Senior Managing Engineer



Nathaniel R. Keller
Senior Hydrogeologist

Chase J. Christenson, PG
Hydrogeologist

LICENSED PROFESSIONAL CERTIFICATIONS

35 I.A.C. § 845.630 Groundwater Monitoring Systems (PE)

I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the groundwater monitoring system described in this document (Groundwater Monitoring Plan, Joppa Power Plant East Ash Pond), has been designed and constructed to meet the requirements of 35 I.A.C. § 845.630. The monitoring system was developed based on information included in the Hydrogeologic Site Characterization Report (Ramboll 2021; included in the Operating Permit to which this Groundwater Monitoring Plan is attached).

Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
Date: October 25, 2021

35 I.A.C. § 845.630 Groundwater Monitoring Systems (PG)

I, Brian G. Hennings, a qualified professional geologist in good standing in the State of Illinois, certify that the groundwater monitoring system described in this document (Groundwater Monitoring Plan, Joppa Power Plant East Ash Pond), has been designed and constructed to meet the requirements of 35 I.A.C. § 845.630. The monitoring system was developed based on information included in the Hydrogeologic Site Characterization Report (Ramboll 2021; included in the Operating Permit to which this Groundwater Monitoring Plan is attached).

Brian G. Hennings
Professional Geologist
196.001482
Illinois
Date: October 25, 2021

CONTENTS

Licensed Professional Certifications		**2**
1.	**Introduction**	**6**
1.1	Overview	6
1.2	Site Location and Background	6
1.3	Conceptual Model	7
2.	**Groundwater Monitoring Systems**	**9**
2.1	Existing Monitoring Well Network and Analysis	9
2.1.1	40 C.F.R. § 257 Monitoring Program	9
2.1.2	Part 845 Well Installation and Monitoring	10
2.2	Proposed Part 845 Monitoring Well Network	10
2.3	Well Abandonment	11
3.	**Applicable Groundwater Quality Standards**	**12**
3.1	Groundwater Classification	12
3.2	Statistical Evaluation of Background Groundwater Data	12
3.3	Applicable Groundwater Protection Standards	12
4.	**Groundwater Monitoring Plan**	**14**
4.1	Monitoring Networks and Parameters	14
4.1.1	40 C.F.R. § 257 Groundwater Monitoring	14
4.1.2	Part 845 Groundwater Monitoring	14
4.2	Sampling Schedule	15
4.3	Groundwater Sample Collection	16
4.4	Laboratory Analysis	16
4.5	Quality Assurance Program	16
4.6	Groundwater Monitoring System Maintenance Plan	17
4.7	Statistical Analysis	17
4.8	Data Reporting	17
4.9	Compliance with Applicable On-site Groundwater Protection Standards	17
4.10	Alternate Source Demonstrations	18
4.11	Assessment of Corrective Measures and Corrective Action	18
5.	**References**	**20**

TABLES (IN TEXT)

Table A 40 C.F.R. § 257 Groundwater Monitoring Program Parameters
Table B Part 845 Groundwater Monitoring Program Parameters
Table C Proposed Part 845 Monitoring Well Network
Table D Part 845 Groundwater Monitoring Program Parameters
Table E Part 845 Sampling Schedule

TABLES (ATTACHED)

Table 1-1 Part 845 Requirements Checklist
Table 2-1 Monitoring Well Locations and Construction Details
Table 3-1 Background Groundwater Quality and Standards
Table 4-1 Sampling and Analysis Summary
Table 4-2 Detection and Reporting Limits for Part 845 Parameters

FIGURES (ATTACHED)

Figure 1-1 Site Location Map
Figure 1-2 Site Map
Figure 1-3 Uppermost Aquifer Groundwater Elevation Contours, March 3 and 4, 2021
Figure 2-1 Proposed Part 845 Groundwater Monitoring Well Network

APPENDICES

Appendix A Statistical Analysis Plan

ACRONYMS AND ABBREVIATIONS

§	Section
35 I.A.C.	Title 35 of the Illinois Administrative Code
40 C.F.R.	Title 40 of the Code of Federal Regulations
ASD	Alternate Source Demonstration
bgs	below ground surface
CCR	coal combustion residuals
cm/s	centimeters per second
CSM	conceptual site model
EAP	East Ash Pond
GMP	Groundwater Monitoring Plan
GWPS	groundwater protection standard
HCR	Hydrogeologic Site Characterization Report
ID	identification
IEPA	Illinois Environmental Protection Agency
JPP	Joppa Power Plant
LAU	lower aquifer unit
LCU	lower confining unit
NA	not applicable
NAVD88	North American Vertical Datum of 1988
NID	National Inventory of Dams
No.	number
NRT/OBG	Natural Resource Technology, an OBG Company
OBG	O'Brien & Gere Engineers, Inc.
Part 845	Residuals in Surface Impoundments: Title 35 of the Illinois Administrative Code § 845
PMP	potential migration pathway
QA/QC	quality assurance/quality control
Ramboll	Ramboll Americas Engineering Solutions, Inc.
RL	reporting limit
SI	surface impoundment
TDS	total dissolved solids
UA	uppermost aquifer
UCU	upper confining unit
USEPA	United States Environmental Protection Agency
WLO	water level only

1. INTRODUCTION

1.1 Overview

In accordance with requirements of the Standards for the Disposal of Coal Combustion Residuals (CCR) in Surface Impoundments (SIs): Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845 (Part 845) (Illinois Environmental Protection Agency [IEPA], April 15, 2021), Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Monitoring Plan (GMP) on behalf of Joppa Power Plant (JPP), operated by Electric Energy, Inc. This report will apply specifically to the CCR Unit referred to as the East Ash Pond (EAP), Vistra identification (ID) number (No.) 401, IEPA ID No. W1270100004-02, and National Inventory of Dams (NID) No. IL50714. The EAP is a 111-acre active unlined CCR SI used to manage CCR and non-CCR waste streams at the JPP. This GMP includes Part 845 content requirements specific to 35 I.A.C. § 845.630 (Groundwater Monitoring System), 35 I.A.C. § 845.640 (Groundwater Sampling and Analysis), and 35 I.A.C. § 845.650 (Groundwater Monitoring Program) for the EAP at the JPP.

A checklist which identifies the specific requirements of 35 I.A.C. § 845.630, 35 I.A.C. § 845.640, and 35 I.A.C. § 845.650 is included in **Table 1-1**. The table provides references to sections, tables, and figures included in this document to locate the information that meets specific requirements of 35 I.A.C. § 845.630, 35 I.A.C. § 845.640, and 35 I.A.C. § 845.650.

1.2 Site Location and Background

The JPP is west of the Village of Joppa in Massac County, Illinois, northeast of the Ohio River in Section 14, Township 15 South, Range 3 East (**Figure 1-1**). The JPP property is bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south. The EAP is located in the west half of Section 14 directly north of the JPP and is bounded immediately to the east by the railway right-of-way which is adjacent to forested portions of residential property in the Village of Joppa.

The JPP currently operates the EAP for management of CCR waste streams. A permit exempt CCR landfill is present in the northwestern portion of the JPP property. In addition, there is a former CCR disposal area, Joppa West, located in the western portion of the JPP property (**Figure 1-2**). The landfill and Joppa West are not the subject of this GMP.

The EAP is classified as an existing unlined CCR SI which is used to manage both fly ash and bottom ash. The EAP was built in two phases. The northern portion (Phase I) was placed into service in late 1973, while the southern portion (Phase II) was permitted in May 1985 with completion of construction occurring in late 1985. These two sections are separated by a dividing dike (*i.e.,* Central Dike) and are referred to as the Northern and Southern Ponds. The pond embankment has not been raised since its construction in 1973, but material has been added in some areas to increase the width. The Northern Pond is diked over the length of its perimeter and the height of the dike varies from approximately 15 to 45 feet above the outboard toe of slope. The crest is at an approximate elevation of 380 feet North American Vertical Datum of 1988 (NAVD88). The Southern Pond is also a diked earthen embankment structure with a height that varies from approximately 15 to 45 feet above its outboard toe. As with the Northern Pond,

the crest is at an approximate elevation of 380 feet NAVD88 (O'Brien & Gere Engineers, Inc. [OBG], 2010).

1.3 Conceptual Model

Significant site investigation has been completed at the JPP to characterize the geology, hydrogeology, and groundwater quality. Based on extensive investigation and monitoring, the EAP has been well characterized and detailed in the Hydrogeologic Site Characterization Report (HCR [Ramboll, 2021]; included in the Operating Permit to which this Plan is attached). A conceptual site model (CSM) has been developed and is discussed below.

In addition to the CCR present at the Joppa EAP, there are four distinct hydrostratigraphic units summarized below that have been identified based on stratigraphic relationships and common hydrogeologic characteristics:

- **Upper Confining Unit (UCU)**: Includes low permeability silt and clay of the Equality Formation, silts of the Peoria/Roxana/Loveland, and clay and silt of the Metropolis Formation. This unit was encountered in all borings advanced at the EAP in 2021 and limits the vertical migration of CCR impacts into the uppermost aquifer.
- **Uppermost Aquifer**: Includes high permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation. The uppermost aquifer at the EAP was encountered at elevations ranging from 222.6 to 318.6 feet NAVD88.
- **Lower Confining Unit (LCU)**: Includes clay and silt of the Lower McNairy Formation that was encountered in all borings advanced to bedrock. Based on material description, continuous lateral extent, and observed vertical gradients this unit is identified as an LCU.
- **Lower Aquifer Unit (LAU)**: The lowermost unit identified at the EAP which underlies all unlithified deposits and is considered a potential migration pathway (PMP). This unit is comprised of the Salem Limestone, which is the uppermost lithified unit identified at the EAP and used as a potable and non-potable water supply in the vicinity of the JPP.

Groundwater flow direction and gradients have not changed significantly since the first hydrogeologic study of the EAP was completed in 2009, and recent data support the existing CSM, which has been refined to incorporate additional data as follows:

- Groundwater migrates downward through the UCU which is composed of the Equality Formation, Silt Unit, and Metropolis Formation into the uppermost aquifer.
- Groundwater migrates within high permeability sands and gravels of the McNairy Formation which comprises the uppermost aquifer generally south towards the Ohio River.
- Vertical gradients measured between the LAU and the uppermost aquifer indicate upward migration of groundwater from the LAU to the uppermost aquifer and into the Ohio River.

Groundwater elevations and contours for March 3 and 4, 2021 are presented in **Figure 1-3**.

Part 845 parameters were monitored in the uppermost aquifer and LAU monitoring wells at the EAP as part of the Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257 monitoring program beginning in 2015. These data were supplemented with sampling of additional locations in 2021. The results indicate that the following parameters were detected at concentrations greater than the applicable 35 I.A.C. § 845.600 groundwater protection standards (GWPSs) and are considered potential exceedances:

- Boron - at five uppermost aquifer wells (G06, G07, G08, G09, and G10).
- Cobalt - at thirteen uppermost aquifer wells (G01D, G03, G05, G06S, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D), and at LAU well G09M.
- pH – at two UCU wells (G54S and G151), and at thirteen uppermost aquifer wells (G01D, G02D, G03, G05, G06S, G07, G09, G10, G11, G51D, G52D, G53D, and G54D).
- Radium 226 and 228 combined – at upgradient uppermost aquifer well G02D.
- Sulfate - at uppermost aquifer wells G10 and G11.
- Thallium – at uppermost aquifer wells G05 and G11.

Concentration results for the above parameters were compared directly to 35 I.A.C. § 845.600 GWPS, without an evaluation of background concentrations. Evaluation of background groundwater quality has been completed as part of this GMP, and compliance with Part 845 will be determined following the first round of groundwater sampling. The first round of groundwater sampling for compliance will be completed the quarter following issuance of the Operating Permit and in accordance with this GMP.

2. GROUNDWATER MONITORING SYSTEMS

2.1 Existing Monitoring Well Network and Analysis

This GMP is being provided to propose a groundwater monitoring network and monitoring program specific to the EAP that will comply with Part 845. Monitoring networks and programs that apply to other units are not discussed in this GMP. Those programs will continue to be performed as specified in IEPA approvals. Any future modifications will be proposed and submitted to IEPA for approval in a separate document. The remaining discussion in this document will include only these networks and monitoring programs that are applicable and specific to the EAP, specifically the 40 C.F.R. § 257 network and the proposed Part 845 monitoring network.

2.1.1 40 C.F.R. § 257 Monitoring Program

The 40 C.F.R. § 257 well network for the EAP consists of six monitoring wells installed nearby or adjacent to the EAP within the unlithified uppermost aquifer. The EAP 40 C.F.R. § 257 well network consists of two background monitoring wells (G01D and G02D) and four compliance monitoring wells (G51D, G52D, G53D, and G54D). The boring logs, well construction forms, and other related monitoring well forms are available in the Operating Records as required by 40 C.F.R. § 257.91 for each monitored CCR Unit or CCR Multi-Unit, and are included in Appendix B of the HCR (included in the Operating Permit to which this Plan is attached).

Assessment monitoring in accordance with 40 C.F.R. § 257.95 was initiated on April 9, 2018. Details on the procedures and techniques used to fulfill the groundwater sampling and analysis program requirements are found in the Sampling and Analysis Plan for the EAP (Natural Resource Technology, an OBG Company [NRT/OBG], 2017).

Groundwater samples are collected semiannually and analyzed for the laboratory and field parameters from Appendix III and Appendix IV of 40 C.F.R. § 257, summarized in **Table A** below.

Table A. 40 C.F.R. § 257 Groundwater Monitoring Program Parameters

Field Parameters[1]			
Groundwater Elevation	pH		
Appendix III Parameters (Total, except total dissolved solids [TDS])			
Boron	Chloride	Sulfate	
Calcium	Fluoride	TDS	
Appendix IV Parameters (Total)			
Antimony	Cadmium	Lithium	Selenium
Arsenic	Chromium	Mercury	Thallium
Barium	Cobalt	Molybdenum	Radium 226 and 228 combined
Beryllium	Lead		

[1] Dissolved oxygen, temperature, specific conductance, oxidation/reduction potential, and turbidity are recorded during sample collection.

Results and analysis of groundwater sampling are reported annually by January 31 of the following year and made available on the CCR public website as required by 40 C.F.R. § 257.

2.1.2 Part 845 Well Installation and Monitoring

In 2021, 12 additional monitoring wells (G03, G04, G05, G06, G06S, G07, G08, G09, G09M, G10, G11, and G54S) were installed along the perimeter of the EAP to assess the vertical and horizontal lithology, stratigraphy, chemical properties, and physical properties of geologic layers to a minimum of 100 feet below ground surface (bgs) as specified in 35 I.A.C. § 845.620(b). Additionally, three leachate monitoring wells (XPW01, XPW02, and XPW03) were installed within the EAP unit to characterize the CCR materials.

Prospective Part 845 monitoring wells were sampled for eight rounds from February to August 2021 and the results were assessed for selection of the EAP Part 845 monitoring well network. Groundwater samples were collected and analyzed for 35 I.A.C. § 845.600 parameters as summarized in **Table B** below.

Table B. Part 845 Groundwater Monitoring Program Parameters

Field Parameters[1]			
Groundwater Elevation	pH	Turbidity	
Metals (Total)			
Antimony	Boron	Cobalt	Molybdenum
Arsenic	Cadmium	Lead	Selenium
Barium	Calcium	Lithium	Thallium
Beryllium	Chromium	Mercury	
Inorganics (Total)			
Fluoride	Sulfate	Chloride	TDS
Other (Total)			
Radium 226 and 228 combined			

[1] Dissolved oxygen, temperature, specific conductance, and oxidation/reduction potential were recorded during sample collection.

Data and results from the Part 845 background monitoring were included in the water quality discussion included in the HCR (included in the Operating Permit to which this Plan is attached). The data collected from background locations during the Part 845 monitoring were used to evaluate and calculate background concentrations for the EAP. The evaluation and discussion are included in **Section 3.2** of this report.

Data collected from the 40 C.F.R. § 257 monitoring network from 2015 to 2021, and from the Part 845 background monitoring were used for selection of the Part 845 monitoring well network proposed in **Section 2.2**.

2.2 Proposed Part 845 Monitoring Well Network

The groundwater monitoring network proposed in this plan will include 14 wells screened in the uppermost aquifer (G01D, G02D, G03, G05, G06, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D) and two temporary water level only surface water staff gages (XSG01 and SG02). The proposed network is summarized in **Table C** below and displayed on **Figure 2-1.**

Fourteen wells (two background and 12 compliance) will be used to monitor groundwater concentrations within the uppermost aquifer.

The groundwater samples collected from the 14 wells will be used to monitor and evaluate groundwater quality and demonstrate compliance with the groundwater quality standards listed in 35 I.A.C. § 845.600(a). The proposed monitoring wells will yield groundwater samples that represent the quality of downgradient groundwater at the CCR boundary (as required in 35 I.A.C. § 845.630(a)(2)). Monitoring well depths and construction details are listed in **Table 2-1** and summarized in **Table C** below.

Table C. Proposed Part 845 Monitoring Well Network

Well ID	Monitored Unit	Well Screen Interval (feet bgs)	Well Type [1]
G01D	UA	54.2 – 63.9	Background
G02D	UA	62.2 – 71.8	Background
G03	UA	55.0 – 65.0	Compliance
G05	UA	50.0 – 60.0	Compliance
G06	UA	75.0 – 85.0	Compliance
G07	UA	50.0 – 60.0	Compliance
G08	UA	75.0 – 85.0	Compliance
G09	UA	59.5 – 69.5	Compliance
G10	UA	60.3 – 70.3	Compliance
G11	UA	55.7 – 65.7	Compliance
G51D	UA	49.6 – 53.0	Compliance
G52D	UA	69.9 – 79.6	Compliance
G53D	UA	47.3 – 56.9	Compliance
G54D	UA	70.0 – 79.7	Compliance
XSG01[2,3]	CCR	NA	WLO
SG02[2,3]	Surface Water	NA	WLO

[1] Well type refers to the role of the well in the monitoring network.

[2] Surface water level measuring points.

[3] Location is temporary pending implementation of impoundment closure per an approved Construction Permit Application.

NA = Not Applicable

UA = uppermost aquifer

WLO = water level only

2.3 Well Abandonment

No wells are currently proposed for abandonment.

3. APPLICABLE GROUNDWATER QUALITY STANDARDS

3.1 Groundwater Classification

Groundwater at the EAP meets the definition of Class I - Potable Resource Groundwater (35 I.A.C. § 620.210), based on the following criteria:

- The groundwater is located more than 10 feet bgs and within an unconsolidated silty sand and gravel unit which is five feet or more in thickness and contains less than 12 percent of fines.
- Slug testing results identified a mean hydraulic conductivity of 3.1×10^{-3} centimeters per second (cm/s), which exceeds the 1×10^{-4} cm/s criterion.
- The groundwater does not underlie a previously mined area or a coal mine refuse disposal area.

3.2 Statistical Evaluation of Background Groundwater Data

A Statistical Analysis Plan (**Appendix A**) has been developed to describe procedures that will be used to establish background conditions and implement compliance monitoring as necessary and required by 35 I.A.C. § 845.640 and 35 I.A.C. § 845.650. The Statistical Analysis Plan was prepared in accordance with the requirements of 35 I.A.C. § 845.640(f), with reference to the acceptable statistical procedures provided in United States Environmental Protection Agency's (USEPA) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (*Unified Guidance,* March 2009), and is intended to provide a logical process and framework for conducting the statistical analysis of the data obtained during groundwater monitoring.

In accordance with 35 I.A.C. § 845.640(f)(1), the statistical method chosen for analysis of background groundwater quality was either the tolerance interval or the prediction interval procedure for each constituent listed in 35 I.A.C. § 845.600(a)(1) at this CCR unit per 35 I.A.C. § 845.640(f)(1)(C). A comparison of the statistical background concentrations and groundwater quality standards listed in 35 I.A.C. § 845.600(a)(1) and the resulting GWPSs are summarized in **Table 3-1**.

3.3 Applicable Groundwater Protection Standards

The applicable GWPS will be established in accordance with 35 I.A.C. § 845.600(a) (greater of the background concentration or numerical limit specified in 35 I.A.C. § 845.600(a)(1)). The results of the statistical analysis of background groundwater data (**Table 3-1**) indicate that most background concentrations in the uppermost aquifer are less than the groundwater quality standards listed in 35 I.A.C. § 845.600(a)(1). Therefore, for these parameters, the groundwater quality standards listed in 35 I.A.C. § 845.600(a)(1) will be applied to the results from the proposed groundwater monitoring network. The exception is for pH lower limit, where the background lower limit for pH is less than the 35 I.A.C. § 845.600 standard. Therefore, the GWPS for pH lower limit will be the background measurement.

Under most circumstances, the GWPS will be compared to the lower confidence limit for the observed concentrations for each constituent in each compliance well. Exceptions are when there are high percentages (greater than 50 percent) of non-detects in compliance well data, for which a future mean (for 50 to 70 percent non-detects) or median (for greater than 70 percent non-detects) will be compared to the GWPS. Consistent with the *Unified Guidance*, the same general statistical method of confidence interval testing against a fixed GWPS is recommended in

compliance and corrective action programs. Confidence intervals provide a flexible and statistically accurate method to test how a parameter estimated from a single sample compares to a fixed numerical limit. Confidence intervals explicitly account for variation and uncertainty in the sample data used to construct them.

Evaluation of the applicable standards will occur in conjunction with the analysis of groundwater quality results. Background calculations and the resulting concentrations may be updated as appropriate, in accordance with the Statistical Analysis Plan included in **Appendix A**.

4. GROUNDWATER MONITORING PLAN

The groundwater monitoring plan will monitor and evaluate groundwater quality to demonstrate compliance with the groundwater quality standards included in 40 C.F.R. § 257.94(e), 40 C.F.R. § 257.95(h) and 35 I.A.C. § 845.600(a)(1). The groundwater monitoring program will include sampling and analysis procedures that are consistent and that provide an accurate representation of groundwater quality at the background and compliance wells as required by 35 I.A.C. § 845.630. As discussed in **Section 2**, two monitoring programs specific to the EAP exist: the 40 C.F.R. § 257 monitoring program and the proposed Part 845 monitoring program. These networks will continue to be monitored until USEPA approves Part 845. It is expected that upon USEPA approval of Part 845, the 40 C.F.R. § 257 monitoring program and reporting will be eliminated, and the proposed Part 845 monitoring and reporting included in this Plan will continue until requirements of Part 845 have been achieved.

4.1 Monitoring Networks and Parameters

4.1.1 40 C.F.R. § 257 Groundwater Monitoring

The existing 40 C.F.R. § 257 monitoring program was discussed in detail in **Section 2.1.1**. Six wells (two background and four compliance) are sampled for Appendix III and Appendix IV parameters on a semi-annual frequency. No changes are proposed to this monitoring network. Well locations and parameters will continue to be monitored and reported as required by 40 C.F.R. § 257 until USEPA approves Part 845.

4.1.2 Part 845 Groundwater Monitoring

The proposed Part 845 monitoring network will consist of two background monitoring wells (G01D and G02D), 12 compliance monitoring wells (G03, G05, G06, G07, G08, G09, G10, G11, G51D, G52D, G53D, G54D), and two temporary water level only surface water staff gages (XSG01 and SG02) to monitor potential impacts from the EAP (**Figure 2-1**). These monitoring wells are screened within the uppermost aquifer (G01D, G02D, G03, G05, G06, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D) along the perimeter of the EAP. Groundwater samples will be collected and analyzed for the laboratory and field parameters in **Table D** below.

Table D. Part 845 Groundwater Monitoring Program Parameters

Field Parameters[1]			
Groundwater Elevation	pH	Turbidity	
Metals (Total)			
Antimony	Boron	Cobalt	Molybdenum
Arsenic	Cadmium	Lead	Selenium
Barium	Calcium	Lithium	Thallium
Beryllium	Chromium	Mercury	
Inorganics (Total)			
Fluoride	Sulfate	Chloride	TDS
Other (Total)			
Radium 226 and 228 combined			

[1] Dissolved oxygen, temperature, specific conductivity, and oxidation/reduction potential will be recorded during sample collection.

All parameters listed above were sampled a minimum of eight times by October 18, 2021 to establish background groundwater quality in accordance with 35 I.A.C. § 845.650 (b)(1)(A). Discussion of background groundwater quality is included in **Section 3.2**.

4.2 Sampling Schedule

Groundwater sampling for the Part 845 monitoring well network will initially be performed quarterly according to the following schedule:

Table E. Part 845 Sampling Schedule

Frequency	Duration
Monthly (groundwater elevations only)	Begins: the quarter following approval of this plan and issuance of the Operating Permit.
	Ends: Following the 30-year post closure care period and following IEPA approval of documentation that groundwater concentrations are below standards in 35 I.A.C. § 845.600 and concentrations exceeding background are not increasing and meet requirements in 35 I.A.C. § 845.780 (c)(2)(B)(i) and (ii).
Quarterly (groundwater quality)	Begins: the quarter following approval of this plan and issuance of the Operating Permit.
	Ends: Following the 30-year post closure care period and following IEPA approval of documentation that groundwater concentrations are below standards in 35 I.A.C. § 845.600 and concentrations exceeding background are not increasing and meet requirements in 35 I.A.C. § 845.780 (c)(2)(B)(i) and (ii), or upon IEPA approval of an alternate schedule as allowed by 35 I.A.C. § 845.650(b)(4).
Semi-annual (groundwater quality)	Begins: Following 5 years of quarterly groundwater monitoring and IEPA approval of a demonstration that groundwater concentrations are below standards in 35 I.A.C. § 845.600 and not exhibiting statistically-significant increasing trends, monitoring effectiveness is not compromised by a semi-annual schedule, and sufficient data has been collected to characterize groundwater.
	Ends: Following detection of a statistically-significant increasing trend in groundwater concentrations or an exceedance of the standards in 35 I.A.C. § 845.600 (quarterly monitoring shall be resumed in these circumstances), or following the 30-year post closure care period and following IEPA approval of documentation that groundwater concentrations

	are below standards in 35 I.A.C. § 845.600 and concentrations exceeding background are not increasing and meet requirements in 35 I.A.C. § 845.780 (c)(2)(B)(i) and (ii).

4.3 Groundwater Sample Collection

Groundwater sampling procedures have been developed and the collection of groundwater samples is being implemented to meet the requirements of 35 I.A.C. § 845.640. In addition to groundwater well samples, quality assurance samples will be collected as described in **Section 4.5** (**Table 4-1**).

4.4 Laboratory Analysis

Laboratory analysis will be performed consistent with the requirements of 35 I.A.C. § 845.640(j) by a state-certified laboratory using methods approved by IEPA and USEPA. Laboratory methods may be modified based on laboratory equipment availability or procedures, but the Reporting Limit (RL) for all parameters analyzed, regardless of method, will be lower than the applicable groundwater quality standard. RLs for the applicable parameters are summarized in **Table 4-2**. Concentrations lower than the RL will be reported as less than the RL.

4.5 Quality Assurance Program

Consistent with the requirements of 35 I.A.C. § 845.640(a)(5), the sampling and analysis program includes procedures and techniques for quality assurance/quality control (QA/QC). Additional quality assurance samples to be collected will include the following:

- Field duplicates will be collected at a frequency of one per group of ten or fewer investigative water samples.
- One equipment blank sample will be collected and analyzed for each day of sampling. If dedicated sampling equipment is used, then equipment blank samples will not be collected.
- The duplicate and equipment blank quality assurance samples will be supplemented by the laboratory QA/QC program, which typically includes:
  - Regular generation of instrument calibration curves to assure instrument reliability
  - Laboratory control samples and/or quality control check standards that have been spiked, and analyses to monitor the performance of the analytical method
  - Matrix spike/matrix spike duplicate analyses to determine percent recoveries and relative percent differences for each of the parameters detected
  - Analysis of replicate samples to check the precision of the instrumentation and/or methodology employed for all analytical methods
  - Analysis of method blanks to assure that the system is free of contamination

Water quality meters used to measure pH and turbidity will be calibrated according to manufacturer's specifications. At a minimum, it is recommended that calibration of pH occur daily prior to sampling and checked for accuracy at the end of each day. Unusual or suspect pH measurements during sampling events will be flagged, evaluated, and additional calibration may be performed throughout the sampling events. Turbidity meters will be checked daily, prior to and following sampling. Unusual measurements or erratic meter performance will be flagged and evaluated for overall effects on the data prior to reporting.

4.6 Groundwater Monitoring System Maintenance Plan

Consistent with the requirements of 35 I.A.C. § 845.630(e)(2), maintenance will be performed as needed to assure that the monitoring wells provide representative groundwater samples. Monitoring wells will be inspected during each groundwater sampling event; inspections will consist of the following:

- Visual inspection, clearing of vegetation, replacement of markers, and painting of protective casings as needed to assure that monitoring wells are clearly marked and accessible
- Visual inspection and repair or replacement of well aprons as needed to assure that they are intact, drain water away from the well, and have not heaved
- Visual inspection and repair or replacement of protective casings as needed to assure that they are undamaged, and that locks are present and functional
- Checks to assure that well caps are intact and vented, unless in flood-prone areas in which case caps will not be vented
- Annual measurement of monitoring well depths to determine the degree of siltation within the wells. Wells will be redeveloped as needed to remove siltation from the screened interval if it impedes flow of water into the well
- Checks to assure that wells are clear of internal obstructions, and flow freely

If maintenance of a monitoring well cannot address an identified deficiency, a replacement well will be installed.

4.7 Statistical Analysis

Statistical analysis will be consistent with procedures listed in 35 I.A.C. § 845.640(f). A Statistical Analysis Plan, provided in **Appendix A**, has been developed to summarize the statistical procedures that will be used to evaluate the groundwater results.

4.8 Data Reporting

Data reporting for the 40 C.F.R. § 257 monitoring program will be consistent with recordkeeping, notification, and internet posting requirements described in 40 C.F.R. § 257.105 through 257.107.

Groundwater monitoring and analysis completed in accordance with the Part 845 monitoring under an approved monitoring program will be reported to IEPA within 60 days after completion of sampling and the data placed in the facility's operating record as required by 35 I.A.C. § 845.610(b)(3)(D). Within 14 days of posting to the operating record, information will be posted to the publicly accessible internet site "Illinois CCR Rule Compliance Data and Information" as required by 35 I.A.C. § 845.810(d). Information will also be submitted to IEPA annually by January 31 as required by 35 I.A.C. § 845.550, for data collected the preceding year. The report will include the status of the groundwater monitoring and any required corrective action plan for the EAP in addition to other requirements detailed in 35 I.A.C. § 845.610(e).

4.9 Compliance with Applicable On-site Groundwater Protection Standards

In accordance with 35 I.A.C. § 845.600(a)(1), the groundwater protection standard at the waste boundary will be the higher of either the 35 I.A.C. § 845.600 standard or the concentration determined by background groundwater monitoring.

As provided in 35 I.A.C. § 845.780(c)(2), at the end of the 30-year post-closure care period, groundwater monitoring will continue to be conducted in post-closure care until the groundwater results show the concentrations are:

- Below the GWPS in 35 I.A.C. § 845.600; and
- Not increasing for those constituents over background, using the statistical procedures and performance standards in 35 I.A.C. § 845.640(f) and (g), provided that:
  - Concentrations have been reduced to the maximum extent feasible; and
  - Concentrations are protective of human health and the environment.

Following detection of an exceedance of the GWPS, an Alternate Source Demonstration (ASD) will be evaluated as described in **Section 4.10**.

4.10 Alternate Source Demonstrations

As allowed in 35 I.A.C. § 845.650(e), following detection of an exceedance of the GWPS, an ASD will be evaluated and, if completed, submitted to IEPA within 60 days. The ASD will provide lines of evidence that a source other than the EAP caused the contamination and the EAP did not contribute to the contamination, or that the exceedance of the GWPS resulted from error in sampling, analysis, statistical evaluation, natural variation in groundwater quality, or a change in the potentiometric surface and groundwater flow direction.

The ASD will include information and analysis that supports the conclusions and a certification of accuracy by a qualified professional engineer. Once the ASD is approved by IEPA, the Part 845 groundwater monitoring will continue as defined in **Section 4.1.2**.

If an ASD is not completed and submitted, or IEPA does not approve the ASD, a notification of the exceedance will be provided to IEPA and placed in the operating record. Additional actions will also be completed as required by 35 I.A.C § 845.650(d)(1) through (3), including initiation of an assessment of corrective measures under 35 I.A.C § 845.660. As allowed in 35 I.A.C § 845.650(e)(7) a petition for review of IEPA's non-concurrence under 35 I.A.C. § 105 may also be filed.

4.11 Assessment of Corrective Measures and Corrective Action

As described in 35 I.A.C. § 845.660, if the ASD summarized in **Section 4.10** has not been approved by IEPA, an assessment of corrective measures will be initiated within 90 days of the detection of a result exceeding 35 I.A.C. § 845.600 standards (*i.e.,* receipt of laboratory data). The assessment of corrective measures will include at least the following (35 I.A.C. § 845.660 (c)):

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;
- The time required to begin and complete the corrective action plan; and
- The institutional requirements, such as State or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the corrective action plan.

Within one year of completing the assessment of corrective measures, a corrective action plan will be developed to identify the selected remedy in accordance with 35 I.A.C. § 845.670. If

closure of the CCR Unit is required, a closure alternatives analysis will be completed as specified in 35 I.A.C. § 845.710. The analysis and selected alternative will be submitted to IEPA in a Closure Plan as specified by 35 I.A.C. § 845.720. Groundwater monitoring proposed in this Addendum will continue as specified until the post closure care period has expired and IEPA has approved termination of post-closure care.

5. REFERENCES

Illinois Environmental Protection Agency, 2021. *Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments: Title 35 of the Illinois Administrative Code § 845*, April 15, 2021.

Natural Resource Technology, an OBG Company (NRT/OBG), 2017. *Sampling and Analysis Plan. Joppa East Ash Pond, Joppa Power Station, Joppa Illinois, Project No. 2285, Revision 0,* October 17, 2017.

O'Brien & Gere Engineers, Inc. (OBG), 2010. *Dam Safety Assessment of CCW Impoundments. Joppa Plant, Prepared for: US Environmental Protection Agency, Washington, DC*, September 24, 2010.

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021. *Hydrogeologic Site Characterization Report. East Ash Pond. Joppa Power Plant*. Joppa, Illinois.

United States Environmental Protection Agency (USEPA), March 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance*. Office of Resource Conservation and Recovery, Program Implementation and Information Division, United States Environmental Protection Agency, Washington D.C. EPA/530/R-09/007.

TABLES

TABLE 1-1. PART 845 REQUIREMENTS CHECKLIST
GROUNDWATER MONITORING PLAN
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Part 845 Reference	Part 845 Components	Location of Information in GMP
845.630	**Groundwater Monitoring Systems**	
845.630(a)(2)	Potential contaminant pathways must be monitored.	NA
845.630(a) 845.630(b) 845.630(c)	At least two upgradient wells and four downgradient wells (min. 1 and 3, but requires additional documentation)	Sections 2.2 & 4.1.2 Table 2-1 Figure 2-1
845.630(a) 845.630(b) 845.630(c)	Downgradient Well Density	Figure 2-1
845.630(a)(2)	Downgradient wells at waste boundary	Figure 2-1
845.640	**Groundwater Sampling and Analysis Requirements**	
845.640(a)	Consistent sampling and analysis procedures	Section 4 Tables 4-1 & 4-2
845.640(b)	Methods are appropriate	Section 4 Tables 4-1 & 4-2
845.640(c)	Groundwater elevations must be measured in each well prior to purging, each time groundwater is sampled.	Section 4.3
845.640 (d)(e)(f)(g)(h)	Establishment of background and application of statistical methods	Sections 3.2 & 4.7 Appendix A
845.640(i)	Analyze total recoverable metals	Section 4.1.2
845.640(j)	Analyze groundwater samples using a certified laboratory	Section 4.4

TABLE 1-1. PART 845 REQUIREMENTS CHECKLIST

GROUNDWATER MONITORING PLAN

JOPPA POWER PLANT

EAST ASH POND

JOPPA, ILLINOIS

Part 845 Reference	Part 845 Components	Location of Information in GMP
845.650	**Groundwater Monitoring Program**	
845.650(a)	Must include monitoring for all constituents with a groundwater protection standard in Section 845.600(a), calcium, and turbidity	Section 4.1.2
845.650(b)(c)	Groundwater Monitoring Frequency	Sections 4.1.2 & 4.2
845.650(d)(e)	Exceedances of the groundwater protection standard	Sections 4.9, 4.10 & 4.11
845.650(b)(2) and (3)	Staff gauge/ piezometer to monitor head in impoundment	Sections 2.2 & 4.1.2 Figure 2-1 (XSG01)
NA	Staff gauge/ piezometer to monitor head of neighboring surface water body	Sections 2.2 & 4.1.2 Figure 2-1 (SG02)

[O: CJC 08/17/21; C: LDC 08/30/21]

Notes:

GMP = Groundwater Monitoring Plan

NA = Not Applicable

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS
GROUNDWATER MONITORING PLAN
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well Number	Type	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
G01D	B	UA	08/14/2015	364.19	364.19	Top of Disk	361.50	54.19	63.85	307.31	297.65	64.40	297.10	9.7	2	37.220429	-88.857179
G02D	B	UA	08/13/2015	363.65	363.65	Top of Disk	360.82	62.21	71.84	298.61	288.98	72.40	288.50	9.6	2	37.220715	-88.853311
G03	C	UA	02/02/2021	357.87	357.87	Top of PVC	354.84	55.00	65.00	302.90	292.90	65.00	289.80	10	2	37.220682	-88.850376
G05	C	UA	02/01/2021	361.21	361.21	Top of PVC	358.45	50.00	60.00	311.20	301.20	60.00	298.50	10	2	37.21719	-88.849014
G06	C	UA	01/29/2021	355.24	355.24	Top of PVC	352.60	75.00	85.00	280.20	270.20	85.00	267.60	10	2	37.212929	-88.848893
G07	C	UA	01/29/2021	353.53	353.53	Top of PVC	350.34	50.00	60.00	303.50	293.50	60.00	290.30	10	2	37.211001	-88.848969
G08	C	UA	01/28/2021	343.54	343.54	Top of PVC	341.72	75.00	85.00	268.50	258.50	85.00	256.70	10	2	37.210531	-88.851015
G09	C	UA	01/31/2021	351.70	351.70	Top of PVC	348.69	59.50	69.50	292.20	282.20	69.50	279.20	10	2	37.210336	-88.854116
G10	C	UA	02/01/2021	353.49	353.49	Top of PVC	350.75	60.30	70.30	293.20	283.20	70.30	280.50	10	2	37.211272	-88.855841
G11	C	UA	01/19/2021	366.55	366.55	Top of PVC	363.38	55.70	65.70	310.90	300.90	65.70	297.70	10	2	37.214408	-88.85633
G51D	C	UA	08/18/2015	363.85	363.85	Top of PVC	361.10	49.61	59.27	311.49	301.83	59.90	301.20	9.7	2	37.216016	-88.855653
G52D	C	UA	08/19/2015	348.41	348.41	Top of PVC	345.88	69.85	79.55	276.03	266.33	80.01	265.90	9.7	2	37.209626	-88.852943
G53D	C	UA	08/21/2015	355.47	355.47	Top of PVC	352.16	47.29	56.89	304.87	295.27	57.33	294.20	9.6	2	37.215069	-88.849367
G54D	C	UA	08/11/2015	357.03	357.03	Top of PVC	353.71	69.96	79.66	283.75	274.05	80.14	273.60	9.7	2	37.212264	-88.857485
XSG01	WLO	CCR	--	--	371.78	Staff gauge	--	--	--	--	--	--	--	--	--	37.21517	-88.8498
SG02	WLO	SW	--	--	--	Staff gauge	--	--	--	--	--	--	--	--	--	37.207287	-88.860503

Notes:
All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
Type refers to the role of the well in the monitoring network: background (B), compliance (C), or water level measurements only (WLO)
WLO wells are temporary pending implementation of impoundment closure per an approved Construction Permit application
-- = data not available
BGS = below ground surface
CCR = Coal Combustion Residual
ft = foot or feet
HSU = Hydrostratigraphic Unit
PVC = polyvinyl chloride
SW = surface water
UA = uppermost aquifer

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TABLE 3-1. BACKGROUND GROUNDWATER QUALITY AND STANDARDS
GROUNDWATER MONITORING PLAN
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Parameter	Background Concentration	845 Limit	Groundwater Protection Standard	Unit
Antimony, total	0.001	0.006	0.006	mg/L
Arsenic, total	0.0017	0.010	0.010	mg/L
Barium, total	0.248	2.0	2.0	mg/L
Beryllium, total	0.0011	0.004	0.004	mg/L
Boron, total	0.0511	2	2	mg/L
Cadmium, total	0.001	0.005	0.005	mg/L
Chloride, total	31	200	200	mg/L
Chromium, total	0.0037	0.1	0.1	mg/L
Cobalt, total	0.0015	0.006	0.006	mg/L
Fluoride, total	0.25	4.0	4.0	mg/L
Lead, total	0.0015	0.0075	0.0075	mg/L
Lithium, total	0.003	0.04	0.04	mg/L
Mercury, total	0.0002	0.002	0.002	mg/L
Molybdenum, total	0.0015	0.1	0.1	mg/L
pH (field)	6.8 / 6.0	9.0 / 6.5	9.0 / 6.0	SU
Radium 226 and 228 combined	1.7	5	5	pCi/L
Selenium, total	0.0041	0.05	0.05	mg/L
Sulfate, total	39	400	400	mg/L
Thallium, total	0.002	0.002	0.002	mg/L
Total Dissolved Solids	332	1200	1200	mg/L

Notes:
For pH, the values presented are the upper / lower limits
Groundwater protection standards for calcium and turbidity do not apply per 35 I.A.C. § 845.600(b)
mg/L = milligrams per liter
SU = standard units
pCi/L = picocuries per liter

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TABLE 4-1. SAMPLING AND ANALYSIS SUMMARY
GROUNDWATER MONITORING PLAN
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Parameter	Analytical Method [1]	Number of Samples	Field Duplicates [2]	Field Blanks [3]	Equipment Blanks [3]	MS/MSD [4]	Total	Container Type	Minimum Volume [5]	Preservation (Cool to 4 °C for all samples)	Sample Hold Time from Collection Date
Metals											
Metals [6]	6020, Li - EPA 200.7	14	2	0	0	1	17	plastic	600 mL	HNO_3 to pH<2	6 months
Mercury	7470A or 6020	14	2	0	0	1	17	plastic	400 mL	HNO_3 to pH<2	28 days
Inorganic Parameters											
Fluoride	9214 or EPA 300	14	2	0	0	1	17	plastic	300 mL	Cool to 4 °C	28 days
Chloride	9251 or EPA 300	14	2	0	0	1	17	plastic	100 mL	Cool to 4 °C	28 days
Sulfate	9036 or EPA 300	14	2	0	0	1	17	plastic	50 mL	Cool to 4 °C	28 days
Total Dissolved Solids	SM 2540 C	14	2	0	0	1	17	plastic	200 mL	Cool to 4 °C	7 days
Radium											
Radium 226	9315 or EPA 903	14	0	0	0	0	14	plastic	1000 mL	HNO_3 to pH<2	6 months
Radium 228	9320 or EPA 904	14	0	0	0	0	14	plastic	1000 mL	HNO_3 to pH<2	6 months
Field Parameters											
pH	SM 4500-H+ B	14	NA	NA	NA	NA	14	flow-through cell	NA	none	immediately
Dissolved Oxygen [8]	SM 4500-O/405.1	14	NA	NA	NA	NA	14	flow-through cell	NA	none	immediately
Temperature [8]	SM 2550	14	NA	NA	NA	NA	14	flow-through cell	NA	none	immediately
Oxidation/Reduction Potential [8]	SM 2580 B	14	NA	NA	NA	NA	14	flow-through cell	NA	none	immediately
Specific Conductance [8]	SM 2510 B	14	NA	NA	NA	NA	14	flow-through cell	NA	none	immediately
Turbidity [7]	SM 2130 B	14	NA	NA	NA	NA	14	flow-through cell or hand-held turbidity meter	NA	none	immediately

[O: CJC 08/17/21; C: LDC 08/30/21]

Notes:

[1] Analytical method numbers are from SW-846 unless otherwise indicated. Analytical methods may be updated with more recent versions as appropriate.
[2] Field duplicates will be collected at a frequency of one per group of 10 or fewer investigative water samples. Field duplicates will not be collected for radium analysis.
[3] Field blanks will be collected at the discretion of the project manager; Equipment blanks will be collected at a rate of 1 per sampling event if non-dedicated equipment is used.
[4] Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples will be collected at a frequency of one per group of 20 or fewer investigative water samples per CCR unit/multi-unit. Additional volume to be determined by laboratory.
[5] Sample volume is estimated and will be determined by the laboratory.
[6] Metals = antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, lead, lithium, molybdenum, selenium, thallium. Metals may be analyzed via ICP/ ICP-MS USEPA methods 6010 or 6020 depending on laboratory instrument availability.
[7] If turbidity exceeds 10 NTUs, a duplicate sample filtered through a .45 micron filter may be collected for metals analysis in addition to the unfiltered sample. Both samples would be submitted for analysis.
[8] Parameter collected for quality assurance and quality control for field sampling purposes only; not required to be collected or reported under Part 845; collection of parameter may be discontinued without notification.
< = less than
°C = degrees Celsius
HNO_3 = nitric acid
mL = milliliter
NA = not applicable
NTU = nephelometric turbidity unit

TABLE 4-2. DETECTION AND REPORTING LIMITS FOR PART 845 PARAMETERS

GROUNDWATER MONITORING PLAN

JOPPA POWER PLANT

EAST ASH POND

JOPPA, ILLINOIS

Constituent	CAS	Unit	Analytical Methods [1]	USEPA MCL [2]	35 I.A.C. § 845.600	RL [4, 5]	MDL [5]
Metals							
Antimony	7440-36-0	mg/L	6020	0.006	0.006	0.003	0.00036
Arsenic	7440-38-2	mg/L	6020	0.01	0.01	0.001	0.00013
Barium	7440-39-3	mg/L	6020	2	2	0.001	0.00028
Beryllium	7440-41-7	mg/L	6020	0.004	0.004	0.001	0.000017
Boron	7440-42-8	mg/L	6020	NS	2	0.01	0.0023
Cadmium	7440-43-9	mg/L	6020	0.005	0.005	0.001	0.000042
Calcium	7440-70-2	mg/L	6020	NS	NS	0.15	0.15
Chromium	7440-47-3	mg/L	6020	0.1	0.1	0.004	0.00027
Cobalt	7440-48-4	mg/L	6020	0.006	0.006	0.002	0.000017
Lead	7439-92-1	mg/L	6020	0.015	0.0075	0.001	0.000025
Lithium	7439-93-2	mg/L	6020 or EPA 200.7	0.04	0.04	0.02	0.0001
Mercury	7439-97-6	mg/L	6020 or 7470A	0.002	0.002	0.0002	0.000078
Molybdenum	7439-98-7	mg/L	6020	0.1	0.1	0.001	0.000063
Selenium	7782-49-2	mg/L	6020	0.05	0.05	0.001	0.00032
Thallium	7440-28-0	mg/L	6020	0.002	0.002	0.001	0.000062
Inorganics							
Fluoride	7681	mg/L	9214 or EPA 300	4	4	0.25	0.065
Chloride	16887-00-6	mg/L	9251 or EPA 300	250 [3]	200	1	0.15
Sulfate	18785-72-3	mg/L	9036 or EPA 300	250 [3]	400	1	0.24
Total Dissolved Solids	10052	mg/L	SM 2540C	500 [3]	1200	17	--
Other							
Radium 226 and 228 combined	7440-14-4	pCi/L	9315/9320 or EPA 903/904	5	5	-- [6]	-- [7]

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TABLE 4-2. DETECTION AND REPORTING LIMITS FOR PART 845 PARAMETERS

GROUNDWATER MONITORING PLAN

JOPPA POWER PLANT

EAST ASH POND

JOPPA, ILLINOIS

Constituent	CAS	Unit	Analytical Methods [1]	USEPA MCL [2]	35 I.A.C. § 845.600	RL [4, 5]	MDL [5]
Field							
pH	NA	SU	SM 4500-H+ B	NS	6.5-9.0	NA	NA
Oxidation/Reduction Potential	NA	mV	SM 2580 B	NS	NS	NA	NA
Dissolved Oxygen	NA	mg/L	SM 4500-O/405.1	NS	NS	NA	NA
Temperature	NA	°C	SM 2550	NS	NS	NA	NA
Specific Conductivity	NA	µS/cm	SM 2510 B	NS	NS	NA	NA
Turbidity	NA	NTU	SM 2130 B	NS	NS	NA	NA

[O: CJC 08/17/21; C: LDC 08/30/21]

Notes:

[1] Analytical method numbers are from SW-846 unless otherwise indicated. Metals will be analyzed via Method 6020 or 6010 depending on laboratory equipment availability. Selected method will ensure reporting limits (RL) are below Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845.600 groundwater protection standards.

[2] USEPA MCL = United States Environmental Protection Agency Maximum Contaminant Level.

[3] USEPA SMCL = United States Environmental Protection Agency Secondary Maximum Contaminant Level.

[4] RLs will be less than the 35 I.A.C. § 845.600 groundwater protection standards.

[5] RLs and method detection limits (MDL) will vary depending on the laboratory performing the work.

[6] All radium results will be reported (values may be positive or negative) and will include uncertainty and the calculated MDC.

[7] Laboratories calculate a minimum detectable concentration (MDC) based on the sample.

°C = degrees Celsius

µS/cm = microSiemens per centimeter

CAS = Chemical Abstract Number

MDL = Method detection limit as established by the laboratory

mg/L = milligrams per liter

mV = millivolts

NS = No standard

NTU = nephelometric turbidity unit

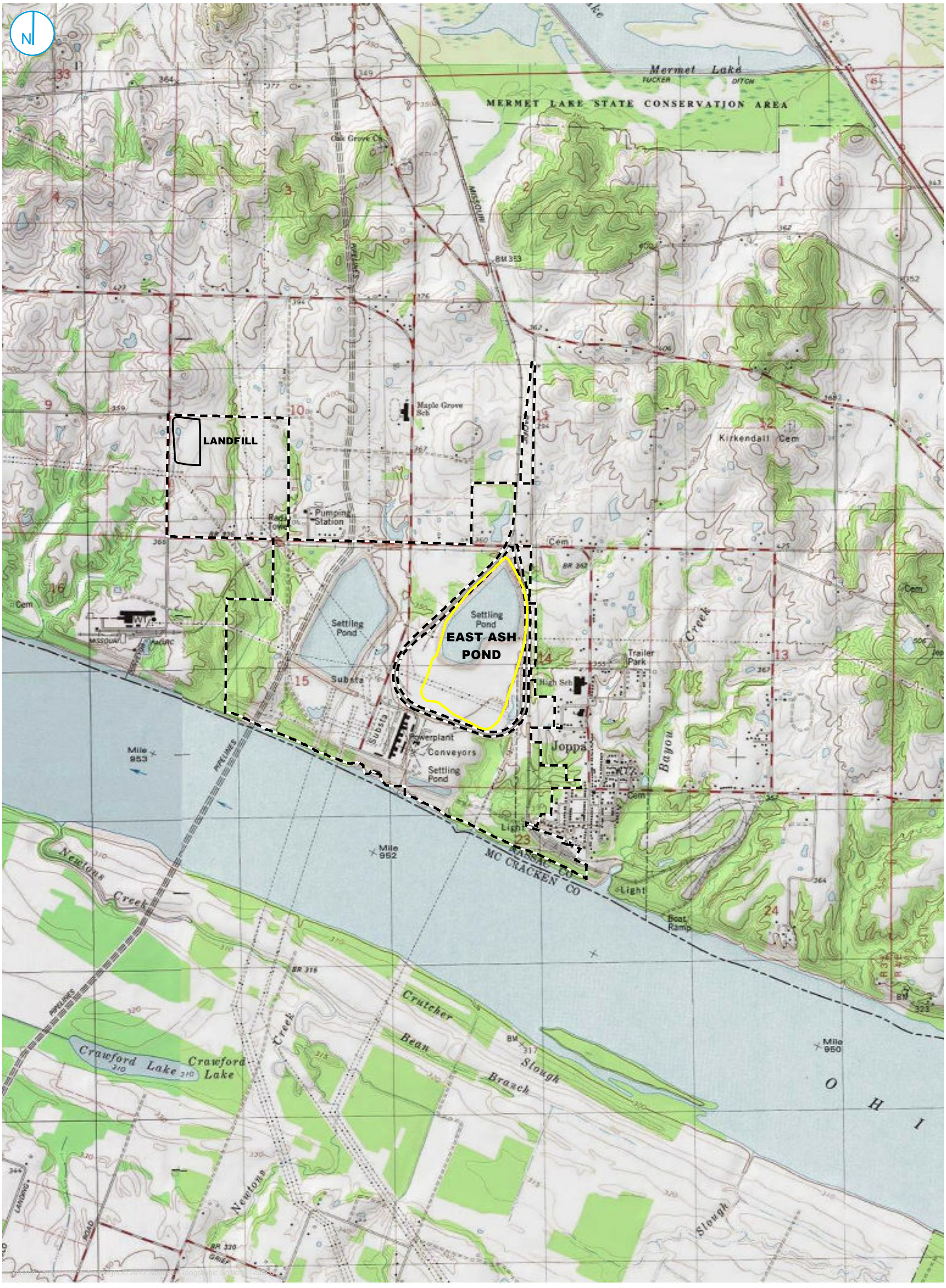
pCi/L = picoCuries per liter

RL = Reporting limit as established by the laboratory

SM = Standard Methods for the Examination of Water and Wastewater

SU = standard units

FIGURES



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PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY

0 1,000 2,000 Feet

SITE LOCATION MAP

GROUNDWATER MONITORING PLAN
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 1-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\845_Operating_PermitJoppa\GMP\Figure 1-2_Site Map.mxd

PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
CENTRAL DIKE
PROPERTY BOUNDARY

0 375 750 Feet

PROJECT: 169000XXXX | DATED: 10/15/2021 | DESIGNER: HOTCALD

SITE MAP

GROUNDWATER MONITORING PLAN
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

MONITORING WELL
STAFF GAUGE
GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 200 400 Feet

NOTES:
1.ELEVATIONS IN PARENTHESIS WERE NOT USED FOR CONTOURING.
2. ELEVATIONS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988

UPPERMOST AQUIFER GROUNDWATER ELEVATION CONTOURS MARCH 3 AND 4, 2021

GROUNDWATER MONITORING PLAN
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 1-3

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

COMPLIANCE WELL
BACKGROUND WELL
STAFF GAUGE
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 200 400 Feet

PROPOSED PART 845 GROUNDWATER MONITORING WELL NETWORK

GROUNDWATER MONITORING PLAN
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

APPENDIX A
STATISTICAL ANALYSIS PLAN

Prepared for
Electric Energy, Inc.

Date
October 25, 2021

Project No.
1940100806-006

STATISTICAL ANALYSIS PLAN

EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL Bright ideas. Sustainable change.

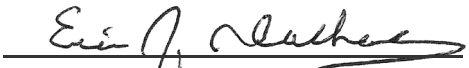
STATISTICAL ANALYSIS PLAN
JOPPA POWER PLANT EAST ASH POND

Project Name	**Joppa Power Plant East Ash Pond**
Project No.	**1940100806-006**
Recipient	**Electric Energy, Inc.**
Document Type	**Statistical Analysis Plan**
Version	**FINAL**
Date	**October 25, 2021**

Ramboll
234 W. Florida Street
Fifth Floor
Milwaukee, WI 53204
USA

T 414-837-3607
F 414-837-3608
https://ramboll.com

Brian G. Hennings, PG
Senior Managing Hydrogeologist



Eric J. Tlachac, PE
Senior Managing Engineer

Rachel A. Banoff, EIT
Project Statistician

LICENSED PROFESSIONAL CERTIFICATIONS

This certification is based on the description of the statistical methods selected to evaluate groundwater as presented in the following Statistical Analysis Plan; Joppa Power Plant East Ash Pond. The procedures described in the plan will be used to establish background conditions and implement compliance monitoring as necessary and required by 35 I.A.C. § 845.640 and 35 I.A.C. § 845.650. The Statistical Analysis Plan was prepared in accordance with the requirements of 35 I.A.C. § 845.640(f), with reference to the acceptable statistical procedures provided in the United States Environmental Protection Agency (USEPA)'s *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (*Unified Guidance,* March 2009), and is intended to provide a logical process and framework for conducting the statistical analysis of the data obtained during groundwater monitoring. In accordance with 35 I.A.C. § 845.640(f)(1), the statistical method chosen for analysis of background groundwater quality will be either the tolerance interval or the prediction interval procedure for each constituent listed in 35 I.A.C. § 845.600(a)(1) at this CCR unit per 35 I.A.C. § 845.640(f)(1)(C). Groundwater Protection Standards (GWPS) will be established in accordance with 35 I.A.C. § 845.600(a) (greater of the background concentration or numerical limit specified in 35 I.A.C. § 845.600(a)(1)). The GWPS will be compared to the lower confidence limit for the observed concentrations for each constituent in each compliance well. Consistent with the *Unified Guidance*, the same general statistical method of confidence interval testing against a fixed GWPS is recommended in compliance and corrective action programs. Confidence intervals provide a flexible and statistically accurate method to test how a parameter estimated from a single sample compares to a fixed numerical limit. Confidence intervals explicitly account for variation and uncertainty in the sample data used to construct them.

Description of the statistical methods chosen for analysis of groundwater monitoring data and application of these methods for determining exceedances of the GWPS identified in 35 I.A.C. § 845.600(a) is provided in this Statistical Analysis Plan.

35 I.A.C. § 845.640 Statistical Analysis (PE)

I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the statistical methods summarized above and described in this document (Statistical Analysis Plan; Joppa Power Plant East Ash Pond) are appropriate for evaluating the groundwater monitoring data collected as described in the attached document and are in substantial compliance with 35 I.A.C. § 845.640.

Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
Date: October 25, 2021

35 I.A.C. § 845.640 Statistical Analysis (PG)

I, Brian G. Hennings, a qualified professional geologist in good standing in the State of Illinois, certify that the statistical methods described in this document (Statistical Analysis Plan; Joppa Power Plant East Ash Pond) are appropriate for evaluating the groundwater monitoring data collected as described in the attached document and are in substantial compliance with 35 I.A.C. § 845.640.

Brian G. Hennings
Professional Geologist
196.001482
Illinois
Date: October 25, 2021

35 I.A.C. § 845.640 Statistical Analysis

I, Rachel A. Banoff, a qualified professional, certify that the statistical methods described in this document (Statistical Analysis Plan; Joppa Power Plant East Ash Pond), are appropriate for evaluating the groundwater monitoring data collected as described in the attached document and are in substantial compliance with 35 I.A.C. § 845.640.

Rachel A. Banoff, EIT
Project Statistician
Date: October 25, 2021

CONTENTS

Licensed Professional Certifications		**2**
1.	**Introduction**	**6**
1.1	Statistical Analysis Objectives	6
1.2	Statistical Analysis Plan Approach	6
2.	**Background Monitoring and Data Preparation**	**8**
2.1	Sample Independence	8
2.2	Non-Detect Data Processing	9
2.3	Testing for Normality	9
2.4	Testing for Outliers	9
2.5	Trend Analysis	10
2.6	Spatial Variation	10
2.7	Temporal Variation	10
2.8	Updating Background	11
3.	**Compliance Monitoring**	**13**
3.1	GWPS Establishment and Exceedance Determination	13
3.1.1	The Upper Tolerance Limit	14
3.1.2	Parametric Confidence Intervals around a Mean	16
3.1.3	Non-Parametric Confidence Intervals around a Median	16
3.1.4	The Upper Prediction Limit for a Future Mean	17
3.1.5	The Non-Parametric Upper Prediction Limit for a Future Median	17
3.1.6	Parametric Linear Regression and Confidence Band	18
3.1.7	Non-Parametric Thiel-Sen Trend Line and Confidence Band	20
3.2	Determination of Statistically Significant Increases over Background	21
4.	**References**	**22**

TABLES (IN TEXT)

Table A Statistical Calculations Used in Compliance Monitoring Procedures

ACRONYMS AND ABBREVIATIONS

§	Section
35 I.A.C.	Title 35 of the Illinois Administrative Code
ANOVA	analysis of variance
CCR	coal combustion residuals
COC	constituents of concern
GWPS	groundwater protection standard
IEPA	Illinois Environmental Protection Agency
LCL	lower confidence limit
LTL	lower tolerance limit
MSE	mean squared error
P	probability
Part 845	Residuals in Surface Impoundments: Title 35 of the Illinois Administrative Code § 845
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
ROS	regression on order statistics
SI	surface impoundment
SSI	statistically significant increase
SWFPR	site-wide false positive rate
Unified Guidance	*Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (USEPA, 2009)
UPL	upper prediction limit
USEPA	United States Environmental Protection Agency
UTL	upper tolerance limit

1. INTRODUCTION

In April 2021, the Illinois Environmental Protection Agency (IEPA) issued a final rule for the regulation and management of Coal Combustion Residuals (CCR) in surface impoundments (SIs) under the Standards for the Disposal of CCR in Surface Impoundments: Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845 (Part 845). Facilities regulated under Part 845 are required to develop and sample a groundwater monitoring well network to evaluate whether impounded CCR materials are impacting downgradient groundwater quality. The groundwater quality evaluation must include selection and certification by a qualified professional engineer of the statistical procedures to be used. The procedures described in the evaluation will be used to establish background conditions and implement compliance and corrective action monitoring as necessary and required by 35 I.A.C. § 845.640 and 35 I.A.C. § 845.650. This Statistical Analysis Plan was prepared in accordance with the requirements of 35 I.A.C. § 845.640(f), with reference to the acceptable statistical procedures provided in United States Environmental Protection Agency's (USEPA's) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (*Unified Guidance*) (March 2009).

This Statistical Analysis Plan does not include procedures for groundwater sample collection and analysis, as these activities are conducted in accordance with the Sampling and Analysis Plan prepared for each CCR unit in accordance with 35 I.A.C. § 845.640. This Statistical Analysis Plan will be used as the primary reference for evaluating groundwater quality during operation and post-closure care.

1.1 Statistical Analysis Objectives

This Statistical Analysis Plan is intended to provide a logical process and framework for conducting the statistical analyses of data obtained during groundwater monitoring conducted in accordance with the Sampling and Analysis Plan for each CCR unit. The Statistical Analysis Plan will enable a qualified professional engineer to certify that the selected statistical methods are appropriate for evaluating the groundwater monitoring data for the applicable CCR unit(s).

1.2 Statistical Analysis Plan Approach

The main sections of this Statistical Analysis Plan should be viewed as a "generic" outline of statistical methods utilized for each CCR unit and constituent required to be monitored. The statistical analysis of the groundwater monitoring data, however, will be conducted on an individual-constituent or well basis, and may involve the use of appropriate statistical procedures depending on multiple factors such as detection frequency and normality distributions.

The CCR Rule outlines two phases of groundwater monitoring:

- Background Monitoring in accordance with 35 I.A.C. § 845.650(b)(1)
- Compliance Monitoring in accordance with 35 I.A.C. § 845.650

Each phase of the groundwater monitoring program requires specific statistical procedures to accomplish the intended purpose. During the background monitoring phase, background groundwater quality will be established utilizing upgradient and background wells and downgradient groundwater quality data will be collected to facilitate statistics in subsequent phases. Compliance Monitoring is then initiated through the evaluation of the downgradient

groundwater monitoring data for exceedances of the groundwater protection standard (GWPS) established by Part 845 (concentration specified in 35 I.A.C. § 845.600 or an IEPA-approved background concentration). The developed statistical analysis plan will be implemented for each monitoring phase and in accordance with the statistical procedures.

2. BACKGROUND MONITORING AND DATA PREPARATION

The background and compliance monitoring wells were sampled and analyzed for constituents, as listed in Part 845 (antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, fluoride, lead, lithium, mercury, molybdenum, pH, radium 226 and 228 combined, selenium, sulfate, thallium, total dissolved solids, and turbidity), during the baseline phase of the groundwater monitoring program.

The background monitoring well(s) were placed upgradient of the CCR unit, or at an alternative background location, where they are not affected by potential leakage from the CCR unit. Compliance monitoring wells were placed at the waste boundary of the CCR unit, along the same groundwater flow path. As 35 I.A.C. § 845.630(a) specifies, the location of these wells ensures that background accurately represents the quality of unaffected groundwater, while compliance wells accurately represent groundwater quality at the waste boundary and monitor all potential contaminant pathways.

As required by 35 I.A.C. § 845.650(a)(1), eight sampling events were completed within 180 days of April 21, 2021. As outlined, groundwater sampling procedures included sampling of the background and compliance wells using low-flow sampling methods, collection of one field quality control sample per event, and groundwater samples were not field filtered before laboratory analysis of total recoverable metals.

Following completion of the eight sampling events, background groundwater quality was established for Part 845 constituents. Groundwater monitoring will be conducted quarterly for at least the first five years. In accordance with 35 I.A.C. § 845.650(b)(4), after the first five years, a request to reduce the monitoring frequency to semiannual may be submitted to IEPA if all of the following can be demonstrated:

- Groundwater monitoring effectiveness will not be compromised by the reduced frequency
- Sufficient data has been collected to characterize groundwater
- Monitoring to date does not show any statistically significant increasing trends
- The concentrations of monitored constituents at the compliance monitoring wells are below the applicable GWPSs established in 35 I.A.C. § 845.600

The following subsections outline the statistical tests and procedures (methods) that will be utilized to evaluate data collected for each constituent in both background and compliance wells for Background and Compliance Monitoring. When necessary and contingent upon equivalent statistical power, an alternative test not included in this Statistical Analysis Plan may be chosen due to site-specific data requirements.

2.1 Sample Independence

Independence of sample results is a major assumption for most statistical analyses. To ensure physical independence of groundwater sampling results, the minimum time between sampling events must be longer than the time required for groundwater to move through the monitoring well. The sampling schedules for both the baseline and compliance monitoring periods are specified in 35 I.A.C. § 845.650(b) and may conflict with the statistical assumption of independence of sample results.

2.2 Non-Detect Data Processing

The reporting limit (RL) will be used as the lower level for the reporting of non-detected groundwater quality data. For all summary statistics (box plots, timeseries, etc.), the RL will be substituted for concentrations reported below the RL, including non-detects. With professional judgement, analytical results between the RL and the method detection limit, *i.e.,* estimated values, typically identified with a "J" flag, may be utilized if provided by the laboratory.

For all statistical test procedures:

- If the frequency of non-detect data are less than or equal to 15 percent, half of the RL will be substituted for these data
- If the non-detect frequency is between 15 percent and 50 percent, either the Kaplan-Meier or robust regression on order statistics (ROS) will be used to estimate the mean and standard deviation adjusted for the presence of left-censored values
- If the non-detect frequency is greater than 50 percent, a non-parametric test will be used
- If only one background result is detected that value will be used as the non-parametric upper prediction limit (UPL)

2.3 Testing for Normality

Many statistical analyses assume that sample data are normally distributed (parametric). However, environmental data are frequently not normally distributed (nonparametric). 35 I.A.C. § 845.640(g) requires the knowledge of the background data distribution for comparison to compliance results. The *Unified Guidance* document recommends the Shapiro-Wilk normality test for sample sizes of 50 or less, and the Shapiro-Francia normality test for sample sizes greater than 50.

When possible, transformation of datasets to achieve normal distributions is preferred.

2.4 Testing for Outliers

Part 845 constituents will be screened for the existence of outliers using a method described by the *Unified Guidance*. Outliers are extreme data points that may represent an anomaly or erroneous data point. To test for outliers, one or more of the following outlier tests will be utilized:

- Dixon's test, for well-constituent pairs with less than 25 samples, assumes normally distributed data.
- Rosner's test, for well-constituent pairs with more than 20 samples, assumes normally distributed data.
- Grubb's test for well-constituent pairs with seven or more samples, assumes normally distributed data.
- Time series, box-whisker plots, and probability plots provide visual tools to identify potential outliers, and evaluation of seasonal, spatial, or temporal variability for both normally and non-normally distributed data.

Data quality control, groundwater geochemistry, and sampling procedures will be evaluated as potential sources of error leading to an outlier result. The outlier tests cannot be used alone to determine whether a value is a true outlier that should be excluded from future statistical

analysis. Corroborating evidence needed to exclude values includes a discrete data reporting or analytical error, or potential laboratory bias. Absent corroborating evidence, the flagged values are considered true, but extreme, values in the data set. Professional judgement will be used to exclude extreme outliers from further statistical analyses. Outliers will be retained in the database.

With professional judgement, a confirmatory sample may be collected to allow for the distinction between an outlier and a true representation of groundwater quality at the monitoring point. If re-sampling is conducted, this sample will be collected within 90 days following outlier identification. If the confirmatory sample indicates the original result as an outlier, it will be reported as such.

2.5 Trend Analysis

Statistical analyses supporting the lack of trend are a fundamental step to confirm the assumption that groundwater quality values are stationary or constant over time at a CCR unit. These analyses allow for evaluation of variation in the background and compliance data for each constituent over time. A statistically significant increasing trend in background data could indicate an existing release from the CCR unit or alternate source, requiring further investigation. In addition, statistically significant trending background data can result in increased standard deviation and, therefore, greater prediction or control limits. Consequently, the increased prediction or control limit will have less power or ability to identify a release from the CCR unit.

A linear regression, coupled with a t-test for slope significance at a 95 percent confidence level (0.05 significance level), may be used on datasets for each constituent with few non-detects and a normally distributed variance of the mean to evaluate time trends. The Theil-Sen trend line, coupled with the Mann-Kendall test for slope significance at a 95 percent confidence level (0.05 significance level), will be used for datasets with frequent non-detects or non-normal variance. Similarly, trend analyses could also be used on compliance data to evaluate a possible release from the CCR unit.

2.6 Spatial Variation

Spatial trends and/or variation between background wells could indicate an existing release from a CCR unit. If the spatial variability is not due to an existing release, intrawell comparisons in compliance wells may be used to account for spatial variability and monitor for a future release. However, the CCR unit being monitored was placed into service prior to the start of groundwater monitoring and it is unknown whether a previous release has occurred. Accordingly, intrawell comparisons in compliance wells cannot be used to determine the occurrence of a future release. Interwell comparisons between compliance wells and background wells will be used.

2.7 Temporal Variation

Time series plots can be used to identify temporal dependence. Potentially significant temporal components of variability can be identified by graphing single constituent data from multiple wells together on a time series plot. With temporal dependence, the time series plot as a pattern of parallel traces, in which the individual wells will tend to rise and fall together across the sequence of sampling dates. Time series plots can be helpful by plotting multiple constituents over time for the same well, or averaging values for each constituent across wells on each sampling event and then plotting the averages over time. In either case, the plots can signify whether the general concentration pattern over time is simultaneously observed for different

constituents. If so, it may indicate that a group of constituents is highly correlated in groundwater or that the same artifacts of sampling and/or lab analysis impacted the results of several monitoring parameters.

Hydrologic factors such as drought, recharge patterns or regular (*e.g.,* seasonal) water table fluctuations may be responsible for the temporal variation. In these cases, it may be useful to test for the presence of a significant temporal effect by first constructing a parallel time series plot and then running a formal one-way analysis of variance (ANOVA) ($\alpha = 0.05$) for temporal effects. A one-way ANOVA for temporal effects considers multiple well data sets for individual sampling events or seasons as the relevant statistical factor. If event-specific analytical differences or seasonality appear to be an important temporal factor, the one-way ANOVA for temporal effects can be used to formally identify seasonality, parallel trends, or changes in lab performance that affect other temporal effects. The one-way ANOVA for temporal effects assumes that the data groups are normally distributed with constant variance. It is also assumed that for each of a series of background wells, measurements are collected at each well on sampling events or dates common to all the wells. Results of the ANOVA can also be used to create temporally stationary residuals, where the temporal effect has been 'subtracted from' the original measurements. These stationary residuals may be used to replace the original data in subsequent statistical testing.

If the data cannot be normalized, a similar test for a temporal or seasonal effect can be performed using the Kruskal-Wallis test ($\alpha = 0.05$). Each sampling event should be treated as a separate 'well,' while each well is treated as a separate 'sampling event.' In this case, no residuals can be computed since the Kruskal-Wallis test employs ranks of the data rather than the measurements themselves.

Where both spatial and temporal variation occur, two-way ANOVA can be considered where both well location and sampling event/season are treated as statistical factors. This procedure is described in Davis (1994).

2.8 Updating Background

Updating the background dataset periodically by adding recent results to an existing background dataset can improve the statistical power and accuracy of the statistical analysis, especially for non-parametric prediction intervals. The *Unified Guidance* recommends updating statistical limits (background) when at least four to eight new measurements (every 1 to 2 years under a quarterly monitoring program), are available for comparison to historical data. Professional judgement will be used to evaluate whether any background data appear to be affected by a release and need to be excluded from a background update. A t-test for equal means (if normal data distribution) or appropriate non-parametric test (if non-normal data distribution) such as a Mann-Whitney (or Wilcoxon) rank-sum or box-whisker plots, will be conducted to evaluate whether the two groups of background sample populations are statistically different prior to updating any background datasets. A 0.05 significance level will be utilized when evaluating the two populations, with the null hypothesis that they are equivalent. In addition, time series graphs or other trend evaluation statistics will be conducted on the new background dataset to verify the absence of a release or changing groundwater quality. If the tests indicate that there are no statistical differences between the two background populations, the new data will be combined with the existing dataset. If the two populations are found to be different, the data will be reviewed to evaluate the cause of the difference. If the differences appear to be caused by a

release (if the new data are significantly higher, or lower for pH), then the previous background dataset may continue to be used. Furthermore, verified outliers will not be added to an existing background dataset. In accordance with the *Unified Guidance*, continual background updates will not be conducted due to the lack of sufficient samples for a statistical comparison.

3. COMPLIANCE MONITORING

Compliance monitoring is designed to monitor groundwater for evidence of a release by comparing Part 845 constituents in compliance wells to both background concentrations and the GWPS. Compliance Monitoring will begin the quarter following approval of this Groundwater Monitoring Plan and issuance of the Operating Permit. The selected Compliance Monitoring statistical method used to compare compliance groundwater quality data for each constituent to the GWPS will provide for adequate statistical power, error levels and individual test false positive rates, and be appropriate for the distribution and detection frequency of the background dataset. Statistical power is the ability of a statistical test to detect a true exceedance.

In accordance with 35 I.A.C. § 845.610(b)(3)(D), compliance monitoring statistical analyses will be completed and submitted to IEPA within 60 days after completion of sampling.

3.1 GWPS Establishment and Exceedance Determination

In accordance with 35 I.A.C. § 845.600(a), the GWPS will be the constituent concentrations specified in 35 I.A.C. § 845.600(a)(1) except for when the background concentration is greater, or no concentration is specified (*i.e.,* for calcium and turbidity), in which case the GWPS will be the background concentration. The GWPS based on background concentration will be calculated using a parametric upper tolerance limit (UTL), a parametric UPL for a future mean, or a non-parametric UPL for a future median.

Statistical calculations that will be utilized in Compliance Monitoring procedures are summarized in **Table A** below and listed in **Sections 3.1.1** through **3.1.7**. Depending on the distribution of the data and the percentage of non-detects, it may be more appropriate to use a parametric model over a non-parametric model. As necessary, other techniques as mentioned in the *Unified Guidance* and/or new methods will be implemented.

Table A. Statistical Calculations Used in Compliance Monitoring Procedures

Compliance Monitoring						
Significant Trend?	Background Data			Compliance Data		
	Percent Non-Detects	Distribution	GWPS Determination	Percent Non-Detects	Distribution	Method to Determine Exceedance
No	0 ≤ 50	Normal	35 I.A.C § 845.600(a)(1) constituent concentration or The Upper Tolerance Limit	≤75	Normal	Parametric Lower Confidence Limit around a Normal Mean
				≤75	Log-Normal	Parametric Lower Confidence Limit around a Lognormal Geometric Mean
				NA	Non-Normal	Non-Parametric Lower Confidence Limit around a Median
				>75	Unknown/ Cannot be determined	
	50 ≤ 70	Normal	The Upper Prediction Limit for a Future Mean	NA	NA	Future mean
	>70	Non-Normal	Upper Prediction Limit for a Future Median	NA	NA	Future median
	100	Non-Normal	Double Quantification Rule	NA	NA	Individual Retesting Values
Yes	0 ≤ 50	Normal	UCL of Confidence Band around Linear Regression	≤75	Residuals after subtracting trend are normal, equal variance	Lower Limit from Confidence Band around Linear Regression
	50 ≤ 100	Non-Normal	UCL of Confidence Band around Thiel-Sen trend line	≤75	Residuals not normal	Lower Limit from Confidence Band around Thiel-Sen

3.1.1 The Upper Tolerance Limit

The UTL will be used to calculate the GWPS when pooled background data are normally distributed, with a non-detect frequency of 50 percent or less. When non-detect frequency is 15 percent or less, half the RL will be substituted for non-detects. The *Unified Guidance* recommends 95 percent confidence level and 95 percent coverage (95/95 tolerance interval).

- When non-detect frequency is 15 percent or less, half the RL will be substituted for non-detects (simple substitution), and the normal mean and standard deviation will be calculated.

- The Kaplan-Meier or the ROS method will be used when the detection frequency is between 15 percent and 50 percent. The Kaplan-Meier method assesses the linearity of a censored probability plot to determine whether the background sample can be approximately normalized. If so, then the Kaplan-Meier method will be used to compute estimates of the mean and standard deviation adjusted for the presence of left-censored values. The Kaplan-Meier or ROS estimate of the mean and standard deviation will be substituted for the sample mean and standard deviation.
- If background normality cannot be achieved, non-parametric UTLs will not be calculated until a minimum of 60 background samples have been collected (to achieve 95 percent coverage).

The parametric UTL on a future mean will be calculated from the background dataset as follows:

$$UTL = \overline{x} + \kappa\,(n, \gamma, \alpha - 1) \cdot s$$

$\overline{x}$ = background sample mean

s = background sample standard deviation

$\kappa\,(n, \gamma, \alpha - 1)$ = one-sided normal tolerance factor based on the chosen coverage (γ) and confidence level (α -1) and the size of the background dataset (n). Values are tabulated in Table 17-3 in Appendix D of the *Unified Guidance*. If exact values are not provided, then κ values can be estimated by linear interpolation.

If the UTL is constructed on the logarithms of original observations to achieve normality, where $\overline{y}$ and s_y are the log-mean and log-standard deviation, the limit will be exponentiated for back-transformation to the concentration scale as follows:

$$UTL = \exp\left[\overline{y} + \kappa\,(n, \gamma, \alpha - 1) \cdot s_y\right]$$

$\overline{y}$ = background sample log-mean

s_y = background sample log-standard deviation

When the GWPS is based on the 35 I.A.C. § 845.600(a)(1) constituent concentrations or a UTL derived from the background dataset, an exceedance in compliance wells relative to the GWPS will be evaluated using confidence intervals. A confidence interval defines the upper and lower bound of the true mean of a constituent concentration in groundwater within a specified confidence range.

- Non-detects in compliance data will be handled similarly to upgradient analyses, with half the RL substituted for non-detects when the frequency is 15 percent or less.
- The Kaplan-Meier, or the ROS method, will be used when the detection frequency is between 15 percent and 50 percent to compute estimates of the mean and standard deviation adjusted for the presence of left-censored values. These estimates will then be substituted for the sample mean and standard deviation.

Once the GWPS is established for background data using the UTL, either parametric or non-parametric confidence intervals will be computed for each constituent in compliance wells to identify GWPS exceedances.

3.1.2 Parametric Confidence Intervals around a Mean

If compliance data are approximately normal, one-sided parametric confidence intervals around a sample mean will be constructed for each constituent and well pair. The lower confidence limit (LCL) will be calculated as:

$$LCL_{1-\alpha} = \overline{x} - t_{1-\alpha,n-1} \cdot \frac{s}{\sqrt{n}}$$

$\overline{x}$ = compliance sample mean

s = compliance sample standard deviation

n = compliance sample size

$t_{1-\alpha,n-1}$ = obtained from a Student's t-table with (n–1) degrees of freedom (Table 16-1 in Appendix D of the *Unified Guidance*)

The chosen t value will aim to achieve both a low false-positive rate, and high statistical power. Minimum α values are tabulated in Table 22-2 of Appendix D of the *Unified Guidance*. The selected minimum α value, from which the t value will be derived, will have at least 80 percent power (1-β = 0.8) when the underlying mean concentration is twice the GWPS.

If compliance data are distributed lognormally, the LCL will be computed around the lognormal geometric mean as:

$$LCL_{1-\alpha} = \exp\left(\overline{y} - t_{1-\alpha,n-1} \cdot \frac{s_y}{\sqrt{n}}\right)$$

$\overline{y}$ = compliance sample log-mean

s_y = compliance sample log-standard deviation

3.1.3 Non-Parametric Confidence Intervals around a Median

Non-parametric confidence intervals around the median will be computed if the compliance data contain greater than 50 percent non-detects or are not normally distributed. The mathematical algorithm used to construct non-parametric confidence intervals is based on the probability (*P*) that any randomly selected measurement in a sample of n concentration measurements will be less than an unknown *P* x 100th percentile of interest (where *P* is between 0 and 1). Then the probability that the measurement will exceed the *P* x 100th percentile is (1–*P*). The number of sample values falling below the *P* x 100th percentile out of a set of n should follow a binomial distribution with parameters n and success probability *P*, where 'success' is defined as the event that a sample measurement is below the *P* x 100th percentile. The probability that the interval formed by a given pair of order statistics will contain the percentile of interest will then be determined by a cumulative binomial distribution *Bin(x;n,p)*, representing the probability of *x* or fewer successes occurring in *n* trials with success probability p. *P* will be set to 0.50 for an interval around the median.

The sample size n will be ordered from least to greatest. Given *P* = 0.50, candidate interval endpoints will be chosen by ordered data values with ranks close to the product of (n+1) x 0.50. If the result of (n+1) x 0.50 is a fraction (for even-numbered sample sizes), the rank values immediately above and below will be selected as possible candidate endpoints. If the result of (n+1) x 0.50 is an integer (for odd-numbered sample sizes), one will be added to and subtracted

from the result to get the upper and lower candidate endpoints. The ranks of the endpoints will be denoted L* and U*. For a one-sided LCL, the confidence level associated with endpoint L* will be computed as:

$$1 - \alpha = Bin(L^* - 1; n, 0.50) = \sum_{x=L^*}^{n} \binom{n}{x} \left(\frac{1}{2}\right)^n$$

If the candidate endpoint(s) do not achieve the desired confidence level, new candidate endpoints (L*–1) and (U*+1) and achieved confidence levels will be calculated. If one candidate endpoint equals the data minimum or maximum, only the rank of the other endpoint will be changed. Achievable confidence levels are tabulated using these equations in Table 21-11 in Appendix D of the *Unified Guidance*.

Both parametric and non-parametric confidence limits will then be compared to the GWPS. The CCR unit is considered to be in compliance if the LCL is equal to or lower than the GWPS for all detected constituents at all compliance monitoring wells. A GWPS exceedance is determined if the LCL exceeds the GWPS.

3.1.4 The Upper Prediction Limit for a Future Mean

The parametric UPL for a future mean will be used to calculate the GWPS if the pooled background data contain 50 to 70 percent non-detects and normality can be achieved. The Kaplan-Meier or ROS methods will be used to estimate the mean and standard deviation. The non-parametric UPL for a future median will be calculated as the GWPS if background samples cannot be normalized or contain greater than 70 percent non-detects. The parametric UPL for a future mean will be calculated from the background dataset at follows:

$$UPL_{1-\alpha} = \overline{x} + \kappa s$$

$\overline{x}$ = background sample mean

s = background standard deviation

κ = multiplier based on the order (p) of the future mean to be predicted, the number of compliance wells to be tested (w), the background sample size (n) the number (c) of constituents of concern (COCs), the "1-of-m" retesting scheme, and the evaluation schedule (annual, semi-annual, quarterly). Values are tabulated in 19-5 to 19-9 in Appendix D of the *Unified Guidance*.

The mean of order p will be computed for each well and compared against the UPL. For any compliance point mean that exceeds the limit, p additional resamples may be collected at that well for a 1-of-2 retesting scheme. Resample means will then be compared to the UPL. A GWPS exceedance has been deemed to occur at a compliance well when the initial mean and all resample means exceed the UPL.

3.1.5 The Non-Parametric Upper Prediction Limit for a Future Median

The non-parametric UPL for a future median will be used to calculate the GWPS if the pooled background data contain greater than 70 percent non-detects and normality cannot be achieved. Non-parametric methods assume that the data does not have an underlying distribution. To calculate the non-parametric UPL on a future value, the target per-constituent false positive rate (α_{const}) will be determined as follows:

$$\alpha_{const} = 1 - (1 - \alpha)^{1/c}$$

α = the site-wide false positive rate (SWFPR) of 0.10 recommended by the *Unified Guidance*

c = the number of monitoring constituents

The number of yearly statistical evaluation (nE) will be multiplied by the number of compliance wells (w) to determine the look-up table entry, w*. The background sample size (n) and w* will be used to select an achievable per-constituent false positive rate value in Table 19-24 of Appendix D in the *Unified Guidance*. The chosen achievable per-constituent false positive rate value will determine the type of non-parametric prediction limit (maximum or 2nd highest value in background) and a retesting scheme for a future median. The background data will be sorted in ascending order, and the upper prediction limit will be set to the appropriate order statistic previously determined by the achievable per-constituent false positive rate value in Table 19-24. If all constituent measurements in a background sample are non-detect, the Double Quantification rule will be used. The use of the Double Quantification rule in Compliance Monitoring will only be applicable if the RL is above the 35 I.A.C. § 845.600(a)(1) constituent concentration or a constituent concentration is not specified in § 845.600(a)(1). This scenario is highly unlikely. The constituent will also be removed from calculations identifying the target false positive rate.

Two initial measurements per compliance well will be collected. If both do not exceed the upper prediction limit, a third initial measurement will not be collected since the median of order 3 will also not exceed the limit. If both exceed the prediction limit, a third initial measurement will not be collected since the median will also exceed the limit. If one initial measurement is above and one below the limit, a third initial observation may be collected to determine the position of the median relative to the UPL. Up to three resamples will be collected in order to assess the resample median. In all cases, if two or more of the compliance point observations are non-detect, the median will be set equal to the RL. The median value for each compliance well will be compared to the UPL. For the 1-of-2 retesting scheme, if any compliance point median exceeds the limit, up to three additional resamples will may be collected from that well. The resample median will be computed and compared to the UPL. A GWPS exceedance has been deemed to occur at a compliance well when either the initial median, or both the initial median and resample median exceed the UPL.

If the concentrations of detected constituents are below the established GWPS, Compliance Monitoring will continue.

3.1.6 Parametric Linear Regression and Confidence Band

If the t-test detects a significant trend in the parametric linear regression line using either background or compliance data for a particular constituent, confidence bands accounting for trends will be constructed to account for the trend-induced variation. If this is not accounted for, a wider confidence interval will inevitably be calculated for a given confidence level and sample size (n). A wider confidence interval will result in less statistical power, or ability to demonstrate an exceedance or return to compliance. When a linear trend line has been estimated, a series of confidence intervals is estimated at each point along the trend. This creates a simultaneous confidence band that follows the trend line. As the underlying population mean increases or decreases, the confidence band does also to reflect this change at that point in time.

Linear regression will be used when background or compliance data are approximately normally distributed, with a constant sample variance around the mean, and the frequency of non-detects is low. The linear regression of concentration against sampling date (time) will be computed as follows:

$$\hat{b} = \sum_{i=1}^{n} (t_i - \overline{t}) \cdot x_i / (n-1) \cdot s_t^2$$

x_i = i^{th} concentration value and

t_i = i^{th} sampling date

$\overline{t}$ = sampling mean date

s_t^2 = variance of the sampling dates

This estimate leads to the following regression equation:

$$\hat{x} = \overline{x} + \hat{b} \cdot (\mathrm{t} - \overline{t})$$

$\overline{x}$ = mean concentration level

$\hat{x}$ = estimated mean concentration at time t

The regression residuals will also be computed at each sampling event to ensure uniformity and lack of significant skewness. Regression residuals will be computed at each sampling event as follows:

$$r_i = x_i - \hat{x}_i$$

The estimated variance around the regression line, or mean squared error (MSE) will be computed as follows:

$$s_e^2 = \frac{1}{n-2} \sum_{i=1}^{n} r_i^2$$

The confidence intervals around a linear regression trend line given confidence level (1-α) and a point in time (t_0), will be computed as follows:

$$LCL_{1-\alpha} = \hat{x}_0 - \sqrt{2 s_e^2 \cdot F_{1-2\alpha,2,\mathrm{n}-1} \cdot \left[\frac{1}{n} + \frac{(t_0 - \overline{t})^2}{(n-1) \cdot s_t^2}\right]}$$

$$UCL_{1-\alpha} = \hat{x}_0 - \sqrt{2 s_e^2 \cdot F_{1-2\alpha,2,\mathrm{n}-2} \cdot \left[\frac{1}{n} + \frac{(t_0 - \overline{t})^2}{(n-1) \cdot s_t^2}\right]}$$

$\hat{x}_0$ = estimated mean concentration from the regression equation at time t_0

$F_{1-2\alpha,2,\mathrm{n}-2}$ = upper $(1\text{-}2\alpha)^{th}$ percentage point from an F-distribution with 2 and (n-2) degrees of freedom

For background data, the UCL around the linear regression line will be used as the GWPS for the trending constituent. For compliance data, confidence bands around the linear regression line will be compared to the GWPS. The CCR unit is considered to be in compliance if the LCL is equal to or lower than the GWPS for all detected constituents at all compliance wells. A GWPS exceedance is determined when the LCL based on the trend line first exceeds the GWPS.

3.1.7 Non-Parametric Thiel-Sen Trend Line and Confidence Band

If the Mann-Kendall test detects a significant trend in the non-parametric Thiel-Sen line using either background or compliance data for a particular constituent, confidence bands accounting for trends will be constructed to account for the trend-induced variation. The Thiel-Sen trend line will be used as a non-parametric alternative to linear regression when trend residuals cannot be normalized or if there are a higher percentage of non-detects in either background or compliance data. The Thiel-Sen trend line estimates the median concentration over time by combining the median pairwise slope with the median concentration value and the median sample date. To compute the Thiel-Sen line, the data will first be ordered by sampling event x1, x2, xn. All possible distinct pairs of measurements (x_i, x_j) for j > i will be considered and the simple pairwise slope estimate will be computed for each pair as follows:

$$m_{ij} = (x_j - x_i)/(j - i)$$

With a sample size of n, there will be a total of N = n(n-1)/2 pairwise estimates (m_{ij}). If a given observation is a non-detect, half the RL will be substituted. The N pairwise slope estimates (m_{ij}) will be ordered from least to greatest (renamed m(1), m(2),..m(N)). The Thiel-Sen estimate of slope (Q) will be calculated as the median value of the list depending on whether N is even or odd as follows:

$$Q = \begin{cases} m_{([N+1]/2)} \; if \; N \; is \; odd \\ (m_{(N/2)} + m_{([N+2]/2)})/2 \; if \; N \; is \; even \end{cases}$$

The sample concentration magnitude will be ordered from least to greatest, x(1), x(2), to x(n) and the median concentration will be calculated as follows:

$$\tilde{x} = \begin{cases} x_{([n+1]/2)} \; if \; n \; is \; odd \\ (x_{(n/2)} + x_{([n+2]/2)})/2 \; if \; n \; is \; even \end{cases}$$

The median sampling date ($\tilde{t}$) with ordered times (t(1), t(2), to t(n)) will also be determined in this way. The Thiel-Sen trend line will then be computed for an estimate at any time (t) of the expected median concentration (x) as follows:

$$x = \tilde{x} + Q \cdot (\mathrm{t} - \tilde{t}) = (\tilde{x} - Q \cdot \tilde{t}) + Q \cdot \mathrm{t}$$

To construct a confidence band around the Thiel-Sen line, sample pairs (ti, xi) will be formed with a sample date (ti) and the concentration measurement from that date (xi). Bootstrap samples (B) will be formed by repeatedly sampling n pairs at random with replacement from the original sample pairs. This will be repeated 500 times. For each bootstrap sample, a Thiel-Sen trend line will be constructed using the equation above. A series of equally spaced time points (tj) will be identified along the range of sampling dates represented in the original sample, j =1 to m. The Thiel-Sen trend line associated with each bootstrap replicate will be used to compute an estimated concentration ($\hat{x}_j^B$). An LCL will be constructed for the lower α^{th} percentile $\hat{x}_j^{[\alpha]}$ from the distribution of estimated concentrations at each time point (tj). For a UCL, compute the upper (1-α)th percentile, $\hat{x}_j^{[1-\alpha]}$ at each time point (tj).

For background data, the UCL around the Thiel-Sen trend line will be used as the GWPS for the trending constituent. For compliance data, confidence bands around the Thiel-Sen trend line will be compared to the GWPS. The CCR unit is considered to be in compliance if the LCL is equal to or lower than the GWPS for all detected constituents at all compliance wells. A GWPS exceedance is confirmed when the LCL based on the trend line first exceeds the GWPS.

3.2 Determination of Statistically Significant Increases over Background

In accordance with 35 I.A.C. §§ 845.610(b)(3)(B) and 845.640(h), individual monitoring event concentrations for each constituent detected in the compliance monitoring wells during compliance monitoring sampling events will be compared to the background concentration as determined by the methods described above. An exceedance of the background concentration for any constituent measured at any compliance monitoring well, or constituent detection if not detected in the background samples, constitutes a Statistically Significant Increase (SSI). An exception to this method is pH, where two-sided (upper and lower) tolerance limits are established from the distribution of the background groundwater quality data. An exceedance of either the UTL or lower tolerance limit (LTL) would constitute an SSI for pH.

4. REFERENCES

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Geosyntec
consultants

Attachment B.3

Hydrogeologic Site Characterization Report

July 2022

Intended for
Electric Energy, Inc.

Date
October 25, 2021

Project No.
1940100806-006

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT

EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT EAST ASH POND

Project Name	**Joppa Power Plant East Ash Pond**
Project No.	**1940100806-006**
Recipient	**Electric Energy, Inc.**
Document Type	**Hydrogeologic Site Characterization Report**
Revision	**FINAL**
Date	**October 25, 2021**

Ramboll
234 W. Florida Street
Fifth Floor
Milwaukee, WI 53204
USA

T 414-837-3607
F 414-837-3608
https://ramboll.com

Nicole M. Pagano, PG
Senior Managing Engineer

Brian G. Hennings, PG
Senior Managing Hydrogeologist

Rachel A. Banoff, EIT
Environmental Engineer

Nathaniel R. Keller
Senior Hydrogeologist

CONTENTS

Executive Summary		**6**
1.	**Introduction**	**11**
1.1	Overview	11
1.2	Part 845 Description	11
1.3	Previous Investigations and Reports	11
1.4	Site Location and Background	13
1.5	Site History	13
2.	**Regional and Site Geology**	**14**
2.1	Topography	14
2.2	Regional Geomorphology	14
2.3	Soils	14
2.4	Regional Geology	15
2.4.1	Unlithified Materials	15
2.4.2	Bedrock	16
2.4.3	Structure	16
2.4.4	Seismic Setting	17
2.4.5	Mining Activities	17
2.4.6	Industrial Activities	17
2.5	Site Geology	18
2.5.1	Site Specific Unlithified Geology	18
2.5.1.1	Fill and CCR	18
2.5.1.2	Equality Formation	19
2.5.1.3	Peoria Silt / Roxana Silt / Loveland Silt	19
2.5.1.4	Metropolis Formation	19
2.5.1.5	McNairy Formation	20
2.5.2	Site Specific Bedrock Geology	21
3.	**Regional and Local Hydrogeology**	**22**
3.1	Regional Hydrogeology	22
3.1.1	Unlithified Deposits Hydrogeology	22
3.1.2	Bedrock Hydrogeology	22
3.2	Site Hydrogeology	23
3.2.1	Hydrostratigraphic Units	23
3.2.2	Uppermost Aquifer	24
3.2.3	Potential Migration Pathways	24
3.2.4	Water Table Elevation and Groundwater Flow	24
3.2.4.1	Vertical Hydraulic Gradients	25
3.2.4.2	Impact of Existing Ponds and Ash Saturation	25
3.2.4.3	Impact of Surface Water Bodies	26
3.2.5	Hydraulic Conductivity	26
3.2.5.1	Field Hydraulic Conductivity	26
3.2.5.2	Laboratory Hydraulic Conductivity	26
3.2.6	Horizontal Groundwater Gradients and Groundwater Flow Velocity	27
3.2.7	Groundwater Classification	27
3.3	Surface Water Hydrology	27
3.3.1	Climate	27

3.3.2	Surface Waters	28
4.	**Groundwater Quality**	**30**
4.1	Summary of Groundwater Monitoring Activities	30
4.1.1	40 C.F.R. § 257 Program Monitoring and Well Network	30
4.1.2	Part 845 Well Installation and Groundwater Monitoring	30
4.2	East Ash Pond Groundwater Monitoring Results and Analysis	31
4.2.1	Boron	31
4.2.2	Cobalt	32
4.2.3	pH	32
4.2.4	Radium 226 and 228 Combined	32
4.2.5	Sulfate	32
4.2.6	Thallium	33
5.	**Evaluation of Potential Receptors**	**34**
5.1	Water Well Survey	34
5.2	Surface Water	35
5.3	Nature Preserves, Historic Sites, Endangered/Threatened Species	35
6.	**Conclusions and Conceptual Site Model**	**37**
7.	**References**	**39**

TABLES (IN TEXT)

Table A Average Monthly Temperature Extremes and Precipitation for Dixon Springs, Illinois
Table B 40 C.F.R. § 257 Groundwater Monitoring Program Parameters
Table C Part 845 Groundwater Monitoring Program Parameters

TABLES (ATTACHED)

Table ES-1 Part 845 Requirements Checklist
Table 2-1 Geotechnical Results
Table 2-2 Ash Analytical Results
Table 2-3 Porewater Analytical Results
Table 2-4 Soil Analytical Results
Table 3-1 Monitoring Well Locations and Construction Details
Table 3-2 Vertical Hydraulic Gradients
Table 3-3 Field Hydraulic Conductivities
Table 3-4 Horizontal Hydraulic Gradients and Groundwater Flow Velocities
Table 4-1 Groundwater Analytical Results
Table 4-2 Groundwater Field Parameter Results

FIGURES (IN TEXT)

Figure A Daily Gage Height (feet) June 1, 2020 to June 1, 2021 for USGS Gaging Station 03612600 at the Ohio River at Olmsted, Illinois.

FIGURES (ATTACHED)

Figure 1-1 Site Location Map
Figure 1-2 Site Map
Figure 2-1 Site Topographic Map
Figure 2-2 Soil Survey Map

Figure 2-3 Surficial Geologic Deposits
Figure 2-4 Generalized Stratigraphic Column for the Joppa Area
Figure 2-5 Major Structural Features of Joppa Quadrangle
Figure 2-6 Field Investigation Locations
Figure 2-7 Geologic Cross Sections A-A'
Figure 2-8 Geologic Cross Sections B-B' & C-C'
Figure 3-1 Monitoring Well Location Map
Figure 3-2 Top of Uppermost Aquifer
Figure 3-3 Uppermost Aquifer Groundwater Elevation Contours, March 3 and 4, 2021
Figure 3-4 Uppermost Aquifer Groundwater Elevation Contours, April 13 and 14, 2021
Figure 3-5 Uppermost Aquifer Groundwater Elevation Contours, May 11 and 12, 2021

APPENDICES

Appendix A Historical Topographic Map (1967)
Appendix B Boring and Well Construction Logs
Appendix C Geotechnical Laboratory Reports
Appendix D Information Pertinent to 35 I.A.C. § 845.220(a)(3)
Appendix E Groundwater Contour Maps and Elevations
Appendix F Hydraulic Conductivity Test Data
Appendix G FEMA Flood Hazard Map

ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
§	Section
35 I.A.C.	Title 35 of the Illinois Administrative Code
40 C.F.R.	Title 40 of the Code of Federal Regulations
bgs	below ground surface
CCR	coal combustion residuals
cm/s	centimeters per second
CPT	cone penetrometer test
CSM	conceptual site model
DWW	IEPA Illinois Drinking Water Watch
EAP	East Ash Pond
ESRI	Environmental Systems Research Institute
Federal CCR Rule	40 C.F.R. § 257 Subpart D
FEMA	Federal Emergency Management Agency
ft/day	feet per day
ft/ft	feet per feet
g	horizontal acceleration
GMP	Groundwater Monitoring Plan
GWPS	groundwater protection standard
Hanson	Hanson Professional Services, Inc.
HCR	Hydrogeologic Site Characterization Report
HMP	Hydrogeologic Monitoring Plan
HUC	Hydrologic Unit Code
ID	identification
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
ILMINES	Illinois Coal Mines
ILWATER	ISGS Illinois Water and Related Wells
ISAS	Illinois State Archaeological Survey
ISGS	Illinois State Geological Survey
ISWS	Illinois State Water Survey
JPP	Joppa Power Plant
LAU	lower aquifer unit
LCU	lower confining unit
mg/L	milligrams per liter
NAVD27	North American Vertical Datum of 1927
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NGWMN	USGS National Groundwater Monitoring Network
NID	National Inventory of Dams
No.	Number
NRT	Natural Resource Technology, Inc.

NRT/OBG	Natural Resource Technology, Inc., an OBG Company
OBG	O'Brien and Gere Engineers, Inc.
Part 845	Residuals in Surface Impoundments: Title 35 of the Illinois Administrative Code § 845
pcf	pounds per cubic foot
pCi/L	picoCuries per liter
PMP	potential migration pathway
PWS	public water system
Ramboll	Ramboll Americas Engineering Solutions, Inc.
RCRA	Resource Conservation and Recovery Act of 1976
SDWIS	USEPA Safe Drinking Water Information System
SI	surface impoundment
Site	East Ash Pond
SSURGO	Soil Survey Geographic database
SU	Standard Unit
TDS	total dissolved solids
UCU	upper confining unit
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey

EXECUTIVE SUMMARY

This Hydrogeologic Site Characterization Report (HCR) for the East Ash Pond (EAP) expands upon the hydrogeology, groundwater quality data, and conceptual site model (CSM) in previous hydrogeologic investigation reports prepared for the EAP. This report has been assembled to satisfy the information and analysis requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845.620 as summarized in **Table ES-1**. The CSM includes hydrogeologic and groundwater quality data specific to the EAP, which has been collected between 2015 and 2021.

The Joppa Power Plant (JPP) property is situated in an industrial/agricultural area, bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north, the Village of Joppa to the east, and the Ohio River to the south. Two coal combustion residuals (CCR) Units are present on the JPP property including the EAP (Vistra identification [ID] number [No.] 401, Illinois Environmental Protection Agency [IEPA] ID No. W1270100004-02, and National Inventory of Dams [NID] No. IL50714), and Landfill (Vistra ID No. 402). In addition, there is a former CCR disposal area, Joppa West, (Vistra ID No. 403, IEPA ID No. W1270100004-01) located west of the EAP. The EAP is located in the west half of Section 14, directly north of the JPP and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa.

In addition to the CCR present in the EAP, there are five layers of unlithified material present above the bedrock, which were categorized into three hydrostratigraphic units in this report. Underlying the constructed CCR unit, the four (including bedrock) hydrostratigraphic units in descending order are:

- **Upper Confining Unit (UCU):** Low permeability silt and clay of the Equality Formation, silts of the Peoria/Roxana/Loveland, and clay and silt of the Metropolis Formation are considered the UCU. This unit was encountered in all borings advanced on site and limits the vertical migration of CCR impacts into the uppermost aquifer.
- **Uppermost Aquifer:** High permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation. The uppermost aquifer was encountered at elevations ranging from 222.6 to 318.6 feet North American Vertical Datum of 1988 (NAVD88).
- **Lower Confining Unit (LCU):** Clay and silt of the Lower McNairy Formation that was encountered in all borings advanced to bedrock. Based on material description, continuous lateral extent, and observed vertical gradients, this unit is identified as the LCU.
- **Lower Aquifer Unit (LAU):** Lowermost unit identified at the site and underlies all unlithified deposits. This unit is comprised of the Salem Limestone, which is the uppermost lithified unit at the Site, and used as a potable and non-potable water supply in the vicinity of the JPP.

Groundwater flow direction and gradients have not changed significantly since the first hydrogeologic study of the EAP was completed in 2009, and recent data support the existing CSM, which has been refined to incorporate additional data as follows:

- Groundwater migrates downward through the UCU which is composed of the Equality Formation, Silt Unit, and Metropolis Formation into the uppermost aquifer.
- Groundwater migrates within high permeability sands and gravels of the McNairy Formation which comprise the uppermost aquifer generally south towards the Ohio River.

- Vertical gradients measured between the LAU and the uppermost aquifer indicate upward migration of groundwater from the LAU to the uppermost aquifer and into the Ohio River.

Part 845 parameters were monitored in the uppermost aquifer and LAU monitoring wells at the EAP as part of the groundwater quality investigations performed between 2015 and 2018. These data were supplemented with installation and sampling of additional locations installed in 2021. The results indicate that the following parameters were greater than the applicable 35 I.A.C. § 845.600 groundwater protection standards (GWPSs) and are considered potential exceedances:

- Boron - at five uppermost aquifer wells G06, G07, G08, G09, and G10
- Cobalt - at thirteen uppermost aquifer wells (G01D, G03, G05, G06S, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D), and at LAU well G09M
- pH – at two UCU wells (G54S and G151), and at thirteen uppermost aquifer wells (G01D, G02D, G03, G05, G06S, G07, G09, G10, G11, G51D, G52D, G53D, and G54D)
- Radium 226 and 228 combined – at uppermost aquifer well G02D
- Sulfate - at two uppermost aquifer wells G10 and G11
- Thallium – at uppermost aquifer wells G05 and G11

Concentration results for the above parameters were compared directly to 35 I.A.C. § 845.600 GWPSs to determine potential exceedances. Potential exceedances include results reported during the background groundwater monitoring or prior period that are greater than the GWPS. The results are considered potential exceedances because the results were compared directly to the standard and did not include an evaluation of background groundwater quality or the statistical methodologies proposed in the groundwater monitoring plan (GMP) provided in the Operating Permit application. Exceedances will be determined following IEPA approval of the GMP.

TABLE ES-1. PART 845 REQUIREMENTS CHECKLIST
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Part 845 Reference	Individual Part 845 Components Reviewed for Completeness	Location of Information in HCR
845.620(b)	**The hydrogeologic site characterization shall include but not be limited to the following:**	--
845.620(b)(1)	Geologic well logs/boring logs;	Table 3-1 Figure 3-1 Appendix B
845.620(b)(2)	Climatic aspects of the site, including seasonal and temporal fluctuations in groundwater flow;	Sections 3.2.4.3 & 3.3.1 Figures 3-3, 3-4 & 3-5
845.620(b)(3)	Identification of nearby surface water bodies and drinking water intakes;	Sections 3.3.2 & 5.2 Appendix D
845.620(b)(4)	Identification of nearby pumping wells and associated uses of the groundwater;	Section 5.1 Appendix D
845.620(b)(5)	Identification of nearby dedicated nature preserves;	Section 5.3 Appendix D
845.620(b)(6)	Geologic setting;	Sections 2.4 & 2.5 Figures 2-3 & 2-4
845.620(b)(7)	Structural characteristics;	Section 2.4.3 Figure 2-5
845.620(b)(8)	Geologic cross-sections;	Figures 2-8 through 2-10
845.620(b)(9)	Soil characteristics;	Section 2.3 Figure 2-2
845.620(b)(10)	Identification of confining layers;	Section 3.2.1

TABLE ES-1. PART 845 REQUIREMENTS CHECKLIST
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Part 845 Reference	Individual Part 845 Components Reviewed for Completeness	Location of Information in HCR
845.620(b)(11)	Identification of potential migration pathways;	Sections 3.2.1 & 3.2.3
845.620(b)(12)	Groundwater quality data;	Section 4.2 Table 4-1
845.620(b)(13)	Vertical and horizontal extent of the geologic layers to a minimum depth of 100 feet below land surface, including lithology and stratigraphy;	Section 2.5 Figures 2-8 through 2-10 Appendix B
845.620(b)(14)	A map displaying any known underground mines beneath a CCR surface impoundment;	Section 2.4.5 Appendix D
845.620(b)(15)	Chemical and physical properties of the geologic layers to a minimum depth of 100 feet below land surface;	Sections 2.5 & 3.2.1 Tables 2-1, 2-2 & 2-4 Appendix C
845.620(b)(16)	Hydraulic characteristics of the geologic layers identified as migration pathways and geologic layers that limit migration, including:	Section 3.2.3 Tables 3-2, 3-3 & 3-4 Appendices B, C & F
845.620(b)(16)(A)	water table depth;	Section 3.2.4 Table 4-2 Figures 3-3, 3-4 & 3-5
845.620(b)(16)(B)	hydraulic conductivities;	Section 3.2.5 Tables 2-1 and 3-3 Appendices C & F
845.620(b)(16)(C)	effective and total porosities;	Section 2.5.1 Table 2-1 Appendix C
845.620(b)(16)(D)	direction and velocity of groundwater flow; and	Sections 3.2.4 & 3.2.6 Tables 3-2, 3-3 & 3-4 Figures 3-3, 3-4 & 3-5

TABLE ES-1. PART 845 REQUIREMENTS CHECKLIST
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Part 845 Reference	Individual Part 845 Components Reviewed for Completeness	Location of Information in HCR
845.620(b)(16)(E)	map of the potentiometric surface;	Figures 3-3, 3-4 & 3-5
845.620(b)(17)	Groundwater classification pursuant to 35 I.A.C. § 620; and	Section 3.2.7

Notes:

[O: CJC 08/24/21, U: CJC 8/27/21, C: LDC 08/27/21]

-- = reference to main regulation
35 I.A.C. § 620 = Title 35 of the Illinois Administrative Code, Part 620
HCR = Hydrogeologic Site Characterization Report

1. INTRODUCTION

1.1 Overview

In accordance with requirements of the Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments: 35 I.A.C. § 845 (Part 845) (IEPA, April 15, 2021), Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this HCR on behalf of JPP (**Figure 1-1**), operated by Electric Energy, Inc. This report will apply specifically to the CCR Unit referred to as the EAP. However, information gathered to evaluate other CCR units in the vicinity of the EAP regarding geology, hydrogeology, and groundwater quality has been incorporated, where appropriate. The EAP is a 111-acre-foot existing unlined CCR surface impoundment (SI) used to manage CCR and non-CCR waste streams at the JPP. This HCR includes Part 845 content requirements specific to 35 I.A.C. § 845.620(b) (Hydrogeologic Site Characterization) for the EAP at JPP.

1.2 Part 845 Description

CCR is commonly referred to as coal ash, and CCR SIs are commonly referred to as coal ash ponds. Part 845 contains comprehensive rules for the design, construction, operation, corrective action, closure, and post closure care of these SIs. This rule includes GWPSs applicable at the waste boundary at each CCR SI and requires each owner or operator to monitor groundwater. IEPA's rule includes a permitting program as well as all federal standards for CCR SIs promulgated by the United States Environmental Protection Agency (USEPA). In addition, the rules include procedures for public participation, closure alternatives analyses, and closure prioritization, and provides access to records via public website. The rule also includes financial assurance requirements for CCR SIs.

A checklist summarizing the specific requirements of 35 I.A.C. § 845.620 is included in **Table ES-1**. The table provides references to sections, tables, and figures included in this document to locate the information that meets specific requirements of 35 I.A.C. § 845.620.

1.3 Previous Investigations and Reports

Numerous hydrogeologic investigations have been performed concerning the CCR Units located at the JPP. The information presented in this HCR includes data collected in support of the monitoring well network established for development of the GMP and supplements comprehensive data collection and evaluations from prior hydrogeologic investigation reports (recent to oldest), including, but not limited to, the following:

- ***Ramboll, January 31, 2021. 2020 Annual Groundwater Monitoring and Corrective Action Report – Joppa East Ash Pond.***
  Annual report prepared as required by Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257.90(e) that documents the status of the Groundwater Monitoring and Corrective Action Program for the EAP.
- ***Natural Resource Technology, an OBG Company (NRT/OBG), October 17, 2017. Hydrogeologic Monitoring Plan – Joppa East Ash Pond.***
  A Hydrogeologic Monitoring Plan (HMP) prepared to provide background information in support of the groundwater monitoring system established to comply with 40 C.F.R. § 257.91 to regulate the disposal of CCR as solid waste under Subtitle D of the Resource Conservation

and Recovery Act of 1976 (RCRA) (40 C.F.R. § 257 Subpart D [Federal CCR Rule]; published in 80 FR 21302-21501, April 17, 2015) for the JPP EAP.

- ***AECOM, October 2016. CCR Certification Report: Initial Structural Stability Assessment, Initial Safety Factor Assessment, and Initial Inflow Design Flood Plan Control System Plan for East Ash Pond at Joppa Power Station.***
  A report documenting that the structural stability assessment, safety factor assessment, and inflow design flood control system plan meet the requirements specified in 40 C.F.R. § 257.73(d), 40 C.F.R. § 257.73(e), and 40 C.F.R. § 257.82, respectively, to support the certification required under each of those regulatory provisions for the JPP EAP.
- ***AECOM, January 2016. 30% Design Data Package for Dynegy, Joppa East Ash Pond.***
  A 30% design package including a geotechnical program consisting of installation of auger borings, cone penetrometer test (CPT) soundings, and vibratory wire piezometers to obtain information for compliance with requirements of the Federal CCR Rule design basis.
- ***Natural Resource Technology (NRT), July 2013. Phase I Hydrogeologic Assessment Report, Coal Combustion Product Impoundments, Joppa Generating Station, Joppa, IL.***
  A report to review hydrogeologic data pertinent to the site, groundwater quality data, the potential for off-site migration in the event of a release from one of the impoundments, and whether or not there are potential groundwater receptors in the event of a release. Included a survey to identify wells within 2,500 feet of the Site.
- ***Geotechnology, Inc., May 2013. Groundwater Monitoring Report, Second Quarter 2013, Electric Energy Incorporated, Joppa, Illinois.***
  A report documenting results of groundwater monitoring activities performed at the Site in the first quarter of 2013.
- ***Geotechnology, Inc., March 2013. Groundwater Monitoring Report, First Quarter 2013, Electric Energy Incorporated, Joppa, Illinois.***
  A report documenting results of groundwater monitoring activities performed at the Site in the second quarter of 2013.
- ***NRT, December 2012. Technical Memorandum No. 1, Class II Groundwater Designation and Replacement Wells, Joppa Ash Ponds.***
  A technical memorandum describing a proposal to reclassify groundwater within the clay unit at the Site from Class I to Class II designation and describing a proposal to modify the groundwater monitoring network.
- ***Geotechnology, Inc., October 2010. Well Installation and Groundwater Monitoring Report, Electric Energy, Inc., Joppa, IL.***
  A report documenting results of monitoring well installation and groundwater monitoring activities performed at the Site, as well as, summarizing field hydraulic conductivity testing and geotechnical soil testing results.
- ***Hanson Professional Services, Inc. (Hanson), August 2009. "Section 3 – Hydrogeologic Report" of Initial Facility Report, Landfill, CCB Management Facility, Joppa Generating Station, Massac County, Illinois.***
  A summary of the geology and hydrogeology of the Joppa Landfill.
- ***Hanson, October 2009. Ash Pond Hydrogeologic Assessment Plan, Joppa Power Station.***

A report to satisfy the IEPA request to characterize subsurface hydrogeology, evaluate potential contaminant migration, develop a groundwater monitoring plan and identify potable wells near the retired Joppa West and active EAP.

- ***SO-BI-CO Materials Testing Service, March 1973. Report of Soil Investigation and Recommendations, Proposed East Ash Pit, Joppa Power Plant, Joppa, IL.***
  A report documenting the results of a soils investigation and foundation evaluation completed to determine the nature of the soil deposits, determine the properties of available borrow soils and provide a basis for making recommendations regarding the stability and structural integrity of embankments for the proposed east ash pit at Joppa Power Plant.

A GMP meeting the requirements of Part 845 is being prepared for the EAP in conjunction with this report.

1.4 Site Location and Background

The JPP is west of the Village of Joppa in Massac County, Illinois, northeast of the Ohio River in Section 14, Township 15 South, Range 3 East (**Figure 1-1**). The JPP property is bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south. The EAP is located in the west half of Section 14 directly north of the JPP and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa.

Figure 1-1 shows the location of the plant; **Figure 1-2** is a site map showing the location of the EAP as described in **Section 1.5**.

1.5 Site History

The JPP currently operates the EAP for management of CCR waste streams. Another inactive SI, referred to as Joppa West, is present in the western portion of the JPP property, and a permitted landfill is present in the northwestern portion of the JPP property. These other CCR units are not the subject of this HCR.

The EAP (Site) is classified as an existing unlined CCR SI which is used to manage both fly ash and bottom ash. The EAP was built in two phases. The northern portion (Phase I) was placed into service in late 1973, while the southern portion (Phase II) was permitted in May 1985, with completion of construction occurring in late 1985. These two sections are separated by a dividing dike (*i.e.,* Central Dike) and were referred to as the Northern and Southern Ponds. The pond embankment has not been raised since its construction in 1973, but material has been added in some areas to increase the width. The Northern Pond is diked over the length of its perimeter and the height of the dike varies from approximately 15 to 45 feet above the outboard toe of slope. The crest is at an approximate elevation of 380 feet NAVD88. The Southern Pond is also a diked earthen embankment structure with a height that varies from approximately 15 to 45 feet above its outboard toe. As with the Northern Pond, the crest is at an approximate elevation of 380 feet NAVD88 (O'Brien and Gere Engineers, Inc. [OBG], 2010).

2. REGIONAL AND SITE GEOLOGY

A report to summarize geologic and hydrogeologic conditions at the EAP was submitted to IEPA in 2013 (NRT, 2013). Since that submittal, several site characterization activities have been performed in the vicinity of the EAP including: 40 C.F.R. § 257 monitoring network installation in 2015, geotechnical investigations in 2016 (AECOM, 2016a), hydraulic conductivity testing in April 2017, and hydrogeologic investigation in 2021. This information (including information sourced from previous investigations and reports identified in **Section 1.3** of this HCR) has been incorporated and updated as needed to satisfy the content requirements specific to 35 I.A.C. § 845.620(b).

2.1 Topography

Topography in the vicinity of the EAP ranges from approximately 370 feet NAVD88 along the north end of the Site to 330 feet NAVD88 towards the south and east sloping toward the Ohio River (**Figure 2-1**). Based on the topographic map, the embankments are at an elevation of approximately 370 feet NAVD88, while CCR material within the Phase I area of the impoundment ranges from approximately 372 to 380 feet NAVD88, and in the Phase II it ranges from approximately 351 to 363 feet NAVD88. The height of the EAP is approximately 55 feet relative to surrounding grade.

A historic topographic map (**Appendix A**) indicates that a former drainage feature was present in the central portion of the EAP. Elevation contours indicate that the ground surface was approximately 320 feet North American Vertical Datum of 1927 (NAVD27) in the southeast corner of the pond prior to filling with CCR. The lower vertical limit of CCR identified within the lateral limits of the EAP is at an elevation of approximately 325.6 feet NAVD88 at AECOM boring location JOP-B019 (AECOM, 2016a, **Appendix B**).

2.2 Regional Geomorphology

The JPP lies at the southern boundary of the Illinois Basin and the northern edge of the Mississippi Embayment, a relatively low-lying area that is part of the Coast Plain Physiographic Province. The vicinity of the JPP generally has less than 6 meters (19.7 feet) of silty and clayey diamictons overlying Cretaceous sediments, silts, sands, etc. from depths of 6 to 15 meters (19 to 50 feet).

2.3 Soils

Surficial soils in the vicinity are shown on **Figure 2-2**, based on the soil survey data for Christian County available in the Soil Survey Geographic database (SSURGO) by the United States Department of Agriculture Natural Resources Conservation Service provided by the Environmental Systems Research Institute (ESRI) web-hosted layer. Soils underlying the JPP that are not identified as disturbed areas (Orthents #802D), are predominantly identified as Hosmer silt loam with percent slopes ranging from 2 to 18 percent (#214B, #214C2, #214C3, #214D2, and #214D3). The Hosmer series soils consist of moderately well drained soils on Loess hills. These soils formed in eolian deposits. This soil association is well suited for farmland.

Areas surrounding the EAP that are not designated Hosmer silt loam are predominantly classified as Stoy Silt Loam (#164A). The Stoy series consists of somewhat poorly drained soils on Loess hills. These soils formed in eolian deposits and are well suited for farmland.

2.4 Regional Geology

The EAP lies adjacent to and north to northeast of the Ohio River at the southern boundary of the Illinois Basin and the northern edge of the Mississippi Embayment, a relatively low-lying area that is part of the Coastal Plain Physiographic Province (Leighton et al., 1948). Based on stack-unit maps prepared by the Illinois State Geological Survey (ISGS) (Berg and Kempton, 1987) the area is characterized by less than 20 feet of silty and clayey diamictons overlying Cretaceous-age sediments, silts, sands, etc., from depths of 20 to 50 feet. The unlithified materials rest on Mississippian-age bedrock. The bedrock dips gently northward toward the center of the Illinois Basin.

2.4.1 Unlithified Materials

Regionally, the unlithified materials consist of diamictons and lacustrine/alluvial deposits. These deposits may exceed 100 feet in thickness. Four principal unlithified deposits exist in the vicinity of the EAP: (1) the Equality Formation; (2) Peoria Silt / Roxana Silt / Loveland Silt; (3) Metropolis Formation; and (4) McNairy Formation (**Figures 2-3 and 2-4**). Deposits displayed in **Figure 2-3** were mapped on a regional scale by the ISGS.

The Equality Formation is the uppermost material encountered in the vicinity of the EAP. The Equality Formation consists of silt, clay, and minor sand and gravel. The silt and clay are medium to dark gray to brown; less commonly they are greenish to bluish gray. Some reddish to orange-brown layers occur in the upper part of the unit. Consistency varies from stiff to soft, plastic "gumbo." Structure varies from massive to finely laminated or varved. Wood fragments and decomposed vegetation are common. This formation is interpreted as fine-grained fluvial overbank sediments and slack-water lacustrine deposits that accumulated during the Wisconsinan age (Nelson, 2007). Based on seventeen borings advanced as part of a subsurface geologic investigation approximately ¼ to 1 mile northwest of Joppa West (Hanson, 2009a), the thickness of the Equality ranges from 14 to 32 feet.

Contiguous with the Equality Formation but unmapped in this area are the Peoria Silt, Roxana Silt, and Loveland Silt. Based on descriptions by Nelson (2007) the Peoria Silt and Roxana Silt are both wind-blown (eolian) deposits of Wisconsinan age that are difficult to distinguish from one another. Their lower contacts are gradational. The Peoria Silt is a massive, slightly clayey silt with rare fine sand grains. The upper part is generally yellowish brown to dark brown, grading downward to mottled gray and yellowish brown. The Roxana Silt is medium dark brown to reddish brown that typically has uniform color with no mottling and higher clay content than the Peoria Silt. The Loveland Silt is of Illinoian age and is a massive silt, interpreted as an eolian deposit, with high clay content. The Loveland is strongly mottled in yellow, red, and orange and has prominent vertical gray streaks. It is strongly weathered and commonly displays root casts or traces. The Loveland is generally thin and lenticular and its lower contact is gradational to the Metropolis Formation but unconformable to older units.

Underlying the Equality Formation, or at some locations the Loveland Silt, is the Metropolis Formation, which consists of silt, sand, clay, and gravel. The Metropolis Formation is composed of silty sand and sandy silt in a clay matrix and contains scattered pebbles and lenses of gravel. Much of the unit may be classified as diamicton. These sediments are strongly mottled and streaked in shades of gray, yellowish brown, and yellowish orange. The lower part of the formation contains bright red and orange sand. Sediments are poorly sorted to unsorted and massive to weakly stratified. Gravel occurs as common scattered pebbles and as lenses up to 4

feet thick (Nelson, 2007). The Metropolis Formation, originally defined by Nelson et al. (1999a), borders the Ohio River, where it underlies a loess-capped terrace. The Metropolis Formation is interpreted as alluvial sediment deposited in the valley of the ancestral Tennessee River (Nelson et al., 1999a; Nelson et al., 1999b). The lower contact is unconformable on the McNairy in most places. Age is Pleistocene, Illinoian and older. Based on thirteen borings advanced approximately ¼ to 1 mile northwest of Joppa West (Hanson, 2009a), the thickness of the Metropolis Formation ranges from 25 to 40 feet.

The lowermost unlithified unit encountered in the vicinity of the JPP is the McNairy Formation, which consists of sands, silts, and clays. The McNairy Formation is Upper Cretaceous in age and consists of very fine- to medium-grained sand, mostly highly micaceous, and range from white and light gray to bright orange, red, and yellow in color. The silts and clays are light to dark gray and may be mottled in yellow, gray, and magenta. The lower contact is unconformable (Nelson, 2007). Based on one boring advanced to bedrock by Hanson (2009a) approximately 0.7 miles northwest of Joppa West, and confirmed by borings completed in 2021, the thickness of the McNairy Formation is approximately 76 feet. The drillers log for plant well 4 (which is 900 feet south of the EAP) indicates sand from a depth of 50 to 135 feet, suggesting that the McNairy Formation is 85 feet thick south of the CCP impoundments (NRT, 2013).

2.4.2 Bedrock

The regional bedrock consists of a sequence of Mississippian System sedimentary rocks hundreds of feet thick and consolidated prior to the Cretaceous Period. The bedrock dips gently northward toward the center of the Illinois Basin. The uppermost bedrock near the JPP generally consists of limestone. The total thickness of the Mississippian System in southern Illinois is greater than 3,200 feet (Willman et al., 1975).

The uppermost unit encountered in the vicinity of the JPP is the Salem Limestone (**Figure 2-4**). The Salem Limestone is described as fine-grained, fossiliferous limestone, and is approximately 200 to 500 feet thick in the area. The Salem Limestone overlies the Ullin Limestone; the Ullin Limestone is described as a light-colored fine- to coarse-grained limestone. The overall thickness of the Ullin Limestone near the JPP is approximately 200 feet. The Fort Payne Formation, which is overlain by the Ullin Limestone, is described as a very fine-grained, siliceous, cherty limestone, and is approximately 200 to 600 feet thick in the study area (Kolata, 2005; Willman et al., 1967; Willman et al., 1975).

2.4.3 Structure

The major geologic structural features around Illinois are shown on **Figure 2-5**. The JPP is located within the zone of the pre-Cretaceous structure of the Pascola Arch. The Pascola Arch was uplifted sometime after the middle of the Pennsylvanian Period and eroded, truncated, and buried beneath Upper Cretaceous and younger rocks in the Mississippi Embayment. The Embayment, as defined by the extent of Cretaceous rocks, reaches into southernmost Illinois and is a northern extension of the Gulf Coastal Plain. The Pascola Arch closes off the southwestern margin of the Illinois Basin between the Nashville and Ozark Domes. Cambrian rocks are directly overlain by Tuscaloosa Formation at the apex of the arch. The northeast dip of Paleozoic strata and southern closure of the Illinois Basin in southernmost Illinois are attributed to the Pascola Arch (Nelson, 1995).

2.4.4 Seismic Setting

Several fault zones cross the Joppa Quadrangle. These faults are part of the Fluorspar Area Fault Complex, an intricate array of fractures that affect a large area of southernmost Illinois and western Kentucky (Nelson and Masters, 2008). The Lusk Creek Fault Zone, **Figure 2-5**, is the westernmost major fault zone in the Fluorspar Area Fault Complex. This fault zone continues more than 30 miles northeast of Joppa into Pope County, where it merges with the east-west trending Rough Creek-Shawneetown Fault System.

Within the Joppa Quadrangle, the Lusk Creek Fault Zone is less than ¼ mile wide and trends about N35°E. Overall the evidence implies that the Lusk Creek Fault Zone underwent a pre-Cretaceous displacement of about 100 feet down to the southeast, offsetting Mississippian limestone. Post-Cretaceous tectonic activity produced narrow grabens that dropped as much as 200 feet. Small movements may have taken place as recently as the Pleistocene (Nelson and Masters, 2008). United States Geological Survey (USGS) seismic hazard maps show peak ground accelerations (g) of approximately 0.8 g to 0.6 g in the Lusk Creek Fault Zone vicinity.

35 I.A.C. § 845.330 requires that existing and new CCR SIs and lateral expansions of existing SIs must not be located in seismic impact areas, unless owners or operators demonstrate that the SI is designed to resist the maximum horizontal acceleration in lithified earth material. This requirement is identical to that in 40 C.F.R. § 257.63. The definition of a seismic impact zone is "areas having a 10 percent or greater probability that the maximum expected horizontal acceleration (g) in hard rock, expressed as a percentage of the earth's gravitation pull, will exceed 0.10 g in 50 years." These areas are identified on maps prepared by the USGS (Algermissen et al., 1982). Based on the data illustrated on Plate 2 (Algermissen et al., 1982), the Site vicinity exhibits a potential horizontal acceleration of approximately 0.11 g with a 90 percent probability of not being exceeded in 50 years. The Site is therefore within a seismic impact area, as currently defined in 40 C.F.R. § Part 257.63, and, by extension, 35 I.A.C. § 845.330.

Per 35 I.A.C. 845.460(a)(4), the calculated seismic factor of safety must equal or exceed 1.00. As a part of the Initial Safety Factor Assessment (AECOM, 2016a), factors of safety were calculated for seismic loading conditions. This calculation models the dike stability under short-term, seismic loading conditions during the design 2,500-year return period seismic event. Six cross sections were analyzed and the minimum calculated factor of safety of 1.01 exceeded the factor of safety requirement of 1.00. Therefore, the Site meets the requirements in 35 I.A.C. 845.460(a)(4).

2.4.5 Mining Activities

Based on the Illinois State Geological Survey (ISGS) Illinois Coal Mines (ILMINES) online database (ISGS, 2018), no surface or underground mines were identified within 1,000 meters of the EAP.

2.4.6 Industrial Activities

As indicated in **Section 1.4**, the surrounding areas include industrial activities to the west and north of the EAP with the village of Joppa to the east and the Ohio River to the south (**Figure 1-2**). The industrial properties include:

- LaFarge North America cement plant is located to the west of the EAP at 2500 Portland Road.

- Trunkline Gas Company-Joppa Compressor Station is located to the north and west of the EAP at 2101 Portland Rd. The compressor station is used for an approximately 2,000-mile natural gas pipeline system.

2.5 Site Geology

A field investigation was performed in 2021 to collect additional data for the discussion of vertical and horizontal lithology, stratigraphy, chemical properties, and physical properties of geologic layers to a minimum of 100 feet below ground surface (bgs) as specified in 35 I.A.C. § 845.620(b). Field investigation locations are shown on **Figure 2-6**.

2.5.1 Site Specific Unlithified Geology

The stratigraphy within and immediately surrounding the EAP consists of the following in descending order: fill material and CCR, the Equality Formation, Peoria Silt / Roxana Silt / Loveland Silt, Metropolis Formation, and McNairy Formation. Boring logs, monitoring well and piezometer construction forms obtained from investigations at the EAP are provided in **Appendix B**.

2.5.1.1 Fill and CCR

Non-CCR fill material was classified as clayey silt, well graded sand, gravelly sand, or sandy clay. In general, fill was encountered at depths of up to 5 feet bgs. Soil borings performed within the EAP (XPW01, XPW02, and XPW03) indicate CCR material consists of both fly ash and bottom ash and is encountered at depths up to 46 feet bgs. Based on borings and historical information, CCR material extends to an elevation of 327.7 feet NAVD88 (**Figures 2-7 through 2-8**).

No geotechnical samples were collected from non-CCR fill. Geotechnical analysis results of five CCR samples yielded Unified Soil Classification System (USCS) soil classifications of silty sand, silty lean clay, and sandy silt. These classifications are consistent with previous geotechnical analyses of samples from 1 to 5 feet bgs. The results of the geotechnical analysis are summarized below and in **Table 2-1** and the geotechnical laboratory report is included in **Appendix C**. The results of the geotechnical analysis of Fill and CCR indicated the following:

- The grain size distributions for the CCR samples indicate that the CCR material is on average approximately 7 percent gravel, 30 percent sand, and 63 percent fines. Although coarser grained material was identified in two samples with approximately 9 to 26 percent gravel, 45 to 74 percent sand, and only 17 to 28 percent silt and clay.
- The moisture content for CCR ranged from 31.7 percent (XPW-01 at 46-48 feet bgs) to 47.6 percent (XPW-02 at 24-26 feet bgs), with an average moisture content of approximately 41 percent.
- Laboratory hydraulic conductivity tests performed for samples from the CCR materials resulted in a range from 1.8×10^{-7} to 2.1×10^{-5} centimeters per second (cm/s); and a geometric mean vertical hydraulic conductivity of 1.0×10^{-6} cm/s.

In addition to geotechnical analyses, samples of CCR material were collected for chemical analysis. The results of these chemical analyses are summarized in **Table 2-2**.

Leachate wells (*i.e.,* XPW01, XPW02, and XPW03) installed within the ash were also sampled in 2021. The results of porewater samples collected from within the EAP are summarized in **Table 2-3**.

2.5.1.2 Equality Formation

The Equality Formation is the uppermost unlithified material encountered in the vicinity of the EAP. The Equality Formation was classified as silt and clay with minor amounts of sand and gravel in borings advanced on site. Thicknesses of the Equality Formation ranged from 14.0 feet at G06 to 28.0 feet at G03 and G09M (**Figures 2-7 through 2-8**). The silt and clay are medium to dark gray to brown; less commonly they are greenish to bluish gray. Based on interpretations of boring logs, this formation was found to extend from 320.60 to 356.2 feet NAVD88. A drillers log for plant well 4, located south of the EAP, indicates fine-grained deposits from the land surface to a depth of 50 feet. These deposits represent the combined thickness of the Equality and Metropolis Formations south of the EAP. The results of geotechnical analysis are summarized below and in **Table 2-1** and the geotechnical laboratory report is included in **Appendix C**. The results of the geotechnical analysis from the Equality Formation indicated the following:

- Moisture content of the samples ranged from 15.5 to 20.6 percent, with an average of 18.2 percent. These observations are at the lower end of the range observed during previous investigations (AECOM, 2016b) that indicate an average of 19.9 percent.
- The average total porosity (calculated) was 35 percent, with a range from 32 to 37 percent.
- The average dry density was 109.1 pounds per cubic foot (pcf) and ranged from 105.4 to 112.7 pcf. These observations are consistent with previous investigations (AECOM, 2016a) which indicated an average dry density of 106.1 pcf.
- The average specific gravity was 2.671 with a range of 2.659 to 2.688.
- The average grain size distribution was 0.2 percent gravel, 23.4 percent sand, and 76.4 percent silt and clay. Previous investigations identified the following grain size distribution: approximately 90 percent silt and clay and 10 percent gravel and sand.

2.5.1.3 Peoria Silt / Roxana Silt / Loveland Silt

Where present, the Peoria Silt, Roxana Silt, and Loveland Silt were not differentiated and are referred to as the Silt Unit in this Report. This unit was generally classified as silt with limited occurrences of sandy silt. The Silt Unit was encountered at locations G07 through G10 located around the south and southeast portions of the EAP with thicknesses ranging from 4.0 to 8.0 feet. No geotechnical or chemical samples were collected from this unit.

2.5.1.4 Metropolis Formation

Underlying the Equality Formation, or at some locations the Silt Unit, is the Metropolis Formation. At the EAP, the Metropolis Formation is composed of clay, sandy clay, and sandy silt with limited occurrences of silty sand and gravel. This unit was encountered in all borings advanced onsite and ranges in thickness from 4.0 feet at G08 to 39.3 feet at G04. These results are within the range of borings advanced approximately ¼ to 1 mile northwest of Joppa West (Hanson, 2009a), which indicate the thickness of the Metropolis Formation ranges from 25 to 40 feet. The percentages of sand/gravel, silt, and clay composition of a sample of the Metropolis Formation collected from G09M (46 to 48 feet bgs) indicates it is approximately 17 percent sand, and 83 percent silt and clay (**Table 2-1**) The geotechnical laboratory report is provided in **Appendix C**.

Samples collected from the Metropolis Formation were also submitted to an analytical laboratory for chemical analysis. The results of this chemical analysis are summarized in **Table 2-4**.

2.5.1.5 McNairy Formation

The McNairy Formation is the lowermost unlithified unit at the JPP and consists of sands, silts, and clay, and was encountered in all borings advanced in the vicinity of the EAP. The material was classified as well- and poorly-graded sand, and gravelly sand with limited lenses of silty sand, silt, or clay. Colors were variable and the material was generally described as light gray, tan, yellowish brown with several observations of yellowish red, strong brown, or reddish yellow in layers.

At the base of the McNairy, above the bedrock, lean clay was encountered with a thickness of 14 feet (G09M, approximately 222 feet NAVD88). This is consistent with JPP wells #2 (API# 121270005000) and #4 (API# 121270000100) which indicate silt or clay at depths of 130 feet and 125 feet, respectively. A former potable well log (API#121270005400, **Figure D-2** in **Appendix D**) also identifies a clay layer at a depth of 115 feet which appears consistent with these two three wells. In addition, a boring advanced to bedrock by Hanson (2009a) approximately 0.8 miles mile northwest of the Joppa West, encountered a white clay from approximately 242 to 222 feet NAVD88.

The McNairy Formation at the JPP has been divided into two units for discussion in **Section 3.2** based on composition of the materials onsite as follows:

- Upper McNairy Formation: consisting of sand and gravel with isolated lenses of silt and clay.
- Lower McNairy Formation: consisting of finer grained materials present at the bedrock surface which appear to be laterally continuous in the vicinity of the JPP.

The percentages of sand/gravel, silt, and clay composition of the McNairy Formation samples are summarized below and in **Table 2-1** and the geotechnical laboratory report is provided in **Appendix C**. The results of the geotechnical analysis from the McNairy Formation indicated the following:

- Moisture content of the samples ranged from 7.6 to 25.5 percent, with an average of 16.9 percent. These observations overlap with the range observed during previous investigations (AECOM, 2016b) that indicate a range of 14.2 to 44.4 percent, with an average of 19.7 percent.
- The average total porosity (calculated) was 41 percent, with a range from 34 to 48 percent.
- The average dry density was 99.0 pcf and ranged from 87.0 to 110.0 pcf. These observations are consistent with previous investigations (AECOM, 2016b) which indicated an average dry density of 107.5 pcf, and range from 92.6 to 113.1 pcf.
- The average specific gravity was 2.673 with a range of 2.661 to 2.686.
- The average grain size distribution was 6.3 percent gravel, 85.4 percent sand, and 8.3 percent silt and clay. Previous investigations identified the following grain size distribution: 74.0 percent silt and clay and 26.0 gravel and sand.

Samples collected from the McNairy Formation were also submitted to an analytical laboratory for chemical analysis. The results of this chemical analysis are summarized in **Table 2-4**.

Geologic cross-sections across of the study area are shown on **Figures 2-7 through 2-8**.

2.5.2 Site Specific Bedrock Geology

The uppermost bedrock unit encountered in the vicinity of the EAP is the Mississippian Salem Limestone. Bedrock was encountered in G09M at an elevation of approximately 222 feet NAVD88 (**Figure 2-5**). This elevation is consistent with the JPP production wells and ISGS's *Geology of Joppa Quadrangle* report completed to evaluate structural geology of the area (Nelson and Masters, 2008). The bedrock was classified as limestone (specifically calcarenite), with a very pale brown color. A sample was collected from the bedrock at a depth of 142 to 144 feet bgs and submitted for chemical analysis. The results of this chemical analysis are summarized in **Table 2-4**.

3. REGIONAL AND LOCAL HYDROGEOLOGY

3.1 Regional Hydrogeology

3.1.1 Unlithified Deposits Hydrogeology

The McNairy-Nacatoch aquifer is in Upper Cretaceous deposits and is the lowermost hydrogeologic unit included in the Mississippi embayment aquifer system. The McNairy-Nacatoch aquifer is included in the aquifer system because of the local hydraulic connection between this aquifer and the overlying aquifers in Tertiary rocks in the northern part of the Mississippi Embayment where the Midway confining unit is thin (USGS, 1995).

The McNairy-Nacatoch aquifer primarily consists of the McNairy Sand but also includes the Nacatoch Sand. Other underlying sands of Late Cretaceous age, including the Coffee Sand and sand beds in the Demopolis, the Eutaw, and the Tuscaloosa Formations, are discontinuous in the region. The McNairy-Nacatoch aquifer thickens from less than 50 feet near its updip limit in southern Illinois to a maximum of more than 400 feet near its southern extent. Sand in the McNairy-Nacatoch aquifer is present as a single thick bed or as two or more thick sand beds separated by thin clay or marl layers. The sand facies is locally overlain by clay and marl of Late Cretaceous age, which, in turn, are overlain by clays of the Midway confining unit. The clean, fine sands change laterally to clay, marl, and limestone toward the southwest and are accompanied by calcareous cementation that fills the pore space between sand grains and greatly reduces the permeability of the sand. Wells completed in the McNairy-Nacatoch aquifer commonly yield from 50 to 500 gallons per minute, but yields might exceed 1,000 gallons per minute (USGS, 1995).

3.1.2 Bedrock Hydrogeology

Groundwater in bedrock occurs in limestone aquifers of Mississippian rocks. The uppermost limestone in the vicinity of the JPP is the Salem Limestone. In general, the limestone aquifers in this area are either flat lying or gently dipping and are capped by a layer of regolith that varies greatly in thickness. Typically, the limestone aquifers that yield the largest quantities of water to wells and springs are the Upper Mississippian Monteagle, the Ste. Genevieve, and the St. Louis Limestones. Where the Monteagle, the Ste. Genevieve, and the St. Louis are thin or missing, such as in the southwestern part of central Tennessee, the Warsaw Limestone (includes the Salem Limestone in Illinois) along with chert and limestone beds of the Fort Payne Formation are the principal aquifers (USGS, 1995).

In most places, the Mississippian aquifers are covered by regolith, which mostly consists of weathered material, or residuum. This material consists of clay, silt, sand, and pebble-sized particles of limestone or chert, which are derived mostly from weathering of the underlying bedrock. The hydraulic characteristics of the Mississippian aquifers vary greatly over short distances. For example, the ability of limestone with large, interconnected solution openings to transmit and yield water is several orders of magnitude greater than that of the almost impermeable blocks of limestone between solution openings, fractures, and bedding planes. Well yields commonly range from 2 to 50 gallons per minute, and reported maximum yields range from about 100 gallons per minute in Indiana to 1,000 gallons per minute in Illinois. Wells that penetrate large, saturated solution openings may yield several thousands of gallons per minute. However, such openings constitute only a small part of the rock and might be difficult to locate (USGS, 1995).

3.2 Site Hydrogeology

Prior to 2021, significant investigation had been completed to characterize the EAP, including CPT and installation of soil borings and monitoring wells. In 2015, a monitoring program consisting of six monitoring wells (G01D, G02D, G51D. G52D, G53D, and G54D) was established to comply with requirements of 40 C.F.R. § 257. In 2021, twelve additional monitoring wells (G03 through G11, G06S, G09M, and G54S) were installed to collect information to meet the requirements of Part 845. Construction details for monitoring wells and piezometers is provided in **Table 3-1** and locations are depicted in **Figure 3-1**. Boring logs, monitoring well, and piezometer construction forms are provided in **Appendix B**.

3.2.1 Hydrostratigraphic Units

Five water-bearing units have been identified in the vicinity of the EAP based on stratigraphic relationships and common hydrogeologic characteristics. The units are described as follows:

- **CCR:** CCR consisting of fly ash and bottom ash. Water elevations measured in early March 2021 within the EAP indicate the phreatic surface is approximately 370 to 374 feet. A maximum thickness of saturated fill and CCR of approximately 42 feet was observed at location XPW01 in April 2021. The amount of saturated fill and CCR in the EAP is generally consistent, ranging from 35 to 45 feet from March through August 2021, based on an estimated base of ash from 425 to 435 feet NAVD88 and the measured phreatic surface.
- **UCU:** The uppermost hydrostratigraphic unit is comprised of the Equality Formation, the Silt Unit, and Metropolis Formation deposits. The average thickness of this unit is 40.7 feet with a range of 8 to 58 feet. The UCU underlies the CCR fill in all locations and is thinnest in the southeast portion of the site. These deposits are predominantly fine-grained, comprised of clay, silt, and silty clay with limited intervals of sandy material. This hydrostratigraphic unit was encountered at all locations and extends down to the McNairy Formation, which was encountered at 34 feet bgs at location G06.
- **Uppermost Aquifer:** This unit consists of the Upper McNairy Formation which is composed of permeable sands and gravels with isolated lenses of finer grained material. This hydrostratigraphic unit at the site was 58 feet thick and is underlain by the LCU. The Upper McNairy Formation is composed of a significantly higher percentage of sand and gravel than the overlying Equality and Metropolis Formations.
- **LCU:** This unit consists of the Lower McNairy Formation which, in the vicinity of the EAP is composed of clay and silt overlying the Salem Limestone. The clay and silt of this unit was encountered in borings advanced to bedrock south and southeast of the EAP, as well as one boring located northwest of the site. The presence of this material at locations advanced to bedrock suggest it is laterally continuous in the vicinity of the JPP.
- **LAU:** This unit, composed of the Salem Limestone bedrock, is the lowermost hydrostratigraphic unit identified and is considered a potential migration pathway (PMP). The limestone bedrock is encountered at an elevation of approximately 200 feet NAVD88 below the EAP, slopes towards a syncline to the east (Nelson and Masters, 2008), and has a reported thickness of 200 to 500 feet. The Salem Limestone is used to supply water for various uses in the region and provides non-potable water for the JPP and potable water for the Village of Joppa (**Appendix D**).

3.2.2 Uppermost Aquifer

The uppermost aquifer is comprised of the sand and gravel, classified as the Upper McNairy Formation. The unit was encountered at its shallowest elevation (approximately 319 feet NAVD88) at G06 located on the east/ southeast edge of the EAP. This hydrostratigraphic unit at the site was approximately 58 feet thick (G09M) and extends down to the clay and silt of the Lower McNairy Formation. The lenses of clay and silt within the Upper McNairy are encountered at isolated locations and not interpreted to be laterally continuous. The base of the uppermost aquifer is the Lower McNairy Formation, comprised of clay and silt which overlies the Mississippian Aged Salem Limestone. **Figure 3-2** shows the top of the uppermost aquifer.

3.2.3 Potential Migration Pathways

The potential pathways for contaminant migration at the Site have been fully characterized and defined in **Section 3.2.1**. Based on a review of the lithology underlying the EAP, potential impacts to groundwater migrate downwards through the unconsolidated UCU into the uppermost aquifer (the Upper McNairy Formation). Further downward migration is limited by the Lower McNairy Formation, which is the LCU. Below the LCU is the LAU which is comprised of the Salem Limestone. The LAU has been identified as a PMP.

3.2.4 Water Table Elevation and Groundwater Flow

Groundwater flow is represented using groundwater elevation contour maps for several sampling events completed during 2021 (**Figures 3-3 through 3-5**). The EAP is located upgradient of the Ohio River and the groundwater elevation measured in wells surrounding the EAP range from 305.27 to 338.96 feet NAVD88 from March to July 2021. Groundwater elevation contours generally illustrate flow from northwest to southeast in the northern half of the EAP. In the southern half of the EAP, flow is southwest and southeast around an elevated measurement at G52D.

The elevations of water within the EAP (as observed in XPW01, XPW02, XPW03, and XSG01) are greater than the surrounding areas. The phreatic surface within the EAP from March to July 2021 averaged 369.85 feet NAVD88, ranging from 357.48 feet NAVD88 in XSG01 (eastern edge of EAP) to 373.84 feet NAVD88 in XPW03 (in the southwestern corner of the EAP) (**Figures 3-3 through 3-5**).

The groundwater elevation in wells within the UCU (G101, G151, G152B, G153, and G54S) from March to July 2021 averaged 322.75 feet NAVD88, with a range from 310.25 feet NAVD88 in G54S (southwest corner of the EAP) to 338.96 feet NAVD88 in G152B (southern edge of EAP). Well G152B, located south of the EAP, consistently recorded the highest groundwater elevation, with an average groundwater elevation of 335.58 feet NAVD88. The elevated groundwater here is assumed to be a result of well G152B screen being situated in low conductivity materials. Groundwater elevations at well G151 (along the western edge of the EAP) were also consistently higher than the remaining UCU wells, with an average groundwater elevation of 326.97 feet NAVD88.

The groundwater elevation in wells within the uppermost aquifer (G01D, G02D, G03, G04, G05, G06, G06S, G07, G08, G09, G10, G11, G51D, G52D, G53D and G54D) from March to July 2021 averaged 319.44 feet NAVD88, with a range from 311.02 feet NAVD88 in G09 (southern edge of EAP) to 327.46 feet NAVD88 in G52D (southern edge of EAP). Wells G11 and G51D (along the western edge of the EAP) were again consistently higher than the remaining uppermost aquifer

wells, with an average groundwater elevation of 322.02 feet NAVD88. Elevations measured in G52D do not appear to be consistent with other uppermost aquifer locations. The boring log from this location indicates more heterogenous geology, and as a result the well may have less hydraulic connection with the uppermost aquifer.

The groundwater elevation within the LAU well G09M from March to July 2021 averaged 319.32 feet NAVD88, with a range from 316.93 to 322.19 feet NAVD88.

Groundwater elevations are primarily controlled by river stage of the Ohio River near the JPP. Seasonal variation of groundwater levels has been observed, and the River has been observed at elevations higher than groundwater (**Figure 3-3**). Flow reversals associated with flooding of the Ohio River (**Appendix E**) have not been observed to extend northward beneath the EAP.

Groundwater elevations vary seasonally and may fluctuate by about 10 feet. Slight seasonal variation in groundwater flow directions ranging from southeast to southwest are also observed; however, the major component of groundwater flow direction is consistently south toward the Ohio River (**Figure 3-3 through 3-5**), which is the primary receiving body of water in the vicinity of the JPP (NRT, 2013).

3.2.4.1 Vertical Hydraulic Gradients

Vertical hydraulic gradients were calculated using available groundwater elevation data from early March to July 2021 at nested well locations within the UCU, the uppermost aquifer, and LAU (**Table 3-2**). The vertical gradients are summarized as follows:

- UCU to uppermost aquifer:
  - Consistent downward gradients were measured at well nests G151/G51D, and G152B/G52D. The gradients ranged from 0.10 to 0.83 feet/feet (ft/ft).
  - Variable gradients were measured at G101/G01D, G153/G53D, and G54S/G54D. On average, gradients were upward in G101/G01D and G54S/G54D, while they were flat at G153/G53D. In general, downward gradients were measured in July.
- Uppermost aquifer (within): Small downward gradients were measured in uppermost aquifer wells G06S/G06, with a range of 0.01 to 0.02 ft/ft.
- Uppermost aquifer to LAU:
  - At nested location G09/G09M, consistent upward vertical gradients (average of 0.06 ft/ft) were observed. Well G09M is screened in the bedrock below the LCU, while G09 is screened within the uppermost aquifer. Consistent upward gradients indicate that the Ohio River is a regional discharge point for the bedrock aquifer system and the LCU is continuous in the vicinity of G09.

3.2.4.2 Impact of Existing Ponds and Ash Saturation

The phreatic surface measured in the EAP ranges from approximately 370 to 375 feet NAVD88 while groundwater elevations measured in monitoring wells located around the EAP and screened within the UCU and uppermost aquifer range from approximately 311 to 327 feet NAVD88. Groundwater elevation contours indicate groundwater generally flows to the south, with no indication of radial flow. The elevation difference between the phreatic surface and groundwater elevations, in addition to no observations of radial flow, provide evidence that the EAP does not

impact groundwater flow directions. The amount of saturated fill and CCR in the EAP is generally consistent, ranging from 35 to 45 feet from March through August 2021.

3.2.4.3 Impact of Surface Water Bodies

The river basin typically experiences annual floods during the months of March, April, May, and occasionally June, while smaller floods occur less frequently in autumn (**Figure 3-3** and **Appendix E**). There have been no monitoring events (between 2015 and 2021) with observations that indicate groundwater flow reverses direction (*i.e.,* groundwater flows from the Ohio River north into the uppermost aquifer) beneath the EAP. Based on this timeframe it does not appear the Ohio River impacts groundwater flow; if it does, however, it is likely limited in extent and magnitude to the areas downgradient (*i.e.*, south) of the EAP.

3.2.5 Hydraulic Conductivity

3.2.5.1 Field Hydraulic Conductivity

Field hydraulic conductivity tests performed on the uppermost aquifer and LAU materials at the EAP were completed as part of the 2021 field investigation. Hydraulic conductivity test analyses and results are summarized in **Table 3-3** and provided in **Appendix F**. Field hydraulic conductivity tests indicated that the horizontal hydraulic conductivity for the Upper McNairy Formation sands and gravels at the site are variable, but mostly permeable with measured hydraulic conductivity ranging from 4.8×10^{-4} to 1.2×10^{-2} cm/s and a geometric mean of 3.1×10^{-3} cm/s (**Table 3-3**). This is higher than measurements of the uppermost aquifer calculated in 2017 (NRT/OBG, 2017), which resulted in a geometric mean conductivity of 3.4×10^{-4} cm/s.

Results of field hydraulic conductivity tests conducted in 2021 in the CCR Fill Unit wells (XPW02 and XPW03) ranged from 4.5×10^{-3} to 1.7×10^{-1} cm/s, with a geometric mean of 1.3×10^{-2} cm/s.

Slug testing was not completed at several wells (XPW01, G04, G05, G06S, and G54S), as these wells repeatedly went dry during well development. Hydraulic conductivity within the LAU as measured at well G09M, ranged from 2.7×10^{-4} to 5.8×10^{-4} cm/s, with a geometric mean of 4.0×10^{-4} cm/s. The hydraulic conductivity test analyses and results are provided in **Appendix F**.

3.2.5.2 Laboratory Hydraulic Conductivity

Falling head permeability tests (ASTM D5084 Method F) were performed in the laboratory on samples collected during the 2021 investigations. Sample locations are shown on **Figure 2-6**. The geotechnical laboratory report is provided in **Appendix C**. The results are summarized in **Table 2-1** and discussed below.

- Three samples were collected from CCR Fill unit borings at XPW01, XPW02, and XPW03. Laboratory falling head permeability test results in the CCR Fill unit indicated a geometric mean vertical hydraulic conductivity of 1.0×10^{-6} cm/s.
- Four UCU samples were collected from borings G03, G09M, and G11. Laboratory falling head permeability results in the UCU indicated a geometric mean vertical hydraulic conductivity of 1.7×10^{-7} cm/s.
- Laboratory hydraulic conductivity tests were not performed on samples from the uppermost aquifer or LAU.

3.2.6 Horizontal Groundwater Gradients and Groundwater Flow Velocity

Groundwater elevations have been measured quarterly since 2015. The Ohio River is the regional receiving body of water for groundwater. Under normal conditions at the EAP, groundwater flows from north to south discharging into the river as shown on **Figures 3-3** and **3-4**. Additional water table contour maps for 2019 through 2020 are available in **Appendix E**.

Horizontal hydraulic gradients and groundwater velocities for the uppermost aquifer were calculated based upon groundwater elevation measurements from March to July 2021 between G02D and G53D, G02D and G08, G11 and G54D, and G11 and G10 (**Table 3-4**). Horizontal hydraulic gradients are slight across the EAP and ranged from 0.0002 ft/ft between G02D and G53D in April 2021 to 0.0103 ft/ft between G11 and G54D in June 2021. The lower hydraulic gradients near the north of the EAP, between G02D and G53D, are consistent with previous calculations of horizontal hydraulic gradients at upgradient locations (NRT/OBG, 2017).

Horizontal hydraulic gradients calculated to the northeast of the EAP, between G02D and G53D, were on average 0.0008 ft/ft with an average groundwater velocity of 0.003 feet per day (ft/day). Horizontal hydraulic gradients calculated through the center of the EAP, between G02D and G08, were on average 0.0019 ft/ft with an average groundwater velocity of 0.046 ft/day. Horizontal hydraulic gradients calculated to the southwest of the EAP, between G11 and G54D, were on average 0.0053 ft/ft, with an average groundwater velocity of 0.23 ft/day. Horizontal hydraulic gradients calculated to the south of the EAP, between G11 and G10, were on average 0.0051 ft/ft with an average groundwater velocity of 0.19 ft/day. Horizontal hydraulic gradients and groundwater flow velocities are presented in **Table 3-4**.

3.2.7 Groundwater Classification

Per 35 I.A.C. § 620.210, groundwater within the uppermost aquifer at the EAP meets the definition of a Class I – Potable Resource Groundwater based on the following criteria:

- The groundwater is located more than 10 feet bgs and within an unconsolidated silty sand and gravel unit which is five feet or more in thickness and contains less than 12 percent of fines.
- Slug testing results identified a mean hydraulic conductivity of 3.1×10^{-3} cm/s, which exceeds the 1×10^{-4} cm/s criterion (**Table 3-4**).
- The groundwater does not underlie a previously mined area or a coal mine refuse disposal area.

3.3 Surface Water Hydrology

3.3.1 Climate

Average climatic data was obtained from the Illinois State Water Survey (ISWS). The data was recorded from 1989 to 2020 from Dixon Springs, Illinois, which is located approximately 15 miles northeast of the JPP. The data includes monthly maximum and monthly minimum daily temperatures (degrees Fahrenheit [°F]) and average rainfall for each month calculated from daily values collected over the 31-year period. The data is summarized in **Table A** below.

Table A: Average Monthly Temperature Extremes and Precipitation for Dixon Springs, Illinois.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Maximum Temperature (ºF)	42.8	47.9	57.5	68.2	76.3	84.2	87.2	86.4	80.6	69.7	56.9	46.6	67.0
Minimum Temperature (ºF)	25.9	29.4	37.2	46.2	55.5	63.7	65.4	65.4	57.8	46.4	36.9	29.7	46.8
Precipitation (inches)	3.88	3.41	4.52	4.84	4.66	3.95	4.22	2.93	3.33	3.74	4.28	4.47	48.2

3.3.2 Surface Waters

The predominant surface water body in the region is the Ohio River and associated lowland backwater lakes. The Ohio River is located directly adjacent to and down-gradient from the EAP. A USGS stream gage (#03612600) for the Ohio River at Olmsted, Illinois is located 12 river miles southwest (downstream) of the JPP. The gage datum elevation is 278.44 feet National Geodetic Vertical Datum of 1929 (NGVD29). Daily gage heights for the periods of June 1, 2020 to June 1, 2021 are shown in the following graph (USGS, 2021).

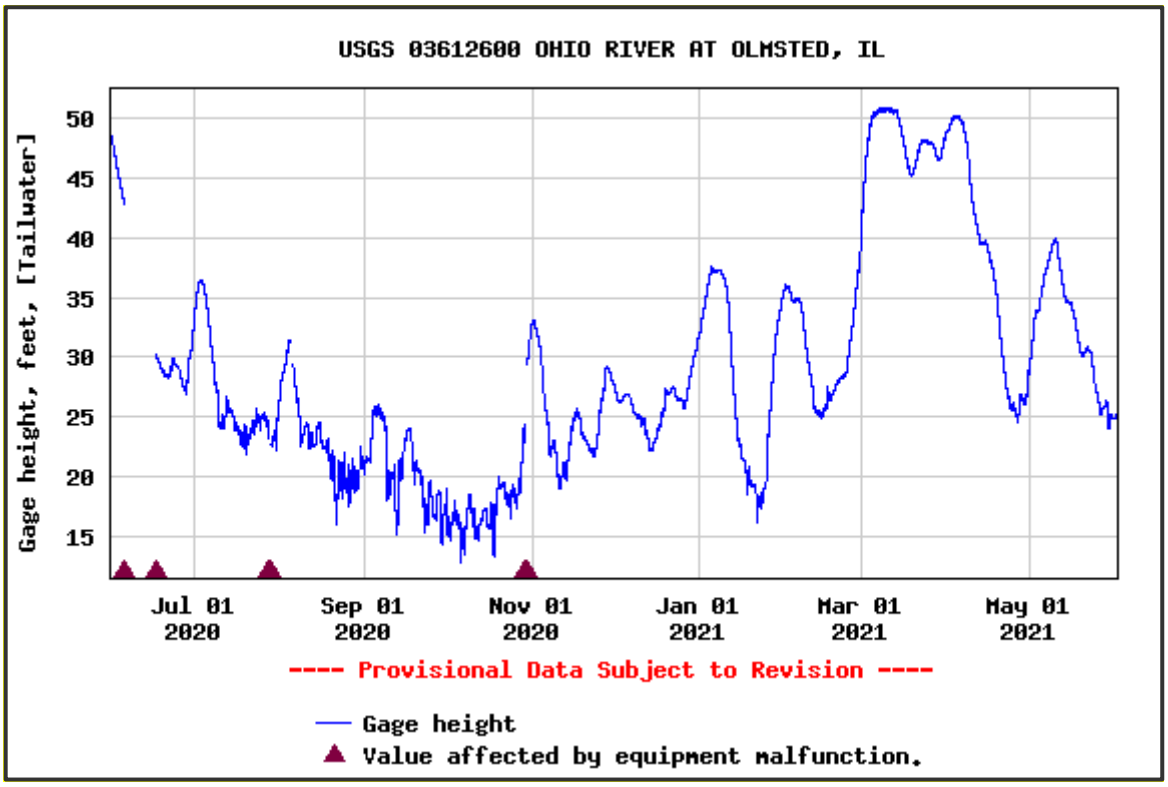

Figure A. Daily Gage Height (feet) June 1, 2020 to June 1, 2021 for USGS Gaging Station 03612600 at the Ohio River at Olmsted, Illinois.

The gage height of 15 feet, representing approximate base flow, occurs at an elevation of 278.62 feet NAVD88.

Other surface water in the vicinity includes Mermet Lake two miles north of the EAP, freshwater emergent wetlands to the east and west of the EAP, freshwater forested/shrub wetlands to the north and south of the EAP, and freshwater ponds spread around the EAP.

A Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map for Massac County (Map No. 1704670025B; Effective Date: July 5, 1983) is attached in **Appendix G** and can also be viewed online at: https://www.illinoisfloodmaps.org/dfirm.aspx?county=massac. None of the impoundment berms within the EAP occur below the base flood elevation value of 335 feet identified on the 2011 FEMA map. The EAP is outside the 100-year flood zone shown on the FEMA map. The flood hazard areas shown on the map are defined as those areas subject to inundation by the 1 percent annual chance flood (*i.e.,* 100-year flood), also known as the base flood, that has a 1 percent chance of being equaled or exceeded in any given year.

4. GROUNDWATER QUALITY

4.1 Summary of Groundwater Monitoring Activities

4.1.1 40 C.F.R. § 257 Program Monitoring and Well Network

The 40 C.F.R. § 257 well network for the EAP consists of six monitoring wells installed nearby and adjacent to the EAP within the unlithified uppermost aquifer. The EAP 40 C.F.R. § 257 well network consists of two upgradient (*i.e.,* background) monitoring wells (G01D and G02D) and four downgradient (*i.e.,* compliance) monitoring wells (G51D, G52D, G53D, and G54D). The boring logs, well construction forms, and other related monitoring well forms for the well network are included in **Appendix B** of this HCR.

Assessment monitoring of these wells was established on April 9, 2018. The 40 C.F.R. § 257 well network locations are shown on **Figure 3-1**. Details on the procedures and techniques used to fulfill the groundwater sampling and analysis program requirements are found in the Sampling and Analysis Plan for the EAP (NRT/OBG, 2017).

Groundwater samples are collected semi-annually and analyzed for the following laboratory parameters from Appendix III and Appendix IV of 40 C.F.R. § 257, summarized in **Table B** below.

Table B. 40 C.F.R. § 257 Groundwater Monitoring Program Parameters

Field Parameters[1]			
Groundwater Elevation	pH		
Appendix III Parameters (Total, except total dissolved solids [TDS])			
Boron	Chloride	Sulfate	
Calcium	Fluoride	TDS	
Appendix IV Parameters (Total)			
Antimony	Cadmium	Lithium	Selenium
Arsenic	Chromium	Mercury	Thallium
Barium	Cobalt	Molybdenum	Radium 226 and 228 combined
Beryllium	Lead		

[1] Dissolved oxygen, temperature, specific conductance, oxidation/reduction potential, and turbidity are recorded during sample collection.

4.1.2 Part 845 Well Installation and Groundwater Monitoring

In 2021, twelve additional monitoring wells (G03, G04, G05, G06, G06S, G07, G08, G09, G09M, G10, G11, and G54S) were installed along the perimeter of the EAP to assess the vertical and horizontal lithology, stratigraphy, chemical properties, and physical properties of geologic layers to a minimum of 100 feet bgs as specified in 35 I.A.C. § 845.620(b). Additionally, three leachate monitoring wells (XPW01, XPW02, and XPW03) were installed within the EAP unit to characterize the CCR materials. These locations and samples were discussed in Section 2.5.1.1. The boring logs, well construction forms, and other related monitoring well forms for the well network are included in **Appendix C** of this HCR. The well locations are shown on **Figure 3-1**.

Prospective Part 845 monitoring wells were sampled for eight rounds from February to August 2021 and the results were assessed for selection of the EAP Part 845 monitoring well network

presented in the groundwater monitoring plan. Groundwater samples were collected and analyzed for 35 I.A.C. § 845.600 parameters summarized in **Table C** below. Part 845 groundwater monitoring results are included below in **Section 4.2**.

Table C. Part 845 Groundwater Monitoring Program Parameters

Field Parameters[1]			
Groundwater elevation	pH	Turbidity	
Metals (Total)			
Antimony	Boron	Cobalt	Molybdenum
Arsenic	Cadmium	Lead	Selenium
Barium	Calcium	Lithium	Thallium
Beryllium	Chromium	Mercury	
Inorganics (Total)			
Fluoride	Sulfate	Chloride	TDS
Other (Total)			
Radium 226 and 228 combined			

[1]Dissolved oxygen, temperature, specific conductance, and oxidation/reduction potential were recorded during sample collection.

4.2 East Ash Pond Groundwater Monitoring Results and Analysis

Groundwater data collected from the 40 C.F.R. § 257 network monitoring wells between 2015 and 2021 were supplemented with sampling of additional locations in 2021 and evaluated with respect to standards included in 35 I.A.C. § 845.600(a)(1). This data set was selected because it includes parameters (total metals) consistent with the parameter list in 35 I.A.C. § 845.600(a)(1). Based on this data set there were no reported concentrations of antimony, arsenic, barium, beryllium, cadmium, chloride, chromium, fluoride, lead, lithium, mercury, molybdenum, selenium, or TDS greater than the GWPSs. Results indicate that the parameters discussed in the following sections were greater than the applicable 35 I.A.C. § 845.600(a)(1) standards and are considered potential exceedances [1]. A summary of the groundwater analytical data is provided in **Table 4-1**, and groundwater elevations and field parameters are included in **Table 4-2**.

4.2.1 Boron

Boron is a primary indicator parameter for CCR leachate impacts on groundwater quality. Boron was consistently detected greater than the GWPS (2 milligrams per liter [mg/L]) in five downgradient uppermost aquifer wells (G06, G07, G08, G09, and G10). Uppermost aquifer wells G06, G07, G08, and G10 had boron concentrations greater than the GWPS during all sampling events in 2021, while G09 had boron concentrations greater than the GWPS during 7 of 8 monitoring rounds. These wells are located on the south-southeast side of the EAP. Concentrations in these wells ranged from 0.282 to 5.25 mg/L with the most elevated concentrations occurring in G07 and G08 (median

[1] Potential exceedances include results reported during the eight rounds of baseline groundwater monitoring that are greater than the applicable 35 I.A.C. § 845.600(a)(1) standards. The results are considered potential exceedances because they were compared directly to the standard and did not include an evaluation of background groundwater quality or apply the statistical methodologies proposed in the Groundwater Monitoring Plan (GMP). For simplicity, "GWPS" will be used hereafter in discussing potential exceedances. Exceedances will be determined following IEPA approval of the GMP.

concentrations of 4.67 and 4.53 mg/L, respectively) located on the southeast corner near the pre-construction intermittent stream.

No UCU wells nor LAU wells had concentrations greater than the GWPS.

4.2.2 Cobalt

Twelve downgradient uppermost aquifer wells (G03, G05, G06S, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D) and one background well (G01D) had concentrations greater than the GWPS (0.006 mg/L) on at least one occasion between 2016 and 2021. Background well G03 and downgradient wells G07, G08, and G11 had cobalt concentrations greater than the GWPS during one or two of the initial sampling events in 2021. Conversely, no cobalt concentrations greater than the GWPS were reported at G51D, G52D, and G53D in 2020 or 2021, although there were concentrations greater than the GWPS between 2015 and 2019. Concentrations at G05, G06S, G10, and G54D have consistently been greater than the GWPS. The range of concentrations in these wells is 0.0045 to 0.0268 mg/L, with a median concentration of 0.012 mg/L.

LAU well G09M had cobalt concentrations greater than the GWPS only during the initial two events following installation in 2021. Concentrations at this well ranged from 0.00162 to 0.0097 mg/L, with a median concentration of 0.0055 mg/L.

4.2.3 pH

UCU wells G54S and G151 had measurements of pH consistently less than the lower limit GWPS (6.5 standard units [SU]). The measurements of pH ranged from 5.5 to 6.4 SU.

Measurements of pH were detected less than the lower limit GWPS in eleven uppermost aquifer wells (background wells G01D and G02D, and downgradient wells G03, G05, G06S, G07, G09, G10, G11, G51D, G52D, G53D, and G54D). All uppermost aquifer wells listed previously have consistently had measurements of pH less than the lower limit GWPS in 2021 with the exception of wells G01D, G04, G06, and G10.

No LAU wells had measurements of pH less than the lower limit GWPS or greater than the upper limit GWPS.

4.2.4 Radium 226 and 228 Combined

Radium 226 and 228 combined was detected at a concentration greater than the GWPS (5 picoCuries per liter [pCi/L]) in upgradient uppermost aquifer well G02D during September 2020. Concentrations in this well range from 0.12 to 5.93 pCi/L with a median of 0.693 pCi/L.

No UCU wells nor LAU wells had concentrations greater than the GWPS.

4.2.5 Sulfate

Sulfate is also a primary indicator parameter of CCR leachate impacts on groundwater quality. Sulfate was detected at concentrations greater than the GWPS (400 mg/L) in downgradient uppermost aquifer wells G10 and G11. Uppermost aquifer well G11 had concentrations greater than the GWPS during every event in 2021 with exception of the initial sampling event. Uppermost aquifer well G10 had concentrations greater than the GWPS during the June and July

2021 sampling events. Concentrations at these wells ranged from 401 to 761 mg/L. No other wells in the uppermost aquifer had concentrations greater than the GWPS.

No UCU wells nor LAU wells had concentrations greater than the GWPS.

4.2.6 Thallium

Thallium was detected at concentrations greater than the GWPS (0.002 mg/L) at downgradient uppermost aquifer wells G05 and G11. Concentrations at G05 were greater than the GWPS during the seventh sample event in July 2021, while concentrations at G11 were greater than the GWPS in the eighth sample event. There were no other detections of thallium in these or any other wells in 2021.

No UCU wells nor LAU wells had concentrations greater than the GWPS.

5. EVALUATION OF POTENTIAL RECEPTORS

Geosyntec completed field work in 2021 to obtain information pertinent to Part 845. This section originates from information provided by Geosyntec (2021) and has been supplemented where needed.

5.1 Water Well Survey

A potable water well inventory was completed in 2021 utilizing federal and state databases to assess nearby pumping wells, drinking water receptors, and other uses of water in the vicinity of the EAP.

The following sources of information were queried to identify well locations, drinking water receptors, and other uses of water within 1,000 meters of the EAP boundary:

- USGS National Groundwater Monitoring Network (NGWMN)[2]
- ISGS Illinois Water and Related Wells (ILWATER) Map[3]
- USEPA Safe Drinking Water Information System (SDWIS)[4]
- IEPA Illinois Drinking Water Watch (DWW)[5]

The EAP is located atop one or more water-bearing units (**Figure D-1** in **Appendix D**). According to the USGS NGWMN, the EAP is located on the Southeastern Coastal Plain Aquifer System, which is designated as a principal aquifer. A principal aquifer is defined as a regionally extensive aquifer or aquifer system that has the potential to be used as a source of potable water. According to the ISGS ILWATER Map, the southern portion of the EAP, and the area adjacent to the Ohio River is located atop a major sand and gravel aquifer (**Appendix D**).

A review of the USEPA SDWIS and IEPA DWW databases for drinking water intakes in the vicinity of the EAP yielded one result for public water systems (PWS) within 1,000 meters of the Site. The Joppa PWS (Water System ID IL1270100), which was reported to serve 462 people, was identified to be approximately 870 meters to the southeast and downgradient of the EAP. However, historical field verification has identified the actual location of the well at approximately 1,070 meters from the EAP. The Joppa PWS obtains drinking water from groundwater. Based on the well log, it is possible that potable wells of the Joppa PWS are hydraulically connected to the uppermost aquifers of the EAP.

A search of the ILWATER Map identified 17 wells, including two co-located wells, within 1,000 meters of the EAP (**Figure D-2** in **Appendix D**). Under normal conditions, five of the wells (121270005000, 121270000100, 121270005400, 121272094200, and 121270005500) are located downgradient from the EAP, eight are located side gradient (121270003100, 121270005300, 121270003000, 121270005100, 121270005200, 121272106100,

[2] USGS NGWMN: https://cida.usgs.gov/ngwmn/index.jsp
[3] ISGS ILWATER Map: https://prairieresearch.maps.arcgis.com/apps/webappviewer/index.html?id=e06b64ae0c814ef3a4e43a191cb57f87
[4] USEPA SDWIS: https://www.epa.gov/enviro/sdwis-search
[5] IEPA Illinois DWW: http://water.epa.state.il.us/dww/index.jsp

121270014600, and 121272103900), and the remaining four are located upgradient (121270015800, 121270011100, 121272067500, and 121272103000).

Five water wells within 1,000-meters of the EAP, including two downgradient wells (121270011100, 121272094200), one cross-gradient well (121272106100), and two upgradient wells (121270011100, 121272103000) were identified to have depths ranging from 65 feet to 94 feet bgs. Based on geologic cross-sections of the EAP, the sand layer beneath the EAP typically occurs from 50 to 100 feet bgs. Based on these depths the wells are likely to be hydraulically connected to the uppermost aquifer beneath the EAP.

5.2 Surface Water

A search was performed utilizing the United States Fish and Wildlife Service (USFWS) Wetlands Mapper[6] and the USGS National Map[7] for surface water bodies within 1,000 meters of the EAP.

The predominant surface water bodies near the EAP are the Ohio River, located to the south of the site, and Bayou Creek, located to the east of the site. A USGS stream gage for the Ohio River at Olmsted, Illinois (#03612600) is located 12 river miles southwest (downstream) of the JPP. The gage datum elevation is 278.44 feet NGVD29. Daily gage heights for the periods of June 1, 2020 to June 1, 2021 are shown on the graph in **Section 3.3.2**. The gage height of 15 feet, representing approximate base flow, occurs at elevation of about 278.62 feet NAVD88.

According to the USFWS Wetlands Mapper and USGS National Map, several small, scattered ponds are located in the vicinity of the EAP. In addition, freshwater emergent wetlands and freshwater forested/shrub wetlands were mapped along the banks of the Ohio River and on several areas to the north, west, and southeast of the EAP. Several unnamed streams were also identified to the east and southwest of the EAP, most of which connect to the Ohio River. A map of wetlands and surface waters in the vicinity of the EAP is presented in **Figure D-3** in **Appendix D**.

The USGS National Map places the EAP within the Bayou Creek-Ohio River Watershed (Hydrologic Unit Code [HUC] 12: 051402060701), which is part of the larger Lower Ohio River watershed (HUC 8: 05140206) and drains to the Ohio River. The HUC watershed location is presented in **Figure D-4** within **Appendix D**.

Based on groundwater elevation contour maps (**Figures 3-3 through 3-5** and **Appendix E**), between 2018 to 2021, groundwater predominantly flows to the south, towards the Ohio River. Due to the downgradient location and proximity of the Ohio River to the EAP, the Ohio River is likely to be hydraulically connected to the uppermost aquifer beneath the EAP.

5.3 Nature Preserves, Historic Sites, Endangered/Threatened Species

A comprehensive search of the Illinois Department of Natural Resources (IDNR) Natural Heritage Database[8] for natural areas and protected areas within 1,000 meters of the Site was performed. No natural or protected areas were identified within 1,000 meters of the EAP.

[6] USFWS Wetlands Mapper: https://www.fws.gov/wetlands/data/mapper.html
[7] USGS National Map: https://apps.nationalmap.gov/viewer/
[8] IDNR Natural Heritage Database: https://www2.illinois.gov/dnr/conservation/NaturalHeritage/Pages/NaturalHeritageDatabase.aspx

According to the Illinois Threatened and Endangered Species by County[9] database, 61 threatened and endangered species are located in Massac County, including 41 endangered and 20 threatened species (**Appendix D**). However, the habitats were identified at the county level only.

Additionally, a search of the IDNR Historic Preservation Division[10] database for historic sites in the vicinity of the Site yielded no results within 1,000 meters of the EAP. The Illinois State Archaeological Survey (ISAS)[11] databases were also searched and yielded no results within 1,000 meters of the EAP.

[9] Illinois Threatened and Endangered Species by County
[10] IDNR Historic Preservation Division: https://www2.illinois.gov/dnrhistoric/Pages/default.aspx
[11] ISAS: https://www.isas.illinois.edu/

6. CONCLUSIONS AND CONCEPTUAL SITE MODEL

Based on extensive site investigation and monitoring, the EAP has been characterized and a detailed CSM has been developed. Results of these hydrogeologic studies include geologic, hydrogeologic, and groundwater quality data collected with a focus on the EAP (Part 845 regulated CCR Unit and subject of this HCR). The data were summarized and evaluated for changes in groundwater conditions since the previous investigations; available groundwater quality data for the Ash Pond was compared to the Part 845 Standards.

The results of the hydrogeologic and groundwater quality evaluation are:

- There are five different unlithified materials in addition to the bedrock in the vicinity of the EAP as summarized below in descending order:
  - Fill (predominantly CCR within the EAP, but also including constructed berms and railroad embankments).
  - Equality Formation (clays and silts interbedded with thin sand lenses).
  - Silt Unit (undifferentiated silts of the Peoria, Roxana, and Loveland Formations).
  - Metropolis Formation (silt and clay, with interbedded sandy layers).
  - McNairy Formation (split into two units: the upper, which consists of predominantly sand with gravelly sand, clay and silt lenses, and the lower, which is composed of clay and silt).
- Bedrock underlying the EAP is the Mississippian bedrock which consists of the Salem Limestone.
- Five water bearing layers have been identified at the EAP based on stratigraphic relationships and common hydrogeologic characteristics, these include the following in descending order:
  - CCR: saturated CCR, consisting primarily of fly ash and bottom ash at thicknesses up to 50 feet.
  - UCU: low permeability clays, silts and sandy lenses within the Equality Formation, Silt Unit, and Metropolis Formation. This unit is thinnest in the southeast portion of the EAP.
  - Uppermost Aquifer: Predominantly composed of high permeability sands of the Upper McNairy Formation, with limited occurrences of silt, clay, and gravel layers within the unit. This unit is at the highest elevation and closest to the CCR fill near G06.
  - LCU: low permeability silt and clay of the Lower McNairy Formation that overlies bedrock at the site. Thicknesses range from 5 to 14 feet based on boring logs and potable well logs advanced to bedrock near the Site.
  - LAU: Bedrock composed of the Salem Limestone.
- The elevations of water within the EAP are greater than the surrounding areas but there is no evidence that the EAP is affecting groundwater flow directions.
- Groundwater flow in the uppermost aquifer is generally to the south toward the Ohio River with seasonal variations to the southeast and southwest. There have been no observations of groundwater flow direction beneath the EAP being impacted by the Ohio River based on measurements collected between 2015 and 2021.

- As determined by the detailed geologic information provided, and the hydrogeologic and groundwater quality data, groundwater within the uppermost aquifer at the Ash Pond is classified as Class I – Potable Resource Groundwater.
- Potential exceedances of 35 I.A.C. § 845.600 GWPSs were detected in monitoring wells downgradient of the EAP in the various hydrostratigraphic units as follows:
  - Boron – at five uppermost aquifer wells G06, G07, G08, G09, and G10.
  - Cobalt – at thirteen uppermost aquifer wells (G01D, G03, G05, G06S, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D), and at LAU well G09M.
  - pH – at two UCU wells (G54S, and G151), and at thirteen uppermost aquifer wells (G01D, G02D, G03, G05, G06S, G07, G09, G10, G11, G51D, G52D, G53D, and G54D).
  - Radium 226 and 228 combined – at uppermost aquifer well G02D.
  - Sulfate – at two uppermost aquifer wells G10 and G11.
  - Thallium – at uppermost aquifer wells G05, and G11.

This HCR satisfies Part 845 content requirements specific to 35 I.A.C. § 845.620(b) (Hydrogeologic Site Characterization) for the EAP at the JPP.

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TABLES

TABLE 2-1. GEOTECHNICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample ID	Field Location ID	Top of Sample (ft bgs)	Bottom of Sample (ft bgs)	Moisture Content (%)	Dry Density (pcf)	Specific Gravity	Calculated Porosity [1] (%)	Vertical Hydraulic Conductivity (cm/s)	LL	PL	PI	Laboratory USCS	Gravel (%)	Sand (%)	Fines (%)
Equality Formation															
SB-G03-(32-34)-20210202	G03	32	34	15.5	112.7	2.659	32.1	4.7E-07	27	16	11	SC	0.6	53.8	45.6
SB-G09M-(16-18)-20210127	G09M	16	18	20.6	105.4	2.666	36.7	8.3E-08	39	16	23	CL	0	5.0	95.0
SB-G11-(24-26)-20210119	G11	24	26	18.5	109.1	2.688	35.0	5.6E-08	36	15	21	CL	0	11.5	88.5
Metropolis Formation															
SB-G09M-(46-48)-20210127	G09M	46	48	19.8	105.7	2.715	37.6	3.5E-07	35	15	20	CL	0	17.2	82.8
McNairy Formation															
SB-G03-(60-62)-20210202	G03	60	62	20.0	- -	2.671	- -	- -	- -	- -	- -	SP	1.5	94.4	4.1
SB-G09M-(82-84)-20210127	G09M	82	84	7.6	100.0	2.686	40.4	- -	- -	- -	- -	SP	22.7	75.4	1.9
SB-G09M-(112-114)-20210127	G09M	112	114	25.5	87.0	2.675	47.9	- -	- -	- -	- -	- -	0.7	84.1	15.2
SB-G11-(56-58)-20210119	G11	56	58	14.4	110.0	2.661	33.8	- -	NP	NP	NP	SM	0.2	87.7	12.1
CCR															
SB-XPW01-(6-8)-20210120	XPW01	6	8	34.7	85.6	2.711	49.4	2.1E-05	NP	NP	NP	SM	26.3	45.4	28.3
SB-XPW01-(46-48)-20210120	XPW01	46	48	31.7	87.7	2.675	47.5	2.8E-07	25	20	5	CL-ML	0	18.7	81.3
SB-XPW02-(24-26)-20210120	XPW02	24	26	47.6	74.0	2.567	53.8	- -	NP	NP	NP	SM	9.3	74.1	16.6
SB-XPW03-(22-24)-20210121	XPW03	22	24	45.4	- -	2.410	- -	- -	- -	- -	- -	- -	0	4.2	95.8
SB-XPW03-(36-38)-20210121	XPW03	36	38	46.5	65.7	1.999	47.4	1.8E-07	46	31	15	ML	0	9.4	90.6

[O: NMP 08/19/21; U: CJC 08/24/21; C: LDC 08/27/21]

Notes:
[1] Porosity calculated as relationship of bulk density (p_b) to particle density (p_d) (n = 100[1- (p_b/p_d)])
- - = Not Applicable/Not Analyzed
% = Percent
bgs = below ground surface
CCR = coal combustion residuals
cm/s = centimeters per second
ft = foot/feet
LL = Liquid limit
NP = Non-Plastic
pcf = pounds per cubic foot
PI = Plasticity Index
PL = Plastic Limit

USCS = Unified Soil Classification System
CL = Lean Clay
CL-ML = Silty Lean Clay
SC = Clayey Sand
SM = Silty Sand
SP = Poorly-Graded Sand

TABLE 2-2. ASH ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Depth (ft BGS)	Sample Date	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Boron (mg/kg)	Cadmium (mg/kg)	Calcium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Lead (mg/kg)	Lithium (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Thallium (mg/kg)
XPW01	4-6	01/20/2021	2.8	16.4	3080	3.7	542	1.41	141000	49.4	22	34.2	30.9	0.758	7.42	8.29	<0.93
XPW01	46-48	01/20/2021	<0.38	8.77	105	0.72	35.1	<0.19	3280	18.3	8.46	15.1	12.2	0.015	32.2	<0.94	0.32
XPW02	4-6	01/20/2021	3.25	21.1	2690	3.18	536	1.61	152000	57.7	22.9	32	28.2	0.583	9.93	6.65	1.13
XPW02	24-26	01/20/2021	2.19	44.1	193	3.86	334	2.37	34600	55.8	11.8	22.4	10.4	<0.014	7.99	2.23	2.11
XPW03	6-8	01/21/2021	4.07	55.8	976	3.3	308	0.95	34700	44.8	11.8	60.3	16.2	0.029	11.6	2.15	1.33
XPW03	34-36	01/21/2021	0.41	52.7	149	1.49	92.6	0.65	4010	31.2	8.26	42.8	17.5	0.33	213	6.94	0.46

Notes:
< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method.
BGS = below ground surface
ft = feet
mg/kg = milligrams per kilogram

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TABLE 2-3. POREWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)
XPW01	03/05/2021	<0.001	0.0243	0.165	<0.001	10.4	<0.001	162	10	<0.0015	<0.001	0.67	<0.001	<0.003	<0.0002	0.46	8.0	1.03	<0.001	345	<0.002
XPW01	03/24/2021	<0.001	0.0346	0.161	<0.001	9.58	<0.001	158	9	<0.0015	<0.001	0.55	<0.001	<0.003	<0.0002	0.36	8.4	0.746	<0.001	355	<0.002
XPW01	04/14/2021	<0.001	0.0362	0.154	<0.001	9.42	<0.001	156	7	<0.0015	<0.001	0.57	<0.001	<0.003	<0.0002	0.362	8.2	0.226	<0.001	355	<0.002
XPW01	05/12/2021	<0.002	0.0329	0.162	<0.001	10.2	<0.001	166	6	<0.001	<0.001	0.62	<0.001	<0.005	<0.0002	0.419	8.4	0.158	<0.001	309	<0.001
XPW01	07/21/2021	<0.001	0.0529	0.175	<0.001	10.1	<0.001	160	6	<0.0015	<0.001	0.54	<0.001	<0.003	<0.0002	0.448	7.3	1.16	<0.001	328	<0.002
XPW02	03/04/2021	0.001	0.0379	0.0342	<0.001	12.1	<0.001	591	130	<0.0015	<0.001	0.42	<0.001	0.0691	<0.0002	0.855	8.0	0.511	<0.001	2380	<0.002
XPW02	03/24/2021	<0.001	0.0366	0.0271	<0.001	12.2	<0.001	484	176	<0.0015	<0.001	0.45	<0.001	0.0647	<0.0002	1.03	8.0	0.474	<0.001	2830	<0.002
XPW02	04/14/2021	<0.001	0.0379	0.0283	<0.001	11.5	<0.001	551	110	<0.0015	<0.001	0.44	<0.001	0.0616	<0.0002	0.781	7.9	0.266	<0.001	2410	<0.002
XPW02	05/12/2021	<0.002	0.0415	0.0287	<0.001	10.8	<0.001	495	134	0.00116	<0.001	0.41	0.00127	0.063	<0.0002	0.846	7.8	0.783	<0.001	2410	<0.001
XPW02	07/21/2021	<0.001	0.0388	0.0226	<0.001	12	<0.001	494	179	<0.0015	<0.001	0.4	<0.001	0.0761	<0.0002	0.856	7.8	1.31	<0.001	2330	<0.002
XPW03	03/04/2021	0.0116	0.401	0.0116	<0.001	12.2	<0.001	17.3	25	<0.0015	<0.001	0.26	<0.001	0.168	<0.0002	0.362	10.5	0.071	0.0102	133	<0.002
XPW03	03/24/2021	0.0105	0.402	0.0124	<0.001	11.6	<0.001	15.9	25	<0.0015	<0.001	0.26	<0.001	0.16	<0.0002	0.322	10.6	0.298	0.0144	138	<0.002
XPW03	04/14/2021	0.0117	0.439	0.0118	<0.001	9.3	<0.001	15.1	27	<0.0015	<0.001	0.26	<0.001	0.157	<0.0002	0.334	10.5	0.0298	0.0156	152	<0.002
XPW03	05/12/2021	0.012	0.452	0.012	<0.001	11.7	<0.001	16.4	25	<0.001	<0.001	0.25	<0.001	0.163	<0.0002	0.358	10.7	0.0533	0.00688	155	<0.001
XPW03	07/21/2021	0.0103	0.467	0.0114	<0.001	11.6	<0.001	15.3	26	<0.0015	<0.001	0.26	<0.001	0.193	<0.0002	0.329	10.0	1.08	0.0171	148	<0.002

Notes:
Field readings are reported with as many significant figures as provided by analytical laboratory.
< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method.
mg/L = milligrams per liter
pCi/L = picocuries per liter
SU = standard units

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RAMBOLL

TABLE 2-4. SOIL ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Geologic Unit	Sample Depth (ft BGS)	Sample Date	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Boron (mg/kg)	Cadmium (mg/kg)	Calcium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Lead (mg/kg)	Lithium (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Thallium (mg/kg)
G03	Equality Formation	30-32	02/02/2021	<0.37	2.59	347	0.71	<4.63	<0.18	1590	18.7	110	27.8	12.6	<0.012	0.38	<0.91	0.26
G03	McNairy Formation	58-60	02/02/2021	<0.37	0.3	6.01	<0.28	<4.72	<0.19	153	4.69	0.82	1.3	0.86	<0.012	<0.19	<0.94	<0.19
G09M	Equality Formation	10-12	01/26/2021	<0.39	3.34	93.6	0.46	<4.55	<0.18	1740	16.6	5.68	7.76	9.67	0.021	0.37	<0.91	<0.18
G09M	McNairy Formation	82-84	01/27/2021	<0.38	6.34	19.6	0.89	<4.55	<0.18	277	19.4	7.69	3.48	0.78	<0.012	1.04	<0.91	<0.18
G09M	McNairy Formation	110-112	01/27/2021	<0.38	4.44	11.5	<0.29	<4.9	<0.2	420	7.43	0.8	3.76	1.72	<0.012	0.51	<0.98	<0.2
G09M	Salem Limestone	142-144	01/28/2021	<0.38	1.88	41.9	<0.29	<4.81	2.75	333000	6.32	2.94	2.02	2.03	<0.027	0.24	<0.96	<0.19
G11	Equality Formation	22-24	01/19/2021	0.79	3.5	173	0.74	<4.55	0.43	1370	15.7	2.72	8.64	5.69	<0.011	0.36	<0.91	0.41
G11	McNairy Formation	58-60	01/19/2021	<0.37	1.15	21.6	0.3	<4.55	<0.18	430	6.05	1.29	3	2.03	<0.011	<0.18	<0.91	<0.18

Notes:
< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method.
BGS = below ground surface
ft = foot or feet
mg/kg = milligrams per kilogram

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TABLE 3-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well Number	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
G01D	UA	08/14/2015	364.19	364.19	Top of Disk	361.50	54.19	63.85	307.31	297.65	64.40	297.10	9.7	2	37.220429	-88.857179
G02D	UA	08/13/2015	363.65	363.65	Top of Disk	360.82	62.21	71.84	298.61	288.98	72.40	288.50	9.6	2	37.220715	-88.853311
G03	UA	02/02/2021	357.87	357.87	Top of PVC	354.84	55.00	65.00	302.90	292.90	65.00	289.80	10	2	37.220682	-88.850376
G04	UA	02/02/2021	359.07	359.07	Top of PVC	356.15	50.00	60.00	309.10	299.10	60.00	296.20	10	2	37.21804	-88.849321
G05	UA	02/01/2021	361.21	361.21	Top of PVC	358.45	50.00	60.00	311.20	301.20	60.00	298.50	10	2	37.21719	-88.849014
G06	UA	01/29/2021	355.24	355.24	Top of PVC	352.60	75.00	85.00	280.20	270.20	85.00	267.60	10	2	37.212929	-88.848893
G06S	UA	01/28/2021	355.35	355.35	Top of PVC	352.47	30.00	40.00	325.30	315.30	40.00	312.50	10	2	37.212957	-88.84889
G07	UA	01/29/2021	353.53	353.53	Top of PVC	350.34	50.00	60.00	303.50	293.50	60.00	290.30	10	2	37.211001	-88.848969
G08	UA	01/28/2021	343.54	343.54	Top of PVC	341.72	75.00	85.00	268.50	258.50	85.00	256.70	10	2	37.210531	-88.851015
G09	UA	01/31/2021	351.70	351.70	Top of PVC	348.69	59.50	69.50	292.20	282.20	69.50	279.20	10	2	37.210336	-88.854116
G09M	LAU	01/28/2021	351.53	351.53	Top of PVC	348.60	145.00	155.00	206.50	196.50	155.00	193.60	10	2	37.210341	-88.85413
G10	UA	02/01/2021	353.49	353.49	Top of PVC	350.75	60.30	70.30	293.20	283.20	70.30	280.50	10	2	37.211272	-88.855841
G11	UA	01/19/2021	366.55	366.55	Top of PVC	363.38	55.70	65.70	310.90	300.90	65.70	297.70	10	2	37.214408	-88.85633
G51D	UA	08/18/2015	363.85	363.85	Top of PVC	361.10	49.61	59.27	311.49	301.83	59.90	301.20	9.7	2	37.216016	-88.855653
G52D	UA	08/19/2015	348.41	348.41	Top of PVC	345.88	69.85	79.55	276.03	266.33	80.01	265.90	9.7	2	37.209626	-88.852943
G53D	UA	08/21/2015	355.47	355.47	Top of PVC	352.16	47.29	56.89	304.87	295.27	57.33	294.20	9.6	2	37.215069	-88.849367
G54S	UCU	01/22/2021	356.57	356.57	Top of PVC	353.58	34.70	44.70	321.90	311.90	44.70	308.90	10	2	37.212291	-88.857497
G54D	UA	08/11/2015	357.03	357.03	Top of PVC	353.71	69.96	79.66	283.75	274.05	80.14	273.60	9.7	2	37.212264	-88.857485
G151	UCU	06/19/2010	363.38	363.38	Top of PVC	360.79	31.70	41.70	329.11	319.11	41.70	318.80	10	2	37.216047	-88.855649
G152	UCU	06/21/2010	351.07	351.07	Top of PVC	348.55	14.70	24.70	333.85	323.85	24.70	323.60	10	2	37.210848	-88.854907
G152B	UCU	01/30/2013	347.56	347.56	Top of PVC	345.84	34.40	44.40	311.34	301.34	44.60	301.20	10	2	37.209621	-88.852935
G153	UCU	06/18/2010	354.11	354.11	Top of PVC	351.56	29.70	39.70	321.98	311.98	39.70	311.70	10	2	37.215057	-88.849378
XPW01	CCR	01/20/2021	383.36	383.36	Top of PVC	380.75	48.70	53.70	334.70	329.70	53.70	327.10	5	2	37.216965	-88.852074

TABLE 3-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well Number	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
XPW02	CCR	01/21/2021	376.05	376.05	Top of PVC	373.23	24.70	29.70	351.30	346.30	29.70	343.60	5	2	37.215865	-88.855001
XPW03	CCR	01/21/2021	381.52	381.52	Top of PVC	378.65	31.70	36.70	349.80	344.80	36.70	342.00	5	2	37.212153	-88.85542
XSG01	CCR	--	--	371.78	Staff gauge	--	--	--	--	--	--	--	--	--	37.21517	-88.8498
SG02	SW	--	--	--	Staff gauge	--	--	--	--	--	--	--	--	--	37.207287	-88.860503

Notes:
All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
-- = data not available
BGS = below ground surface
CCR = coal combustion residuals
ft = foot or feet
HSU = Hydrostratigraphic Unit
LAU = lower aquifer unit
PVC = polyvinyl chloride
SW = surface water
UA = uppermost aquifer
UCU = upper confining unit
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TABLE 3-2. VERTICAL HYDRAULIC GRADIENTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Date	G06S Groundwater Elevation (ft NAVD88)	G06 Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	UA				
3/4/2021	317.76	317.63	0.13	45.16	0.003	down
3/24/2021	324.85	323.74	1.11	44.87	0.025	down
4/13/2021	323.95	323.14	0.81	44.87	0.018	down
5/11/2021	319.60	319.12	0.48	47.00	0.010	down
6/14/2021-6/15/2021	317.01	316.38	0.63	44.41	0.014	down
6/1/2021	317.66	317.08	0.58	45.06	0.013	down
7/6/2021	315.88	315.44	0.44	43.28	0.010	down
7/20/2021	315.80	315.42	0.38	43.20	0.009	down
			Middle of screen elevation G06S			317.5
			Middle of screen elevation G06			272.6

Date	G09 Groundwater Elevation (ft NAVD88)	G09M Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	LAU				
3/4/2021	318.48	321.48	-3.00	85.59	-0.035	up
3/25/2021	322.65	324.08	-1.43	85.59	-0.017	up
4/14/2021	319.59	322.19	-2.60	85.59	-0.030	up
5/11/2021	316.57	321.42	-4.85	85.59	-0.057	up
6/1/2021	311.02	317.47	-6.45	85.59	-0.075	up
6/14/2021-6/15/2021	311.68	318.47	-6.79	85.59	-0.079	up
7/6/2021	313.60	316.93	-3.33	85.59	-0.039	up
7/21/2021	312.34	317.29	-4.95	85.59	-0.058	up
			Middle of screen elevation G09			284.2
			Middle of screen elevation G09M			198.6

TABLE 3-2. VERTICAL HYDRAULIC GRADIENTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Date	G101 Groundwater Elevation (ft NAVD88) UCU	G01D Groundwater Elevation (ft NAVD88) UA	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
3/24/2021	319.95	327.02	-7.07	11.87	-0.596	up
4/14/2021	319.74	325.92	-6.18	11.87	-0.521	up
5/12/2021	319.37	324.12	-4.75	11.87	-0.400	up
6/1/2021	323.24	320.46	2.78	11.87	0.234	down
6/14/2021-6/15/2021	318.91	322.10	-3.19	16.45	-0.194	up
7/6/2021	321.42	321.38	0.04	11.87	0.003	down
07/20/2021-07/21/2021	321.17	320.89	0.28	11.87	0.024	down
			Middle of screen elevation G101			314.3
			Middle of screen elevation G01D			302.5

Date	G151 Groundwater Elevation (ft NAVD88) UCU	G51D Groundwater Elevation (ft NAVD88) UA	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
3/3/2021	326.64	321.47	5.17	19.98	0.259	down
3/24/2021	330.47	326.10	4.37	17.43	0.251	down
4/14/2021	329.35	325.45	3.90	17.43	0.224	down
5/11/2021	329.35	323.14	6.21	17.43	0.356	down
6/1/2021	325.68	321.10	4.58	19.02	0.241	down
6/14/2021	326.03	320.84	5.19	19.37	0.268	down
7/6/2021	324.48	322.67	1.81	17.82	0.102	down
7/20/2021	324.77	319.59	5.18	18.11	0.286	down
			Middle of screen elevation G151			324.1
			Middle of screen elevation G51D			306.7

TABLE 3-2. VERTICAL HYDRAULIC GRADIENTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Date	G152B Groundwater Elevation (ft NAVD88)	G52D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UCU	UA				
3/3/2021	338.25	327.46	10.79	35.26	0.306	down
3/24/2021-3/25/2021	338.38	323.36	15.02	35.26	0.426	down
4/14/2021	336.25	321.87	14.38	35.26	0.408	down
5/12/2021	338.96	309.79	29.17	35.26	0.827	down
6/1/2021	334.71	324.23	10.48	35.26	0.297	down
6/15/2021	335.06	323.91	11.15	35.26	0.316	down
7/6/2021	332.91	323.36	9.55	35.26	0.271	down
7/20/2021	332.91	322.91	10.00	35.26	0.284	down
			Middle of screen elevation G152B			306.4
			Middle of screen elevation G52D			271.2

Date	G153 Groundwater Elevation (ft NAVD88)	G53D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UCU	UA				
3/3/2021	319.04	319.40	-0.36	18.97	-0.019	up
3/24/2021-3/25/2021	324.74	325.15	-0.41	16.79	-0.024	up
4/13/2021-4/14/2021	324.60	324.23	0.37	16.79	0.022	down
5/11/2021	320.59	320.99	-0.40	20.52	-0.019	up
6/1/2021	319.71	319.65	0.06	19.64	0.003	down
6/14/2021	320.19	320.17	0.02	20.12	0.001	flat
7/6/2021	318.17	318.02	0.15	18.10	0.008	down
7/20/2021	317.91	317.83	0.08	17.84	0.004	down
			Middle of screen elevation G153			316.9
			Middle of screen elevation G53D			300.1

TABLE 3-2. VERTICAL HYDRAULIC GRADIENTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Date	G54S Groundwater Elevation (ft NAVD88)	G54D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UCU	UA				
3/3/2021	310.25	317.69	-7.44	31.35	-0.237	up
3/24/2021	311.48	324.08	-12.60	32.58	-0.387	up
4/14/2021	312.84	322.45	-9.61	33.94	-0.283	up
5/12/2021	315.44	319.02	-3.58	36.54	-0.098	up
6/1/2021	312.65	314.79	-2.14	33.75	-0.063	up
6/14/201	314.30	314.93	-0.63	35.40	-0.018	up
7/6/2021	316.75	314.73	2.02	37.85	0.053	down
7/20/2021	318.87	314.77	4.10	39.97	0.103	down
			Middle of screen elevation G54S			313.9
			Middle of screen elevation G54D			278.9

[O: RAB 8/20/21, U: CJC 8/26/21, C: LDC 8/30/21, U: RAB 10/6/21, C: KLT 10/6/21]

Notes:
[1] Distance change was calculated using the midpoint of the piezometer screen and water table surface. If the water table surface was above the top of the monitoring well screen, then distance change was calculated using the midpoint of both screens.
[2] Vertical gradients between ±0.0015 are considered flat, and typically have less than 0.02 foot difference in groundwater elevation between wells.
dh = head change
dl = distance change
ft = foot/feet
LAU = lower aquifer unit
NAVD88 = North American Vertical Datum of 1988
UA = uppermost aquifer
UCU = upper confining unit

TABLE 3-3. FIELD HYDRAULIC CONDUCTIVITIES
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	Gradient Position	Bottom of Screen Elevation (ft NAVD88)	Screen Length [1] (ft)	Field Identified Screened Material	Slug Type	Analysis Method	Falling Head (Slug In) K (cm/s)			Rising Head (Slug Out) K (cm/s)			Average Hydraulic Conductivity (cm/s)	Minimum Hydraulic Conductivity (cm/s)	Maximum Hydraulic Conductivity (cm/s)	Hydraulic Conductivity Geometric Mean (cm/s)
							1	2	3	1	2	3				
Uppermost Aquifer																
G06	D	267.60	10.0	Gravely Silty Clay	Solid	Bouwer-Rice	1.20E-03	1.02E-03	---	1.03E-03	8.14E-04	---	1.02E-03	4.84E-04	1.18E-02	3.10E-03
G07	D	290.34	10.0	Sand	Solid	Bouwer-Rice	6.96E-03	1.18E-02	8.98E-03	8.22E-03	1.05E-02	1.02E-02	9.45E-03			
G08	D	256.72	10.0	Sand	Solid	Bouwer-Rice	5.51E-03	5.82E-03	---	2.92E-03	3.69E-03	---	4.49E-03			
G09	D	279.19	10.0	Sandy Gravel	Solid	Bouwer-Rice	2.62E-03	---	---	1.55E-03	---	---	2.08E-03			
G10	D	280.45	10.0	Sand and Sandy Gravel	Solid	Bouwer-Rice	1.36E-03	8.69E-04	---	4.84E-04	5.25E-04	---	8.08E-04			
G11	U	297.68	10.0	Sand	Solid	Bouwer-Rice	7.15E-03	6.36E-03	---	6.72E-03	7.23E-03	---	6.86E-03			
Lower Aquifer Unit																
G09M	D	193.60	10.0	Bedrock	Solid	Bouwer-Rice	2.73E-04	5.82E-04	---	3.78E-04	4.16E-04	---	4.12E-04	2.73E-04	5.82E-04	3.97E-04
CCR Fill																
XPW-02	NA	343.53	5.0	Ash	Solid	Bouwer-Rice	9.82E-03	9.25E-03	---	4.46E-03	5.39E-03	---	7.23E-03	4.46E-03	1.65E-01	1.29E-02
XPW-03	NA	341.95	5.0	Ash	Solid	Springer-Gelhar	---	---	---	1.65E-01	---	---	1.65E-01			

Notes:
[1] All wells are constructed from 2 inch PVC with 0.01 inch slotted screens.
--- = Test not analyzed/performed
CCR = coal combustion residuals
cm/s = centimeters per second
D = downgradient
ft = foot/feet
NA = Not Applicable
NAVD88 = North American Vertical Datum of 1988
U = upgradient

[O: XXX MM/DD/YY; U: CJC 08/24/21; C: LDC 08/30/21]

TABLE 3-4. HORIZONTAL HYDRAULIC GRADIENTS AND GROUNDWATER FLOW VELOCITIES
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

$V = K i / n_e$ V = Groundwater Velocity
K = Hydraulic Conductivity [1]
i = hydraulic gradient
n_e = Effective Porosity [2]

Northeast of CCR Unit (G02D to G53D): Uppermost Aquifer

Distance between Wells (ft): 2352
Hydraulic Conductivity (ft/day): 1.2
Effective Porosity (%): 27 Assumes: gravel and sand

Date	G02D Groundwater Elevation (ft NAVD88)	G53D Groundwater Elevation (ft NAVD88)	Change in Elevation (ft)	Horizontal Gradient (ft/ft)	Velocity (ft/day)
3/3/2021	321.77	319.40	2.37	0.0010	0.004
3/24/2021	325.91	325.15	0.76	0.0003	0.001
4/14/2021	324.71	324.23	0.48	0.0002	0.001
5/11/2021-5/12/2021	323.72	320.99	2.73	0.0012	0.005
6/1/2021	321.23	319.65	1.58	0.0007	0.003
6/14/2021	321.86	320.17	1.69	0.0007	0.003
7/6/2021	319.74	318.02	1.72	0.0007	0.003
7/20/2021-7/21/2021	320.62	317.83	2.79	0.0012	0.005
			Average	0.0008	0.003

Center of CCR Unit (G02D to G08): Uppermost Aquifer

Distance between Wells (ft): 3768
Hydraulic Conductivity (ft/day): 6.8
Effective Porosity (%): 27 Assumes: gravel and sand

Date	G02D Groundwater Elevation (ft NAVD88)	G08 Groundwater Elevation (ft NAVD88)	Change in Elevation (ft)	Horizontal Gradient (ft/ft)	Velocity (ft/day)
3/3/2021-3/4/2021	321.77	316.89	4.88	0.0013	0.032
3/24/2021	325.91	- - -	- - -	- - -	- - -
4/14/2021-4/14/2021	324.71	320.77	3.94	0.0010	0.026
5/11/2021-5/12/2021	323.72	315.82	7.90	0.0021	0.052
6/1/2021	321.23	313.42	7.81	0.0021	0.051
6/14/2021-6/15/2021	321.86	312.94	8.92	0.0024	0.059
7/6/2021	319.74	312.52	7.22	0.0019	0.047
7/20/2021-7/21/2021	320.62	312.49	8.13	0.0022	0.053
			Average	0.0019	0.046

TABLE 3-4. HORIZONTAL HYDRAULIC GRADIENTS AND GROUNDWATER FLOW VELOCITIES
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Southwest of CCR Unit (G11 to G54D): Uppermost Aquifer

Distance between Wells (ft): 848
Hydraulic Conductivity (ft/day): 10.8
Effective Porosity (%): 25 Assumes: gravel, sand, and silt

Date	G11 Groundwater Elevation (ft NAVD88)	G54D Groundwater Elevation (ft NAVD88)	Change in Elevation (ft)	Horizontal Gradient (ft/ft)	Velocity (ft/day)
3/3/3031-3/4/2021	319.77	317.69	2.08	0.0025	0.106
4/14/2021	325.15	322.45	2.70	0.0032	0.138
5/12/2021	322.77	319.02	3.75	0.0044	0.191
6/1/2021	323.49	314.79	8.70	0.0103	0.444
6/14/2021	320.25	314.93	5.32	0.0063	0.271
7/6/2021	319.25	314.73	4.52	0.0053	0.231
7/20/2021	319.20	314.77	4.43	0.0052	0.226
			Average	0.0053	0.230

South of CCR Unit (G11 to G10): Uppermost Aquifer

Distance between Wells (ft): 1150
Hydraulic Conductivity (ft/day): 10.9
Effective Porosity (%): 27 Assumes: gravel and sand

Date	G11 Groundwater Elevation (ft NAVD88)	G10 Groundwater Elevation (ft NAVD88)	Change in Elevation (ft)	Horizontal Gradient (ft/ft)	Velocity (ft/day)
3/4/2021	319.77	319.43	0.34	0.0003	0.012
4/13/2021-4/14/2021	325.15	320.85	4.30	0.0037	0.149
5/11/2021-5/12/2021	322.77	- - -	- - -	- - -	- - -
6/1/2021	323.49	313.37	10.12	0.0088	0.350
6/14/2021-6/15/2021	320.25	313.34	6.91	0.0060	0.239
7/6/2021	319.25	313.38	5.87	0.0051	0.203
7/20/2021	319.20	313.54	5.66	0.0049	0.196
			Average	0.0048	0.191

[O: CJC 8/24/21, U: CJC 8/26/21, C: LDC 08/30/21, U: RAB 10/8/21, C: KLT 10/8/21]

Notes:

[1] Hydraulic conductivity values used above are average of the individual wells used in each velocity calculation as derived from slug tests reported in O'Brien and Gere Engineers, Inc. 2017 *Hydrogeologic Monitoring Plan, Joppa East Ash Pond* and March 2021 by Geosyntec Consultants, Inc.

[2] Effective porosity used in these calculations was derived from an average between estimated values of 0.20 for silt material, 0.267 for gravel, 0.07 for clay, and 0.28 for sand from Morris, D.A. and A.I. Johnson, 1967. *Summary of hydrologic and physical properties of rock and soil materials as analyzed by the Hydrologic Laboratory of the U.S. Geological Survey,* U.S. Geological Survey Water-Supply Paper 1839-D, 42p. and Heath, R.C., 1983. *Basic ground-water hydrology* , U.S. Geological Survey Water-Supply Paper 2220, 86p.

Effective porosity may be as high as maximum total porosity (50%) calculated in Table 2-1.
% = percent
ft= foot/feet
ft/ft = feet per feet
ft/day = feet per day
NAVD88 = North American Vertical Datum of 1988

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G01D	12/03/2015	<0.001	0.0015	0.254	<0.001	<0.025	<0.001	37.9	13	0.0047	0.006	0.26	0.0018	0.0018	<0.0002	0.001	6.7	0.07	<0.001	20	<0.001	216
G01D	03/15/2016	<0.001	0.0026	0.283	<0.001	0.036	<0.001	45.5	20	0.0032	0.0136	0.29	0.0012	0.0017	<0.0002	0.0013	6.7	0.96	<0.001	126	<0.001	496
G01D	06/15/2016	<0.001	0.0018	0.204	<0.001	0.0296	<0.001	43.9	21	0.0016	0.0128	0.25	<0.001	0.0015	<0.0002	0.001	6.9	0.44	<0.001	157	<0.001	518
G01D	09/14/2016	<0.001	0.0021	0.19	<0.001	0.0416	<0.001	40.8	21	0.0031	0.0113	0.26	0.0013	0.0024	<0.0002	0.001	6.8	0.58	<0.001	129	<0.001	498
G01D	12/14/2016	<0.001	0.0012	0.163	<0.001	<0.025	<0.001	35.9	14	0.0036	0.0077	0.24	0.0012	0.0024	<0.0002	<0.001	6.8	0.4	<0.001	53	<0.001	294
G01D	03/07/2017	<0.001	<0.001	0.155	<0.001	<0.025	<0.001	34.9	16	0.0014	0.0061	0.22	<0.001	0.0013	<0.0002	<0.001	6.2	0.24	<0.001	72	<0.001	384
G01D	06/15/2017	<0.001	<0.001	0.14	<0.001	<0.025	<0.001	32.1	15	0.0032	0.0047	0.23	0.0013	0.0018	<0.0002	<0.001	6.7	0.93	<0.001	56	<0.001	372
G01D	07/20/2017	<0.001	0.001	0.14	<0.001	<0.025	<0.001	29.5	12	0.0042	0.0035	0.24	0.0014	0.0017	<0.0002	0.0018	6.8	0.41	<0.001	31	<0.001	368
G01D	11/30/2017	--	--	--	--	<0.025	--	37.2	18	--	--	0.22	--	--	--	--	6.8	--	--	117	--	450
G01D	06/19/2018	<0.001	0.0019	0.202	<0.001	<0.025	<0.001	29.5	13	0.0093	0.0057	0.24	0.0034	0.0038	<0.0002	<0.0015	6.8	1.41	<0.001	70	<0.002	394
G01D	09/05/2018	--	<0.001	0.147	--	<0.025	--	30.5	14	0.0026	0.0022	0.2	<0.001	0.0017	--	--	7.0	0.37	0.001	94	--	414
G01D	03/27/2019	<0.001	<0.001	0.129	<0.001	<0.025	<0.001	25.1	8	0.003	0.0014	0.23	<0.001	0.0015	<0.0002	<0.0015	6.7	0.78	0.0015	30	<0.002	310
G01D	09/09/2019	--	<0.001	0.123	--	<0.025	--	25.6	8	0.0044	0.0014	0.23	0.0012	<0.003	--	--	6.4	0.79	0.0011	37	--	336
G01D	03/30/2020	<0.001	0.0011	0.13	<0.001	<0.025	<0.001	22.7	8	0.0065	0.0018	0.21	0.0019	0.0034	<0.0002	<0.0015	6.8	1.44	0.0013	35	<0.002	296
G01D	09/23/2020	--	0.0014	0.123	--	<0.025	--	24.4	10	0.004	0.0016	0.21	0.0014	<0.003	--	--	6.7	2.27	0.0011	34	--	294
G01D	03/03/2021	<0.001	0.0017	0.137	0.0011	<0.025	0.001	25.8	10	0.0027	0.0015	0.2	0.0015	<0.003	<0.0002	0.0015	6.6	0.932	0.0024	18	<0.002	308
G01D	03/24/2021	<0.001	<0.001	0.136	<0.001	<0.025	<0.001	24.8	9	0.0022	<0.001	0.21	<0.001	<0.003	<0.0002	<0.0015	6.5	0	0.0016	21	<0.002	300
G01D	04/14/2021	<0.001	<0.001	0.112	<0.001	<0.025	<0.001	23.3	6	<0.0015	<0.001	0.23	<0.001	<0.003	<0.0002	<0.0015	6.7	0.831	0.001	39	<0.002	308
G01D	05/12/2021	<0.0066	<0.0033	0.133	<0.0033	0.0167	<0.0033	24.9	7	0.00204	<0.0033	0.21	<0.0033	<0.0165	<0.0002	<0.0033	6.5	0.176	0.00136	20	<0.0033	280
G01D	06/01/2021	<0.001	<0.001	0.134	<0.001	<0.025	<0.001	24.4	7	0.0033	<0.001	0.23	0.001	<0.003	<0.0002	<0.0015	6.3	0.525	0.0015	18	<0.002	260
G01D	06/14/2021	<0.001	<0.001	0.136	<0.001	<0.025	<0.001	24.4	9	0.0025	<0.001	0.23	<0.001	<0.003	<0.0002	<0.0015	6.5	0.706	0.0015	20	<0.002	268
G01D	07/06/2021	<0.001	<0.001	0.136	<0.001	<0.025	<0.001	23.3	10	0.0033	<0.001	0.22	0.001	<0.003	<0.0002	<0.0015	6.3	0.486	0.0015	20	0.002	262

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G01D	07/21/2021	<0.001	<0.001	0.125	<0.001	<0.025	<0.001	26	9	0.0023	<0.001	0.21	<0.001	<0.003	<0.0002	<0.0015	6.4	0.936	0.0016	18	<0.002	286
G02D	12/03/2015	<0.001	<0.001	0.232	<0.001	0.0536	<0.001	39.9	24	<0.001	0.0024	0.24	<0.001	0.0011	<0.0002	<0.001	6.7	1.1	0.0019	16	<0.001	244
G02D	03/15/2016	<0.001	<0.001	0.218	<0.001	0.0494	<0.001	39.8	24	<0.001	<0.001	0.22	<0.001	<0.001	<0.0002	<0.001	6.6	0.47	0.0022	17	<0.001	256
G02D	06/15/2016	<0.001	<0.001	0.203	<0.001	0.0508	<0.001	38.6	21	<0.001	<0.001	0.21	<0.001	0.0012	<0.0002	<0.001	6.8	0.63	0.0022	15	<0.001	248
G02D	09/14/2016	<0.001	<0.001	0.206	<0.001	0.0534	<0.001	34.7	24	<0.001	<0.001	0.2	<0.001	0.0013	<0.0002	<0.001	6.6	0.33	0.0033	22	<0.001	276
G02D	12/14/2016	<0.001	<0.001	0.224	<0.001	0.0552	<0.001	40.4	24	0.0057	0.0019	0.19	<0.001	0.0019	<0.0002	<0.001	6.3	0.4	0.0039	22	<0.001	266
G02D	03/08/2017	<0.001	<0.001	0.211	<0.001	0.0546	<0.001	40	24	<0.001	<0.001	0.19	<0.001	<0.001	<0.0002	<0.001	6.9	1.06	0.0024	18	<0.001	270
G02D	06/14/2017	<0.001	<0.001	0.192	<0.001	0.0467	<0.001	33.2	25	<0.001	<0.001	0.19	<0.001	0.0013	<0.0002	<0.001	6.3	0.63	0.0023	20	<0.001	198
G02D	07/20/2017	<0.001	<0.001	0.211	<0.001	0.044	<0.001	37.5	22	0.0016	<0.001	0.22	<0.001	<0.001	<0.0002	<0.001	6.7	1.33	0.0016	12	<0.001	264
G02D	11/30/2017	--	--	--	--	0.0496	--	40.1	23	--	--	0.21	--	--	--	--	6.9	--	--	17	--	246
G02D	06/19/2018	<0.001	<0.001	0.245	<0.001	0.0404	<0.001	33.9	23	<0.0015	<0.001	0.21	<0.001	<0.0015	<0.0002	<0.0015	6.7	0.92	0.0023	17	<0.002	232
G02D	09/05/2018	--	<0.001	0.209	--	0.0468	--	36.3	23	<0.0015	<0.001	0.18	<0.001	<0.0015	--	--	6.6	0.46	0.002	19	--	252
G02D	03/27/2019	<0.001	<0.001	0.235	<0.001	0.0473	<0.001	38.7	20	0.0026	<0.001	0.2	<0.001	<0.0015	<0.0002	<0.0015	6.6	0.12	0.003	20	<0.002	262
G02D	09/09/2019	--	<0.001	0.208	--	0.0429	--	40.3	18	<0.0015	<0.001	0.21	<0.001	<0.003	--	--	6.5	0.49	0.0021	20	--	264
G02D	03/30/2020	<0.001	<0.001	0.202	<0.001	0.0449	<0.001	33.5	20	<0.0015	<0.001	0.18	<0.001	<0.003	<0.0002	<0.0015	6.6	0.79	0.0035	22	<0.002	222
G02D	09/23/2020	--	<0.001	0.253	--	0.0442	--	45.8	19	<0.0015	<0.001	0.18	<0.001	<0.003	--	--	6.6	5.93	0.0052	22	--	234
G02D	03/03/2021	<0.001	<0.001	0.207	<0.001	0.0296	<0.001	34.5	21	<0.0015	<0.001	0.17	<0.001	<0.003	<0.0002	<0.0015	6.5	0.693	0.0024	21	<0.002	266
G02D	03/24/2021	<0.001	<0.001	0.206	<0.001	0.033	<0.001	34.4	22	<0.0015	<0.001	0.2	<0.001	<0.003	<0.0002	<0.0015	6.3	2.7	0.0024	18	<0.002	244
G02D	04/14/2021	<0.001	<0.001	0.187	<0.001	0.0318	<0.001	32.4	24	<0.0015	<0.001	0.21	<0.001	<0.003	<0.0002	<0.0015	6.3	0.464	0.0031	19	<0.002	242
G02D	05/12/2021	<0.0066	<0.0033	0.208	<0.0033	0.0356	<0.0033	34.6	18	<0.0033	<0.0033	0.18	<0.0033	<0.0165	<0.0002	<0.0033	6.3	0.152	0.00336	27	<0.0033	232
G02D	06/01/2021	<0.001	<0.001	0.191	<0.001	0.0433	<0.001	32.6	18	<0.0015	<0.001	0.19	<0.001	<0.003	<0.0002	<0.0015	6.2	1.33	0.0034	23	<0.002	246
G02D	06/14/2021	<0.001	<0.001	0.202	<0.001	0.0352	<0.001	34.6	20	<0.0015	<0.001	0.19	<0.001	<0.003	<0.0002	<0.0015	6.4	1.06	0.0027	23	<0.002	216

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G02D	07/06/2021	<0.001	<0.001	0.189	<0.001	0.0431	<0.001	32.3	21	<0.0015	<0.001	0.19	<0.001	<0.003	<0.0002	<0.0015	6.2	1.24	0.0026	22	<0.002	230
G02D	07/21/2021	<0.001	<0.001	0.181	<0.001	0.0329	<0.001	36.6	22	<0.0015	<0.001	0.2	<0.001	<0.003	<0.0002	<0.0015	6.2	0.774	0.0022	20	<0.002	246
G03	03/05/2021	<0.001	0.0043	0.112	<0.001	0.213	<0.001	46.1	20	0.0228	0.0063	0.2	0.0052	0.0049	<0.0002	0.0019	6.4	2.83	<0.001	66	<0.002	284
G03	03/24/2021	<0.001	0.0023	0.0821	<0.001	0.343	<0.001	53.5	24	0.0129	0.0037	0.21	0.0024	0.003	<0.0002	<0.0015	6.3	0.673	<0.001	104	<0.002	342
G03	04/14/2021	<0.001	0.003	0.0787	<0.001	0.603	<0.001	77.8	33	0.0114	0.0044	0.19	0.0032	0.004	<0.0002	0.0015	6.2	1.62	<0.001	168	<0.002	422
G03	05/12/2021	<0.0066	0.00133	0.0728	<0.0033	0.26	<0.0033	47.7	29	0.00606	0.00257	0.2	0.00229	<0.0165	<0.0002	<0.0033	6.4	0.739	<0.0033	112	<0.0033	304
G03	06/01/2021	<0.001	0.0019	0.0787	<0.001	0.232	<0.001	46	19	0.0094	0.002	0.22	0.0022	<0.003	<0.0002	<0.0015	6.3	0.211	<0.001	73	<0.002	294
G03	06/15/2021	<0.001	<0.001	0.0705	<0.001	0.225	<0.001	46.7	22	0.0025	<0.001	0.22	<0.001	<0.003	<0.0002	<0.0015	6.2	0.152	<0.001	79	<0.002	298
G03	07/06/2021	<0.001	<0.001	0.0564	<0.001	0.235	<0.001	42.1	22	<0.0015	<0.001	0.22	<0.001	<0.003	<0.0002	<0.0015	6.3	0.71	<0.001	77	<0.002	282
G03	07/21/2021	<0.001	<0.001	0.0555	<0.001	0.294	<0.001	50	24	0.0031	<0.001	0.2	0.0011	<0.003	<0.0002	<0.0015	6.4	0.503	<0.001	92	<0.002	310
G04	03/04/2021	<0.001	<0.001	0.339	<0.001	<0.025	<0.001	38.3	22	<0.0015	0.0017	0.22	<0.001	<0.003	<0.0002	0.0031	6.5	1.06	0.0023	21	<0.002	264
G04	03/24/2021	<0.001	<0.001	0.345	<0.001	<0.025	<0.001	42.7	31	<0.0015	0.0019	0.28	<0.001	<0.003	<0.0002	0.0042	6.5	2.79	0.0021	41	<0.002	308
G04	04/13/2021	<0.001	<0.001	0.291	<0.001	<0.025	<0.001	53.6	34	<0.0015	0.0016	0.27	<0.001	<0.003	<0.0002	0.0042	6.5	0.481	0.0033	63	<0.002	358
G04	05/11/2021	<0.0066	<0.0033	0.302	<0.0033	0.0157	<0.0033	51.5	35	<0.0033	0.00142	0.27	<0.0033	<0.0165	<0.0002	0.00485	6.3	1.93	0.00224	73	<0.0033	454
G04	07/20/2021	<0.001	<0.001	0.187	<0.001	<0.025	<0.001	57.4	36	<0.0015	0.0036	0.26	0.0012	<0.003	<0.0002	0.0037	6.3	1.33	0.0015	131	<0.002	436
G05	03/04/2021	<0.001	<0.001	0.13	<0.001	0.181	<0.001	55.3	13	0.0031	0.0101	0.28	<0.001	0.0032	<0.0002	0.0049	6.5	0.355	0.0029	94	<0.002	370
G05	03/24/2021	<0.001	<0.001	0.129	<0.001	0.195	<0.001	59.4	15	0.0028	0.0096	0.32	<0.001	<0.003	<0.0002	0.0058	6.4	1.85	0.0021	92	<0.002	370
G05	04/13/2021	<0.001	<0.001	0.126	<0.001	0.19	<0.001	68.5	21	<0.0015	0.0095	0.33	<0.001	<0.003	<0.0002	0.0055	6.5	0.381	0.002	95	<0.002	368
G05	05/11/2021	<0.0066	<0.0033	0.132	<0.0033	0.158	<0.0033	60.3	19	<0.0033	0.0087	0.34	<0.0033	<0.0165	<0.0002	0.00505	6.4	0.237	0.00142	109	<0.0033	348
G05	06/01/2021	<0.001	<0.001	0.144	<0.001	0.157	<0.001	57.1	21	<0.0015	0.0078	0.34	<0.001	<0.003	<0.0002	0.0051	6.5	0.572	0.0016	83	<0.002	366
G05	06/15/2021	<0.001	<0.001	0.132	<0.001	0.14	<0.001	58.6	18	<0.0015	0.0057	0.33	<0.001	<0.003	<0.0002	0.0049	6.3	1.65	0.0022	91	<0.002	366
G05	07/06/2021	<0.001	<0.001	0.139	<0.001	0.148	<0.001	51.8	22	<0.0015	0.0091	0.34	<0.001	0.0031	<0.0002	0.0058	6.4	0.94	0.0012	90	0.0033	334

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G05	07/20/2021	<0.001	<0.001	0.133	<0.001	0.131	<0.001	55.9	20	<0.0015	0.0059	0.32	<0.001	<0.003	<0.0002	0.0039	6.3	0.434	0.0011	87	<0.002	378
G06	03/04/2021	<0.001	0.0011	0.0484	<0.001	2.9	<0.001	90.2	22	0.0034	0.0026	0.3	<0.001	0.0039	<0.0002	<0.0015	6.7	1.26	<0.001	250	<0.002	546
G06	03/24/2021	<0.001	0.0019	0.049	<0.001	3.4	<0.001	90.1	23	0.0075	0.0034	0.27	0.0016	0.0045	<0.0002	<0.0015	6.6	0.4	<0.001	215	<0.002	536
G06	04/13/2021	<0.001	0.001	0.0382	<0.001	3.27	<0.001	124	22	0.0033	0.0021	0.28	<0.001	0.0042	<0.0002	<0.0015	6.6	0.253	<0.001	229	<0.002	534
G06	05/11/2021	<0.0066	<0.0033	0.0311	<0.0033	3.37	<0.0033	93.4	22	<0.0033	<0.0033	0.26	<0.0033	<0.0165	<0.0002	<0.0033	6.4	0.393	<0.0033	219	<0.0033	500
G06	06/01/2021	<0.001	<0.001	0.0323	<0.001	3.56	<0.001	92.6	22	0.0016	<0.001	0.28	<0.001	0.0037	<0.0002	<0.0015	6.6	0.89	<0.001	216	<0.002	546
G06	06/15/2021	<0.001	<0.001	0.028	<0.001	2.97	<0.001	91.5	21	<0.0015	<0.001	0.28	<0.001	<0.003	<0.0002	<0.0015	6.5	1.03	<0.001	230	<0.002	542
G06	07/06/2021	<0.001	<0.001	0.0272	<0.001	3.93	<0.001	86.7	22	<0.0015	<0.001	0.27	<0.001	0.005	<0.0002	<0.0015	6.3	0.493	<0.001	223	<0.002	500
G06	07/20/2021	<0.001	<0.001	0.0244	<0.001	3.41	<0.001	90.6	21	<0.0015	<0.001	0.26	<0.001	0.0035	<0.0002	<0.0015	6.4	1.12	<0.001	213	<0.002	548
G06S	03/04/2021	<0.001	<0.001	0.0886	<0.001	0.229	<0.001	27.7	<4	<0.0015	0.0045	0.28	<0.001	<0.003	<0.0002	<0.0015	6.2	0.542	<0.001	35	<0.002	198
G06S	03/24/2021	<0.001	<0.001	0.084	<0.001	0.253	<0.001	21.7	1	<0.0015	0.0144	0.37	<0.001	0.0055	<0.0002	<0.0015	5.8	0.95	<0.001	31	<0.002	166
G06S	04/13/2021	<0.001	<0.001	0.0823	<0.001	0.265	<0.001	29.4	1	<0.0015	0.0189	0.41	<0.001	0.0057	<0.0002	<0.0015	5.8	0.108	<0.001	30	<0.002	176
G06S	05/11/2021	<0.0066	<0.0033	0.0869	<0.0033	0.245	<0.0033	23.5	1	<0.0033	0.0141	0.4	<0.0033	0.00501	<0.0002	<0.0033	5.6	0.237	<0.0033	31	<0.0033	146
G06S	07/20/2021	<0.001	<0.001	0.0798	<0.001	0.248	<0.001	26.5	1	<0.0015	0.0021	0.3	<0.001	0.003	<0.0002	<0.0015	5.7	1.25	<0.001	30	<0.002	198
G07	03/04/2021	<0.001	0.0025	0.0958	<0.001	4.37	<0.001	93.9	21	0.0116	0.0062	0.2	0.002	0.0048	<0.0002	<0.0015	6.5	0.706	<0.001	285	<0.002	636
G07	03/24/2021	<0.001	<0.001	0.0643	<0.001	4.67	<0.001	92.8	21	0.0047	0.0035	0.42	<0.001	<0.003	<0.0002	<0.0015	6.4	0.226	<0.001	258	<0.002	600
G07	04/13/2021	<0.001	<0.001	0.0497	<0.001	5.04	<0.001	126	20	0.0024	0.0024	0.42	<0.001	<0.003	<0.0002	<0.0015	6.3	0.229	<0.001	274	<0.002	624
G07	05/11/2021	<0.0066	<0.0033	0.0448	<0.0033	4.55	<0.0033	90.4	19	<0.0033	0.00185	0.41	<0.0033	<0.0165	<0.0002	<0.0033	6.3	0.161	<0.0033	248	<0.0033	570
G07	06/01/2021	<0.001	<0.001	0.054	<0.001	5.23	<0.001	96.6	22	0.0038	0.0023	0.43	<0.001	0.0032	<0.0002	<0.0015	6.2	0.208	<0.001	257	<0.002	594
G07	06/15/2021	<0.001	<0.001	0.0429	<0.001	3.91	<0.001	89.3	20	<0.0015	0.0013	0.41	<0.001	<0.003	<0.0002	<0.0015	6.2	0.681	<0.001	246	<0.002	562
G07	07/06/2021	<0.001	<0.001	0.0373	<0.001	4.95	<0.001	84.8	21	<0.0015	0.0012	0.4	<0.001	<0.003	<0.0002	<0.0015	6.0	0.598	<0.001	258	<0.002	562
G07	07/20/2021	<0.001	<0.001	0.047	<0.001	4.48	<0.001	96.5	21	<0.0015	0.0014	0.4	<0.001	<0.003	<0.0002	<0.0015	6.1	1.36	<0.001	252	<0.002	598

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G08	03/04/2021	<0.001	0.0096	0.166	<0.001	4.53	<0.001	111	14	0.006	0.0103	0.41	0.0018	0.0038	<0.0002	0.0028	7.0	0.576	<0.001	241	<0.002	604
G08	03/24/2021	<0.001	0.0063	0.0946	<0.001	4.39	<0.001	115	16	0.0018	0.0064	0.36	<0.001	<0.003	<0.0002	0.0021	6.9	0.0774	<0.001	225	<0.002	592
G08	04/13/2021	<0.001	0.0073	0.0772	<0.001	5.25	<0.001	142	15	0.0016	0.0041	0.34	<0.001	<0.003	<0.0002	0.0024	7.0	0.635	<0.001	286	<0.002	620
G08	05/11/2021	<0.0066	0.00946	0.0685	<0.0033	3.77	<0.0033	101	12	<0.0033	0.0022	0.36	<0.0033	<0.0165	<0.0002	0.00227	6.9	0.699	<0.0033	203	<0.0033	508
G08	06/01/2021	<0.001	0.0061	0.0588	<0.001	4.63	<0.001	114	15	0.0023	0.0041	0.34	<0.001	<0.003	<0.0002	0.0022	7.0	0.256	<0.001	204	<0.002	568
G08	06/15/2021	<0.001	0.0066	0.0608	<0.001	3.97	<0.001	111	15	0.002	0.0029	0.32	<0.001	<0.003	<0.0002	0.0017	6.9	1.35	<0.001	226	<0.002	540
G08	07/06/2021	<0.001	0.0091	0.0575	<0.001	4.56	<0.001	109	16	0.0028	0.004	0.32	<0.001	<0.003	<0.0002	0.0015	6.8	1.49	<0.001	227	<0.002	548
G08	07/20/2021	<0.001	0.0091	0.0635	<0.001	3.98	<0.001	116	16	0.0039	0.0045	0.32	0.001	<0.003	<0.0002	0.0031	6.8	0.894	<0.001	227	<0.002	556
G09	03/04/2021	<0.001	0.0012	0.0675	<0.001	3.19	<0.001	103	24	<0.0015	0.0108	0.25	<0.001	0.0046	<0.0002	<0.0015	6.2	0.213	<0.001	351	<0.002	728
G09	03/25/2021	<0.001	0.0057	0.0984	0.0012	3.15	<0.001	95.2	29	0.0135	0.0159	0.31	0.0028	0.0058	<0.0002	<0.0015	6.3	1.65	<0.001	286	<0.002	688
G09	04/14/2021	<0.001	0.0044	0.0673	<0.001	3.48	<0.001	110	25	0.008	0.0131	0.35	0.0019	0.0047	<0.0002	<0.0015	6.3	0.206	<0.001	297	<0.002	712
G09	05/12/2021	<0.0066	0.00326	0.0586	<0.0033	3.26	<0.0033	87.7	22	0.00254	0.0103	0.37	<0.0033	<0.0165	<0.0002	<0.0033	6.4	0.215	<0.0033	272	<0.0033	656
G09	06/01/2021	<0.001	0.0028	0.0548	<0.001	3.65	<0.001	91.3	23	0.0024	0.0096	0.33	<0.001	0.0038	<0.0002	<0.0015	6.2	0.587	<0.001	284	<0.002	672
G09	06/15/2021	<0.001	<0.001	0.0136	<0.001	0.282	<0.001	137	21	<0.0015	0.0011	0.32	<0.001	0.0034	<0.0002	<0.0015	6.0	0.53	0.0053	294	<0.002	632
G09	07/06/2021	<0.001	0.0037	0.0444	<0.001	4.05	<0.001	79	22	<0.0015	0.0089	0.36	<0.001	0.0042	<0.0002	<0.0015	6.3	0.729	<0.001	289	<0.002	614
G09	07/21/2021	<0.001	0.0026	0.0454	<0.001	3.75	<0.001	92.1	21	0.0018	0.0085	0.31	<0.001	0.0034	<0.0002	<0.0015	6.0	0.321	<0.001	286	<0.002	652
G09M	03/04/2021	<0.001	0.0091	0.442	<0.001	0.0507	<0.001	114	7	0.0108	0.0097	0.31	0.0039	0.0103	<0.0002	0.0046	6.9	0.971	0.0011	20	<0.002	444
G09M	03/25/2021	<0.001	0.0062	0.437	<0.001	0.0299	<0.001	98.6	7	0.004	0.0066	0.34	0.0013	0.008	<0.0002	0.0044	6.8	2.06	<0.001	<10	<0.002	432
G09M	04/14/2021	<0.001	0.0038	0.407	<0.001	0.0544	<0.001	134	7	0.002	0.0041	0.36	<0.001	0.0089	<0.0002	0.0051	6.9	2.34	<0.001	<10	<0.002	506
G09M	05/12/2021	<0.0066	0.00719	0.34	<0.0033	0.0191	<0.0033	73.7	5	<0.0033	0.00162	0.27	<0.0033	<0.0165	<0.0002	0.00385	7.0	1.24	<0.0033	<10	<0.0033	282
G09M	07/21/2021	<0.001	0.0098	0.316	<0.001	0.0376	0.0018	99.9	7	0.0183	0.0105	0.34	0.0066	0.0096	<0.0002	0.0056	6.9	3.9	<0.001	<10	0.002	316
G10	03/04/2021	<0.001	0.0011	0.0608	<0.001	4.98	<0.001	107	35	0.0032	0.0109	0.29	<0.001	0.0035	<0.0002	0.0018	6.7	0.503	<0.001	391	<0.002	798

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G10	03/24/2021	<0.001	0.0019	0.0553	<0.001	4.31	<0.001	115	31	0.0053	0.0122	0.3	<0.001	0.0031	<0.0002	0.0018	6.7	0.709	<0.001	369	<0.002	752
G10	04/13/2021	<0.001	0.0017	0.0496	<0.001	4.26	<0.001	142	29	0.0063	0.01	0.31	<0.001	0.0033	<0.0002	0.0015	6.6	0.245	<0.001	382	<0.002	754
G10	05/11/2021	<0.0066	0.00118	0.0453	<0.0033	3.95	<0.0033	120	25	0.00109	0.00754	0.28	<0.0033	<0.0165	<0.0002	0.00107	6.3	0.954	<0.0033	364	<0.0033	746
G10	06/01/2021	<0.001	0.0014	0.0444	<0.001	4.73	<0.001	124	29	0.0037	0.0071	0.29	<0.001	0.0032	<0.0002	<0.0015	6.5	1.13	<0.001	401	<0.002	810
G10	06/15/2021	<0.001	<0.001	0.0439	<0.001	3.74	<0.001	128	26	<0.0015	0.005	0.28	<0.001	<0.003	<0.0002	<0.0015	6.5	1.33	<0.001	407	<0.002	760
G10	07/06/2021	<0.001	<0.001	0.0356	<0.001	4.81	<0.001	119	26	<0.0015	0.0049	0.27	<0.001	<0.003	<0.0002	<0.0015	6.5	1.31	<0.001	415	<0.002	750
G10	07/20/2021	<0.001	<0.001	0.0368	<0.001	4.2	<0.001	132	26	<0.0015	0.0045	0.26	<0.001	<0.003	<0.0002	<0.0015	6.5	0.693	<0.001	410	<0.002	806
G11	03/04/2021	<0.001	<0.001	0.0287	<0.001	0.247	<0.001	125	44	0.0017	0.0039	0.16	<0.001	0.0041	<0.0002	<0.0015	5.9	0.357	0.0038	400	<0.002	804
G11	03/24/2021	<0.001	<0.001	0.0244	<0.001	0.42	<0.001	178	35	<0.0015	0.0079	0.21	<0.001	0.0052	<0.0002	<0.0015	5.9	0.43	0.0128	658	<0.002	1110
G11	04/14/2021	<0.001	<0.001	0.0195	<0.001	0.411	<0.001	177	33	<0.0015	0.0031	0.22	<0.001	0.0058	<0.0002	0.0019	5.8	0.659	0.0118	761	<0.002	1200
G11	05/12/2021	<0.0066	<0.0033	0.0167	<0.0033	0.321	<0.0033	166	30	<0.0033	0.00393	0.2	<0.0033	<0.0165	<0.0002	<0.0033	5.9	0.0533	0.0092	730	<0.0033	1130
G11	06/01/2021	<0.001	<0.001	0.0166	<0.001	0.309	<0.001	165	33	<0.0015	0.0029	0.21	<0.001	0.0067	<0.0002	<0.0015	5.8	0.909	0.0077	671	<0.002	1120
G11	06/14/2021	<0.001	<0.001	0.0139	<0.001	0.266	<0.001	136	39	<0.0015	<0.001	0.19	<0.001	0.0034	<0.0002	<0.0015	5.9	1.18	0.0056	505	<0.002	850
G11	07/06/2021	<0.001	<0.001	0.0109	<0.001	0.358	<0.001	135	42	<0.0015	<0.001	0.18	<0.001	0.005	<0.0002	<0.0015	5.8	0.563	0.0041	474	<0.002	862
G11	07/20/2021	<0.001	<0.001	0.0119	<0.001	0.302	<0.001	149	39	<0.0015	<0.001	0.19	<0.001	0.0042	<0.0002	<0.0015	5.8	0.249	0.0062	487	0.0023	874
G51D	12/03/2015	<0.001	<0.001	0.129	<0.001	0.117	<0.001	39.2	9	<0.001	0.0141	0.13	<0.001	0.0035	<0.0002	<0.001	6.2	0.02	0.0024	117	<0.001	304
G51D	03/15/2016	<0.001	<0.001	0.0702	<0.001	0.184	<0.001	39.7	9	0.0014	0.0249	0.1	<0.001	0.0048	<0.0002	<0.001	5.9	0.69	0.0019	145	<0.001	342
G51D	06/15/2016	<0.001	<0.001	0.0628	<0.001	0.213	<0.001	42.3	7	<0.001	0.0198	<0.1	<0.001	0.0059	<0.0002	<0.001	5.8	0.43	0.0028	139	<0.001	330
G51D	09/14/2016	<0.001	<0.001	0.0536	<0.001	0.263	<0.001	29.6	9	<0.001	0.011	<0.1	<0.001	0.0052	<0.0002	<0.001	5.6	0.8	0.0031	136	<0.001	360
G51D	12/14/2016	<0.001	<0.001	0.0459	<0.001	0.171	<0.001	30	11	<0.001	0.0119	<0.1	<0.001	0.005	<0.0002	<0.001	5.9	0.29	0.0031	101	<0.001	270
G51D	03/08/2017	<0.001	<0.001	0.0493	<0.001	0.309	<0.001	32.6	8	<0.001	0.0082	<0.1	<0.001	0.0045	<0.0002	<0.001	6.2	0.52	0.0033	146	<0.001	340
G51D	06/15/2017	<0.001	<0.001	0.0442	<0.001	0.58	<0.001	34	9	<0.001	0.0052	<0.1	<0.001	0.0058	<0.0002	<0.001	5.6	0.56	0.0039	149	<0.001	340

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G51D	07/20/2017	<0.001	<0.001	0.0462	<0.001	0.332	<0.001	31.8	8	<0.001	0.0055	<0.1	<0.001	0.0047	<0.0002	<0.001	5.9	1.68	0.0035	140	<0.001	344
G51D	11/30/2017	--	--	--	--	0.302	--	34.4	8	--	--	<0.1	--	--	--	--	5.6	--	--	138	--	356
G51D	06/19/2018	<0.001	<0.001	0.0756	<0.001	0.337	<0.001	31.1	7	<0.0015	0.0038	<0.1	<0.001	0.007	<0.0002	<0.0015	5.7	1.22	0.0035	124	<0.002	324
G51D	09/05/2018	--	<0.001	0.0395	--	0.263	--	29.1	7	<0.0015	0.0043	<0.1	<0.001	0.0054	--	--	6.0	0.42	0.0036	134	--	342
G51D	03/27/2019	<0.001	<0.001	0.0495	<0.001	0.778	<0.001	34.7	6	0.0016	0.0026	<0.1	<0.001	0.0059	<0.0002	<0.0015	5.7	0.23	0.005	125	<0.002	350
G51D	09/09/2019	--	<0.001	0.0377	--	0.501	--	31.3	6	<0.0015	0.0017	<0.1	<0.001	0.0057	--	--	5.3	0.36	0.0042	109	--	320
G51D	03/30/2020	<0.001	<0.001	0.0445	<0.001	0.697	<0.001	31.2	6	0.0019	0.0024	<0.1	<0.001	0.0065	<0.0002	<0.0015	5.6	0.9	0.0048	130	<0.002	304
G51D	09/23/2020	--	<0.001	0.0445	--	0.863	--	42.1	6	<0.0015	0.002	<0.1	<0.001	0.0071	--	--	5.7	1.4	0.0063	121	--	314
G51D	03/24/2021	<0.001	<0.001	0.04	<0.001	0.786	<0.001	31.7	5	<0.0015	0.0022	<0.1	<0.001	0.0061	<0.0002	<0.0015	5.6	1.74	0.0055	122	<0.002	322
G52D	12/03/2015	<0.001	0.0032	0.318	<0.001	<0.025	<0.001	46.6	22	<0.001	0.0056	0.25	<0.001	0.0026	<0.0002	0.0017	6.5	0.31	<0.001	65	<0.001	332
G52D	03/15/2016	<0.001	0.0051	0.345	<0.001	<0.025	<0.001	49.1	22	<0.001	0.0064	0.26	<0.001	0.0023	<0.0002	<0.001	6.3	1.16	<0.001	99	<0.001	310
G52D	06/15/2016	<0.001	0.0072	0.506	<0.001	<0.025	<0.001	69.2	21	<0.001	0.0093	0.25	<0.001	0.004	<0.0002	<0.001	6.6	2.18	<0.001	88	<0.001	360
G52D	09/14/2016	<0.001	0.0043	0.362	<0.001	<0.025	<0.001	47.6	20	<0.001	0.0063	0.26	<0.001	0.0027	<0.0002	0.0017	6.4	1.81	<0.001	84	<0.001	376
G52D	12/14/2016	<0.001	0.003	0.356	<0.001	<0.025	<0.001	53.4	20	<0.001	0.003	0.25	<0.001	0.0036	<0.0002	0.0024	6.7	1.24	<0.001	82	<0.001	356
G52D	03/07/2017	<0.001	0.0066	0.358	<0.001	<0.025	<0.001	55	18	<0.001	0.0072	0.24	<0.001	0.0024	<0.0002	<0.001	5.9	0.8	<0.001	115	<0.001	410
G52D	06/14/2017	<0.001	0.0054	0.289	<0.001	<0.025	<0.001	51	17	<0.001	0.0062	0.24	<0.001	0.003	<0.0002	<0.001	6.2	1.28	<0.001	112	<0.001	372
G52D	07/19/2017	<0.001	0.0016	0.293	<0.001	<0.025	<0.001	50.7	15	<0.001	0.0013	0.27	<0.001	0.0028	<0.0002	0.0011	6.4	0.8	<0.001	108	<0.001	412
G52D	11/30/2017	--	--	--	--	<0.025	--	54.7	15	--	--	0.26	--	--	--	--	6.0	--	--	97	--	392
G52D	06/19/2018	<0.001	0.0025	0.34	<0.001	<0.025	<0.001	50.1	15	<0.0015	0.0045	0.26	<0.001	0.0035	<0.0002	<0.0015	6.4	1.64	<0.001	97	<0.002	388
G52D	09/05/2018	--	0.0014	0.275	--	<0.025	--	49.8	14	<0.0015	0.0019	0.24	<0.001	0.0032	--	--	6.3	0.68	<0.001	101	--	384
G52D	03/27/2019	<0.001	0.0064	0.271	<0.001	<0.025	<0.001	59.8	13	<0.0015	0.0069	0.28	<0.001	0.0028	<0.0002	<0.0015	6.4	0.58	<0.001	81	<0.002	376
G52D	09/09/2019	--	0.0021	0.254	--	<0.025	--	52.2	14	<0.0015	0.0022	0.27	<0.001	<0.003	--	--	6.0	1.54	<0.001	78	--	370

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G52D	03/30/2020	<0.001	0.0017	0.254	<0.001	<0.025	<0.001	48.8	14	<0.0015	0.0033	0.27	<0.001	<0.003	<0.0002	<0.0015	6.4	1.3	<0.001	84	<0.002	362
G52D	09/23/2020	--	0.0014	0.278	--	<0.025	--	59	15	<0.0015	0.0015	0.26	<0.001	<0.003	--	--	6.5	0.61	<0.001	84	--	336
G52D	03/25/2021	<0.001	0.0015	0.254	<0.001	<0.025	<0.001	48.6	14	<0.0015	0.0016	0.27	<0.001	<0.003	<0.0002	<0.0015	6.2	0.966	<0.001	75	<0.002	332
G53D	12/03/2015	<0.001	<0.001	0.353	<0.001	0.332	<0.001	62.6	22	0.0017	0.0087	0.79	<0.001	0.002	<0.0002	0.0013	6.8	0.28	<0.001	103	<0.001	368
G53D	03/15/2016	<0.001	<0.001	0.279	<0.001	0.334	<0.001	50.5	20	<0.001	0.0087	0.72	<0.001	0.0015	<0.0002	0.0012	6.7	1.24	<0.001	107	<0.001	406
G53D	06/15/2016	<0.001	<0.001	0.207	<0.001	0.342	<0.001	47.2	17	<0.001	0.0059	0.68	<0.001	0.0017	<0.0002	<0.001	6.6	1.11	<0.001	107	<0.001	392
G53D	09/14/2016	<0.001	<0.001	0.191	<0.001	0.368	<0.001	44.4	20	<0.001	0.002	0.7	<0.001	0.0016	<0.0002	<0.001	6.5	0.1	<0.001	104	<0.001	424
G53D	12/14/2016	<0.001	<0.001	0.169	<0.001	0.364	<0.001	44.5	20	<0.001	0.0029	0.69	<0.001	0.0018	<0.0002	<0.001	6.8	0.39	<0.001	106	<0.001	418
G53D	03/08/2017	<0.001	<0.001	0.109	<0.001	0.138	<0.001	23.6	6	0.0018	0.0027	0.49	<0.001	0.0021	<0.0002	<0.001	7.2	0.08	<0.001	35	<0.001	216
G53D	06/15/2017	<0.001	<0.001	0.172	<0.001	0.309	<0.001	38.9	18	<0.001	<0.001	0.59	<0.001	0.0022	<0.0002	<0.001	6.6	0.16	<0.001	79	<0.001	348
G53D	07/20/2017	<0.001	<0.001	0.165	<0.001	0.366	<0.001	40.8	18	<0.001	0.0011	0.69	<0.001	0.0015	<0.0002	<0.001	6.8	1.25	<0.001	94	<0.001	396
G53D	11/30/2017	--	--	--	--	0.427	--	44.6	20	--	--	0.74	--	--	--	--	6.6	--	--	98	--	348
G53D	06/19/2018	<0.001	<0.001	0.176	<0.001	0.361	<0.001	37.8	18	<0.0015	<0.001	0.66	<0.001	0.0019	<0.0002	<0.0015	6.6	0.77	<0.001	84	<0.002	360
G53D	09/05/2018	--	<0.001	0.133	--	0.392	--	40.3	20	<0.0015	0.0016	0.61	<0.001	0.0018	--	--	6.8	0.55	<0.001	81	--	390
G53D	03/27/2019	<0.001	<0.001	0.101	<0.001	0.269	<0.001	30.5	12	<0.0015	<0.001	0.59	<0.001	<0.0015	<0.0002	<0.0015	6.6	0.17	<0.001	54	<0.002	272
G53D	09/09/2019	--	<0.001	0.128	--	0.385	--	42.2	18	<0.0015	0.002	0.67	<0.001	<0.003	--	--	6.2	0.03	<0.001	80	--	364
G53D	03/30/2020	<0.001	<0.001	0.109	<0.001	0.334	<0.001	34.8	17	<0.0015	<0.001	0.63	<0.001	<0.003	<0.0002	<0.0015	6.7	1.32	<0.001	66	<0.002	296
G53D	09/23/2020	--	<0.001	0.122	--	0.411	--	44.4	20	<0.0015	0.0024	0.74	<0.001	<0.003	--	--	6.7	1.16	<0.001	79	--	342
G53D	03/25/2021	<0.001	<0.001	0.112	<0.001	0.355	<0.001	38.6	19	<0.0015	0.0026	0.71	<0.001	<0.003	<0.0002	<0.0015	6.5	0.321	<0.001	71	<0.002	334
G54S	03/03/2021	<0.001	<0.001	0.0456	<0.001	0.0966	<0.001	88.5	28	<0.0015	0.001	0.31	<0.001	0.0051	<0.0002	0.0035	6.3	0.648	0.0181	363	<0.002	788
G54S	03/24/2021	<0.001	<0.001	0.0573	<0.001	0.0563	<0.001	56.6	43	<0.0015	<0.001	0.36	<0.001	<0.003	<0.0002	0.0034	6.4	0.659	0.0324	150	<0.002	528
G54S	04/14/2021	<0.001	<0.001	0.0701	<0.001	0.0382	<0.001	59.6	39	<0.0015	<0.001	0.4	0.0013	<0.003	<0.0002	0.0039	6.2	0.231	0.0332	145	<0.002	468

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G54S	05/12/2021	<0.0066	<0.0033	0.0623	<0.0033	0.0528	<0.0033	56	36	<0.0033	<0.0033	0.34	<0.0033	<0.0165	<0.0002	0.00243	6.3	0.162	0.0298	144	<0.0033	440
G54S	07/20/2021	<0.001	<0.001	0.0917	<0.001	0.0353	<0.001	42.7	40	<0.0015	<0.001	0.52	<0.001	<0.003	<0.0002	0.0039	6.4	1.41	0.0286	71	<0.002	394
G54D	12/03/2015	<0.001	0.002	0.115	<0.001	0.663	<0.001	103	33	0.0016	0.0268	0.38	<0.001	0.0069	<0.0002	<0.001	7.0	0.2	<0.001	191	<0.001	556
G54D	03/15/2016	<0.001	0.0025	0.106	<0.001	0.513	<0.001	75.2	32	0.003	0.0183	0.38	<0.001	0.0078	<0.0002	0.001	6.8	0.354	<0.001	176	<0.001	554
G54D	06/15/2016	<0.001	0.002	0.114	<0.001	0.508	<0.001	72.8	28	<0.001	0.0158	0.34	<0.001	0.0068	<0.0002	<0.001	6.6	1.02	<0.001	160	<0.001	476
G54D	09/14/2016	<0.001	0.0026	0.134	<0.001	0.557	<0.001	70.4	28	<0.001	0.0167	0.34	<0.001	0.0062	<0.0002	<0.001	6.6	0.39	<0.001	149	<0.001	502
G54D	12/14/2016	<0.001	0.0033	0.138	<0.001	0.564	<0.001	74.3	26	<0.001	0.0178	0.32	<0.001	0.0061	<0.0002	<0.001	6.7	1.05	<0.001	144	<0.001	456
G54D	03/08/2017	<0.001	0.0025	0.132	<0.001	0.499	<0.001	74.1	26	<0.001	0.017	0.3	<0.001	0.0048	<0.0002	<0.001	7.1	0.68	<0.001	131	<0.001	482
G54D	06/15/2017	<0.001	<0.001	0.105	<0.001	0.685	<0.001	80.5	24	0.0018	0.016	0.32	<0.001	0.0047	<0.0002	<0.001	6.8	1.67	<0.001	170	<0.001	506
G54D	07/20/2017	<0.001	0.0012	0.127	<0.001	0.58	<0.001	75.7	24	0.0017	0.0139	0.32	<0.001	0.0044	<0.0002	<0.001	6.8	0.32	<0.001	151	<0.001	512
G54D	11/30/2017	--	--	--	--	0.646	--	76.2	26	--	--	0.33	--	--	--	--	6.7	--	--	136	--	472
G54D	06/19/2018	<0.001	0.0019	0.196	<0.001	0.631	<0.001	72.7	26	0.0019	0.0134	0.34	<0.001	0.006	<0.0002	<0.0015	6.7	1	<0.001	146	<0.002	486
G54D	09/05/2018	--	0.001	0.131	--	0.66	--	73.6	25	0.002	0.0109	0.3	<0.001	0.0046	--	--	6.5	1.32	<0.001	152	--	480
G54D	03/27/2019	<0.001	0.0011	0.12	<0.001	1.03	<0.001	115	22	<0.0015	0.0138	0.35	<0.001	0.0037	<0.0002	<0.0015	6.8	0.42	<0.001	142	<0.002	510
G54D	09/09/2019	--	<0.001	0.128	--	0.614	--	79.9	<25	<0.0015	0.0117	0.32	<0.001	0.0037	--	--	6.4	0.84	<0.001	136	--	482
G54D	03/30/2020	<0.001	<0.001	0.105	<0.001	0.766	<0.001	84.9	22	<0.0015	0.013	0.33	<0.001	0.0036	<0.0002	<0.0015	6.8	0.89	<0.001	184	<0.002	508
G54D	09/23/2020	--	<0.001	0.16	--	0.819	--	122	25	<0.0015	0.0163	0.33	<0.001	0.0047	--	--	6.7	1.18	<0.001	173	--	508
G54D	03/24/2021	<0.001	<0.001	0.0941	<0.001	0.404	<0.001	78.1	23	<0.0015	0.0045	0.32	<0.001	0.0036	<0.0002	<0.0015	6.6	0.576	<0.001	186	<0.002	532
G151	03/03/2021	<0.001	<0.001	0.0459	<0.001	0.103	<0.001	23.4	10	<0.0015	<0.001	<0.1	<0.001	0.007	<0.0002	<0.0015	5.8	0.173	0.0024	111	<0.002	310
G151	03/24/2021	<0.001	<0.001	0.0477	<0.001	0.137	<0.001	23.9	11	<0.0015	<0.001	<0.1	<0.001	0.0057	<0.0002	<0.0015	5.8	0.368	0.0029	113	<0.002	282
G151	04/14/2021	<0.001	<0.001	0.0454	<0.001	0.0992	<0.001	27.2	11	<0.0015	<0.001	<0.1	<0.001	0.006	<0.0002	<0.0015	5.7	0.17	0.0027	119	<0.002	272
G151	05/11/2021	<0.0066	<0.0033	0.0471	<0.0033	0.134	<0.0033	25.4	10	<0.0033	<0.0033	<0.1	<0.0033	<0.0165	<0.0002	<0.0033	5.5	1.05	0.00252	129	<0.0033	264

TABLE 4-1. GROUNDWATER ANALYTICAL RESULTS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 and 228 combined (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G151	07/20/2021	<0.001	<0.001	0.0767	<0.001	0.114	<0.001	24	11	0.0028	0.0025	<0.1	<0.001	0.0064	<0.0002	<0.0015	5.5	1.58	0.0033	101	<0.002	288
G152B	03/03/2021	<0.001	<0.001	0.575	<0.001	<0.025	<0.001	53.1	45	0.0025	<0.001	0.46	<0.001	0.0057	<0.0002	<0.0015	6.6	0.631	0.0045	16	<0.002	444
G152B	03/25/2021	<0.001	<0.001	0.579	<0.001	<0.025	<0.001	56.1	44	0.0023	<0.001	0.48	<0.001	0.0047	<0.0002	<0.0015	6.5	1.4	0.0047	14	<0.002	406
G152B	04/14/2021	<0.001	<0.001	0.548	<0.001	<0.025	<0.001	53.4	42	0.0022	<0.001	0.49	<0.001	0.0046	<0.0002	<0.0015	6.7	0.69	0.0047	17	<0.002	440
G152B	05/12/2021	<0.0066	<0.0033	0.558	<0.0033	<0.033	<0.0033	55.6	43	0.00228	<0.0033	0.5	<0.0033	<0.0165	<0.0002	<0.0033	6.5	0.761	0.00476	22	<0.0033	424
G152B	07/20/2021	<0.001	<0.001	0.588	<0.001	<0.025	<0.001	55.9	43	0.0025	<0.001	0.49	<0.001	0.0049	<0.0002	<0.0015	6.5	2.36	0.0054	17	<0.002	430
G153	03/03/2021	<0.001	<0.001	0.192	<0.001	<0.025	<0.001	29.6	23	0.0016	<0.001	0.98	<0.001	<0.003	<0.0002	0.0031	6.9	1.49	<0.001	72	<0.002	362
G153	03/25/2021	<0.001	<0.001	0.186	<0.001	<0.025	<0.001	30.9	24	<0.0015	<0.001	0.88	<0.001	<0.003	<0.0002	0.0035	6.8	0.736	<0.001	69	<0.002	322
G153	04/13/2021	<0.001	<0.001	0.183	<0.001	<0.025	<0.001	29.9	23	<0.0015	<0.001	0.92	<0.001	<0.003	<0.0002	0.0038	6.9	0.334	<0.001	70	<0.002	344
G153	05/11/2021	<0.0066	<0.0033	0.208	<0.0033	<0.033	<0.0033	32	22	<0.0033	<0.0033	0.91	<0.0033	<0.0165	<0.0002	0.00305	6.6	0.289	<0.0033	77	<0.0033	330
G153	07/20/2021	<0.001	<0.001	0.164	<0.001	<0.025	<0.001	30.4	24	<0.0015	<0.001	0.9	<0.001	<0.003	<0.0002	0.0019	6.8	2.07	<0.001	69	<0.002	356

Notes:
Detected at concentration greater than the GWPS
-- = data not available
GWPS = groundwater protection standard
mg/L = milligrams per liter
pCi/L = picocuries per liter
SU = standard units
< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method. Estimated concentrations below the reporting limit and associated qualifiers are not provided since they are not utilized in statistics to determine exceedances above Part 845 standards.
35 I.A.C. 845.600 = Residuals in Surface Impoundments: Title 35 of the Illinois Administrative Code § 845

TABLE 4-2. GROUNDWATER FIELD PARAMETERS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (field) (SU)	Specific Conductance (micromhos/cm)	Temperature (deg. C)	Turbidity (NTU)
G01D	12/03/2015	<1	60	6.7	372	16.1	51.6
G01D	03/15/2016	<1	-103	6.7	667	18.3	<1
G01D	06/15/2016	1.36	-110	6.9	662	16.9	6.5
G01D	09/14/2016	2.71	-26	6.8	555	18.4	4.1
G01D	12/14/2016	1.47	113	6.8	593	15.5	57
G01D	03/07/2017	<1	80	6.2	434	14.1	16.8
G01D	06/15/2017	2.08	123	6.7	518	17.5	36
G01D	07/20/2017	<1	102	6.8	464	17.6	95.1
G01D	11/30/2017	<1	21	6.8	679	15.0	2.5
G01D	06/19/2018	2.88	29	6.8	512	17.6	3.6
G01D	09/05/2018	<1	131	7.0	614	17.8	<1
G01D	03/27/2019	2.57	118	6.7	522	15.4	56.4
G01D	09/09/2019	<1	193	6.4	664	17.6	7.6
G01D	03/30/2020	<1	138	6.8	548	15.8	5
G01D	09/23/2020	2.13	202	6.7	534	16.3	8.9
G01D	03/03/2021	4.18	145	6.6	495	15.7	26
G01D	03/24/2021	4.37	160	6.5	352	16.2	22
G01D	04/14/2021	2.28	134	6.7	562	16.3	2.1
G01D	05/12/2021	4.81	180	6.5	682	15.9	31
G01D	06/01/2021	4.98	164	6.3	556	15.8	47
G01D	06/14/2021	4.28	160	6.5	507	17.3	42
G01D	07/06/2021	5.57	139	6.3	550	16.9	52
G01D	07/21/2021	4.58	122	6.4	531	16.6	37
G02D	12/03/2015	<1	146	6.7	317	14.8	<1
G02D	03/15/2016	<1	28	6.6	344	17.4	<1
G02D	06/15/2016	<1	82	6.8	351	16.2	<1
G02D	09/14/2016	1.52	69	6.6	271	23.0	<1
G02D	12/14/2016	1.36	218	6.3	439	15.4	2.8
G02D	03/08/2017	1.97	254	6.9	318	13.8	<1
G02D	06/14/2017	9.12	95	6.3	298	17.7	3.8
G02D	07/20/2017	<1	132	6.7	372	16.8	15.8
G02D	11/30/2017	2.49	70	6.9	424	14.8	<1
G02D	06/19/2018	4.73	187	6.7	287	16.7	<1
G02D	09/05/2018	2.19	169	6.6	392	15.8	<1
G02D	03/27/2019	3.26	130	6.6	441	14.5	<1
G02D	09/09/2019	6.12	186	6.5	456	16.0	<1
G02D	03/30/2020	3.12	179	6.6	379	14.8	1.3
G02D	09/23/2020	2.49	246	6.6	400	15.2	1.9
G02D	03/03/2021	2.02	151	6.5	434	14.6	<1
G02D	03/24/2021	3.10	175	6.3	307	14.9	<1
G02D	04/14/2021	3.76	151	6.3	438	14.7	<1
G02D	05/12/2021	2.99	183	6.3	600	14.9	9.8
G02D	06/01/2021	2.57	140	6.2	437	14.9	<1
G02D	06/14/2021	3.01	169	6.4	441	15.6	<1

TABLE 4-2. GROUNDWATER FIELD PARAMETERS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (field) (SU)	Specific Conductance (micromhos/cm)	Temperature (deg. C)	Turbidity (NTU)
G02D	07/06/2021	3.87	128	6.2	477	15.8	<1
G02D	07/21/2021	3.72	100	6.2	464	15.4	1
G03	03/05/2021	3.70	117	6.4	409	15.2	200
G03	03/24/2021	2.95	150	6.3	454	15.7	85
G03	04/14/2021	2.23	137	6.2	805	15.6	78
G03	05/12/2021	3.45	180	6.4	734	15.7	250
G03	06/01/2021	3.82	149	6.3	569	15.6	140
G03	06/15/2021	3.78	128	6.2	472	15.9	30
G03	07/06/2021	4.15	116	6.3	557	15.9	20
G03	07/21/2021	3.81	52	6.4	584	16.2	44
G04	03/04/2021	3.02	120	6.5	401	18.5	16
G04	03/24/2021	0.60	257	6.5	623	16.8	8.2
G04	04/13/2021	1.13	104	6.5	605	16.8	1.3
G04	05/11/2021	1.21	101	6.3	631	16.6	1.3
G04	07/20/2021	1.30	17	6.3	769	17.9	7.1
G05	03/04/2021	1.79	56	6.5	519	15.7	9.9
G05	03/24/2021	1.06	35	6.4	599	16.6	60
G05	04/13/2021	0.74	18	6.5	630	16.3	33
G05	05/11/2021	0.71	42	6.4	650	16.1	10
G05	06/01/2021	2.49	452	6.5	687	16.4	9.9
G05	06/15/2021	1.44	59	6.3	553	16.1	<1
G05	07/06/2021	1.52	102	6.4	663	17.3	7.1
G05	07/20/2021	1.22	134	6.3	591	17.5	3.6
G06	03/04/2021	0.21	92	6.7	734	14.9	66
G06	03/24/2021	1.29	313	6.6	804	16.0	110
G06	04/13/2021	0.36	130	6.6	829	15.1	77
G06	05/11/2021	0.40	140	6.4	823	15.0	28
G06	06/01/2021	1.07	122	6.6	926	15.0	27
G06	06/15/2021	0.48	94	6.5	754	15.1	12
G06	07/06/2021	0.42	101	6.3	903	15.4	14
G06	07/20/2021	0.51	122	6.4	817	15.4	13
G06S	03/04/2021	4.10	116	6.2	251	15.2	5.3
G06S	03/24/2021	0.50	259	5.8	259	15.5	6.6
G06S	04/13/2021	0.57	167	5.8	265	15.3	<1
G06S	05/11/2021	0.45	123	5.6	271	14.9	<1
G06S	07/20/2021	1.26	102	5.7	267	16.1	1.3
G07	03/04/2021	0.18	80	6.5	826	15.3	110
G07	03/24/2021	0.43	192	6.4	892	15.5	35
G07	04/13/2021	0.36	163	6.3	921	15.2	33
G07	05/11/2021	0.30	120	6.3	889	15.1	17
G07	06/01/2021	0.26	37	6.2	1030	15.1	40
G07	06/15/2021	0.42	76	6.2	804	15.2	2.6
G07	07/06/2021	0.46	141	6.0	975	15.5	3
G07	07/20/2021	0.40	145	6.1	903	15.3	9.9

TABLE 4-2. GROUNDWATER FIELD PARAMETERS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (field) (SU)	Specific Conductance (micromhos/cm)	Temperature (deg. C)	Turbidity (NTU)
G08	03/04/2021	0.23	-63	7.0	757	15.6	220
G08	03/24/2021	0.40	-36	6.9	846	16.6	71
G08	04/13/2021	0.34	-40	7.0	898	16.3	36
G08	05/11/2021	0.73	-188	6.9	812	16.4	15
G08	06/01/2021	0.42	95	7.0	938	16.0	44
G08	06/15/2021	0.36	-164	6.9	766	16.1	62
G08	07/06/2021	0.41	-72	6.8	920	16.6	97
G08	07/20/2021	0.45	-29	6.8	834	16.3	110
G09	03/04/2021	0.23	9	6.2	917	16.6	18
G09	03/25/2021	0.26	42	6.3	994	16.1	22000
G09	04/14/2021	0.45	-22	6.3	999	16.2	140
G09	05/12/2021	0.35	-78	6.4	1300	16.3	71
G09	06/01/2021	0.30	-24	6.2	1080	16.5	44
G09	06/15/2021	0.80	-46	6.0	873	16.6	7.1
G09	07/06/2021	0.86	-40	6.3	1030	17.3	23
G09	07/21/2021	0.41	-6	6.0	998	16.8	27
G09M	03/04/2021	0.29	-130	6.9	670	16.8	240
G09M	03/25/2021	0.99	-126	6.8	763	17.3	100
G09M	04/14/2021	0.22	-151	6.9	833	15.9	26
G09M	05/12/2021	2.31	-158	7.0	1070	16.3	26.8
G09M	07/21/2021	0.36	-153	6.9	610	17.4	360
G10	03/04/2021	0.19	16	6.7	946	16.0	35
G10	03/24/2021	0.43	33	6.7	1040	17.1	9.4
G10	04/13/2021	0.28	42	6.6	1070	16.6	53
G10	05/11/2021	0.58	30	6.3	1040	16.6	20
G10	06/01/2021	0.28	5	6.5	1210	16.5	38
G10	06/15/2021	0.42	-22	6.5	995	16.8	10
G10	07/06/2021	0.63	35	6.5	1220	18.0	5.8
G10	07/20/2021	0.81	52	6.5	1110	17.6	4.1
G11	03/04/2021	0.37	69	5.9	1020	16.3	8.6
G11	03/24/2021	0.46	154	5.9	1150	16.5	2.7
G11	04/14/2021	1.08	100	5.8	1650	16.1	2.3
G11	05/12/2021	0.77	194	5.9	2260	16.5	<1
G11	06/01/2021	0.72	159	5.8	1760	16.4	<1
G11	06/14/2021	0.60	149	5.9	1360	16.6	4.2
G11	07/06/2021	0.73	78	5.8	1400	16.7	2
G11	07/20/2021	0.88	135	5.8	1320	16.9	<1
G151	03/03/2021	4.87	156	5.8	413	16.5	3.2
G151	03/24/2021	8.64	189	5.8	298	17.3	8.8
G151	04/14/2021	7.65	124	5.7	432	17.2	1.6
G151	05/11/2021	8.48	205	5.5	423	17.2	9.7
G151	07/20/2021	5.08	159	5.5	386	21.8	24
G152B	03/03/2021	2.19	146	6.6	759	15.2	1.7
G152B	03/25/2021	2.59	107	6.5	583	14.5	2.6

TABLE 4-2. GROUNDWATER FIELD PARAMETERS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (field) (SU)	Specific Conductance (micromhos/cm)	Temperature (deg. C)	Turbidity (NTU)
G152B	04/14/2021	4.74	151	6.7	765	15.1	<1
G152B	05/12/2021	5.17	190	6.5	1070	14.7	<1
G152B	07/20/2021	3.76	176	6.5	771	18.4	7.5
G153	03/03/2021	7.28	110	6.9	533	16.4	6.4
G153	03/25/2021	7.16	323	6.8	549	13.1	9.8
G153	04/13/2021	8.88	136	6.9	560	17.4	<1
G153	05/11/2021	8.12	136	6.5	564	16.0	2.5
G153	07/20/2021	6.64	91	6.8	559	20.0	1
G51D	12/03/2015	<1	133	6.2	327	16.7	5.5
G51D	03/15/2016	<1	122	5.9	397	17.6	12.2
G51D	06/15/2016	<1	213	5.8	375	17.8	13.9
G51D	09/14/2016	<1	231	5.6	315	20.8	1.2
G51D	12/14/2016	<1	134	5.9	421	16.2	2.7
G51D	03/08/2017	<1	282	6.2	328	15.1	<1
G51D	06/15/2017	<1	168	5.6	397	18.5	4.4
G51D	07/20/2017	<1	180	5.9	381	18.9	3.5
G51D	11/30/2017	<1	168	5.6	464	16.2	<1
G51D	06/19/2018	<1	247	5.7	319	19.1	<1
G51D	09/05/2018	<1	217	6.0	412	17.7	<1
G51D	03/27/2019	<1	130	5.7	478	16.2	9.3
G51D	09/09/2019	<1	157	5.3	468	17.3	10
G51D	03/30/2020	1.12	261	5.6	398	16.4	4.2
G51D	09/23/2020	1.48	292	5.7	415	16.9	4.2
G51D	03/24/2021	<1	136	5.6	317	17.0	7.1
G52D	12/03/2015	<1	-5	6.5	370	15.4	1.26
G52D	03/15/2016	<1	-81	6.3	454	17.9	<1
G52D	06/15/2016	<1	-131	6.6	433	19.6	<1
G52D	09/14/2016	<1	-76	6.4	391	19.0	<1
G52D	12/14/2016	8.94	104	6.7	531	16.1	1.8
G52D	03/07/2017	<1	26	5.9	389	14.1	<1
G52D	06/14/2017	3.25	61	6.2	351	24.1	<1
G52D	07/19/2017	<1	-48	6.4	414	23.8	<1
G52D	11/30/2017	<1	-59	6.0	509	14.8	<1
G52D	06/19/2018	2.63	-136	6.4	361	17.0	<1
G52D	09/05/2018	<1	-49	6.3	475	17.1	<1
G52D	03/27/2019	<1	-31	6.4	525	14.8	<1
G52D	09/09/2019	<1	164	6.0	535	17.3	1.6
G52D	03/30/2020	1.00	-12	6.4	438	15.2	1.3
G52D	09/23/2020	<1	-19	6.5	459	15.7	2
G52D	03/25/2021	<1	4	6.2	357	15.3	<1
G53D	12/03/2015	<1	45	6.8	465	16.3	<1
G53D	03/15/2016	<1	64	6.7	512	18.2	<1
G53D	06/15/2016	<1	112	6.6	515	16.8	<1
G53D	09/14/2016	<1	189	6.5	448	18.8	3.4

TABLE 4-2. GROUNDWATER FIELD PARAMETERS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (field) (SU)	Specific Conductance (micromhos/cm)	Temperature (deg. C)	Turbidity (NTU)
G53D	12/14/2016	<1	70	6.8	607	17.0	1.8
G53D	03/08/2017	4.63	251	7.2	180	14.2	9
G53D	06/15/2017	<1	200	6.6	465	16.5	9.2
G53D	07/20/2017	<1	100	6.8	497	18.1	3.3
G53D	11/30/2017	<1	85	6.6	580	15.9	<1
G53D	06/19/2018	<1	151	6.6	371	17.4	2.2
G53D	09/05/2018	<1	37	6.8	544	17.3	<1
G53D	03/27/2019	<1	172	6.6	385	15.9	9.7
G53D	09/09/2019	<1	171	6.2	603	17.6	4.9
G53D	03/30/2020	1.00	141	6.7	337	15.9	6.2
G53D	09/23/2020	<1	101	6.7	516	16.4	6.2
G53D	03/25/2021	<1	138	6.5	550	15.6	6
G54D	12/03/2015	<1	3	7.0	580	15.8	7.5
G54D	03/15/2016	<1	-73	6.8	641	17.8	9.8
G54D	06/15/2016	<1	-118	6.6	599	17.1	4.8
G54D	09/14/2016	<1	7	6.6	517	18.3	4.4
G54D	12/14/2016	<1	142	6.7	668	16.3	5.3
G54D	03/08/2017	1.31	92	7.1	519	14.3	4.3
G54D	06/15/2017	3.72	100	6.8	603	17.2	30.6
G54D	07/20/2017	5.07	37	6.8	567	17.6	25.4
G54D	11/30/2017	6.71	39	6.7	676	15.5	12.3
G54D	06/19/2018	<1	25	6.7	513	17.3	4.9
G54D	09/05/2018	<1	-13	6.5	699	16.8	<1
G54D	03/27/2019	1.49	43	6.8	770	15.3	21.1
G54D	09/09/2019	<1	121	6.4	788	17.4	86
G54D	03/30/2020	1.00	-1	6.8	706	15.6	2.5
G54D	09/23/2020	<1	62	6.7	677	15.8	8.7
G54D	03/24/2021	<1	92	6.6	586	16.0	2.6
G54S	03/03/2021	7.35	190	6.3	1080	15.8	9.9
G54S	03/24/2021	7.26	152	6.4	621	17.2	<1
G54S	04/14/2021	7.83	63	6.2	773	14.3	<1
G54S	05/12/2021	7.89	168	6.3	949	15.7	9.7
G54S	07/20/2021	8.00	116	6.4	665	19.3	1.1

Notes:
Field readings are reported with as many significant figures as provided by analytical laboratory.
cm = centimeter
deg. C = degrees Celsius
mg/L = milligrams per liter
mV = millivolts
NTU = nephelometric turbidity units
SU = standard units

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FIGURES

PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY

0 1,000 2,000 Feet

SITE LOCATION MAP

FIGURE 1-1

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\845_Operating_PermitJoppa\GMP\Figure 1-2_Site Map.mxd

PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
CENTRAL DIKE
PROPERTY BOUNDARY

0 375 750
Feet

PROJECT: 169000XXXX | DATED: 10/15/2021 | DESIGNER: HOTCALD

SITE MAP

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

10FT TOPOGRAPHIC CONTOUR
2FT TOPOGRAPHIC CONTOUR
PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY

Note:
Elevation contours shown in feet, North American Vertical Datum of 1988 (NAVD88)

0 250 500 Feet

SOURCE:
INGENAE SURVEY, 2021

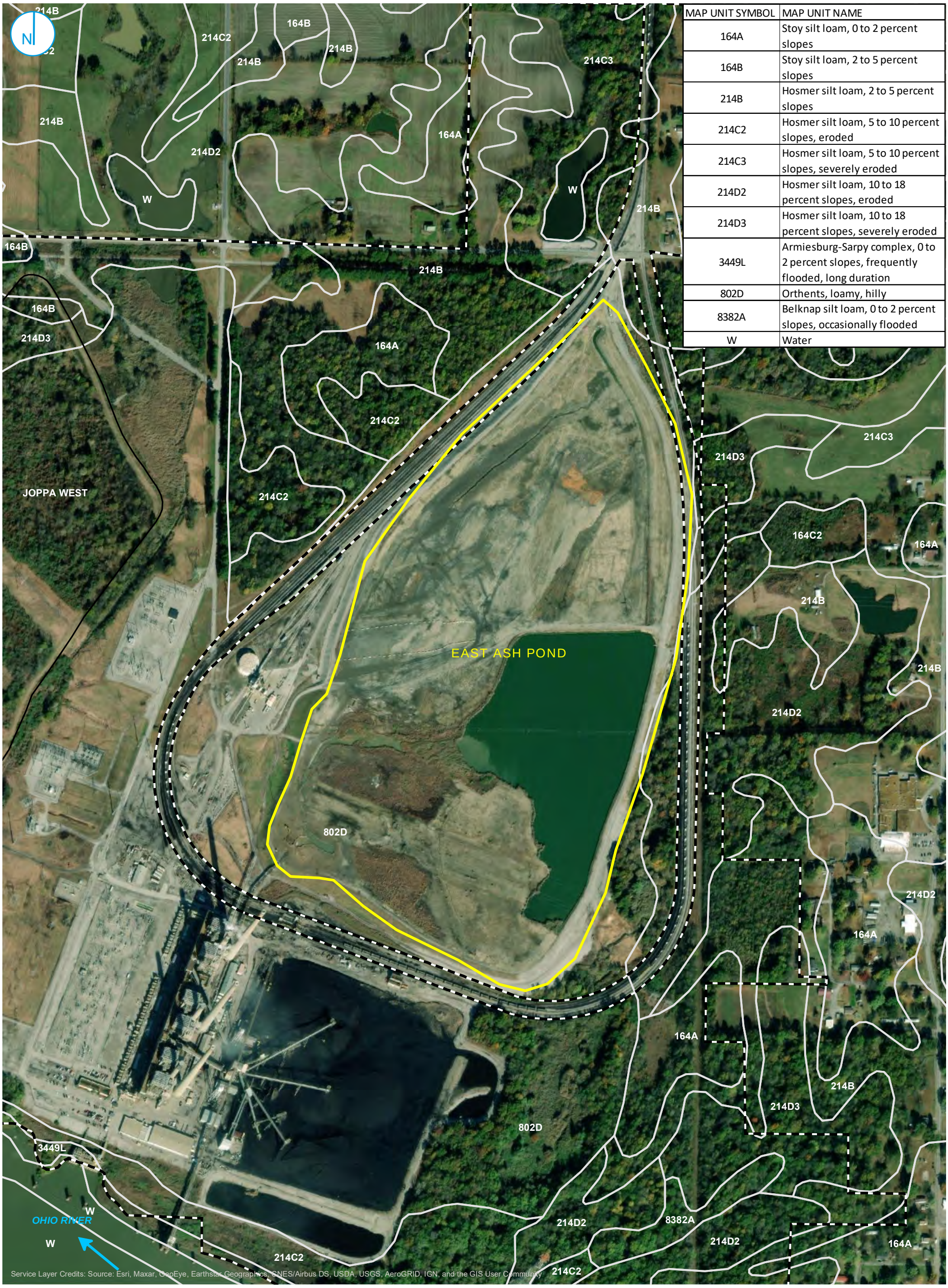
SITE TOPOGRAPHIC MAP

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



MAP UNIT SYMBOL	MAP UNIT NAME
164A	Stoy silt loam, 0 to 2 percent slopes
164B	Stoy silt loam, 2 to 5 percent slopes
214B	Hosmer silt loam, 2 to 5 percent slopes
214C2	Hosmer silt loam, 5 to 10 percent slopes, eroded
214C3	Hosmer silt loam, 5 to 10 percent slopes, severely eroded
214D2	Hosmer silt loam, 10 to 18 percent slopes, eroded
214D3	Hosmer silt loam, 10 to 18 percent slopes, severely eroded
3449L	Armiesburg-Sarpy complex, 0 to 2 percent slopes, frequently flooded, long duration
802D	Orthents, loamy, hilly
8382A	Belknap silt loam, 0 to 2 percent slopes, occasionally flooded
W	Water

PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY
NRCS SOIL SURVEY MAP UNIT BOUNDARY

SOURCE:
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

0 250 500 Feet

SOIL SURVEY MAP

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY
CAHOKIA ALLUVIUM (INCLUDES ALLUVIAL FAN FACIES)
EQUALITY FORMATION
HENRY FORMATION
MOUNDS GRAVEL
MCNAIRY FORMATION

0 1,000 2,000 Feet

SOURCE:
ILLINOIS STATE GEOLOGICAL SURVEY (ISGS)

SURFICIAL GEOLOGIC DEPOSITS

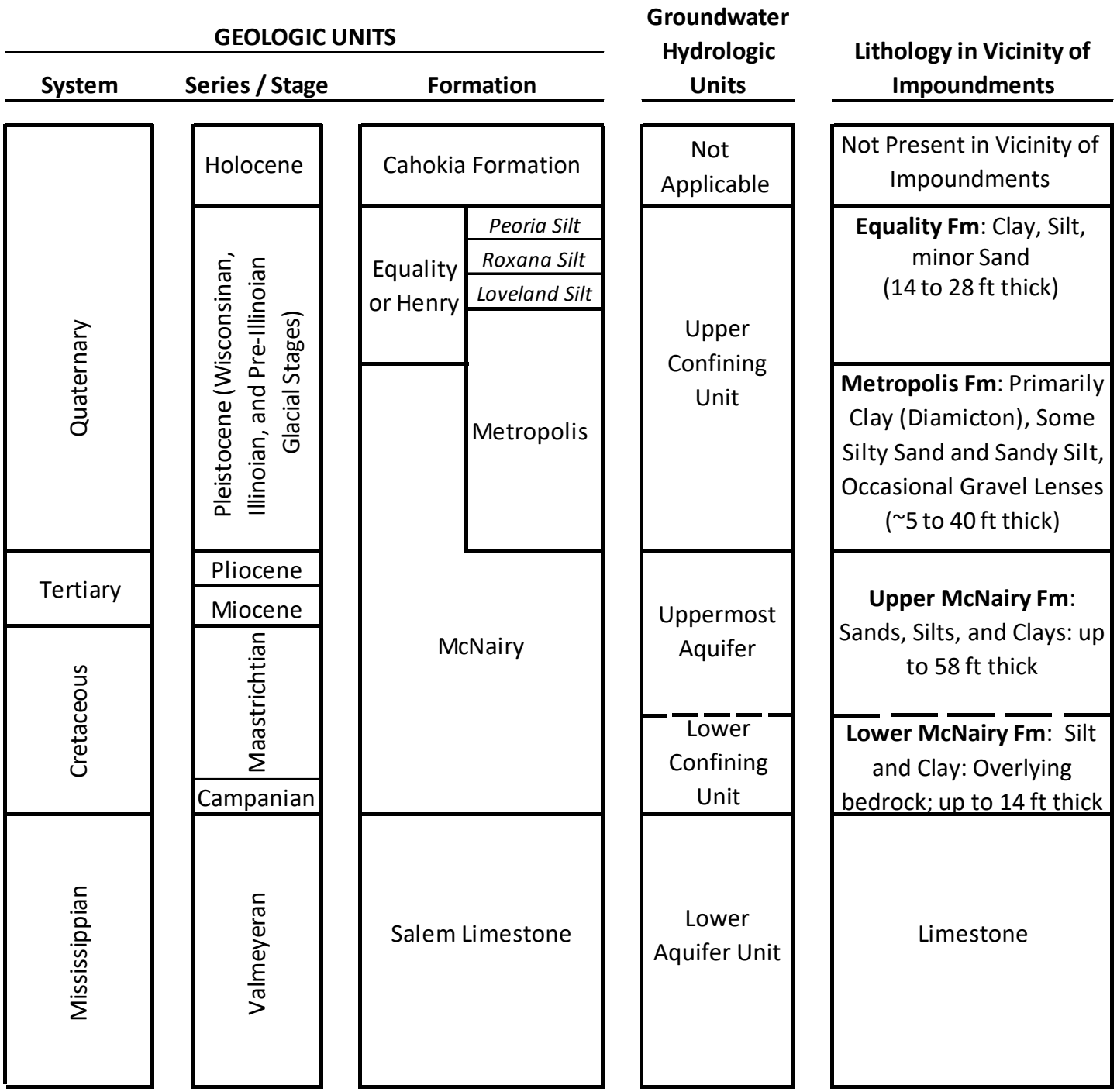
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-3

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\2\2285\MXD\845_Operating_Permit\Joppa\Figure 2-4_Generalized Stratigraphic Column.mxd
PROJECT: 169000XXXX | DATED: 8/30/2021 | DESIGNER: STOLZSD



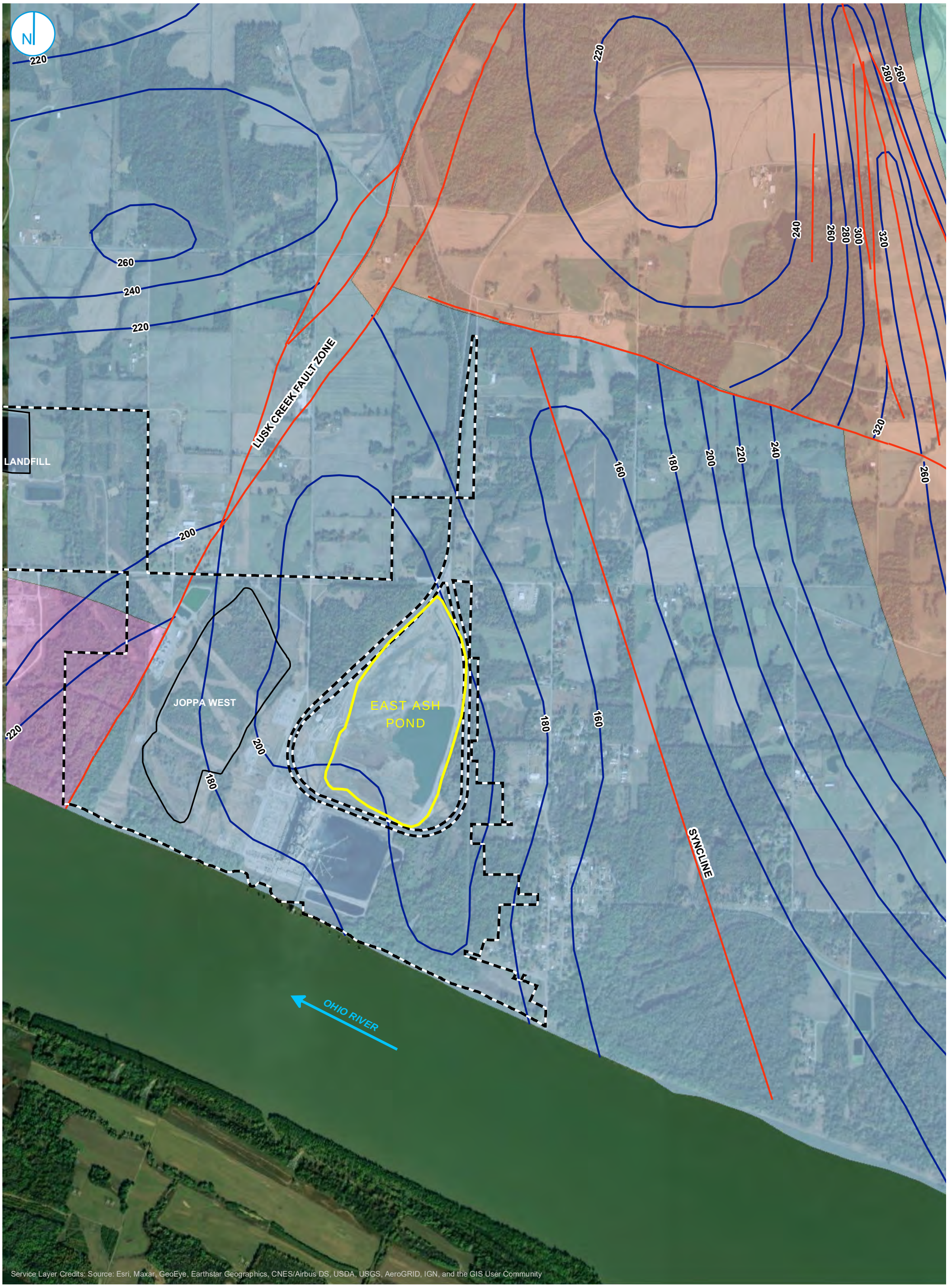
GENERALIZED STRATIGRAPHIC COLUMN FOR THE JOPPA AREA

FIGURE 2-4

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



- GEOLOGIC STRUCTURE
- BEDROCK ELEVATION CONTOURS, (20-FT CONTOUR INTERVAL, NAD 83)
- SALEM LIMESTONE
- ST LOUIS LIMESTONE
- STE GENEVIEVE LIMESTONE AND POPE GROUP
- ULLIN LIMESTONE
- PART 845 REGULATED UNIT (SUBJECT UNIT)
- OTHER UNIT
- PROPERTY BOUNDARY

0 750 1,500 Feet

MAJOR STRUCTURAL FEATURES OF JOPPA QUADRANGLE

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-5

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

PROJECT: 169000XXXX | DATED: 9/3/2021 | DESIGNER: STOLZSD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\Figure 2-6_Field Investigation Locations.mxd

MONITORING WELL

STAFF GAGE

PART 845 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

0 200 400 Feet

FIELD INVESTIGATION LOCATIONS

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

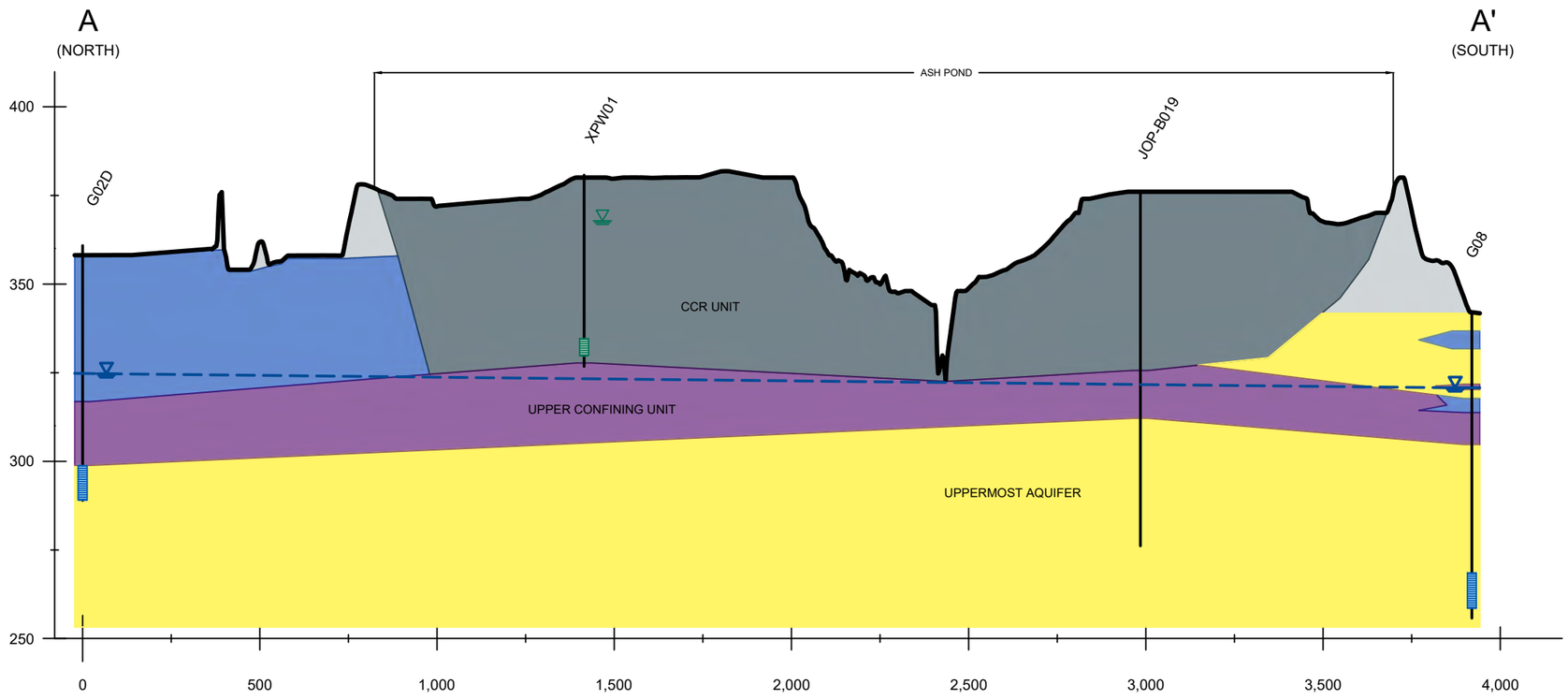
FIGURE 2-6

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

NOTES

1. This profile was developed by interpolation between widely spaced boreholes. Only at the borehole location should it be considered as an approximately accurate representation and then only to the degree implied by the notes on the borehole logs.
2. Scale is approximate.
3. Vertical scale is exaggerated 10X.
4. Groundwater elevations measured on April 13-14, 2021.



LEGEND

- COAL COMBUSTION RESIDUALS (CCR)
- FILL
- CLAY (CL/CH)
- SILT (ML)
- SAND (SP/SM/SW)
- WELL SCREEN INTERVAL
- UPPERMOST AQUIFER POTENTIOMETRIC SURFACE
- UPPERMOST AQUIFER GROUNDWATER ELEVATION
- POREWATER ELEVATION

40' 0 400'

GEOLOGIC CROSS SECTIONS
A-A'

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-7

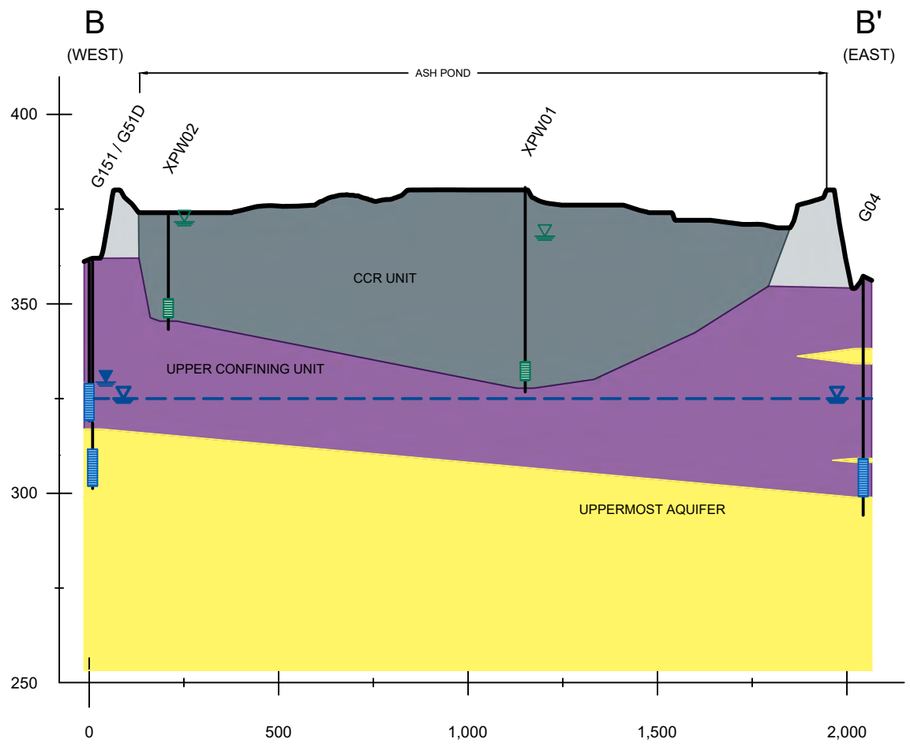
RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

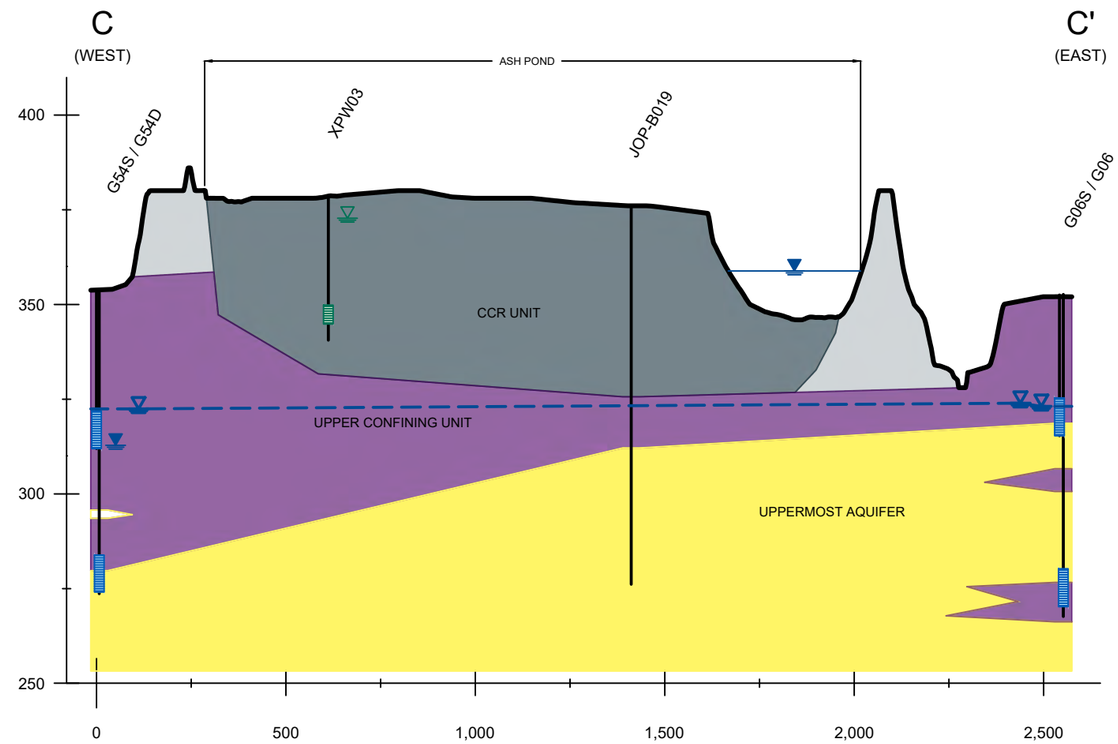
RAMBOLL

PROJECT: 1940100806 DATED: 10/9/2021 \\ramboll.sharepoint.com@SSL\DavWWWRoot\sites\vistra\Shared Documents\-CCR GWDeliverables\Part 845 Operating Permits\Sites\Joppa\HCR\Figures\CAD working files\Joppa East Cross Sections.dwg

NOTES

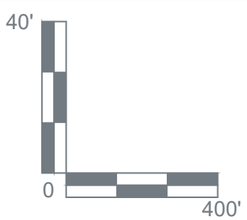
1. This profile was developed by interpolation between widely spaced boreholes. Only at the borehole location should it be considered as an approximately accurate representation and then only to the degree implied by the notes on the borehole logs.
2. Scale is approximate.
3. Vertical scale is exaggerated 10X.
4. Groundwater elevations measured on April 13-14, 2021.





LEGEND

- COAL COMBUSTION RESIDUALS (CCR)
- FILL
- CLAY (CL/CH)
- SAND (SP/SM/SW)
- WELL SCREEN INTERVAL
- UPPERMOST AQUIFER POTENTIOMETRIC SURFACE
- UPPERMOST AQUIFER GROUNDWATER ELEVATION
- POREWATER ELEVATION
- BEDROCK GROUNDWATER / OTHER GROUNDWATER / SURFACE WATER ELEVATION(S)



GEOLOGIC CROSS SECTIONS
B-B' & C-C'

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-8

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 1940100806 DATED: 10/7/2021 \\ramboll.sharepoint.com@SSL\DavWWWRoot\sites\vistra\Shared Documents\~CCR GWDeliverables\Part 845 Operating Permits\Sites\Joppa\HCR\Figures\CAD working files\Joppa East Cross Sections.dwg

PROJECT: 169000XXXX | DATED: 10/14/2021 | DESIGNER: HOTCALD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\Figure 3-1_Monitoring Well Location Map.mxd

BACKGROUND WELL
MONITORING WELL
SOURCE SAMPLE LOCATION
STAFF GAGE
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 200 400 Feet

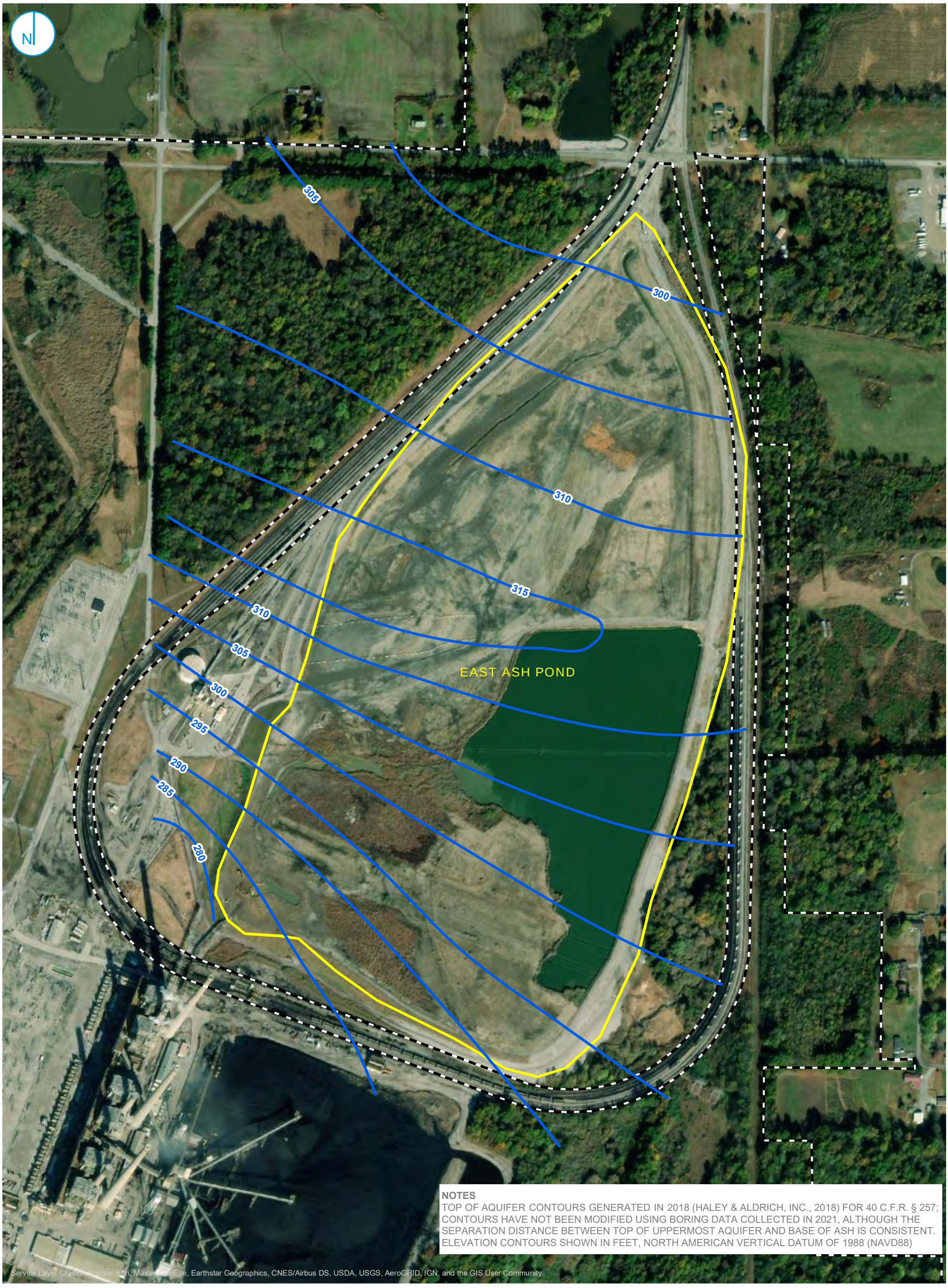
MONITORING WELL LOCATION MAP

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 3-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



INTERPRETED TOP OF UPPERMOST AQUIFER (95TH PERCENTILE GROUNDWATER ELEVATION CONTOURS, 2017)

PART 845 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

0 200 400 Feet

TOP OF UPPERMOST AQUIFER

FIGURE 3-2

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

BACKGROUND WELL
MONITORING WELL
SOURCE SAMPLE LOCATION
STAFF GAGE
GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 200 400 Feet

NOTES:
1.ELEVATIONS IN PARENTHESIS WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988

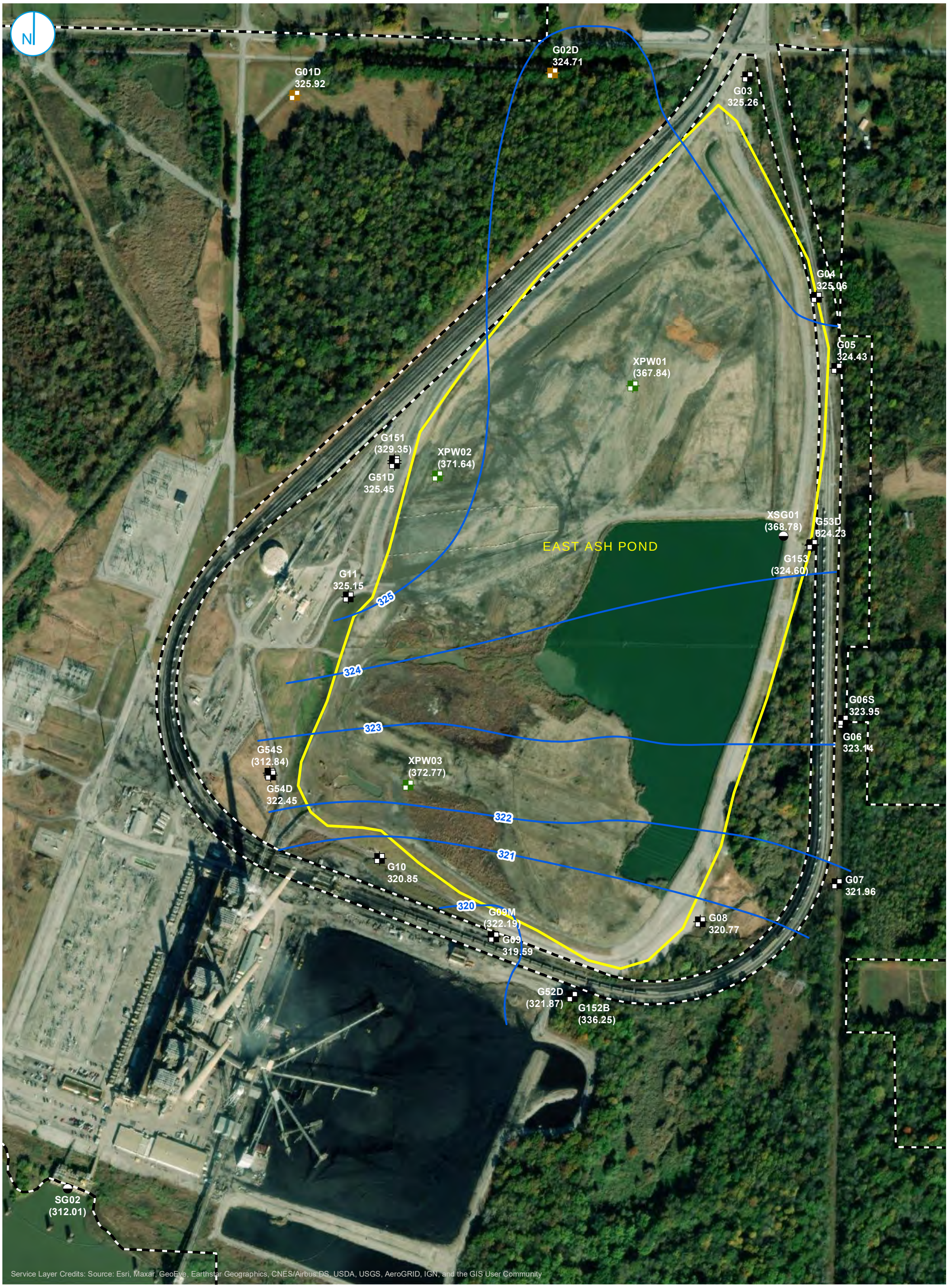
UPPERMOST AQUIFER GROUNDWATER ELEVATION CONTOURS MARCH 3 AND 4, 2021

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 3-3

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



BACKGROUND WELL
MONITORING WELL
SOURCE SAMPLE LOCATION
STAFF GAGE
GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 200 400 Feet

NOTES:
1.ELEVATIONS IN PARENTHESIS WERE NOT USED FOR CONTOURING.
2. ELEVATIONS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988

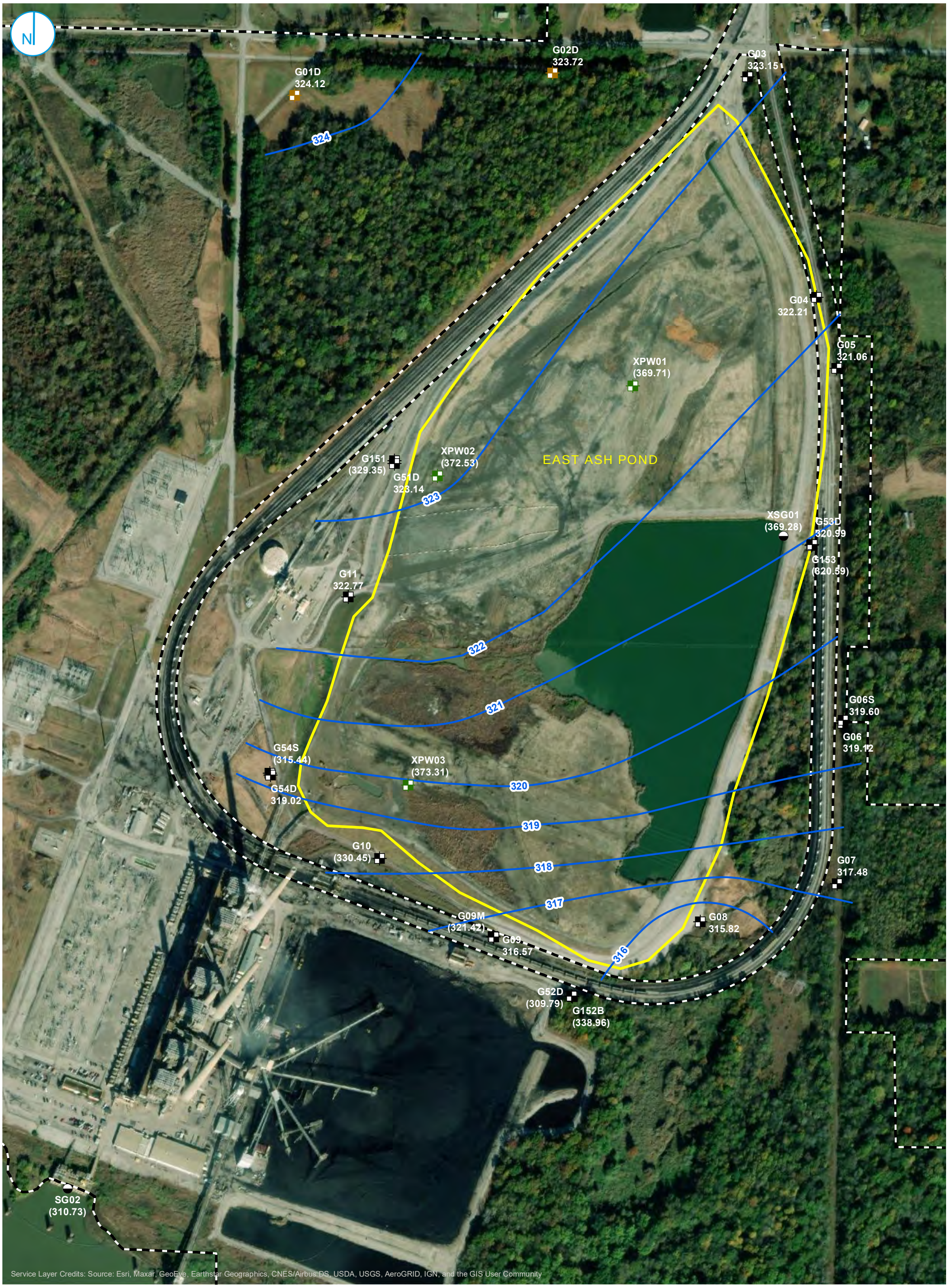
UPPERMOST AQUIFER GROUNDWATER ELEVATION CONTOURS APRIL 13 AND 14, 2021

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 3-4

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



BACKGROUND WELL
MONITORING WELL
SOURCE SAMPLE LOCATION
STAFF GAGE
GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 200 400 Feet

NOTES:
1.ELEVATIONS IN PARENTHESIS WERE NOT USED FOR CONTOURING.
2. ELEVATIONS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988

UPPERMOST AQUIFER GROUNDWATER ELEVATION CONTOURS MAY 11 AND 12, 2021

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 3-5

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

APPENDICES

APPENDIX A
HISTORICAL TOPOGRAPHIC MAP (1967)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

JOPPA QUADRANGLE
ILLINOIS–KENTUCKY
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 LA CENTER 15' QUADRANGLE

3258 IV SW (KARNAK)
3258 I SW (REEVESVILLE)
3258 III NW (BANDANA)
3258 III SW (LA CENTER)
3258 IV SE (MERMET)
3258 II NW (METROPOLIS)
3258 II SW (PADUCAH WEST)

88°52'30" 88°45'
37°15' 37°07'30"
T. 14 S. T. 15 S. T. 16 S.
R. 3 E. R. 4 E.
334 000m E. 47'30" 341 000m E.
1 100 000 FEET (KY.) 1 120 000 FEET (KY.)
350 000 FEET (ILL.) 370 000 FEET (ILL.)
340 000 FEET (KY.) 210 000 FEET (ILL.)
310 000 FEET (KY.) 170 000 FEET (ILL.)
4123 000m N. 4122 4121 4120 4119 4118 4116 4115 4114 4113 4112 4111 000m N.

3 MI. TO ILL. 169
VIENNA 13 MI.
MERMET 2 MI.
HILLERMAN 0.9 MI.
LA CENTER 12 MI.
RAGLAND 0.7 MI.
HIGH POINT 2.1 MI.
METROPOLIS 1.9 MI.
PADUCAH, KY. 15 MI.
WOODVILLE 2 MI.
GRAHAMVILLE 1.7 MI.
PADUCAH 15 MI.
GRAHAMVILLE 1.3 MI.

MERMET LAKE STATE CONSERVATION AREA
TUCKER DITCH
Oak Grove Ch
PIPELINE
BM 353
Gravel Pit
Q DITCH
BR 354
Maple Grove Sch
CHICAGO AND EASTERN ILLINOIS
Kirkendall Cem
Pumping Station
Radio Tower
BR 336
C & E I
BR 362
Cumberland Ch
Mt Hebron Ch
Macedonia Ch
Cem
Choat
CHICAGO BURLINGTON AND QUINCY
Liberty Ridge Cem
Franklin Sch
SEN BECK DITCH
Ash Disposal Ponds
Substa
High Sch
Joppa
Bayou Creek
Conveyors
Piles
Light
Mile 952
MASSAC CO
MC CRACKEN CO
Mile 950
OHIO RIVER
NORMAL POOL ELEVATION 290
ILLINOIS KENTUCKY
Alkins Cem
Oak Glen Lake
Mt Mission Ch
Church of Christ
Metropolis Municipal Airport
Crawford Lake
Crutcher Bean Branch Slough
Newtons Creek
BR 315
BR 330
GRIEF ROAD
Brewer Cem
Snake Slough
Nasty Creek
JOPPA LANDINGS ROAD
BM 364
BR 348
New Liberty Ch
OGDEN LANDING ROAD
CHURCH
NEW LIBERTY CHURCH ROAD
Rossington
Deer Lick Creek
Martin Cem
Brushy Creek
BETHEL CHURCH ROAD
BM 391
BURNLEY SCHOOL ROAD
WALLACE ROAD
STATE WEST KENTUCKY WILDLIFE MANAGEMENT AREA
ASH DISPOSAL POND
SHAWNEE STEAM PLANT (TVA)
CONVEYOR
Substation
Water Tank
Little Bayou Creek
ILLINOIS CENTRAL
Hopper Cem
BM 359
BM 367
ANDERSON ROAD
METROPOLIS LAKE ROAD
GIPSON ROAD
RD 996
CARNEAL ROAD
PADUCAH PLANT (AEC)
Metropolis Lake
Rocky Branch Creek
Mile 945

Mapped, edited, and published by the Geological Survey. Kentucky area mapped in cooperation with Kentucky Geological Survey

Control by USGS, USC&GS, and Tennessee Valley Authority

Topography of Illinois area by photogrammetric methods from aerial photographs taken 1965. Field checked 1967. Planimetry of Kentucky area by photogrammetric methods from aerial photographs taken 1952. Topography by planetable surveys 1954. Revised 1967

Polyconic projection. 1927 North American datum
10,000 foot grids based on Illinois coordinate system, east zone, and Kentucky coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 16, shown in blue

The state boundary as shown represents the approximate position of the low waterline as determined from U. S. Corps of Engineers, Ohio River Charts, surveyed 1912, and supplementary information
Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

MN GN 1°06' 19 MILS 4° 71 MILS
UTM GRID AND 1967 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000
1 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242,
STATE GEOLOGICAL SURVEY, URBANA, ILLINOIS 61801,
KENTUCKY GEOLOGICAL SURVEY, LEXINGTON, KENTUCKY 40506,
AND KENTUCKY DEPARTMENT OF COMMERCE, FRANKFORT, KENTUCKY 40601
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

USGS
Historical File
Topographic Division

ROAD CLASSIFICATION
Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U. S. Route — State Route

ILLINOIS
QUADRANGLE LOCATION

U.S.G.S.
FILE COPY
TOPOGRAPHIC DIVISION

JOPPA, ILL.–KY.
NE/4 LA CENTER 15' QUADRANGLE
N3707.5—W8845/7.5
1967
AMS 3258 III NE—SERIES V853

2855
SEP 20 1968

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1968

APPENDIX B
BORING LOGS AND WELL CONSTRUCTION LOGS

BORING AND WELL LOCATION MAPS

GEOSYNTEC BORING LOGS AND WELL CONSTRUCTION LOGS

BORING LOGS

Geosyntec consultants
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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 1 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	67	Well Depth (ft):	67
Drilling End Date:	02/02/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	38.23	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	358.56	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	354.84	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.22078, -88.85045	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	14/24	2 2 3 6	5	(0') CLAY (CL); some silt, high organics/roots, brown (10YR 4/3). (0.25') CLAYEY SILT (ML); brownish yellow (10YR 6/6), soft, dry, some light gray mottling.		
				SS	20/24	2 3 4 5	7	(2') As above: higher plasticity. (MH)		
5				SS	23/24	2 3 5 6	8	(4') As above: few sand, lower plasticity. (ML)		
				SS	24/24	2 3 4 6	7	(6') SILT (ML); few sand and clay, yellowish brown (10YR 5/6), medium dense, dry, some light gray mottling.		
				SS	23/24	1 4 6 7	10	(8') As above.		
10				SS	23/24	2 6 6 8	12	(11') As above: trace fine gravel from 11 to 11.5' bgs.		
				SS	24/24	2 6 7 10	13	(12') As above: brownish yellow (10YR 6/6).		
				SS	24/24	2 3 5 5	8	(14') As above: more light gray (10YR 7/2) mottling.		
15				SS	24/24	2 3 5 6	8	(16') As above: trace sand.		
				SS	24/24	3 4 5 9	9	(18') As above: light gray (10YR 7/2) becomes dominant.		
20										

NOTES:

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 2 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	67	Well Depth (ft):	67
Drilling End Date:	02/02/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	38.23	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	358.56	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	354.84	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.22078, -88.85045	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	1 4 8 10	12	(20') SILT (ML); few clay, brownish yellow (10YR 6/6), very stiff, dry.		
				SS	24/24	4 6 7 4	13	(22') SANDY SILT (ML); yellowish brown (10YR 5/6), soft, dry.		
				SS	24/24	2 5 5 8	10	(24') As above: becomes moist, few red (2.5YR 4/6) silt.		
25				SS	24/24	1 5 5 6	10	(26') As above: red silt disappears.		
				SS	24/24	1 3 4 6	7	(28') As above: becomes grayish brown (10YR 5/2).		
30				SS	24/24	1 4 4 5	8	(30') As above.	30-32 Chem	
				SH	24/24				32-34 Geotech	
				SS	24/24	3 4 5 6	9	(34') POORLY GRADED SAND (SP-SM); fine grained, few silt, brownish yellow (10YR 6/6), loose, moist to wet.		
35				SS	24/24	2 2 3 5	5	(36') SANDY SILT (ML); light yellowish brown (10YR 6/4), soft, moist, medium plasticity.		
		▼		SS	24/24	2 2 3 5	5	(38') As above: becomes evenly mottled with light gray (10YR 7/2).		
40										

NOTES: SBG03- (32-34)-20210202: 15.5% moisture content, 730 U mg/kg total organic carbon, 112.7 pcf dry unit weight, 2.659 specific gravity, 4.7x 10^{-7}, 27 LL, 16 PL, 11 PI, 0.6% gravel, 53.8% sand, 45.6% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 3 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	67	Well Depth (ft):	67
Drilling End Date:	02/02/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	38.23	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	358.56	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	354.84	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.22078, -88.85045	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	24/24	1 4 4 4	8	(40') SILT (ML); little sand, brownish yellow (10YR 6/6), soft, moist, medium plasticity.		
				SS	24/24	1 3 4 5	7	(42') As above.		
				SS	24/24	2 4 6 6	10	(44') As above: becomes dry, stiff.		
45				SS	24/24	2 4 13 13	17	(46') SILTY SAND (SP-SM); very pale brown (10YR 7/3), loose, moist.		
				SS	23/24	8 10 10 9	20	(48') As above: becomes brownish yellow (10YR 6/8).		
50				SS	20/24	1 6 10 13	16	(50.5') Wet at 50.5 to 50.8' bgs.		
								(51') SAND (SP); fine grained, light gray (10YR 7/2), loose, moist.		
				SS	24/24	1 1 1 5	2	(52') As above: brownish yellow (10YR 6/6).		
				SS	12/24	1 1 1 3	2	(54') GRAVELLY SAND (SW); very pale brown (10YR 7/4), loose, wet.		
55				SS	24/24	1 1 1 3	2	(56') As above: moist, very loose.		
				SS	11/24	1 1 1 7	2	(58') WELL-GRADED SAND (SW); medium to coarse grained, few gravel, very pale brown (10YR 7/4), very loose, moist.	58-60 Chem and Geotech (not tested)	
60										

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Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 4 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	67	Well Depth (ft):	67
Drilling End Date:	02/02/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	38.23	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	358.56	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	354.84	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.22078, -88.85045	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	20/24	2 6 10 11	16	(60') WELL-GRADED SAND (SW); medium to coarse grained, few gravel, very pale brown (10YR 7/4), wet, loose.	60-62 Geotech	
				SS	24/24	1 3 13 12	16	(62') As above: reddish yellow (7.5YR 6/6).		
65				SS	24/24	1 15 14 13	29	(64') GRAVELLY SAND (SW); reddish yellow (7.5YR 6/8), wet, loose.		
				SS	8/12	1 4		(66') As above: brownish yellow (10YR 6/6).		
70								(67') End of Boring.		

NOTES: SBG03- (60-62)-20210202: 20.0% moisture content, 740 U mg/kg total organic carbon, 2.671 specific gravity, 1.5% gravel, 94.4% sand, 4.1% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G04
Page: 1 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	02/02/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	359.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	356.15	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21902, -88.8494	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	12/24	2 3 3 2	6	(0') TOPSOIL. (0.25') CLAY (CL); low plasticity, brown (7.5YR 5/6), dry, very stiff.		
				SS	12/24	2 3 3 3	6	(3') As above.		
5				SS	18/24	2 2 2 3	4	(4') CLAY (CH); high plasticity, dry, moist, soft, brown (7.5YR 5/6) mottled with light gray (8/1).		
				SS	12/24	1 2 2 3	4	(6') As above: some organics (black).		
				SS	18/24	2 2 2 1	4	(8') As above: light gray dominant (brown mottled), moist.		
10				SS	24/24	3 3 3 5	6	(11') As above: now stiff, low plasticity. (CL)		
				SS	24/24	3 4 6 7	12	(12') As above: dry, some silt and fine to very fine sand.		
15				SS	24/24	3 6 7 9	13	(14') As above.		
				SS	24/24	3 5 7 9	12	(16-17') As above: medium stiff. (17-18') As above: stiff.		
20				SS	24/24	5 9 2 4	11	(18') SILTY SAND (SM); light gray (8/1), tight, moist (18-19'), dry (19-20'), poorly graded, mostly very fine to fine grained sand and silt, some clay.		

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Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G04
Page: 2 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	02/02/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	359.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	356.15	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21902, -88.8494	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	4 6 8 4	14	(20') SILTY SAND AND CLAY (CL/SM); light gray (8/1), interbedded, stiff/tight, mostly clay.		
				SS	24/24	8 7 8 8	15	(22') SANDY CLAY (CL); low plasticity, dry, medium stiff, mostly clay with some silt and very fine sand.		
				SS	24/24	3 6 7 9	15	(24') As above: trace fine gravel.		
25				SS	24/24	3 4 7 15	11	(26') As above: soft to medium stiff.		
				SS	24/24	8 7 8 9	15	(28') As above: less sand, very stiff, moist to dry, less brown mottling.		
				SS	24/24	5 7 9 11	16	(30') As above: moist/wet.		
30				SH	24/24	4 5 8 8	13	(32') As above: dry, brown mottling back.		
				SS	24/24	3 6 7 9	13	(34') As above: little sand/silt, moist, stiff.		
				SS	24/24	4 7 10 10	17	(36') As above: dry.		
35				SS	24/24	4 5 7 9	12	(38') As above: very stiff to hard.		
40										

NOTES:

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G04
Page: 3 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	02/02/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	359.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	356.15	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21902, -88.8494	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	MEASURE: DEPTH (ft)
40				SS	24/24	5 7 9 12	16	(40') As above: all clay, moderate plasticity, gray dominant (8/1).		
				SS	24/24	3 5 7 8	12	(42') As above: brown dominant (5YR 5/8).		
45				SS	24/24	5 5 7 11	12	(44') As above: sandy clay, some black splotches.		
				SS	24/24	19 33 15 11	48	(46') As above: wet. (47') SILTY SAND (SM); mostly silt, very fine to fine grained sand, poorly graded, dry, very tight, light gray (8/1).		
				SS	24/24	5 7 5 6	9	(48') SANDY CLAY (CL); stiff, low plasticity, gray/brown mottled, dry, mostly clay, some sand.		
50				SS	24/24	9 5 8 11	14	(50') CLAY (CL); little sand, very stiff to hard, low plasticity, moist to dry, brown/gray mottled.		
				SS	24/24	3 4 6 8	14	(52') As above: moist, stiff to medium stiff.		
55				SS	24/24	4 5 8 8	13	(54-55') As above: soft. (55-56') As above: trace coarse gravel, stiff.		
				SS	24/24	4 7 21 32	28	(56') SANDY CLAY (CH); soft, high plasticity, gray/brown mottled, moist. (57.25') SILTY SAND (SM); tight, poorly graded, moist, very fine to fine grained sand and silt, gray/brown mottled.		
60				SS	24/24	17 21 22 19	43	(58') SILTY SAND (SM); pinkish white (7.5YR 8/2), poorly graded, tight, saturated for middle 4", rest is moist.		

NOTES:

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WELL LOG
Well No. G04
Page: 4 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	02/02/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	359.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	356.15	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21902, -88.8494	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	24/24	8 9 12 20	21	(60') As above.		
								(62') End of Boring.		
65										

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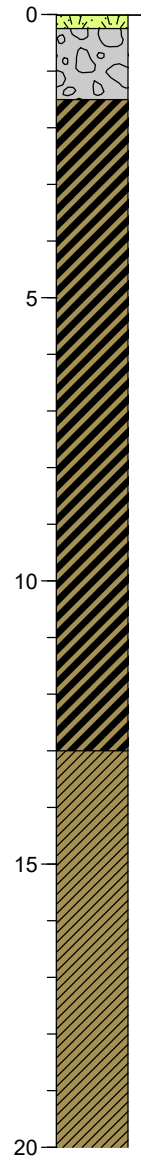
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G05
Page: 1 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	66	Well Depth (ft):	60
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	361.68	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	358.45	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21716, -88.84883	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
0	SS	18/24	6 8 3	11	(0') TOPSOIL. (0.25') POORLY GRADED GRAVEL (GP)		
			4		(1.5') CLAY (CL); light brown (10YR 7/3), very stiff, low plasticity, dry.		
	SS	12/24	2 3 4	7	(2') As above.		
	SS	24/24	4 3 3	10	(4') As above: medium stiff.		
5			7 7				
	SS	24/24	3 6 7	13	(6') As above: mottled light brown (10YR 7/3) and light gray (8/1).		
	SS	24/24	9 3 5	10	(8') As above: trace coarse gravel.		
10			5 7				
	SS	24/24	3 4 5	9	(10') As above: stiff.		
	SS	24/24	6 2 3	8	(12') As above.		
			5		(13') CLAY (CL); mostly same as above with some very fine to fine grained sand and silt.		
	SS	24/24	6 4 5	13	(14') As above: slightly moist.		
15			8 9				
	SS	24/24	2 3 5	8	(16') As above: dry.		
	SS	24/24	7 2 3	7	(18') As above.		
20			4				

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WELL LOG
Well No. G05
Page: 2 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	66	Well Depth (ft):	60
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	361.68	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	358.45	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21716, -88.84883	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	4 6 6 9	12	(20') As above.		
				SS	24/24	3 5 6 7	11	(22') As above: medium stiff.		
				SS	24/24	4 7 7 4	14	(24') As above.		
25				SS	24/24	3 4 7 9	11	(26') As above: stiff.		
				SS	24/24	4 5 8 10	13	(28') As above.		
30				SS	24/24	2 4 6 7	10	(30') As above.		
				SH	24/24	3 8 11 12	19	(32') As above.		
				SS	24/24	8 10 11 12	21	(34') As above.		
35				SS	24/24	3 5 7 9	12	(36') As above.		
				SS	24/24	3 8 11 14	19	(38') SILTY CLAY (CL); same as above with more silt.		
40										

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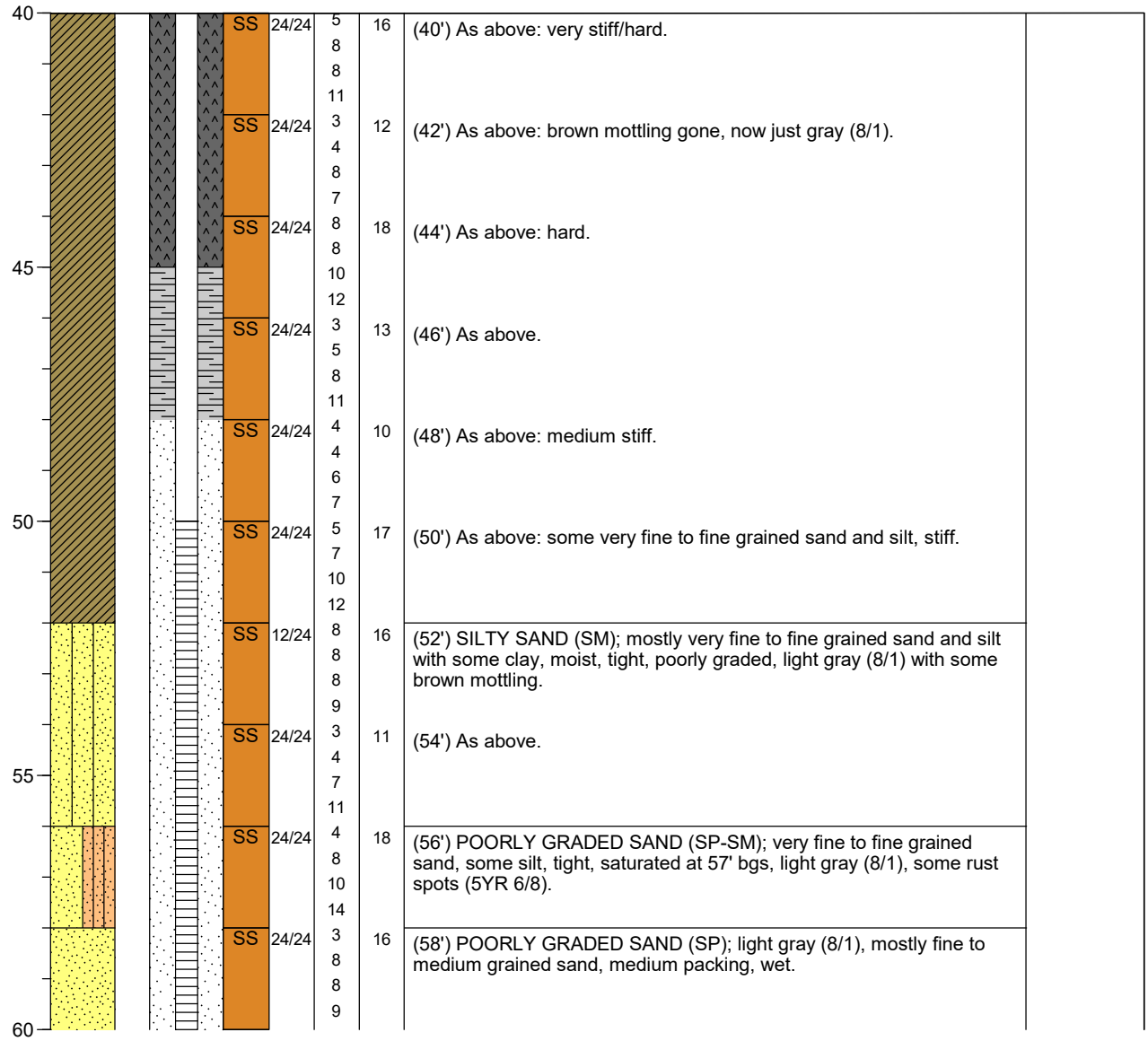
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G05
Page: 3 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	66	Well Depth (ft):	60
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	361.68	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	358.45	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21716, -88.84883	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
40	SS	24/24	5 8 8 11	16	(40') As above: very stiff/hard.	
	SS	24/24	3 4 8 7	12	(42') As above: brown mottling gone, now just gray (8/1).	
	SS	24/24	8 8 10 12	18	(44') As above: hard.	
45	SS	24/24	3 5 8 11	13	(46') As above.	
	SS	24/24	4 4 6 7	10	(48') As above: medium stiff.	
	SS	24/24	5 7 10 12	17	(50') As above: some very fine to fine grained sand and silt, stiff.	
50	SS	12/24	8 8 8 9	16	(52') SILTY SAND (SM); mostly very fine to fine grained sand and silt with some clay, moist, tight, poorly graded, light gray (8/1) with some brown mottling.	
	SS	24/24	3 4 7 11	11	(54') As above.	
55	SS	24/24	4 8 10 14	18	(56') POORLY GRADED SAND (SP-SM); very fine to fine grained sand, some silt, tight, saturated at 57' bgs, light gray (8/1), some rust spots (5YR 6/8).	
	SS	24/24	3 8 8 9	16	(58') POORLY GRADED SAND (SP); light gray (8/1), mostly fine to medium grained sand, medium packing, wet.	
60						

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WELL LOG
Well No. G05
Page: 4 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	66	Well Depth (ft):	60
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	361.68	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	358.45	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21716, -88.84883	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	24/24	2 4 5 8	9	(60') As above: wet. (61') As above: moist, some red color lamination.		
				SS	24/24	2 2 3 4	5	(62') As above: some silt, saturated, poorly graded, medium packing/toughness. (SP-SM) (63') As above: moist, some red lamination.		
65				SS	24/24	1 2 3 5	5	(64') As above: saturated, medium to loose toughness. (65.5') SAND (SW); some gravel, color change to (5YR 7/6) (66') End of Boring.		
70										

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WELL LOG
Well No. G06
Page: 1 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	12/24	2 3 3 3	6	(0') TOPSOIL. (0.25') FAT CLAY (CH); brown (5YR 6/8), soft, dry.		
				SS	12/24	2 3 3 4	6	(2') As above: trace coarse gravel.		
5				SS	6/24	2 2 3 3	5	(4') CLAY (CH); brown (5YR 6/8), high plasticity, dry, soft. ~2" coal seam.		
				SS	12/24	2 1 2 2	3	(6') As above: moist.		
				SS	12/24	1 1 3 2	4	(8') CLAY (CH); dark gray, trace coarse gravel, friable, dry.		
10				SS	12/24	2 2 3 4	5	(9') CLAY (CH); brown (5YR 6/8), high plasticity, moist, soft. (10') As above: trace fine gravel.		
				SS	12/24	1 1 2 3	3	(12') As above: dry.		
15				SS	24/24	3 3 4 4	7	(14') CLAY (CH); mottle (brown and light gray), high plasticity, soft, dry.		
				SS	12/24	3 3 4 4	7	(16') As above: wet.		
				SS	18/24	1 2 1 2	3	(18') As above: dry.		
20										

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WELL LOG
Well No. G06
Page: 2 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	18/24	1 2 4 7	6	(20') CLAY (CH); soft, dry, light brown (7.5YR 8/2), moderate plasticity.		
				SS	24/24	5 7 7 8	14	(22') CLAY (CL); stiff, low plasticity, light brown (7.5YR 8/2) with dark brown mottling, dry.		
25				SS	24/24	3 2 3 3	5	(24') As above.		
				SS	24/24	2 3 3 7	6	(26') CLAY (CL); low plasticity, very stiff, dry, light brown (7.5YR 8/2) mottled with dark brown.		
				SS	24/24	3 4 4 4	8	(28') CLAY (CH); dry, high plasticity, medium stiffness, light brown (7.5YR 8/2) mottled with dark brown.		
30				SS	24/24	8 17 15 12	32	(30') SILTY SAND (SM); mostly silt and fine sand, poorly graded, dry, light gray (7.5YR 8/1), tight.		
				SH	12/24	8 7 7 9	14	(32') As above: with dark brown (7.5YR 5/8) mottling.		
				SS	18/24	3 14 12 12	26	(34') POORLY GRADED (SP); light gray (7.5YR 8/1), tight, dry, some silt, mostly very fine to fine grained sand, some rust marks.		
35				SS	18/24	4 4 9 12	13	(36') As above: moist.		
				SS	18/24	6 7 12 14	19	(38') As above: dry.		
40										

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WELL LOG
Well No. G06
Page: 3 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	18/24	9 12 18 18	30	(40') As above: mottled with orange (5YR 6/8) color, medium packing, poorly graded, dry.		
				SS	12/24	8 15 16 21	31	(42') POORLY GRADED SAND (SP); red (5YR 7/8), loose, dry, mostly fine grained sand.		
				SS	18/24	7 11 12 12	23	(44') As above. (45') As above: wet.		
45				SS	24/24	8 7 14 8	21	(46') CLAY (CL); low plasticity, moist to wet, stiff, gray to reddish orange (5YR 7/8).		
				SS	24/24	5 8 10 11	18	(48') SILTY SAND (SM); mostly silt, very fine to fine grained sand, some clay, poorly sorted, tight, moist, gray (8/1).		
50				SS	24/24	10 11 9 3	20	(50') As above: saturated, mottled with (5YR 7/8) and (8/1).		
				SS	24/24	3 6 7 14	13	(52') POORLY GRADED SAND (SP); red (5YR 7/8), loose, wet, coarse gravel at bottom 1".		
				SS	24/24	4 18 18 15	36	(54') As above: sand with 1-2" gravel at bottom.		
55				SS	24/24	3 7 8 14	15	(56') POORLY GRADED SAND (SP); mostly fine to medium grained sand, wet, medium packing, reddish yellow (5YR 7/6).		
				SS	24/24	8 12 26 27	38	(58') As above: some fine to coarse gravel. (59') DIAMICTON - mostly fine-coarse grained WELL-GRADED GRAVEL and SAND (GW-SW); wet, medium packing, reddish yellow		
60										

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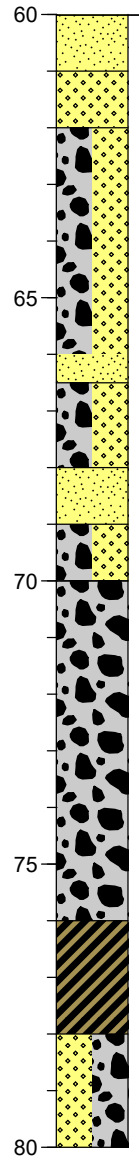
WELL LOG
Well No. G06
Page: 4 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand



DEPTH (ft)	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60	SS	18/24	8 11 36 23	47	(5YR 7/6). (60') POORLY GRADED SAND (SP); reddish yellow (5YR 7/6), tight, wet.		
	SS	18/24	7 18 29 31	47	(61') WELL-GRADED SAND (SW); lots of coarse gravel (orange chert), loose. (62') DIAMICTON - mostly fine-coarse grained GRAVEL AND SAND (GW-SW); (orange chert), wet, very loose, reddish yellow (5YR 7/6).		
65	SS	12/24	11 12 28 26	40	(64') As above: saturated.		
	SS	18/24	21 33 52	85	(66') 6" tan (5YR 7/6), same as above (SP) (66.5') DIAMICTON same as above (GW-SW)		
	SS	18/24	5 3 10 16	13	(68') POORLY GRADED SAND same as above (SP) (69') DIAMICTON same as above (GW-SW)		
70	SS	18/24	7 12 15 17	27	(70') GRAVELLY SILT DIAMICTON (GW/SM); mostly fine to coarse gravel, fine to coarse sand, silt and some clay, wet, stiff, well-graded, orangish tan (5YR 7/6).		
	SS	24/24	9 9 14 9	23	(72') As above: saturated.		
75	SS	12/24	6 7 10 11	17	(74') As above: very stiff/tight.		
	SS	18/24	6 6 10 11	16	(76') As above: more clay than sand (medium to high plasticity). (CH/MH/GW)		
	SS	12/24	7 9 7 5	16	(78') As above: less clay. (GW/SW) (79') Moist, 1cm dark brown layer diamicton gravel up to 1.5" diameter.		
80							

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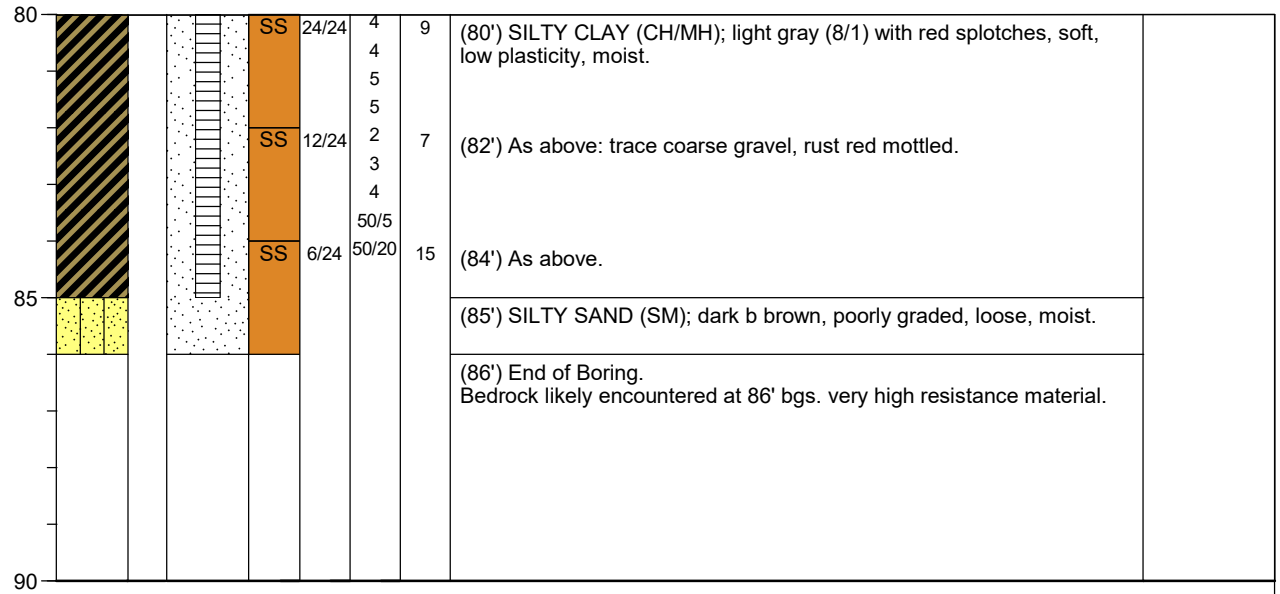
WELL LOG
Well No. G06
Page: 5 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
80	SS	24/24	4 4 5 5	9	(80') SILTY CLAY (CH/MH); light gray (8/1) with red splotches, soft, low plasticity, moist.		
	SS	12/24	2 3 4 50/5	7	(82') As above: trace coarse gravel, rust red mottled.		
85	SS	6/24	50/20	15	(84') As above.		
					(85') SILTY SAND (SM); dark b brown, poorly graded, loose, moist.		
90					(86') End of Boring. Bedrock likely encountered at 86' bgs. very high resistance material.		

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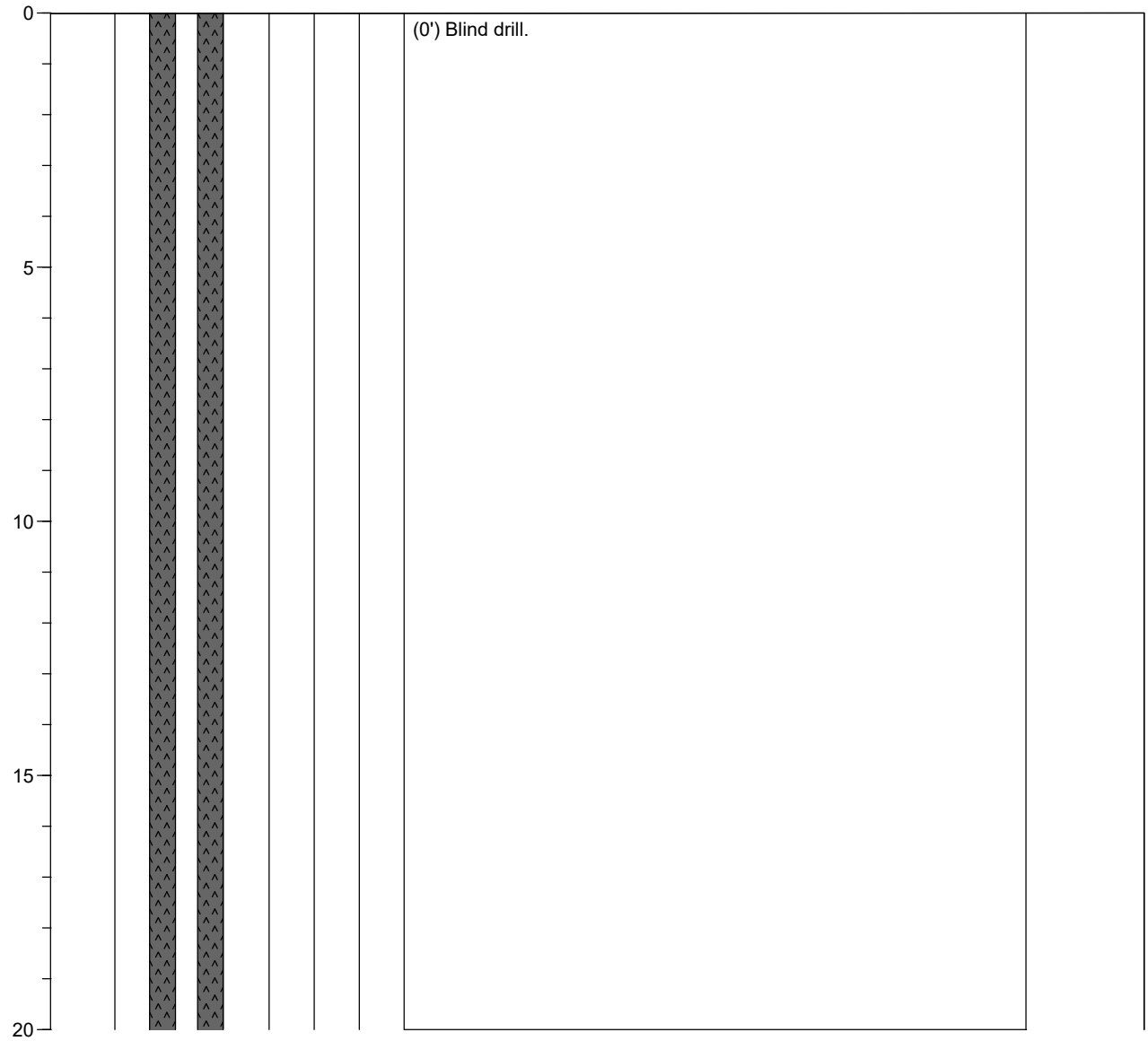
WELL LOG
Well No. G06S
Page: 1 of 3

Drilling Start Date:	02/01/2021	Boring Depth (ft):	44	Well Depth (ft):	40
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.92	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.22187, -88.84904	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		



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WELL LOG
Well No. G06S
Page: 2 of 3

Drilling Start Date:	02/01/2021	Boring Depth (ft):	44	Well Depth (ft):	40
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.92	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.22187, -88.84904	Filter Pack:	Sand

DTW

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		
25				SS	24/24	4 7 8 9	15	(26') CLAY (CH); light gray (7.5YR 8/1) mottled with brown, dry, very stiff, low plasticity.		
				SS	24/24	5 5 9 8	14	(28') As above.		
30				SS	24/24	3 7 14 24	21	(30') As above.		
				SH	24/24	4 1 8 11	9	(31') SILTY SAND (SM); very tight, mostly silt and fine to very fine grained sand, poorly graded, dry, (8/1) with (5YR 7/8), some clay. (32') As above.		
35				SS	12/24	9 22 10 10	32	(34') SAND AND SILTY SAND (SP-SM); mostly very fine to fine grained sand with some silt, poorly graded, tight, dry, light gray/organic.		
				SS	24/24	3 6 8 16	14	(36') As above. (SM)		
				SS	18/24	7 10 12 17	22	(38') As above. (SP-SM)		
40										

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WELL LOG
Well No. G06S
Page: 3 of 3

Drilling Start Date:	**02/01/2021**	Boring Depth (ft):	**44**	Well Depth (ft):	**40**
Drilling End Date:	**02/01/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**355.92**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**352.47**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**BA**	Location (Lat/Long):	**37.22187, -88.84904**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	24/24	8		(40') POORLY GRADED SAND (SP); (5YR 7/8), mostly fine grained sand, medium density, dry.		
				SS	24/24			(42') As above.		
45								(44') End of Boring.		

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WELL LOG
Well No. G07
Page: 1 of 4

Drilling Start Date:	01/29/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	01/29/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.86	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA & CL	Location (Lat/Long):	37.21116, -88.8492	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	24/24	4 8 6 6	14	(0') TOPSOIL. (0.25') FAT CLAY (CH); light brown (5YR 6/8), stiff, dry.		
				SS	12/24	4 5 5 6	10	(2') As above.		
5				SS	24/24	4 4 7 5	11	(4') As above.		
				SS	24/24	4 6 7 8	13	(6') As above.		
				SS	24/24	4 3 3 5	6	(8') As above: medium stiffness.		
10				SS	24/24	4 4 7 8	11	(10') LEAN CLAY (CL); light brown (5YR 7/4) to gray (mottled), stiff, dry.		
				SS	24/24	4 5 5 6	10	(12') As above: top 6" soft with plant material.		
				SS	24/24	3 3 4 4	7	(14') As above.		
15				SS	24/24			(16') As above.		
				SS	24/24	3 4 5 7	9	(18') As above: silt and clay, some fine sand, stiff, dry. (ML-CL)		
20										

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WELL LOG
Well No. G07
Page: 2 of 4

Drilling Start Date:	01/29/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	01/29/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.86	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA & CL	Location (Lat/Long):	37.21116, -88.8492	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	3 4 6 7	10	(20') As above: rust spots.		
				SS	24/24	3 3 4 6	7	(22') As above: moist.		
				SS	24/24	3 3 4 5	7	(24') As above: mottled (10R 8/1).		
25				SS	24/24	3 4 7 7	11	(26') SILTY SAND (SP-SM); mostly silt, fine grained sand, some mottling as previous, poorly graded, tight, moist.		
				SS	24/24	3 6 7 7	13	(28') POORLY GRADED SAND (SP); very fine to fine grained sand, light gray (10R 8/1), tight, moist.		
30				SS	24/24	9 20 21 26	41	(30') As above. (31') POORLY GRADED SAND (SP); medium to coarse grained, loose, moist, (10R 8/1).		
				SH	18/24	10 6 9 9	15	(32') As above: color change to orange (5YR 6/8), clay at bottom.		
				SS	24/24	4 5 6 7	11	(34') FAT CLAY (CH); stiff, moist, light gray/orange mottled (10R 8/1 to 5YR 6/8).		
35				SS	24/24	3 3 5 5	8	(36') As above: medium stiffness.		
				SS	24/24	2 2 2 3	4	(38') As above.		
40										

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Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G07
Page: 3 of 4

Drilling Start Date:	01/29/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	01/29/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.86	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA & CL	Location (Lat/Long):	37.21116, -88.8492	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	24/24	3 3 5 8	8	(40') As above.		
				SS	24/24	6 12 23 24	35	(42') SILTY SAND (SP-SM); very fine grained sand and silt, tight, moist, poorly graded, light gray (10R 8/1).		
				SS	18/24	7 18 27 33	45	(44') As above. (45') POORLY GRADED SAND (SP); very fine to fine grained sand, tight, moist, (10R 8/1).		
				SS	24/24	7 18 43 47	61	(46') POORLY GRADED SAND (SP); fine to medium grained sand, loose, wet, interbedded gray to reddish orange (5YR 6/8) - seams 2cm.		
45				SS	18/24	14 17 18 7	35	(48') DIAMICTON (GW); mostly fine to coarse gravel and medium to coarse sand, saturated, very loose, well graded, (5YR 7/8).		
				SS	24/24	12 22 36 39	58	(50') WELL-GRADED SAND (SW); medium to coarse grained with fine gravel, saturated, loose.		
				SS	24/24	9 11 14 18	25	(52') As above: (5YR 7/6). (53') DIAMICTON (GW-SW); same as above, (5YR 6/8).		
50				SS	24/24	19 31 53	84	(54') Same as above (SW).		
				SS	24/24	7 21 14 8	35	(55') WELL-GRADED GRAVEL and SAND (GW-SW); mostly fine to coarse grained gravel and fine to medium sand, loose, wet, light gray (10R 8/1), orangish tan chert nodules. (57') As above: top 1' tan (5YR 6/8) bottom gray (10R 8/1), wet.		
				SS	24/24	6 9 11 16	20	(58') POORLY GRADED SAND (SP); mostly very fine to fine grained sand, wet, loose, tan (7.5YR 8/4).		
55										
60										

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Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G07
Page: 4 of 4

Drilling Start Date:	**01/29/2021**	Boring Depth (ft):	**62**	Well Depth (ft):	**60**
Drilling End Date:	**01/29/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**353.86**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**352.47**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**BA & CL**	Location (Lat/Long):	**37.21116, -88.8492**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	24/24	32 48 38 8	86	(60') As above. (62') DIAMICTON (GW-SW); same as above.		
								(62') End of Boring.		
65										

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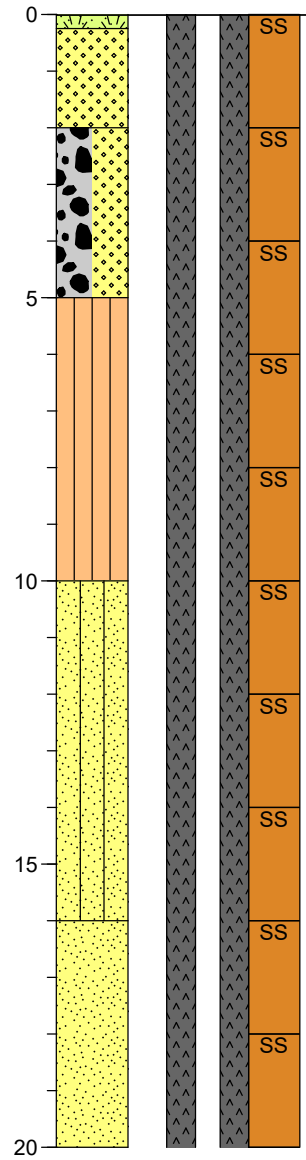
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G08
Page: 1 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
0	SS	7	3 4	7	(0') TOPSOIL. (0.25') WELL-GRADED SAND (SW); light brown/gray, loose, dry.		
	SS	18	6 14	18	(2') GRAVELLY SAND (GW-SW); loose, dry, mostly fine to coarse grained gravel and sand.		
	SS	7	11 7	7			
5	SS		6 4		(5') SILT (ML); low plasticity, dark gray, dry, trace coarse gravel.		
	SS	4	3 4	4	(6') As above.		
	SS	4	4 3	4	(8') As above: trace fine gravel.		
10	SS	8	2 2	8	(10') SILTY SAND (SM); dark gray, loose, dry, well-graded.		
	SS	5	2 2	5	(12') As above.		
	SS	5	3 3	5	(14') As above: clay seam at 15' (1-2").		
15	SS	4	2 3	4	(16') POORLY GRADED SAND and CLAY (SP/CL); dark gray interbedded with dark gray, medium stiff, clay - 2" beds alternating.		
	SS	3	2 2	3			
20			1 1				

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Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G08
Page: 2 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS		1 1 1	2	(20') CLAY (CH); high plasticity, soft, moist, gray to green.		
				SS		2 1 1 1 1	2	(21.5') SILTY SAND (SM); wet, loose, gray to green. (22') As above.		
25				SS		3 2 2 2 2	4	(24') SILT (ML); loose, dark gray, black clay seam - 2".		
				SS		2 2 1 2	3	(26') CLAY (CH); gray to green, saturated, high plasticity. (27') SILT (ML); soft, moist, gray to green.		
30				SS		1 1 1 2	2	(28') SILTY SAND (SM-SP); light gray, firm, saturated, mostly poorly graded fine to medium grained sand and silt.		
				SS		3 2 3 4	5	(30') As above.		
				SS		3 3 4 4	7	(31') SILTY SAND (SM); tight, light gray, poorly graded, fine to medium grained sand. (32') As above.		
35				SS		4 4 3 3	7	(33') CLAY (CL); light gray, hard, low plasticity, dry. (35') As above: some fine grained sand.		
				SS		3 4 4 5	8	(36') As above: gradually grades to fine to medium sand.		
40				SS		3 3 3 3	6	(37') POORLY GRADED SAND (SP); fine to medium grained sand, tight, trace gravel, mottled with rusty red color. (38') As above.		

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WELL LOG
Well No. G08
Page: 3 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	MEASURE: DEPTH (ft)
40				SS		5 10 12 12	22	(40') POORLY GRADED SAND (SP); fine to medium grained, tight, light gray, mottled with rust color. (41') As above: saturated.		
				SS		3 5 8 8	13	(42') As above: some fine to coarse gravel. (43.5') As above: nodule (red chert), saturated.		
45				SS		3 6 7 7	13	(44') As above: lots of fine to coarse gravel, yellow/orange/red, gravel/nodules.		
				SS		5 7 7 11	14	(46') GRAVELLY SAND (GW-SW); mostly fine grained sand and fine to coarse gravel, light gray, gravel bits are red/yellow, saturated.		
				SS		1 5 5 5	10	(48') As above: very loose.		
50				SS		9 9 5 14	14	(50') As above. (51.5') As above: some silt.		
				SS		3 11 11 10	22	(52') WELL-GRADED SAND (SW); fine to coarse grained, trace fine gravel, tan, very loose.		
				SS		9 14 12 10	26	(54') WELL-GRADED GRAVELLY SAND (GW-SW); tan, moist, coarse grained gravel, fine to coarse sand, very loose, wet. (55') As above: light gray.		
55				SS		17 19 17 17	36	(56') POORLY GRADED SAND (SP); fine to medium grained, wet, loose, dark tan.		
				SS		6 8 11 12	19	(57.5') WELL-GRADED GRAVELLY SAND (GW); dark tan, loose. (58') As above. (59') WELL-GRADED SAND (SW); dark tan, wet, loose, trace fine gravel.		
60										

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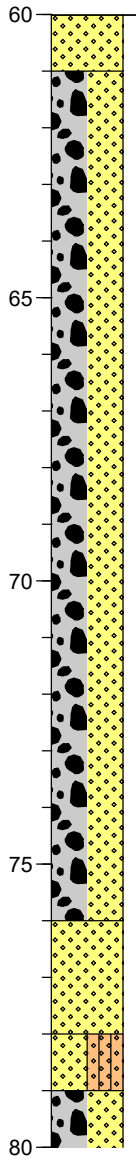
WELL LOG
Well No. G08
Page: 4 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
60	SS	24/24	14, 10	24	(60') As above.		
			14, 11		(61') GRAVELLY SAND (GW-SW); dark tan, well-graded, coarse chert nodules, wet, loose.		
	SS	18/24	5, 3	7	(62') As above.		
			4, 5				
	SS	12/24	4, 8	13	(64') As above.		
65			5, 8				
	SS	18/24	5, 8	16	(66') As above.		
			8, 7				
	SS	18/24	5, 7	14	(68') As above: saturated.		
			7, 8				
70	SS	12/24	5, 6	13	(70') As above.		
			7, 7				
	SS	18/24	7, 9	18	(72') As above.		
			9, 11				
	SS	24/24	7, 7	15	(74') As above: mostly silt and gravel, (5YR 6/8).		
75			8, 9				
	SS	18/24	10, 16	33	(76') WELL-GRADED SAND (SW); mostly medium to coarse grained sand, wet, loose, (5YR 6/8).		
			17, 25				
	SS	24/24	8, 15	54	(78') DIAMICTON (SW-SM); mostly coarse grained gravel, fine sand, silt, wet, medium density, (5YR 6/8).		
80			39, 42		(79') Same fine to coarse gravel, more coarse gravel, (5YR 6/8). (GW-SW)		

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Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G08
Page: 5 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80				SS	18/24	6 11 12 14	23	(80') As above. (SW)		
				SS	24/24	7 14 19 21	33	(81.5') 1/2" seam - orangish sand, medium packing, moist, (7.5YR 8/6). (SP) (82') Same as above. (SW) (83') Same as above, top 3" (10R 6/6), tight, moist. (SP)		
85				SS	12/24	19 27 15 5	42	(84') As above. (85') 2cm seam of reddish/oxidized fine grained sand, dry.		
90								(86') End of Boring.		

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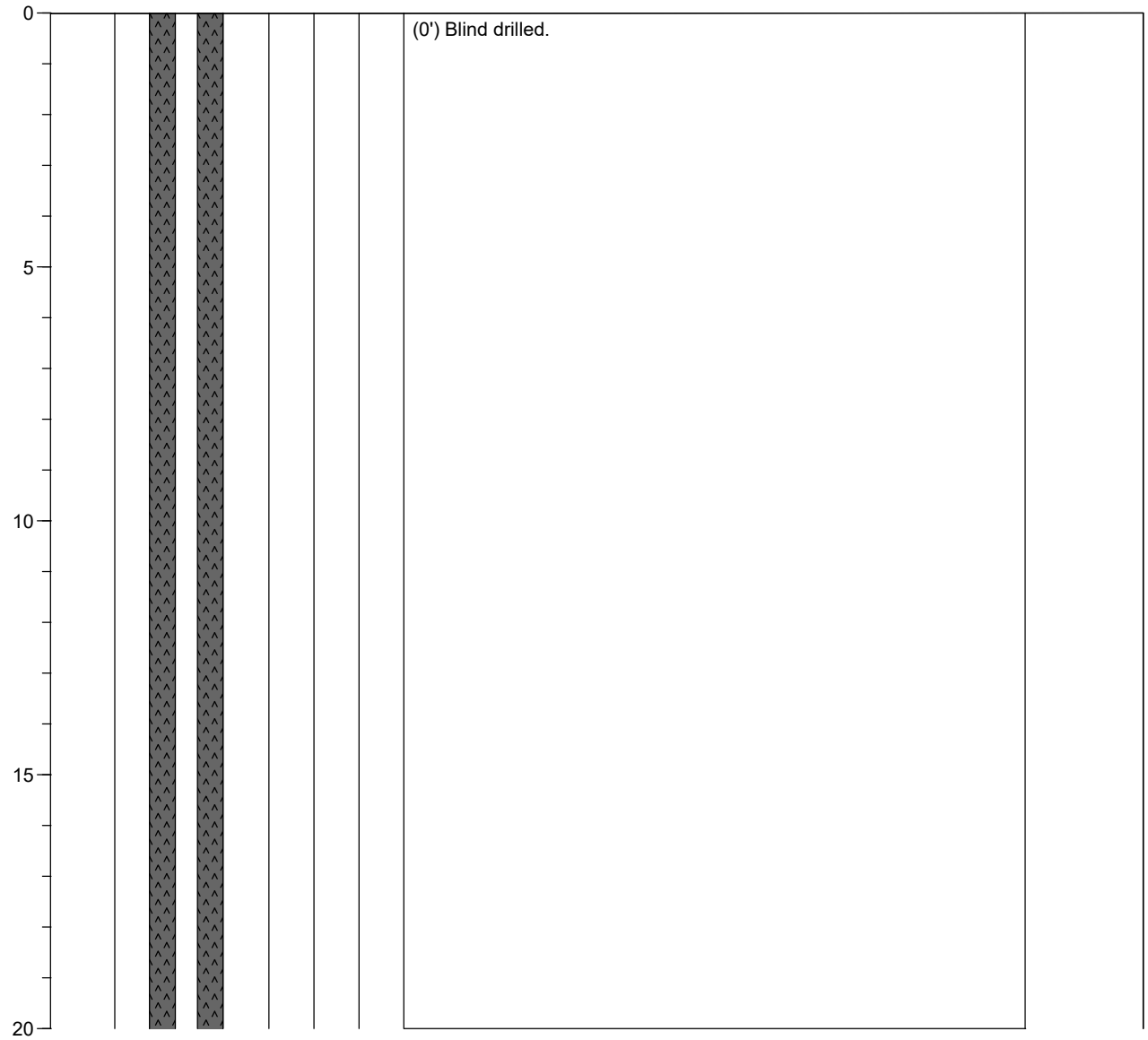
WELL LOG
Well No. G09
Page: 1 of 4

Drilling Start Date:	01/31/2021	Boring Depth (ft):	72	Well Depth (ft):	70
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	36.31	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.99	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.69	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21039, -88.54247	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drilled.		



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WELL LOG
Well No. G09
Page: 2 of 4

Drilling Start Date:	**01/31/2021**	Boring Depth (ft):	**72**	Well Depth (ft):	**70**
Drilling End Date:	**01/31/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**36.31**	Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**351.99**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**348.69**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**SK**	Location (Lat/Long):	**37.21039, -88.54247**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drilled.		
25										
30										
35		▼								
40										

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WELL LOG
Well No. G09
Page: 3 of 4

Drilling Start Date:	01/31/2021	Boring Depth (ft):	72	Well Depth (ft):	70
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	36.31	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.99	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.69	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21039, -88.54247	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') Blind drilled.		
45										
50										
55				SS	13/24	1 1 5 15	6	(54') POORLY GRADED SAND (SP); fine to medium grained sand, light gray (2.5Y 7/1), medium dense, dry, few coarse gravel.		
				SS	23/24	8 13 15 20	28	(56') As above.		
60				SS	15/24	4 9 17 16	26	(58') WELL-GRADED SAND (SW); coarse grained with gravel, reddish yellow (7.5YR 6/6), loose, moist. (59') Becomes wetter.		

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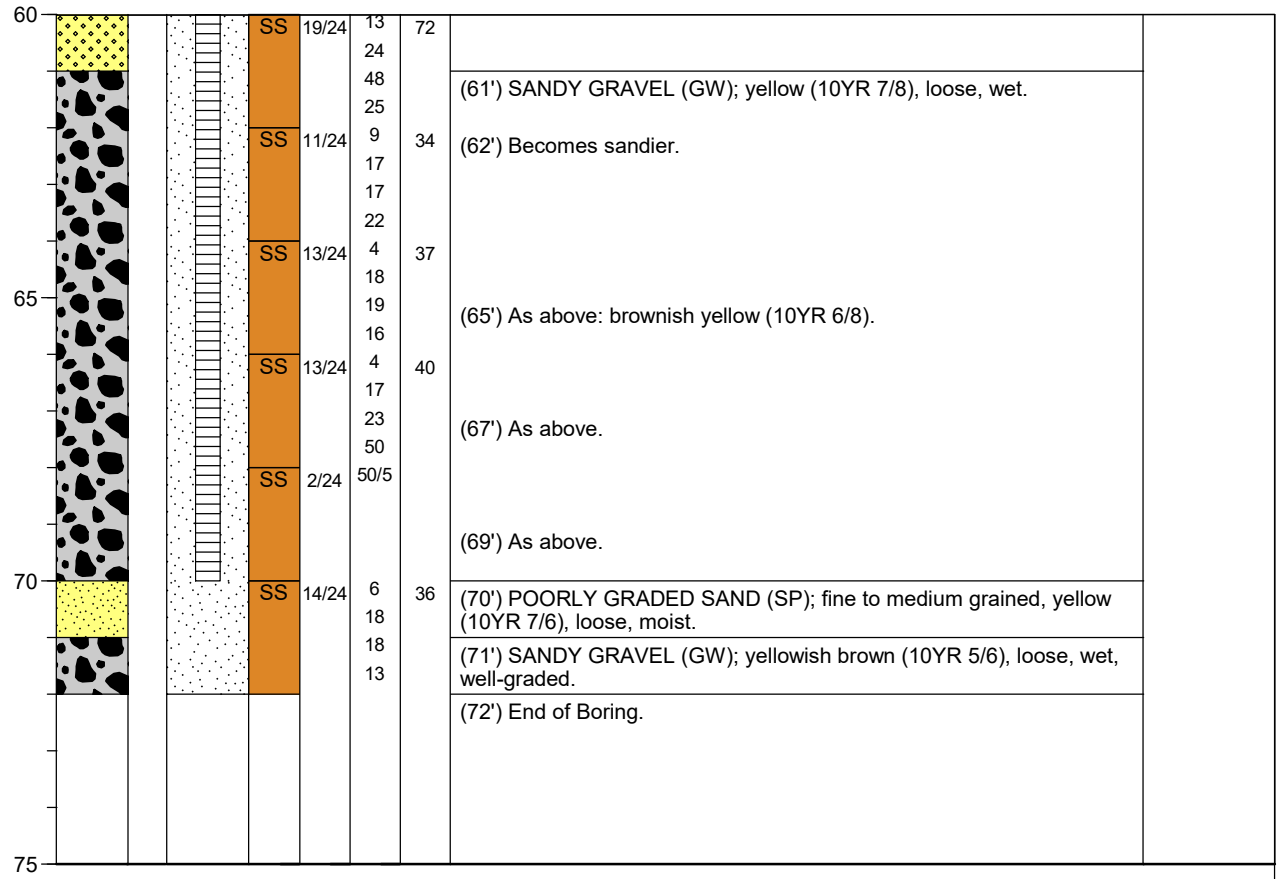
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G09
Page: 4 of 4

Drilling Start Date:	01/31/2021	Boring Depth (ft):	72	Well Depth (ft):	70
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	36.31	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.99	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.69	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21039, -88.54247	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION
60	SS	19/24	13 24 48 25	72	
					(61') SANDY GRAVEL (GW); yellow (10YR 7/8), loose, wet.
	SS	11/24	9 17 17 22	34	(62') Becomes sandier.
65	SS	13/24	4 18 19 16	37	(65') As above: brownish yellow (10YR 6/8).
	SS	13/24	4 17 23 50	40	(67') As above.
	SS	2/24	50/5		(69') As above.
70	SS	14/24	6 18 18 13	36	(70') POORLY GRADED SAND (SP); fine to medium grained, yellow (10YR 7/6), loose, moist.
					(71') SANDY GRAVEL (GW); yellowish brown (10YR 5/6), loose, wet, well-graded.
					(72') End of Boring.
75					

NOTES:

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Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G09M
Page: 1 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	6/24	6 4 5	9	(0') LEAN CLAY (CL); brown (7.5YR 5/3), stiff, dry, some reddish brown mottling, trace sand.		
				SS	22/24	6 4 5	11			
				SS	24/24	4 2 3	6	(4') FAT CLAY (CH); light brown (7.5YR 6/4), medium dense, moist.		
5				SS	24/24	3 4 0	6	(6') As above: lean clay, moist. (CL)		
				SS	24/24	3 4 2	8	(8') As above: brown (7.5YR 5/4), some reddish brown mottling.		
10				SS	20/24	3 5 5	7	(10') As above.	10-12 Chem	
				SS	22/24	2 3 4	9	(12') CLAY (CL); gray to light brown (7.5YR 6/1) mottled, medium dense, dry, few sand.		
				SS	21/24	5 5 2	8	(14') As above: brown (7.5YR 5/4).		
15				SH	24/24	3 5 5		(16') As above: light brown (7.5YR 6/3).	16-18 Geotech	
				SS	23/24	2 5 6	11	(18') CLAY (CL); gray to light brown (7.5YR 6/1) mottled, very stiff, moist, few sand.		
20						7				

NOTES: SBG09M- (16-18)-20210127: 20.6% moisture content, 950 mg/kg total organic carbon, 105.4 pcf dry unit weight, 2.666 specific gravity, 8.3x 10^{-8} cm/s vertical hydraulic conductivity, 39 LL, 16PL, 23PI, 0.0% gravel, 5.0% sand, 95.0% fines.

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WELL LOG
Well No. G09M
Page: 2 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	2 4 7 8	11	(20') CLAY (CL); light gray with brown (10YR 7/1) mottling, very stiff, moist, trace sand and silt.	20-22 Chem	
				SS	24/24	4 6 7 8	13	(22') As above: (10YR 7/2).		
				SS	24/24	2 5 7 8	12	(24') As above: fewer brown mottling.		
25				SS	24/24	3 3 6 7	9	(27-28') As above: increased reddish brown mottling.		
				SS	24/24	4 8 8 7	16	(28') SILT (ML); with few sand and clay, light gray (10YR 7/2) with some brown mottling, dry, stiff.		
				SS	24/24	4 8 6 8	14	(30') As above: moist.		
30				SS	24/24	4 5 6 7	11	(32') As above.		
				SS	24/24	2 4 4 6	8	(34') SANDY CLAY (SC); light gray (10YR 7/2) with some brown mottling, moist.		
								(34.5') SILT (ML); with some sand, few clay, stiff.		
35				SS	24/24	3 4 5 8	9	(36') As above: trace black organics.		
				SS	24/24	5 20 18 17	38	(38') SANDY CLAY (SC); fine grained sand, few silt, gray (7.5YR 5/1), moist.		
40										

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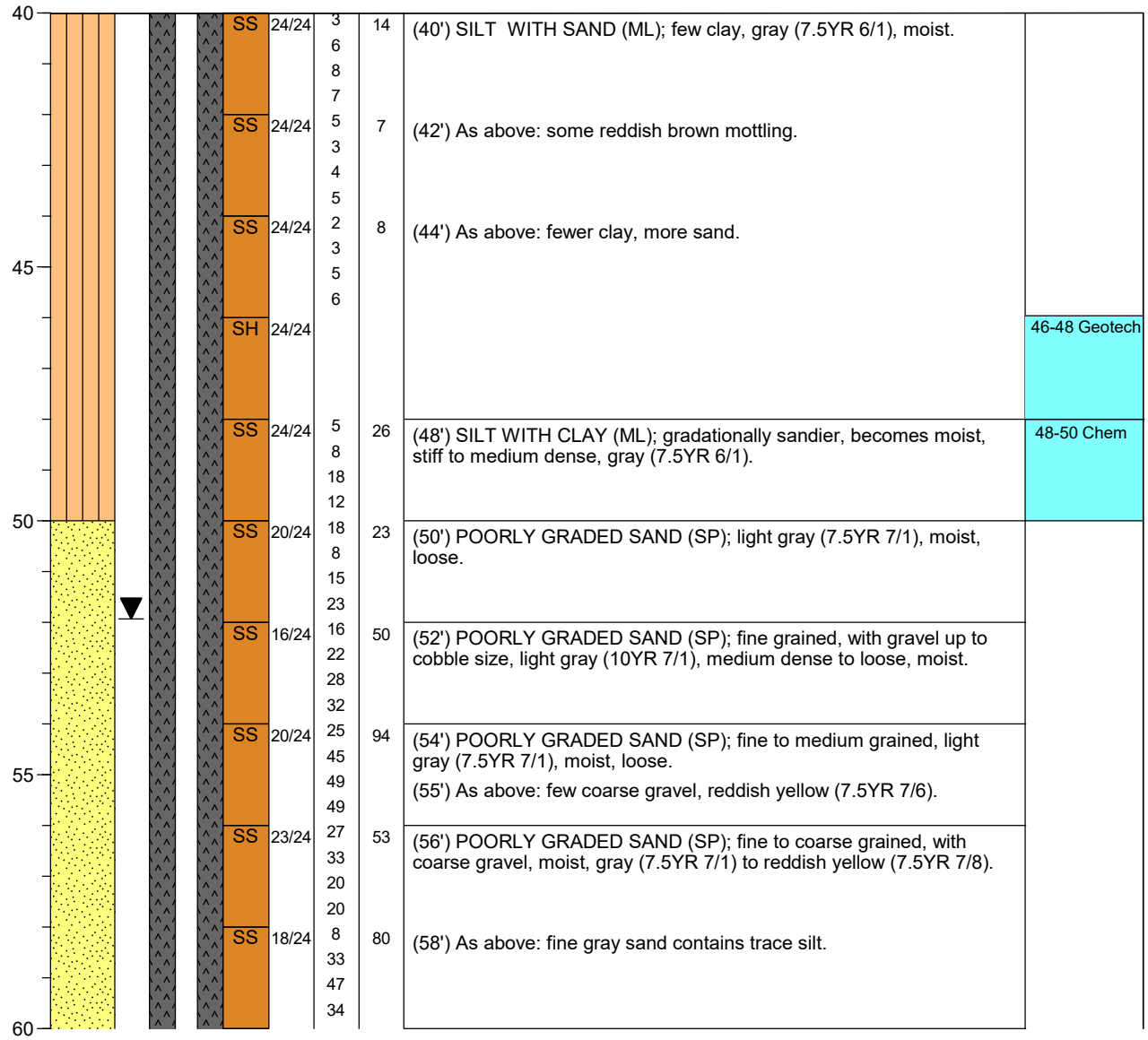
WELL LOG
Well No. G09M
Page: 3 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand



NOTES: SBG09M- (46-48)-20210127: 19.8% moisture content,105.4 pcf dry unit weight, 2.715 specific gravity, 3.5x 10^{-7} cm/s vertical hydraulic conductivity, 35 LL, 15 PL, 20 PI, 0.0% gravel, 17.2% sand, 82.8% fines.

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WELL LOG
Well No. G09M
Page: 4 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	16/24	32 35 47 21	82	(60') POORLY GRADED SAND (SP); coarse grained, reddish yellow (7.5YR 6/8), moist, loose.		
				SS	16/24	22 50/5 14	64	(62') POORLY GRADED SAND (SP); coarse grained, reddish yellow (7.5YR 6/8), medium dense, some coarse gravel pebble size.		
				SS	13/24	17 11 12 12	23	(64') As above: increasing fine to coarse gravel.		
65				SS	12/24	15 16 15 11	31	(66') As above.		
				SS	11/24	38 50	50	(68') POORLY GRADED GRAVEL WITH SAND (GP); strong brown (7.5YR 5/6), loose, moist.		
70				SS	12/24	14 17 30 32	47	(70') As above.		
				SS	12/24	25 24 15 16	39	(72') As above: reddish yellow (7.5YR 6/8).		
				SS	8/24	6 25 20 12	45	(74') As above: sand disappears, wet.		
75				SS	14/24	7 7 8 7	15	(76') As above: strong brown (7.5YR 5/8).		
				SS	16/24	11 22 14 8	36	(78') As above: with some sand.		
80										

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WELL LOG
Well No. G09M
Page: 5 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80				SS	12/24	2 17 19 12	36	(80') POORLY GRADED GRAVEL (GP); little sand, reddish yellow (7.5YR 6/8), very loose, wet.	80-82 Chem	
				SS	10/24	5 18 13 14	31		82-84 Geotech	
85				SS	14/24		19	(83.7') POORLY GRADED SAND (SP); medium grained, trace gravel, reddish brown (7.5YR 6/8), loose, moist.		
				SS	14/24	12 9 10 10	22	(86') WELL-GRADED GRAVEL (GW); few sand, trace clay, reddish brown (7.5YR 6/8), loose, wet.		
				SS	14/24	25 14 8 6	14	(88') As above: clay disappears.		
90				SS		4 6 8 7		(91') GRAVELLY LEAN CLAY (CL); very pale brown (10YR 8/2), moist, soft.		
				SS		2 3 3 4	6	(92') CLAY (CL); trace gravel, gray (7.5YR 6/1), medium dense.		
				SS		2 1 3 3	4	(94') As above: gray (10YR 5/1).		
95				SS		1 6 23 23	29	(96') POORLY GRADED SAND (SP); fine grained, strong brown (7.5YR 5/8), loose.		
				SS		5 14 25 23	39	(98') As above.		
100										

NOTES: SBG09M- (82-84)-20210127: 7.6% moisture content, 740 U mg/kg total organic carbon, 100.0 pcf dry unit weight, 2.686 specific gravity, 22.7% gravel, 75.4% sand, 1.9% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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WELL LOG
Well No. G09M
Page: 6 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100				SS	14/24	14 14	27	(100') CLAY (CL); (10YR 6/1), very soft, trace gravel.		
						13 15		(101') CLAYEY GRAVEL (GC); (7.5YR 5/8), moist, loose.		
				SS	15/24	14 12	20	(102') As above: some sand, brown (7.5YR 4/4).		
						8 15				
				SS	9/24	12 12	21	(104') GRAVELLY CLAY (CL); light gray (2.5Y 7/2), stiff, moist.		
105						9 14				
				SS	15/24	12 12	24	(106') CLAYEY GRAVEL (GC); pinkish gray (7.5YR 7/2), medium dense, moist.		
						12 20				
				SS	14/24	9 28	39	(108') POORLY GRADED SAND (SP); fine grained, yellow (10YR 7/6) to white (10YR 8/1) at 109.8' bgs, moist, loose.		
						11 11				
110				SS	15/24	8 12	20	(110') As above: light gray (10YR 7/1).	110-112 Chem	
						8 12				
				SH	8/24				112-114 Geotech	
				SS	13/24	10 11	20	(114') As above: yellow (10YR 7/6), trace gravel.		
115						9 10				
				SS	12/24	7 9	18	(116') As above: light gray (10YR 7/2), no gravel.	116-118 Geotech (not tested)	
						9 12				
				SS	22/24	7 1	3	(118') SILT WITH SAND (ML); gray (10YR 6/1) with some light brown mottling, soft, moist.		
						2 3				
120								(119.5') CLAY (CL); little silt, gray (10YR 6/1), stiff, moist.		

NOTES: SBG09M- (110-112)-20210127: 25.5% moisture content, 760 U mg/kg total organic carbon, 87.0 pcf dry unit weight, 2.675 specific gravity, 0.7% gravel, 84.1% sand, 15.2% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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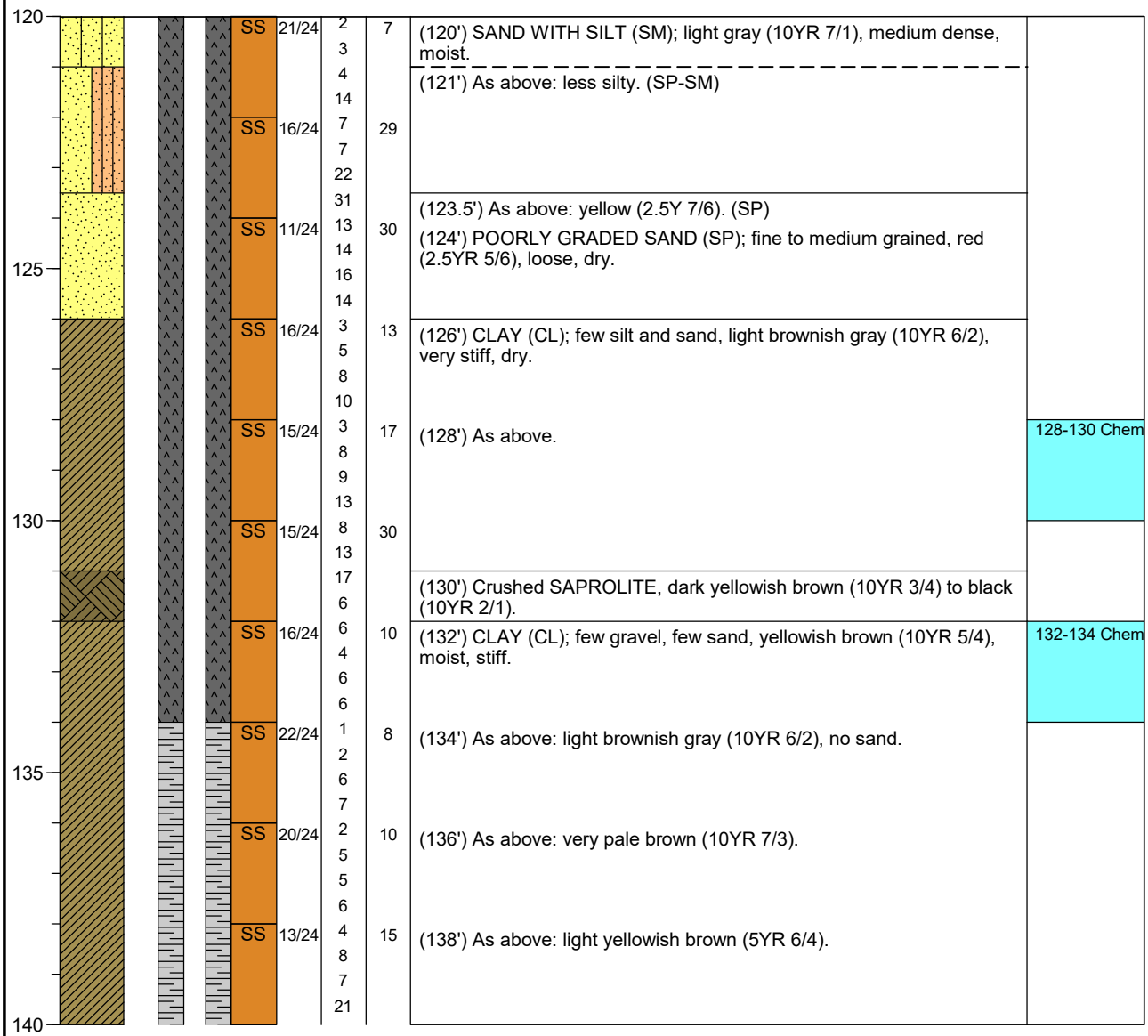
WELL LOG
Well No. G09M
Page: 7 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
120	SS	21/24	2 3 4	7	(120') SAND WITH SILT (SM); light gray (10YR 7/1), medium dense, moist.		
			14		(121') As above: less silty. (SP-SM)		
	SS	16/24	7 7 22	29			
			31		(123.5') As above: yellow (2.5Y 7/6). (SP)		
	SS	11/24	13 14 16	30	(124') POORLY GRADED SAND (SP); fine to medium grained, red (2.5YR 5/6), loose, dry.		
125			14				
	SS	16/24	3 5 8	13	(126') CLAY (CL); few silt and sand, light brownish gray (10YR 6/2), very stiff, dry.		
			10				
	SS	15/24	3 8 9	17	(128') As above.	128-130 Chem	
			13				
130	SS	15/24	8 13 17	30			
			6		(130') Crushed SAPROLITE, dark yellowish brown (10YR 3/4) to black (10YR 2/1).		
	SS	16/24	6 4 6	10	(132') CLAY (CL); few gravel, few sand, yellowish brown (10YR 5/4), moist, stiff.	132-134 Chem	
			6				
	SS	22/24	1 2 6	8	(134') As above: light brownish gray (10YR 6/2), no sand.		
135			7				
	SS	20/24	2 5 5	10	(136') As above: very pale brown (10YR 7/3).		
			6				
	SS	13/24	4 8 7	15	(138') As above: light yellowish brown (5YR 6/4).		
140			21				

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WELL LOG
Well No. G09M
Page: 8 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
140				SS	6/24	70/1		(140') CALCARENITE, very pale brown (10YR 7/3), dry.	140-142 Chem	
145										
150										
155								(155') End of Boring.		
								(158') Redrilled to 158' due to well installation difficulties.		
160										

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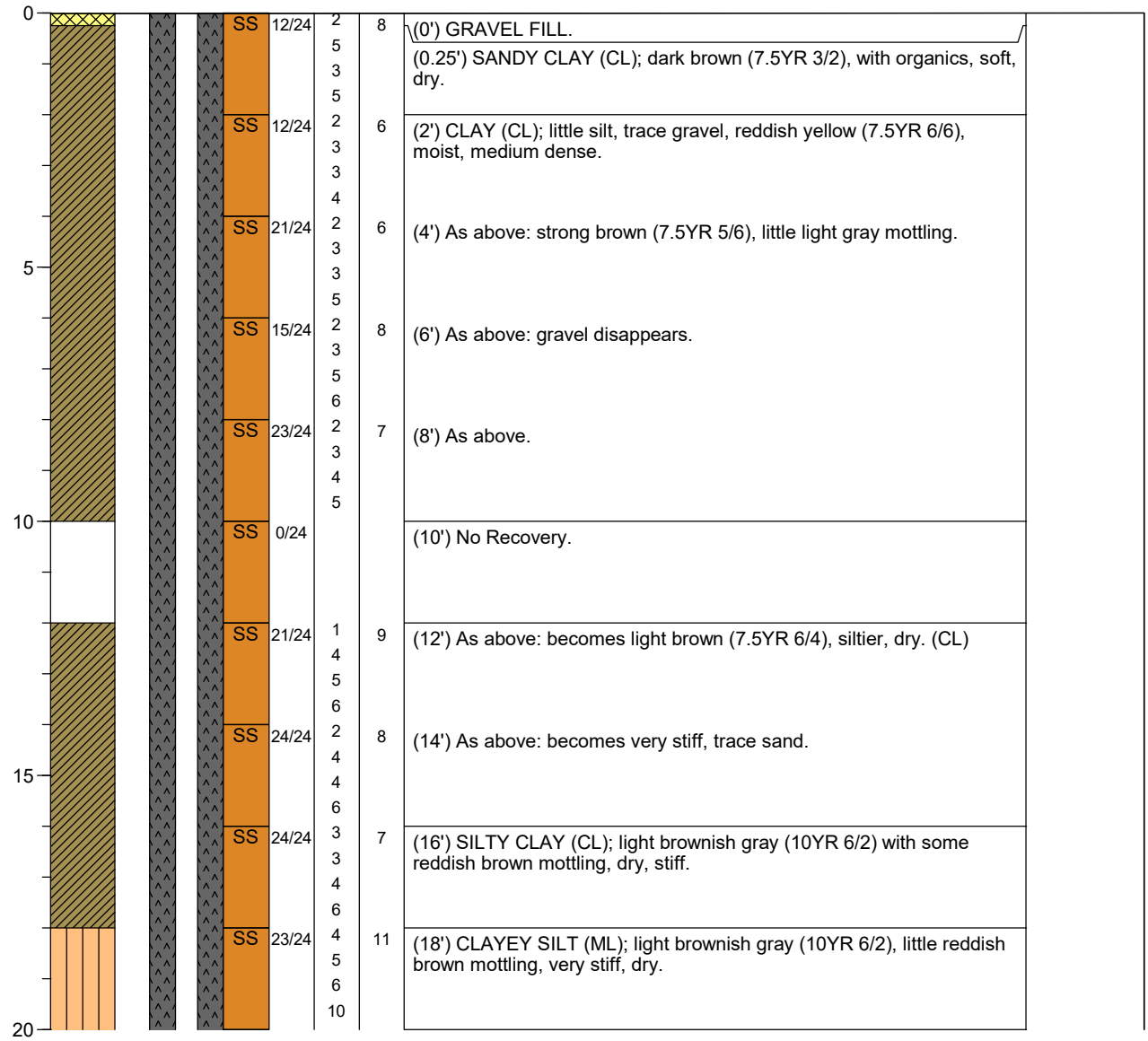
WELL LOG
Well No. G10
Page: 1 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	72	Well Depth (ft):	72
Drilling End Date:	02/01/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	33.35	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.83	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21125, -88.85573	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
0	SS	12/24	2 5 3 5	8	(0') GRAVEL FILL. (0.25') SANDY CLAY (CL); dark brown (7.5YR 3/2), with organics, soft, dry.		
	SS	12/24	2 3 3 4	6	(2') CLAY (CL); little silt, trace gravel, reddish yellow (7.5YR 6/6), moist, medium dense.		
5	SS	21/24	2 3 3 5	6	(4') As above: strong brown (7.5YR 5/6), little light gray mottling.		
	SS	15/24	2 3 5 6	8	(6') As above: gravel disappears.		
	SS	23/24	2 3 4 5	7	(8') As above.		
10	SS	0/24			(10') No Recovery.		
	SS	21/24	1 4 5 6	9	(12') As above: becomes light brown (7.5YR 6/4), siltier, dry. (CL)		
	SS	24/24	2 4 4 6	8	(14') As above: becomes very stiff, trace sand.		
15	SS	24/24	3 3 4 6	7	(16') SILTY CLAY (CL); light brownish gray (10YR 6/2) with some reddish brown mottling, dry, stiff.		
	SS	23/24	4 5 6 10	11	(18') CLAYEY SILT (ML); light brownish gray (10YR 6/2), little reddish brown mottling, very stiff, dry.		
20							

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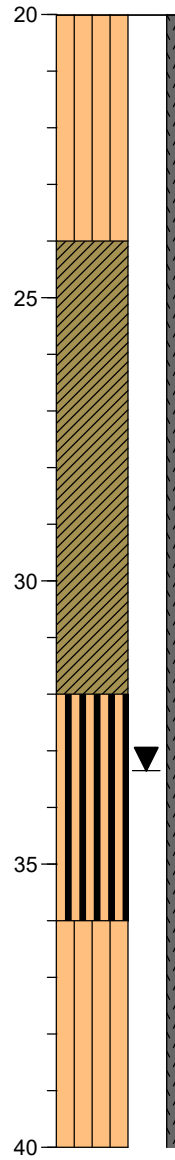
WELL LOG
Well No. G10
Page: 2 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	72	Well Depth (ft):	72
Drilling End Date:	02/01/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	33.35	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.83	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21125, -88.85573	Filter Pack:	Sand



DEPTH (ft)	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20	SS	20/24	4 6 6 9	12	(20') SILT (ML); some sand and little clay, very pale brown (10YR 7/3), very stiff, dry.		
	SS	24/24	3 4 7 8	11	(22') As above: becomes more clayey.		
25	SS	24/24	3 5 6 7	11	(24') SILTY CLAY (CL); light yellowish brown (10YR 6/4), very stiff, dry.		
	SS	24/24	2 4 5 7	9	(26') As above: becomes gray (10YR 6/1) with little reddish brown mottling.		
	SS	24/24	2 4 1 8	5	(28') As above.		
30	SS	24/24	3 5 8 7	13	(30') As above: becomes light brownish gray (10YR 6/2).		
	SS	24/24	3 4 4 6	8	(32') SILT (MH); little clay, pale brown (10YR 6/3), stiff, dry, high plasticity.		
35	SS	24/24	3 4 5 6	9	(34') As above: moist.		
	SS	24/24	3 7 6 7	13	(36') As above: clay disappears, lower plasticity. (ML)		
	SS	21/24	3 8 27 32	35	(38') SANDY SILT (ML); pale brown (10YR 6/3), very stiff, wet.		
40							

NOTES:

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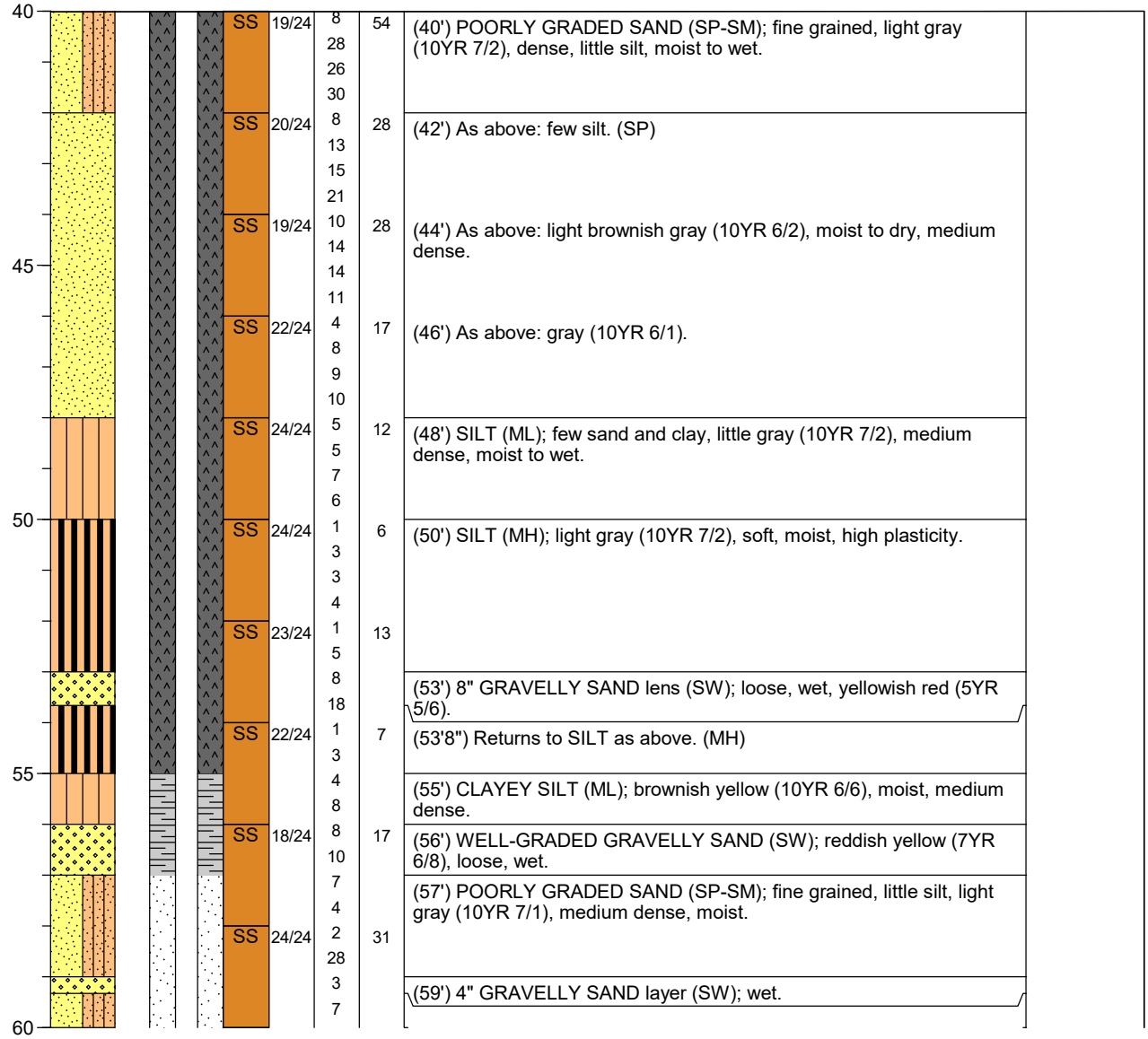
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G10
Page: 3 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	72	Well Depth (ft):	72
Drilling End Date:	02/01/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	33.35	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.83	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21125, -88.85573	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
40	SS	19/24	8, 28, 26, 30	54	(40') POORLY GRADED SAND (SP-SM); fine grained, light gray (10YR 7/2), dense, little silt, moist to wet.	
	SS	20/24	8, 13, 15, 21	28	(42') As above: few silt. (SP)	
45	SS	19/24	10, 14, 14, 11	28	(44') As above: light brownish gray (10YR 6/2), moist to dry, medium dense.	
	SS	22/24	4, 8, 9, 10	17	(46') As above: gray (10YR 6/1).	
	SS	24/24	5, 5, 7, 6	12	(48') SILT (ML); few sand and clay, little gray (10YR 7/2), medium dense, moist to wet.	
50	SS	24/24	1, 3, 3, 4	6	(50') SILT (MH); light gray (10YR 7/2), soft, moist, high plasticity.	
	SS	23/24	1, 5, 8, 18	13	(53') 8" GRAVELLY SAND lens (SW); loose, wet, yellowish red (5YR 5/6).	
	SS	22/24	1, 3, 4, 8	7	(53'8") Returns to SILT as above. (MH)	
55					(55') CLAYEY SILT (ML); brownish yellow (10YR 6/6), moist, medium dense.	
	SS	18/24	8, 10, 7, 4	17	(56') WELL-GRADED GRAVELLY SAND (SW); reddish yellow (7YR 6/8), loose, wet.	
	SS	24/24	2, 28, 3, 7	31	(57') POORLY GRADED SAND (SP-SM); fine grained, little silt, light gray (10YR 7/1), medium dense, moist.	
60					(59') 4" GRAVELLY SAND layer (SW); wet.	

NOTES:

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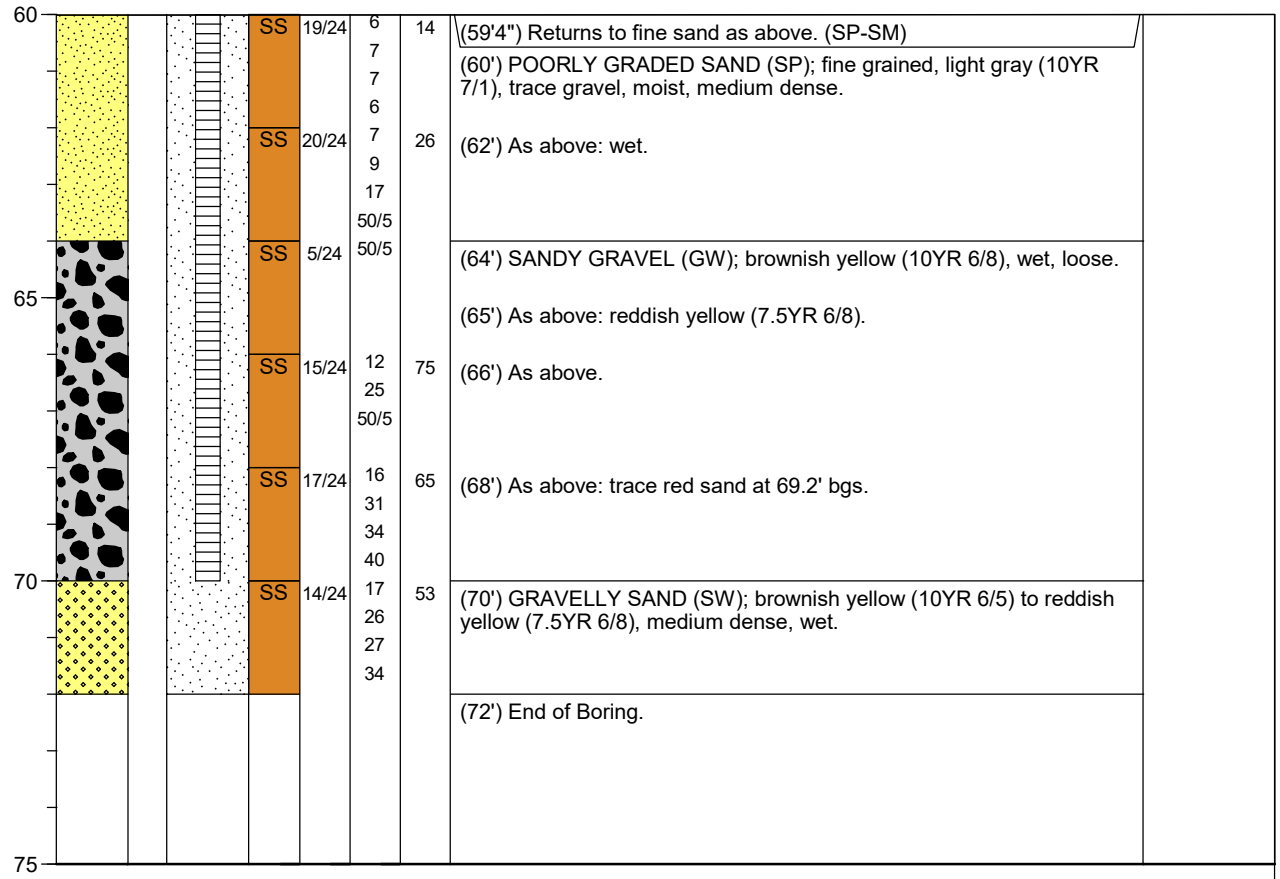
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G10
Page: 4 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	72	Well Depth (ft):	72
Drilling End Date:	02/01/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	33.35	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.83	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21125, -88.85573	Filter Pack:	Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	19/24	6 7 7 6	14	(59'4") Returns to fine sand as above. (SP-SM) (60') POORLY GRADED SAND (SP); fine grained, light gray (10YR 7/1), trace gravel, moist, medium dense.		
				SS	20/24	7 9 17 50/5	26	(62') As above: wet.		
65				SS	5/24	50/5		(64') SANDY GRAVEL (GW); brownish yellow (10YR 6/8), wet, loose. (65') As above: reddish yellow (7.5YR 6/8).		
				SS	15/24	12 25 50/5	75	(66') As above.		
				SS	17/24	16 31 34 40	65	(68') As above: trace red sand at 69.2' bgs.		
70				SS	14/24	17 26 27 34	53	(70') GRAVELLY SAND (SW); brownish yellow (10YR 6/5) to reddish yellow (7.5YR 6/8), medium dense, wet.		
75								(72') End of Boring.		

NOTES:

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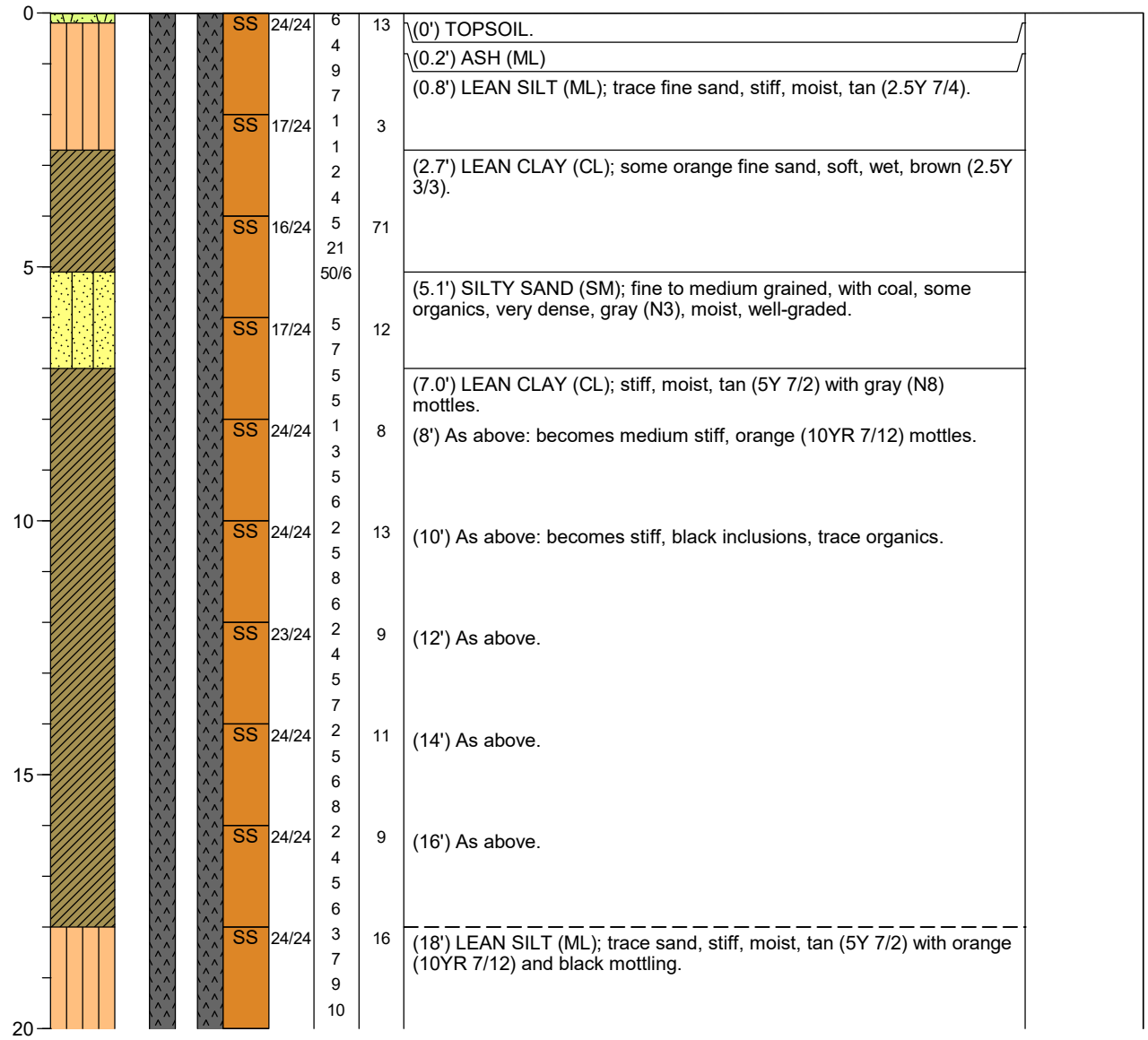
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G11
Page: 1 of 4

Drilling Start Date:	01/19/2021	Boring Depth (ft):	66	Well Depth (ft):	66
Drilling End Date:	01/19/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	45.66	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	366.88	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	363.38	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF & AT	Location (Lat/Long):	37.21436, -88.85636	Filter Pack:	Sand



NOTES:

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G11
Page: 2 of 4

Drilling Start Date:	01/19/2021	Boring Depth (ft):	66	Well Depth (ft):	66
Drilling End Date:	01/19/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	45.66	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	366.88	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	363.38	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF & AT	Location (Lat/Long):	37.21436, -88.85636	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	3 6 8 8	14	(20.1') LEAN CLAY (CL); trace fine sand, stiff, moist, tannish orange (10YR 7/6) with gray (N8) mottles.		
				SS	27/24	2 4 6 7	10	(22') As above.	22-24 Chem	
				SS	27/24			(24') As above.	24-26 ST	
25				SS	24/24	3 4 5 7	9	(26') As above.		
				SS	24/24	3 4 6 7	10	(28') As above.		
30				SS	26/24	2 4 4 6	8	(30') As above: with increased moisture.		
				SS	24/24	2 4 4 6	8	(32') As above.		
				SS	25/24	4 5 8 7	13	(34') As above: with fine sand.		
35				SS	26/24	2 5 5 5	10	(36') As above: orange (10YR 7/12) inclusions, gray (N8) with tan orange (10YR 7/6) mottling.		
				SS	25/24	2 4 6 6	10	(38') As above: trace silt.		
40										

NOTES: SBG11-(24-26)-20210119: 18.5% moisture content, 415 U mg/kg total organic carbon, 109.1 pcf dry unit weight, 2.688 specific gravity, 5.6×10^{-8} cm/s vertical hydraulic conductivity, 36 LL, 15 PL, 21 PI, 0.0% gravel, 11.5% sand, 88.5% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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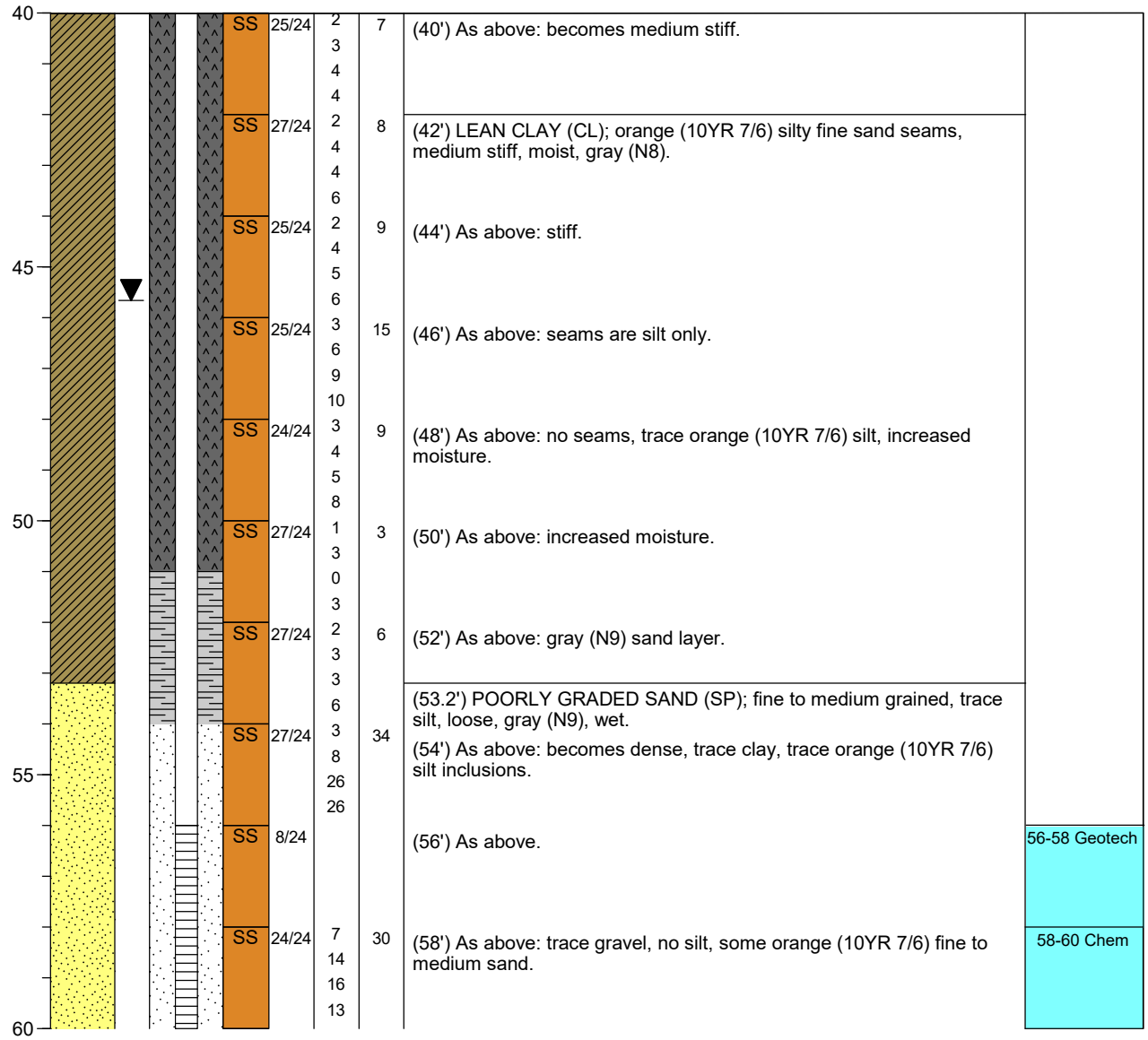
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G11
Page: 3 of 4

Drilling Start Date:	01/19/2021	Boring Depth (ft):	66	Well Depth (ft):	66
Drilling End Date:	01/19/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	45.66	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	366.88	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	363.38	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF & AT	Location (Lat/Long):	37.21436, -88.85636	Filter Pack:	Sand



NOTES:
SBG11-(56-58)-20210119: 14.4% moisture content, 679 U mg/kg total organic carbon, 110.0 pcf dry unit weight, 2.661 specific gravity, 0.2% gravel, 87.7% sand, 12.1% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G11
Page: 4 of 4

Drilling Start Date:	**01/19/2021**	Boring Depth (ft):	**66**	Well Depth (ft):	**66**
Drilling End Date:	**01/19/2021**	Boring Diameter (in):	**7.5**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**45.66**	Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**366.88**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**363.38**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**ZJF & AT**	Location (Lat/Long):	**37.21436, -88.85636**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	20/24	6 14 15 16	29	(60') As above: increased orange sand.		
				SS	14/24	0 6 11 13	17	(62') WELL-GRADED SAND (SW); fine to medium grained, medium dense, wet, orangish tan (7.5YR 8/8) with some gray (N9) sand layers.		
65				SS	18/24	2 10 15 11	25	(64') As above: with sandy gravel layer (~5" thick).		
70								(66') End of Boring.		

NOTES:

As indicated in Illinois Administrative Code Part 845 Data Gap Analysis, Joppa Power Plant, East Ash Pond - CCR Unit 401 provided by Geosyntec, G54S was blind drilled until the screened interval. G54S was advanced adjacent to G54D and a separate boring log was not provided.

FIELD BORING LO

HANSON

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/11/2015
Finish: 8/11/2015
WEATHER: Sunny, warm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G54D
Well ID: G54D
Surface Elev: 353.71 ft. MSL
Completion: 80.14 ft. BGS
Station: 199,066.83N
831,610.42E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 18.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
1A	13/24 54%	ss	3-2 3-4 N=5	21			0	FILL - Black (10YR2/1), moist, medium, SILT with few clay, trace very fine- to medium-grained sand, and trace roots.			
							1	FILL - Yellowish brown (10YR5/4), moist, medium, SILT with few clay, trace very fine- to coarse-grained sand, and trace roots.		352	
2A	16/24 67%	ss	2-4 16-8 N=20	13			2	FILL - Yellowish brown (10YR5/4) with 25% gray (10YR5/1), moist, medium, SILT with few clay, trace very fine- to coarse-grained sand, trace small to large gravel, and trace roots.			
3A	18/24 75%	ss	4-4 5-8 N=9	23		2.00	4	Light gray (10YR7/1) with 20% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with few clay, trace very fine- to fine-grained sand.		350	
4A	21/24 88%	ss	2-2 4-4 N=6	25		2.00	6			348	
5A	24/24 100%	ss	1-3 4-6 N=7	23		1.80	8	Brown (10YR5/3) with 20% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with few clay, trace very fine-grained sand.		346	
6A	22/24 92%	ss	1-3 4-5 N=7	22		3.00	10			344	
7A	17/24 71%	ss	1-1 2-4 N=3	22		2.00	12	Gray (10YR6/1) with 35% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with few clay, trace very fine-grained sand.		342	
8A	22/24 92%	ss	1-2 4-5 N=6	22		2.00	14			340	
9A	17/24 71%	ss	2-3 6-8 N=9	22		1.80	16			338	
10A	24/24 100%	ss	2-3 6-5 N=9	20		2.50	18 ▼	Yellowish brown (10YR5/6) with 30% gray (10YR6/1) mottles, moist, stiff, silty CLAY with trace very fine-grained sand.		336	
							20			334	
11A	24/24		1-3	20		1.90					

NOTE(S): G54D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/11/2015
Finish: 8/11/2015
WEATHER: Sunny, warm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G54D
Well ID: G54D
Surface Elev: 353.71 ft. MSL
Completion: 80.14 ft. BGS
Station: 199,066.83N
831,610.42E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 18.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	100%	ss	5-6 N=8				22	Yellowish brown (10YR5/6) with 30% gray (10YR6/1) mottles, moist, stiff, silty CLAY with trace very fine-grained sand. *[Continued from previous page]*		332	
12A	24/24 100%	ss	1-4 6-8 N=10	19		3.00	24			330	
13A	24/24 100%	ss	1-3 4-6 N=7	19		1.80	26			328	
14A	24/24 100%	ss	2-4 7-7 N=11	21		2.00	28	Light brownish gray (10YR6/2) with 35% dark yellowish brown (10YR4/6) mottles, moist, very stiff, SILT with few clay, trace very fine- to medium-grained sand.		326	
15A	22/24 92%	ss	1-3 6-8 N=9	20		2.30	30			324	
16A	20/24 83%	ss	1-3 6-6 N=9	18		2.40	32			322	
17A	24/24 100%	ss	1-4 8-8 N=12	20		3.50	34			320	
18A	22/24 92%	ss	1-3 4-5 N=7	22		2.80	36	Grayish brown (10YR5/2) with 10% dark yellowish brown (10YR4/6) mottles, moist, very stiff, SILT with little clay, trace very fine-grained sand.		318	
19A	24/24 100%	ss	3-4 8-8 N=12	19		3.00	38			316	
20A	24/24 100%	ss	1-4 7-10 N=11	19		2.50	40	Light gray (10YR7/1) with 5% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with few clay, trace very fine-grained sand.		314	
21A	24/24 100%	ss	1-3 10-10 N=13	17		3.80	42			312	

NOTE(S): G54D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/11/2015
Finish: 8/11/2015
WEATHER: Sunny, warm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G54D
Well ID: G54D
Surface Elev: 353.71 ft. MSL
Completion: 80.14 ft. BGS
Station: 199,066.83N
831,610.42E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 18.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
22A	24/24 100%	ss	5-8 9-10 N=17	16		3.00	44	Light gray (10YR7/1) with 5% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with few clay, trace very fine-grained sand. *[Continued from previous page]*		310	
23A	24/24 100%	ss	3-6 8-8 N=14	19		3.00	46			308	
24A	24/24 100%	ss	2-4 5-5 N=9	19		3.20	48	Light brownish gray (10YR6/2) with 10% dark yellowish brown (10YR4/4) mottles, moist, very stiff, silty CLAY, trace very fine- to coarse-grained sand.		306	
25A	24/24 100%	ss	4-7 7-6 N=14	18		2.40	50			304	
26A	17/24 71%	ss	1-4 6-8 N=10	18		2.00	52	Gray (10YR6/1) with 15% dark yellowish brown (10YR4/6) mottles, moist, very stiff, silty CLAY with little very fine- to coarse-grained sand and trace small gravel.		302	
27A	22/24 92%	ss	3-3 7-18 N=10	21		3.30	54	Gray (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, very stiff, SILT with few clay, trace very fine-grained sand.		300	
28A	21/24 88%	ss	5-11 18-20 N=29	21		4.00	56			298	
29A	11/11 100%	ss	25-50/5"	15		3.80		Gray (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, hard, SILT with few very fine- to fine-grained sand, trace clay.			
30A	20/24 83%	ss	21-19 35-29 N=54	14			58	Gary (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, very dense, silty, very fine- to fine-grained sand, trace clay.		296	
31A	17/24 71%	ss	4-6 10-9 N=16	17		1.80	60	Gray (10YR6/1) with 15% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with little clay, trace very fine- to fine-grained sand.		294	
32A	22/24		6-8	22		3.30	62			292	

NOTE(S): G54D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/11/2015
Finish: 8/11/2015
WEATHER: Sunny, warm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G54D
Well ID: G54D
Surface Elev: 353.71 ft. MSL
Completion: 80.14 ft. BGS
Station: 199,066.83N
831,610.42E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 18.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	92%	SS	*5-7* N=13				64	Gray (10YR6/1) with 15% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with little clay, trace very fine- to fine-grained sand. *[Continued from previous page]*		290	
33A	24/24 *100%*	SS	*2-4* *7-9* N=11	18		*2.50*	66			288	
34A	24/24 *100%*	SS	*3-5* *10-15* N=15	19		*2.50*	68	Gray (10YR6/1) with 15% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with little clay, few very fine- to coarse-grained sand, trace small gravel.		286	
35A	22/24 *92%*	SS	*1-3* *3-5* N=6	23		*1.50*	70	Yellowish brown (10YR5/6) with 10% gray (10YR6/1) mottles, moist, stiff, SILT with little clay, trace very fine-grained sand.		284	
36A	24/24 *100%*	SS	*woh-1* *5-6* N=6	23		*1.50*	72	Gray (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with little clay, trace very fine- to fine-grained sand.		282	
37A	24/24 *100%*	SS	*woh-1* *2-4* N=3	23		*1.50*	74			280	
38A	16/24 *67%*	SS	*30-40* *27-34* N=67	11			76			278	
39A	12/15 *80%*	SS	*10-47* *50/3"*	14			78	Yellowish brown (10YR5/6), moist, very dense, silty, fine- to coarse-grained SAND and small to large GRAVEL.		276	
40A	5/5 *100%*	SS	*50/5"*	12			80			274	
	0/21 *0%*	BD						**End of boring = 80.14 feet**			

NOTE(S): G54D installed in borehole.

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW01
Page: 1 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	24/24	5 4 3 4	7	(0') SILTY SANDY WELL-GRADED GRAVEL (GM); loose, wet, gray (N4). [BOTTOM ASH]		
				SS	19/24	3 3 4 3	7	(2') As above.		
5				SS	18/24	3 2 2 4	4	(4') As above.	4-6 Chem	
				SS	24/24			(6') As above.	6-8 Geotech	
				SS	15/24	4 4 3 2	7	(8') As above.		
10				SS	18/24	1 1 1 1	2	(9.6') LEAN SILT (ML); some fine sand, very soft, wet, grayish brown (N4) with white speckling. [FLY ASH MIXTURE] (10') As above: trace organics.		
		▼		SS	14/24	0 0 1 2	1	(12') As above: trace coarse sand.		
15				SS	14/24	0 1 1 1	2	(14') As above: trace gravel.		
				SS	4/24	1 1 1 1	2	(16') POORLY GRADED SAND (SP); fine grained, some silt, very loose, wet, grayish brown (N4) with black and orange speckles. [BOTTOM ASH]		
				SS	8/24	0 1 0 1	1	(18') As above.		
20										

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.
XPW01-(06-08)-20210120: 34.2% moisture content, 85.6 pcf dry unit weight, 2.711 specific gravity, 2.1×10^{-5} cm/s vertical hydraulic conductivity, 26.3% gravel, 45.4% sand, 58.3% fines.

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW01
Page: 2 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	10/24	0 0 0	0	(20') As above.		
						1		(21.3') LEAN SILT (ML); very soft, wet, grayish brown (N4) with white and orange speckling. [FLY ASH MIXTURE]		
				SS	1/24	0 0 0 0 0	0	(22') As above: little fine sand, trace coal.		
				SS	24/24	0 0 0 0 0	0	(24') LEAN SILT (ML); very soft, wet, grayish brown (N4). [FLY ASH]		
25				SS	24/24	0 0 0 0 0	0	(26') As above.		
				SS	26/24	0 0 0 0 0	0	(28') As above.		
30				SS	26/24	0 0 0 0 0	0	(30') As above.		
				SS	26/24	0 0 0 0 0	0	(32') As above.		
				SS	26/24	0 0 0 0 0	0	(34') As above.		
35				SS	24/24	0 0 0 0 0	0	(36') As above.		
				SS	25/24	0 0 0 0 0	0	(38') As above.		
40										

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.

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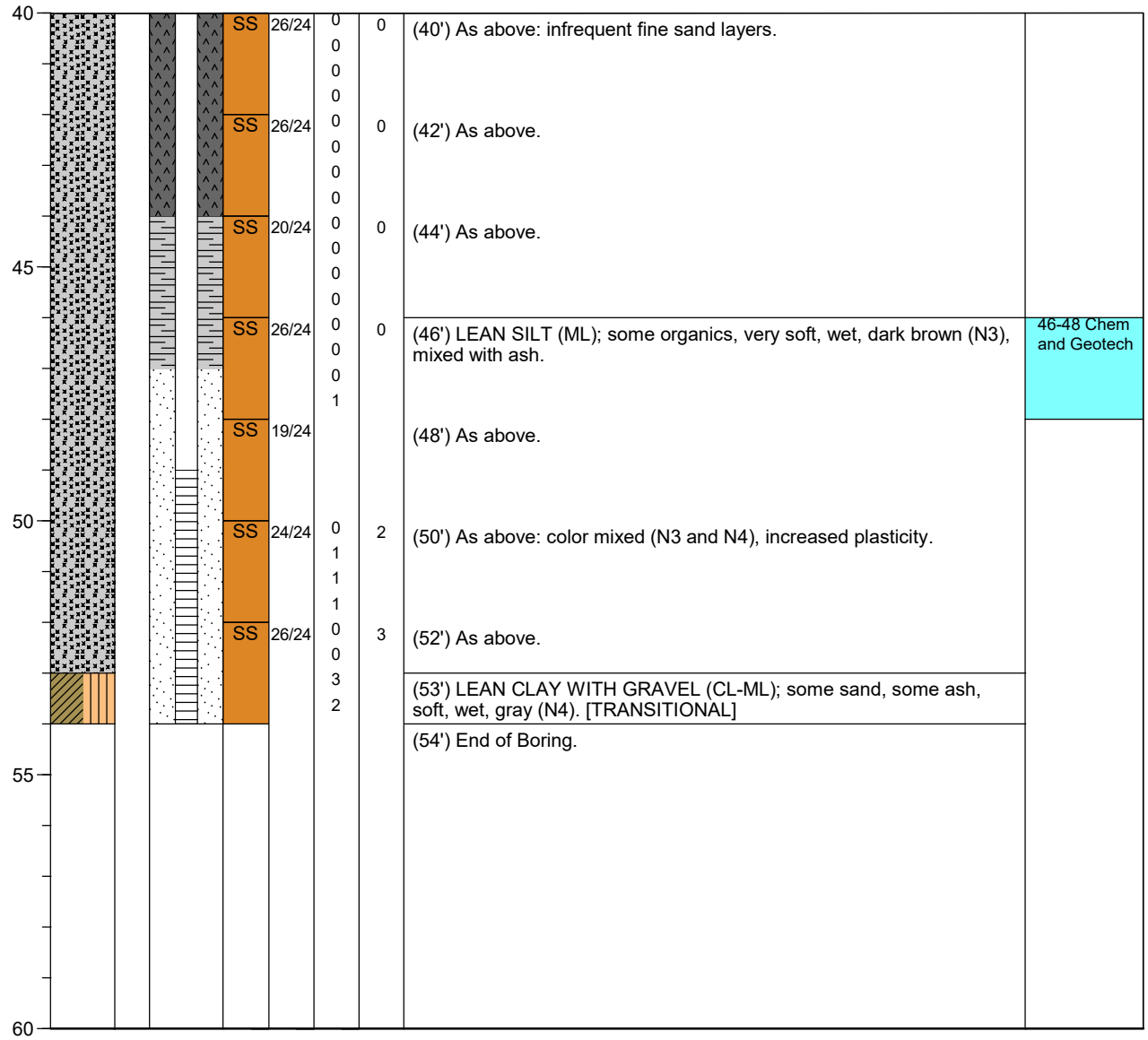
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW01
Page: 3 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand



DEPTH (ft)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40	(40') As above: infrequent fine sand layers.		
	(42') As above.		
45	(44') As above.		
	(46') LEAN SILT (ML); some organics, very soft, wet, dark brown (N3), mixed with ash.	46-48 Chem and Geotech	
	(48') As above.		
50	(50') As above: color mixed (N3 and N4), increased plasticity.		
	(52') As above.		
	(53') LEAN CLAY WITH GRAVEL (CL-ML); some sand, some ash, soft, wet, gray (N4). [TRANSITIONAL]		
55	(54') End of Boring.		
60			

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.
XPW01-(46-48)-20210120: 31.7% moisture content, 87.7 pcf dry unit weight, 2.675 specific gravity, 2.8×10^{-7} cm/s vertical hydraulic conductivity, 25 LL, 20 PL, 5 PI, 0.0% gravel, 18.7% sand, 81.3% fines.

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW02
Page: 1 of 2

Drilling Start Date:	01/20/2021	Boring Depth (ft):	30	Well Depth (ft):	30
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	376.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	373.23	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21575, -88.85504	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	24/24	4 17 44 22	61	(0') SANDY WELL-GRADED GRAVEL WITH SILT (GW); very dense, moist, gray (N4).		
				SS	22/24	3 9 6 7	15	(2') GRAVELLY LEAN SILT WITH SAND (ML); very soft, moist, gray (N4).		
5				SS	26/24	17 17 10 7	27	(4') As above: becomes wet.	4-6 Chem	
				SS	18/24	2 5 3 2	8	(6.2') SILTY SANDY GRAVEL (GM); loose, wet, gray (N4).		
				SS	14/24	2 1 1 1	2	(8.1') LEAN SILT WITH SAND (ML); some gravel, very soft, wet, gray (N4 to brown (10YR 3/1).		
10				SS	12/24	12 13 7 5	20	(10') As above: becomes very stiff, sandy, gravelly.		
				SS	10/24	2 5 3 2	8	(12') GRAVELLY WELL-GRADED SAND WITH SILT (ML); loose, wet, brown (10YR 3/1).		
				SS	10/24	1 2 2 2	4	(14') As above: with gravel, white speckles.		
15				SS	16/24	3 2 2 2	4	(16') As above: silty, trace coal.		
				SS	8/24	1 2 2 3	4	(18') As above: gravelly layer.		
20										

NOTES: Augers were washed out using water & tremie pipe.
Ash mixed with logged materials throughout boring

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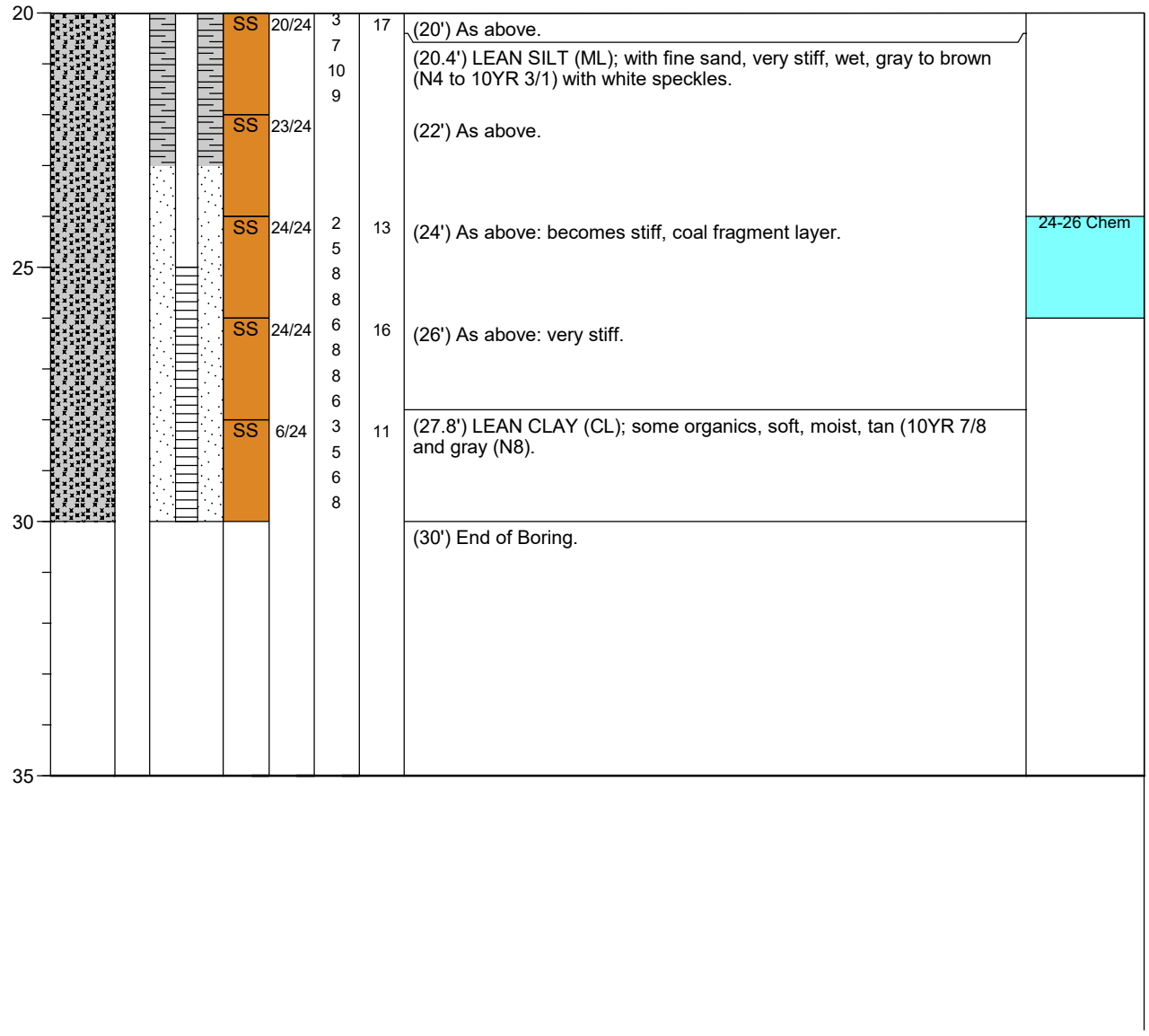
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW02
Page: 2 of 2

Drilling Start Date:	01/20/2021	Boring Depth (ft):	30	Well Depth (ft):	30
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	376.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	373.23	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21575, -88.85504	Filter Pack:	Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	20/24	3 7 10 9	17	(20') As above. (20.4') LEAN SILT (ML); with fine sand, very stiff, wet, gray to brown (N4 to 10YR 3/1) with white speckles.		20
				SS	23/24			(22') As above.		
25				SS	24/24	2 5 8 8	13	(24') As above: becomes stiff, coal fragment layer.	24-26 Chem	25
				SS	24/24	6 8 8 6	16	(26') As above: very stiff.		
30				SS	6/24	3 5 6 8	11	(27.8') LEAN CLAY (CL); some organics, soft, moist, tan (10YR 7/8 and gray (N8). (30') End of Boring.		30
35										35

NOTES: Augers were washed out using water & tremie pipe. Ash mixed with logged materials throughout boring
XPW02-(22-24)-20210120: 47.6% moisture content, 74.0 pcf dry unit weight, 2.567 specific gravity, 9.3% gravel, 74.1% sand, 16.6% fines.

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW03
Page: 1 of 2

Drilling Start Date:	01/21/2021	Boring Depth (ft):	30	Well Depth (ft):	37
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	382.04	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	378.65	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21197, -88.85555	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	22/24	4 14 7	21	(0') SILTY SANDY GRAVEL (GW); medium dense, moist, grayish brown (7.5YR 9/2).		
								(1.2') LEAN SILT (ML); with fine sand, coal fragments, very stiff, moist, brown (N4) with white and orange speckles.		
				SS	24/24	3 1 0	1	(1.9') LEAN SILT (ML); frequent tan (2.5YR 9/2) silt layers, very soft, wet, brown (2.5YR 9/2). [FLY ASH]		
5		▼		SS	26/24	1 1 1	8	(4') As above: becomes medium stiff, no tan silt layers, gravelly layer (coal fragments).		
				SS	20/24	4 4 1	2	(6') As above: becomes very soft.	6-8 Chem	
				SS	26/24	0 1 1	2	(8') As above: some fine sand and white and black speckles.		
10				SS	23/24	2 2 1	0	(10') As above: no gravelly layers.		
				SS	26/24	1 1 1	0	(12') As above: frequent black sandy layers		
				SS	3/24	0 0 0		(14') As above.		
15				SS	0/24	0 0 0				
				SS	0/24	0 0 1		(18') As above.		
20										

NOTES:

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Client:	Dynegy
Project:	GLP0821, Joppa Ash Pond
Address:	Unnamed Road, Metropolis, IL 62960

WELL LOG

Well No. XPW03

Drilling Start Date:	**01/21/2021**	Boring Depth (ft):	**30**	Well Depth (ft):	**37**
Drilling End Date:	**01/21/2021**	Boring Diameter (in):	**7.5**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**382.04**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**378.65**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**ZJF**	Location (Lat/Long):	**37.21197, -88.85555**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	0/24			(20') As above.		
				SS	26/24	0 0 0 0	0	(22') As above: no gravel or sand.	22-24 Geotech	
				SS	26/24	0 0 0 0	0	(24') As above.		
25										
				SS	26/24	0 0 0 0	0	(26') As above: infrequent black fine sand seams.		
				SS	26/24	0 0 0 0	0	(28') As above.		
30				SS	26/24	0 0 0 0	0	(30') As above.		
				SS	26/24	0 0 0 0	0	(32') As above.		
				SS	26/24	0 0 0 0	0	(34.3') LEAN SILT (ML); very soft, wet, dark brown (N2). [LOWER ASH]	34-36 Chem	
35										
				SS	24/24	0 0 0 0	0	(36') As above.	36-38 Geotech	
								(37') LEAN CLAY (CL); stiff, moist, tan (10YR 7/8) and gray (N8).		
								(38') End of Boring.		
40										

NOTES: XPW03-(22-24)-20210121: 45.4% moisture content, 2.410 specific gravity, 0.0% gravel, 4.2% sand, 95.8% fines.
XPW03-(36-38)-20210121: 46.5% moisture content, 65.7 pcf dry unit weight, 1.999 specific gravity, 1.8×10^{-7} cm/s vertical hydraulic conductivity, 46 LL, 31 PL, 15 PI, 0.0% gravel,9.4% sand, 90.6% fines.

WELL CONSTRUCTION LOGS

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G03
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Sean Karoly
Project Number: GLP8021
Recorded By: SK

Permit Number:
Installation Date(s): 2/2/21
Drilling Method: HSA
Borehole Diameter: 4.25"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.010 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

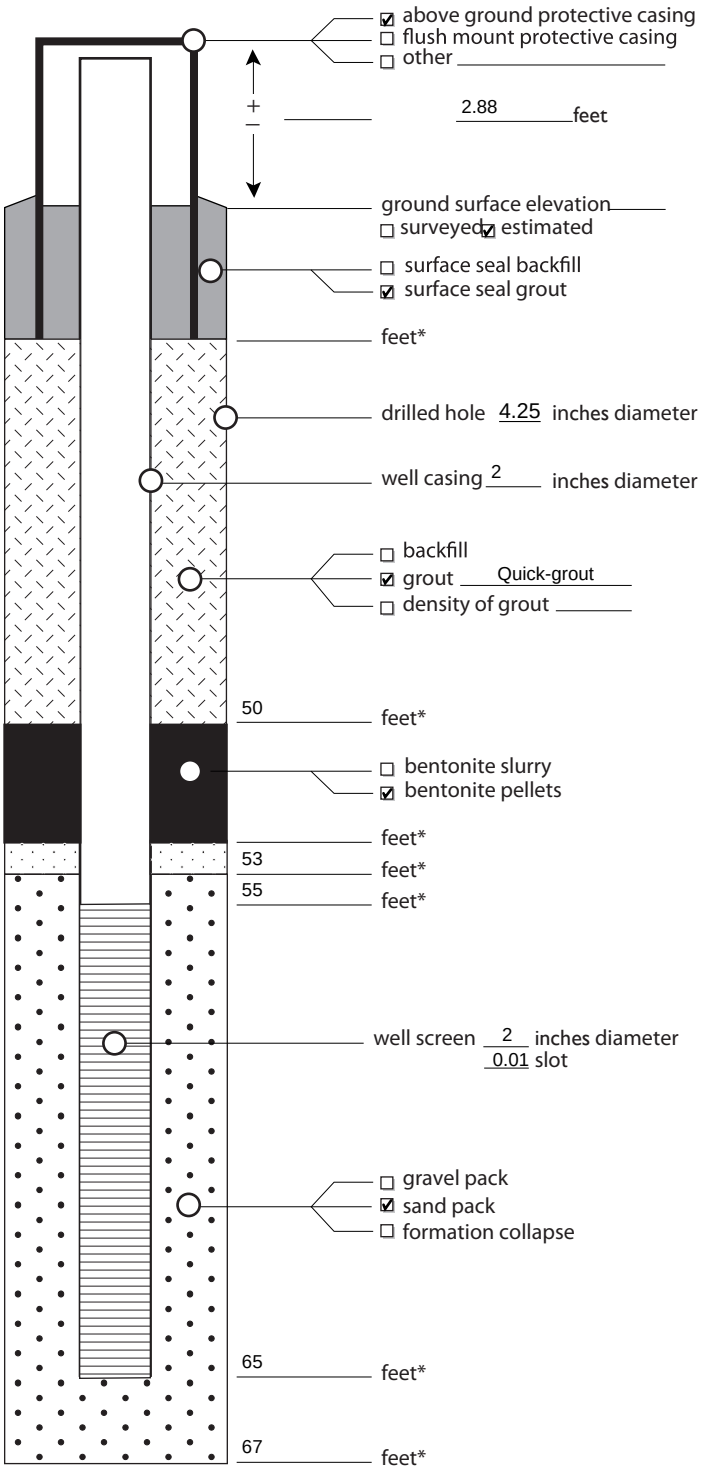
Protective Casing: Length 3.08 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack: Graded Sand
Coarse Sand: 5.5 bags of 50 lb per bag Size
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 1 bucket Type Pel-plug
Bentonite Slurry: bags of lb per bag Type 1/4"

Grout:
Cement: 5 bags of 50 lb per bag Type Quick-grout
Bentonite: bags of lb per bag Type



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G04
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Brian Ares
Project Number: GLP8021
Recorded By: BA

Permit Number:
Installation Date(s): 2/2/21
Drilling Method: HSA
Borehole Diameter: 7.25"
Drilling Contractor: Geotechnology
Driller: Jason Smith
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

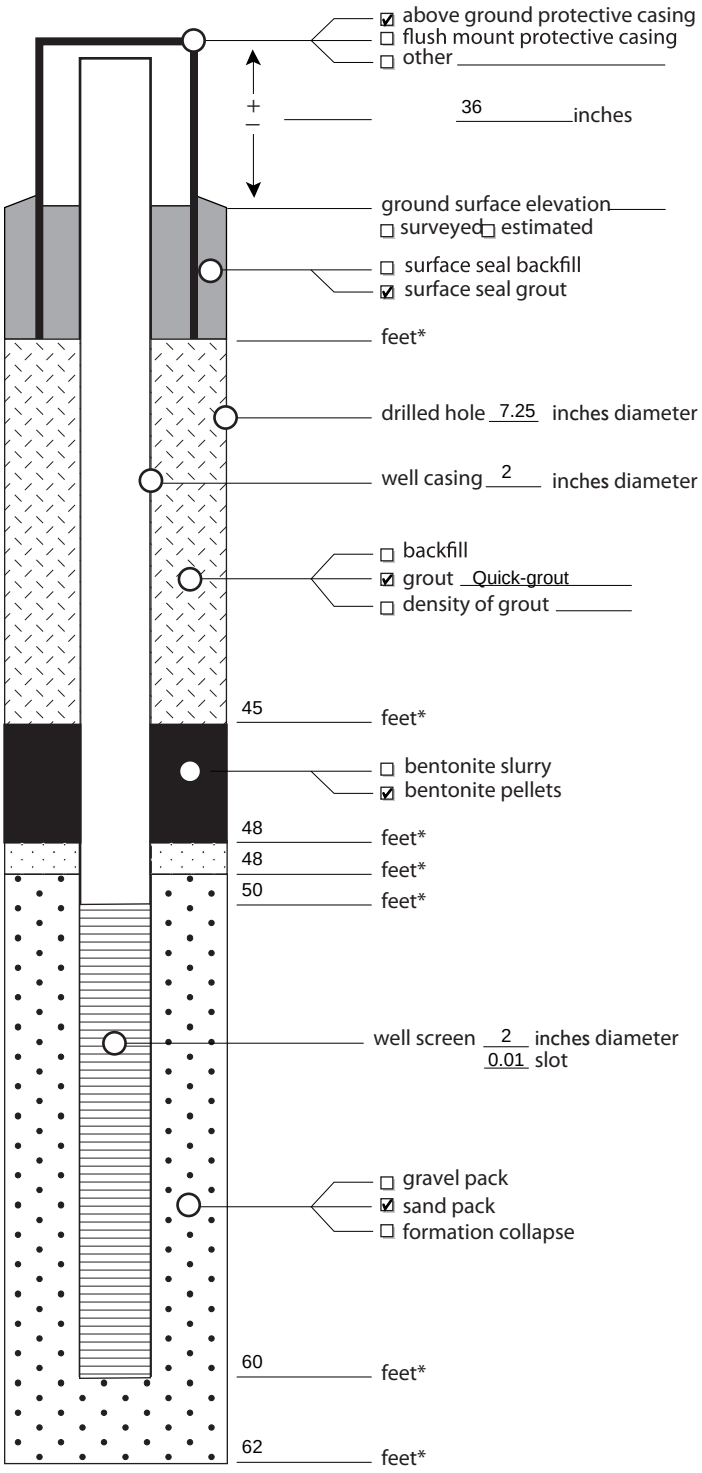
Protective Casing: Length 3 feet
Diameter inches
Construction ☐ Cast Aluminum ☐ Cast Steel ☐ Other

Casing Installation: Length 3 feet
Diameter inches
Material

Sandpack: Mix of coarse and fine sand
Coarse Sand: 4 bags of ___ lb per bag Size
Fine Sand: ___ bags of ___ lb per bag Size

Seal:
Bentonite Pellets: 2 bags of ___ lb per bag Type 3/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type

Grout:
Cement: ___ bags of ___ lb per bag Type 2090: Quik-grout
Bentonite: ___ bags of ___ lb per bag Type 20% solid



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G05
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Brian Ares
Project Number: GLP8021
Recorded By: BA

Permit Number:
Installation Date(s): 2/2/21
Drilling Method: HSA
Borehole Diameter: 7.25"
Drilling Contractor: Geotechnology
Driller: Jason Smith
Drilling Fluid:
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

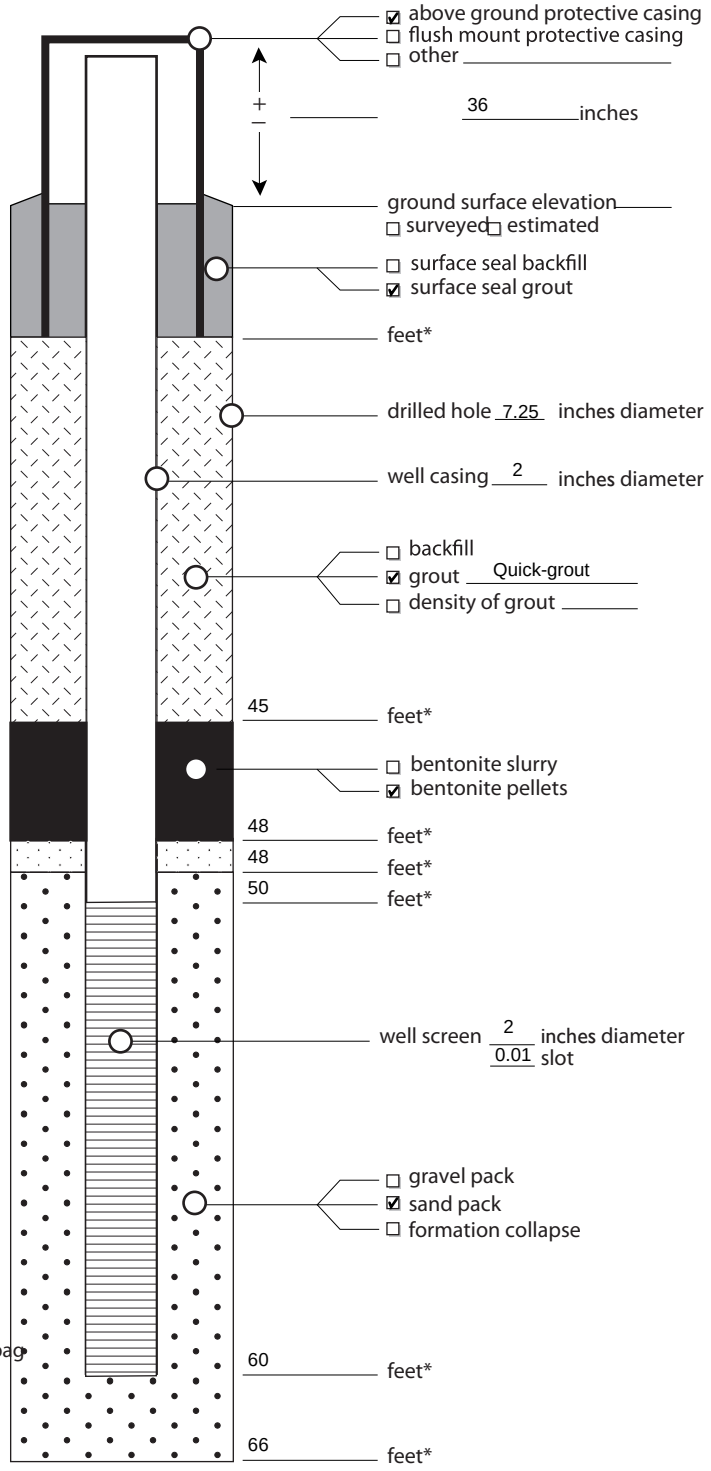
Protective Casing: Length 3 feet
Diameter inches
Construction ☐ Cast Aluminum ☐ Cast Steel ☐ Other

Casing Installation: Length 3 feet
Diameter inches
Material

Sandpack: Mix of coarse and fine sand
Coarse Sand: 5 bags of lb per bag Size bags of lb per bag
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 2.5 bags of lb per bag Type 1/4, 3/8
Bentonite Slurry: Type

Grout:
Cement: 2 bags of lb per bag Type Quick-grout;
Bentonite: bags of lb per bag Type 20% solid



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G06
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Brian Ares
Project Number: GLP8021
Recorded By: BA

Permit Number:
Installation Date(s): 1/31/21
Drilling Method: HSA
Borehole Diameter: 7.25"
Drilling Contractor: Geotechnology
Driller: Jason Smith
Drilling Fluid: Water
Fluid Loss During Drilling: ____ Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

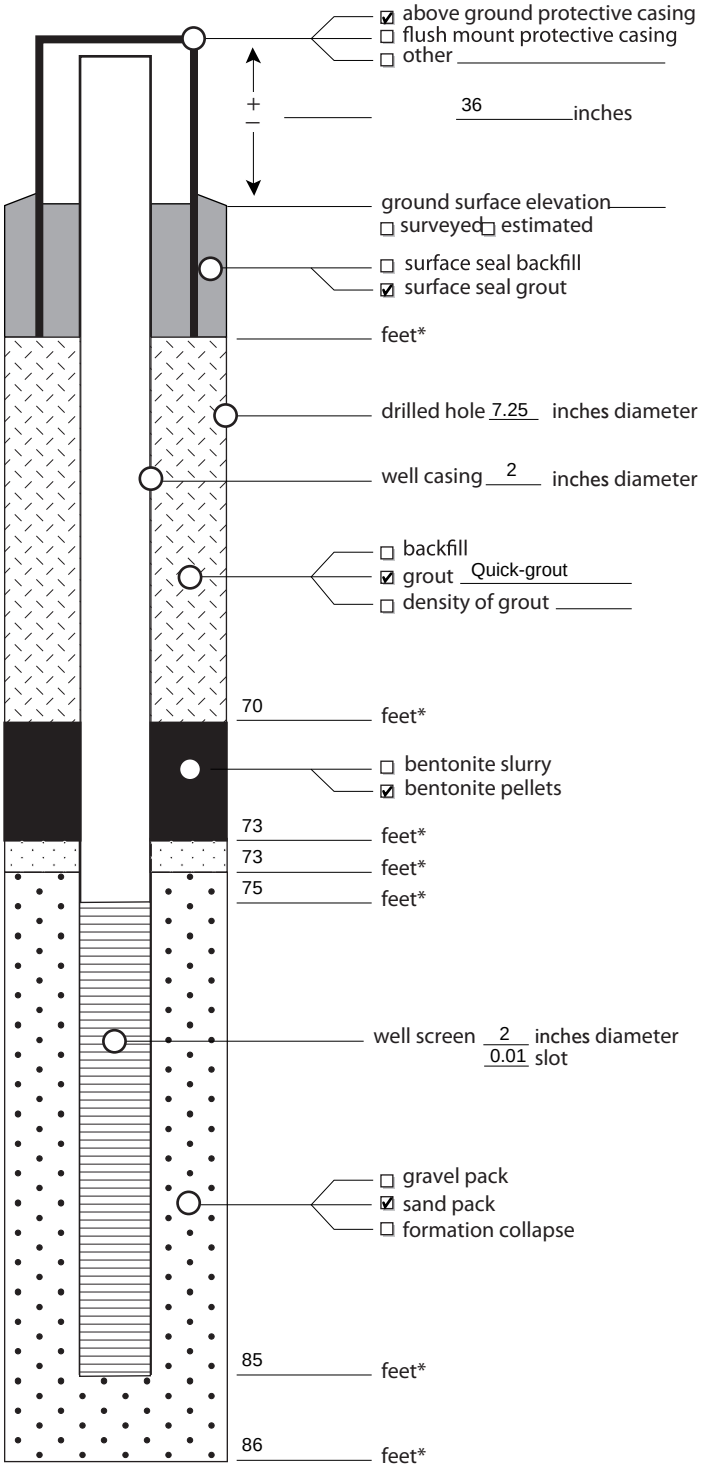
Protective Casing: Length 3 feet
Diameter ____ inches
Construction ☐ Cast Aluminum ☐ Cast Steel ☐ Other

Casing Installation: Length 3 feet
Diameter ____ inches
Material

Sandpack: Mix of Course and Fine Sand
Coarse Sand: 4 bags of ___ lb per bag Size
Fine Sand: ___ bags of ___ lb per bag Size

Seal:
Bentonite Pellets: 12 bags of ___ lb per bag Type
Bentonite Slurry: ___ bags of ___ lb per bag Type

Grout: Quick-grout 2 bags
Cement: ___ bags of ___ lb per bag Type Quik-grout;
Bentonite: ___ bags of ___ lb per bag Type 20% solid



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* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G06S
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Brian Ares
Project Number: GLP8021
Recorded By: BA

Permit Number:
Installation Date(s): 2/1/21
Drilling Method: HSA
Borehole Diameter: 7.25"
Drilling Contractor: Geotechnology
Driller: Jason Smith
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

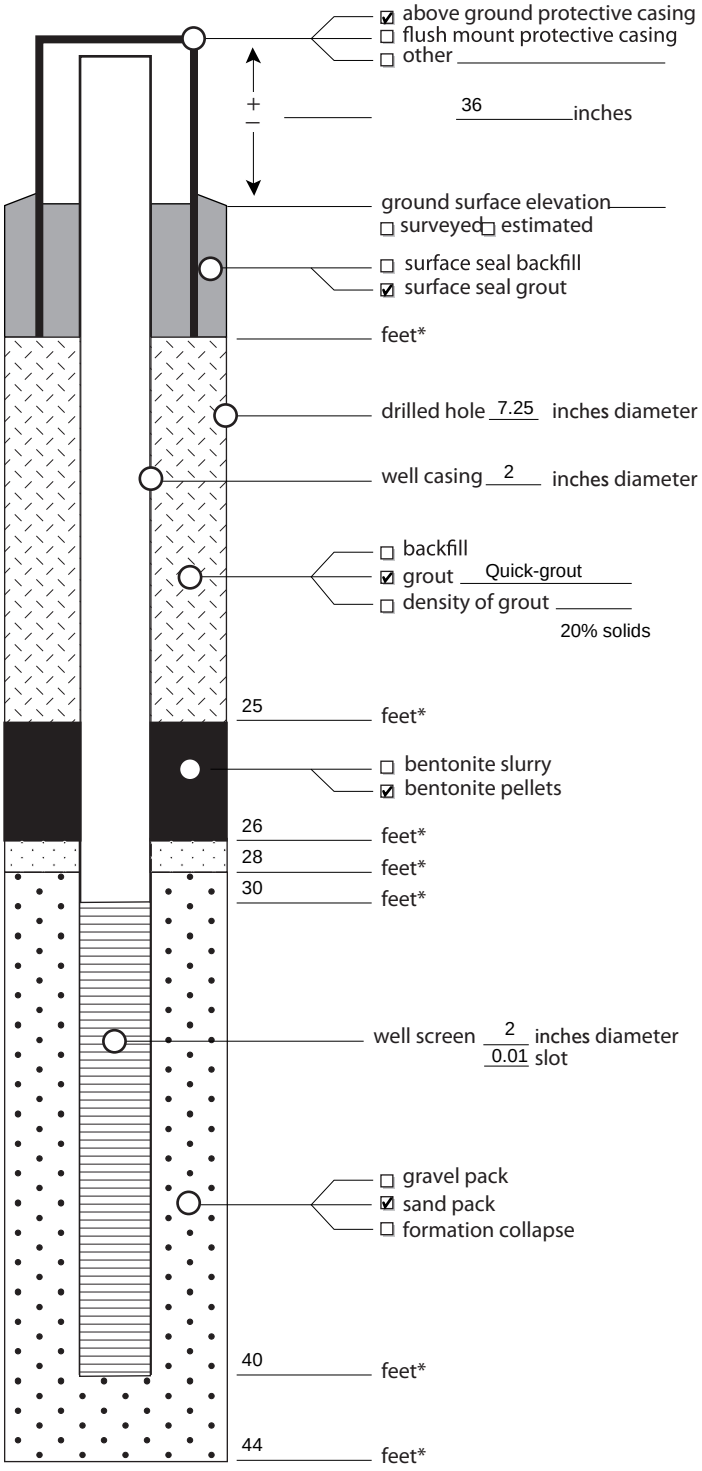
Protective Casing: Length 3 feet
Diameter inches
Construction ☐ Cast Aluminum ☐ Cast Steel ☐ Other

Casing Installation: Length 3 feet
Diameter inches
Material

Sandpack: Mix of Course and Fine Sand
Coarse Sand: 4 bags of ___ lb per bag Size
Fine Sand: ___ bags of ___ lb per bag Size

Seal:
Bentonite Pellets: 1 bags of 2 lb per bag Type 3/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type

Grout: Quick-grout
Cement: 2 bags of ___ lb per bag Type Quik-grout;
Bentonite: ___ bags of ___ lb per bag Type 20% solid



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MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G07
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Brian Ares
Project Number: GLP8021
Recorded By: BA

Permit Number:
Installation Date(s): 1/29/21
Drilling Method: HSA
Borehole Diameter: 7.25"
Drilling Contractor: Geotechnology
Driller: Jason Smith
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☑ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

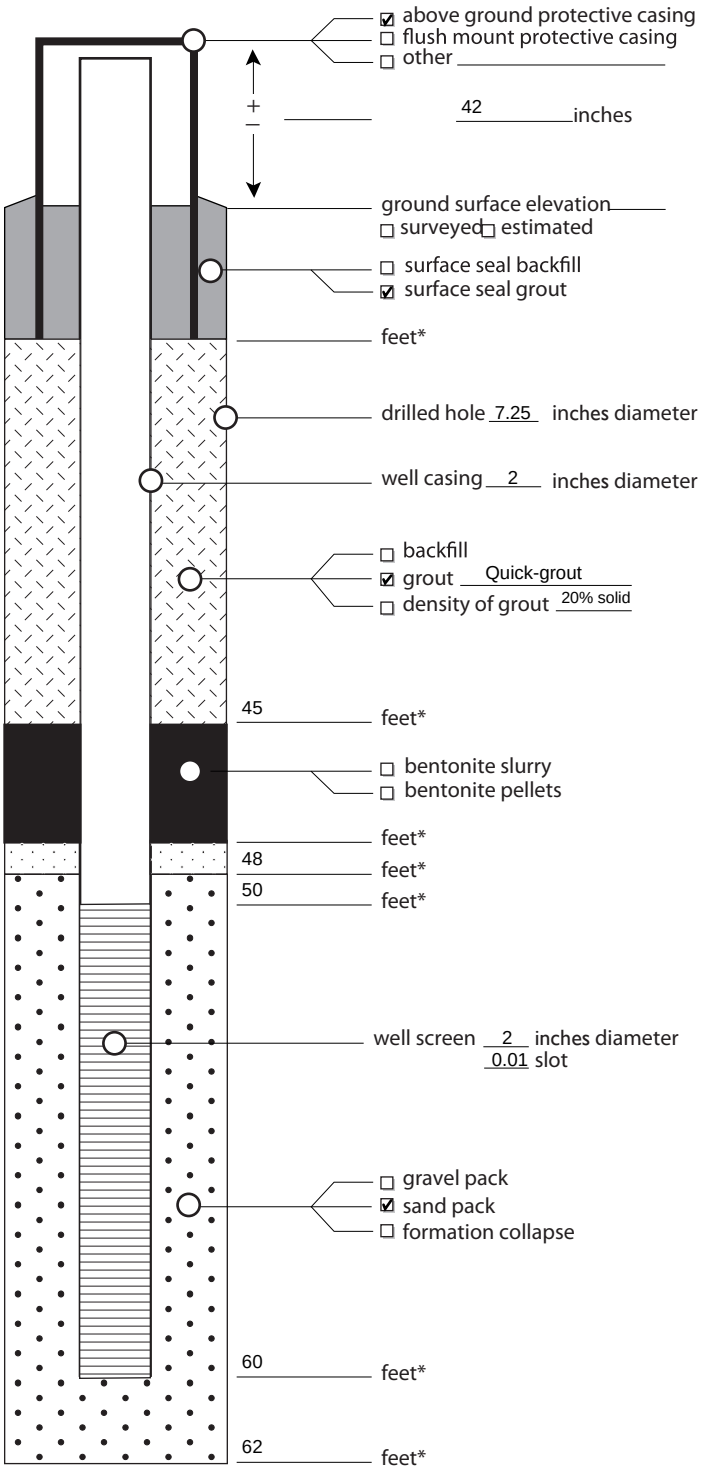
Protective Casing: Length 44 feet
Diameter inches
Construction ☐ Cast Aluminum ☐ Cast Steel ☐ Other

Casing Installation: Length 44 feet
Diameter inches
Material

Sandpack: Mix of Course and Fine Sand
Coarse Sand: 4 bags of ___ lb per bag Size
Fine Sand: ___ bags of ___ lb per bag Size

Seal:
Bentonite Pellets: 2 bags of ___ lb per bag Type Chips
Bentonite Slurry: ___ bags of ___ lb per bag Type

Grout: Quick-grout
Cement: ___ bags of ___ lb per bag Type Quik-grout;
Bentonite: ___ bags of ___ lb per bag Type 20% solid



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MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G08
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Brian Ares
Project Number: GLP8021
Recorded By: BA

Permit Number:
Installation Date(s): 1/28/21
Drilling Method: HSA
Borehole Diameter: 7.25"
Drilling Contractor: Geotechnology
Driller: Jason Smith
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☑ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

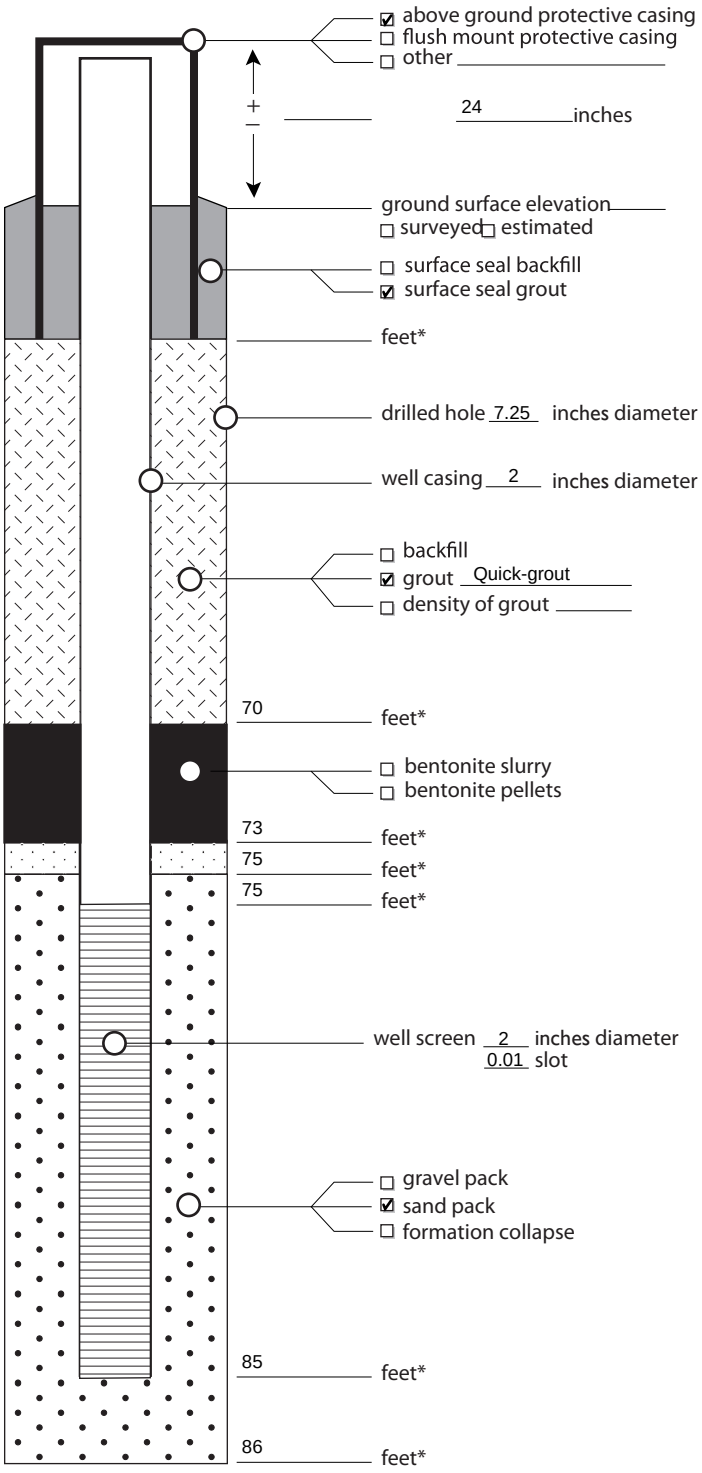
Protective Casing: Length 2 feet
Diameter inches
Construction ☐ Cast Aluminum ☐ Cast Steel ☐ Other

Casing Installation: Length 2 feet
Diameter inches
Material

Sandpack: Mix of Course and Fine Sand
Coarse Sand: bags of lb per bag Size
Fine Sand: 4 bags of lb per bag Size

Seal:
Bentonite Pellets: 1 bags of lb per bag Type Chips
Bentonite Slurry: bags of lb per bag Type 3/8"

Grout:
Cement: bags of lb per bag Type Quik-grout;
Bentonite: bags of lb per bag Type 20% solid



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MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G09
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Sean Karoly
Project Number: GLP8021
Recorded By: SK

Permit Number:
Installation Date(s): 1/31/21
Drilling Method: HSA
Borehole Diameter: 4.25"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

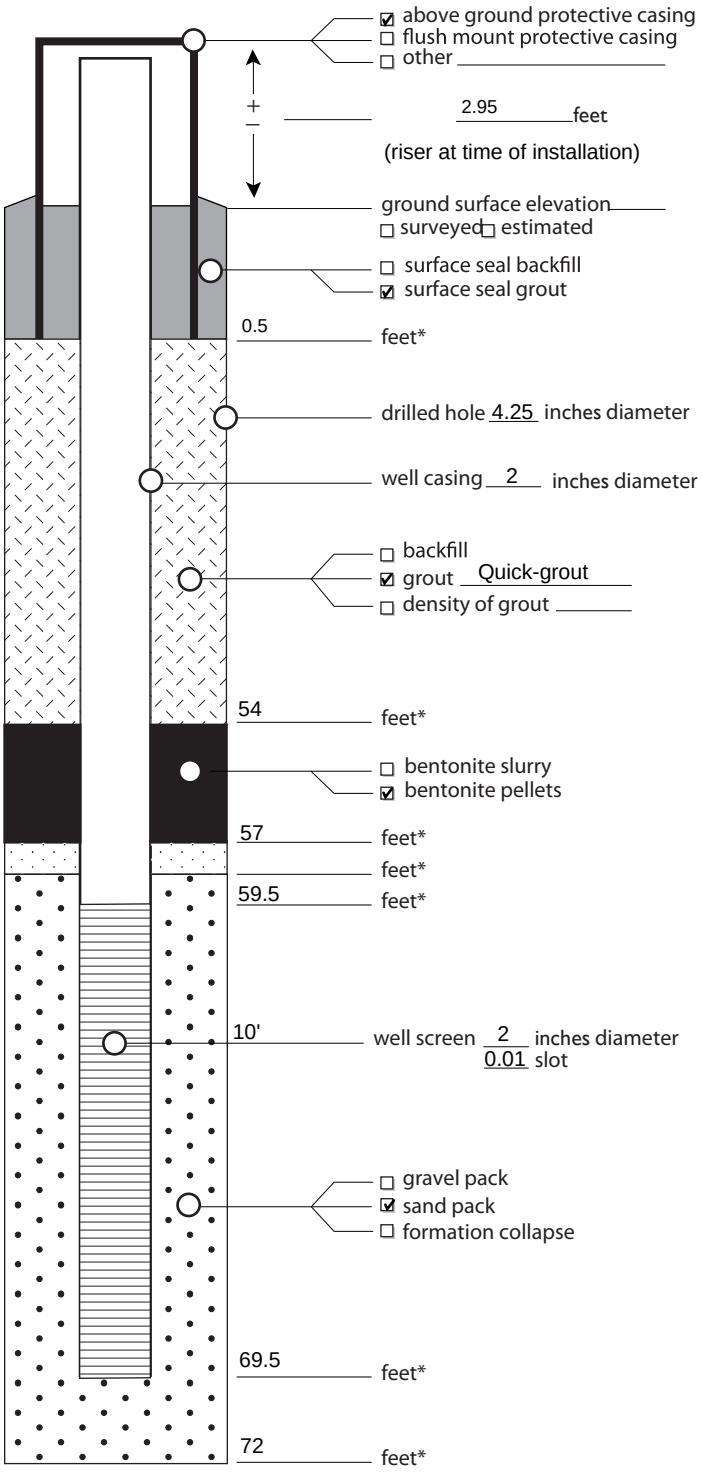
Protective Casing: Length 2.75 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack:
Coarse Sand: 5.5 bags of 50 lb per bag Size graded
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 1 bucket of 50 lb per bucket Type Pel-plug
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 5 bags of 50 lb per bag Type Quick-grout
Bentonite: bags of lb per bag Type



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MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G09M
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Sean Karoly, Amanda Toye
Project Number: GLP8021
Recorded By: SK

Permit Number:
Installation Date(s): 1/29/21-1/31/21
Drilling Method: HSA / Mud Rotary
Borehole Diameter: 4.25"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 80
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 80
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip 4"
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☑ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

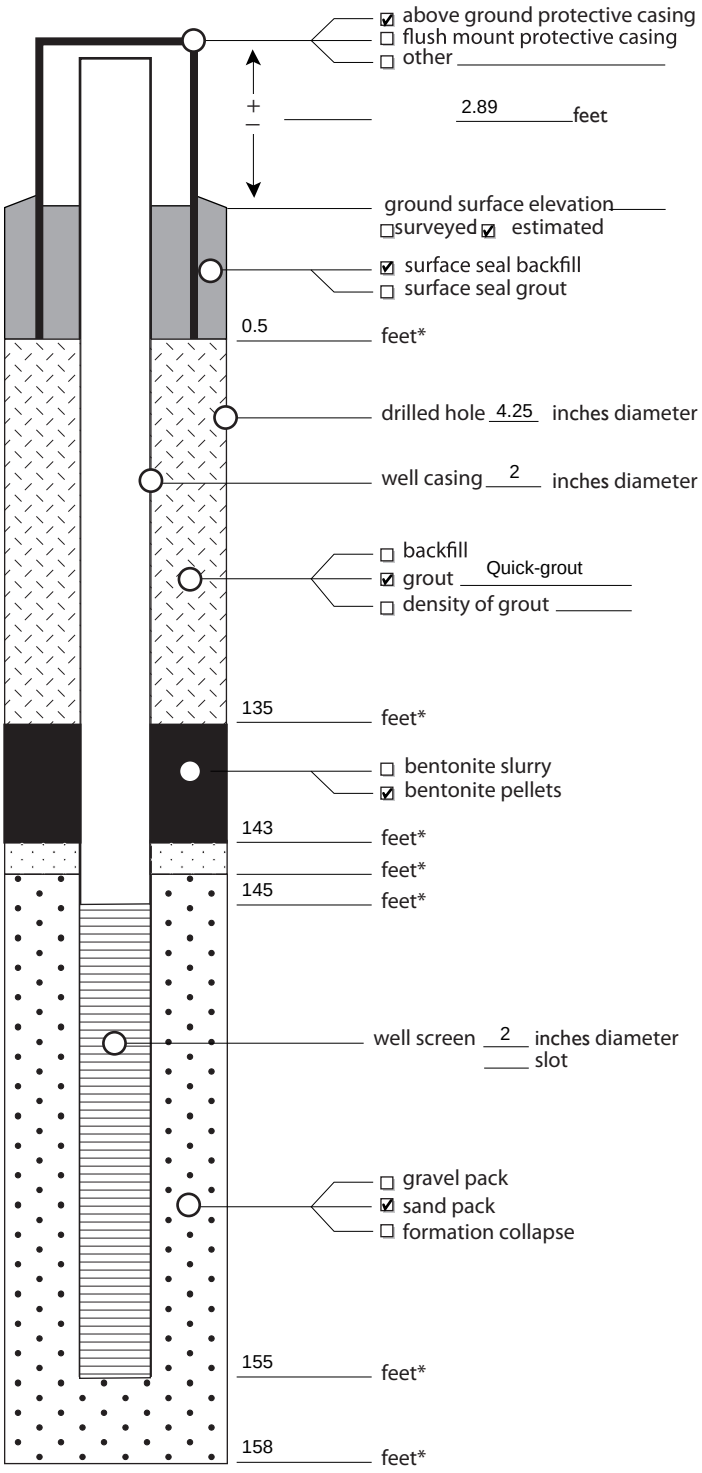
Protective Casing: Length 2.75 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack:
Coarse Sand: 1.5 bags of 50 lb per bag Size graded
Fine Sand: bags of lb per bag Size

Seal: (bucket)
Bentonite Pellets: 1 bags of 50 lb per bag Type Pel-plug
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 6 bags of 50 lb per bag Type Quick-grout
Bentonite: bags of lb per bag Type



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* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G10
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Sean Karoly
Project Number: GLP8021
Recorded By: SK

Permit Number:
Installation Date(s): 2/1/21
Drilling Method: HSA
Borehole Diameter: 4.25"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☐ PVC schedule 40
☐ Stainless Steel
☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
☐ PVC
☐ Stainless Steel
☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other

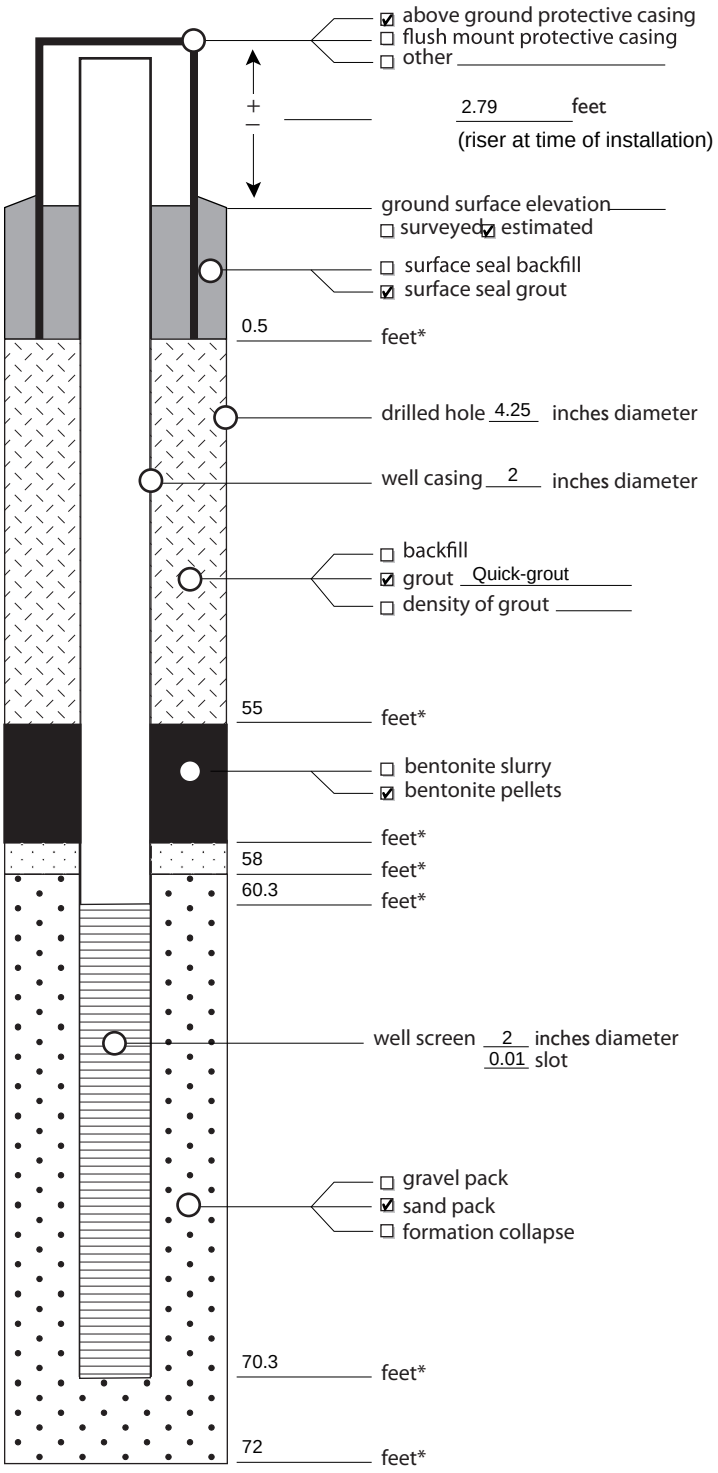
Protective Casing: Length 2.67 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack:
Coarse Sand: 6 bags of 50 lb per bag Size graded
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 1 (bucket) bags of 50 lb per bag Type Pel-plug
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 5 bags of 50 lb per bag Type Quick-grout
Bentonite: bags of lb per bag Type



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* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G11
Project Name: Vistra - Joppa Power Station
Project Number: GLP8021
Site Location: Joppa, IL
Field Personnel: Zachary Fallert and Amanda Toye
Recorded By: Z. Fallert

Permit Number:
Installation Date(s): 1/19/21
Drilling Method: HSA
Borehole Diameter: 7.5"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other

Top Cap: ☑ Male ☐ Female ☐ Slip ☐ J Plug
☐ PVC
☐ Stainless Steel
☐ Other

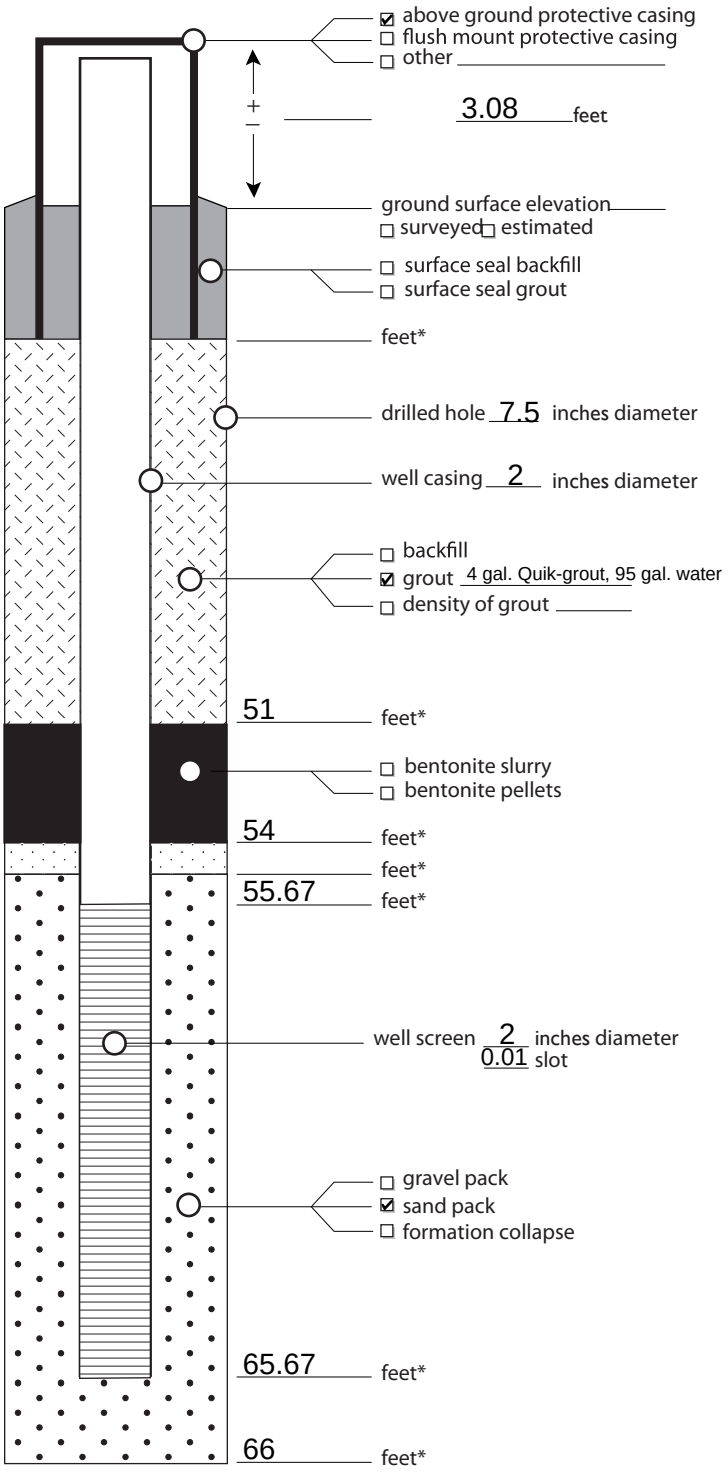
Protective Casing: Length 3.08 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack:
Coarse Sand: 5 bags of Filter Sil lb per bag 50 Size
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 1 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 4 bags of 50 lb per bag Type Quik-grout
Bentonite: bags of lb per bag Type



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MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G54S
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Zachary Fallert and Amanda Toye
Project Number: GLP8021
Recorded By: Z. Fallert

Permit Number:
Installation Date(s): 1/22/21
Drilling Method: HSA
Borehole Diameter: 7.5"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other

Top Cap: ☑ Male ☐ Female ☐ Slip ☐ J Plug
☐ PVC
☐ Stainless Steel
☐ Other

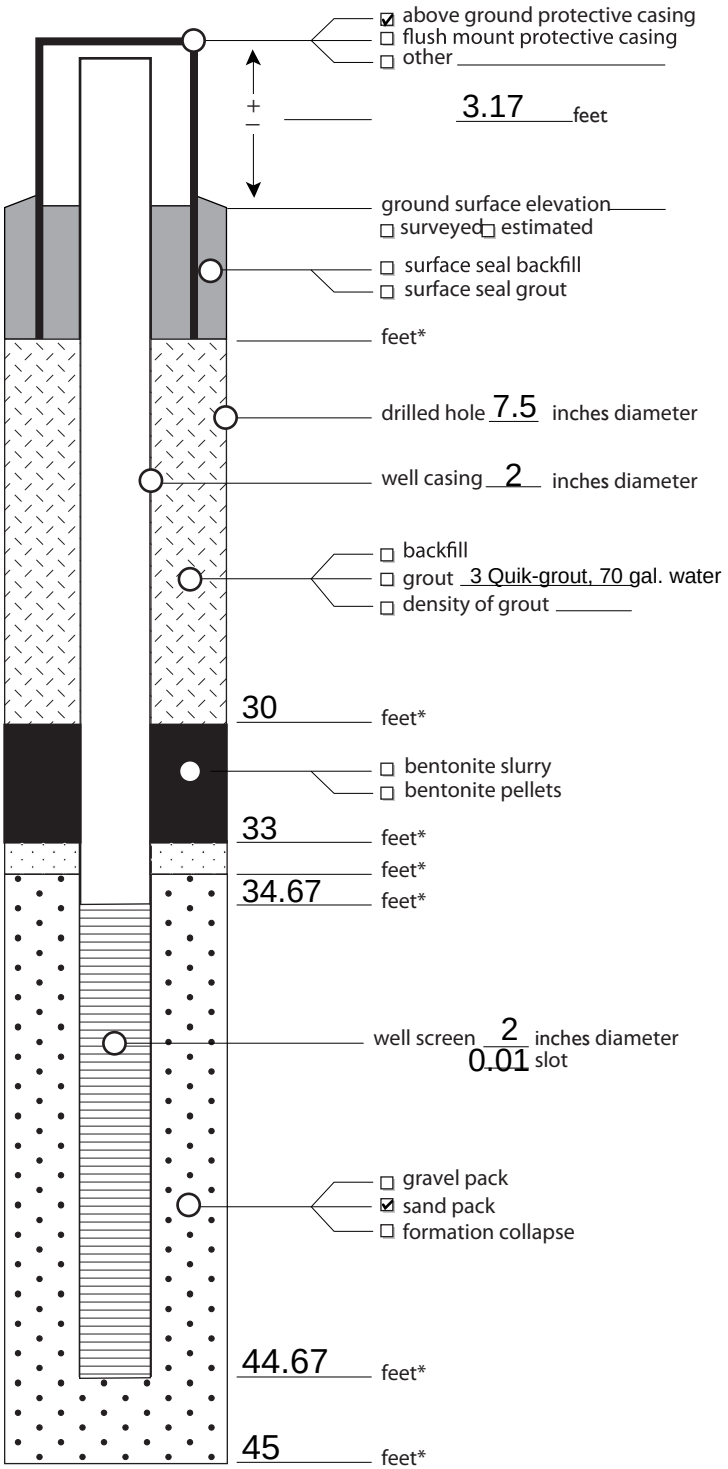
Protective Casing: Length 3.17 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack:
Coarse Sand: 6 bags of Filter Sil lb per bag 50 Size
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 1 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 3 bags of 50 lb per bag Type Quik-grout
Bentonite: bags of lb per bag Type



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* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: XPW-01
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Zachary Fallert and Amanda Toye
Project Number: GLP8021
Recorded By: Z. Fallert

Permit Number:
Installation Date(s): 1/20/21
Drilling Method: HSA
Borehole Diameter: 7.5"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other

Slotted Area: Length 5 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other

Top Cap: ☑ Male ☐ Female ☐ Slip ☐ J Plug
☐ PVC
☐ Stainless Steel
☐ Other

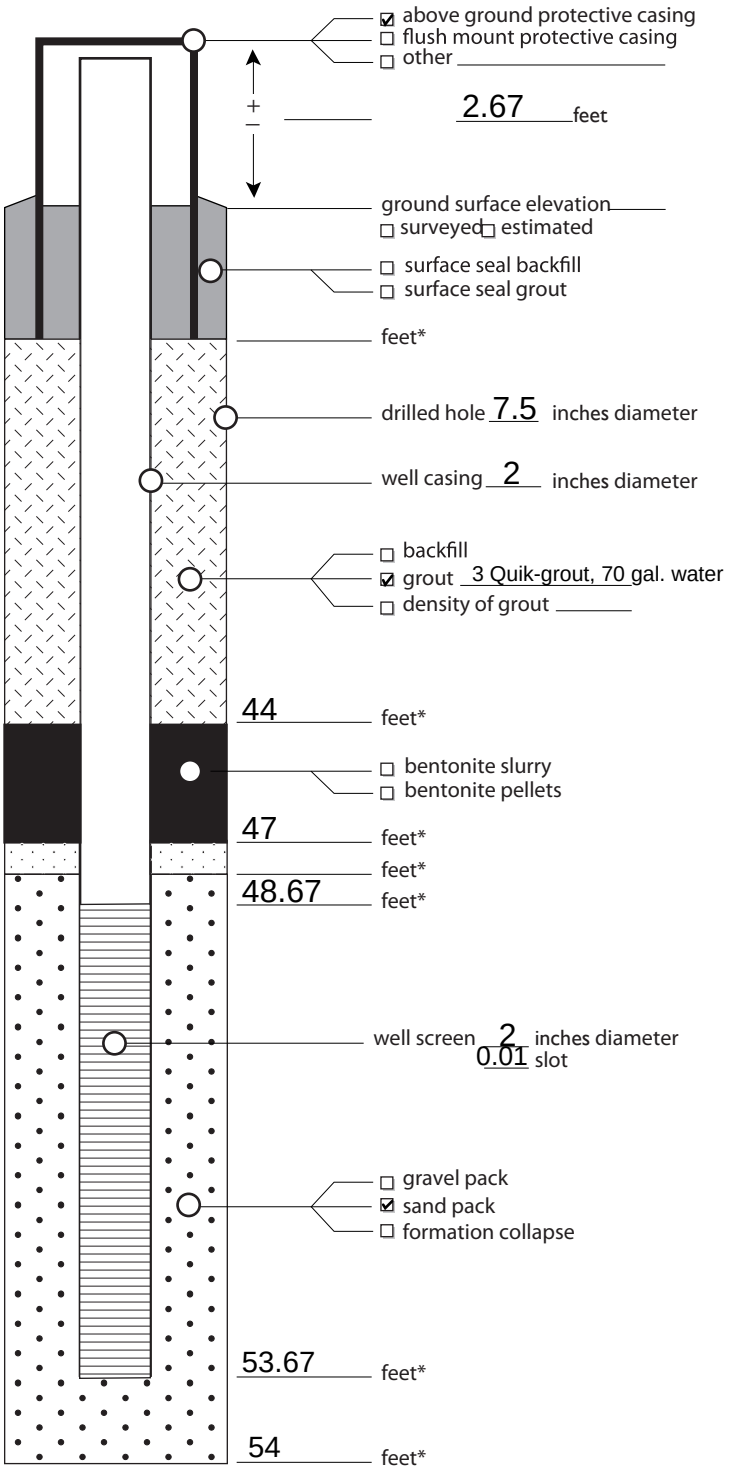
Protective Casing: Length 2.67 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack:
Coarse Sand: 4 bags of Filter Sil lb per bag 50 Size
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 1 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 3 bags of 50 lb per bag Type Quik-grout
Bentonite: bags of lb per bag Type



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* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: XPW-02
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Zachary Fallert and Amanda Toye
Project Number: GLP8021
Recorded By: Z. Fallert

Permit Number:
Installation Date(s): 1/21/21
Drilling Method: HSA
Borehole Diameter: 7.5"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 5 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☑ Male ☐ Female ☐ Slip ☐ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

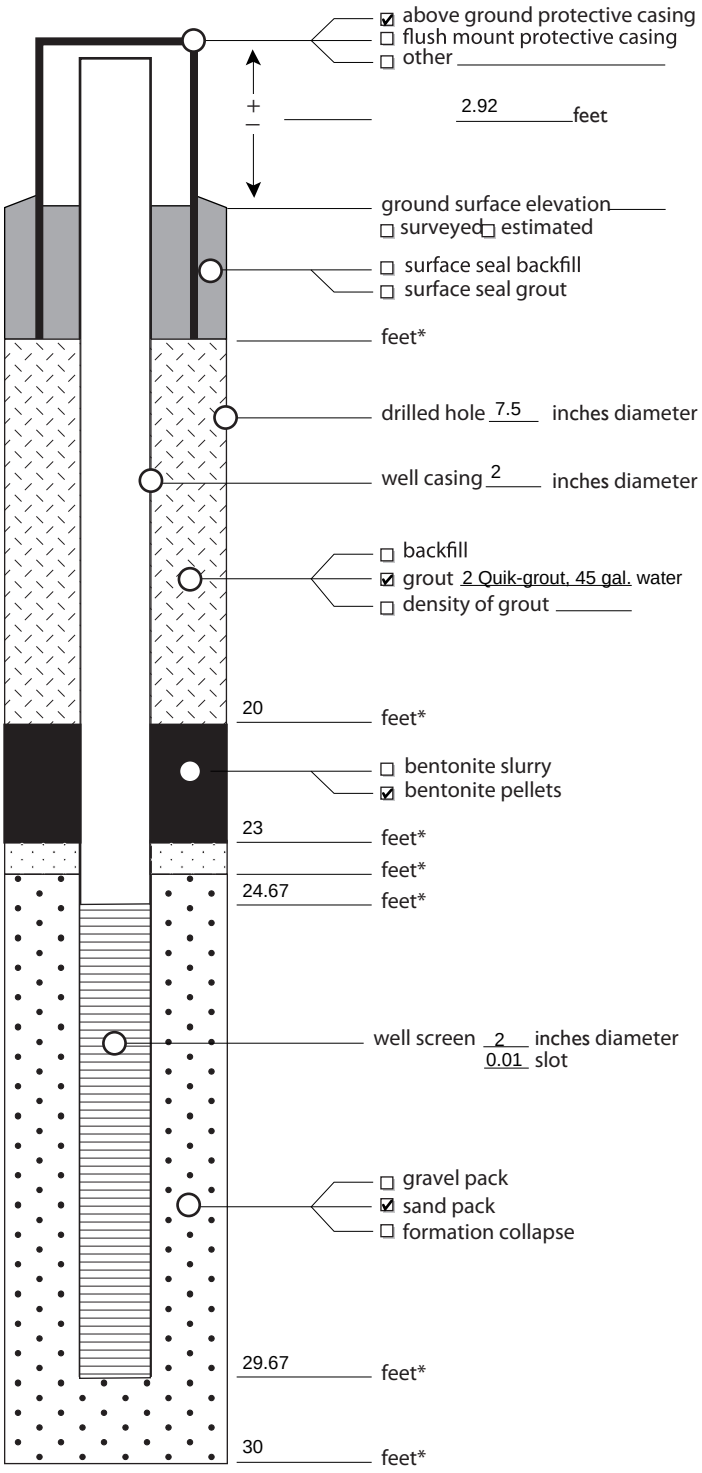
Protective Casing: Length 2.92 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack:
Coarse Sand: 3.5 bags of Filter Sil lb per bag 50 Size
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 1 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 2 bags of 50 lb per bag Type Quik-grout
Bentonite: bags of lb per bag Type



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MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: XPW-03
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: Zachary Fallert and Amanda Toye
Project Number: GLP8021
Recorded By: Z. Fallert

Permit Number:
Installation Date(s): 1/21/21
Drilling Method: HSA
Borehole Diameter: 7.5"
Drilling Contractor: Geotechnology
Driller: Patrick Hart
Drilling Fluid: N/A
Fluid Loss During Drilling: - Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Slotted Area: Length 5 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other

Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☑ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other

Top Cap: ☑ Male ☐ Female ☐ Slip ☐ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other

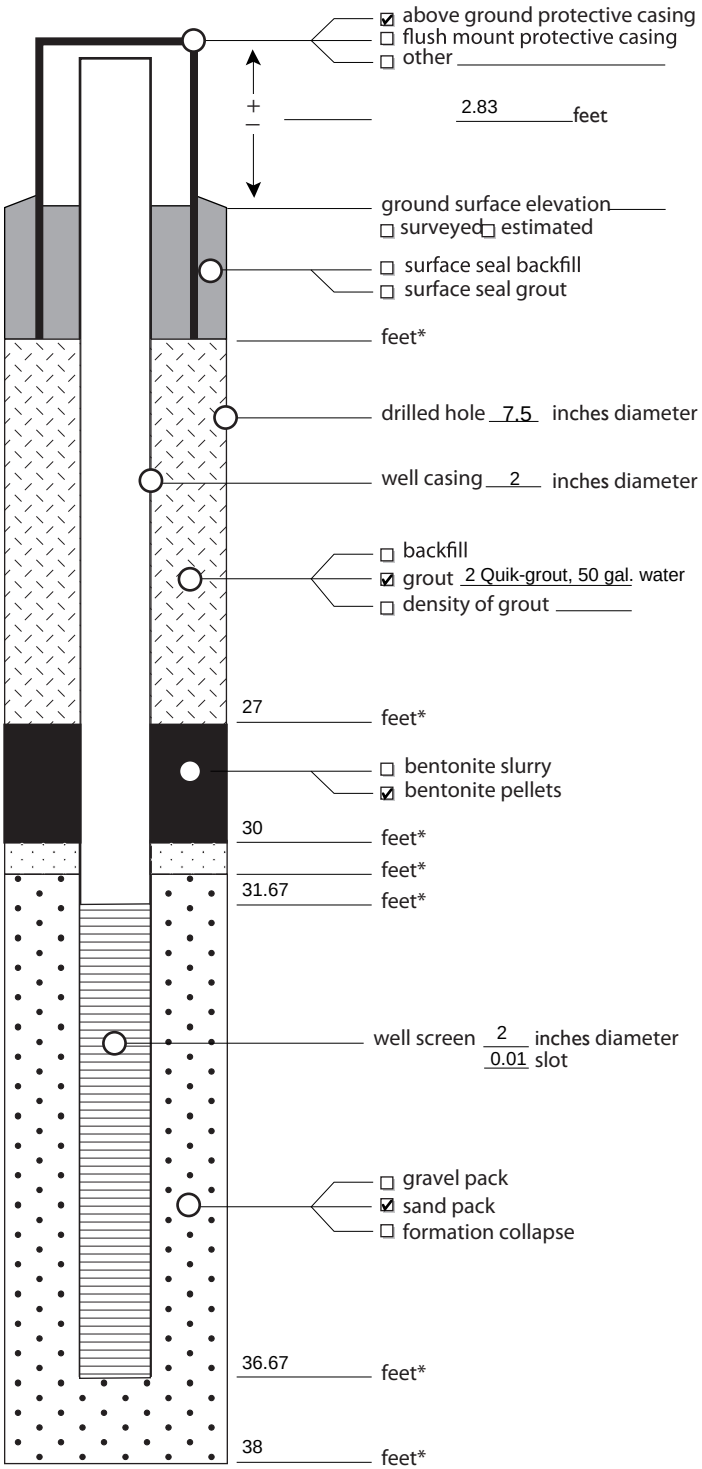
Protective Casing: Length 2.83 feet
Diameter inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other

Casing Installation: Length feet
Diameter inches
Material

Sandpack:
Coarse Sand: 4.5 bags of Filter Sil lb per bag 50 Size
Fine Sand: bags of lb per bag Size

Seal:
Bentonite Pellets: 1 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: bags of lb per bag Type

Grout:
Cement: 2 bags of 50 lb per bag Type Quik-grout
Bentonite: bags of lb per bag Type



Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

HANSON BORING LOGS AND WELL CONSTRUCTION LOGS

BORING LOGS

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/14/2015
Finish: 8/14/2015
WEATHER: Partly cloudy, calm, warm, mid-70s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler

FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G01D
Well ID: G01D
Surface Elev: 361.50 ft. MSL
Completion: 64.38 ft. BGS
Station: 202,039.30N
831,716.11E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 54.00 - During Drilling
▼ = 45.77 - 8/14/15
▽ =

SAMPLE			TESTING						
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	0/60 *0%*	BD					2	Blind drill - see G101 boring log		360	
	0/60 *0%*	BD					4			358	
							6			356	
							8			354	
	0/60 *0%*	BD					10			352	
							12			350	
							14			348	
	0/60 *0%*	BD					16			346	
							18			344	
							20			342	

NOTE(S): G01D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/14/2015
Finish: 8/14/2015
WEATHER: Partly cloudy, calm, warm, mid-70s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler

FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G01D
Well ID: G01D
Surface Elev: 361.50 ft. MSL
Completion: 64.38 ft. BGS
Station: 202,039.30N
831,716.11E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 54.00 - During Drilling
▼ = 45.77 - 8/14/15
▽ =

SAMPLE			TESTING					
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description
	0/60 *0%*	BD					22	
							24	
	0/60 *0%*	BD					26	
							28	
	0/60 *0%*	BD					30	Blind drill - see G101 boring log *[Continued from previous page]*
							32	
	0/60 *0%*	BD					34	
							36	
							38	
							40	

Borehole Detail

Elevation ft. MSL	Remarks
340	
338	
336	
334	
332	
330	
328	
326	
324	
322	

NOTE(S): G01D installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/14/2015
Finish: 8/14/2015
WEATHER: Partly cloudy, calm, warm, mid-70s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G01D
Well ID: G01D
Surface Elev: 361.50 ft. MSL
Completion: 64.38 ft. BGS
Station: 202,039.30N
831,716.11E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 54.00 - During Drilling
▼ = 45.77 - 8/14/15
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	0/48 *0%*	BD					42	Blind drill - see G101 boring log *[Continued from previous page]*		320	
9A	24/24 *100%*	SS	*5-13* *6-5* N=19	13		*1.00*	44	Strong brown (7.5YR5/6), moist, medium dense, silty, very fine- to coarse-grained SAND with trace small gravel.		318	
9B				20			▼ 46			316	
10A	22/24 *92%*	SS	*2-3* *3-4* N=6	20		*1.50*		Gray (10YR6/1) with 40% yellowish brown (10YR5/6) mottles, moist, stiff, SILT, few to little clay, trace fine- to medium-grained sand.		314	
11A	24/24 *100%*	SS	*1-2* *3-3* N=5	21		*0.80*	48			312	
12A	19/24 *79%*	SS	*1-1* *2-4* N=3	20		*0.50*	50	Gray (10YR6/1) with 30% yellowish brown (10YR5/6) mottles, moist, medium, silty CLAY, few fine- to medium-grained sand.		310	
13A	24/24 *100%*	SS	*woh-1* *2-3* N=3	19		*0.50*	52	Gray (10YR6/1) with 25% yellowish brown (10YR5/6) mottles, moist, medium, CLAY with few very fine- to fine-grained sand and trace silt.		308	
14A	19/24 *79%*	SS	*14-18* *20-24* N=38	14			▼ 54	Light yellowish brown (10YR6/4), moist, dense, silty, very fine- to fine-grained SAND.		306	
15A	16/24 *67%*	SS	*woh-woh* *5-13*	23			56	Light yellowish brown (10YR6/4), wet, dense, silty, very fine- to fine-grained SAND.		304	
16A	20/24 *83%*	SS	*4-21* *25-21* N=46	18			58			302	
							60	Gray (10YR6/1), wet, dense, silty, very fine- to coarse-grained SAND.			

NOTE(S): G01D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/14/2015
Finish: 8/14/2015
WEATHER: Partly cloudy, calm, warm, mid-70s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G01D
Well ID: G01D
Surface Elev: 361.50 ft. MSL
Completion: 64.38 ft. BGS
Station: 202,039.30N
831,716.11E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 54.00 - During Drilling
▼ = 45.77 - 8/14/15
▽ =

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
17A	23/24 *96%*	SS	*7-15 32-37* N=47	19				Gray (10YR6/1), wet, dense, silty, very fine- to coarse-grained SAND. *[Continued from previous page]*			
							62			300	
18A	15/18 *83%*	SS	*8-25 50/6"*	17				Light brownish gray (10YR6/2), wet, dense, silty, very fine- to coarse-grained SAND with trace small gravel.			
	0/11 *0%*	BD								298	
							64				

End of boring = 64.38 feet

NOTE(S): G01D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/12/2015
Finish: 8/13/2015
WEATHER: Sunny, warm, calm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G02D
Well ID: G02D
Surface Elev: 360.82 ft. MSL
Completion: 72.36 ft. BGS
Station: 202,137.08N
832,842.99E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 43.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
1A	20/24 83%	ss	1-1 2-3 N=3	24		2.00	0	Grayish brown (10YR5/2), moist, soft, SILT with few clay, trace very fine- to medium-grained sand, wood fragments, and roots.		360	
2A	24/24 100%	ss	1-3 5-5 N=8	23		2.50	2	Brown (10YR5/3) with 40% yellowish brown (10YR5/6) mottles, moist, stiff, SILT with few clay, trace very fine-grained sand and roots.		358	
3A	24/24 100%	ss	1-3 5-5 N=8	20		2.00	4			356	
4A	19/24 79%	ss	1-4 4-6 N=8	21		2.30	6	Brown (10YR5/3) with 40% yellowish brown (10YR5/6) and 10% gray (10YR6/1) mottles, moist, stiff, SILT with few clay, trace very fine-grained sand.		354	
5A	24/24 100%	ss	1-4 5-6 N=9	20		3.00	8			352	
6A	20/24 83%	ss	1-2 5-6 N=7	20		2.50	10	Gray (10YR6/1) with 30% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with few clay and trace very fine- to fine-grained sand.		350	
7A	22/24 92%	ss	1-5 7-11 N=12	18		3.00	12			348	
8A	19/24 79%	ss	2-9 13-18 N=22	15		4.50	14	Yellowish brown (10YR5/8) with 35% grayish brown (10YR5/2) mottles, moist, hard, SILT with few clay and trace very fine- to medium-grained sand.		346	
9A	24/24 100%	ss	4-8 11-15 N=19	17		3.00	16			344	
10A	18/24 75%	ss	1-7 10-14 N=17	16		3.50	18	Gray (10YR6/1) with 30% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with few clay and trace very fine- to fine-grained sand.		342	
							20				

NOTE(S): G02D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/12/2015
Finish: 8/13/2015
WEATHER: Sunny, warm, calm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G02D
Well ID: G02D
Surface Elev: 360.82 ft. MSL
Completion: 72.36 ft. BGS
Station: 202,137.08N
832,842.99E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 43.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
11A	21/24 88%	ss	2-8 12-17 N=20	15		4.00					
12A	22/24 92%	ss	4-9 12-13 N=21	16		4.00	22			340	
13A	24/24 100%	ss	3-8 11-11 N=19	17		3.00	24	Gray (10YR6/1) with 30% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with few clay and trace very fine- to fine-grained sand. *[Continued from previous page]*		338	
14A	20/24 83%	ss	2-6 8-9 N=14	16		2.50	26			336	
15A	22/24 92%	ss	1-5 7-8 N=12	19		3.30	28			334	
16A	24/24 100%	ss	1-6 8-9 N=14	17		2.30	30	Gray (10YR6/1) with 30% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with little clay and trace very fine- to fine-grained sand.		332	
17A	23/23 100%	ss	2-7 40-50/5" N=47	16		2.80	32	Yellowish brown (10YR5/4) with 10% gray (10YR6/1) mottles, moist, very stiff, SILT with few clay and very fine- to fine-grained sand, trace small gravel.		330	
18A	18/24 75%	ss	8-25 43-19 N=68	11			34	Strong brown (7.5YR4/6), moist, very stiff, SILT with little very fine- to coarse-grained sand and small to large gravel.		328	
19A	24/24 100%	ss	1-3 4-30 N=7	22		0.80	36	Strong brown (7.5YR4/6), moist, very dense, silty, very fine- to coarse-grained SAND with little small to large gravel.		326	
20A	12/16 75%	ss	6-35 50/4"	13			38	Yellowish brown (10YR5/4) with 10% gray (10YR6/1) mottles, moist, medium, silty CLAY with few fine- to medium-grained sand, trace gravel.		324	
							40	Strong brown (7.5YR4/6) moist, hard, SILT with little very fine- to coarse-grained sand and little small to large gravel.		322	

NOTE(S): G02D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/12/2015
Finish: 8/13/2015
WEATHER: Sunny, warm, calm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G02D
Well ID: G02D
Surface Elev: 360.82 ft. MSL
Completion: 72.36 ft. BGS
Station: 202,137.08N
832,842.99E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 43.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) / % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
21A	9/9 100%	ss	39-50/3"	11				Strong brown (7.5YR4/6) moist, hard, SILT with little very fine- to coarse-grained sand and little small to large gravel. *[Continued from previous page]*		320	
							42				
22A	8/24 33%	ss	5-14 17-8 N=31	15			▼	Brownish yellow (10YR6/6), moist, dense, silty, fine-grained SAND with trace medium- to coarse-grained sand.		318	
							44				
23A	24/24 100%	ss	1-2 3-4 N=5	22		0.50		Brownish yellow (10YR6/6), moist, medium, silty CLAY with few very fine- to medium-grained sand.		316	
							46				
24A	18/24 75%	ss	woh-woh 4-7	18		0.50		Brownish yellow (10YR6/6), moist, soft, CLAY with some very fine- to medium-grained sand and trace coarse-grained sand and trace small gravel.		314	
							48				
25A	20/24 83%	ss	1-2 6-5 N=8	18		0.80		Brownish yellow (10YR6/6), moist, medium, CLAY with some very fine- to medium-grained sand and trace coarse-grained sand and trace small gravel.		312	
							50				
26A	17/24 71%	ss	2-5 5-8 N=10	23		2.50		Gray (10YR6/1) with 40% yellowish brown (10YR5/6) mottles, moist, stiff, silty CLAY with few fine-grained sand.		310	
							52				
27A	22/24 92%	ss	1-3 3-5 N=6	18		1.50				308	
							54				
28A	24/24 100%	ss	woh-3 3-4 N=6	17		1.00		Gray (10YR6/1), moist, medium, CLAY with some fine-grained sand and few silt.		306	
							56				
29A	24/24 100%	ss	woh-4 5-5 N=9	22		3.00		Gray (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with few clay, trace fine-grained sand.		304	
							58				
30A	20/24 83%	ss	2-4 6-6 N=10	19		2.00				302	
							60				

NOTE(S): G02D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/12/2015
Finish: 8/13/2015
WEATHER: Sunny, warm, calm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G02D
Well ID: G02D
Surface Elev: 360.82 ft. MSL
Completion: 72.36 ft. BGS
Station: 202,137.08N
832,842.99E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 43.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
31A	19/24 *79%*	SS	*woh-1 4-14* N=5	20			62	Gray (10YR6/1) with 30% dark yellowish brown (10YR4/6) mottles, moist, medium, SILT with little clay and little very fine- to medium-grained sand.	300	
32A	16/24 *67%*	SS	*3-14 18-25* N=32	20			64	Gray (10YR6/1), wet, dense, very fine- to coarse-grained SAND with some silt.	298	
33A	14/24 *58%*	SS	*5-18 37-33* N=55	18			66	Gray (10YR6/1), wet, dense, very fine- to coarse-grained SAND with some silt and trace small to large gravel.	296	
34A	16/24 *67%*	SS	*18-29 35-21* N=64	13			68	Brownish yellow (10YR6/6), wet, very dense, silty, very fine- to coarse-grained SAND and small to large GRAVEL.	294	
35A	14/24 *58%*	SS	*20-24 30-30* N=54	16			70	Gray (10YR6/1), wet, very dense, silty, very fine- to coarse-grained SAND with trace small to large gravel.	292	
36A	16/24 *67%*	SS	*12-19 37-28* N=56	14					290	
	0/4 *0%*	BD					72			

End of boring = 72.36 feet

NOTE(S): G02D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/17/2015
Finish: 8/18/2015
WEATHER: Partly cloudy, warm, mid-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G51D
Well ID: G51D
Surface Elev: 361.10 ft. MSL
Completion: 59.90 ft. BGS
Station: 200,430.10N
832,151.51E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 39.50 - During Drilling
▼ = 34.91 - 8/18/15
▽ =

SAMPLE			TESTING						
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	0/60 *0%*	BD					2			360	
							4			358	
	0/60 *0%*	BD					6			356	
							8			354	
	0/60 *0%*	BD					10	Blind drill - see G151 boring log		352	
							12			350	
	0/60 *0%*	BD					14			348	
							16			346	
	0/60 *0%*	BD					18			344	
							20			342	

NOTE(S): G51D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/17/2015
Finish: 8/18/2015
WEATHER: Partly cloudy, warm, mid-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler

FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G51D
Well ID: G51D
Surface Elev: 361.10 ft. MSL
Completion: 59.90 ft. BGS
Station: 200,430.10N
832,151.51E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 39.50 - During Drilling
▼ = 34.91 - 8/18/15
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	0/60 *0%*	BD					22				
							24			338	
							26			336	
	0/60 *0%*	BD					28			334	
							30	Blind drill - see G151 boring log *[Continued from previous page]*		332	
	0/60 *0%*	BD					32			330	
							34			328	
							▼			326	
	0/60 *0%*	BD					36			324	
							38			322	
							▼				
9A	24/24 *100%*	SS	*6-7* *4-4* N=11	22		*1.50*	40	Yellowish brown (10YR5/8) with 20% gray (10YR5/1) mottles, moist, medium, CLAY with few silt and little very fine- to fine-grained sand.		320	
							42				

NOTE(S): G51D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/17/2015
Finish: 8/18/2015
WEATHER: Partly cloudy, warm, mid-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G51D
Well ID: G51D
Surface Elev: 361.10 ft. MSL
Completion: 59.90 ft. BGS
Station: 200,430.10N
832,151.51E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 39.50 - During Drilling
▼ = 34.91 - 8/18/15
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
10A	24/24 100%	SS	1-2 4-5 N=6	20		1.50	44	Yellowish brown (10YR5/8) with 20% gray (10YR5/1) mottles, moist, medium, CLAY with few silt and little very fine- to fine-grained sand. *[Continued from previous page]*		318	
11A	24/24 100%	SS	3-4 4-4 N=8	16		0.25	46	Yellowish brown (10YR5/8) with 50% gray (10YR6/1) mottles, moist, soft, very fine- to medium-grained SAND with some silt and little clay.		316	
12A	24/24 100%	SS	5-7 10-11 N=17	13		1.50	48	Yellowish brown (10YR5/8) with 50% gray (10YR6/1) mottles, moist, stiff, very fine- to medium-grained SAND with some silt, little clay, and trace small gravel.		314	
13A	20/24 83%	SS	5-12 14-15 N=26	15		0.25	50	Yellowish brown (10YR5/8) with 20% gray (10YR6/1) mottles, wet, loose, very fine- to medium-grained SAND with trace silt, trace clay and trace small gravel.		312	
14A	23/24 96%	SS	5-15 19-21 N=34	15		1.25	52			310	
15A	22/24 92%	SS	3-12 14-7 N=26	15		1.50	54			308	
16A	24/24 100%	SS	1-5 6-11 N=11	17		0.00	56	Strong brown (7.5YR5/8), wet, loose, very fine- to medium-grained SAND with trace silt, trace clay, and trace small gravel.		306	
17A	24/24 100%	SS	2-7 8-11 N=15	19		0.00	58			304	
	0/23 0%	BD								302	Drilled past end of sample interval

End of boring = 59.9 feet

NOTE(S): G51D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/18/2015
Finish: 8/19/2015
WEATHER: Overcast, humid, mid-70s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G52D
Well ID: G52D
Surface Elev: 345.88 ft. MSL
Completion: 80.01 ft. BGS
Station: 198,098.93N
832,927.89E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 28.45 - During Drilling
▼ =
▽ =

SAMPLE			TESTING						
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	0/60 *0%*	BD					2	Blind drill - see G152 boring log		344	
							4			342	
	0/60 *0%*	BD					6			340	
							8			338	
	0/60 *0%*	BD					10			336	
							12			334	
	0/60 *0%*	BD					14			332	
							16			330	
							18			328	
							20			326	

NOTE(S): G52D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/18/2015
Finish: 8/19/2015
WEATHER: Overcast, humid, mid-70s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G52D
Well ID: G52D
Surface Elev: 345.88 ft. MSL
Completion: 80.01 ft. BGS
Station: 198,098.93N
832,927.89E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 28.45 - During Drilling
▼ =
▽ =

SAMPLE Number	SAMPLE Recov / Total (in) *% Recovery*	SAMPLE Type	TESTING *Blows / 6 in* N - Value **RQD**	TESTING Moisture (%)	TESTING Dry Den. (lb/ft³)	TESTING Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	0/60 *0%*	BD					22			324	
							24			322	
							26			320	
	0/60 *0%*	BD					28 ▼			318	
							30			316	
							32	Blind drill - see G152 boring log *[Continued from previous page]*		314	
	0/60 *0%*	BD					34			312	
							36			310	
	0/60 *0%*	BD					38			308	
							40			306	
	0/24 *0%*	BD					42			304	

NOTE(S): G52D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/18/2015
Finish: 8/19/2015
WEATHER: Overcast, humid, mid-70s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G52D
Well ID: G52D
Surface Elev: 345.88 ft. MSL
Completion: 80.01 ft. BGS
Station: 198,098.93N
832,927.89E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 28.45 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
10A	24/24 100%	SS	3-3 5-6 N=8	22		3.75	44	Gray (10YR5/1) with 40% yellowish brown (10YR5/8) mottles, moist, medium, CLAY with some silt and trace very fine-grained sand.		302	
11A	24/24 100%	SS	3-3 4-6 N=7	21		3.75	46			300	
12A				20		3.50					
12B	24/24 100%	SS	3-4 4-7 N=8	23			48	Gray (10YR6/1), moist, medium, SILT with some very fine-grained sand and trace clay.		298	
13A	24/24 100%	SS	2-4 5-6 N=9	23				Gray (10YR5/1) with 30% yellowish brown (10YR5/8) mottles, moist, medium, CLAY with some silt and trace very fine-grained sand.			
14A	24/24 100%	SS	5-7 8-10 N=15	20		4.00	50	Gray (10YR6/1) with 15% yellowish brown (10YR5/8) mottles, moist, stiff, CLAY with some silt and trace very fine-grained sand.		296	
15A	24/24 100%	SS	1-4 4-5 N=8	24		2.50	52	Gray (10YR6/1) with 10% yellowish brown (10YR5/8) mottles, moist, medium, SILT with few very fine-grained sand and little clay.		294	
16A	24/24 100%	SS	2-3 7-7 N=10	24		2.50	54	Gray (10YR6/1), moist, soft, CLAY with some silt and trace very fine-grained sand.		292	
16B				20				Gray (10YR6/1) with 10% yellowish brown (10YR5/8) mottles, moist, soft, SILT with little clay and very fine-grained sand.			
17A	24/24 100%	SS	4-4 7-9 N=11	21		3.75	56	Gray (10YR6/1), moist, soft, CLAY with some silt and trace very fine-grained sand.		290	
18A	24/24 100%	SS	2-6 7-7 N=13	24		3.25		Gray (10YR6/1), moist, medium, SILT and very fine-grained SAND with few clay.			
19A	22/24 92%	SS	3-3 4-4 N=7	20		2.25	58			288	
	24/24		2-3				60	Gray (10YR6/1), moist, medium, interbedded (0.1-0.2') SILT and very fine-grained SAND with few clay and CLAY with some silt and trace very fine-grained sand.		286	
							62	Gray (10YR6/1), moist, medium, SILT with very fine-grained sand and few clay.		284	

NOTE(S): G52D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/18/2015
Finish: 8/19/2015
WEATHER: Overcast, humid, mid-70s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G52D
Well ID: G52D
Surface Elev: 345.88 ft. MSL
Completion: 80.01 ft. BGS
Station: 198,098.93N
832,927.89E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 28.45 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
20A	100%	SS	5-6 N=8	23		2.25	64			282	
21A	24/24 100%	SS	4-4 6-7 N=10	23		4.25	66	Gray (10YR6/1), moist, medium, SILT with very fine-grained sand and few clay. *[Continued from previous page]*		280	
22A	24/24 100%	SS	3-4 8-9 N=12	19		2.00	68			278	
23A	24/24 100%	SS	2-7 6-6 N=13	22		2.50	70			276	
24A	24/24 100%	SS	wor-6 9-9 N=15	22		2.50	72	Gray (10YR6/1) with 20% yellowish brown (10YR5/8) mottles, moist, stiff, SILT and very fine-grained SAND with few clay.		274	
25A	24/24 100%	SS	wor-3 5-7 N=8	22		2.25	74	Gray (10YR6/1), wet, dense, SILT and very fine-grained SAND with trace clay. Gray (10YR6/1), wet, loose, very fine- to medium-grained SAND with trace silt.		272	
26A				17							
26B	24/24 100%	SS	6-7 8-9 N=15	22		3.25	76			270	Rods dropped, no blows
27A	24/24 100%	SS		22		2.75	78	Yellowish brown (10YR5/8) with 10% gray (10YR5/1) mottles, moist, stiff, CLAY with some silt and trace very fine-grained sand.		268	
28A	22/24 92%	SS	woh-3 6-7 N=9	27		3.25	80			266	

End of boring = 80.01 feet

NOTE(S): G52D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/20/2015
Finish: 8/21/2015
WEATHER: Sunny, mild mid-60s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler

FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G53D
Well ID: G53D
Surface Elev: 352.16 ft. MSL
Completion: 58.00 ft. BGS
Station: 200,075.16N
833,980.21E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 43.45 - During Drilling
▼ =
▽ =

SAMPLE			TESTING						
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	0/60 *0%*	BD					0			352	
							2			350	
							4			348	
							6			346	
	0/60 *0%*	BD					8			344	
							10	Blind drill - see G153 boring log		342	
	0/60 *0%*	BD					12			340	
							14			338	
							16			336	
	0/60 *0%*	BD					18			334	
							20			332	

NOTE(S): G55D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/20/2015
Finish: 8/21/2015
WEATHER: Sunny, mild mid-60s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G53D
Well ID: G53D
Surface Elev: 352.16 ft. MSL
Completion: 58.00 ft. BGS
Station: 200,075.16N
833,980.21E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 43.45 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Qp* (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	0/60 *0%*	BD					22			330	
							24			328	
	0/60 *0%*	BD					26			326	
							28			324	
	0/60 *0%*	BD					30	Blind drill - see G153 boring log *[Continued from previous page]*		322	
							32			320	
	0/36 *0%*	BD					34			318	
							36			316	
9A	24/24 *100%*	SS	*3-3* *5-5* N=8	19		*1.25*	38	Gray (10YR5/1) with 30% yellowish brown (10YR5/8) mottles, moist, dense, very fine- to medium-grained SAND with some silt and little clay.		314	
10A	21/24 *88%*	SS	*3-6* *7-8* N=13	17		*1.50*	40	Dark yellowish orange (10YR6/6) with 20% gray (10YR5/1) mottles, wet, dense, very fine- to medium-grained SAND with some silt, little clay, and trace small gravel.		312	
							42				

NOTE(S): G55D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/20/2015
Finish: 8/21/2015
WEATHER: Sunny, mild mid-60s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: R. Hasenyager

BOREHOLE ID: G53D
Well ID: G53D
Surface Elev: 352.16 ft. MSL
Completion: 58.00 ft. BGS
Station: 200,075.16N
833,980.21E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 43.45 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
11A	24/24 100%	SS	1-3 4-5 N=7	20			44	Dark yellowish orange (10YR6/6) with 20% gray (10YR5/1) mottles, wet, dense, very fine- to medium-grained SAND with some silt, little clay, and trace small gravel. *[Continued from previous page]*		310	
12A	21/24 88%	SS	2-5 12-14 N=17	16			46	Yellowish brown (10YR5/8) with 10% gray (10YR6/10 mottles, wet, dense, very fine- to fine-grained SAND with some silt and trace clay.		308	
13A	23/24 96%	SS	1-1 6-10 N=7	20			48			306	
14A	15/24 63%	SS	wor-wor woh-3	25			50	Gray (10YR6/1) wet, loose, very fine- to medium-grained SAND (micaceous) with little silt and trace clay.		304	
15A	19/24 79%	SS	1-3 8-14 N=11	23			52			302	
16A	20/24 83%	SS	1-4 5-14 N=9	23			54	Gray (10YR6/1) wet, loose, very fine- to medium-grained SAND (micaceous) with little silt and trace clay and small gravel.		300	
17A				22						298	
17B	19/24 79%	SS	4-10 14-20 N=24	16			56	Gray (10YR6/1), wet, loose, very fine- to very coarse-grained SAND with few small to large gravel and little silt.		296	
18A				12							
18B	18/24 75%	SS	1-9 10-11 N=19	21			58	Gray (10YR6/1) wet, loose, very fine- to fine-grained SAND with little silt and trace small gravel.			

End of boring = 58.0 feet

NOTE(S): G55D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/11/2015
Finish: 8/11/2015
WEATHER: Sunny, warm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G54D
Well ID: G54D
Surface Elev: 353.71 ft. MSL
Completion: 80.14 ft. BGS
Station: 199,066.83N
831,610.42E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 18.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
1A	13/24 54%	ss	3-2 3-4 N=5	21			0	FILL - Black (10YR2/1), moist, medium, SILT with few clay, trace very fine- to medium-grained sand, and trace roots.		
							1	FILL - Yellowish brown (10YR5/4), moist, medium, SILT with few clay, trace very fine- to coarse-grained sand, and trace roots.	352	
2A	16/24 67%	ss	2-4 16-8 N=20	13			2	FILL - Yellowish brown (10YR5/4) with 25% gray (10YR5/1), moist, medium, SILT with few clay, trace very fine- to coarse-grained sand, trace small to large gravel, and trace roots.		
3A	18/24 75%	ss	4-4 5-8 N=9	23		2.00	4		350	
4A	21/24 88%	ss	2-2 4-4 N=6	25		2.00	6	Light gray (10YR7/1) with 20% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with few clay, trace very fine- to fine-grained sand.	348	
5A	24/24 100%	ss	1-3 4-6 N=7	23		1.80	8		346	
6A	22/24 92%	ss	1-3 4-5 N=7	22		3.00	10	Brown (10YR5/3) with 20% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with few clay, trace very fine-grained sand.	344	
7A	17/24 71%	ss	1-1 2-4 N=3	22		2.00	12		342	
8A	22/24 92%	ss	1-2 4-5 N=6	22		2.00	14	Gray (10YR6/1) with 35% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with few clay, trace very fine-grained sand.	340	
9A	17/24 71%	ss	2-3 6-8 N=9	22		1.80	16		338	
10A	24/24 100%	ss	2-3 6-5 N=9	20		2.50	18 ▼	Yellowish brown (10YR5/6) with 30% gray (10YR6/1) mottles, moist, stiff, silty CLAY with trace very fine-grained sand.	336	
11A	24/24		1-3	20		1.90	20		334	

NOTE(S): G54D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/11/2015
Finish: 8/11/2015
WEATHER: Sunny, warm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G54D
Well ID: G54D
Surface Elev: 353.71 ft. MSL
Completion: 80.14 ft. BGS
Station: 199,066.83N
831,610.42E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 18.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
	100%	ss	5-6 N=8				22	Yellowish brown (10YR5/6) with 30% gray (10YR6/1) mottles, moist, stiff, silty CLAY with trace very fine-grained sand. *[Continued from previous page]*		332	
12A	24/24 100%	ss	1-4 6-8 N=10	19		3.00	24			330	
13A	24/24 100%	ss	1-3 4-6 N=7	19		1.80	26			328	
14A	24/24 100%	ss	2-4 7-7 N=11	21		2.00	28	Light brownish gray (10YR6/2) with 35% dark yellowish brown (10YR4/6) mottles, moist, very stiff, SILT with few clay, trace very fine- to medium-grained sand.		326	
15A	22/24 92%	ss	1-3 6-8 N=9	20		2.30	30			324	
16A	20/24 83%	ss	1-3 6-6 N=9	18		2.40	32			322	
17A	24/24 100%	ss	1-4 8-8 N=12	20		3.50	34			320	
18A	22/24 92%	ss	1-3 4-5 N=7	22		2.80	36	Grayish brown (10YR5/2) with 10% dark yellowish brown (10YR4/6) mottles, moist, very stiff, SILT with little clay, trace very fine-grained sand.		318	
19A	24/24 100%	ss	3-4 8-8 N=12	19		3.00	38			316	
20A	24/24 100%	ss	1-4 7-10 N=11	19		2.50	40	Light gray (10YR7/1) with 5% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with few clay, trace very fine-grained sand.		314	
21A	24/24 100%	ss	1-3 10-10 N=13	17		3.80	42			312	

NOTE(S): G54D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/11/2015
Finish: 8/11/2015
WEATHER: Sunny, warm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G54D
Well ID: G54D
Surface Elev: 353.71 ft. MSL
Completion: 80.14 ft. BGS
Station: 199,066.83N
831,610.42E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 18.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
22A	24/24 100%	ss	5-8 9-10 N=17	16		3.00	44	Light gray (10YR7/1) with 5% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with few clay, trace very fine-grained sand. *[Continued from previous page]*		310	
23A	24/24 100%	ss	3-6 8-8 N=14	19		3.00	46			308	
24A	24/24 100%	ss	2-4 5-5 N=9	19		3.20	48	Light brownish gray (10YR6/2) with 10% dark yellowish brown (10YR4/4) mottles, moist, very stiff, silty CLAY, trace very fine- to coarse-grained sand.		306	
25A	24/24 100%	ss	4-7 7-6 N=14	18		2.40	50			304	
26A	17/24 71%	ss	1-4 6-8 N=10	18		2.00	52	Gray (10YR6/1) with 15% dark yellowish brown (10YR4/6) mottles, moist, very stiff, silty CLAY with little very fine- to coarse-grained sand and trace small gravel.		302	
27A	22/24 92%	ss	3-3 7-18 N=10	21		3.30	54	Gray (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, very stiff, SILT with few clay, trace very fine-grained sand.		300	
28A	21/24 88%	ss	5-11 18-20 N=29	21		4.00	56			298	
29A	11/11 100%	ss	25-50/5"	15		3.80	58	Gray (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, hard, SILT with few very fine- to fine-grained sand, trace clay.		296	
30A	20/24 83%	ss	21-19 35-29 N=54	14			60	Gary (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, very dense, silty, very fine- to fine-grained sand, trace clay.		294	
31A	17/24 71%	ss	4-6 10-9 N=16	17		1.80	62	Gray (10YR6/1) with 15% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with little clay, trace very fine- to fine-grained sand.		292	
32A	22/24		6-8	22		3.30					

NOTE(S): G54D installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resource Technology, Inc.
Site: Joppa Power Station
Location: Joppa, Illinois
Project: 15E0030
DATES: **Start:** 8/11/2015
Finish: 8/11/2015
WEATHER: Sunny, warm, lo-80s

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA, split spoon sampler
FIELD STAFF: **Driller:** J. Dittmaier
Helper: M. Hill
Eng/Geo: S. Keim

BOREHOLE ID: G54D
Well ID: G54D
Surface Elev: 353.71 ft. MSL
Completion: 80.14 ft. BGS
Station: 199,066.83N
831,610.42E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Joppa
Township: 15S;3E
Section 14, **Tier** 15S; **Range** 3E

WATER LEVEL INFORMATION:
▼ = 18.00 - During Drilling
▼ =
▽ =

SAMPLE Number	Recov / Total (in) % Recovery	Type	TESTING Blows / 6 in N - Value RQD	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) Qp (tsf) Failure Type	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
	92%	SS	5-7 N=13				64	Gray (10YR6/1) with 15% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with little clay, trace very fine- to fine-grained sand. *[Continued from previous page]*	290	
33A	24/24 100%	SS	2-4 7-9 N=11	18		2.50	66		288	
34A	24/24 100%	SS	3-5 10-15 N=15	19		2.50		Gray (10YR6/1) with 15% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with little clay, few very fine- to coarse-grained sand, trace small gravel.	286	
35A	22/24 92%	SS	1-3 3-5 N=6	23		1.50	68	Yellowish brown (10YR5/6) with 10% gray (10YR6/1) mottles, moist, stiff, SILT with little clay, trace very fine-grained sand.	284	
36A	24/24 100%	SS	woh-1 5-6 N=6	23		1.50	70		282	
37A	24/24 100%	SS	woh-1 2-4 N=3	23		1.50	72	Gray (10YR6/1) with 10% dark yellowish brown (10YR4/6) mottles, moist, stiff, SILT with little clay, trace very fine- to fine-grained sand.	280	
38A	16/24 67%	SS	30-40 27-34 N=67	11			74		278	
39A	12/15 80%	SS	10-47 50/3"	14			76	Yellowish brown (10YR5/6), moist, very dense, silty, fine- to coarse-grained SAND and small to large GRAVEL.	276	
40A	5/5 100%	SS	50/5"	12			78		274	
	0/21 0%	BD					80			

End of boring = 80.14 feet

NOTE(S): G54D installed in borehole.

WELL CONSTRUCTION LOGS

Illinois Environmental Protection Agency — Well Completion Report

Site #: _____ County: Massac County Well #: G01D

Site Name: Joppa Power Station Borehole #: G01D

State Plane Coordinate: X 831,716.1 Y 202,039.3 (or) Latitude: _____ Longitude: _____

Surveyed By: Gary C. Rogers IL Registration #: 035-002957

Drilling Contractor: Bulldog Drilling, Inc. Driller: J. Dittmaier

Consulting Firm: Hanson Professional Services Inc. Geologist: Rhonald W. Hasenyager, LPG #196-000246

Drilling Method: Hollow Stem Auger Drilling Fluid (Type): Water

Logged By: Suzanna L. Keim Date Started: 8/14/2015 Date Finished: 8/14/2015

Report Form Completed By: Suzanna L. Keim Date: 8/18/2015

ANNULAR SPACE DETAILS

Type of Surface Seal: Concrete

Type of Annular Sealant: High-solids bentonite

Installation Method: Tremie

Setting Time: >48 hours

Type of Bentonite Seal -- Granular (Pellet) Slurry (choose one)

Installation Method: Gravity

Setting Time: >48 hours

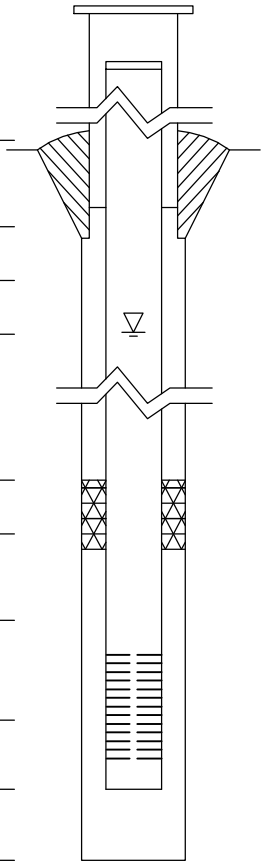
Type of Sand Pack: Quartz Sand

Grain Size: 10-20 (sieve size)

Installation Method: Gravity

Type of Backfill Material: n/a (if applicable)

Installation Method: _____



Elevations (MSL)*	Depths (BGS) (0.01 ft.)	
364.50	-3.00	Top of Protective Casing
364.19	-2.69	Top of Riser Pipe
361.50	0.00	Ground Surface
359.50	2.00	Top of Annular Sealant
311.42	50.08	Static Water Level (After Completion) 10/5/2015
310.15	51.35	Top of Seal
308.90	52.60	Top of Sand Pack
307.31	54.19	Top of Screen
297.65	63.85	Bottom of Screen
297.12	64.38	Bottom of Well
297.12	64.38	Bottom of Borehole

* Referenced to a National Geodetic Datum

WELL CONSTRUCTION MATERIALS

(Choose one type of material for each area)

Protective Casing	SS304	SS316	PTFE	PVC	OTHER: (Steel)
Riser Pipe Above W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Riser Pipe Below W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Screen	SS304	SS316	PTFE	(PVC)	OTHER:

CASING MEASUREMENTS

Diameter of Borehole	(inches)	8.0
ID of Riser Pipe	(inches)	2.0
Protective Casing Length	(feet)	5.0
Riser Pipe Length	(feet)	56.88
Bottom of Screen to End Cap	(feet)	0.53
Screen Length (1st slot to last slot)	(feet)	9.66
Total Length of Casing	(feet)	67.07
Screen Slot Size **	(inches)	0.010

**Hand-Slotted Well Screens Are Unacceptable

Illinois Environmental Protection Agency — Well Completion Report

Site #: _____ County: Massac County Well #: G02D

Site Name: Joppa Power Station Borehole #: G02D

State Plane Coordinate: X 832,843.0 Y 202,137.1 (or) Latitude: _____ Longitude: _____

Surveyed By: Gary C. Rogers IL Registration #: 035-002957

Drilling Contractor: Bulldog Drilling, Inc. Driller: J. Dittmaier

Consulting Firm: Hanson Professional Services Inc. Geologist: Rhonald W. Hasenyager, LPG #196-000246

Drilling Method: Hollow Stem Auger Drilling Fluid (Type): Water

Logged By: Suzanna L. Keim Date Started: 8/12/2015 Date Finished: 8/13/2015

Report Form Completed By: Suzanna L. Keim Date: 8/18/2015

ANNULAR SPACE DETAILS

Type of Surface Seal: Concrete

Type of Annular Sealant: High-solids bentonite

Installation Method: Tremie

Setting Time: >48 hours

Type of Bentonite Seal -- Granular (Pellet) Slurry (choose one)

Installation Method: Gravity

Setting Time: 45 minutes

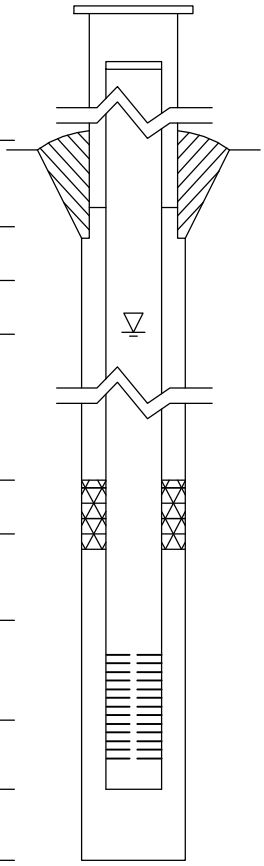
Type of Sand Pack: Quartz Sand

Grain Size: 10-20 (sieve size)

Installation Method: Gravity

Type of Backfill Material: n/a (if applicable)

Installation Method: _____



	Elevations (MSL)*	Depths (BGS) (0.01 ft.)
Top of Protective Casing	364.09	-3.27
Top of Riser Pipe	363.65	-2.83
Ground Surface	360.82	0.00
Top of Annular Sealant	358.82	2.00
Static Water Level (After Completion) 10/5/2015	312.82	48.00
Top of Seal	301.82	59.00
Top of Sand Pack	300.42	60.40
Top of Screen	298.61	62.21
Bottom of Screen	288.98	71.84
Bottom of Well	288.46	72.36
Bottom of Borehole	288.46	72.36

* Referenced to a National Geodetic Datum

WELL CONSTRUCTION MATERIALS

(Choose one type of material for each area)

Protective Casing	SS304	SS316	PTFE	PVC	OTHER: (Steel)
Riser Pipe Above W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Riser Pipe Below W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Screen	SS304	SS316	PTFE	(PVC)	OTHER:

CASING MEASUREMENTS

Diameter of Borehole	(inches)	8.0
ID of Riser Pipe	(inches)	2.0
Protective Casing Length	(feet)	5.0
Riser Pipe Length	(feet)	65.04
Bottom of Screen to End Cap	(feet)	0.52
Screen Length (1st slot to last slot)	(feet)	9.63
Total Length of Casing	(feet)	75.19
Screen Slot Size **	(inches)	0.010

**Hand-Slotted Well Screens Are Unacceptable

Illinois Environmental Protection Agency — Well Completion Report

Site #: _____ County: Massac County Well #: G51D

Site Name: Joppa Power Station Borehole #: G51D

State Plane Coordinate: X 832,151.5 Y 200,430.1 (or) Latitude: _____ Longitude: _____

Surveyed By: Gary C. Rogers IL Registration #: 035-002957

Drilling Contractor: Bulldog Drilling, Inc. Driller: J. Dittmaier

Consulting Firm: Hanson Professional Services Inc. Geologist: Rhonald W. Hasenyager, LPG #196-000246

Drilling Method: Hollow Stem Auger Drilling Fluid (Type): Water

Logged By: Rhonald W. Hasenyager Date Started: 8/17/2015 Date Finished: 8/18/2015

Report Form Completed By: Suzanna L. Keim Date: 8/28/2015

ANNULAR SPACE DETAILS

Type of Surface Seal: Concrete

Type of Annular Sealant: High-solids bentonite

Installation Method: Tremie

Setting Time: >48 hours

Type of Bentonite Seal -- Granular (Pellet) Slurry (choose one)

Installation Method: Gravity

Setting Time: 70 minutes

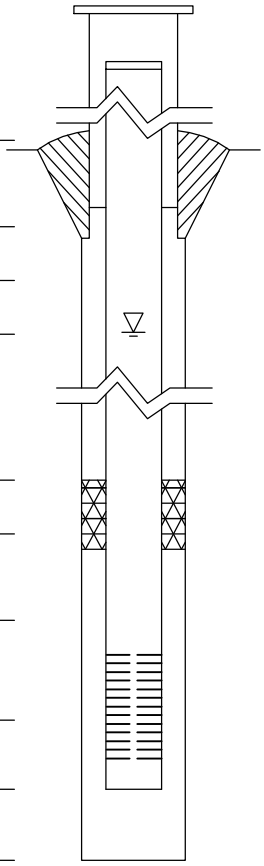
Type of Sand Pack: Quartz Sand

Grain Size: 10-20 (sieve size)

Installation Method: Gravity

Type of Backfill Material: n/a (if applicable)

Installation Method: _____



	Elevations (MSL)*	Depths (BGS) (0.01 ft.)
Top of Protective Casing	364.22	-3.12
Top of Riser Pipe	363.85	-2.75
Ground Surface	361.10	0.00
Top of Annular Sealant	359.10	2.00
Static Water Level (After Completion) 10/5/2015	311.65	49.45
Top of Seal	315.42	45.68
Top of Sand Pack	313.59	47.51
Top of Screen	311.49	49.61
Bottom of Screen	301.83	59.27
Bottom of Well	301.20	59.90
Bottom of Borehole	301.20	59.90

* Referenced to a National Geodetic Datum

WELL CONSTRUCTION MATERIALS

(Choose one type of material for each area)

Protective Casing	SS304	SS316	PTFE	PVC	OTHER: (Steel)
Riser Pipe Above W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Riser Pipe Below W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Screen	SS304	SS316	PTFE	(PVC)	OTHER:

CASING MEASUREMENTS

Diameter of Borehole	(inches)	8.0
ID of Riser Pipe	(inches)	2.0
Protective Casing Length	(feet)	5.0
Riser Pipe Length	(feet)	52.36
Bottom of Screen to End Cap	(feet)	0.63
Screen Length (1st slot to last slot)	(feet)	9.66
Total Length of Casing	(feet)	62.65
Screen Slot Size **	(inches)	0.010

Well Completion Form (revised 02/06/02)

**Hand-Slotted Well Screens Are Unacceptable

Illinois Environmental Protection Agency — Well Completion Report

Site #: _____ County: Massac County Well #: G52D

Site Name: Joppa Power Station Borehole #: G52D

State Plane Coordinate: X 832,927.9 Y 198,098.9 (or) Latitude: _____ Longitude: _____

Surveyed By: Gary C. Rogers IL Registration #: 035-002957

Drilling Contractor: Bulldog Drilling, Inc. Driller: J. Dittmaier

Consulting Firm: Hanson Professional Services Inc. Geologist: Rhonald W. Hasenyager, LPG #196-000246

Drilling Method: Hollow Stem Auger Drilling Fluid (Type): Water

Logged By: Rhonald W. Hasenyager Date Started: 8/18/2015 Date Finished: 8/19/2015

Report Form Completed By: Suzanna L. Keim Date: 8/28/2015

ANNULAR SPACE DETAILS

Type of Surface Seal: Concrete

Type of Annular Sealant: High-solids bentonite

Installation Method: Tremie

Setting Time: >48 hours

Type of Bentonite Seal -- Granular (Pellet) Slurry (choose one)

Installation Method: Gravity

Setting Time: 32 minutes

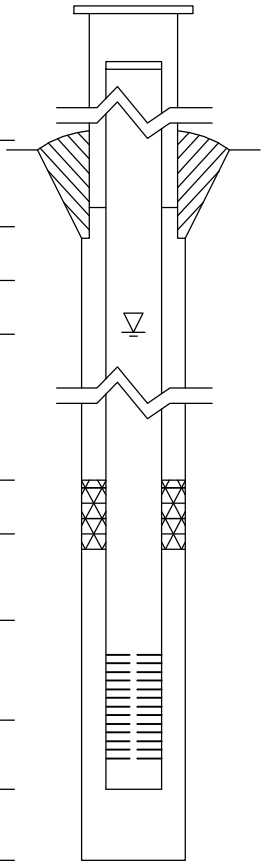
Type of Sand Pack: Quartz Sand

Grain Size: 10-20 (sieve size)

Installation Method: Gravity

Type of Backfill Material: n/a (if applicable)

Installation Method: _____



	Elevations (MSL)*	Depths (BGS) (0.01 ft.)
Top of Protective Casing	348.67	-2.79
Top of Riser Pipe	348.41	-2.53
Ground Surface	345.88	0.00
Top of Annular Sealant	343.88	2.00
Static Water Level (After Completion) 10/5/2015	313.46	32.42
Top of Seal	278.91	66.97
Top of Sand Pack	277.22	68.66
Top of Screen	276.03	69.85
Bottom of Screen	266.33	79.55
Bottom of Well	265.87	80.01
Bottom of Borehole	265.87	80.01

* Referenced to a National Geodetic Datum

WELL CONSTRUCTION MATERIALS

(Choose one type of material for each area)

Protective Casing	SS304	SS316	PTFE	PVC	OTHER: (Steel)
Riser Pipe Above W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Riser Pipe Below W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Screen	SS304	SS316	PTFE	(PVC)	OTHER:

CASING MEASUREMENTS

Diameter of Borehole	(inches)	8.0
ID of Riser Pipe	(inches)	2.0
Protective Casing Length	(feet)	5.0
Riser Pipe Length	(feet)	72.38
Bottom of Screen to End Cap	(feet)	0.46
Screen Length (1st slot to last slot)	(feet)	9.70
Total Length of Casing	(feet)	82.54
Screen Slot Size **	(inches)	0.010

**Hand-Slotted Well Screens Are Unacceptable

Illinois Environmental Protection Agency — Well Completion Report

Site #: _____ County: Massac County Well #: G53D

Site Name: Joppa Power Station Borehole #: G53D

State Plane Coordinate: X 833,980.2 Y 200,075.2 (or) Latitude: _____ Longitude: _____

Surveyed By: Gary C. Rogers IL Registration #: 035-002957

Drilling Contractor: Bulldog Drilling, Inc. Driller: J. Dittmaier

Consulting Firm: Hanson Professional Services Inc. Geologist: Rhonald W. Hasenyager, LPG #196-000246

Drilling Method: Hollow Stem Auger Drilling Fluid (Type): Water

Logged By: Rhonald W. Hasenyager Date Started: 8/20/2015 Date Finished: 8/21/2015

Report Form Completed By: Suzanna L. Keim Date: 8/28/2015

ANNULAR SPACE DETAILS

Type of Surface Seal: Concrete

Type of Annular Sealant: High-solids bentonite

Installation Method: Tremie

Setting Time: >48 hours

Type of Bentonite Seal -- Granular (Pellet) Slurry (choose one)

Installation Method: Gravity

Setting Time: 65 minutes

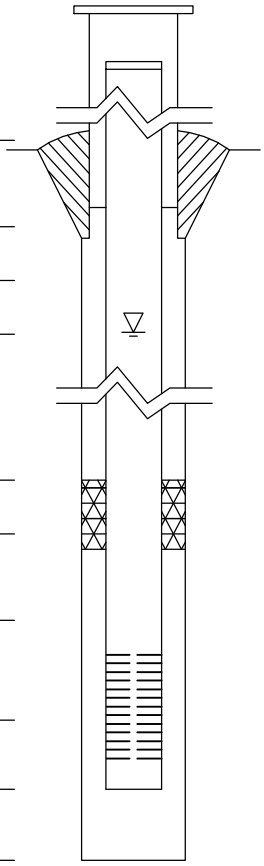
Type of Sand Pack: Quartz Sand

Grain Size: 10-20 (sieve size)

Installation Method: Gravity

Type of Backfill Material: Formation (if applicable)

Installation Method: Drilling



	Elevations (MSL)*	Depths (BGS) (0.01 ft.)
Top of Protective Casing	355.82	-3.66
Top of Riser Pipe	355.47	-3.31
Ground Surface	352.16	0.00
Top of Annular Sealant	350.16	2.00
Static Water Level (After Completion) 10/6/2015	309.91	42.25
Top of Seal	309.77	42.39
Top of Sand Pack	307.85	44.31
Top of Screen	304.87	47.29
Bottom of Screen	295.27	56.89
Bottom of Well	294.83	57.33
Bottom of Borehole	294.16	58.00

* Referenced to a National Geodetic Datum

WELL CONSTRUCTION MATERIALS

(Choose one type of material for each area)

Protective Casing	SS304	SS316	PTFE	PVC	OTHER: (Steel)
Riser Pipe Above W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Riser Pipe Below W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Screen	SS304	SS316	PTFE	(PVC)	OTHER:

CASING MEASUREMENTS

Diameter of Borehole	(inches)	8.0
ID of Riser Pipe	(inches)	2.0
Protective Casing Length	(feet)	5.0
Riser Pipe Length	(feet)	50.60
Bottom of Screen to End Cap	(feet)	0.44
Screen Length (1st slot to last slot)	(feet)	9.60
Total Length of Casing	(feet)	60.64
Screen Slot Size **	(inches)	0.010

**Hand-Slotted Well Screens Are Unacceptable

Illinois Environmental Protection Agency — Well Completion Report

Site #: _____ County: Massac County Well #: G54D

Site Name: Joppa Power Station Borehole #: G54D

State Plane Coordinate: X 831,610.4 Y 199,066.8 (or) Latitude: _____ Longitude: _____

Surveyed By: Gary C. Rogers IL Registration #: 035-002957

Drilling Contractor: Bulldog Drilling, Inc. Driller: J. Dittmaier

Consulting Firm: Hanson Professional Services Inc. Geologist: Rhonald W. Hasenyager, LPG #196-000246

Drilling Method: Hollow Stem Auger Drilling Fluid (Type): Water

Logged By: Suzanna L. Keim Date Started: 8/11/2015 Date Finished: 8/11/2015

Report Form Completed By: Suzanna L. Keim Date: 8/18/2015

ANNULAR SPACE DETAILS

Type of Surface Seal: Concrete

Type of Annular Sealant: High-solids bentonite

Installation Method: Tremie

Setting Time: >48 hours

Type of Bentonite Seal -- Granular (Pellet) Slurry (choose one)

Installation Method: Gravity

Setting Time: >48 hours

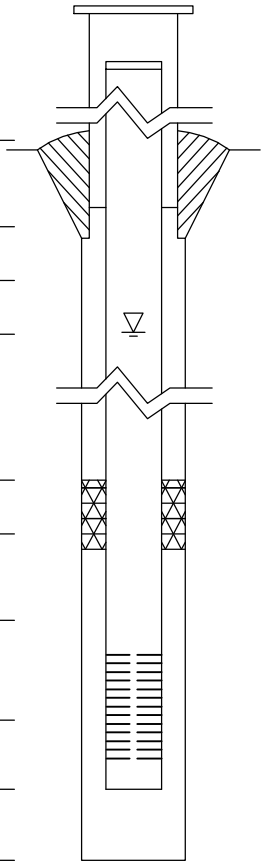
Type of Sand Pack: Quartz Sand

Grain Size: 10-20 (sieve size)

Installation Method: Gravity

Type of Backfill Material: n/a (if applicable)

Installation Method: _____



Elevations (MSL)*	Depths (BGS) (0.01 ft.)	
357.39	-3.68	Top of Protective Casing
357.03	-3.32	Top of Riser Pipe
353.71	0.00	Ground Surface
351.71	2.00	Top of Annular Sealant
304.50	49.21	Static Water Level (After Completion) 10/5/2015
286.76	66.95	Top of Seal
285.71	68.00	Top of Sand Pack
283.75	69.96	Top of Screen
274.05	79.66	Bottom of Screen
273.57	80.14	Bottom of Well
273.57	80.14	Bottom of Borehole

* Referenced to a National Geodetic Datum

WELL CONSTRUCTION MATERIALS

(Choose one type of material for each area)

Protective Casing	SS304	SS316	PTFE	PVC	OTHER: (Steel)
Riser Pipe Above W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Riser Pipe Below W.T.	SS304	SS316	PTFE	(PVC)	OTHER:
Screen	SS304	SS316	PTFE	(PVC)	OTHER:

CASING MEASUREMENTS

Diameter of Borehole	(inches)	8.0
ID of Riser Pipe	(inches)	2.0
Protective Casing Length	(feet)	5.0
Riser Pipe Length	(feet)	73.28
Bottom of Screen to End Cap	(feet)	0.48
Screen Length (1st slot to last slot)	(feet)	9.70
Total Length of Casing	(feet)	83.46
Screen Slot Size **	(inches)	0.010

Well Completion Form (revised 02/06/02)

**Hand-Slotted Well Screens Are Unacceptable

AECOM BORING LOGS AND WELL CONSTRUCTION LOGS

O:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - North.mxd

Legend

- AECOM Boring Location
- AECOM CPT Location

N
W E
S

250 0 250 500 Feet

DYNEGY

Figure D-01
Exploration Locations - North Pond
Joppa Power Station
Massac County, Illinois

AECOM

Q:\Projects\DOE10 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - South.mxd

Legend

- AECOM Boring Location
- AECOM CPT Location

N
W E
S

250 0 250 500 Feet

DYNEGY

Figure D-01
Exploration Locations - South Pond
Joppa Power Station
Massac County, Illinois

AECOM

Project: Dynegy

Project Location: Joppa Energy Complex, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Date(s) Drilled	08/08/2015 10:00 AM to 08/08/2015 4:10 PM	Logged By	Gabriel Cuestas	Checked By	David Pieczynski
Drilling Method	HSA/Mud rotary	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	100.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	376.091 ft NAVD88
Borehole Backfill	Bentonite/Grout with vibrating wire piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199211.282 E 832989.788 (ft NAD83)	Groundwater Level(s)	3.2 ft on 10/2/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					Elevation (feet) 376.1 / Depth (feet) 0.0								
375						[ASH] Sandy SILT to Silt (ML), very loose, gray to dark gray, wet, non-plastic								*Begin 8/8/15 @ 10:44 AM*
		S-1	1 0 1	100										*P200 = 51.4*
	5													
370														*Observed water*
		ST-1		11										*P200 = 94.5*
	10													
365														
		S-2	0 1 1	100										
	15													
360														
		S-3	WFR	100										
	20													
355														
		S-4	WFR	100										*Switch to mud rotary* *Vibrating wire piezometer installed at 25' on 8/8/2015 (Serial number 1520846)*
	25													
350														
		S-5	WFR	100										*P200 = 97.6*
	30													

Report: GEO_SOIL; File Q:\PROJECTS\DOE\0 PROJECTS\DYNEGY\JOPPA\05_ANALYSIS AND ENGINEERING\FIELD INVESTIGATION\BORING LOGS\DYNEGY_2015_GINT\DYNEGY_2015-12012015.GPJ; 12/29/2015 4:37:27 PM

Project: Dynegy

Project Location: Joppa Energy Complex, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
345	30													
	35	S-6		0										*Sample fell out of tube, recovered with split spoon*
340	40	S-7	WFR	100										*P200 = 70.8*
335	45	ST-2		50										
330	50	S-8	WFR	100		325.6 / 50.5 [FOUNDATION] Sandy Lean CLAY (CL), stiff, yellow, wet								
325	55	S-9	10 5 4	100										*Driller reports drilling getting harder* *P200 = 64.2*
320		S-10												*Sample fell out of tube at surface. Bagged and labeled*
	60	S-11	2 3 4	33										*P200 = 61.1*
315		ST-3		75		vibrant orange, moist/saturated, medium sand								
	65	S-12	10 15 20			312.1 / 64.0 Silty SAND (SM), dense, gray, wet								

Report: GEO_SOIL; File Q:\PROJECTS\DOE\0 PROJECTS\DYNEGY\JOPPA\05_ANALYSIS AND ENGINEERING\FIELD INVESTIGATION\BORING LOGS\DYNEGY_2015_GINT\DYNEGY_2015-12012015.GPJ; 12/29/2015 4:37:27 PM

Project: Dynegy

Project Location: Joppa Energy Complex, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310														
		S-13	15 19 17	28										
	70					304.1 / 72.0								
305						Silty CLAY with Sand (CL-ML), stiff, gray, low to medium plasticity, fine sand, vertical orange stripping								
		S-14	1 6 6	100										*P200 = 71.5*
	75					299.1 / 77.0								
300						Poorly-Graded SAND with Clay (SP-SC), very dense, yellow, medium to coarse sand, angular								
		S-15	17 28 21	56										
	80													
295														
		S-16	14 30 30	28										*End of Day 8/8/15 at 5:20 PM* *P200 = 7.6* *Begin 8/9/15 7:20 PM*
	85													
290														
		S-17	24 24 23	33										
	90													
285														
		S-18	11 10 11	33										
	95													
280						278.1 / 98.0								
		S-19	13 19 18	33		Poorly-Graded SAND with Gravel (SP), dense, burnt yellow/orange, angular								*End 8/9/15 at 9:10 AM*
	100					276.1 / 100.0								

End of Boring at 100 ft

Report: GEO_SOIL; File Q:\PROJECTS\DOE\0 PROJECTS\DYNEGY\JOPPA\05_ANALYSIS AND ENGINEERING\FIELD INVESTIGATION\BORING LOGS\DYNEGY_2015_GINT\DYNEGY_2015-12012015.GPJ; 12/29/2015 4:37:27 PM

NATURAL RESOURCE TECHNOLOGY BORING LOGS AND WELL CONSTRUCTION LOGS

NATURAL RESOURCE TECHNOLOGY

SOIL BORING LOG INFORMATION

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Joppa Power Station (EEI)		G152B

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Matt Cooper Bulldog Drilling, Inc.	1/28/2013	1/30/2013	hollow stem auger

Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
G152B	312.3 Feet (NAVD88)	345.2 Feet (NAVD88)	7.8 inches

Local Grid Origin ☒ (estimated: ☐) or Boring Location ☐

State Plane Illinois East Zone N, E S / C /Ⓝ

1/4 of 1/4 of Section , T N, R

Lat ° ' "

Long ° ' "

Local Grid Location ☒ N ☒ E

198094.58 Feet ☐ S 832931.61 Feet ☐ W

Facility ID	County	State	Civil Town/City/ or Village
	Massac	Illinois	Joppa

Sample Number and Type	Sample Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID 10.6 eV Lamp	Soil Properties: Compressive Strength (tsf)	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
1	42 19		0 1 2 3	0 - 0.75' **SILTY CLAY** CL, disturbed with gravel, tree limbs, wood from clearing activities; dark brown, wet. 0.75 - 4.5' **SILTY CLAY** CL, light yellowish brown (10YR 6/4), high plasticity, very soft to soft, silty clay with organics (roots), soft, high plasticity, light yellowish brown (10YR 6/4), moist.	CL CL									PP 2 - 2.25
2	60 56		4 5 6 7	4' Silty Clay grading to a Clayey Silt, low plasticity, stiff, light gray (10YR 7/1), with 50% reddish brown mottling, moist. 4.5 - 12.5' **SILT:** ML, non plastic, stiff, very pale brown (10YR 8/2), dry. 7.3' soil horizon with small rootlets, 50% reddish brown mottling.					3.25 3 3 2					
3	60 58		8 9 10 11 12	7.5' very pale brown (10YR 8/2), non plastic, stiff, dry. 9' silt with clay, very stiff, non plastic, very pale brown (10YR 7/3) with 10-25% reddish brown mottling.	ML				1.75 4 3.5 2					

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature

Firm Natural Resource Technology
23713 W. Paul Road Suite D, Pewaukee, WI 53072

Tel: (262) 523-9000
Fax: (262) 523-9001

NATURAL RESOURCE TECHNOLOGY

Boring Number G152B

Sample Number and Type	Sample Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID 10.6 eV Lamp	Soil Properties: Compressive Strength (tsf)	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
									2					
			13	12.5 - 28.5' **SILTY CLAY** CL, medium to stiff, low to medium plasticity, light gray (10YR 7/1), with 50% mottling, moist.					2					
4	60 60		14	13.5' 10-50% reddish brown mottling.					2.5					
			15	15' light gray (10YR 7/1).					2.25					
			16						2.25					
			17						3.25					
			18	18' yellowish brown (10YR 6/8) mottling, moist.										PP 2.5 - 3.5
5	60 60		19	18.5' medium to stiff, medium to high plasticity, light gray (10YR 7/1), with 10-25% reddish brown mottling, moist.					2.25					
			20						2.5					
			21		CL				1.75					
			22						1.75					
			23						1.75					
6	60 60		24	23.5' medium to stiff, high plasticity, light gray (10YR 7/1), with 25-50% reddish brown mottling, moist.					2					
			25						1.5					
			26						1.5					
			27						2.5					
			28						2					
NR	12 0		29	28.5 - 29.5' CL.	CL									stopped sampling for the day (1/28/13), cleaned hole with augers to 29.5' resumed sampling on 1/30/2013
7	60 44		30	29.5 - 44.5' **SILTY CLAY** CL, stiff, medium to high plasticity, gray with >75% light yellowish brown (10YR 6/4) mottling, moist.					2.75					
			31		CL				3.25					
			32	31.5' 25-75% mottling.										

NATURAL RESOURCE TECHNOLOGY

Boring Number G152B

Sample Number and Type	Sample Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID 10.6 eV Lamp	Soil Properties: Compressive Strength (tsf)	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
			33	29.5 - 44.5' **SILTY CLAY** CL, stiff, medium to high plasticity, gray with >75% light yellowish brown (10YR 6/4) mottling, moist. *(continued)* 33' very stiff to hard, gray (10YR 6/1), with < 25% yellowish brown (10YR 6/8) mottling.					3.5 4.5					
			34						2.5					
8	60 57		35	34.5' stiff to very stiff, high plasticity.					3.5					
			36						2.5					
			37						4.25					
			38	38' hard, < 10% mottling.	CL				2.5					
			39											PP is >4.5
9	60 55		40	39.5' very stiff to hard, high plasticity, gray (10YR 6/1) with < 10% yellowish brown (10YR 5/6) mottling, moist.					3					
			41						3					
			42						3					
			43						4.5					
			44						3.75					
				44.5' End of Boring.										

NATURAL RESOURCE TECHNOLOGY

MONITORING WELL CONSTRUCTION

Facility/Project Name: Joppa Power Station (EEI)	Local Grid Location of Well: 198094.58 ft. ☒ N. ☐ S. 832931.61 ft. ☒ E. ☐ W.	Well Name: G152B
Facility License, Permit or Monitoring No.	Local Grid Origin ☒ (estimated: ☐) or Well Location ☐ Lat. ° ' " Long. ° ' " or St. Plane Illinois East Zone ft. N, ft. E. S / C / (N)	Date Well Installed: 01/30/2013
Facility ID	Section Location of Waste/Source: 1/4 of 1/4 of Sec. , T. N, R. ☐ E ☐ W	Well Installed By: (Person's Name and Firm): Matt Cooper, Kelron Environmental
Type of Well: Well Code 11/mw	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Gov. Lot Number
Distance from Waste/Source ft. / State: Illinois		

A. Protective pipe, top elevation ____ ft. (NAVD88)

B. Well casing, top elevation 347.48 ft. (NAVD88)

C. Land surface elevation 345.2 ft. (NAVD88)

D. Surface seal, bottom 344.2 ft. (NAVD88) or 1.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐
SM ☐ SC ☐ ML ☒ MH ☐ CL ☒ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☐ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐ ____

15. Drilling fluid used: Water ☐ 0 2 Air ☐ Drilling Mud ☐ 0 3 None ☒

16. Drilling additives used? ☒ Yes ☐

Describe N

17. Source of water (attach analysis, if required):
n/a

E. Bentonite seal, top 344.2 ft. (NAVD88) or 1.0 ft.

F. Fine sand, top ____ ft. (NAVD88) or ____ ft.

G. Filter pack, top 313.1 ft. (NAVD88) or 32.1 ft.

H. Screen joint, top 310.8 ft. (NAVD88) or 34.4 ft.

I. Well bottom 300.6 ft. (NAVD88) or 44.6 ft.

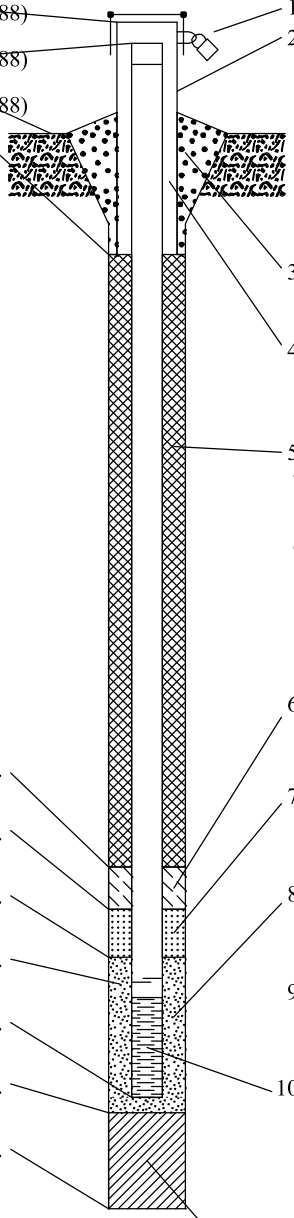
J. Filter pack, bottom 300.7 ft. (NAVD88) or 44.5 ft.

K. Borehole, bottom 300.7 ft. (NAVD88) or 44.5 ft.

L. Borehole, diameter 7.8 in.

M. O.D. well casing 2.38 in.

N. I.D. well casing 2.07 in.



Casing depth (well bottom) is greater than borehole bottom because the bottom well cap was pushed into the soft material at the base of the borehole.

1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: ____ in.
b. Length: ____ ft.
c. Material: Steel ☒ Other ☐ ____
d. Additional protection? ☐ Yes ☒ No
If yes, describe: ____
3. Surface seal: Bentonite ☐ Concrete ☒ Other ☐ ____
4. Material between well casing and protective pipe: Bentonite ☐ Other ☐ ____
5. Annular space seal: a. Granular/Chipped Bentonite ☒
b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ____ Lbs/gal mud weight . . . Bentonite slurry ☐
d. ____ % Bentonite . . . Bentonite-cement grout ☐
e. 14.5 Ft^3 volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☒
6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2 in. Bentonite chips ☐
c. ____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. ____
b. Volume added ____ ft^3
8. Filter pack material: Manufacturer, product name & mesh size
a. Filter Sil Silica
b. Volume added 7 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐ ____
10. Screen material: Schedule 40 PVC
a. Screen Type: Factory cut ☒ Continuous slot ☐ Other ☐ ____
b. Manufacturer ____
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☐ Other ☐ ____

I hereby certify that the information on this form is true and correct to the best of my knowledge. Date Modified: 2/19/2013

Signature ____ Firm Natural Resource Technology, 23713 W. Paul Road Suite D, Pewaukee, WI 53072 Tel: (262) 523-9000 Fax: (262) 523-9001

GEOTECHNOLOGY BORING LOGS AND WELL CONSTRUCTION LOGS

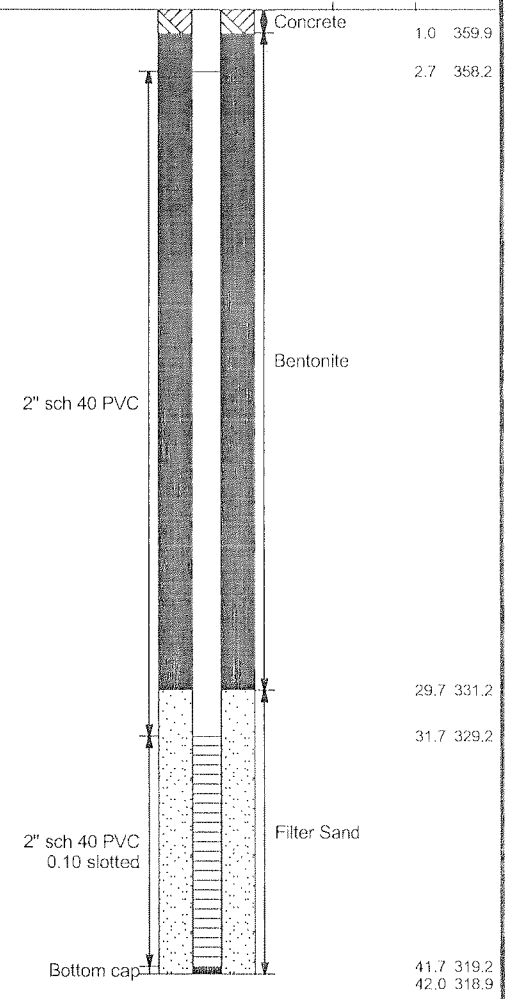
Surface Elevation: 360.9 | Completion Date: 6/19/10

Datum msl

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	GRAVEL			SS1
	Medium stiff to stiff, brown and gray, silty CLAY - (CL)		3-4-4-5	SS2
5			2-3-3-5	SS3
			3-3-4-4	SS4
	k = 1.6 x 10^{-8}cm/s		1-2-3-5	SS5
10			3-5-5-6	SS6
			2-4-5-6	SS7
15			2-3-4-5	SS8
	Medium stiff to stiff, brown and gray, silty CLAY, trace sand - CL		3-4-6-7	SS9
			3-4-6-6	SS10
20			3-5-7-8	SS11
			3-5-7-9	SS12
25			2-3-5-6	SS13
			3-5-7-6	SS14
			3-5-8-8	SS15
30			4-7-9-4	SS16
			4-4-6-7	SS17
35			2-4-3-5	SS18
	Medium stiff to very stiff, brown and gray, sandy CLAY with silt - CL		5-5-7-14	SS19
			13-13-10 -8	SS20
40			2-4-6-7	SS21
	Boring terminated at 42 feet.			
45				
50				

WELL DIAGRAM

Flushmount



NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002 WL J017150.02ENV - EEI JOPPA.GPJ GTINC 063301.GPJ 9/22/10

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

___ AUGER ___ HOLLOW STEM

WASHBORING FROM ___ FEET

PH DRILLER BGF LOGGER

___ DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: KA	Checked by: RJP	App'vd. by: RAP
Date: 7/14/10	Date: 9/20/10	Date: 9/20/10

GEOTECHNOLOGY INC
FROM THE GROUND UP

Ash Pond Evaluation
EEI Facility
Joppa, Illinois

LOG OF BORING: G-151

Project No. J017150.02

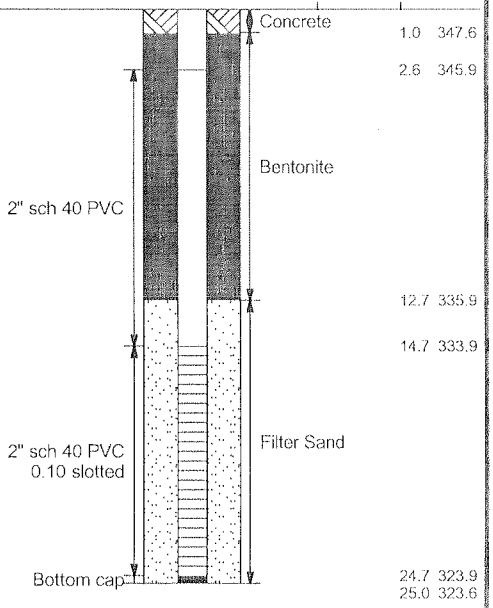
Surface Elevation: 348.56 | Completion Date: _____

Datum msl

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	Medium stiff, brown CLAY with organics - CH		2-3-3-4	SS1
	Medium stiff, brown and gray, silty CLAY - (CL)		1-1-2-3	SS2
5			1-2-3-5	SS3
			2-3-4-5	SS4
			1-3-4-4	SS5
10			2-3-5-5	SS6
	becoming stiff		2-5-8-9	SS7
15			2-5-3-6	SS8
			3-5-5-7	SS9
	trace sand to 25 feet		3-4-7-6	SS10
20	k = 1.1 x 10^{-8}cm/s	▽	3-6-10-9	SS11
			2-4-5-5	SS12
25	Boring terminated at 25 feet.			
30				
35				
40				
45				
50				

WELL DIAGRAM

Flushmount



NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002 WL J017150.02ENV - EEI JOPPA.GPJ GTINC 063301.GPJ 9/22/10

GROUNDWATER DATA

ENCOUNTERED AT 20 FEET ▽

DRILLING DATA

___ AUGER ___ HOLLOW STEM

WASHBORING FROM ___ FEET

PH DRILLER BGF LOGGER

ATV DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: KA	Checked by: KGP	App'vd. by: KGP
Date: 7/14/10	Date: 9/20/10	Date: 9/20/10

GEOTECHNOLOGY INC
FROM THE GROUND UP

Ash Pond Evaluation
EEI Facility
Joppa, Illinois

LOG OF BORING: G-152

Project No. J017150.02

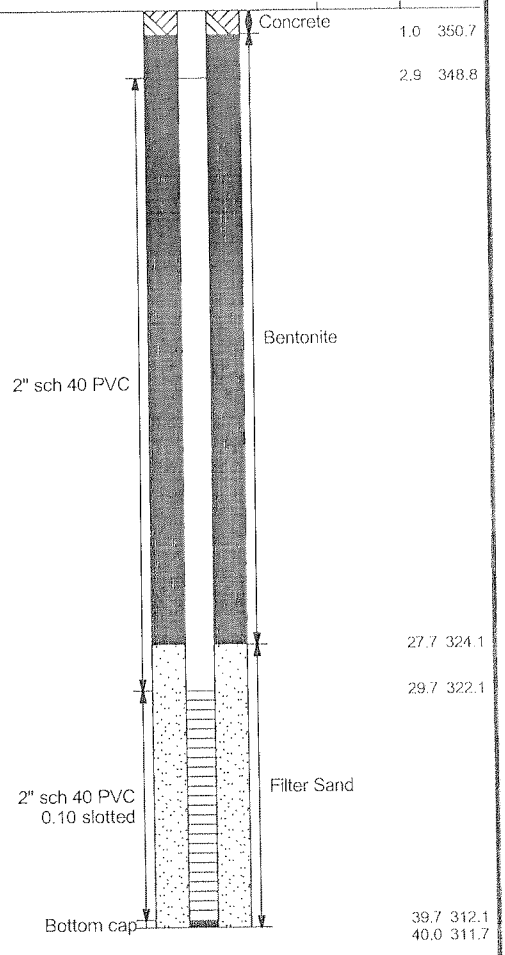
Surface Elevation: 351.73 | Completion Date: 6/18/10

Datum msl

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	Medium stiff, brown and gray CLAY - CH		2-2-3-4	SS1
	Soft, brown and gray CLAY - CH		1-1-2-1	SS2
5	Medium stiff to stiff, brown, silty CLAY, trace sand - (CL)		1-2-4-4	SS3
			2-4-4-5	SS4
10			2-3-6-6	SS5
			3-5-5-6	SS6
			1-4-4-8	SS7
15	k = 1.2 x 10^{-6}cm/s		2-4-5-8	SS8
			2-6-6-7	SS9
20			3-5-7-7	SS10
			2-5-7-8	SS11
			3-5-6-7	SS12
25			4-4-6-6	SS13
	Very stiff to stiff, brown, silty CLAY - CL		4-8-8-11	SS14
			3-4-7-9	SS15
30			4-6-8-10	SS16
	Stiff, brown, sandy CLAY with silt - CL		5-6-6-8	SS17
			3-4-6-8	SS18
35			5-5-7-7	SS19
	Stiff, brown clayey SILT - ML		2-3-6-7	SS20
40	Boring terminated at 40 feet.			
45				
50				

WELL DIAGRAM

Flushmount



NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002 WL J017150.02ENV - EEI JOPPA.GPJ GTINC 0638301.GPJ 9/22/10

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

___ AUGER ___ HOLLOW STEM

WASHBORING FROM ___ FEET

PH DRILLER BGF LOGGER

ATV DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: KA	Checked by: KGP	App'vd. by: KGP
Date: 7/14/10	Date: 9/20/10	Date: 9/20/10

GEOTECHNOLOGY INC
FROM THE GROUND UP

Ash Pond Evaluation
EEI Facility
Joppa, Illinois

LOG OF BORING: G-153

Project No. J017150.02

APPENDIX C
GEOTECHNICAL LABORATORY REPORTS

Via email: akreinberg@geosyntec.com

March 29, 2021

Ms. Allison Kreinberg
Geosyntec Consultants, Inc.
941 Chatham Lane Suite 103
Columbus, Ohio 43221

Re: Laboratory Testing Services
Vistra Energy
Joppa, Illinois
Geotechnology Project No. J037936.01

Dear Ms. Kreinberg:

Provided herein are the laboratory test results for the referenced project. Our services were performed in accordance with ASTM procedures.

This report has been prepared for the exclusive use of Geosyntec Consultants, Inc. Our scope of services was limited to performing specific tests on the provided samples and did not include engineering or interpretation of the test results.

Our services shall not be construed to constitute an expressed or implied warranty, including, but not limited to, any warranty for merchantability or fitness for a particular use. We do not accept responsibility for the manner in which the test results are used.

It has been our pleasure to provide laboratory testing services to you, and we would welcome the opportunity to provide other services during the course of the project. Please contact us if you need further information or clarification about this document.

* * * * *

Yours very truly,
GEOTECHNOLOGY, INC.

Erin Grimes
Laboratory Manager

EKG/CKK:ekg

Attachments: Appendix A – Summary of Laboratory Results
Appendix B – Atterberg Limits Results
Appendix C – Grain Size Distribution
Appendix D – Test Report

Copies submitted: PDF

APPENDIX A

Summary of Laboratory Results

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Moisture Content (%)	Dry Unit Weight (pcf)	Qu/2 (tsf)	Specific Gravity (20°C)
G03	32.0	27	16	11	9.5	45.6	SC	15.5	113.0		2.659
G03	60.0				12.5	4.1	SP	20.0			2.671
G09M	16.0	39	16	23	2	95.0	CL	20.6	105.0		2.666
G09M	46.0	35	15	20	2	82.8	CL	19.8	106.0		2.715
G09M	84.0				9.5	1.9	SP	7.6	100.0		2.686
G09M	112.0				9.5	15.2		25.5	87.0		2.675
G11	24.0	36	15	21	2	88.5	CL	18.5	109.0		2.688
G11	56.0	NP	NP	NP	9.5	12.1	SM	14.4	110.0		2.661
XPW01	6.0	NP	NP	NP	25	28.3	SM	34.7	85.0		2.711
XPW01	48.0	25	20	5	2	81.3	CL-ML	31.7	88.0		2.675
XPW02	22.0	NP	NP	NP	12.5	16.6	SM	47.6	74.0		2.567
XPW03	22.0				2	95.8		45.4			2.410
XPW03	36.0	46	31	15	2	90.6	ML	46.5	66.0		1.999

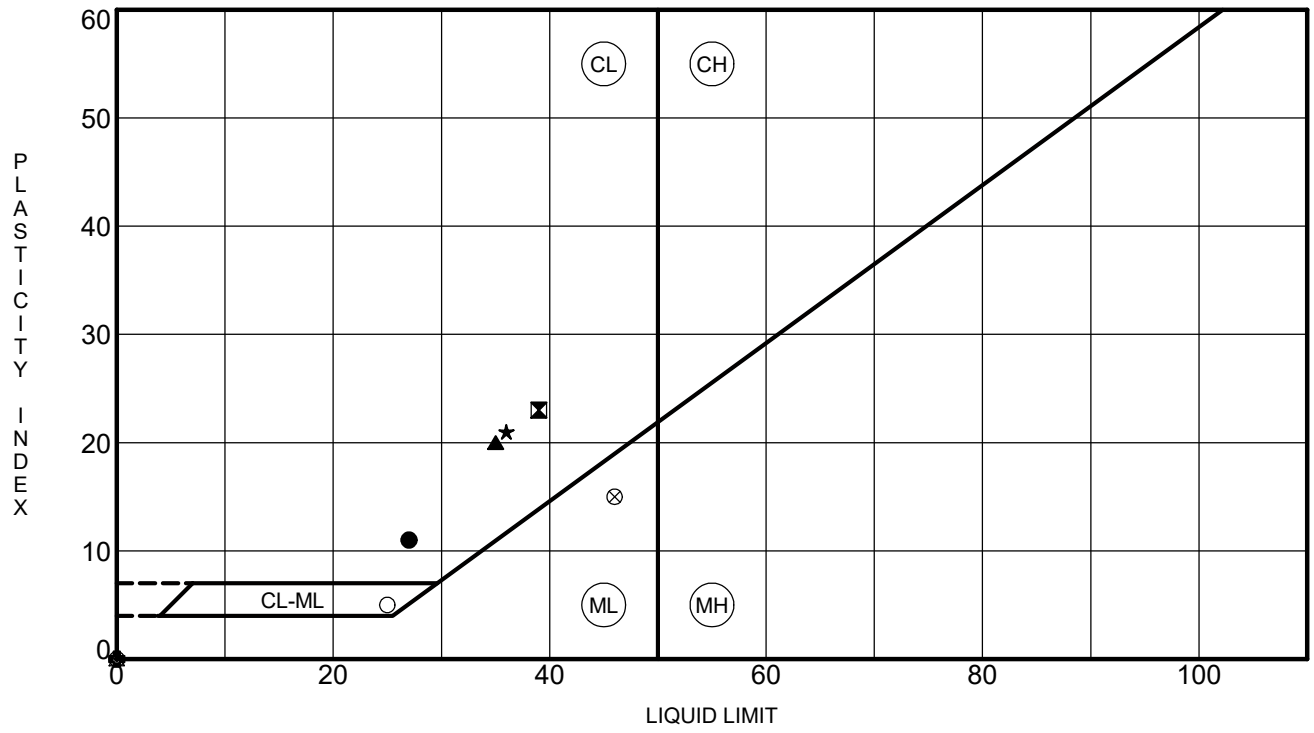
GEOTECHNOLOGY INC
FROM THE GROUND UP

Summary of Laboratory Results

Vistra Energy
Joppa, Illinois
J037936.01

APPENDIX B

Atterberg Limits Results



	Boring	Depth (ft.)	LL	PL	PI	Fines	Sample Description
●	G03	32.0	27	16	11	46	CLAYEY SAND(SC)
⧓	G09M	16.0	39	16	23	95	LEAN CLAY(CL)
▲	G09M	46.0	35	15	20	83	LEAN CLAY with SAND(CL)
★	G11	24.0	36	15	21	89	LEAN CLAY(CL)
⊙	G11	56.0	NP	NP	NP	12	SILTY SAND(SM)
✿	XPW01	6.0	NP	NP	NP	28	SILTY SAND with GRAVEL(SM)
○	XPW01	48.0	25	20	5	81	SILTY CLAY with SAND(CL-ML)
△	XPW02	22.0	NP	NP	NP	17	SILTY SAND(SM)
⊗	XPW03	36.0	46	31	15	91	SILT(ML)

GEOTECHNOLOGY INC
FROM THE GROUND UP

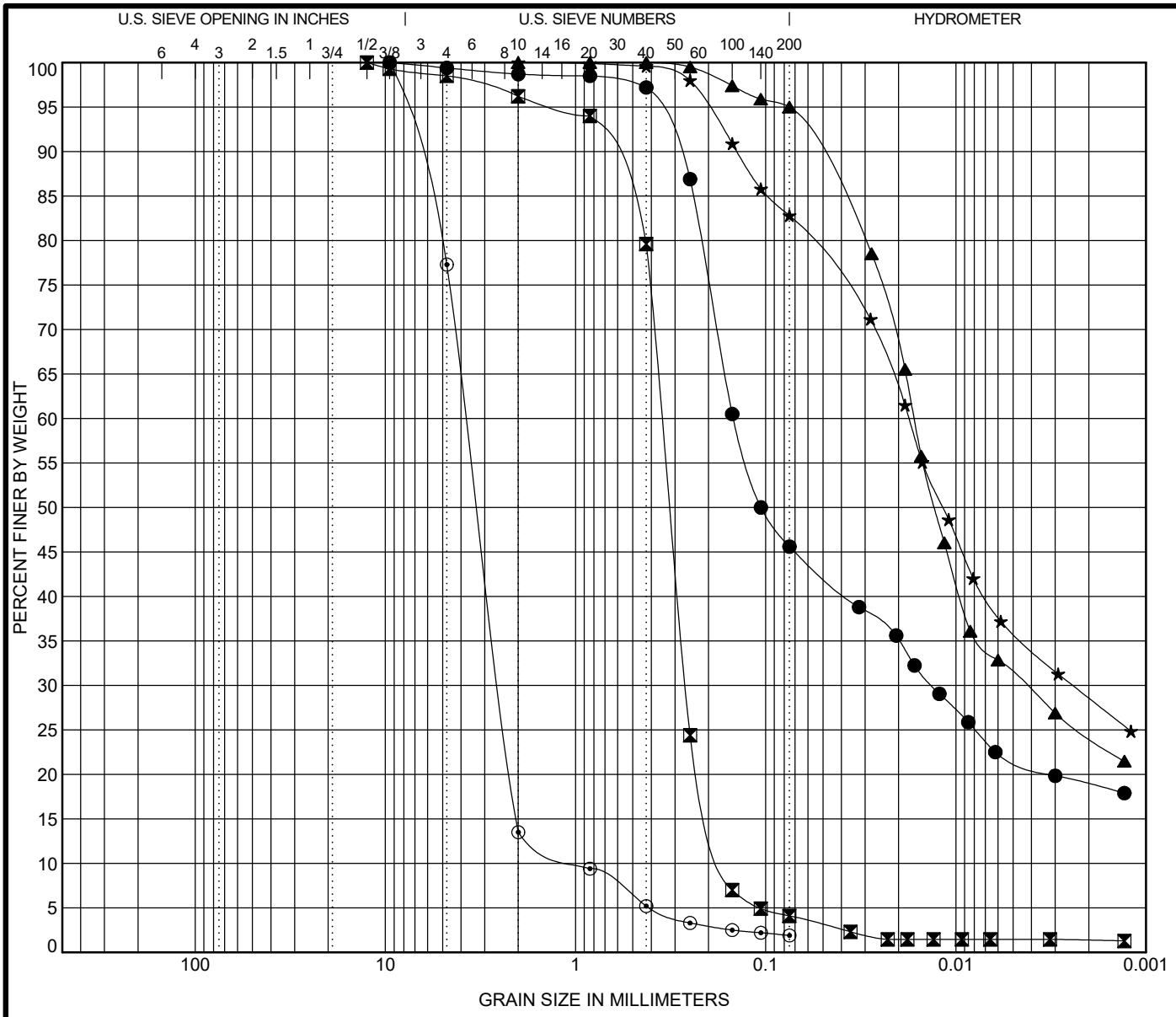
ATTERBERG LIMITS RESULTS

Vistra Energy
Joppa, Illinois
J037936.01

ATTERBERG LIMIT 2018 J037936.01 - VISTRA JOPPA.GPJ 00 CLONE ME.GPJ 3/25/21

APPENDIX C

Grain Size Distribution



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Depth (ft.)	Sample Description	LL	PL	PI	Cc	Cu
●	G03	32.0	CLAYEY SAND(SC)	27	16	11		
⊠	G03	60.0	POORLY GRADED SAND(SP)				1.21	2.15
▲	G09M	16.0	LEAN CLAY(CL)	39	16	23		
★	G09M	46.0	LEAN CLAY with SAND(CL)	35	15	20		
⊙	G09M	84.0	POORLY GRADED SAND with GRAVEL(SP)				1.75	3.94

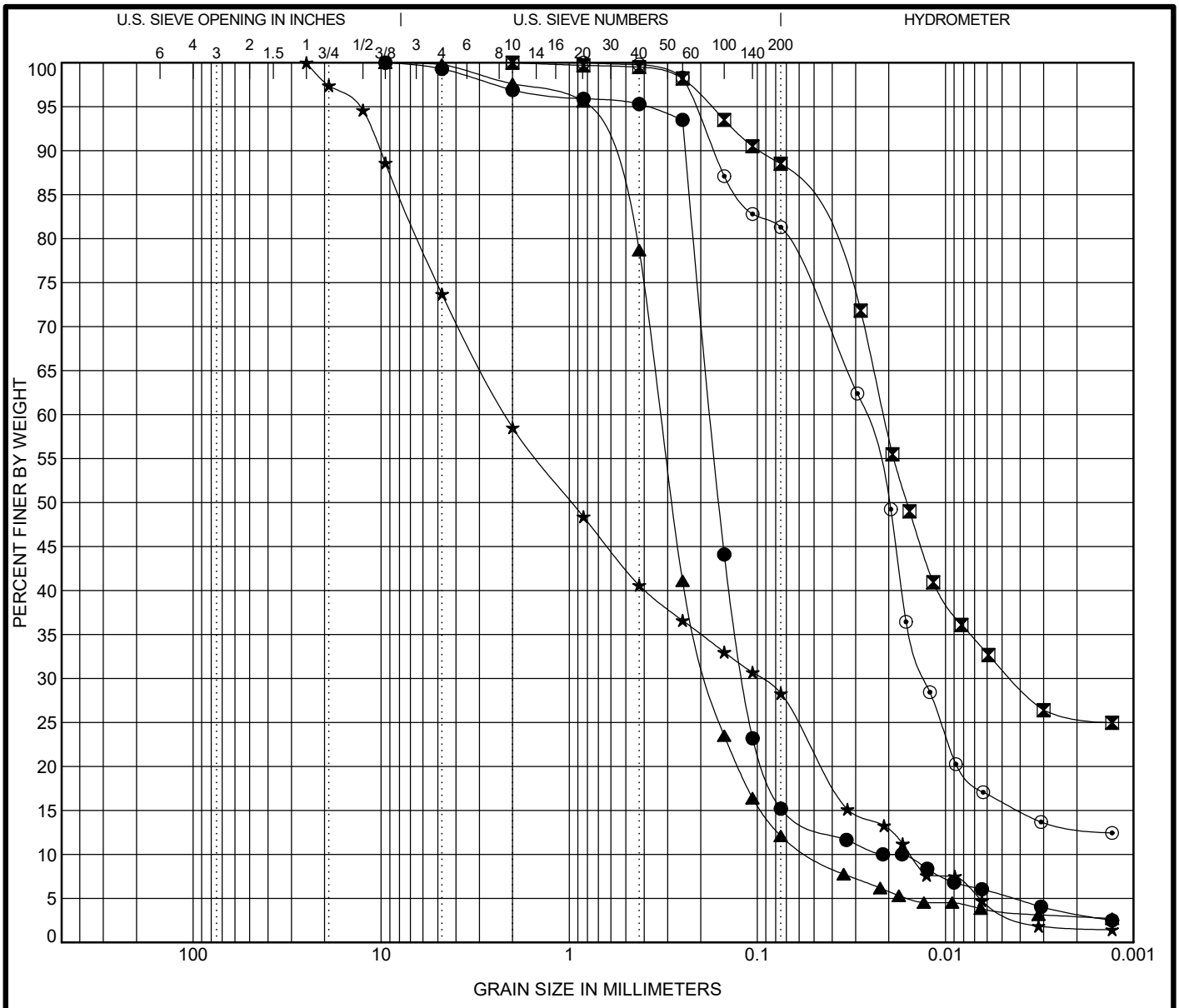
	Boring	Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	G03	32.0	9.5	0.15	0.01		0.6	53.8	23.9	21.7
⊠	G03	60.0	12.5	0.35	0.26	0.164	1.5	94.4	2.6	1.5
▲	G09M	16.0	2	0.02	0		0.0	5.0	63.7	31.3
★	G09M	46.0	2	0.02	0		0.0	17.2	46.9	35.9
⊙	G09M	84.0	9.5	3.76	2.5	0.954	22.7	75.4	1.9	

GEOTECHNOLOGY INC
FROM THE GROUND UP

GRAIN SIZE DISTRIBUTION

Vistra Energy
Joppa, Illinois
J037936.01

GRAIN SIZE 2018 J037936.01 - VISTRA JOPPA.GPJ 00 CLONE ME.GPJ 3/25/21



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Depth (ft.)	Sample Description	LL	PL	PI	Cc	Cu
●	G09M	112.0					4.69	10.42
⊠	G11	24.0	LEAN CLAY(CL)	36	15	21		
▲	G11	56.0	SILTY SAND(SM)	NP	NP	NP	1.94	6.30
★	XPW01	6.0	SILTY SAND with GRAVEL(SM)	NP	NP	NP	0.28	142.34
⊙	XPW01	48.0	SILTY CLAY with SAND(CL-ML)	25	20	5		

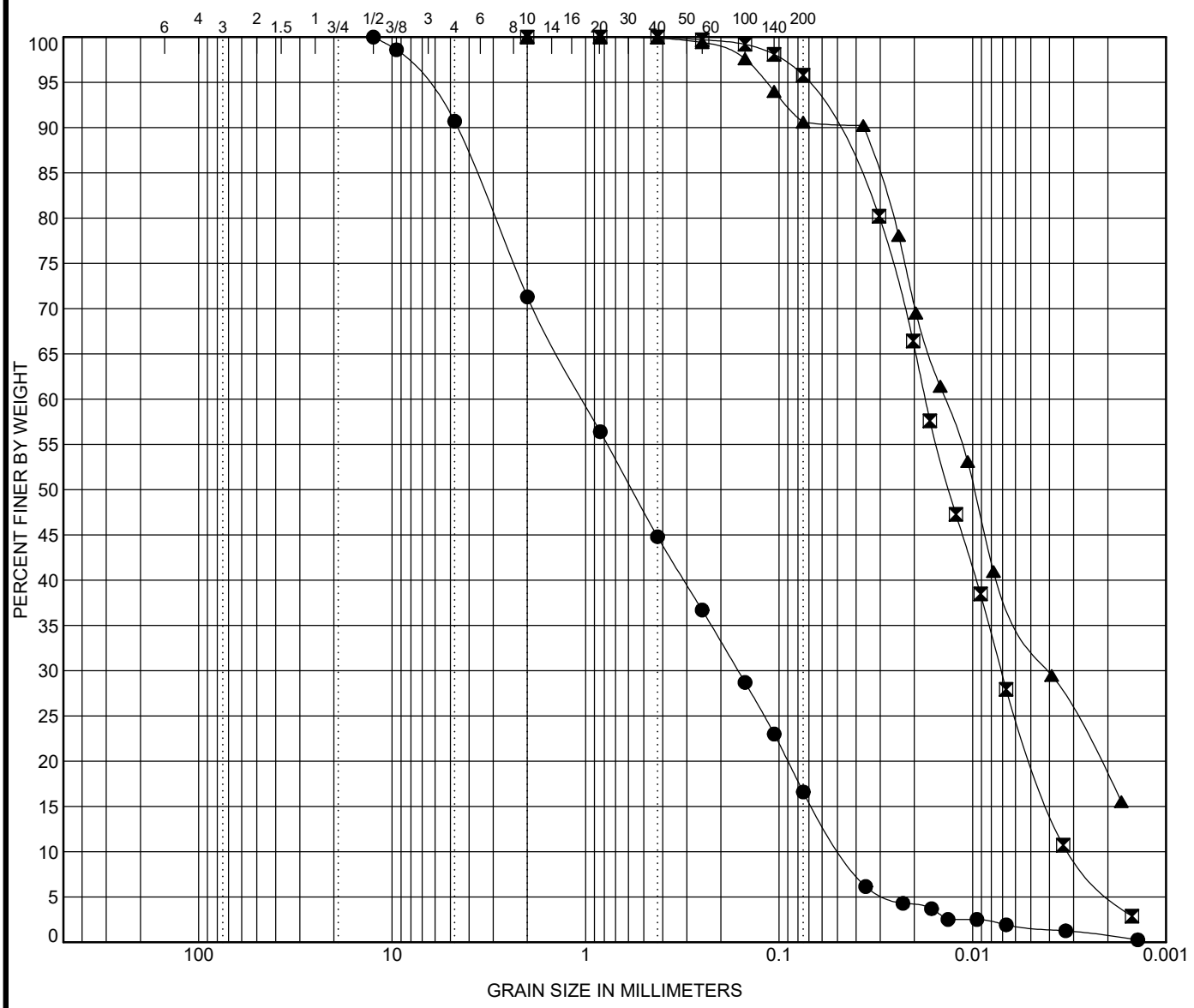
	Boring	Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	G09M	112.0	9.5	0.18	0.12	0.017	0.7	84.1	9.8	5.4
⊠	G11	24.0	2	0.02	0		0.0	11.5	57.4	31.1
▲	G11	56.0	9.5	0.33	0.18	0.052	0.2	87.7	8.5	3.6
★	XPW01	6.0	25	2.18	0.1	0.015	26.3	45.4	24.6	3.7
⊙	XPW01	48.0	2	0.03	0.01		0.0	18.7	65.3	16.0

GEOTECHNOLOGY INC
FROM THE GROUND UP

GRAIN SIZE DISTRIBUTION

Vistra Energy
Joppa, Illinois
J037936.01

GRAIN SIZE 2018 J037936.01 - VISTRA JOPPA.GPJ 00 CLONE ME.GPJ 3/25/21



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Depth (ft.)	Sample Description	LL	PL	PI	Cc	Cu
●	XPW02	22.0	SILTY SAND(SM)	NP	NP	NP	0.55	22.08
⊠	XPW03	22.0					0.91	5.56
▲	XPW03	36.0	SILT(ML)	46	31	15		

	Boring	Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	XPW02	22.0	12.5	1.04	0.16	0.047	9.3	74.1	15.0	1.6
⊠	XPW03	22.0	2	0.02	0.01	0.003	0.0	4.2	75.3	20.5
▲	XPW03	36.0	2	0.01	0		0.0	9.4	57.0	33.6

GEOTECHNOLOGY INC
FROM THE GROUND UP

GRAIN SIZE DISTRIBUTION

Vistra Energy
Joppa, Illinois
J037936.01

GRAIN SIZE 2018 J037936.01 - VISTRA JOPPA.GPJ 00 CLONE ME.GPJ 3/25/21

APPENDIX D

Test Report

Geotechnology, Inc.
11816 Lackland Road, Suite 150
St. Louis, MO 63146
314-997-7440

TEST REPORT

Prepared For:
Geosyntec Consultants, Inc.
941 Chatham Lane Suite 103
Columbus, Ohio 43221

Project No.:	**J037936.01**	**March 29, 2021**
Project Name:	**Vistra Energy - Joppa**	**Page 1 of 1**
Sampled By:	**Geotechnology, Inc.**	
Attention:	**Ms. Allison Kreinberg**	

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST & DENSITY DETERMINATION (UNIT WEIGHT) ASTM D5084 & D7263

Sample #	Moisture Content (%)	Initial Wet Density (pcf)	Initial Dry Density (pcf)	Hydraulic Conductivity (cm/s)
G03-(32-34)	15.5	130.2	112.7	4.7×10^{-7}
G09M-(16-18)	20.6	127.1	105.4	8.3×10^{-8}
G09M-(46-48)	19.8	126.6	105.7	3.5×10^{-7}
G11-(24-26)	18.5	129.4	109.1	5.6×10^{-8}
XPW01-(6-8)*	34.2	114.8	85.6	2.1×10^{-5}
XPW01-(48-50)	31.7	115.5	87.7	2.8×10^{-7}
XPW03-(36-38)	46.5	96.3	65.7	1.8×10^{-7}

* Remolded sample.

APPENDIX D
INFORMATION PERTINENT TO 35 I.A.C. § 845.220(a)(3)

TABLES

Table A-1. Surrounding Surface Water Bodies

Part 845
Joppa East Ash Pond (Unit ID: 401)
Joppa Power Station
Joppa, Illinois

HUC	Surface Water ID	Distance from Unit (m)	Physical Orientation to Unit	Hydraulic Orientation to Unit	Classification Code	Size (acres)	Notes
05140206	Riverine 1	0	SSE	Downgradient	R4SBC	0.29	
05140206	Freshwater Pond 1	0	SE	Downgradient	PUSCx	12.94	
05140206	Lake 1	0	NNE	Upgradient	L1UBHx	16.33	
05140206	Riverine 2	0	SSE	Downgradient	R5UBH	0.22	
05140206	Lake 2	0	NNW	Upgradient	L2USCx	34.52	
05140206	Riverine 3	0	ENE	Sidegradient	R5UBH	0.04	
05140206	Riverine 4	0	NNE	Upgradient	R5UBH	0.13	
05140206	Riverine 5	2	NE	Upgradient	R4SBC	5.43	
05140206	Freshwater Emergent Wetland 1	20	SE	Downgradient	PEM1Cx	1.20	
05140206	Freshwater Pond 2	40	SSE	Downgradient	PUBGx	1.41	
05140206	Freshwater Emergent Wetland 2	48	SSE	Downgradient	PEM1Cx	1.18	
05140206	Freshwater Forested/Shrub Wetland 1	97	N	Upgradient	PFO1A	6.04	
05140206	Freshwater Pond 3	105	N	Upgradient	PUBGh	2.70	
05140206	Freshwater Forested/Shrub Wetland 2	122	S	Downgradient	PSS1C	5.22	
05140206	Riverine 6	183	S	Downgradient	R4SBC	0.42	
05140206	Freshwater Forested/Shrub Wetland 3	281	S	Downgradient	PFO1A	9.86	
05140206	Riverine 7	296	WSW	Sidegradient	R4SBC	1.81	
05140206	Freshwater Emergent Wetland 3	317	NW	Sidegradient	PEM1A	7.39	
05140206	Riverine 8	342	SE	Downgradient	R5UBH	0.06	
05140206	Riverine 9	351	SSE	Downgradient	R4SBC	1.53	
05140206	Freshwater Pond 4	393	WNW	Sidegradient	PUSCx	22.54	
05140206	Freshwater Pond 5	402	E	Sidegradient	PUBGx	0.24	
05140206	Freshwater Pond 6	431	NNW	Upgradient	PUBGx	0.22	
05140206	Riverine 10	453	S	Downgradient	R4SBC	0.11	
05140206	Freshwater Pond 7	456	NNW	Upgradient	PUBGx	0.27	
05140206	Freshwater Pond 8	476	NE	Upgradient	PUBGh	0.95	
05140206	Freshwater Pond 9	481	NNW	Upgradient	PUBGx	0.24	
05140206	Freshwater Pond 10	490	SSW	Downgradient	PUBGx	4.22	
05140206	Riverine 11	498	S	Downgradient	R4SBC	0.15	
05140206	Freshwater Pond 11	506	NW	Upgradient	PUBGh	1.88	
05140206	Freshwater Pond 12	534	NNW	Upgradient	PUBGx	0.21	
05140206	Riverine 12	556	S	Downgradient	R4SBC	0.14	
05140206	Freshwater Pond 13	562	NW	Sidegradient	PUBGx	1.66	
05140206	Freshwater Pond 14	565	NNW	Upgradient	PUBGx	0.22	
05140206	Freshwater Pond 15	571	WSW	Sidegradient	PUBGx	0.55	
05140206	Freshwater Pond 16	574	E	Sidegradient	PUBGx	0.29	
05140206	Freshwater Pond 17	575	NW	Upgradient	PUBGh	2.33	
05140206	Riverine 13 (Ohio River)	601	S	Downgradient	R2UBH	26072.13	
05140206	Freshwater Forested/Shrub Wetland 4	601	S	Downgradient	PFO1Ah	18.54	
05140206	Freshwater Emergent Wetland 4	612	WSW	Sidegradient	PEM1Cx	4.35	
05140206	Freshwater Forested/Shrub Wetland 5	621	NNW	Upgradient	PSS1C	4.71	
05140206	Freshwater Pond 18	625	ESE	Sidegradient	PUBGh	0.26	
05140206	Freshwater Forested/Shrub Wetland 6	626	WSW	Sidegradient	PFO1Ch	4.83	

Table A-1. Surrounding Surface Water Bodies

Part 845
Joppa East Ash Pond (Unit ID: 401)
Joppa Power Station
Joppa, Illinois

HUC	Surface Water ID	Distance from Unit (m)	Physical Orientation to Unit	Hydraulic Orientation to Unit	Classification Code	Size (acres)	Notes
05140206	Freshwater Pond 19	630	N	Upgradient	PUBGh	1.30	
05140206	Freshwater Pond 20	633	ENE	Sidegradient	PUBGx	1.43	
05140206	Riverine 14	636	ESE	Sidegradient	R4SBC	0.53	
05140206	Freshwater Pond 21	644	NNE	Upgradient	PUBGh	0.24	
05140206	Freshwater Pond 22	648	WSW	Sidegradient	PUBGx	1.85	
05140206	Riverine 15	660	E	Sidegradient	R4SBC	1.52	
05140206	Freshwater Pond 23	685	ENE	Sidegradient	PUBGx	0.72	
05140206	Freshwater Emergent Wetland 5	713	SE	Sidegradient	PEM1A	2.54	
05140206	Freshwater Pond 24	740	NE	Upgradient	PUBGh	1.99	
05140206	Riverine 16	766	SE	Sidegradient	R4SBC	0.08	
05140206	Freshwater Emergent Wetland 6	818	NE	Sidegradient	PEM1F	0.26	
05140206	Riverine 17	858	ESE	Sidegradient	R4SBC	0.05	
05140206	Freshwater Forested/Shrub Wetland 7	924	ESE	Sidegradient	PFO1A	9.16	
05140206	Freshwater Emergent Wetland 7	988	WSW	Sidegradient	PEM1Ch	5.10	

Notes:

List of wetlands and water bodies obtained from the US Fish and Wildlife Service. Distance and direction were calculated by Geosyntec.
Based on groundwater elevation contour maps in the vicinity of the EAP from 2015 to 2020, groundwater predominantly flows to the south, towards the Ohio River (Ramboll, 2020).
Distance and direction from EAP were calculated by Geosyntec.
Wetlands and surface water features located within 1,000 meters of the Joppa EAP are included in this table.
Watershed codes are provided as HUC8
m = meter/meters
EAP = East Ash Pond
HUC = Hydrologic Unit Code
E = east
ENE = east-northeast
ESE = east-southeast
N = north
NE = northeast
NNE = north-northeast
NNW = north-northwest
NW = northwest
S = south
SE = southeast
SSE = south-southeast
SSW = south-southwest
W = west
WNW = west-northwest
WSW = west-southwest

Table A-2. Surrounding Wells

Part 845
Joppa East Ash Pond (Unit ID: 401)
Joppa Power Station
Joppa, Illinois

Well Number	Date Constructed	Ground Elevation (ft NAVD88/ GEOID 12A)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft NAVD88/ GEOID 12A)	Screen Bottom Elevation (ft NAVD88/ GEOID 12A)	Bottom of Boring Elevation (ft NAVD88/ GEOID 12A)	Screen Length (ft)	Screen Diameter (inches)	Well Depth from Ground Surface (ft bgs)
121270005000	12/31/1950	--	--	--	--	--	--	--	--	350
121270003100	3/31/1941	340	--	--	--	--	184	--	--	156
121270005300	12/31/1950	348	--	--	--	--	113	--	--	235
121270003000	12/31/1940	--	--	--	--	--	--	--	--	153
121270015800	6/30/1971	--	--	--	--	--	--	--	--	160
121270005100	12/31/1950	355	--	--	--	--	-48	--	--	403
121270000100	6/30/1955	--	--	--	--	--	--	--	--	304
121270011100	8/20/1969	--	58	78	--	--	--	20	--	78
121272067500	10/8/1994	--	85	94	--	--	--	9	--	94
121270005200	3/31/1940	340	--	--	--	--	202	--	--	138
121270005400	5/31/1940	340	--	--	--	--	203	--	--	137
121272106100	--	--	89	92	--	--	--	3	--	92
121272094200	--	--	0	0	--	--	--	--	--	90
121270005500	12/31/1940	340	--	--	--	--	275	--	--	65
121270014600	--	--	0	0	--	--	--	--	--	150
121272103000	3/29/2000	--	175	200	--	--	--	25	--	202
121272103900	2/28/2000	380	228	238	152	142	142	10	--	238

Notes:

Water well information obtained from the Illinois Geological Survey (ISGS) Illinois Water Wells (ILWATER) database.
Based on groundwater elevation contour maps in the vicinity of the EAP from 2015 to 2020, groundwater predominantly flows to the south, towards the Ohio River (Ramboll, 2020).
Distance and direction from EAP were calculated by Geosyntec.
Wells located within 1,000 meters of the Joppa EAP are included in this table.
bgs = below ground surface
EAP = East Ash Pond
D = downgradient
DD = decimal degrees
m = meter/meters
S= Source water (Porewater or Pond water)
Sd= Sidegradient
U = upgradient
-- = information not available

Table A-2. Surrounding Wells

Part 845
Joppa East Ash Pond (Unit ID: 401)
Joppa Power Station
Joppa, Illinois

Well Number	Total Boring Depth (ft BGS)	State Planar Northing - Y (NAD83/ East Zone)	State Planar Easting - X (NAD 83/ East Zone)	Latitude (DD)	Longitude (DD)	X, Y Survey Date	Hydraulic Position Designation (B/Sd/U/D/P)	Distance From Unit (m)
121270005000	350	832181.9016	198703.512	37.211275	-88.855516	--	D	31
121270003100	156	834193.2389	199582.7676	37.21372	-88.848626	--	Sd	135
121270005300	235	831120.9491	198963.8992	37.211974	-88.859164	--	Sd	172
121270003000	153	834531.0745	199909.0024	37.214621	-88.847472	--	Sd	202
121270015800	160	834566.0707	201903.8157	37.2201	-88.847389	--	U	265
121270005100	403	834758.5822	199868.0796	37.214512	-88.84669	--	Sd	272
121270000100	304	831780.3209	197864.2513	37.208964	-88.856879	--	D	311
121270011100	78	834190.3525	202959.6159	37.222994	-88.848699	--	U	336
121272067500	94	833923.7478	203248.3576	37.223783	-88.84962	--	U	382
121270005200	138	835331.0223	198557.073	37.21092	-88.8447	--	Sd	559
121270005400	137	833533.3056	196430.9199	37.205054	-88.850833	--	D	586
121272106100	92	835895.5226	201878.7907	37.220051	-88.842823	--	Sd	646
121272094200	90	834126.7172	196134.2069	37.204248	-88.84879	--	D	733
121270005500	65	834126.7172	196134.2069	37.204248	-88.84879	--	D	733
121270014600	150	836570.23	202533.8594	37.22186	-88.840518	--	Sd	906
121272103000	202	831277.4113	203965.296	37.225712	-88.858722	--	U	912
121272103900	238	829190.2249	201364.3963	37.218537	-88.86584	--	Sd	971

Notes:

Water well information obtained from the Illinois Geological Survey (ISGS) Illinois Water Wells (ILWATER) database.
Based on groundwater elevation contour maps in the vicinity of the EAP from 2015 to 2020, groundwater predominantly flows to the south, towards the Ohio River (Ramboll, 2020).
Distance and direction from EAP were calculated by Geosyntec.
Wells located within 1,000 meters of the Joppa EAP are included in this table.
bgs = below ground surface
EAP = East Ash Pond
D = downgradient
DD = decimal degrees
m = meter/meters
S= Source water (Porewater or Pond water)
Sd= Sidegradient
U = upgradient
-- = information not available

Table A-3 Threatened and Endangered Species

Part 845
Joppa East Ash Pond (Unit ID: 401)
Joppa Power Station
Joppa, Illinois

Scientific Name	Common Name	Status	Distance from Unit (m)	Physical Orientation to Unit	Hydraulic Orientation to Unit	Occurences	Last Observed	Notes
Actaea rubifolia	Black Cohosh	LE	--	--	--	1	August 2013	Habitat identified at the county level only
Amorpha nitens	Smooth False Indigo	LE	--	--	--	1	June 2004	Habitat identified at the county level only
Asio flammeus	Short-eared Owl	LE	--	--	--	1	December 2005	Habitat identified at the county level only
Carex gigantea	Large Sedge	LE	--	--	--	2	June 2018	Habitat identified at the county level only
Carex intumescens	Swollen Sedge	LE	--	--	--	1	July 2018	Habitat identified at the county level only
Carex reniformis	Sedge	LE	--	--	--	3	June 2010	Habitat identified at the county level only
Carya aquatica	Water Hickory	LT	--	--	--	4	July 1905	Habitat identified at the county level only
Chamaelirium luteum	Fairy Wand	LE	--	--	--	2	June 2015	Habitat identified at the county level only
Cryptobranchus alleganiensis	Hellbender	LE	--	--	--	1	April 1956	Habitat identified at the county level only
Cyclonaias tuberculata	Purple Wartyback	LT	--	--	--	2	October 2016	Habitat identified at the county level only
Cyperus lancastriensis	Galingale	LT	--	--	--	1	October 2005	Habitat identified at the county level only
Ellipsaria lineolata	Butterfly	LT	--	--	--	4	November 2018	Habitat identified at the county level only
Elliptio crassidens	Elephant-ear	LE	--	--	--	3	November 2018	Habitat identified at the county level only
Eryngium prostratum	Eryngo	LE	--	--	--	1	August 2002	Habitat identified at the county level only
Euonymus americanus	American Strawberry Bush	LT	--	--	--	2	August 2013	Habitat identified at the county level only
Eurynia dilatata	Spike	LE	--	--	--	1	September 2014	Habitat identified at the county level only
Faxonius placidus	Bigclaw Crayfish	LE	--	--	--	3	July 2001	Habitat identified at the county level only
Galactia mohlenbrockii	Boykin's Dioclea	LE	--	--	--	2	July 1905	Habitat identified at the county level only
Gallinula galeata	Common Gallinule	LE	--	--	--	1	July 2013	Habitat identified at the county level only
Halesia carolina	Silverbell Tree	LE	--	--	--	2	April 2016	Habitat identified at the county level only
Helianthus angustifolius	Narrow-leaved Sunflower	LE	--	--	--	4	October 2015	Habitat identified at the county level only
Hyla avivoca	Bird-voiced Treefrog	LT	--	--	--	1	September 2019	Habitat identified at the county level only
Iresine rhizomatosa	Bloodleaf	LE	--	--	--	1	June 1905	Habitat identified at the county level only
Ixobrychus exilis	Least Bittern	LT	--	--	--	1	June 2005	Habitat identified at the county level only
Lanius ludovicianus	Loggerhead Shrike	LE	--	--	--	1	June 1986	Habitat identified at the county level only
Lepomis miniatus	Redspotted Sunfish	LT	--	--	--	2	July 1987	Habitat identified at the county level only
Malus angustifolia	Narrow-leaved Crabapple	LE	--	--	--	1	June 2019	Habitat identified at the county level only
Margaritifera monodonta	Spectaclecase	LE	--	--	--	1	August 1994	Habitat identified at the county level only
Melanthera nivea	White Melanthera	LE	--	--	--	1	October 2005	Habitat identified at the county level only
Melica mutica	Two-flowered Melic Grass	LE	--	--	--	3	April 2016	Habitat identified at the county level only
Melothria pendula	Squirting Cucumber	LT	--	--	--	1	May 2004	Habitat identified at the county level only
Myotis austroriparius	Southeastern Myotis	LE	--	--	--	1	June 2005	Habitat identified at the county level only
Myotis septentrionalis	Northern Long-eared Myotis	LT	--	--	--	1	July 2005	Habitat identified at the county level only
Nemophila triloba	Baby blue-eyes	LE	--	--	--	1	April 2010	Habitat identified at the county level only
Nerodia fasciata	Southern Watersnake	LE	--	--	--	1	March 2004	Habitat identified at the county level only
Notropis maculatus	Taillight Shiner	LE	--	--	--	1	July 1988	Habitat identified at the county level only
Noturus stigmosus	Northern Madtom	LE	--	--	--	1	2009-07	Habitat identified at the county level only
Nyctanassa violacea	Yellow-crowned Night-Heron	LE	--	--	--	1	July 1998	Habitat identified at the county level only
Pandion haliaetus	Osprey	LT	--	--	--	5	July 1905	Habitat identified at the county level only
Phaeophyscia leana	Lea's Bog Lichen	LT	--	--	--	2	February 2002	Habitat identified at the county level only
Phemeranthus parviflorus	Small Flower-of-an-hour	LT	--	--	--	1	May 1952	Habitat identified at the county level only
Planera aquatica	Water Elm	LT	--	--	--	2	October 2005	Habitat identified at the county level only
Platanthera flava	Tubercled Orchid	LT	--	--	--	1	June 1976	Habitat identified at the county level only

Table A-3 Threatened and Endangered Species

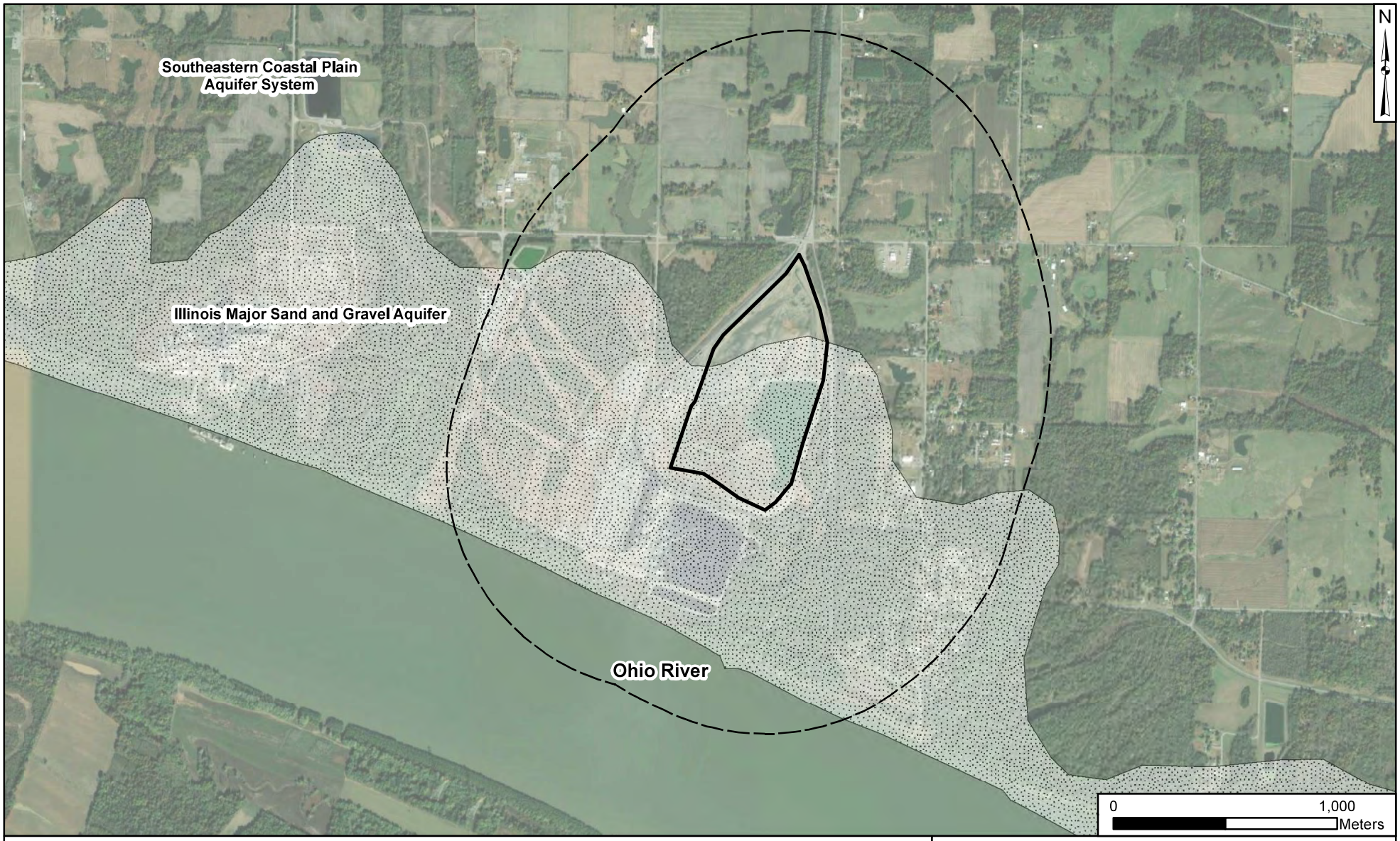
Part 845
Joppa East Ash Pond (Unit ID: 401)
Joppa Power Station
Joppa, Illinois

Scientific Name	Common Name	Status	Distance from Unit (m)	Physical Orientation to Unit	Hydraulic Orientation to Unit	Occurences	Last Observed	Notes
Plethobasus cooperianus	Orange-foot Pimpleback	LE	--	--	--	1	October 2015	Habitat identified at the county level only
Plethobasus cyphyus	Sheepnose	LE	--	--	--	3	July 1905	Habitat identified at the county level only
Pleurobema cordatum	Ohio Pigtoe	LE	--	--	--	2	November 2018	Habitat identified at the county level only
Potamilus capax	Fat Pocketbook	LE	--	--	--	3	November 2018	Habitat identified at the county level only
Pseudemys concinna	River Cooter	LE	--	--	--	3	April 2019	Habitat identified at the county level only
Quadrula metanevra	Monkeyface	LT	--	--	--	3	August 1998	Habitat identified at the county level only
Quercus phellos	Willow Oak	LT	--	--	--	7	November 2019	Habitat identified at the county level only
Rallus elegans	King Rail	LE	--	--	--	1	June 2006	Habitat identified at the county level only
Reginaia ebenus	Ebonyshell	LE	--	--	--	4	November 2018	Habitat identified at the county level only
Rhexia mariana	Dull Meadow Beauty	LE	--	--	--	1	July 2018	Habitat identified at the county level only
Scirpus polyphyllus	Leafy Bulrush	LE	--	--	--	1	September 2019	Habitat identified at the county level only
Scleria pauciflora	Carolina Whipgrass	LE	--	--	--	1	June 2004	Habitat identified at the county level only
Setophaga cerulea	Cerulean Warbler	LT	--	--	--	1	1993-07	Habitat identified at the county level only
Sternula antillarum	Least Tern	LE	--	--	--	1	June 1996	Habitat identified at the county level only
Styrax americana	Storax	LT	--	--	--	5	September 2010	Habitat identified at the county level only
Thamnophis saurita	Eastern Ribbon Snake	LT	--	--	--	2	August 2020	Habitat identified at the county level only
Thelidermа cylindrica	Rabbitsfoot	LE	--	--	--	3	July 1905	Habitat identified at the county level only
Tilia heterophylla	White Basswood	LE	--	--	--	1	October 2005	Habitat identified at the county level only

Notes:

List of endangered species obtained from the Illinois Department of Natural Resources (IDNR)
-- = not provided/cannot be determined
m = meter/meters
LE = listed endangered
LT = listed threatened

FIGURES



Legend

- Illinois Major Sand and Gravel Aquifer
- East Ash Pond (EAP)
- Joppa EAP 1000-meter Buffer

Notes:

- The entire extent of the map is located on a designated Principal Aquifer.
- Principal Aquifer dataset was obtained from the United States Geologic Survey (USGS).
- Illinois Major Sand and Gravel Aquifer dataset was obtained from the Illinois Geological Survey (ISGS) .

Aquifers within 1,000 meters of the Joppa East Ash Pond

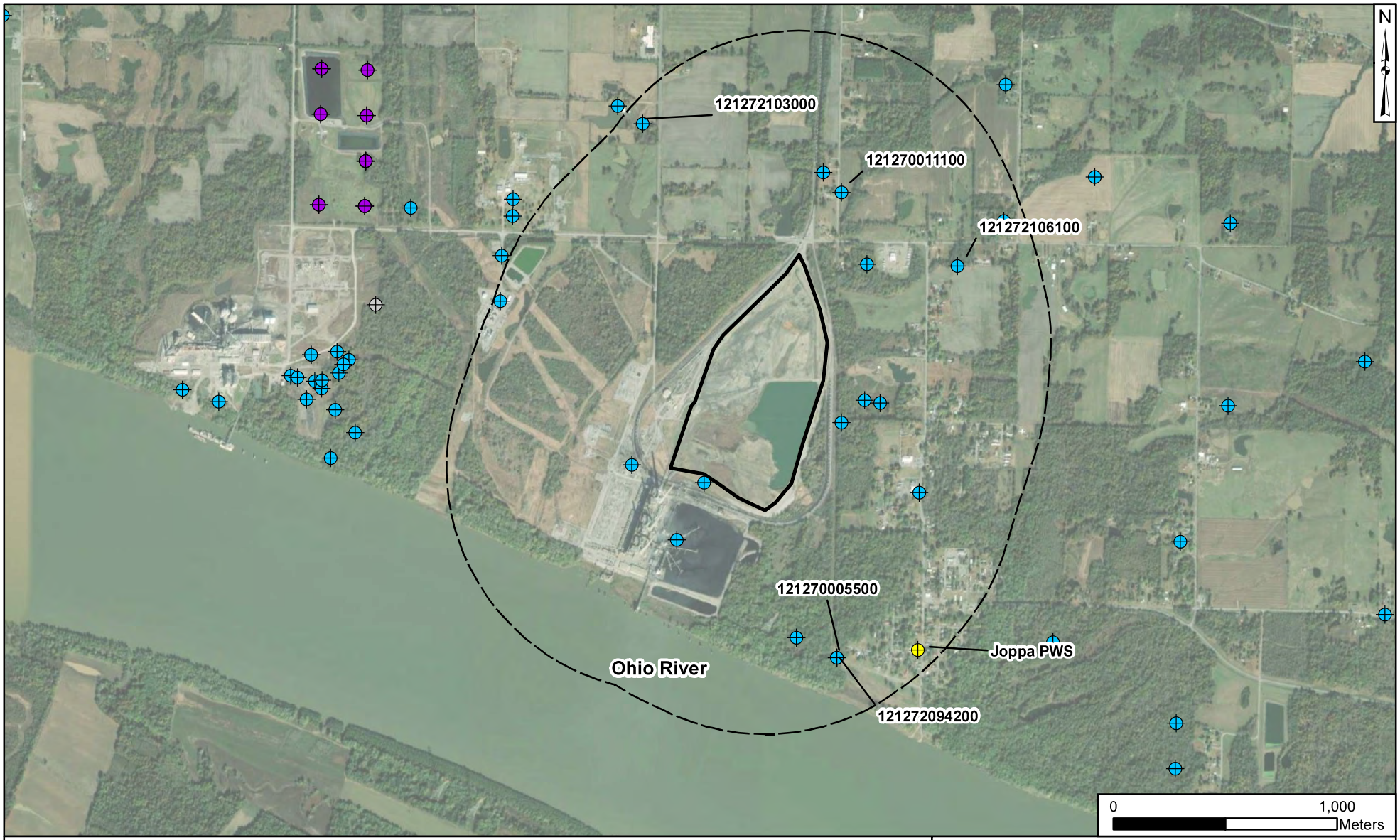
Joppa Power Station
Joppa, Illinois

Geosyntec consultants

GLP8021	March 2021

Figure D-1

C:\Users\CCua\Desktop\Projects\Vistra\GIS\MXD Joppa\Fig A-3 Aquifers Joppa.mxd 3/25/2021 4:57:27 PM



Legend

- Water Well
- Water Well Monitoring Well
- Water Well Test Hole
- Public Water Supply (PWS) Wells
- East Ash Pond (EAP)
- Joppa EAP 1000-meter Buffer

Notes:

- Water well data obtained from Illinois Geological Survey (ISGS) Illinois Water and Related Wells (ILWATER) database.
- Two wells (121270005500 and 121272094200) are indicated to have the same location coordinates.
- Wells resulting in a significant finding are called out.
- PWS wells were obtained from the United States Environmental Protection Agency (USEPA) Safe Drinking Water Information System (SDWIS) and the Illinois Environmental Protection Agency (IEPA) Illinois Drinking Water Watch (DWW) databases. Locations were geocoded from the addresses provided, which may correspond with the location of the water system, or with a contact address.

Water Wells within 1,000 meters of the Joppa East Ash Pond

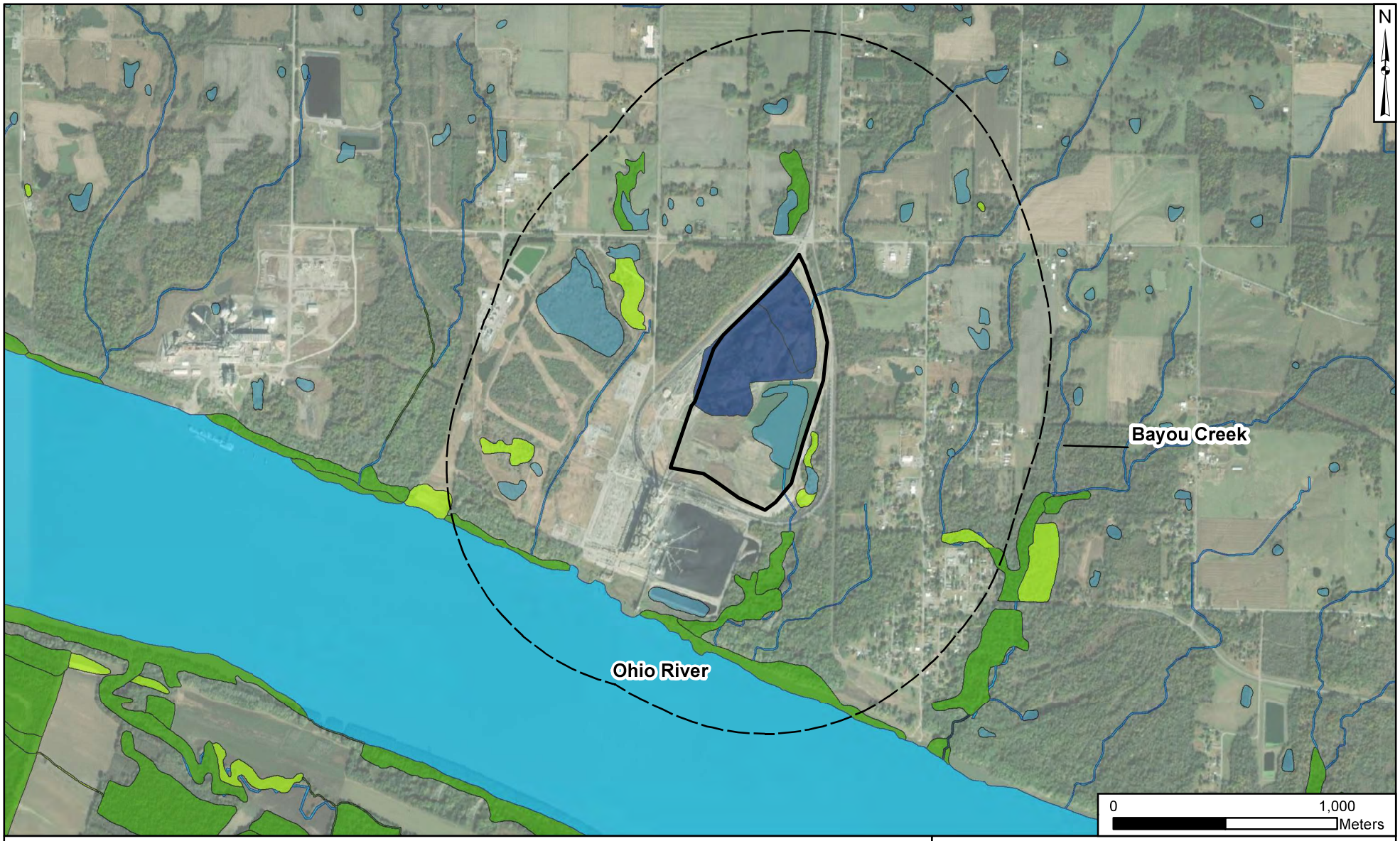
Joppa Power Station
Joppa, Illinois

Geosyntec consultants

GLP8021	March 2021

Figure D-2

C:\Users\CCua\Desktop\Projects\Vistra\GIS\MXD Joppa\Fig A-4 Surrounding Wells Joppa.mxd 3/25/2021 4:57:47 PM



Legend

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Riverine
- East Ash Pond (EAP)
- Joppa EAP 1000-meter Buffer

Notes:
- Wetlands and Surface data were provided by the United States Fish and Wildlife Service (USFWS) Data Mapper and the United States Geologic Survey (USGS) National Hydrography Dataset (NHD).

Surface Water and Wetlands within 1,000 meters of the Joppa East Ash Pond

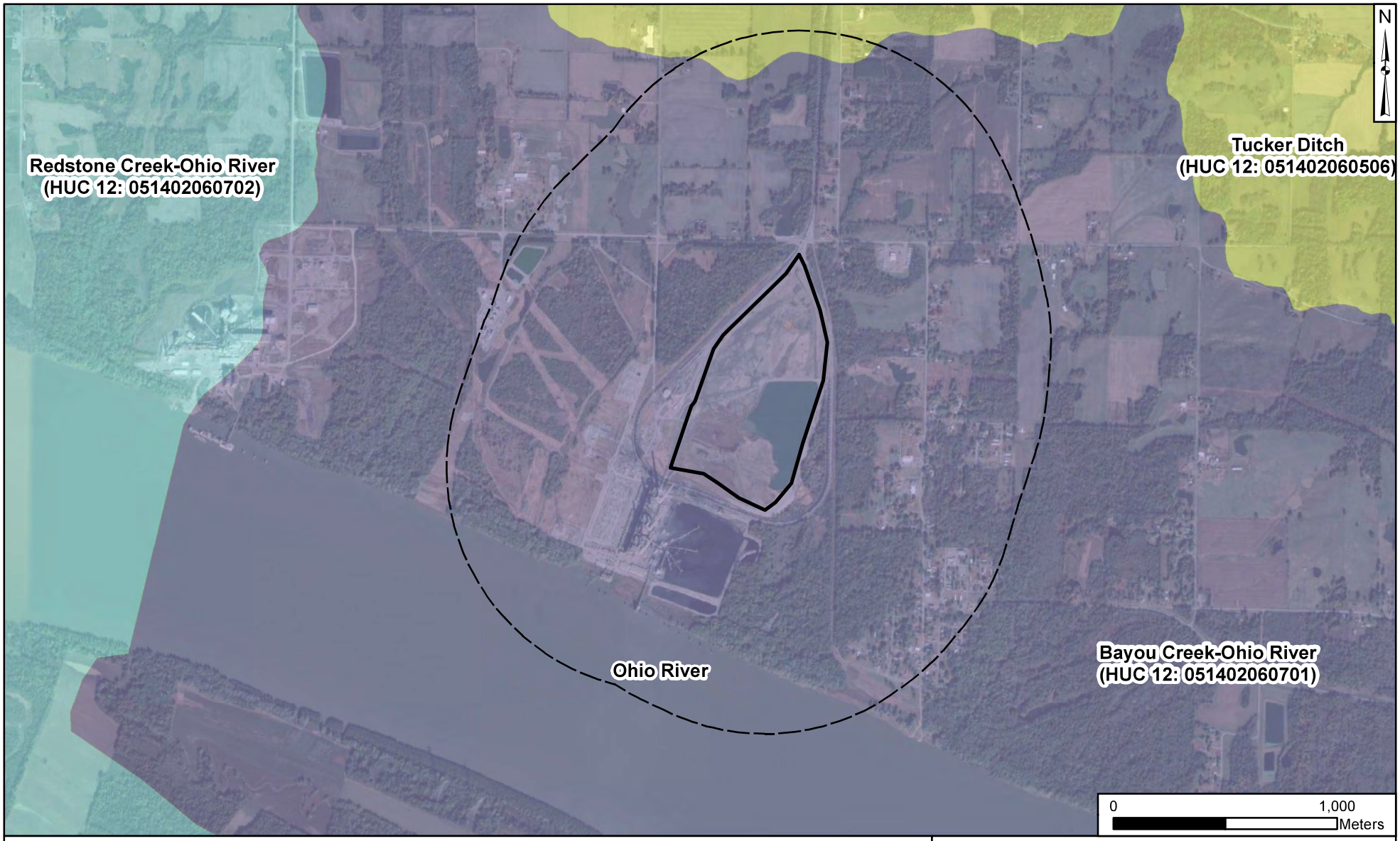
Joppa Power Station
Joppa, Illinois

Geosyntec consultants

GLP8021 | March 2021

Figure D-3

C:\Users\CCua\Desktop\Projects\Vistra\GIS\MXD Joppa\Fig A-1 Wetlands Joppa.mxd 3/25/2021 4:57:32 PM



Legend

- Bayou Creek-Ohio River
- Redstone Creek-Ohio River
- Tucker Ditch
- East Ash Pond (EAP)
- Joppa EAP 1000-meter Buffer

Notes:
- Watershed boundary data was obtained from the United States Geologic Survey (USGS) Watershed Boundary Dataset.
- HUC 12 = Hydrologic Unit Code 12

Watersheds within 1,000 meters of the Joppa East Ash Pond

Joppa Power Station
Joppa, Illinois

Geosyntec consultants

GLP8021 | March 2021

Figure D-4

C:\Users\CCua\Desktop\Projects\Vistra\GIS\MXD Joppa\Fig A-2 Watersheds Joppa.mxd 3/25/2021 4:57:29 PM

ISGS BORING LOGS

ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
Total Depth		304
Driller's Log filed		
Survey Sample Study filed		
Sample set # 25675 (0' - 304') Received: July 29, 1955		

Image viewing help: New users please read this.

GET FILE Related File - Survey Core Study

Permit Date: **Permit #:**

COMPANY Layne Western Co., Inc.

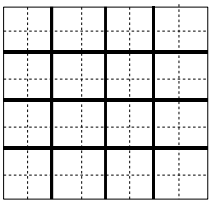
FARM Bechtel Corp

DATE DRILLED July 1, 1955 **NO.** 4

ELEVATION 0 **COUNTY NO.** 00001

LOCATION 4400'N line, 275'W line of section

LATITUDE 37.208964 **LONGITUDE** -88.856879



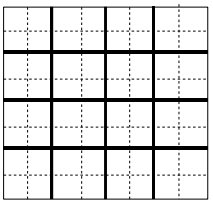
COUNTY Massac **API** 121270000100 **14 - 15S - 3E**

ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
Total Depth		153
Driller's Log filed		

Permit Date: **Permit #:**

COMPANY Smith & Cunningham
FARM Bunchman A J
DATE DRILLED January 1, 1941 **NO.**
ELEVATION 0 **COUNTY NO.** 00030
LOCATION SW SW NE
LATITUDE 37.214621 **LONGITUDE** -88.847472
COUNTY Massac **API** 121270003000 **14 - 15S - 3E**



ILLINOIS STATE GEOLOGICAL SURVEY

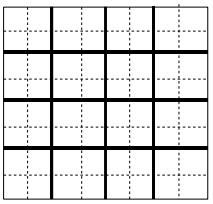
Water Well	Top	Bottom
Total Depth		156

Driller's Log filed
Survey Sample Study filed
Sample set # 6594 (1' - 156') Received: September 25, 1941

Image viewing help: New users please read this.
GET FILE Related File - Survey Core Study

Permit Date: **Permit #:**

COMPANY Smith & Cunningham
FARM Roberts M G
DATE DRILLED April 1, 1941 **NO.** 1
ELEVATION 340GL **COUNTY NO.** 00031
LOCATION
LATITUDE 37.21372 **LONGITUDE** -88.848626
COUNTY Massac **API** 121270003100 **14 - 15S - 3E**



ILLINOIS STATE GEOLOGICAL SURVEY

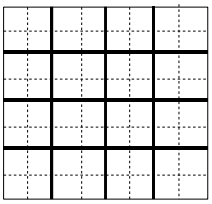
Water Well	Top	Bottom
Total Depth		350

Driller's Log filed
Survey Sample Study filed
Sample set # 21219 (0' - 350') Received: January 9, 1951

Image viewing help: New users please read this.
GET FILE Related File - Survey Core Study

Permit Date: **Permit #:**

COMPANY Layne Western Co., Inc.
FARM Electric Enrgy Inc
DATE DRILLED January 1, 1951 **NO.** 2
ELEVATION 0 **COUNTY NO.** 00050
LOCATION 910'N line, 660'W line of NW SW
LATITUDE 37.211275 **LONGITUDE** -88.855516
COUNTY Massac **API** 121270005000 **14 - 15S - 3E**



ILLINOIS STATE GEOLOGICAL SURVEY

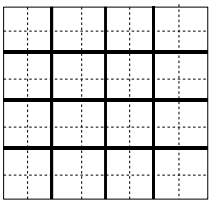
Water Well	Top	Bottom
Total Depth		403

Driller's Log filed
Survey Sample Study filed
Sample set # 21445 (0' - 405') Received: January 9, 1951

Image viewing help: New users please read this.
GET FILE Related File - Survey Core Study

Permit Date: **Permit #:**

COMPANY Layne Western Co., Inc.
FARM Electric Energy Inc
DATE DRILLED January 1, 1951 **NO.** 3
ELEVATION 355GL **COUNTY NO.** 00051
LOCATION 2352'N line, 2088'E line of NE
LATITUDE 37.214512 **LONGITUDE** -88.84669
COUNTY Massac **API** 121270005100 **14 - 15S - 3E**



ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
Total Depth		138
Driller's Log filed		
Survey Sample Study filed		
Sample set # 4599 (5' - 138') Received: June 4, 1940		

Permit Date: **Permit #:**

COMPANY Smith & Cunningham

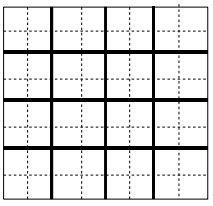
FARM Joppa Grade School

DATE DRILLED April 1, 1940 **NO.**

ELEVATION 340GL **COUNTY NO.** 00052

LOCATION 1000'N line, 1150'W line of SE

LATITUDE 37.21092 **LONGITUDE** -88.8447



COUNTY Massac **API** 121270005200 **14 - 15S - 3E**

ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
Total Depth		235

Driller's Log filed

Sample set # 21218 (0' - 235') Received: July 11, 1951

Image viewing help: New users please read this.

GET FILE Related File - Survey Core Study

Permit Date: **Permit #:**

COMPANY Layne Western Co., Inc.

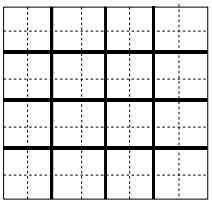
FARM Electric Energy Inc

DATE DRILLED January 1, 1951 **NO.** 1

ELEVATION 348GL **COUNTY NO.** 00053

LOCATION 675'N line, 400'E line of NE SE

LATITUDE 37.211974 **LONGITUDE** -88.859164



COUNTY Massac **API** 121270005300 **15 - 15S - 3E**

ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
Total Depth		137
Driller's Log filed		
Survey Sample Study filed		
Sample set # 4671 (0' - 137') Received: June 20, 1940		

Image viewing help: New users please read this.

GET FILE Related File - Survey Core Study

Permit Date: **Permit #:**

COMPANY Smith & Cunningham

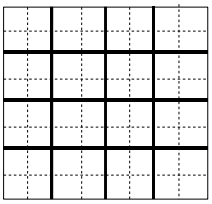
FARM Joppa Colored Schl

DATE DRILLED June 1, 1940 **NO.** 1

ELEVATION 340GL **COUNTY NO.** 00054

LOCATION 500'N line, 600'E line of NW

LATITUDE 37.205054 **LONGITUDE** -88.850833



COUNTY Massac **API** 121270005400 **23 - 15S - 3E**

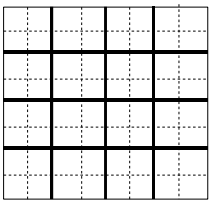
ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
Total Depth		65

Driller's Log filed
Survey Sample Study filed
Sample set # 6595 (1' - 65') Received: September 25, 1941

Permit Date: **Permit #:**

COMPANY Smith & Cunningham
FARM Wilson Marie
DATE DRILLED January 1, 1941 **NO.** 1
ELEVATION 340GL **COUNTY NO.** 00055
LOCATION
LATITUDE 37.204248 **LONGITUDE** -88.84879
COUNTY Massac **API** 121270005500 **23 - 15S - 3E**



ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
soil	0	11
yellow clay	11	26
gravel	26	31
yellow clay	31	38
sandy clay	38	45
gravel & sand	45	78
Total Depth		**78**

Casing: 6" PVC from 30' to -2'
24" CONCRETE from 78' to 30'

Grout: TILE 24" from 78 to 30.

Grout: PVC 6" from 30 to -2.

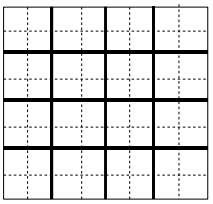
Water from gravel & sand at 58' to 78'.
Static level 20' below casing top which is 2' above GL
Pumping level 15' when pumping at 10 gpm for 1 hour

Driller's Log filed

Owner Address: Joppa, IL
Location source: Location from permit

Permit Date: August 11, 1969 **Permit #:** 06803

COMPANY Jennings, James E.
FARM Adams, Guy
DATE DRILLED August 21, 1969 **NO.** 19
ELEVATION 0 **COUNTY NO.** 00111
LOCATION 50'N 60'W SE/c NE SE SW
LATITUDE 37.222994 **LONGITUDE** -88.848699



COUNTY Massac **API 121270011100** **11 - 15S - 3E**

ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
clay	0	20
gravel	20	130
sand	130	150
Total Depth		**150**

Casing: 7" NEW STEEL 23# FT from 0' to 104'

Size hole below casing: 6.25"

Water from sand gravel at 0' to 0'.
Static level 60' below casing top which is 1' above GL
Pumping level 100' when pumping at 15 gpm for 4 hours

Permanent pump installed at 120'
on , with a capacity of 15 gpm

Driller's Log filed

Owner Address: Joppa, IL

Location source: Location from permit

Permit Date: **Permit #:** 12094

COMPANY Sergent, William E.

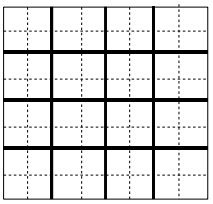
FARM Kapley, Homer & Levina

DATE DRILLED **NO.** 1

ELEVATION 0 **COUNTY NO.** 00146

LOCATION SE SE SE

LATITUDE 37.22186 **LONGITUDE** -88.840518



COUNTY **Massac** **API 121270014600** **11 - 15S - 3E**

ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
Total Depth		160
Driller's Log filed		

Permit Date: **Permit #:**

COMPANY Geer, Alonzo

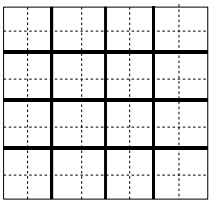
FARM Mathes David L

DATE DRILLED July 1, 1971 **NO.** 1

ELEVATION 0 **COUNTY NO.** 00158

LOCATION NW NW NE

LATITUDE 37.2201 **LONGITUDE** -88.847389



COUNTY **Massac** **API 121270015800** **14 - 15S - 3E**

ILLINOIS STATE GEOLOGICAL SURVEY

Private Water Well	Top	Bottom
dirt & clay	0	18
clay & soapstone	18	72
brown pea gravel	72	94
Total Depth		**94**

Casing: 6" SDR 21 from -1' to 88'
6" PVC SCREEN from 88' to 94'
Screen: 6' of 6" diameter .02 slot
Grout: BENSEAL/SLRY from 0 to 72.
Grout: GRAVEL PACK from 72 to 94.

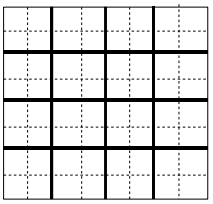
Size hole below casing: 6"

Water from gravel at 85' to 94'.
Static level 52' below casing top which is 1' above GL
Pumping level 70' when pumping at 0 gpm for 24 hours
Permanent pump installed at 80'
on October 21, 1994, with a capacity of 10 gpm

Owner Address: Rt. #1 Box #468 Metropolis, IL
Address of well:
Joppa, IL
Location source: Location from permit

Permit Date: October 7, 1994 **Permit #:**

COMPANY Beanland, Leonard Ralph
FARM Jewel, William
DATE DRILLED October 9, 1994 **NO.**
ELEVATION 0 **COUNTY NO.** 20675
LOCATION NE SE SW
LATITUDE 37.223783 **LONGITUDE** -88.84962
COUNTY **Massac** **API 121272067500** **11 - 15S - 3E**



ILLINOIS STATE GEOLOGICAL SURVEY

	Top	Bottom
Total Depth		90

Sample set # 23753 (5' - 90') Received: January 9, 1952

Owner Address: ,

Permit Date: **Permit #:**

COMPANY Layne Western

FARM Electrical Energy Corp (Joppa)

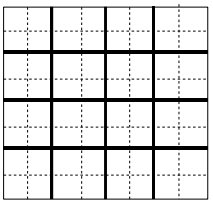
DATE DRILLED **NO.** 3

ELEVATION 0 **COUNTY NO.** 20942

LOCATION

LATITUDE 37.204248 **LONGITUDE** -88.84879

COUNTY **Massac** **API** **121272094200** **23 - 15S - 3E**



ILLINOIS STATE GEOLOGICAL SURVEY

Irrigation Well	Top	Bottom
yellow clay	0	27
gravel	27	28
white clay	28	36
yellow sandy clay/gravel	36	58
yellow sandy clay/coarse ylw sand	58	65
yellow sandy clay/white streaks	65	105
fine yellow sand & clay streaks	105	118
chert	118	142
chert w/yellow/white clay streaks	142	160
chert w/gravel clay streaks	160	178
weathered limestone	178	180
chert w/gray clay	180	191
fractured gray limestone	191	202
Total Depth		**202**

Casing: 6.12" PVC from -1' to 140'
4" PVC from 135' to 195'

Grout: BENTONITE from 0 to 139.

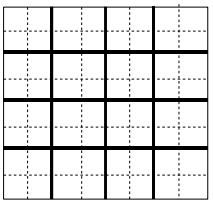
Water from limestone at 175' to 200'.
Static level 41' below casing top which is 1' above GL
Pumping level 100' when pumping at 15 gpm for 72 hours

Remarks: driller's est. well yield 30 gpm

Owner Address: 4242 Green Acres Ln. Grand Chain, IL
Address of well: same as above
Location source: Location from permit

Permit Date: February 8, 2000 **Permit #:**

COMPANY Beanland, Ronald D.
FARM Snell, Arnold
DATE DRILLED March 30, 2000 **NO.**
ELEVATION 0 **COUNTY NO.** 21030
LOCATION SE NE SE
LATITUDE 37.225712 **LONGITUDE** -88.858722
COUNTY **Massac** **API 121272103000** **10 - 15S - 3E**



ILLINOIS STATE GEOLOGICAL SURVEY

Non Potable Water Well	Top	Bottom
topsoil & clay w/silty sand	0	22
clay w/fine to medium sand	22	136
fine to medium sand w/clay seams	136	220
weathered limestone	220	225
fractured limestone	225	238
Total Depth		**238**

Casing: 12" STAINLESS #49.56/FT from -2' to 228'

Grout: CEMENT from 1 to 228.

Size hole below casing: 12"

Water from limestone at 228' to 238'.
Static level 40' below casing top which is 2' above GL
Pumping level 44' when pumping at 603 gpm for 12 hours

Permanent pump installed at 150'
on , with a capacity of 600 gpm

Owner Address: P. O. Box 355 Joppa, IL

Address of well: 2100 Portland Rd
Joppa IL

Location source: Location from permit

Permit Date: November 18, 1999 **Permit #:**

COMPANY Stollhans, Jeff

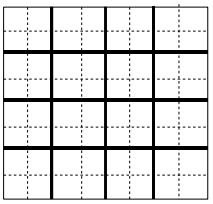
FARM Midwest Electric Power Co.

DATE DRILLED February 29, 2000 **NO.** 6

ELEVATION 380 **COUNTY NO.** 21039

LOCATION SW NW NE

LATITUDE 37.218537 **LONGITUDE** -88.86584



COUNTY **Massac** **API 121272103900** **15 - 15S - 3E**

ILLINOIS STATE GEOLOGICAL SURVEY

Private Water Well	Top	Bottom
dirt & clay	0	42
sandy clay	42	50
gravel & clay	50	62
sand & clay	62	87
gravel	87	92
Total Depth		**92**

Casing: 6.25" PVC from 1' to 89'
6.25" PVC SCREEN from 89' to 92'

Screen: 3' of 6.25" diameter .03 slot

Grout: CLAY from 0 to 3.

Grout: ENVIROPLUG from 3 to 85.

Grout: WASHED PEA GVL from 85 to 92.

Water from gravel at 89' to 92'.

Static level 60' below casing top which is 1' above GL

Pumping level 70' when pumping at 10 gpm for 24 hours

Permanent pump installed at 83'

on , with a capacity of 10 gpm

Remarks: driller's est. well yield 30 gpm

Owner Address: 4173 Joppa Bypass Rd. Metropolis, IL

Address of well: same as above

Location source: Location from permit

Permit Date: September 17, 2001 **Permit #:**

COMPANY Beanland, Leonard Ralph

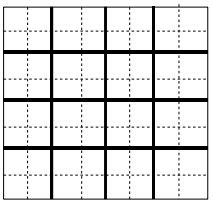
FARM Terbrak, Rodger

DATE DRILLED **NO.**

ELEVATION 0 **COUNTY NO.** 21061

LOCATION NW NE NE

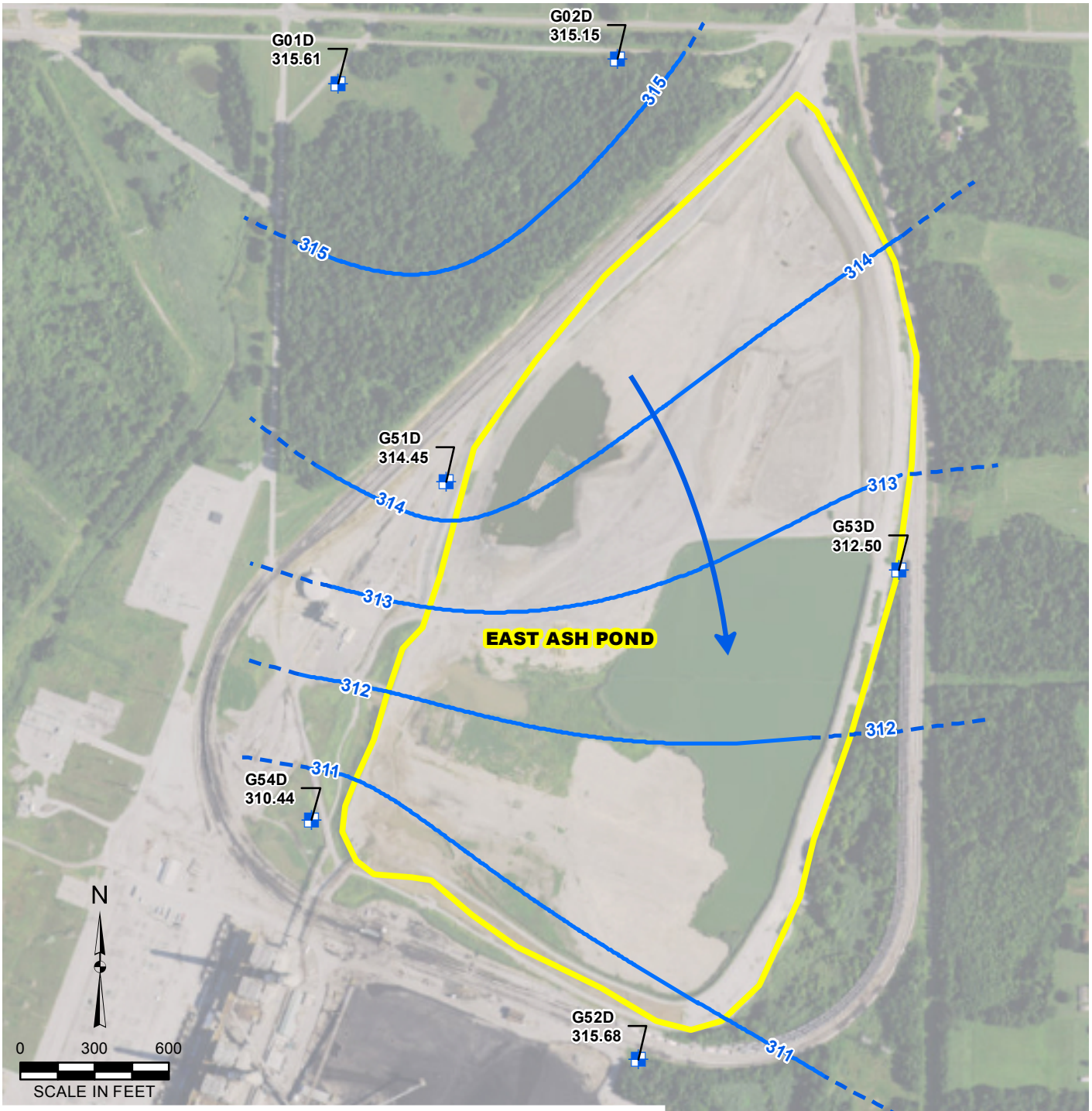
LATITUDE 37.220051 **LONGITUDE** -88.842823



COUNTY **Massac** **API 121272106100** **14 - 15S - 3E**

APPENDIX E
GROUNDWATER CONTOUR MAPS AND ELEVATIONS

GROUNDWATER CONTOUR MAPS



CCR RULE MONITORING WELL LOCATION
GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION
CCR MONITORED UNIT

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NOTE: G52D GROUNDWATER ELEVATION IS NOT INCLUDED IN POTENTIOMETRIC SURFACE CONTOURS

DRAWN BY/DATE:
SDS 1/23/17
REVIEWED BY/DATE:
ANS 1/25/17
APPROVED BY/DATE:
JJW 2/7/17

JOPPA EAST ASH POND (UNIT ID: 401)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
ROUND 1: DECEMBER 2, 2015

DYNEGY CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

PROJECT NO: 2285/1.6

FIGURE NO: 1

Natural Resource Technology
AN OBG COMPANY

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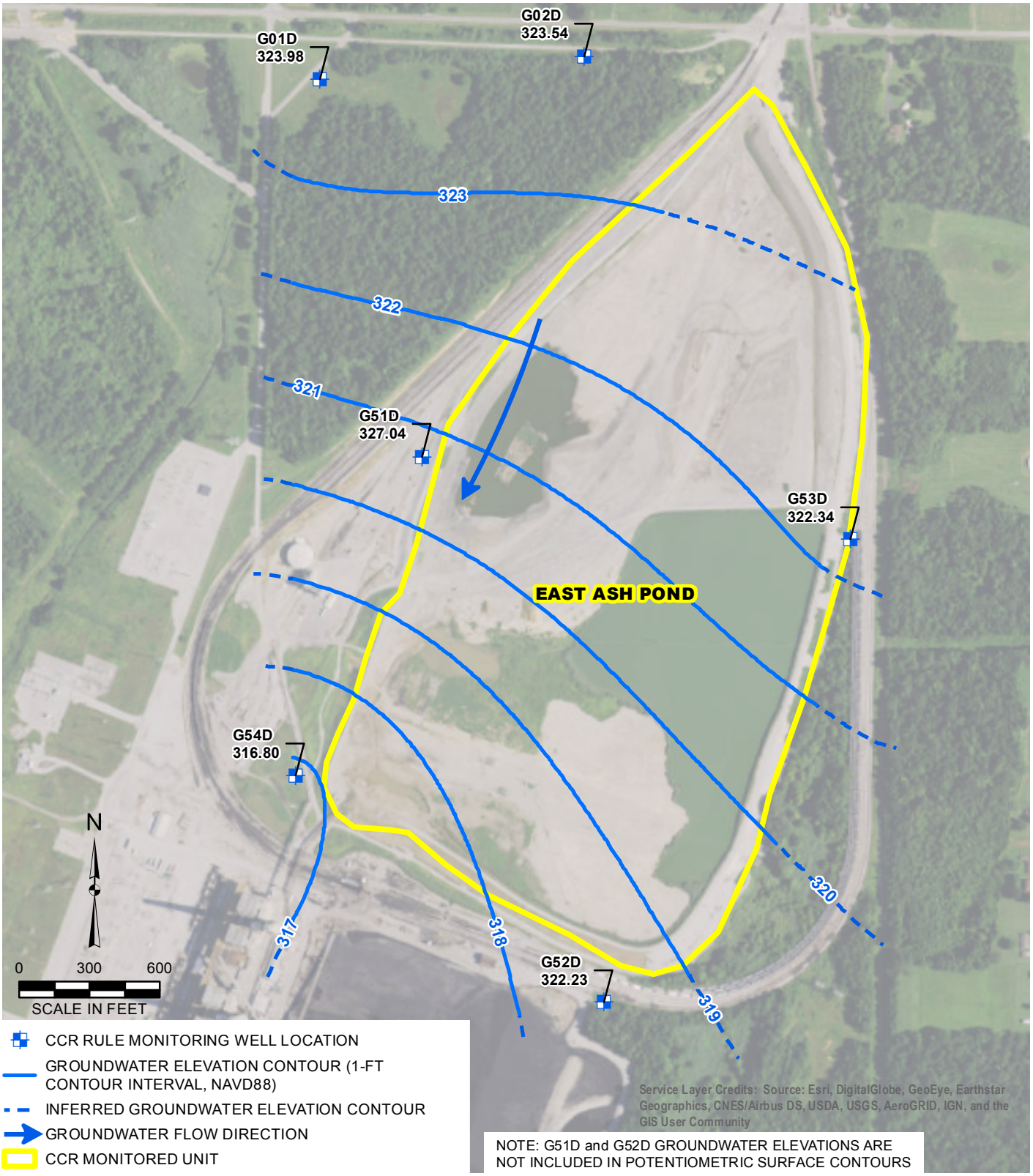

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ANS 1/25/17
APPROVED BY/DATE:
JJW 2/8/17

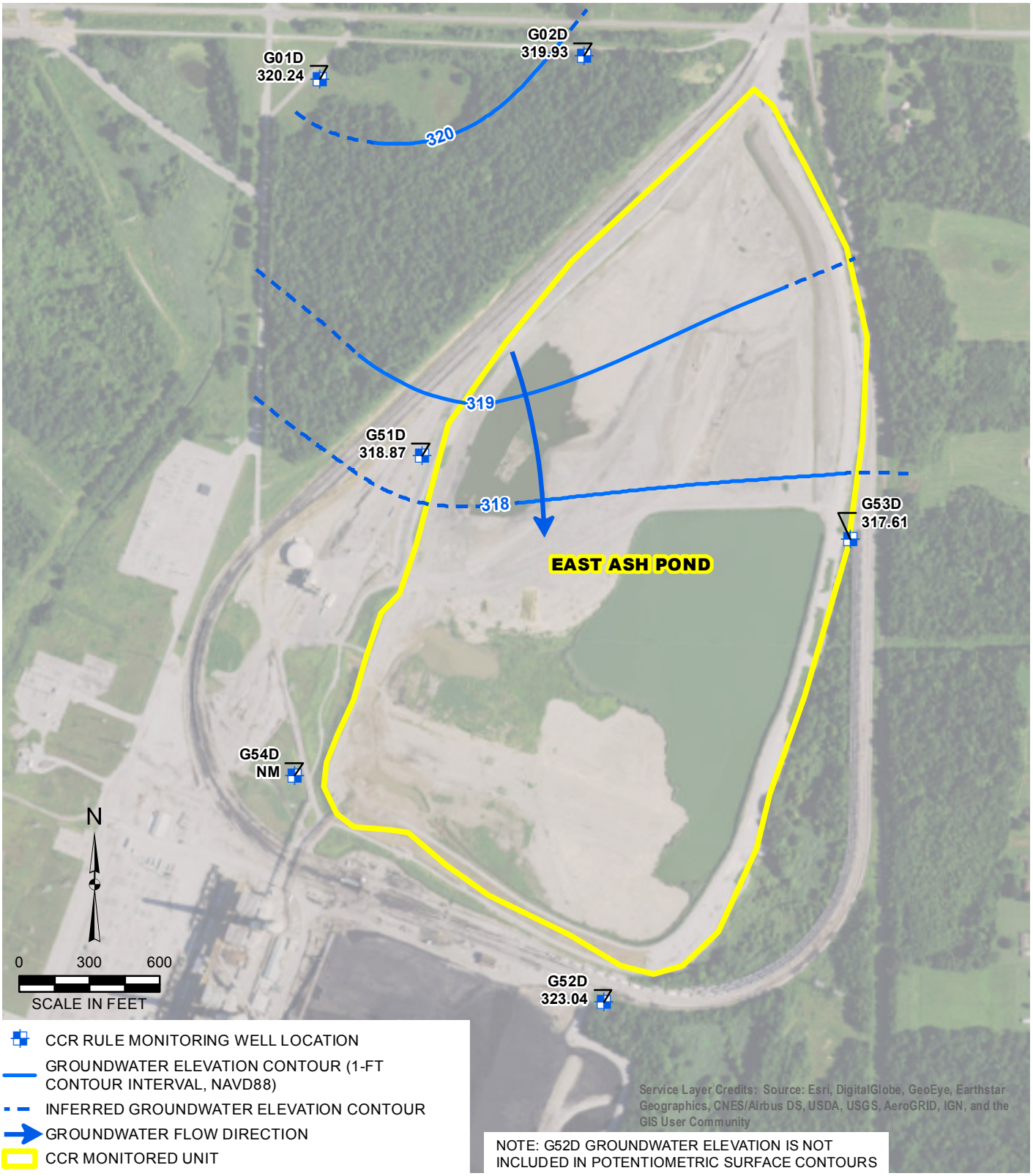
JOPPA EAST ASH POND (UNIT ID: 401)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
ROUND 2: MARCH 15, 2016

DYNEGY CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

PROJECT NO: 2285

FIGURE NO: 1

Natural Resource Technology
AN OBG COMPANY



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ANS 1/25/17
APPROVED BY/DATE:
JJW 2/8/17

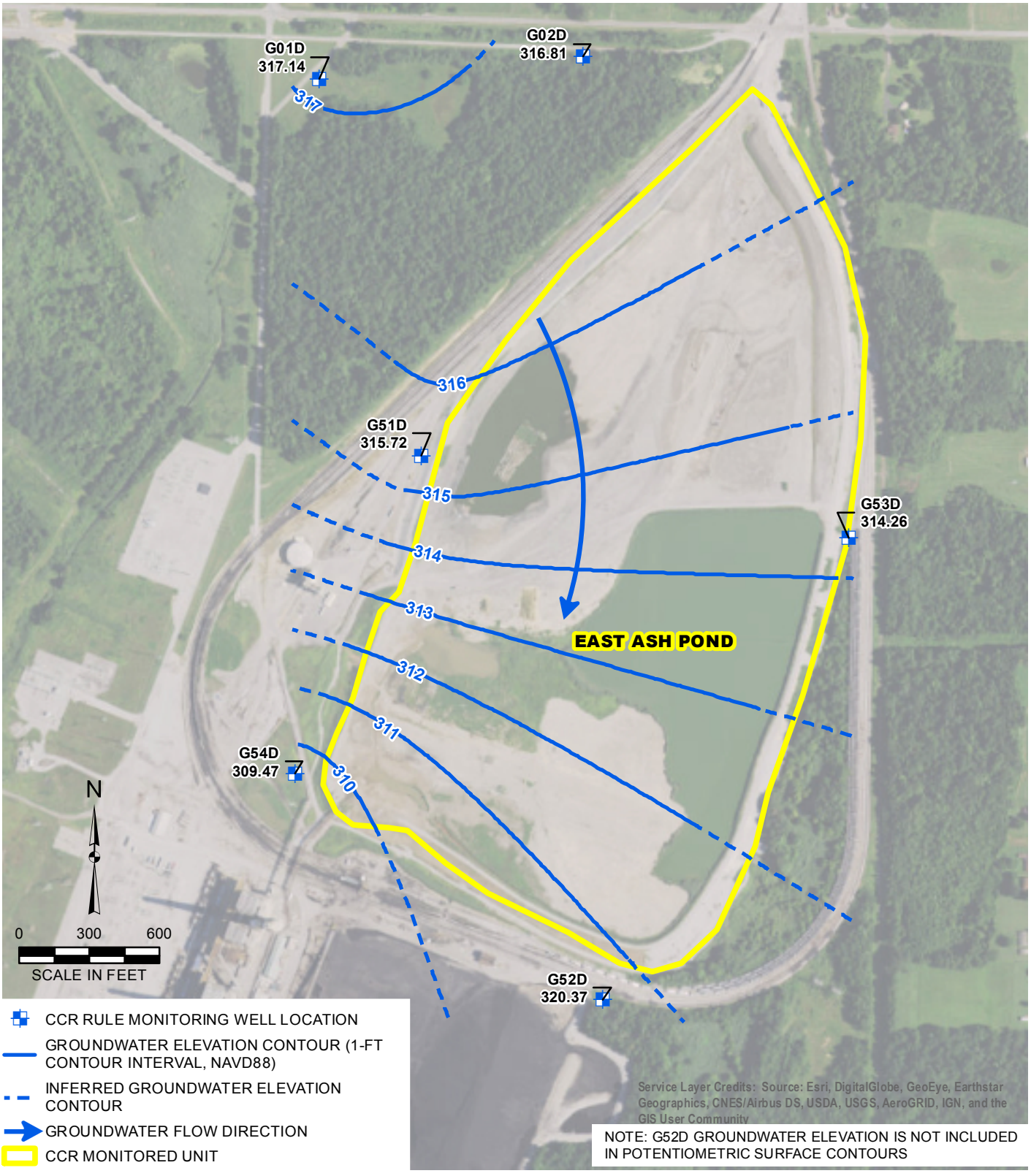
JOPPA EAST ASH POND (UNIT ID: 401)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
ROUND 3: JUNE 14, 2016

DYNEGY CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

PROJECT NO: 2285

FIGURE NO: 1

Natural Resource Technology
AN OBG COMPANY



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APPROVED BY/DATE:
JJW 2/8/17

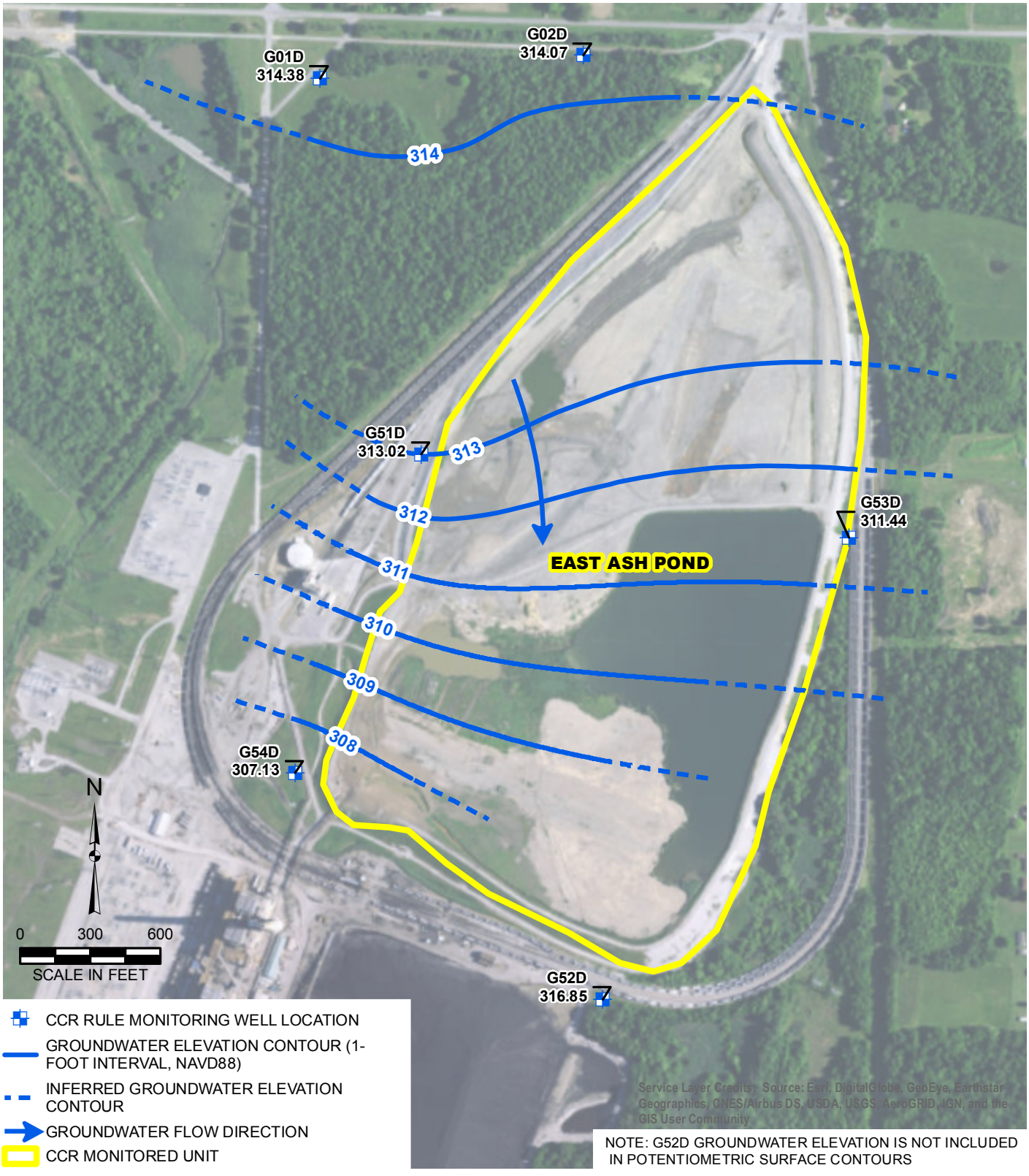
JOPPA EAST ASH POND (UNIT ID: 401)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
ROUND 4: SEPTEMBER 13, 2016

DYNEGY CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

PROJECT NO: 2285

FIGURE NO: 1

Natural Resource Technology
AN OBG COMPANY



NOTE: G52D GROUNDWATER ELEVATION IS NOT INCLUDED IN POTENTIOMETRIC SURFACE CONTOURS

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REVIEWED BY/DATE:
ANS 3/6/17
APPROVED BY/DATE:
JJW 8/30/17

JOPPA EAST ASH POND (UNIT ID: 401)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
ROUND 5: DECEMBER 14, 2016

DYNEGY CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

PROJECT NO: 2285

FIGURE NO: 1

Natural Resource Technology
AN OBG COMPANY

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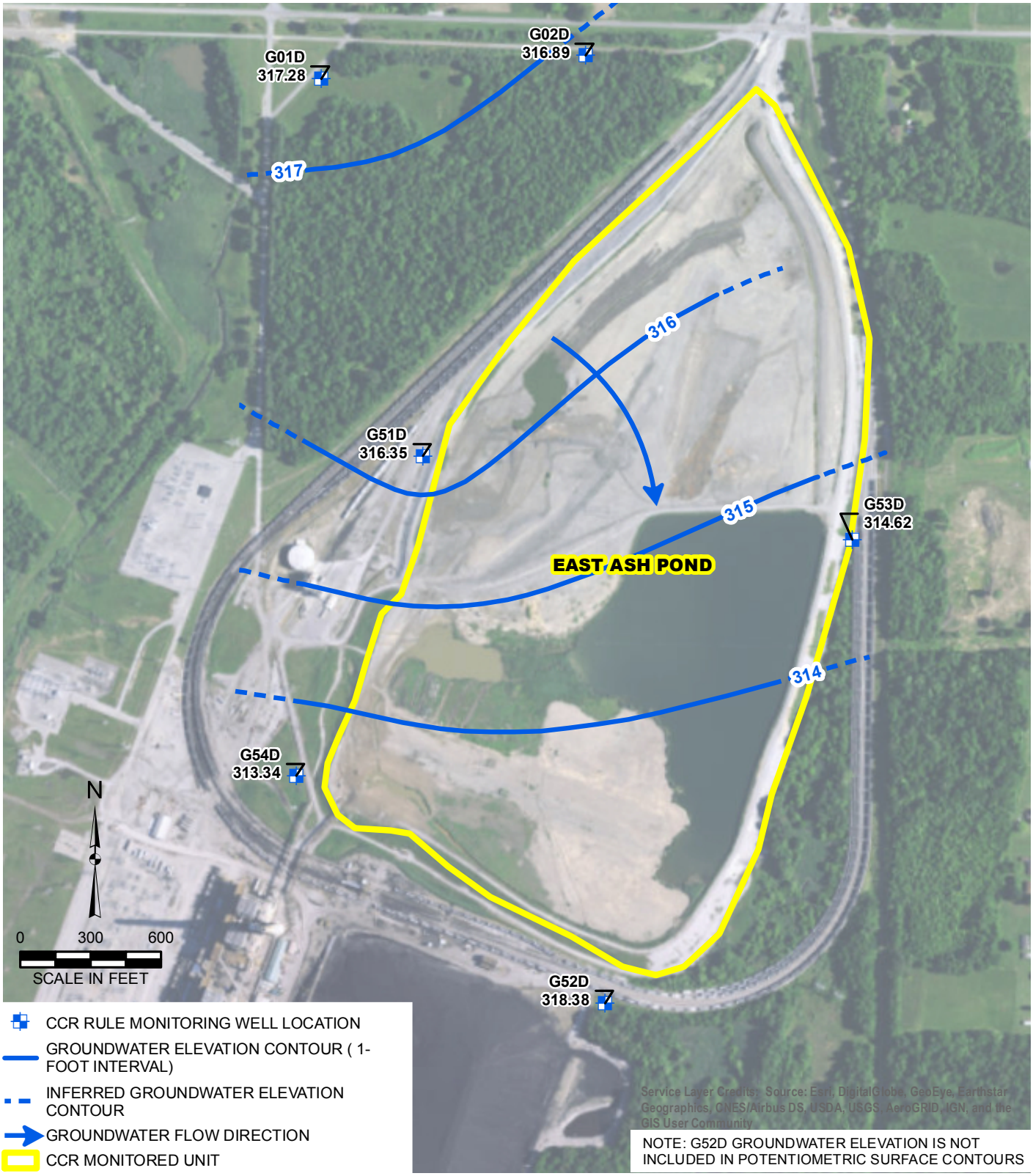

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JJW 8/30/17

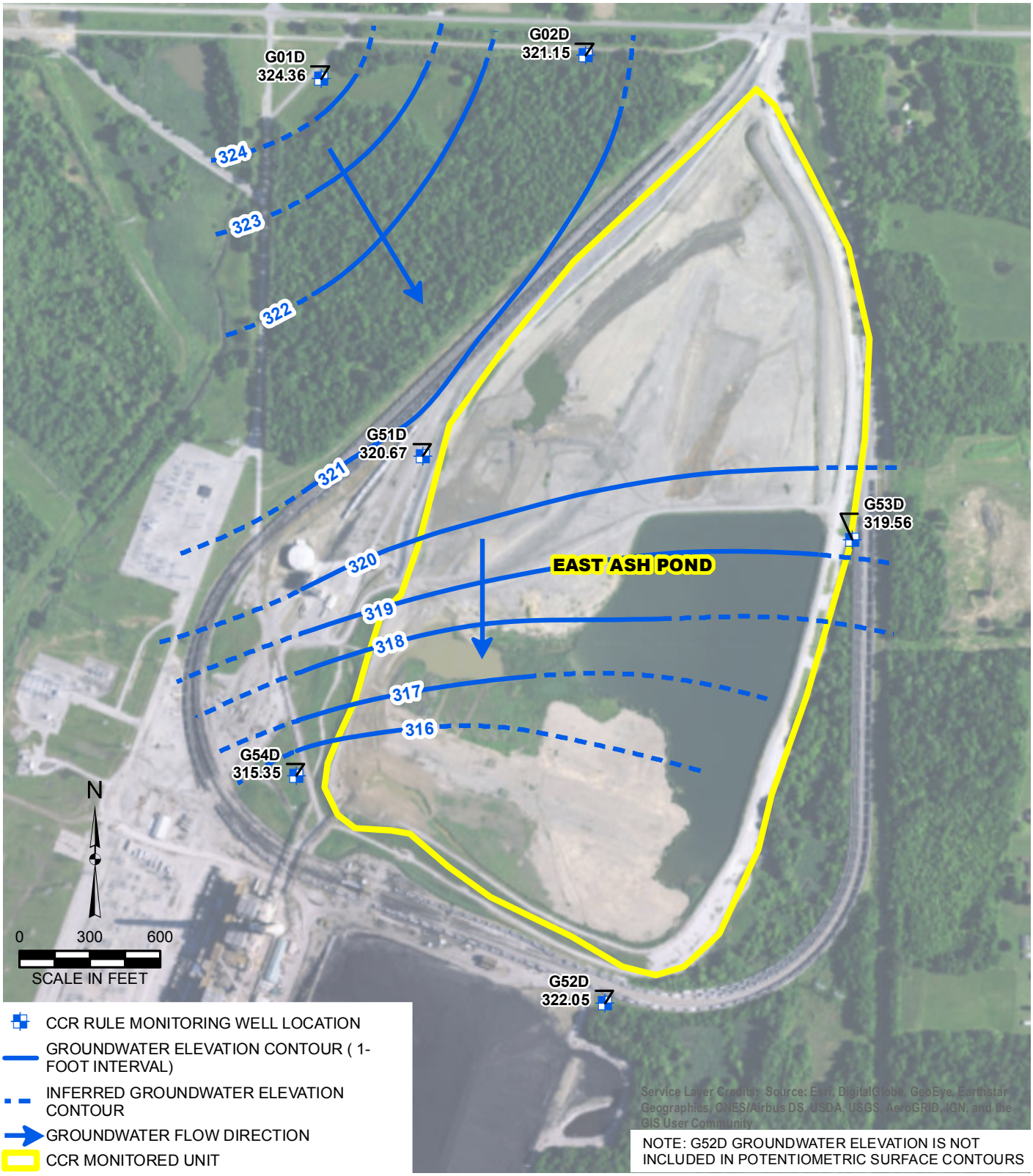
JOPPA EAST ASH POND (UNIT ID: 401)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
ROUND 6: MARCH 7, 2017

DYNEGY CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

PROJECT NO: 2285

FIGURE NO: 1

Natural Resource Technology
AN OBG COMPANY



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ANS 7/10/17
APPROVED BY/DATE:
JJW 8/30/17

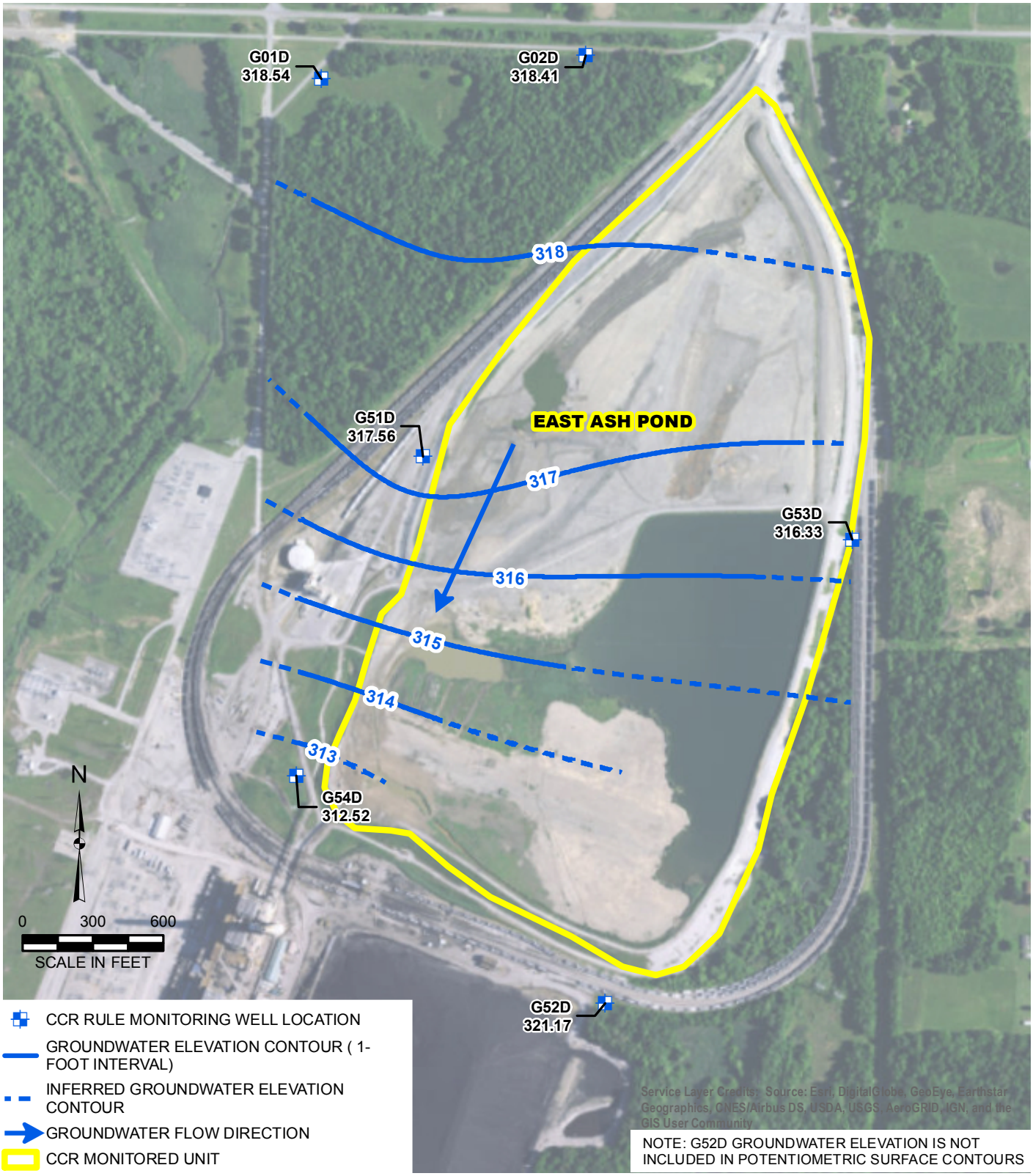
JOPPA EAST ASH POND (UNIT ID: 401)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
ROUND 7: JUNE 14, 2017

DYNEGY CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

PROJECT NO: 2285

FIGURE NO: 1

Natural Resource Technology
AN OBG COMPANY



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ANS 8/10/17
APPROVED BY/DATE:
JJW 8/30/17

JOPPA EAST ASH POND (UNIT ID: 401)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
ROUND 8: JULY 19, 2017

DYNEGY CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

PROJECT NO: 2285

FIGURE NO: 1

Natural Resource Technology
AN OBG COMPANY

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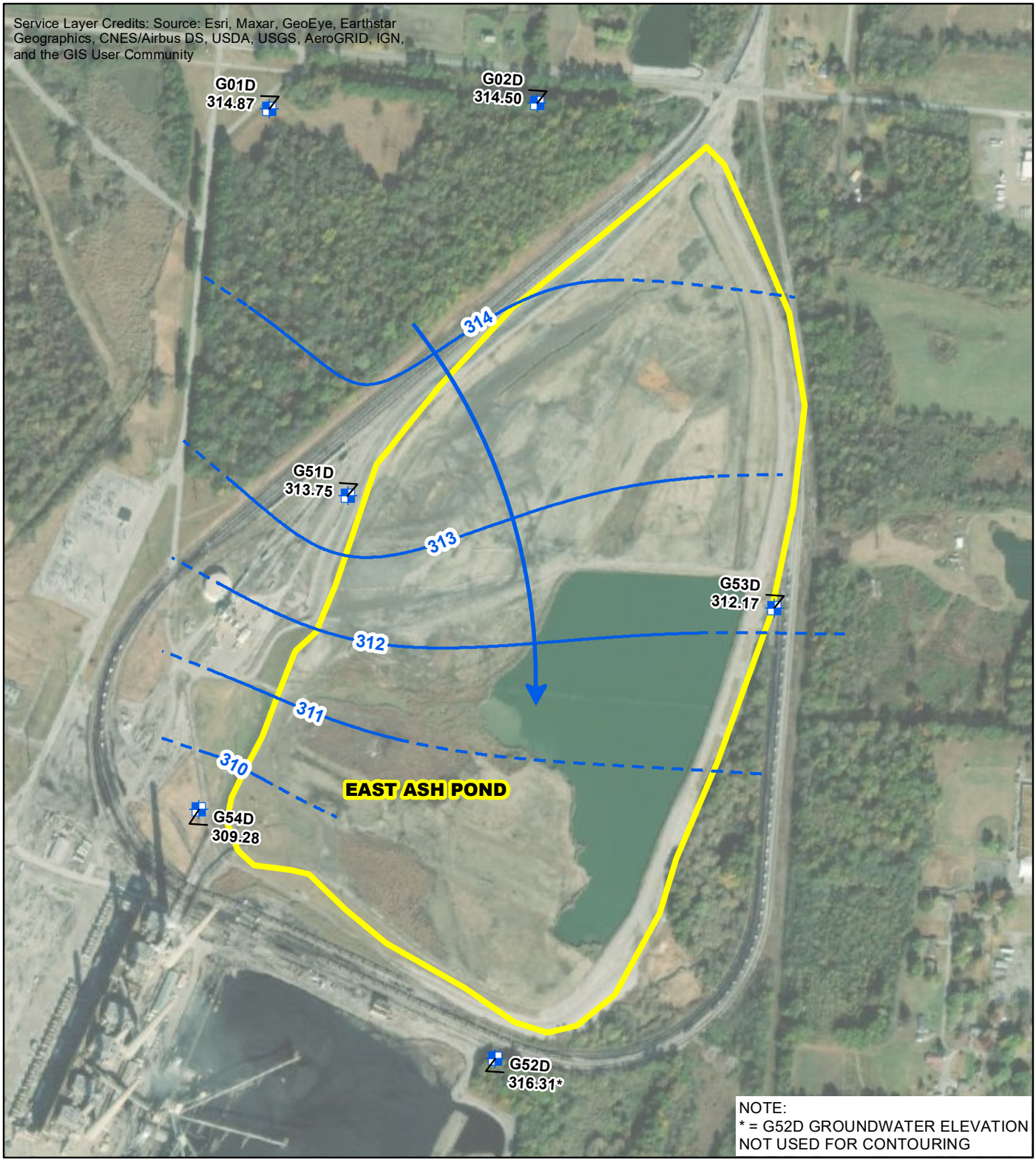

CCR RULE MONITORING WELL LOCATION

GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

CCR MONITORED UNIT

JOPPA EAST ASH POND (UNIT ID: 401)
GROUNDWATER ELEVATION CONTOUR MAP
NOVEMBER 30, 2017

CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

0 150 300 600
Feet

N

O'BRIEN & GERE ENGINEERS, INC.

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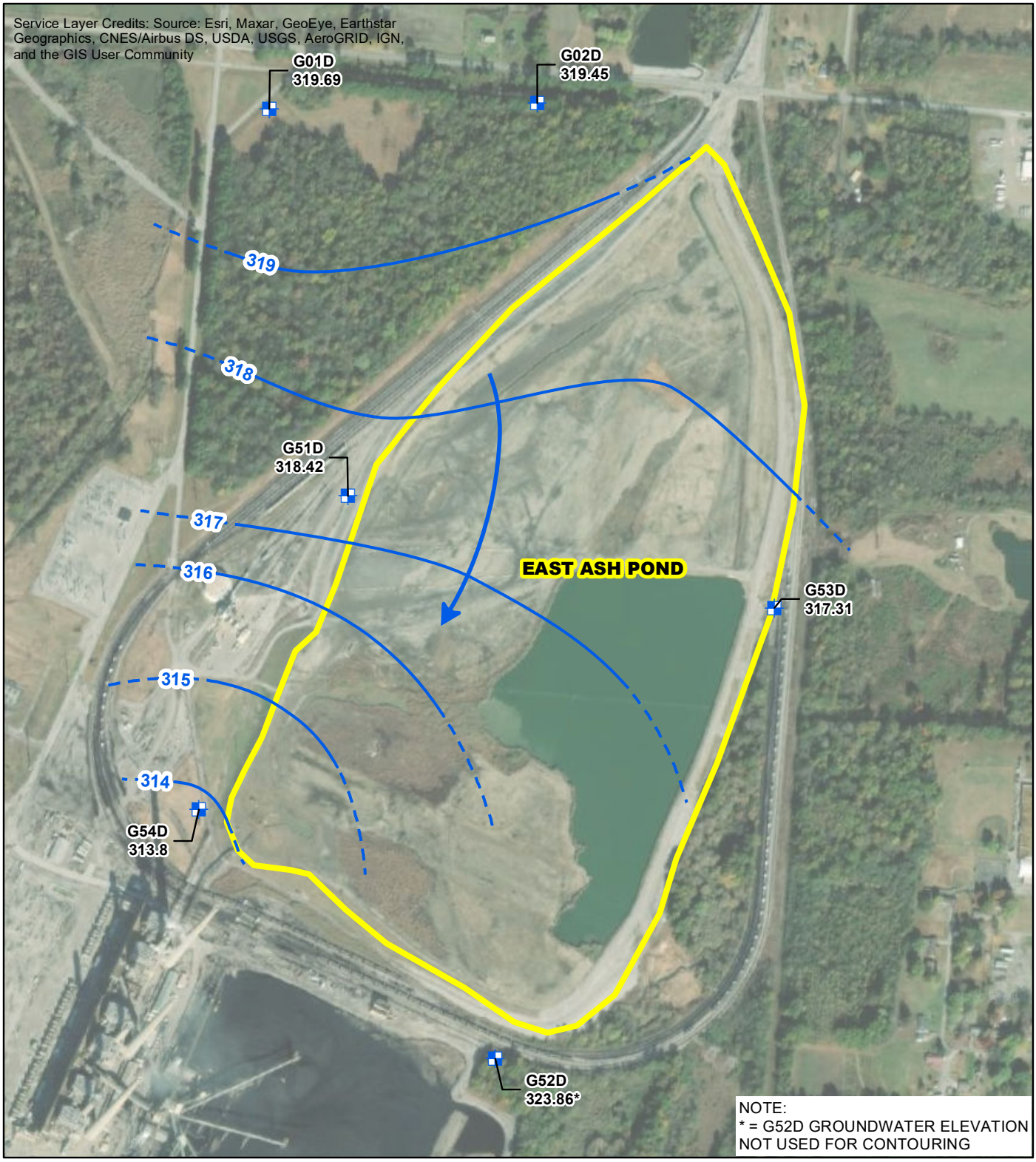

CCR RULE MONITORING WELL LOCATION

GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

CCR MONITORED UNIT

JOPPA EAST ASH POND (UNIT ID: 401)
GROUNDWATER ELEVATION CONTOUR MAP
JUNE 9, 2018

CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

0 150 300 600
Feet

N

O'BRIEN & GERE ENGINEERS, INC.

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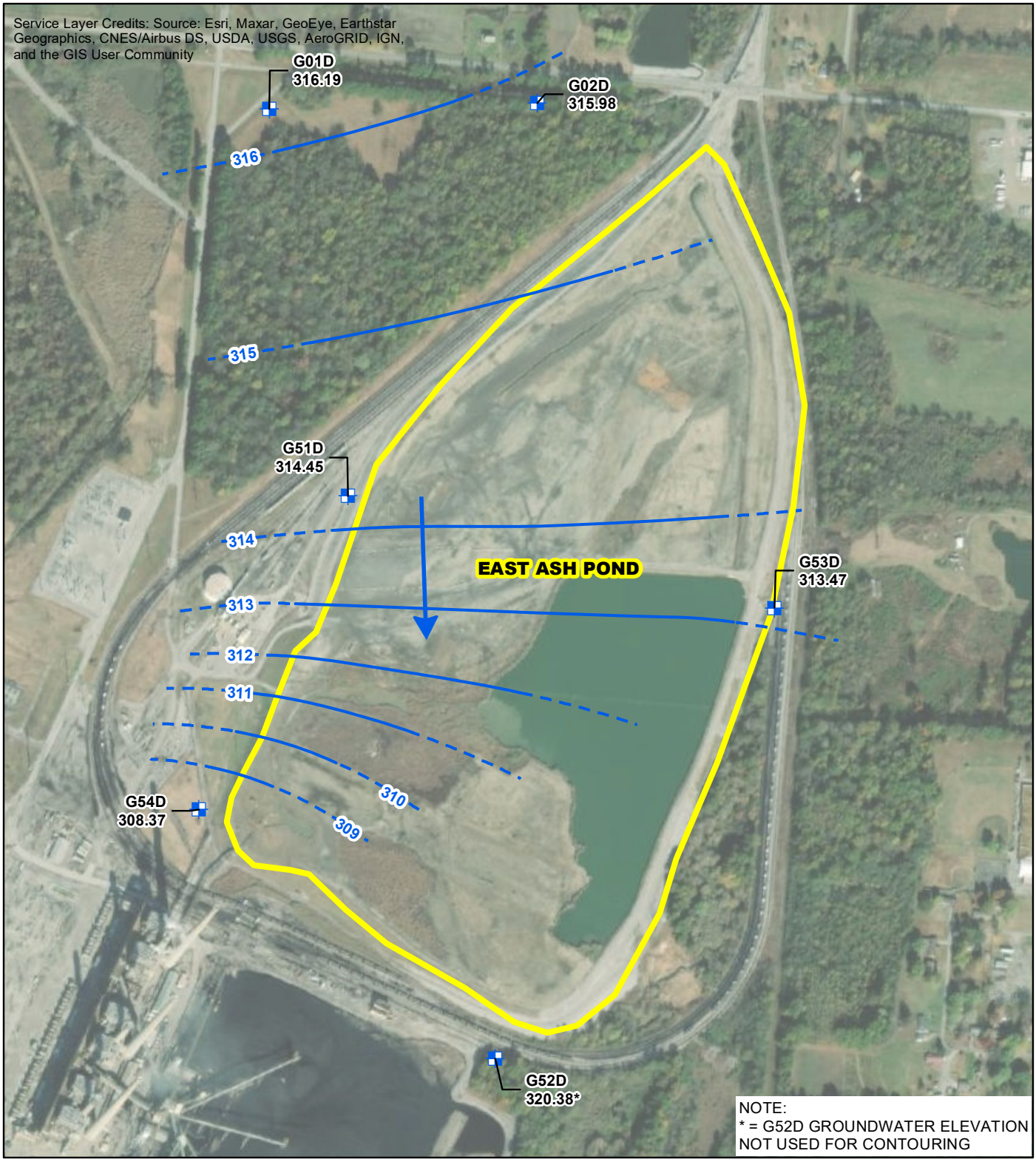

CCR RULE MONITORING WELL LOCATION

GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

CCR MONITORED UNIT

JOPPA EAST ASH POND (UNIT ID: 401)
GROUNDWATER ELEVATION CONTOUR MAP
SEPTEMBER 5, 2018

CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

0 150 300 600
Feet

N

O'BRIEN & GERE ENGINEERS, INC.

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CCR RULE MONITORING WELL LOCATION

GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

CCR MONITORED UNIT

JOPPA EAST ASH POND (UNIT ID: 401)
GROUNDWATER ELEVATION CONTOUR MAP
MARCH 27, 2019

CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

0 150 300 600
Feet

N

O'BRIEN & GERE ENGINEERS, INC.

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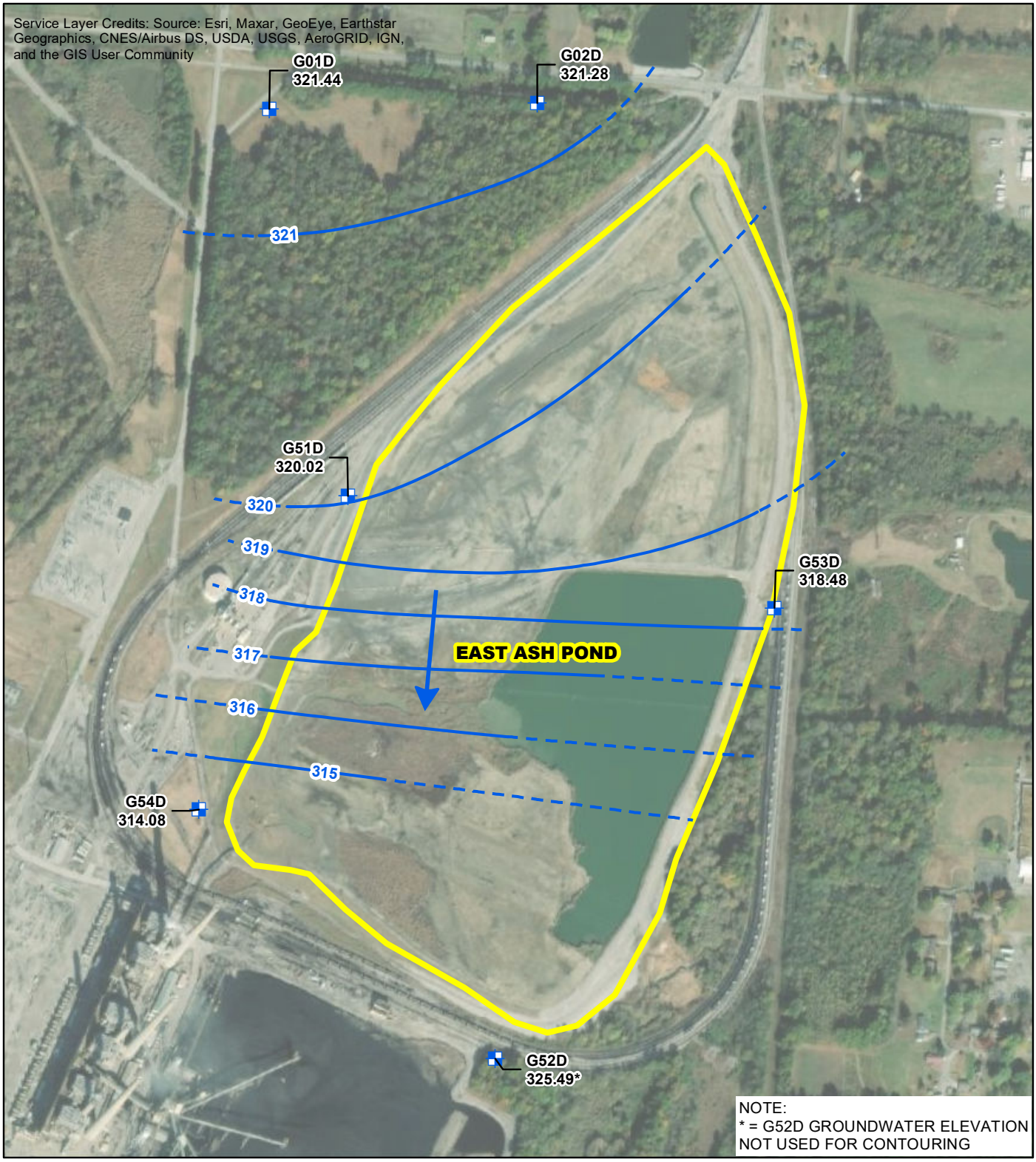

CCR RULE MONITORING WELL LOCATION

GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

CCR MONITORED UNIT

JOPPA EAST ASH POND (UNIT ID: 401)
GROUNDWATER ELEVATION CONTOUR MAP
SEPTEMBER 9, 2019

CCR RULE GROUNDWATER MONITORING
JOPPA POWER STATION
JOPPA, ILLINOIS

0 150 300 600
Feet

N

O'BRIEN & GERE ENGINEERS, INC.

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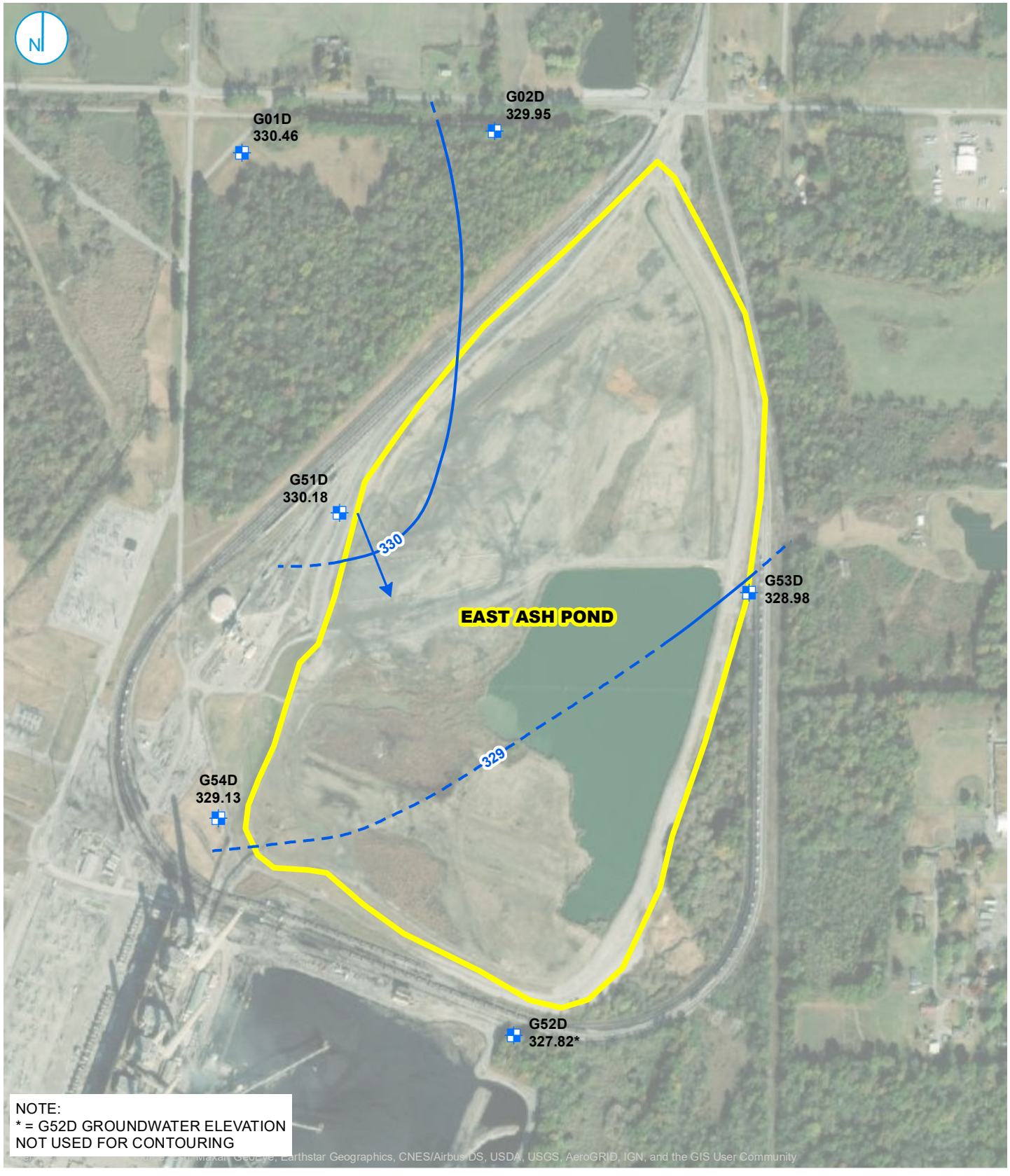

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PROJECT: 169000XXXX | DATED: 8/13/2020 | DESIGNER: STOLZSD

CCR MONITORING WELL

GROUNDWATER ELEVATION CONTOUR (1-FOOT CONTOUR INTERVAL, NAVD 88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

CCR UNIT BOUNDARY, SUBJECT SITE

0 275 550 Feet

GROUNDWATER ELEVATION CONTOUR MAP
MARCH 30, 2020

JOPPA EAST ASH POND (UNIT ID: 401)
VISTRA ENERGY
JOPPA POWER STATION
JOPPA, ILLINOIS

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

RAMBOLL

TABLE E-1
GROUNDWATER ELEVATION RESULTS (2015-2021)

TABLE E-1. GROUNDWATER ELEVATIONS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G01D	12/02/2015	315.61
G01D	03/15/2016	323.98
G01D	06/14/2016	320.24
G01D	06/15/2016	320.24
G01D	09/13/2016	317.14
G01D	09/14/2016	317.14
G01D	12/14/2016	314.38
G01D	03/07/2017	317.28
G01D	06/14/2017	324.36
G01D	07/19/2017	318.54
G01D	11/30/2017	314.87
G01D	06/09/2018	319.69
G01D	09/05/2018	316.19
G01D	03/27/2019	329.69
G01D	09/09/2019	321.44
G01D	03/30/2020	330.46
G01D	09/23/2020	320.32
G01D	09/24/2020	320.32
G01D	03/03/2021	305.27
G01D	03/24/2021	327.02
G01D	04/14/2021	325.92
G01D	05/12/2021	324.12
G01D	06/01/2021	320.46
G01D	06/14/2021	322.10
G01D	07/06/2021	321.38
G01D	07/21/2021	320.89
G01D	09/20/2021	320.05
G02D	12/02/2015	315.15
G02D	03/15/2016	323.54
G02D	06/14/2016	319.93
G02D	06/15/2016	319.93
G02D	09/13/2016	316.81
G02D	09/14/2016	316.81
G02D	12/14/2016	314.07
G02D	03/07/2017	316.89
G02D	06/14/2017	321.15
G02D	07/19/2017	318.41
G02D	11/30/2017	314.50
G02D	06/09/2018	319.45
G02D	09/05/2018	315.98
G02D	03/27/2019	329.22
G02D	09/09/2019	321.28
G02D	03/30/2020	329.95
G02D	09/23/2020	320.14
G02D	09/24/2020	320.14
G02D	03/03/2021	321.77

TABLE E-1. GROUNDWATER ELEVATIONS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G02D	03/24/2021	325.91
G02D	04/14/2021	324.71
G02D	05/12/2021	323.72
G02D	06/01/2021	321.23
G02D	06/14/2021	321.86
G02D	07/06/2021	319.74
G02D	07/21/2021	320.62
G02D	09/20/2021	318.86
G03	03/05/2021	321.37
G03	03/24/2021	325.29
G03	04/14/2021	325.26
G03	05/12/2021	323.15
G03	06/01/2021	318.88
G03	06/15/2021	321.29
G03	07/06/2021	320.43
G03	07/21/2021	320.21
G04	03/04/2021	320.41
G04	03/24/2021	324.92
G04	04/13/2021	325.06
G04	05/11/2021	322.21
G04	06/01/2021	320.79
G04	06/14/2021	320.28
G04	07/06/2021	319.28
G04	07/20/2021	319.12
G05	03/04/2021	316.86
G05	03/24/2021	324.65
G05	04/13/2021	324.43
G05	05/11/2021	321.06
G05	06/01/2021	319.28
G05	06/15/2021	318.66
G05	07/06/2021	318.71
G05	07/20/2021	318.61
G06	03/04/2021	317.63
G06	03/24/2021	323.74
G06	04/13/2021	323.14
G06	05/11/2021	319.12
G06	06/01/2021	317.08
G06	06/15/2021	316.38
G06	07/06/2021	315.44
G06	07/20/2021	315.42
G06S	03/04/2021	317.76
G06S	03/24/2021	324.85
G06S	04/13/2021	323.95
G06S	05/11/2021	319.60
G06S	06/01/2021	317.66
G06S	06/14/2021	317.01

TABLE E-1. GROUNDWATER ELEVATIONS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G06S	07/06/2021	315.88
G06S	07/20/2021	315.80
G07	03/04/2021	316.17
G07	03/24/2021	322.71
G07	04/13/2021	321.96
G07	05/11/2021	317.48
G07	06/01/2021	315.22
G07	06/15/2021	314.48
G07	07/06/2021	313.63
G07	07/20/2021	313.63
G08	03/04/2021	316.89
G08	03/24/2021	322.52
G08	04/13/2021	320.77
G08	05/11/2021	315.82
G08	06/01/2021	313.42
G08	06/15/2021	312.94
G08	07/06/2021	312.52
G08	07/20/2021	312.49
G09	03/04/2021	318.48
G09	03/25/2021	322.65
G09	04/14/2021	319.59
G09	05/11/2021	316.57
G09	05/12/2021	316.57
G09	06/01/2021	311.02
G09	06/15/2021	311.68
G09	07/06/2021	313.60
G09	07/21/2021	312.34
G09M	03/04/2021	321.48
G09M	03/25/2021	324.08
G09M	04/14/2021	322.19
G09M	05/11/2021	321.42
G09M	05/12/2021	321.42
G09M	06/01/2021	317.47
G09M	06/14/2021	318.47
G09M	07/06/2021	316.93
G09M	07/21/2021	317.29
G10	03/04/2021	319.43
G10	03/24/2021	323.30
G10	04/13/2021	320.85
G10	05/11/2021	330.45
G10	06/01/2021	313.37
G10	06/15/2021	313.34
G10	07/06/2021	313.38
G10	07/20/2021	313.54
G11	03/04/2021	319.77
G11	03/24/2021	326.09

TABLE E-1. GROUNDWATER ELEVATIONS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G11	04/14/2021	325.15
G11	05/12/2021	322.77
G11	06/01/2021	323.49
G11	06/14/2021	320.25
G11	07/06/2021	319.25
G11	07/20/2021	319.20
G51D	12/02/2015	314.45
G51D	03/15/2016	327.04
G51D	06/14/2016	318.87
G51D	06/15/2016	318.87
G51D	09/13/2016	315.72
G51D	09/14/2016	315.72
G51D	12/14/2016	313.02
G51D	03/07/2017	316.35
G51D	06/14/2017	320.67
G51D	07/19/2017	317.56
G51D	11/30/2017	313.75
G51D	06/09/2018	318.42
G51D	09/05/2018	314.45
G51D	03/27/2019	329.28
G51D	09/09/2019	320.02
G51D	03/30/2020	330.18
G51D	09/23/2020	318.91
G51D	09/24/2020	318.91
G51D	03/03/2021	321.47
G51D	03/24/2021	326.10
G51D	04/14/2021	325.45
G51D	05/11/2021	323.14
G51D	06/01/2021	321.10
G51D	06/14/2021	320.84
G51D	07/06/2021	322.67
G51D	07/20/2021	319.59
G51D	09/20/2021	317.85
G52D	12/02/2015	315.68
G52D	03/15/2016	322.23
G52D	06/14/2016	323.04
G52D	06/15/2016	323.04
G52D	09/13/2016	320.37
G52D	09/14/2016	320.37
G52D	12/14/2016	316.85
G52D	03/07/2017	318.38
G52D	06/14/2017	322.05
G52D	07/19/2017	321.17
G52D	11/30/2017	316.31
G52D	06/09/2018	323.86
G52D	09/05/2018	320.38

TABLE E-1. GROUNDWATER ELEVATIONS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G52D	03/27/2019	328.73
G52D	09/09/2019	325.49
G52D	03/30/2020	327.82
G52D	09/23/2020	322.71
G52D	09/24/2020	322.71
G52D	03/03/2021	327.46
G52D	03/24/2021	323.36
G52D	03/25/2021	323.36
G52D	04/14/2021	321.87
G52D	05/12/2021	309.79
G52D	06/01/2021	324.23
G52D	06/15/2021	323.91
G52D	07/06/2021	323.36
G52D	07/20/2021	322.91
G52D	09/20/2021	321.10
G53D	12/02/2015	312.50
G53D	03/15/2016	322.34
G53D	06/14/2016	317.61
G53D	06/15/2016	317.61
G53D	09/13/2016	314.26
G53D	09/14/2016	314.26
G53D	12/14/2016	311.44
G53D	03/07/2017	314.62
G53D	06/14/2017	319.56
G53D	07/19/2017	316.33
G53D	11/30/2017	312.17
G53D	06/09/2018	317.31
G53D	09/05/2018	313.47
G53D	03/27/2019	328.27
G53D	09/09/2019	318.48
G53D	03/30/2020	328.98
G53D	09/23/2020	317.41
G53D	09/24/2020	317.41
G53D	03/03/2021	319.40
G53D	03/24/2021	325.15
G53D	03/25/2021	325.15
G53D	04/14/2021	324.23
G53D	05/11/2021	320.99
G53D	06/01/2021	319.65
G53D	06/14/2021	320.17
G53D	07/06/2021	318.02
G53D	07/20/2021	317.83
G53D	09/20/2021	316.26
G54S	03/03/2021	310.25
G54S	03/24/2021	311.48
G54S	04/14/2021	312.84

TABLE E-1. GROUNDWATER ELEVATIONS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G54S	05/12/2021	315.44
G54S	06/01/2021	312.65
G54S	06/14/2021	314.30
G54S	07/06/2021	316.75
G54S	07/20/2021	318.87
G54D	12/02/2015	310.44
G54D	03/15/2016	316.80
G54D	06/15/2016	312.24
G54D	09/13/2016	309.47
G54D	09/14/2016	309.47
G54D	12/14/2016	307.13
G54D	03/07/2017	313.34
G54D	06/14/2017	315.35
G54D	07/19/2017	312.52
G54D	11/30/2017	309.28
G54D	06/09/2018	313.80
G54D	09/05/2018	308.37
G54D	03/27/2019	326.30
G54D	09/09/2019	314.08
G54D	03/30/2020	329.13
G54D	09/23/2020	313.18
G54D	09/24/2020	313.18
G54D	03/03/2021	317.69
G54D	03/24/2021	324.08
G54D	04/14/2021	322.45
G54D	05/12/2021	319.02
G54D	06/01/2021	314.79
G54D	06/14/2021	314.93
G54D	07/06/2021	314.73
G54D	07/20/2021	314.77
G54D	09/20/2021	312.54
G151	03/03/2021	326.64
G151	03/24/2021	330.47
G151	04/14/2021	329.35
G151	05/11/2021	329.35
G151	06/01/2021	325.68
G151	06/14/2021	326.03
G151	07/06/2021	324.48
G151	07/20/2021	324.77
G152B	03/03/2021	338.25
G152B	03/25/2021	338.38
G152B	04/14/2021	336.25
G152B	05/12/2021	338.96
G152B	06/01/2021	334.71
G152B	06/15/2021	335.06
G152B	07/06/2021	332.91

TABLE E-1. GROUNDWATER ELEVATIONS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G152B	07/20/2021	332.91
G153	03/03/2021	319.04
G153	03/25/2021	324.74
G153	04/13/2021	324.60
G153	05/11/2021	320.59
G153	06/01/2021	319.71
G153	06/14/2021	320.19
G153	07/06/2021	318.17
G153	07/20/2021	317.91
XPW01	03/05/2021	369.84
XPW01	03/24/2021	370.64
XPW01	04/14/2021	367.84
XPW01	05/12/2021	369.71
XPW01	06/01/2021	367.76
XPW01	06/14/2021	368.67
XPW01	07/06/2021	367.83
XPW01	07/21/2021	368.46
XPW02	03/04/2021	372.79
XPW02	03/24/2021	373.89
XPW02	04/14/2021	371.64
XPW02	05/12/2021	372.53
XPW02	06/01/2021	370.79
XPW02	06/14/2021	371.54
XPW02	07/06/2021	370.52
XPW02	07/21/2021	371.15
XPW03	03/04/2021	373.84
XPW03	03/24/2021	374.54
XPW03	04/14/2021	372.77
XPW03	05/12/2021	373.31
XPW03	06/01/2021	372.07
XPW03	06/14/2021	372.40
XPW03	07/06/2021	372.06
XPW03	07/21/2021	372.27
XSG01	03/05/2021	357.48
XSG01	03/25/2021	367.78
XSG01	04/14/2021	368.78
XSG01	05/12/2021	369.28
XSG01	06/01/2021	368.86
XSG01	06/14/2021	367.28
XSG01	07/06/2021	367.18
XSG01	07/20/2021	367.03
SG02	03/03/2021	323.28
SG02	03/04/2021	324.48
SG02	03/05/2021	324.83
SG02	03/24/2021	320.66
SG02	04/13/2021	312.19

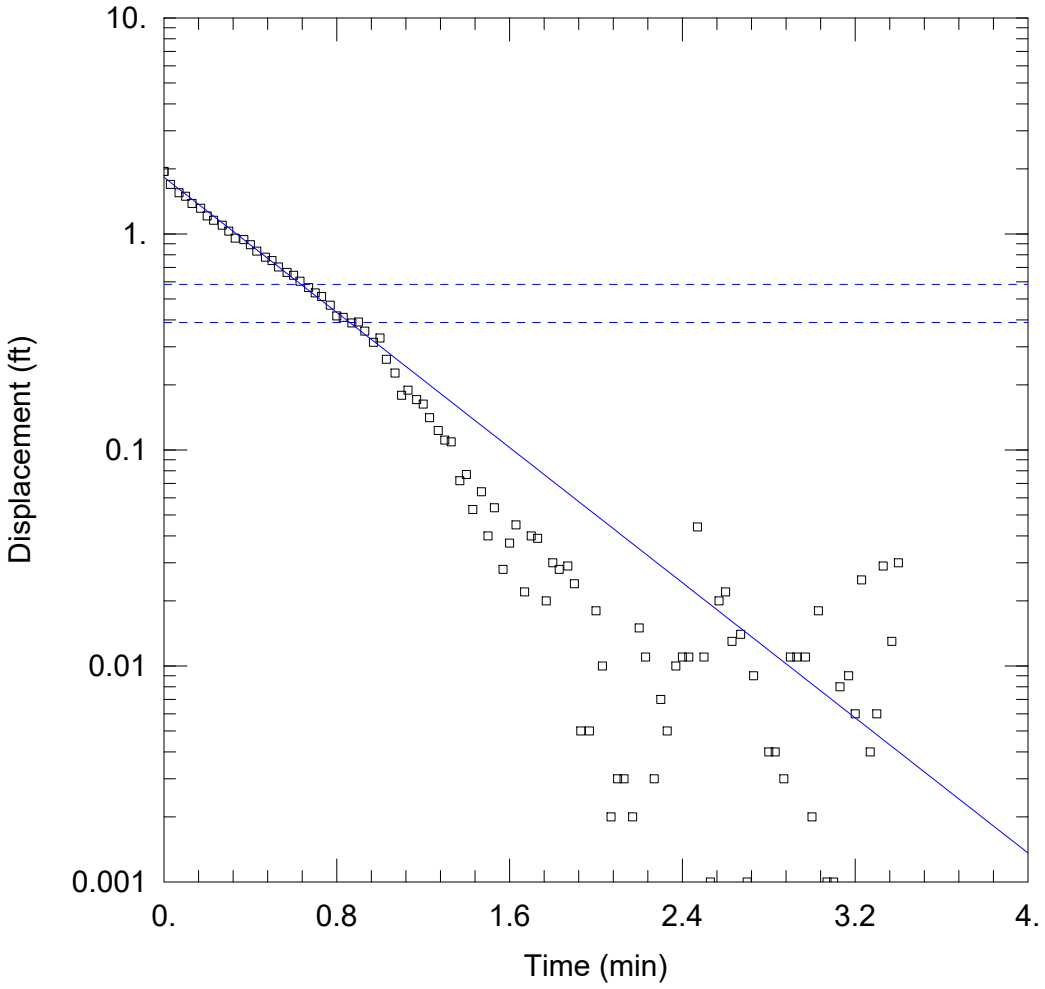
TABLE E-1. GROUNDWATER ELEVATIONS
HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
SG02	04/14/2021	312.01
SG02	05/11/2021	312.39
SG02	05/12/2021	310.73
SG02	06/01/2021	301.18
SG02	06/14/2021	303.62
SG02	06/15/2021	302.69
SG02	07/06/2021	306.26
SG02	07/20/2021	309.37
SG02	07/21/2021	309.33

Notes:
ft NAVD88 = feet relative to the North American Vertical Datum 1988, GEOID 12A

generated 10/11/2021, 12:35:23 PM CDT

APPENDIX F
HYDRAULIC CONDUCTIVITY TEST DATA



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-06 test 1 (slug-in) BR.aqt
Date: 03/31/21 Time: 11:36:29

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa
Test Well: G-06

AQUIFER DATA

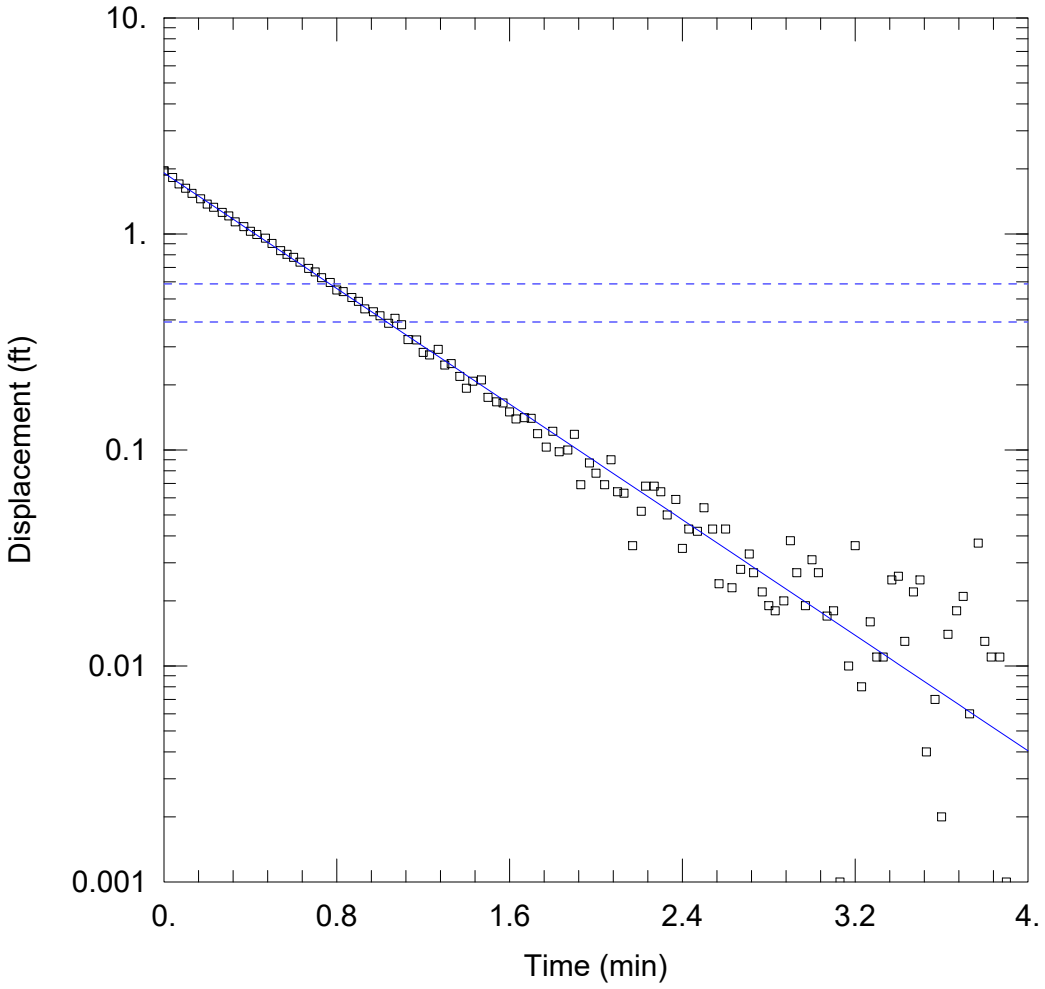
Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-06 (test 1 slug in))

Initial Displacement: 1.945 ft
Total Well Penetration Depth: 52.85 ft
Casing Radius: 0.083 ft
Static Water Column Height: 52.85 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.001199 cm/sec
y0 = 1.829 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-06 test 2 (slug-out) BR.aqt
Date: 03/31/21 Time: 11:37:34

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa
Test Well: G-06

AQUIFER DATA

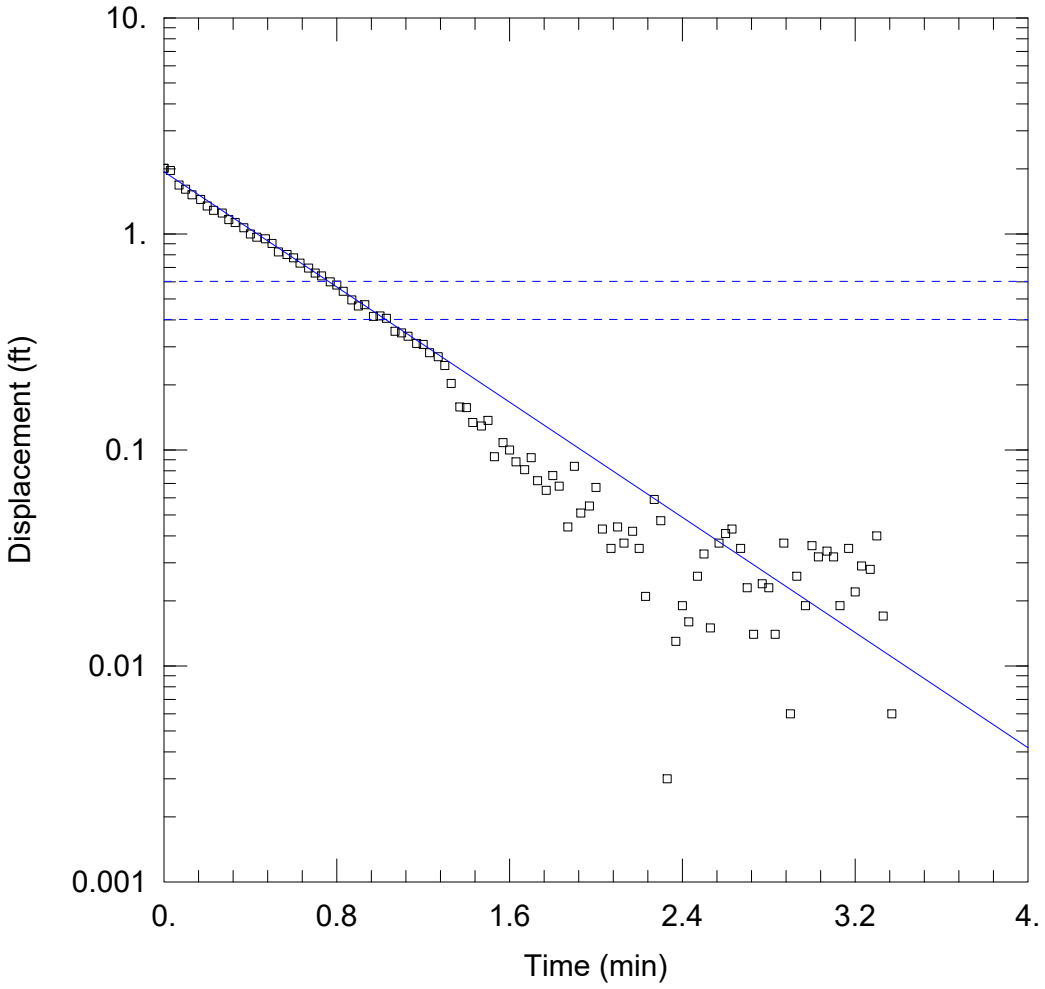
Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-06 (test 2 slug out))

Initial Displacement: 1.956 ft
Total Well Penetration Depth: 52.85 ft
Casing Radius: 0.083 ft
Static Water Column Height: 52.85 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.001025 cm/sec
y0 = 1.915 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-06 test 3 (slug-in) BR.aqt
Date: 03/31/21 Time: 11:38:16

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa
Test Well: G-06

AQUIFER DATA

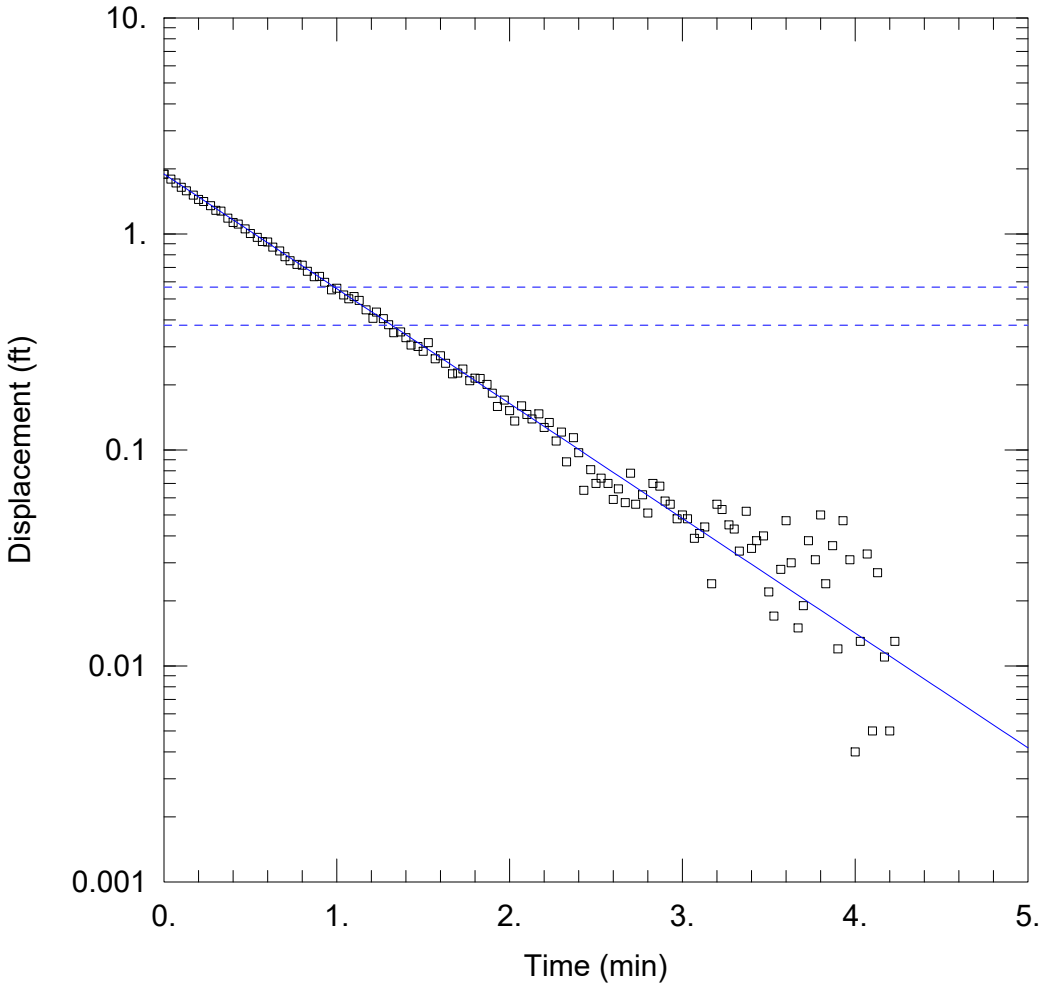
Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-06 (test 3 slug in))

Initial Displacement: 2.01 ft
Total Well Penetration Depth: 52.85 ft
Casing Radius: 0.083 ft
Static Water Column Height: 52.85 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.001022 cm/sec
y0 = 1.941 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-06 test 4 (slug-out) BR.aqt
Date: 03/31/21 Time: 11:38:53

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa
Test Well: G-06

AQUIFER DATA

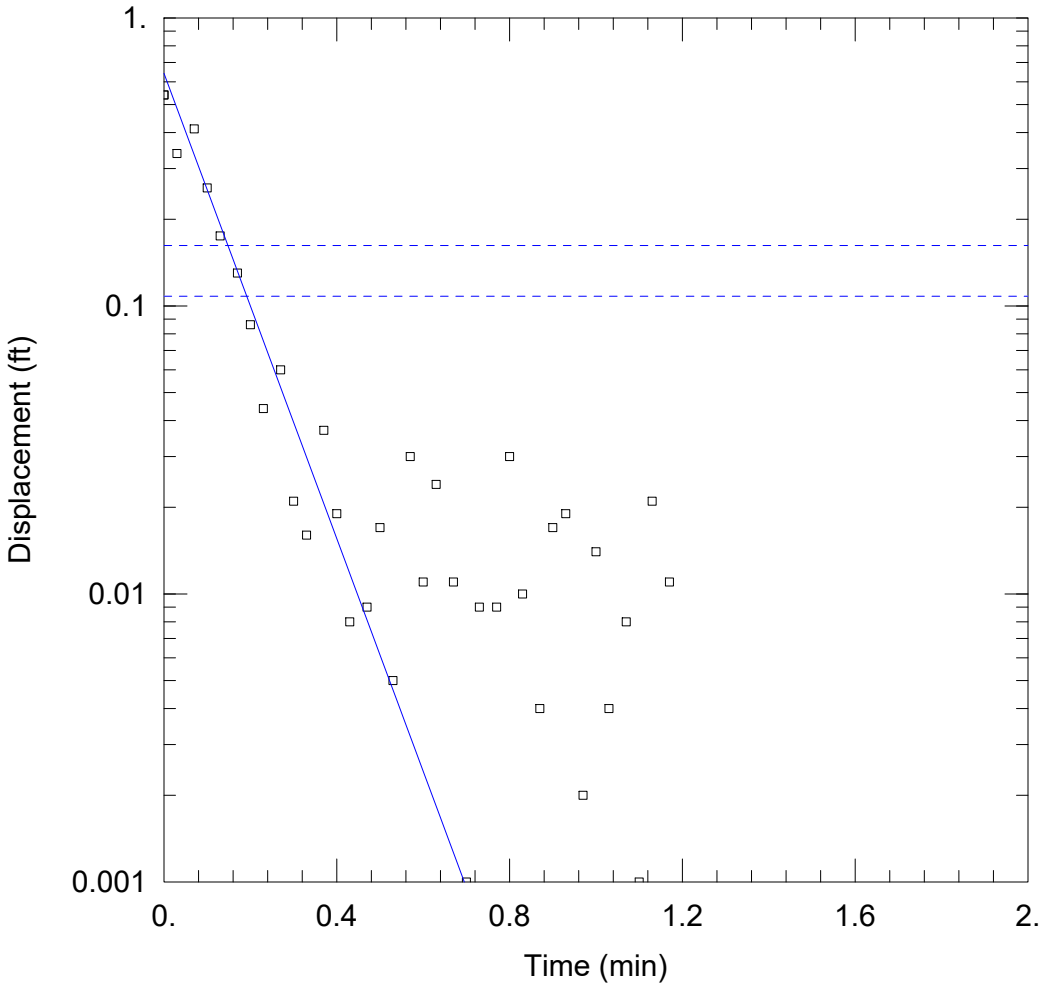
Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-06 (test 4 slug out))

Initial Displacement: 1.89 ft
Total Well Penetration Depth: 52.85 ft
Casing Radius: 0.083 ft
Static Water Column Height: 52.85 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0008143 cm/sec
y0 = 1.895 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-07 test 1 (slug-in) BR.aqt
Date: 03/31/21 Time: 11:41:12

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa
Test Well: G-07

AQUIFER DATA

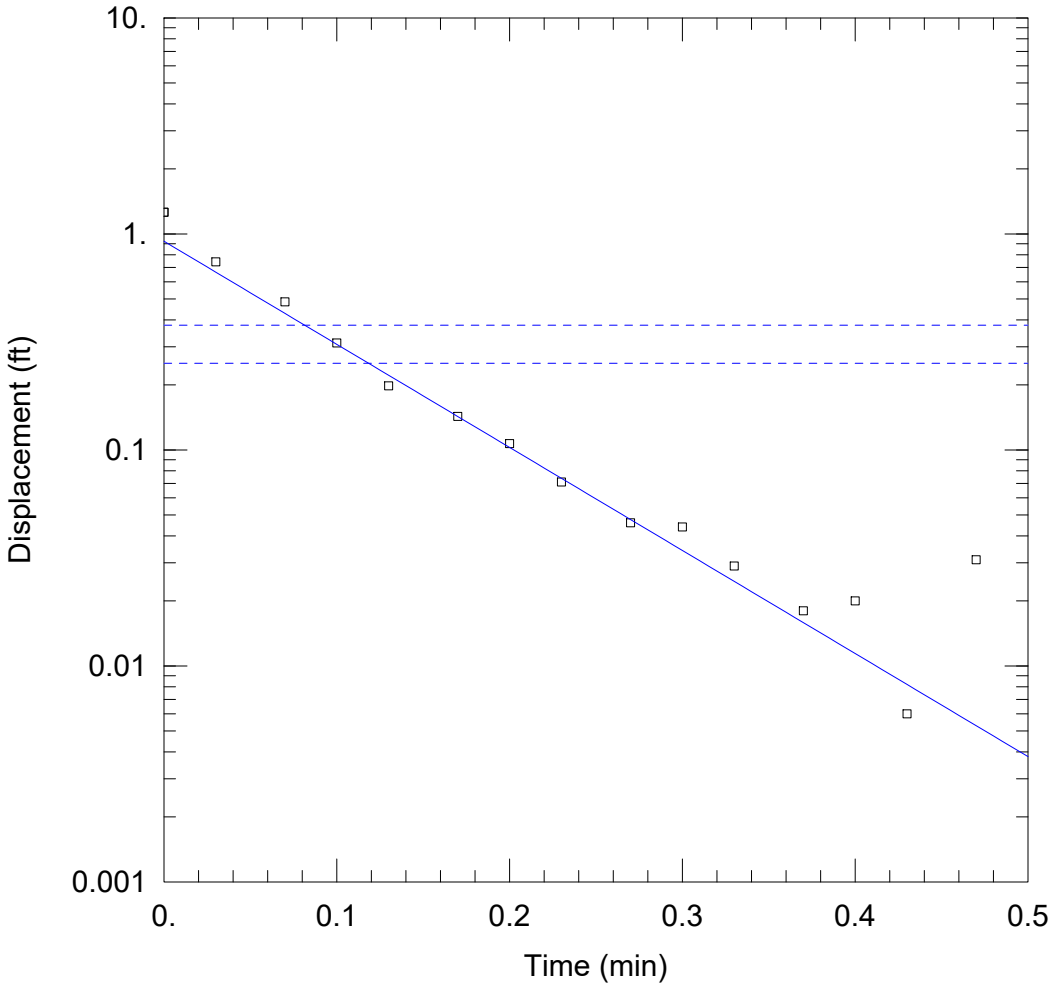
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-07 (test 1 slug in))

Initial Displacement: 0.54 ft
Total Well Penetration Depth: 23.39 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.39 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.006959 cm/sec
y0 = 0.6416 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-07 test 2 (slug-out) BR.aqt
Date: 03/31/21 Time: 11:41:51

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa Ash Pond
Test Well: G-07

AQUIFER DATA

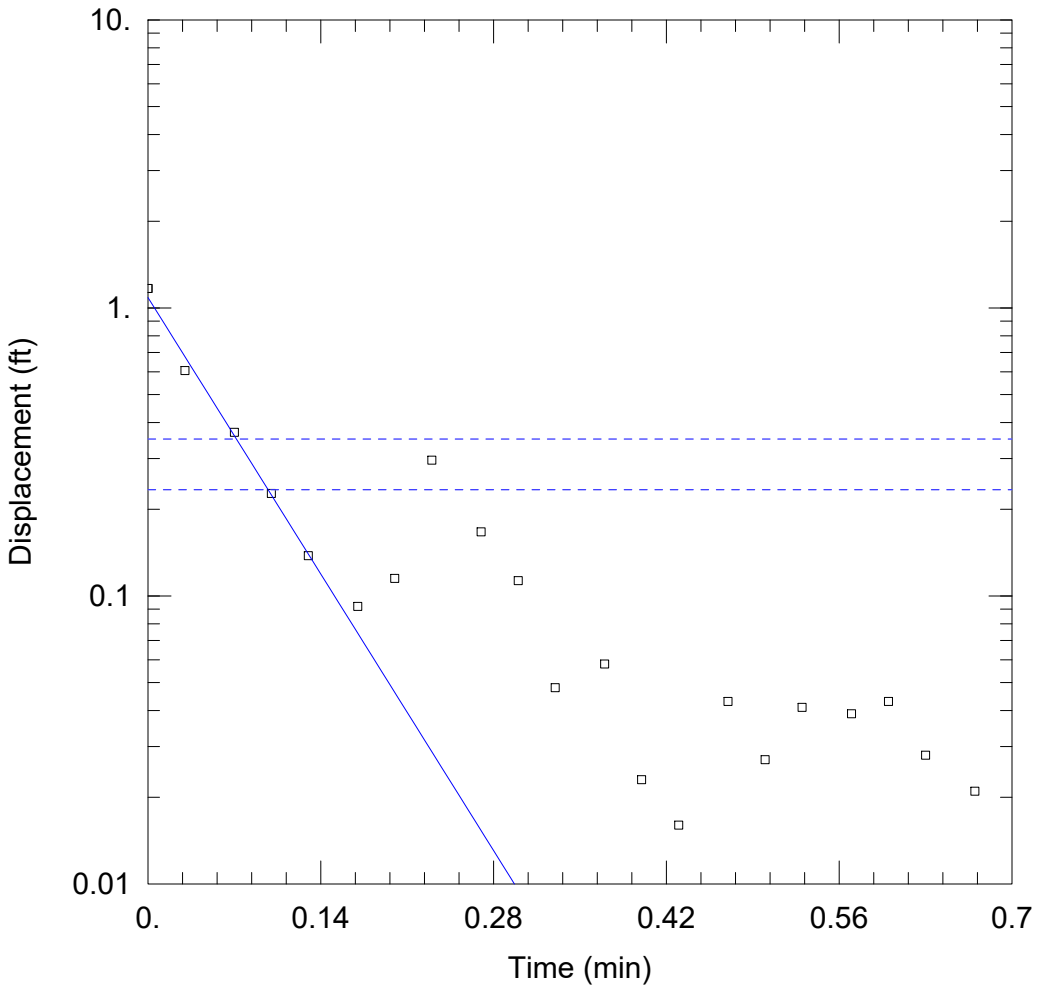
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-07 (test 2 slug-out))

Initial Displacement: 1.26 ft
Static Water Column Height: 23.39 ft
Total Well Penetration Depth: 23.39 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.008223 cm/sec
y0 = 0.9246 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-07 test 3 (slug-in) BR.aqt
Date: 03/31/21 Time: 11:42:56

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa Ash Pond
Test Well: G-07

AQUIFER DATA

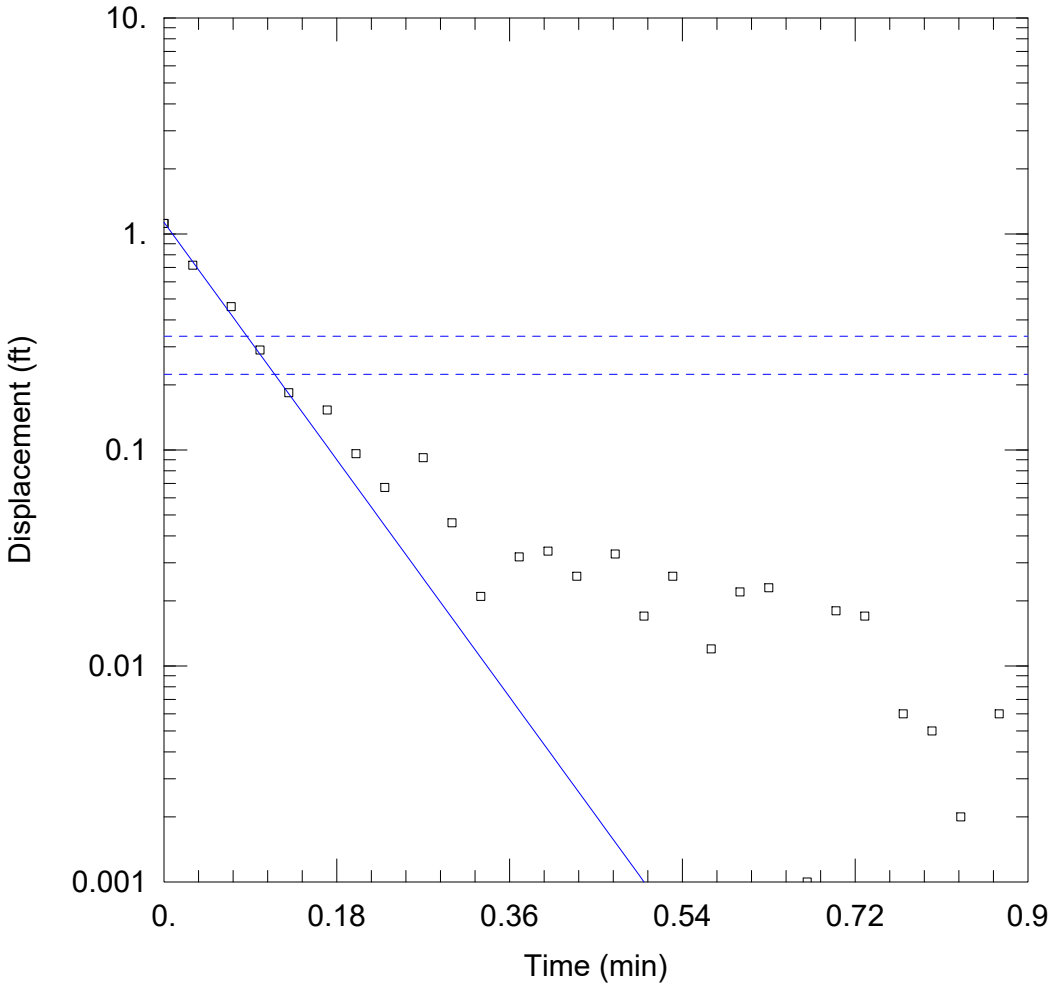
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-07 (test 3 slug-in))

Initial Displacement: 1.168 ft
Static Water Column Height: 23.39 ft
Total Well Penetration Depth: 23.39 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.01182 cm/sec
y0 = 1.087 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-07 test 4 (slug-out) BR.aqt
Date: 03/31/21 Time: 11:43:39

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa
Test Well: G-07

AQUIFER DATA

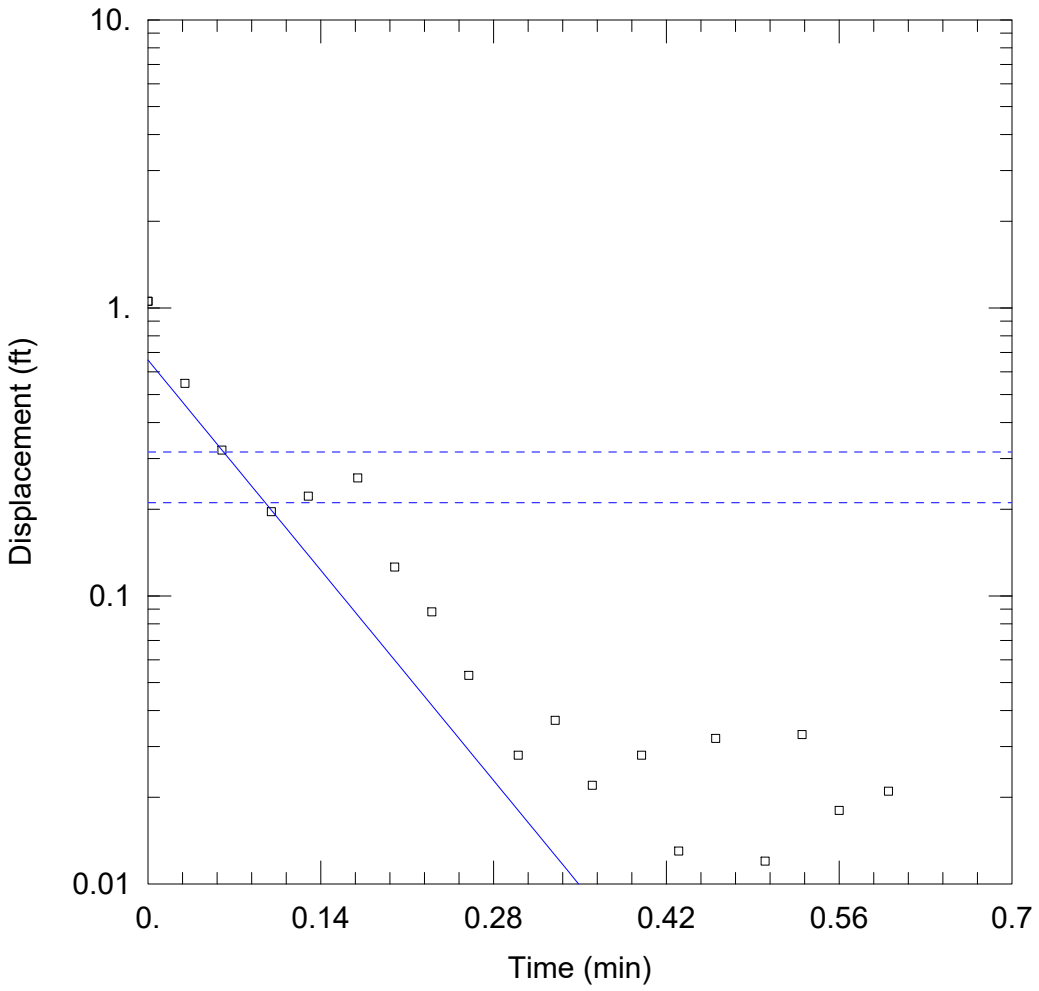
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-07 (test 4 slug-out))

Initial Displacement: 1.119 ft
Total Well Penetration Depth: 23.39 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.39 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.01052 cm/sec
y0 = 1.132 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-07 test 5 (slug-in) BR.aqt
Date: 03/31/21 Time: 11:44:38

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa
Test Well: G-07

AQUIFER DATA

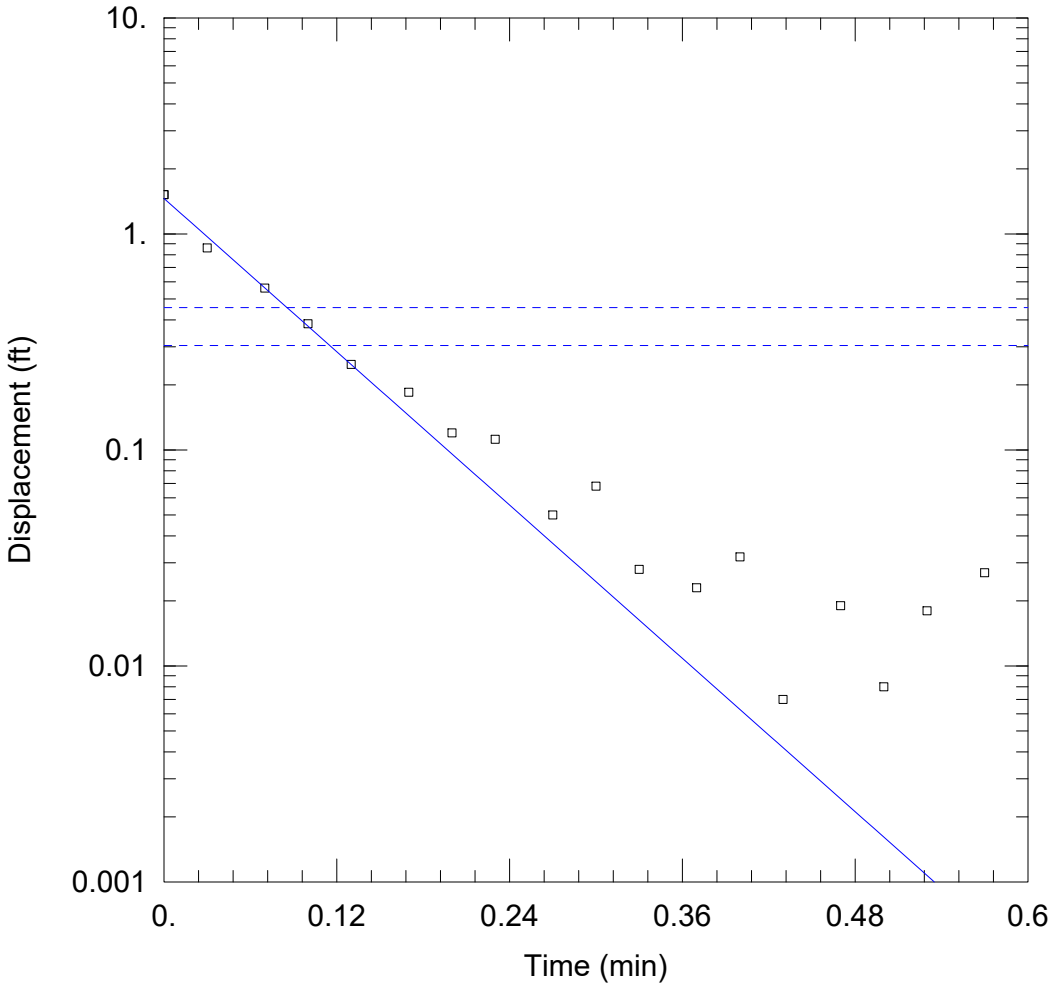
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-07 (test 5 slug-out))

Initial Displacement: 1.054 ft
Static Water Column Height: 23.39 ft
Total Well Penetration Depth: 23.39 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.008984 cm/sec
y0 = 0.6591 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G-07 test 6 (slug-out) BR.aqt
Date: 03/31/21 Time: 11:45:44

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa
Test Well: G-07

AQUIFER DATA

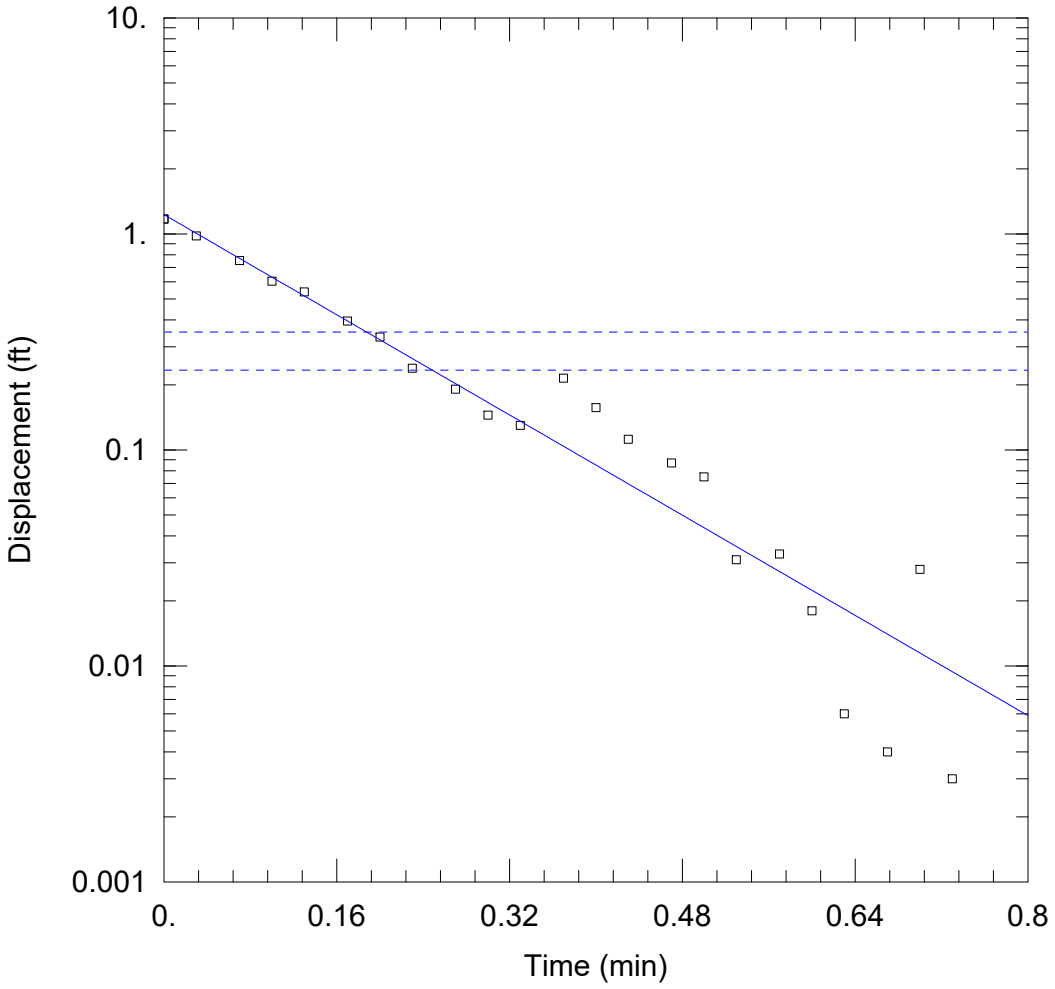
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-07 (test 6 slug-out))

Initial Displacement: 1.521 ft
Total Well Penetration Depth: 23.39 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.39 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.01019 cm/sec
y0 = 1.46 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-8 test 1 (slug-in) BR.aqt
Date: 04/09/21 Time: 16:26:39

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-8

AQUIFER DATA

Saturated Thickness: 48. ft Anisotropy Ratio (Kz/Kr): 0.1

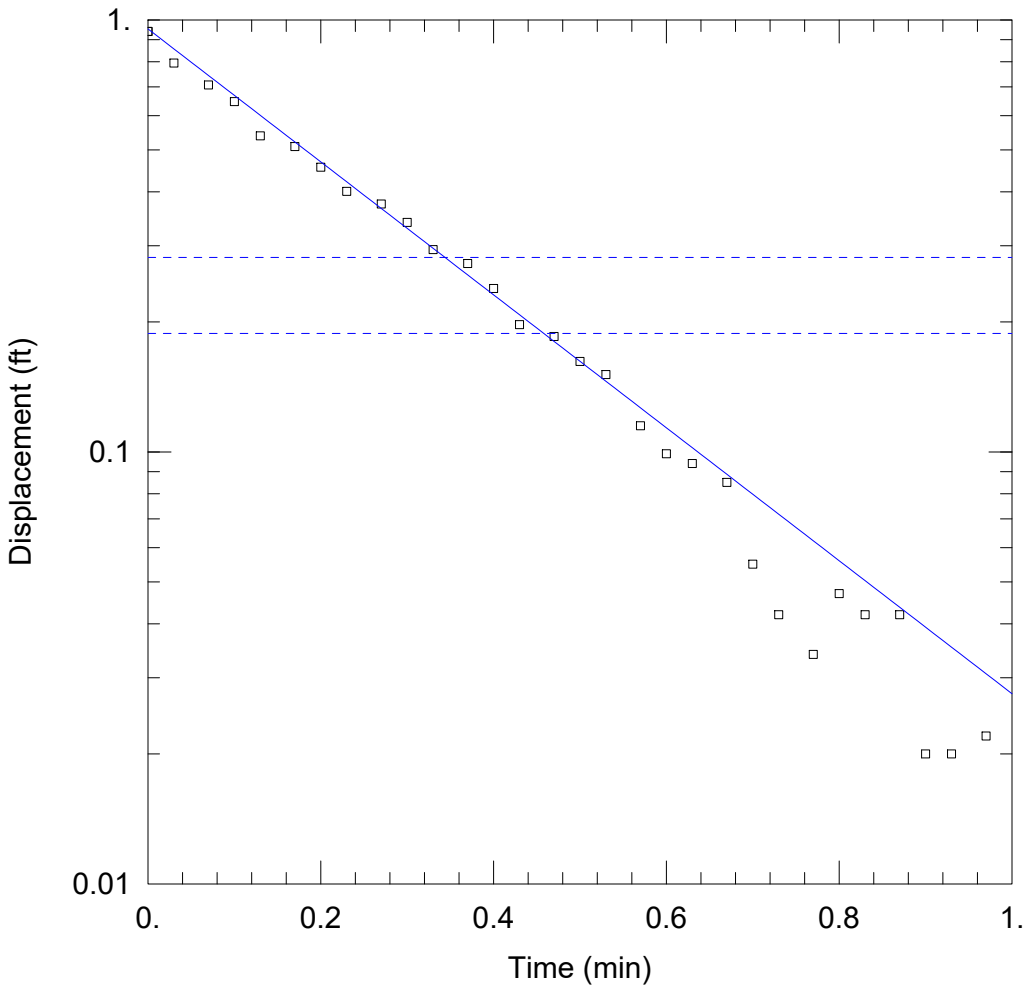
WELL DATA (G-8 (test 1 slug-in))

Initial Displacement: 1.17 ft
Total Well Penetration Depth: 48. ft
Casing Radius: 0.083 ft
Static Water Column Height: 60.85 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.005507 cm/sec y0 = 1.229 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-8 test 2 (slug-out) BR.aqt
Date: 04/09/21 Time: 16:29:24

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-8

AQUIFER DATA

Saturated Thickness: 48. ft Anisotropy Ratio (Kz/Kr): 0.1

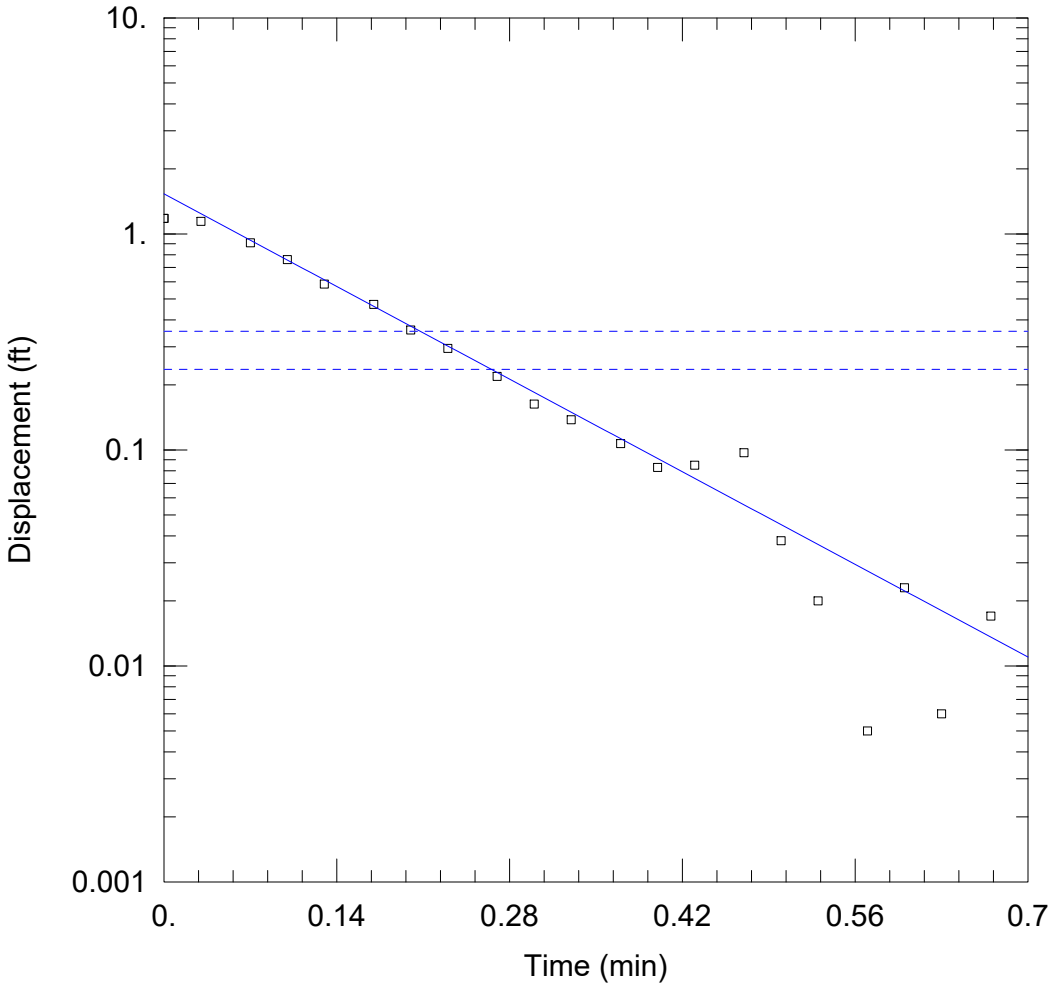
WELL DATA (G-8 (test 2 slug-out))

Initial Displacement: 0.94 ft
Total Well Penetration Depth: 48. ft
Casing Radius: 0.083 ft
Static Water Column Height: 60.85 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.002923 cm/sec y0 = 0.953 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-8 test 3 (slug-in) BR.aqt
Date: 04/09/21 Time: 16:31:33

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-8

AQUIFER DATA

Saturated Thickness: 48. ft Anisotropy Ratio (Kz/Kr): 0.1

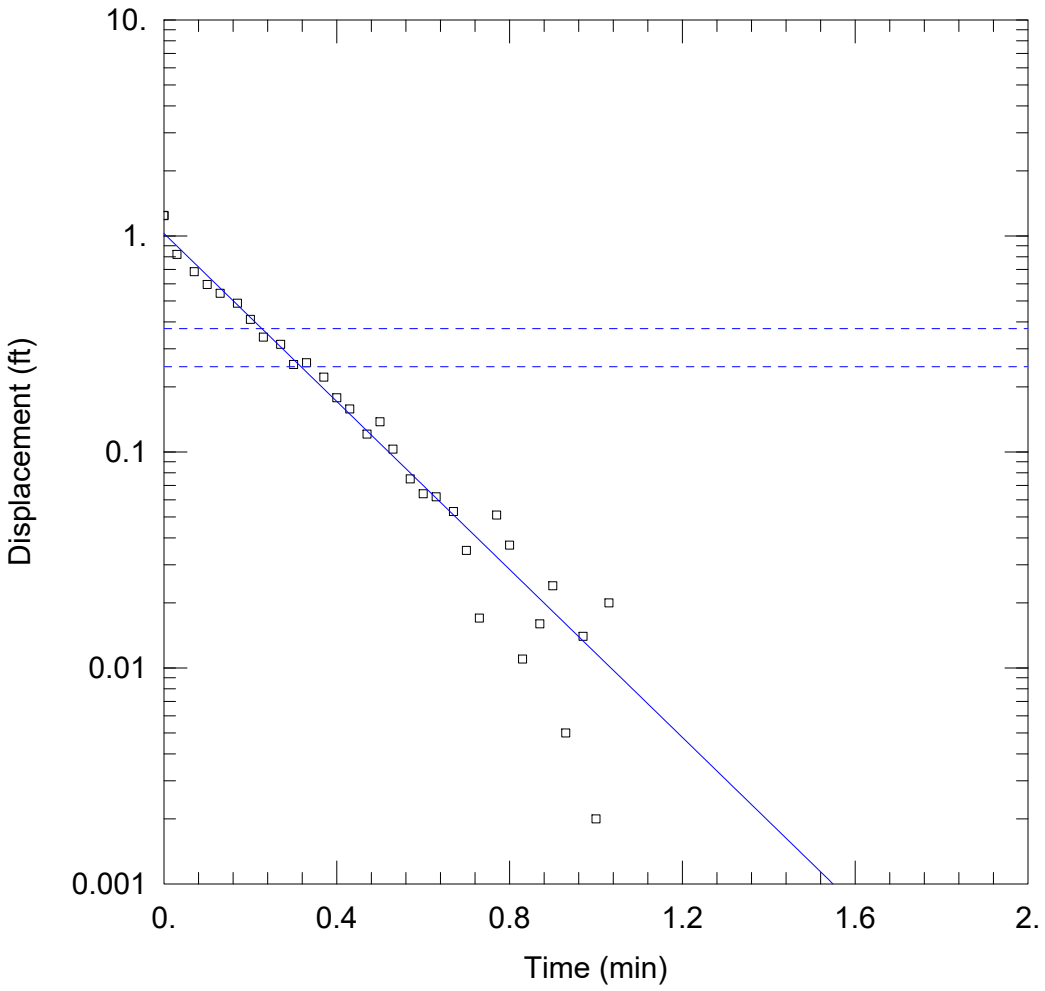
WELL DATA (G-8 (test 2 slug-out))

Initial Displacement: 1.18 ft
Total Well Penetration Depth: 48. ft
Casing Radius: 0.083 ft
Static Water Column Height: 60.85 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.005818 cm/sec y0 = 1.532 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-8 test 4 (slug-out) BR.aqt
Date: 04/09/21 Time: 16:33:50

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-8

AQUIFER DATA

Saturated Thickness: 48. ft Anisotropy Ratio (Kz/Kr): 0.1

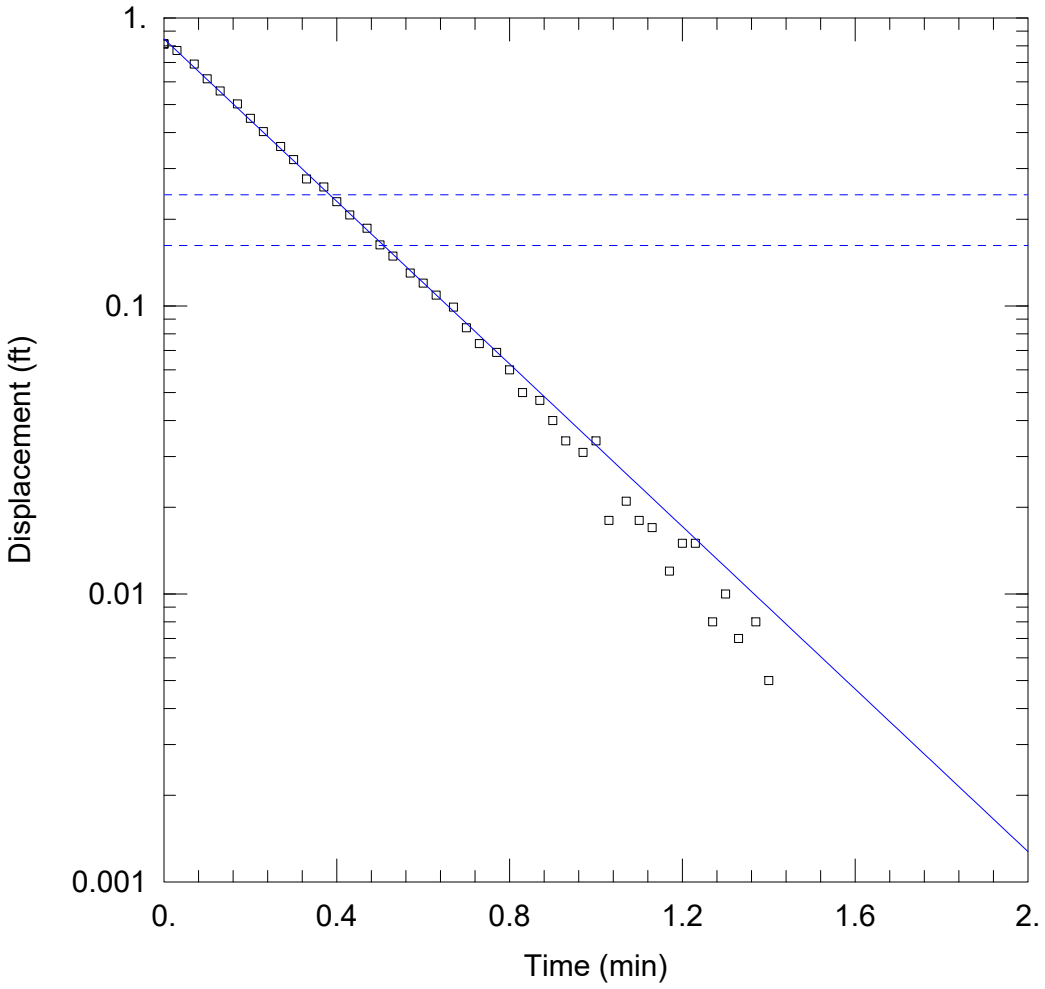
WELL DATA (G-8 (test 4 slug-out))

Initial Displacement: 1.24 ft
Total Well Penetration Depth: 48. ft
Casing Radius: 0.083 ft
Static Water Column Height: 60.85 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.003693 cm/sec y0 = 1.026 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-9 test 1 (slug-in) BR.aqt
Date: 04/09/21 Time: 15:43:53

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-9

AQUIFER DATA

Saturated Thickness: 13. ft Anisotropy Ratio (Kz/Kr): 0.1

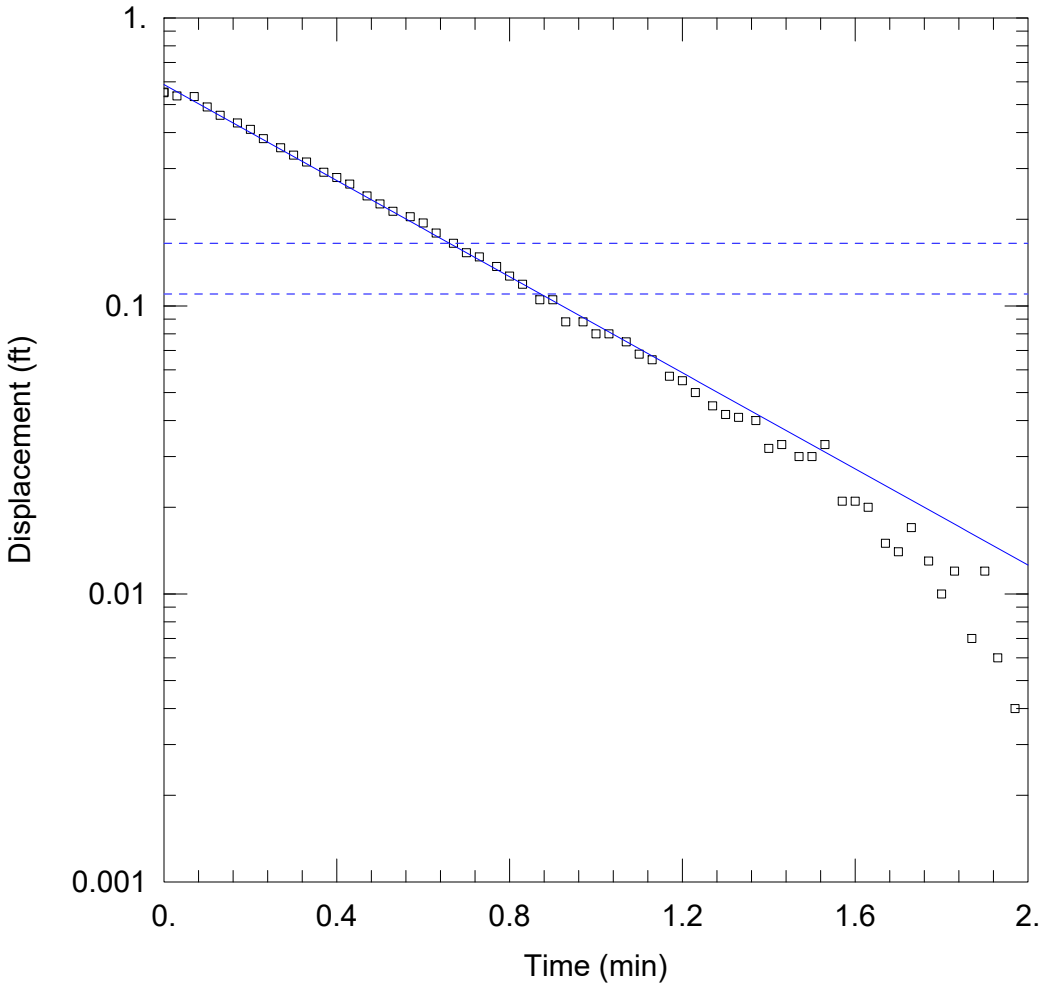
WELL DATA (G-9 (test 1 slug-in))

Initial Displacement: 0.81 ft
Total Well Penetration Depth: 40.03 ft
Casing Radius: 0.083 ft
Static Water Column Height: 40.03 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.002618 cm/sec y0 = 0.8457 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-9 test 2 (slug-out) BR.aqt
Date: 04/09/21 Time: 15:46:36

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-9

AQUIFER DATA

Saturated Thickness: 13. ft Anisotropy Ratio (Kz/Kr): 0.1

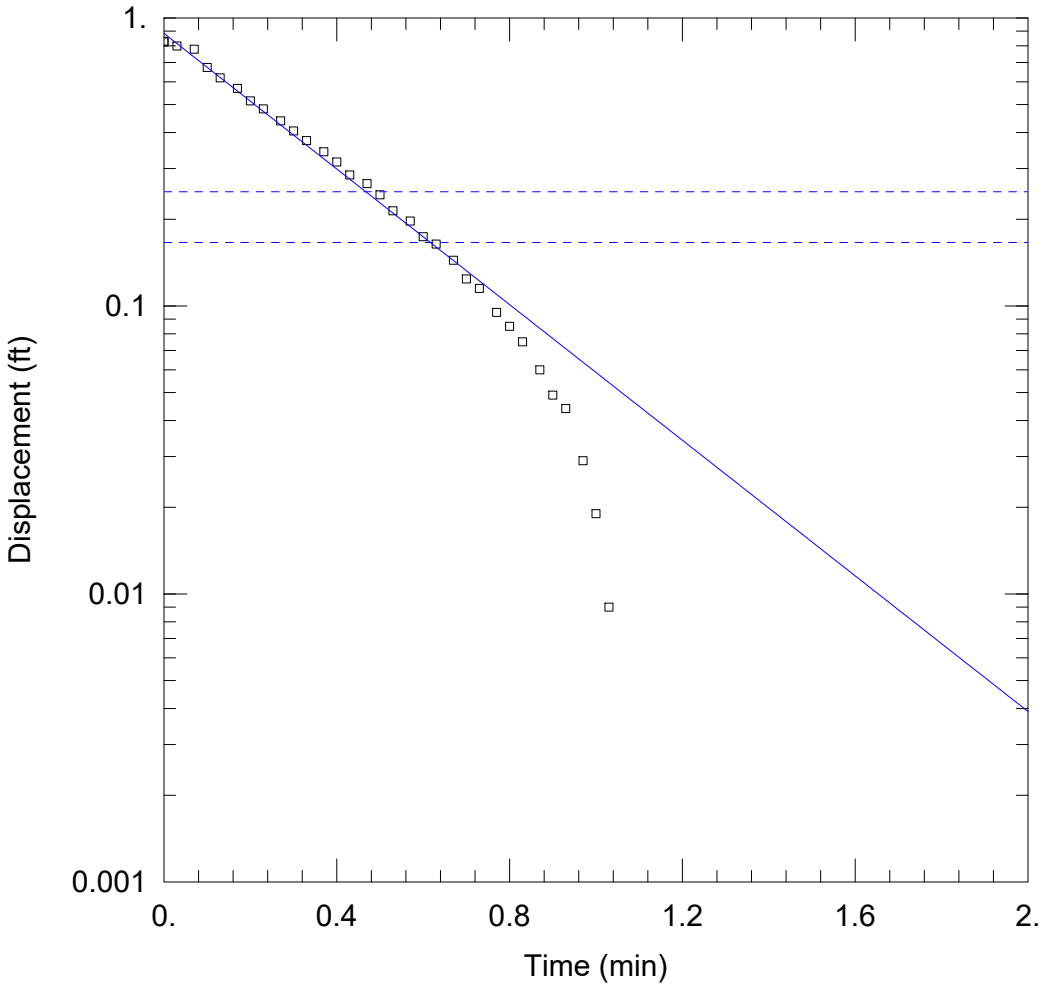
WELL DATA (G-9 (test 2 slug-out))

Initial Displacement: 0.55 ft
Total Well Penetration Depth: 40.03 ft
Casing Radius: 0.083 ft
Static Water Column Height: 40.03 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.001548 cm/sec y0 = 0.5873 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-10 test 1 (slug-in) BR.aqt
Date: 04/09/21 Time: 14:40:34

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-10

AQUIFER DATA

Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 0.1

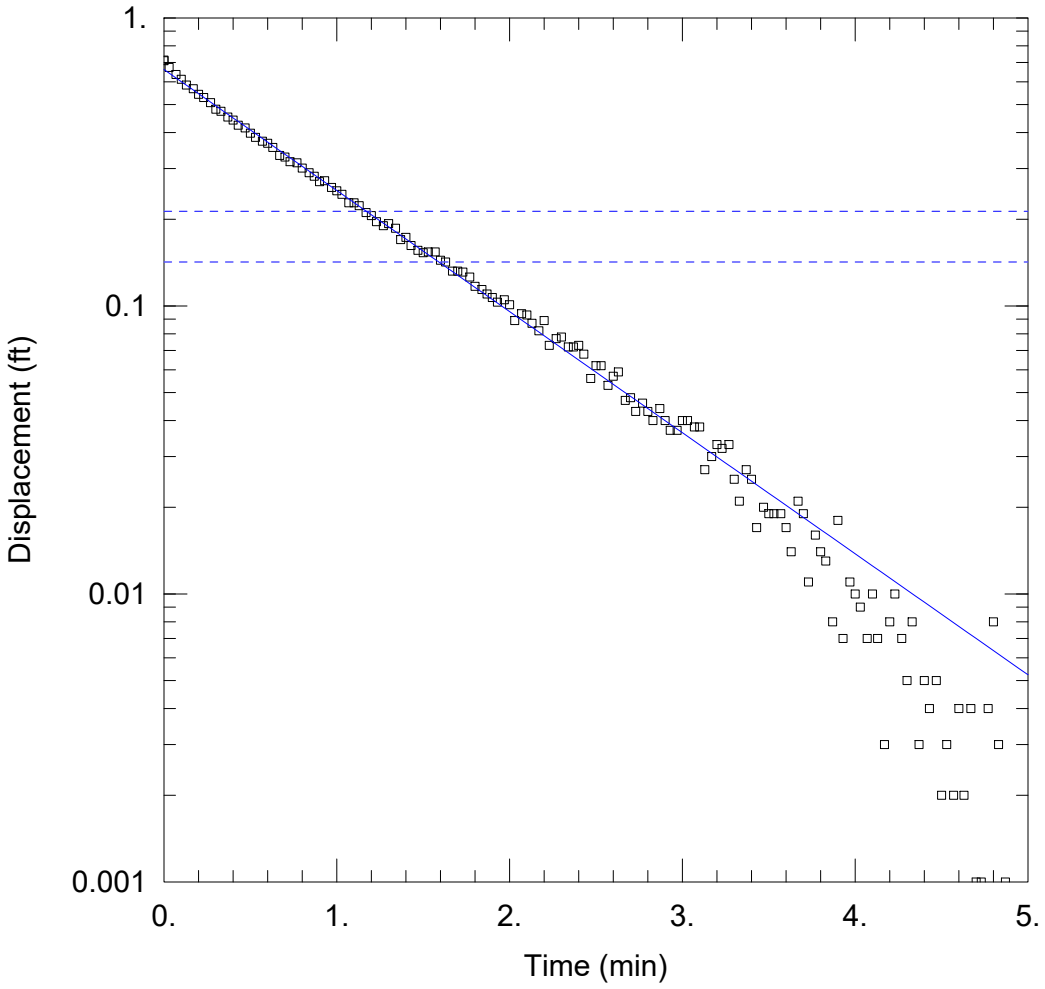
WELL DATA (G-10 (test 1 slug-in))

Initial Displacement: 0.83 ft
Total Well Penetration Depth: 10.73 ft
Casing Radius: 0.083 ft
Static Water Column Height: 10.73 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.001355 cm/sec y0 = 0.8835 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-10 test 2 (slug-out) BR.aqt
Date: 04/09/21 Time: 14:42:40

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-10

AQUIFER DATA

Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 0.1

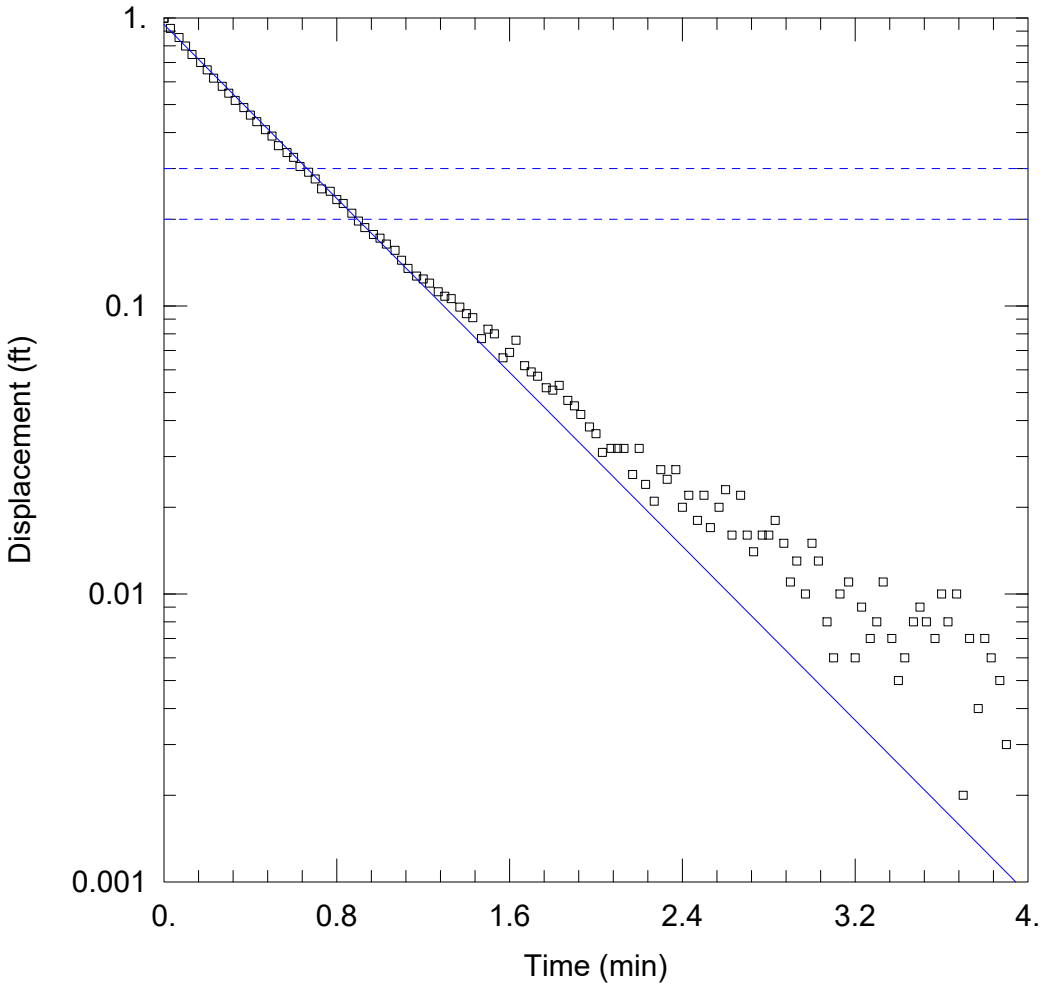
WELL DATA (G-10 (test 2 slug-out))

Initial Displacement: 0.71 ft
Total Well Penetration Depth: 10.73 ft
Casing Radius: 0.083 ft
Static Water Column Height: 10.73 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.0004838 cm/sec y0 = 0.662 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-10 test 3 (slug-in) BR.aqt
Date: 04/09/21 Time: 14:44:50

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-10

AQUIFER DATA

Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 0.1

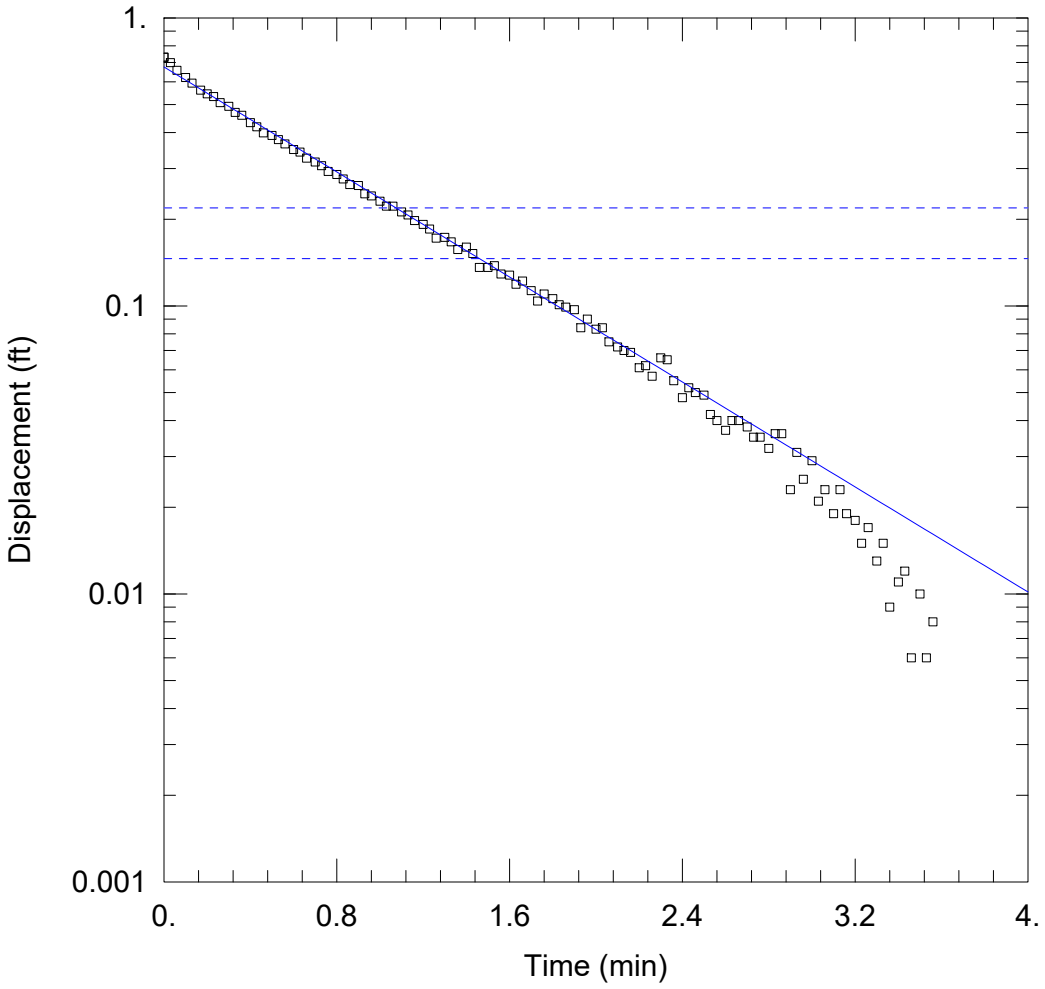
WELL DATA (G-10 (test 3 slug-in))

Initial Displacement: 1. ft
Total Well Penetration Depth: 10.73 ft
Casing Radius: 0.083 ft
Static Water Column Height: 10.73 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.0008689 cm/sec y0 = 0.9483 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-10 test 4 (slug-out) BR.aqt
Date: 04/09/21 Time: 14:46:31

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-10

AQUIFER DATA

Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 0.1

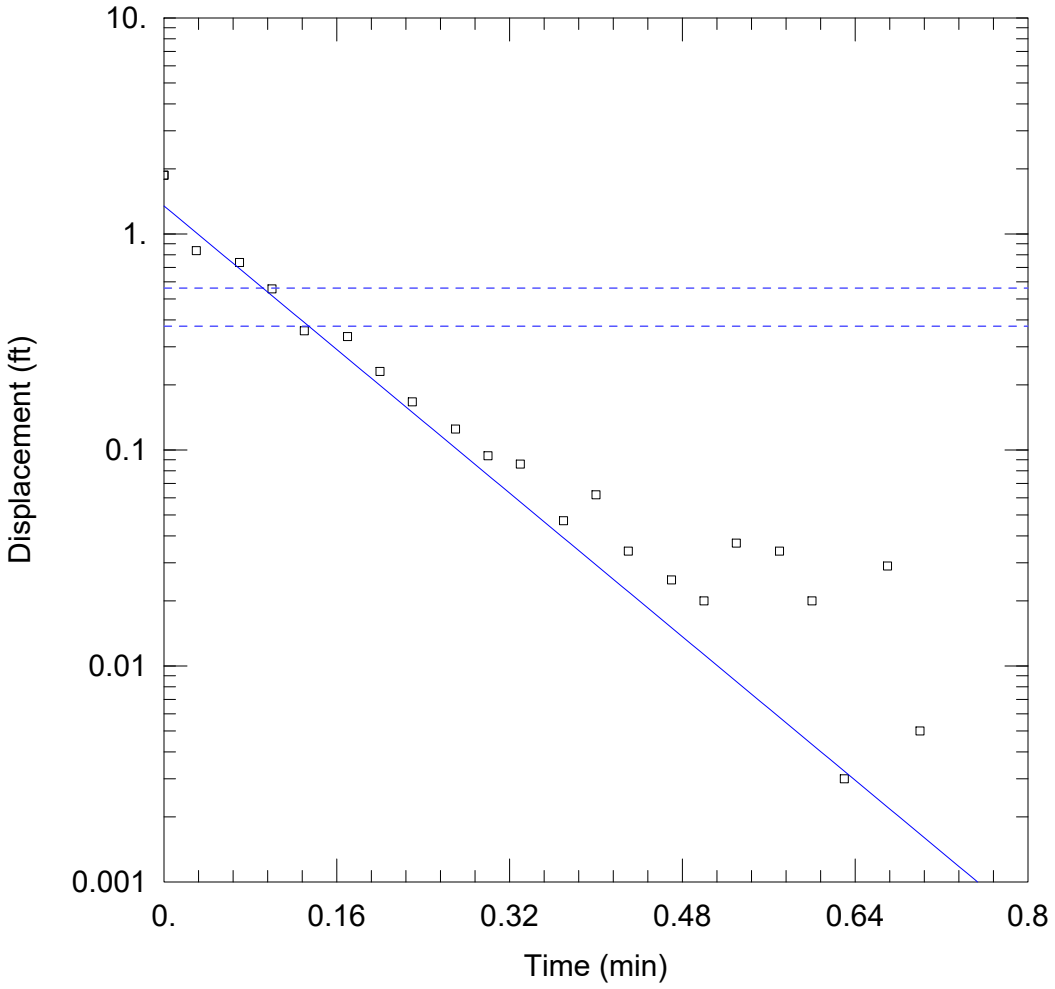
WELL DATA (G-10 (test 4 slug-out))

Initial Displacement: 0.73 ft
Total Well Penetration Depth: 10.73 ft
Casing Radius: 0.083 ft
Static Water Column Height: 10.73 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.0005246 cm/sec y0 = 0.6756 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-11 test 1 (slug-in) BR.aqt
Date: 04/09/21 Time: 15:09:34

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-11

AQUIFER DATA

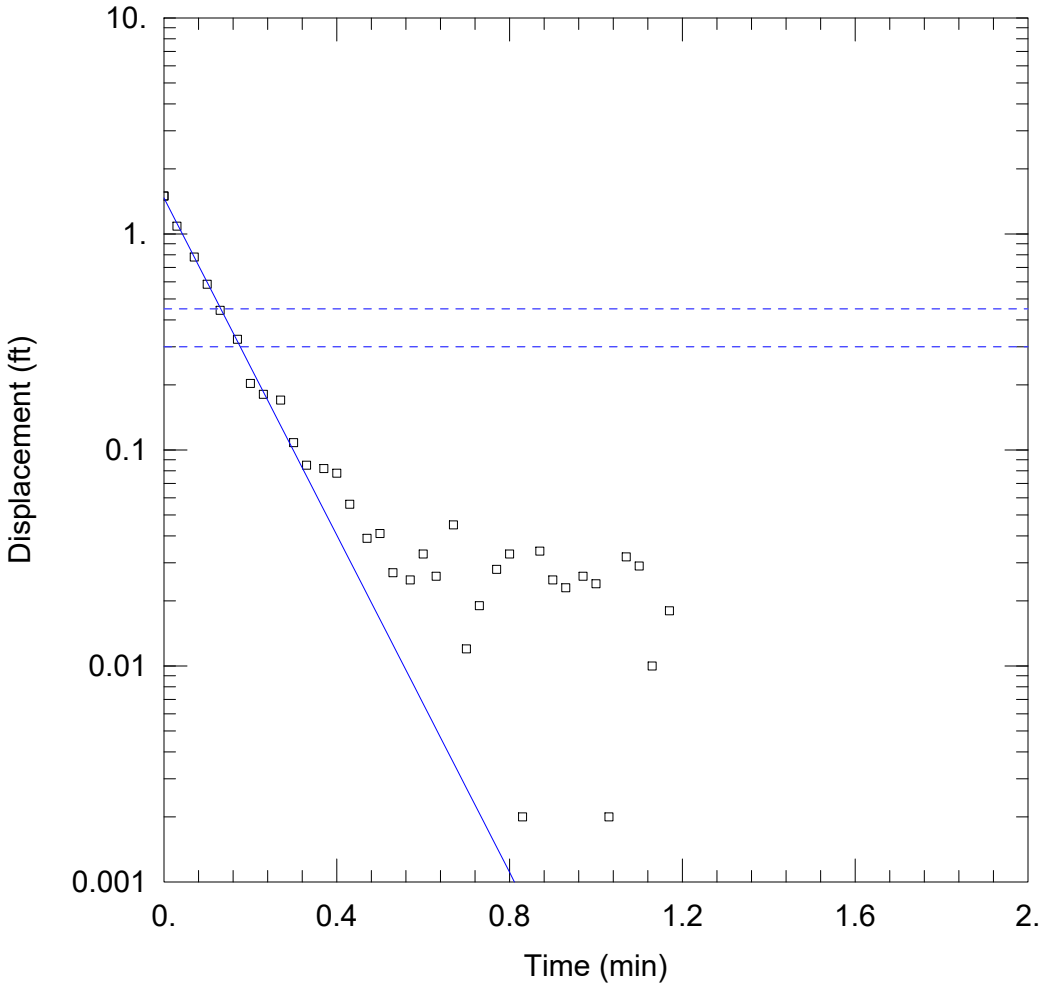
Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-11 (test 1 slug-in))

Initial Displacement: 1.87 ft
Total Well Penetration Depth: 23.2 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.2 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.007151 cm/sec
y0 = 1.348 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-11 test 2 (slug-out) BR.aqt
Date: 04/09/21 Time: 15:11:32

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-11

AQUIFER DATA

Saturated Thickness: 13. ft Anisotropy Ratio (Kz/Kr): 0.1

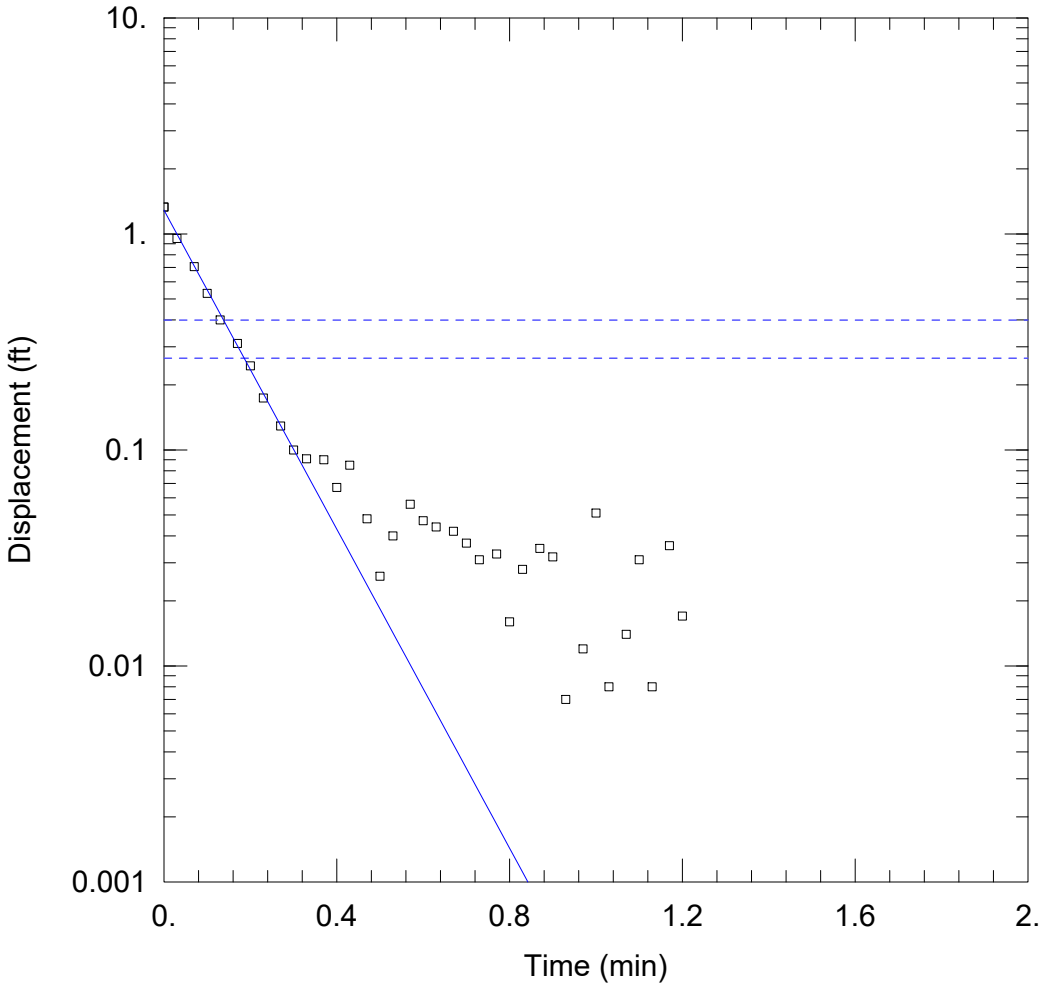
WELL DATA (G-11 (test 2 slug-out))

Initial Displacement: 1.5 ft Static Water Column Height: 23.2 ft
Total Well Penetration Depth: 23.2 ft Screen Length: 10. ft
Casing Radius: 0.083 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.006716 cm/sec y0 = 1.466 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-11 test 3 (slug-in) BR.aqt
Date: 04/09/21 Time: 15:15:17

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-11

AQUIFER DATA

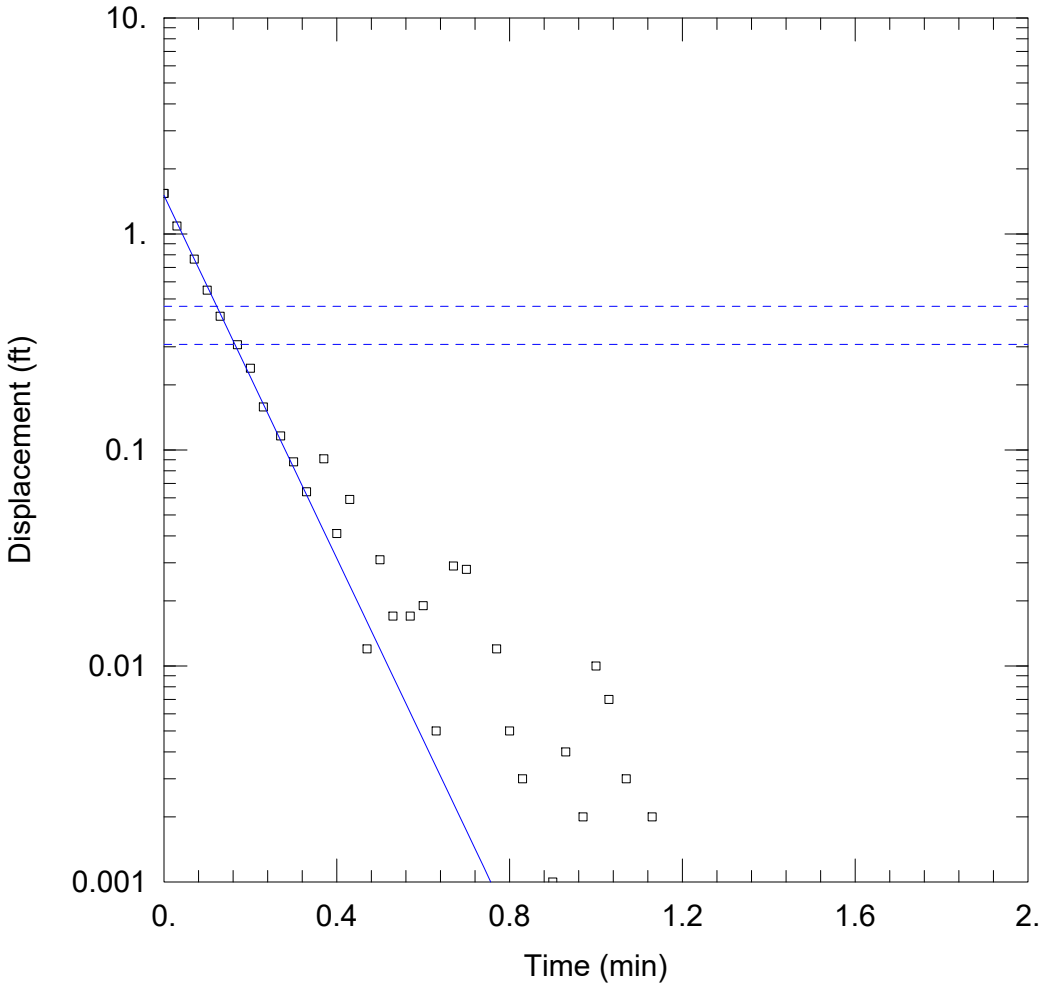
Saturated Thickness: 13. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-11 (test 3 slug-in))

Initial Displacement: 1.33 ft
Total Well Penetration Depth: 23.2 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.2 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.006355 cm/sec
y0 = 1.288 ft



WELL TEST ANALYSIS

Data Set: P:\...\G-11 test 4 (slug-out) BR.aqt
Date: 04/09/21 Time: 15:19:03

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: G-11

AQUIFER DATA

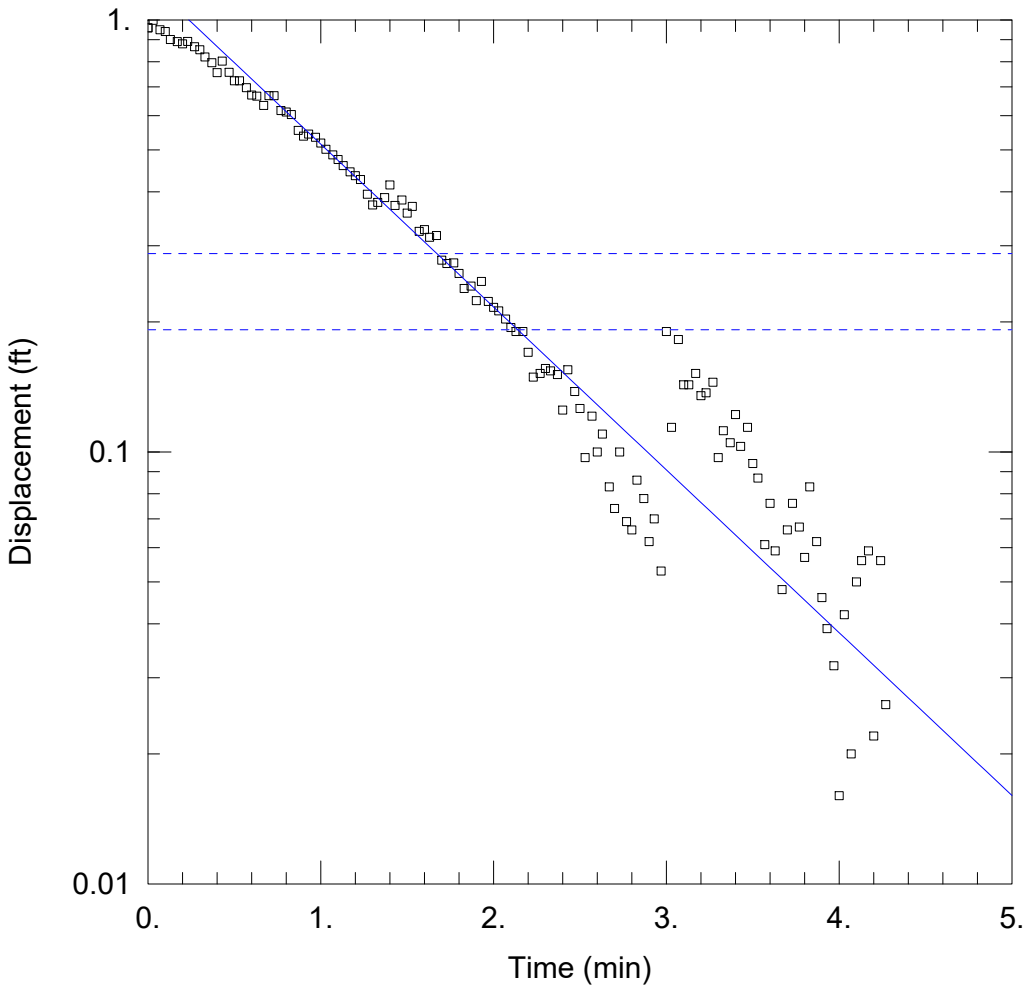
Saturated Thickness: 13. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (G-11 (test 4 slug-out))

Initial Displacement: 1.54 ft
Total Well Penetration Depth: 23.2 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.2 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.007229 cm/sec
y0 = 1.506 ft



TEST 1 SLUG IN

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G09M test 1 (Slug-in).aqt
Date: 03/31/21 Time: 08:32:59

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa, IL
Test Well: G09M
Test Date: 2/26/2021

AQUIFER DATA

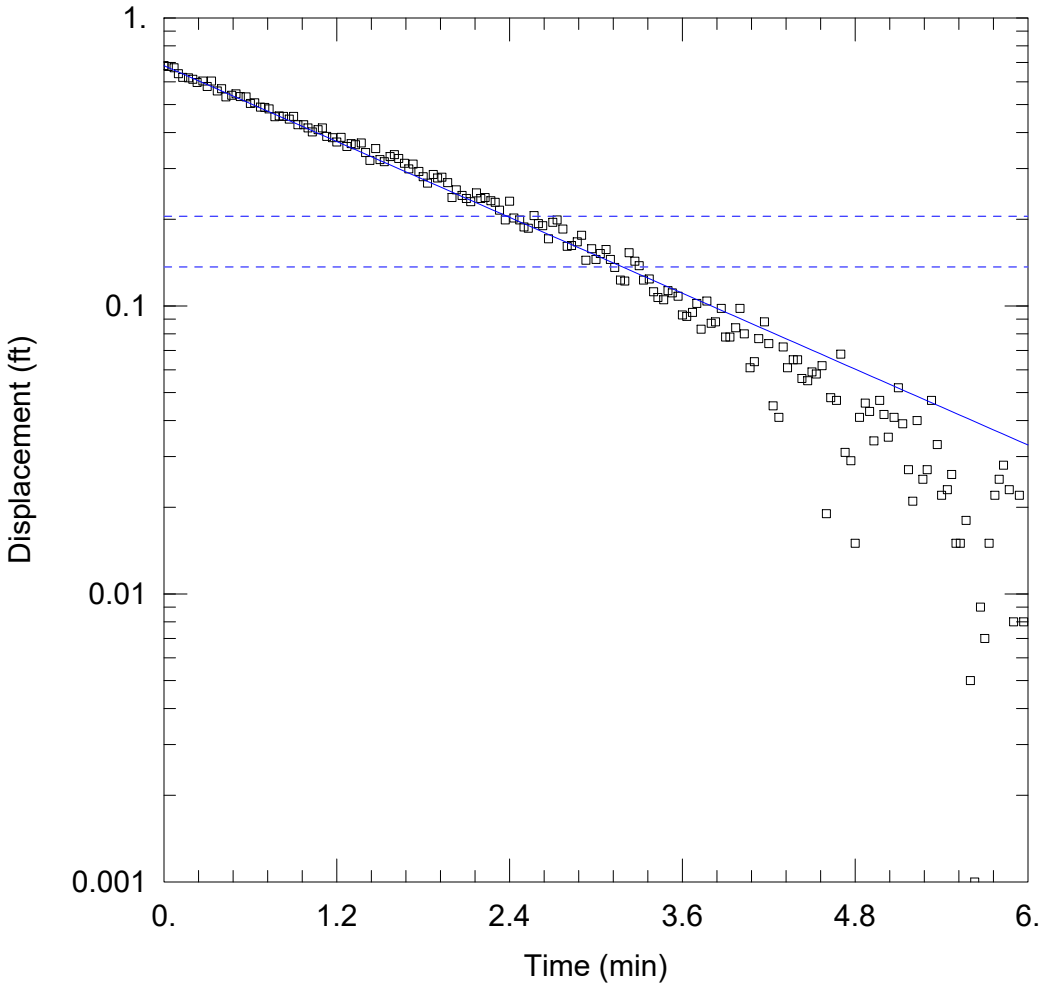
Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (G09M test 1 (Slug in))

Initial Displacement: 0.959 ft
Total Well Penetration Depth: 127.8 ft
Casing Radius: 0.083 ft
Static Water Column Height: 127.8 ft
Screen Length: 10. ft
Well Radius: 1. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0002725 cm/sec
y0 = 1.228 ft



TEST 1 SLUG IN

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G09M test 2 (Slug-out).aqt
Date: 03/31/21 Time: 08:41:16

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa, IL
Test Well: G09M
Test Date: 2/26/2021

AQUIFER DATA

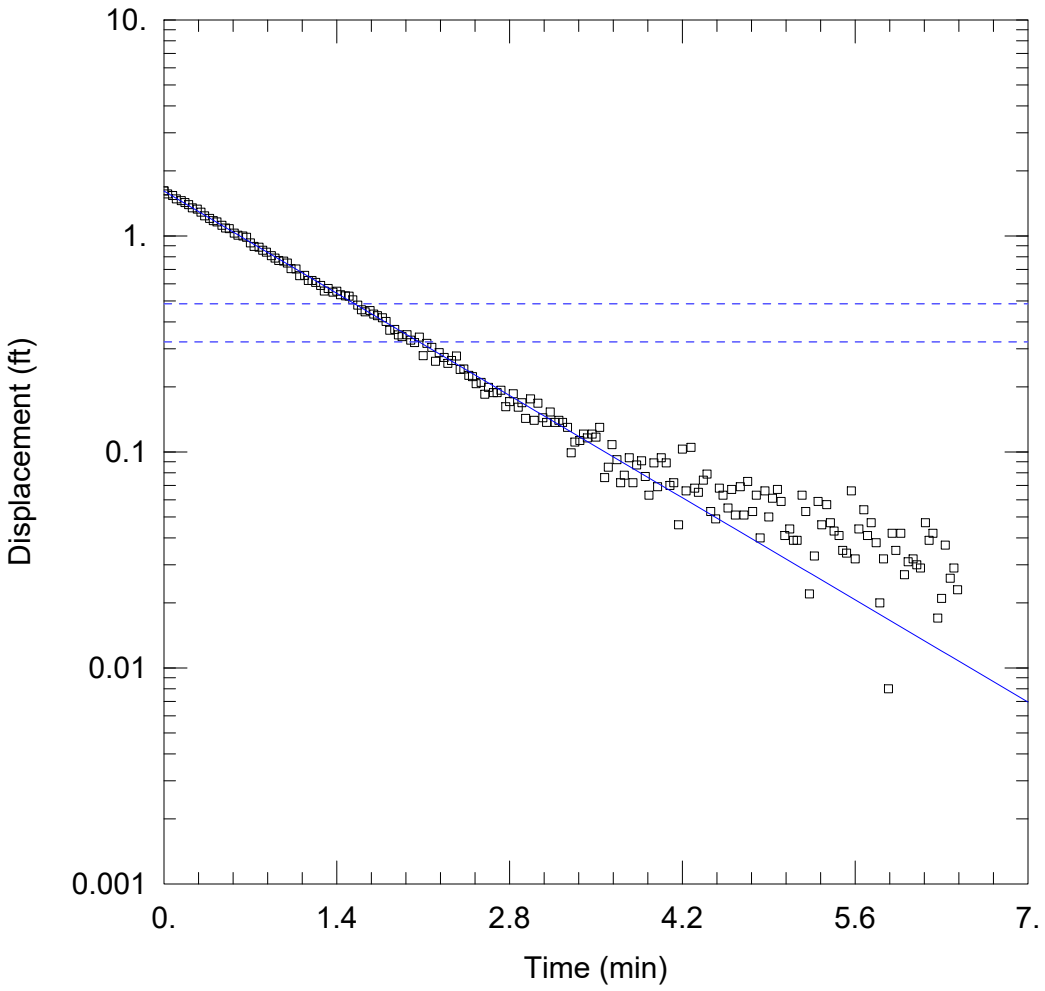
Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (G09M test 2 (Slug out))

Initial Displacement: 0.683 ft Static Water Column Height: 127.8 ft
Total Well Penetration Depth: 127.8 ft Screen Length: 10. ft
Casing Radius: 0.083 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice
K = 0.0003783 cm/sec y0 = 0.6827 ft



TEST 1 SLUG IN

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G09M test 3 (Slug-in).aqt
Date: 03/31/21 Time: 08:44:06

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa, IL
Test Well: G09M
Test Date: 2/26/2021

AQUIFER DATA

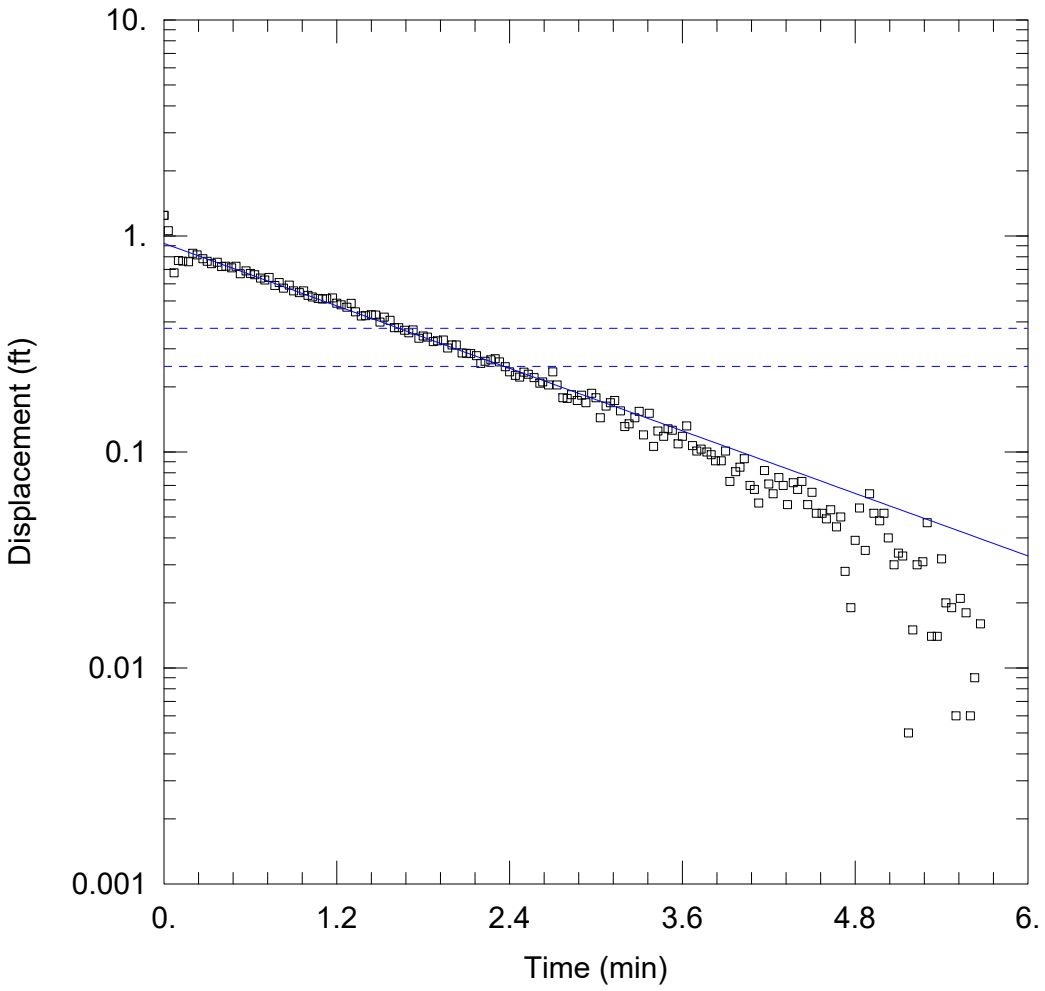
Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (G09M test 3 (Slug in))

Initial Displacement: 1.615 ft
Total Well Penetration Depth: 127.8 ft
Casing Radius: 0.083 ft
Static Water Column Height: 127.8 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0005824 cm/sec
y0 = 1.613 ft



TEST 1 SLUG IN

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\G09M test 4 (Slug-out).aqt
Date: 03/31/21 Time: 08:48:06

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa, IL
Test Well: G09M
Test Date: 2/26/2021

AQUIFER DATA

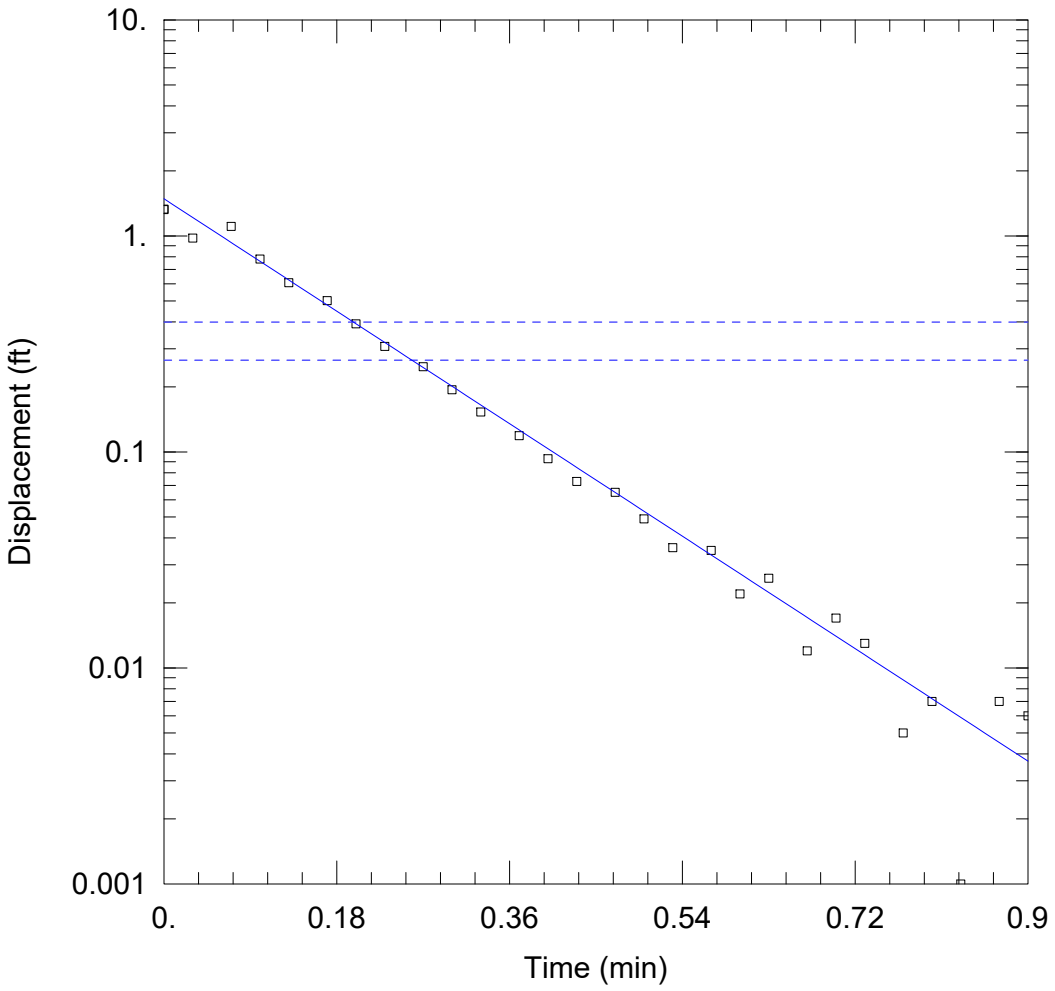
Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (G09M test 4 (Slug out))

Initial Displacement: 1.244 ft
Total Well Penetration Depth: 127.8 ft
Casing Radius: 0.083 ft
Static Water Column Height: 127.8 ft
Screen Length: 10. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0004155 cm/sec
y0 = 0.9235 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\XPW-02 test 1 (slug-in) BR.aqt
Date: 03/31/21 Time: 11:03:08

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa Ash Pond
Test Well: XPW-02

AQUIFER DATA

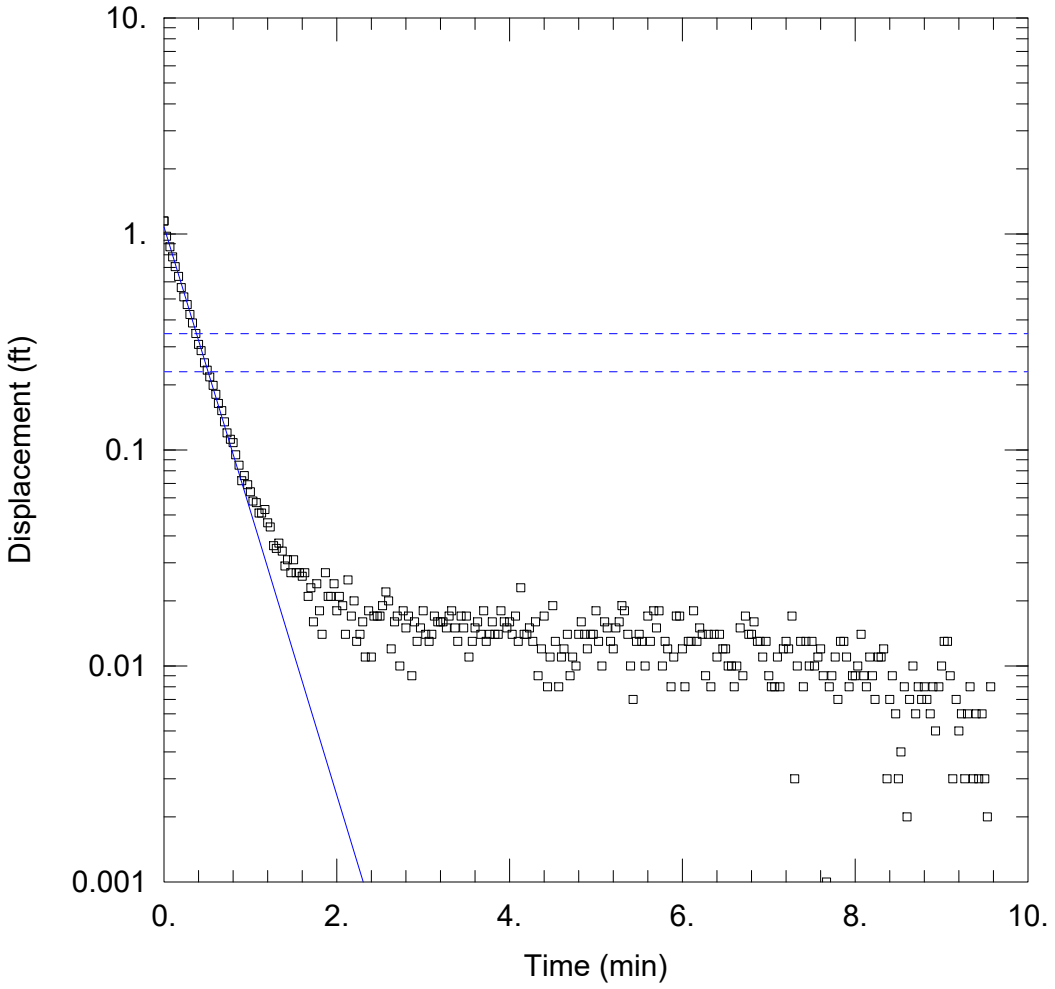
Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (XPW-02 ((test 1 slug-in))

Initial Displacement: 1.33 ft
Static Water Column Height: 27.13 ft
Total Well Penetration Depth: 27.13 ft
Screen Length: 5. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.009817 cm/sec
y0 = 1.486 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\XPW-02 test 2 (slug-out) BR.aqt
Date: 03/31/21 Time: 11:19:01

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa Ash Pond
Test Well: XPW-02

AQUIFER DATA

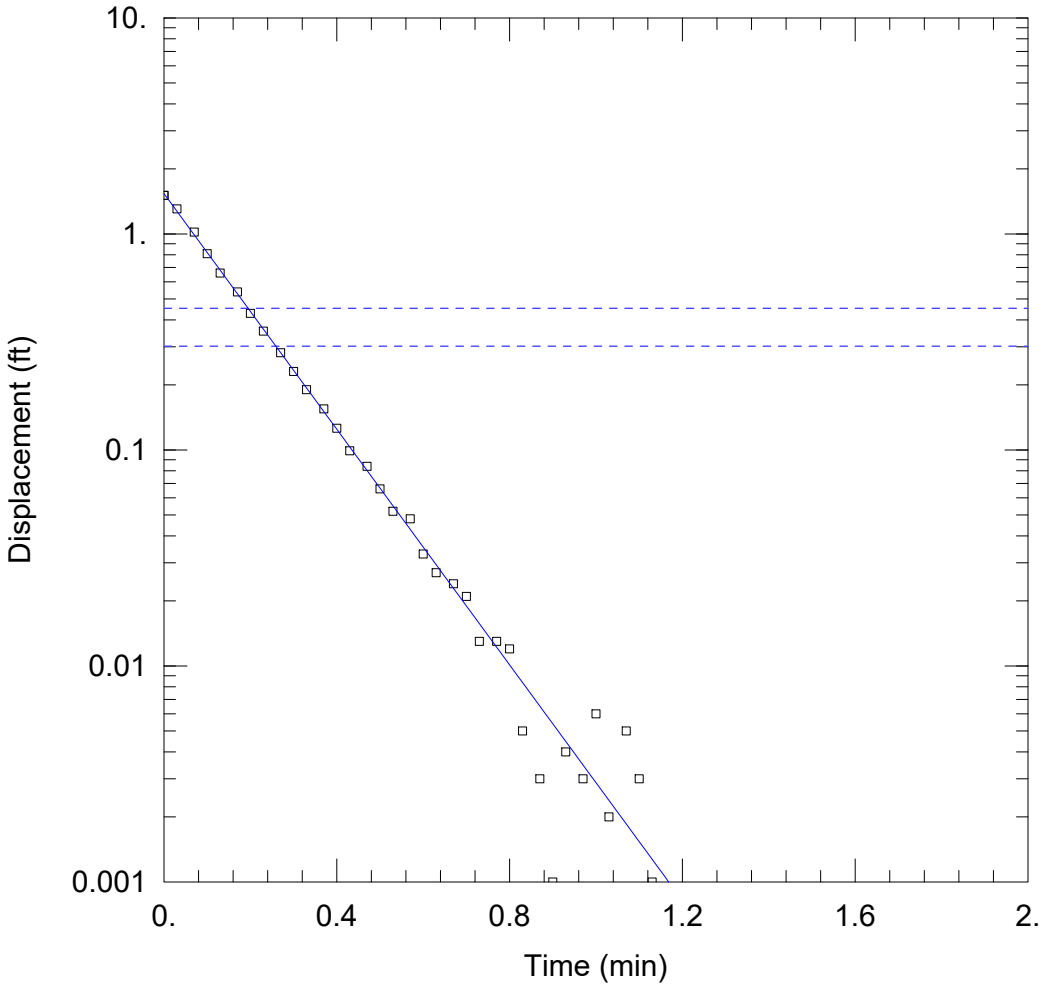
Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (XPW-02 ((test 2 slug-out))

Initial Displacement: 1.15 ft
Static Water Column Height: 27.13 ft
Total Well Penetration Depth: 27.13 ft
Screen Length: 5. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.004464 cm/sec
y0 = 1.079 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\XPW-02 test 3 (slug-in) BR.aqt
Date: 03/31/21 Time: 11:22:08

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa Ash Pond
Test Well: XPW-02

AQUIFER DATA

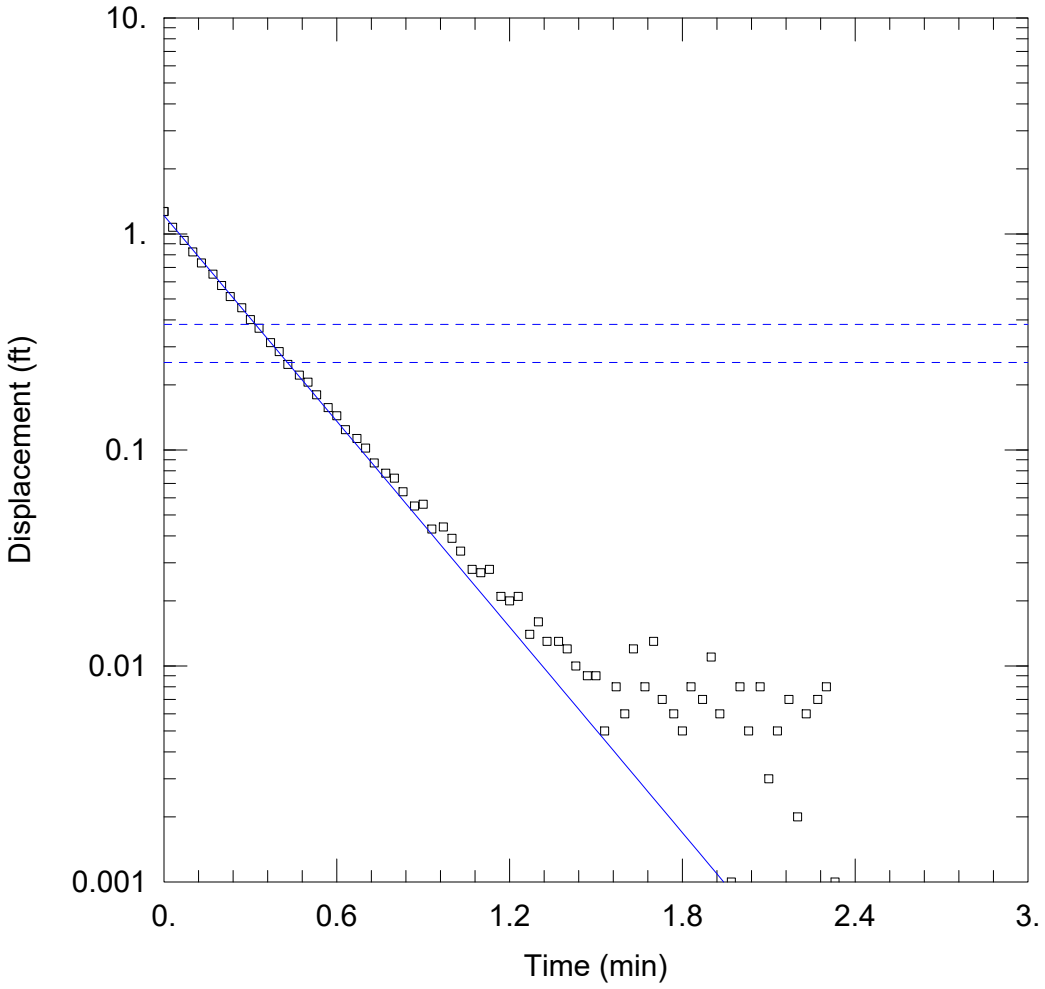
Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (XPW-02 ((test 3 slug-in))

Initial Displacement: 1.51 ft
Total Well Penetration Depth: 27.13 ft
Casing Radius: 0.083 ft
Static Water Column Height: 27.13 ft
Screen Length: 5. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.009254 cm/sec
y0 = 1.537 ft



WELL TEST ANALYSIS

Data Set: C:\Users\kcarlton\Desktop\Joppa Slug Tests\XPW-02 test 4 (slug-out) BR.aqt
Date: 03/31/21 Time: 11:24:39

PROJECT INFORMATION

Company: Geosyntec
Location: Joppa Ash Pond
Test Well: XPW-02

AQUIFER DATA

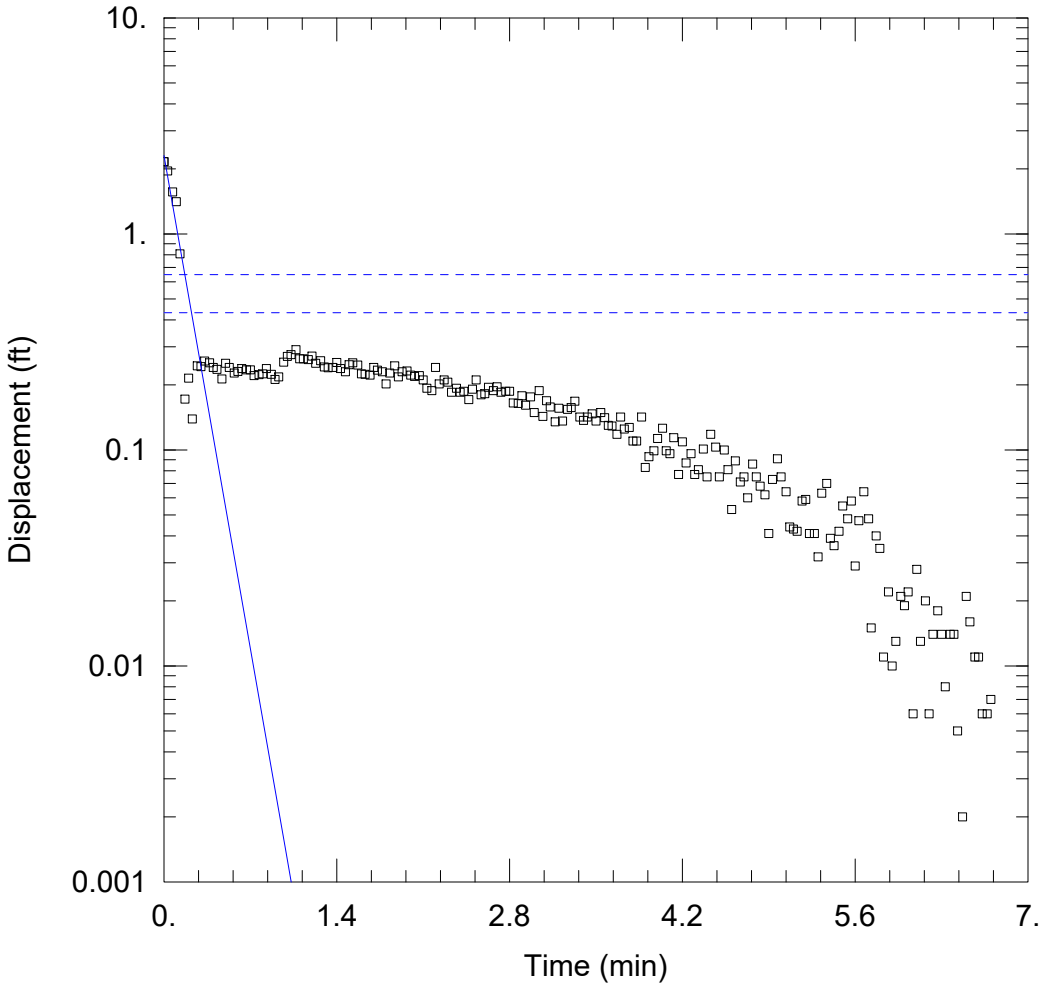
Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (XPW-02 ((test 4 slug-out))

Initial Displacement: 1.27 ft
Static Water Column Height: 27.13 ft
Total Well Penetration Depth: 27.13 ft
Screen Length: 5. ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.005386 cm/sec
y0 = 1.217 ft



WELL TEST ANALYSIS

Data Set: P:\...\XPW-03 test 1 (slug-in) BR.aqt
Date: 04/09/21 Time: 13:57:26

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: XPW-03

AQUIFER DATA

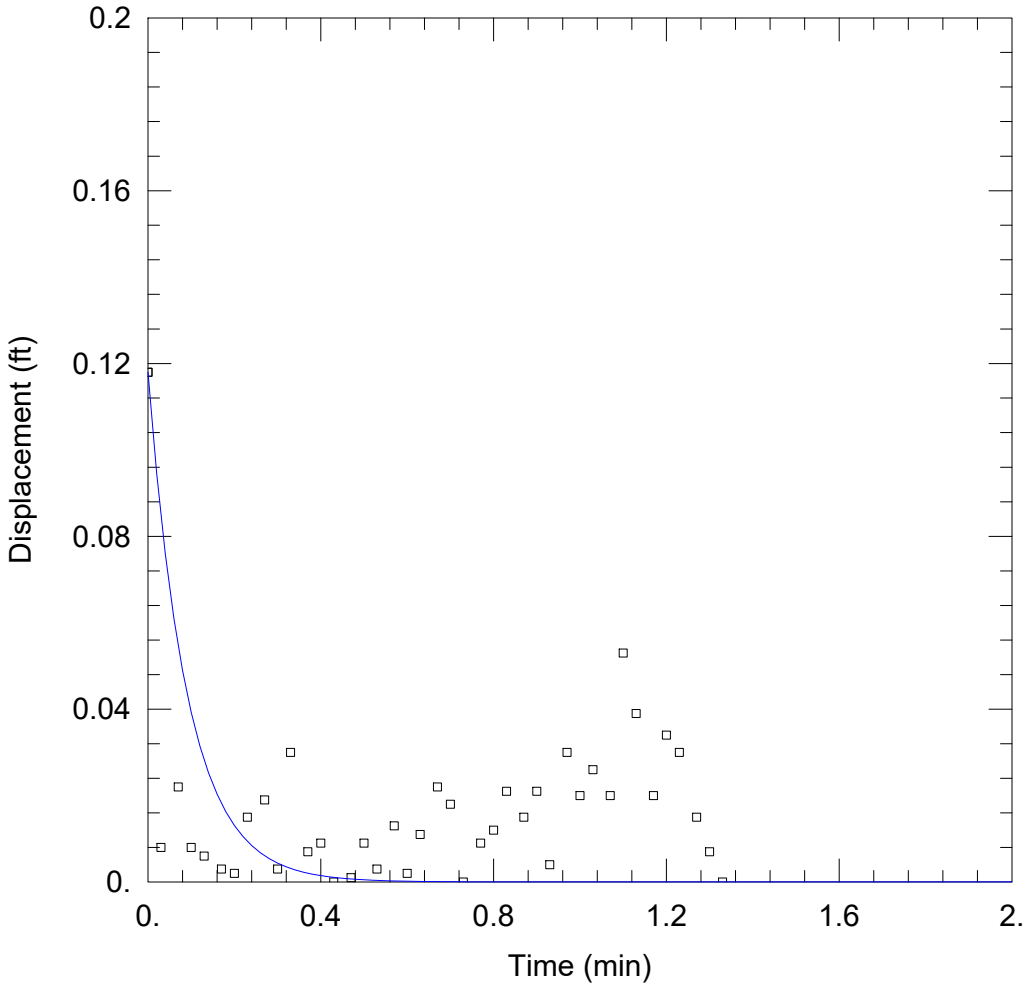
Saturated Thickness: 31. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (XPW-03 (test 1 slug-in))

Initial Displacement: 2.159 ft Static Water Column Height: 31.43 ft
Total Well Penetration Depth: 31.43 ft Screen Length: 5. ft
Casing Radius: 0.083 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice
K = 0.01129 cm/sec y0 = 2.303 ft



WELL TEST ANALYSIS

Data Set: P:\...\XPW-03 test 2 (slug-out) BR.aqt
Date: 04/09/21 Time: 14:00:35

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: XPW-03

AQUIFER DATA

Saturated Thickness: 31. ft Anisotropy Ratio (Kz/Kr): 0.1

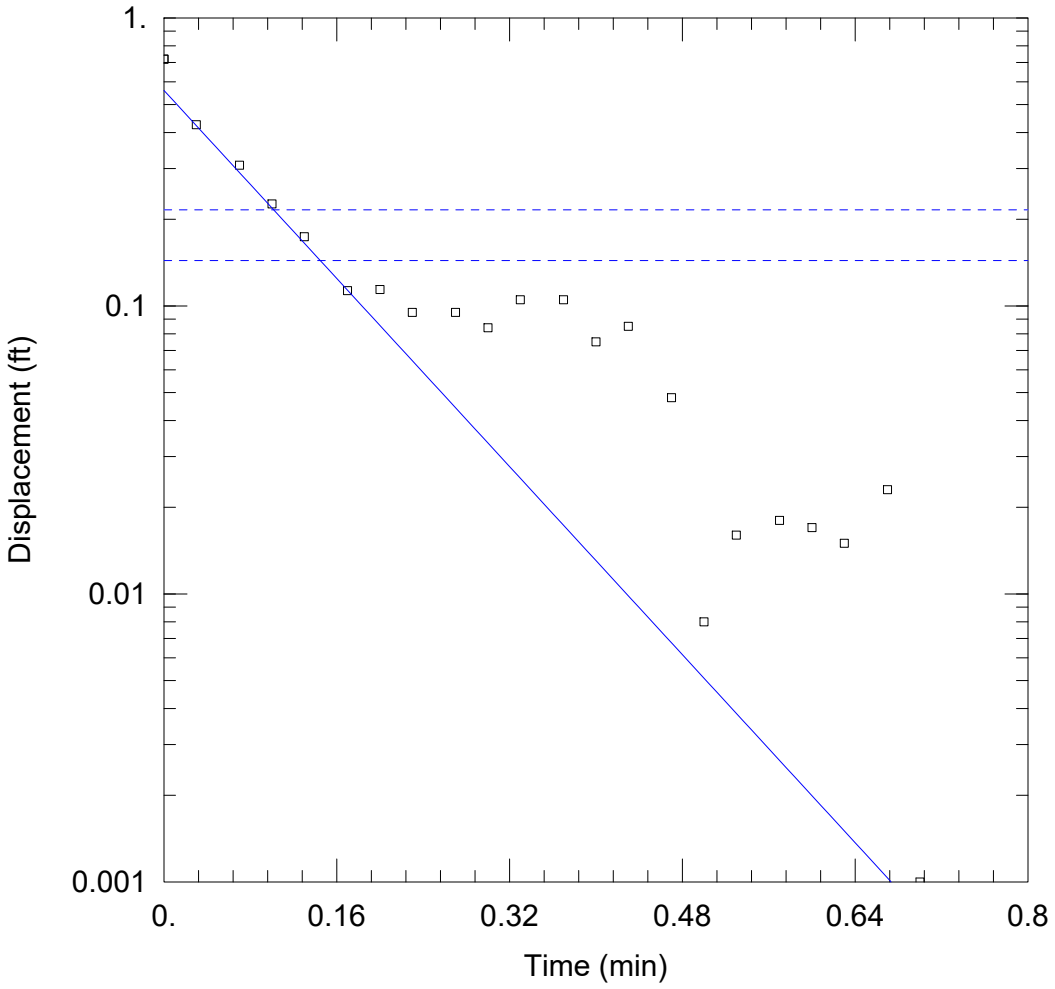
WELL DATA (XPW-03 (test 1 slug-in))

Initial Displacement: 0.118 ft
Total Well Penetration Depth: 31.43 ft
Casing Radius: 0.083 ft
Static Water Column Height: 31.43 ft
Screen Length: 5. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Springer-Gelhar

K = 0.01653 cm/sec Le = 0.1 ft



WELL TEST ANALYSIS

Data Set: P:\...\XPW-03 test 3 (slug-in) BR.aqt
Date: 04/09/21 Time: 14:04:42

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: XPW-03

AQUIFER DATA

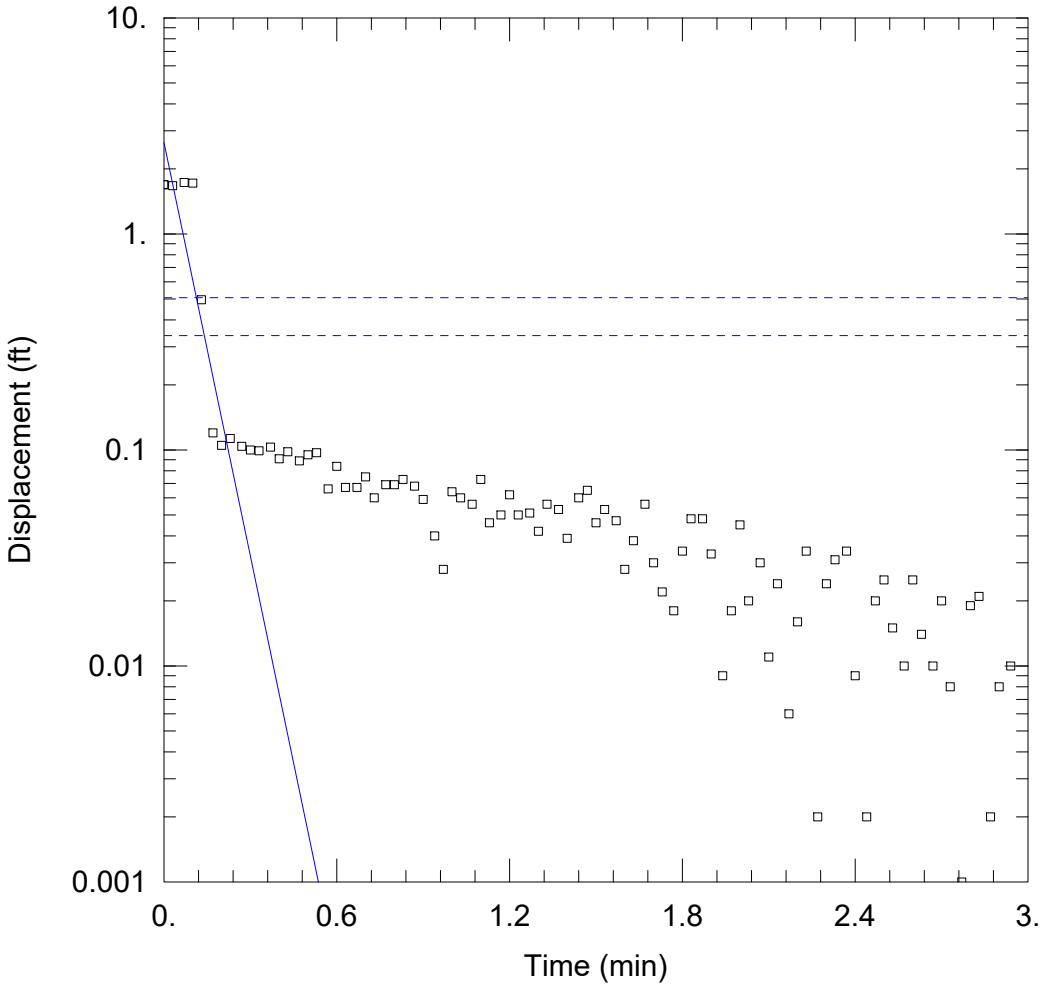
Saturated Thickness: 31. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (XPW-03 (test 3 slug-out))

Initial Displacement: 0.719 ft Static Water Column Height: 31.43 ft
Total Well Penetration Depth: 31.43 ft Screen Length: 5. ft
Casing Radius: 0.083 ft Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice
K = 0.01413 cm/sec y0 = 0.5601 ft



WELL TEST ANALYSIS

Data Set: P:\...\XPW-03 test 4 (slug-out) BR.aqt
Date: 04/09/21 Time: 14:07:51

PROJECT INFORMATION

Company: Geosyntec
Client: Vistra
Project: GLP8021
Location: Joppa Ash Pond
Test Well: XPW-03

AQUIFER DATA

Saturated Thickness: 31. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (XPW-03 (test 4 slug-out))

Initial Displacement: 1.69 ft
Total Well Penetration Depth: 31.43 ft
Casing Radius: 0.083 ft
Static Water Column Height: 31.43 ft
Screen Length: 5. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

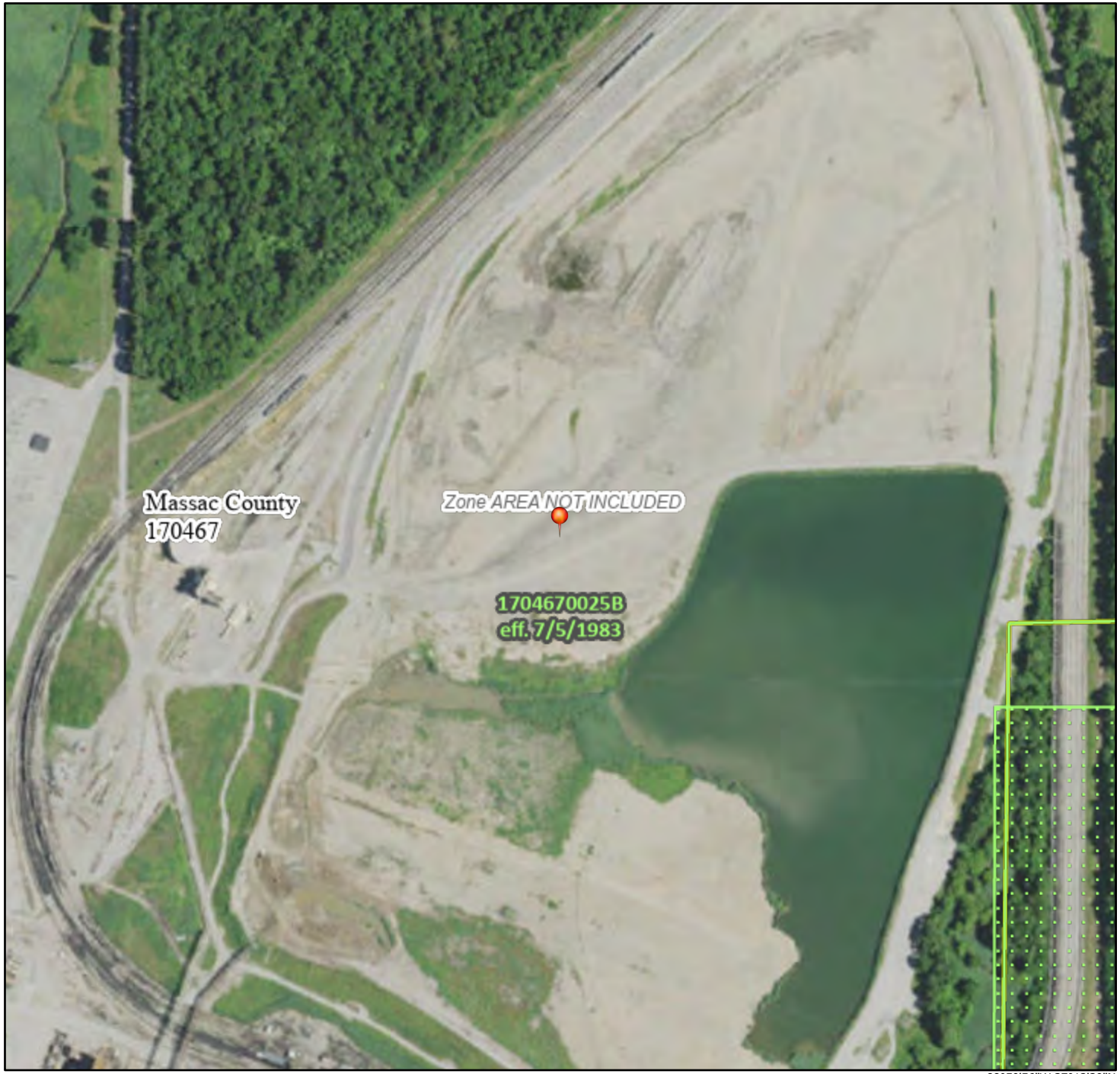
K = 0.02209 cm/sec y0 = 2.648 ft

APPENDIX G
FEMA FLOOD HAZARD MAP

National Flood Hazard Layer FIRMette

FEMA

88°51'33"W 37°13'8"N



88°50'56"W 37°12'39"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

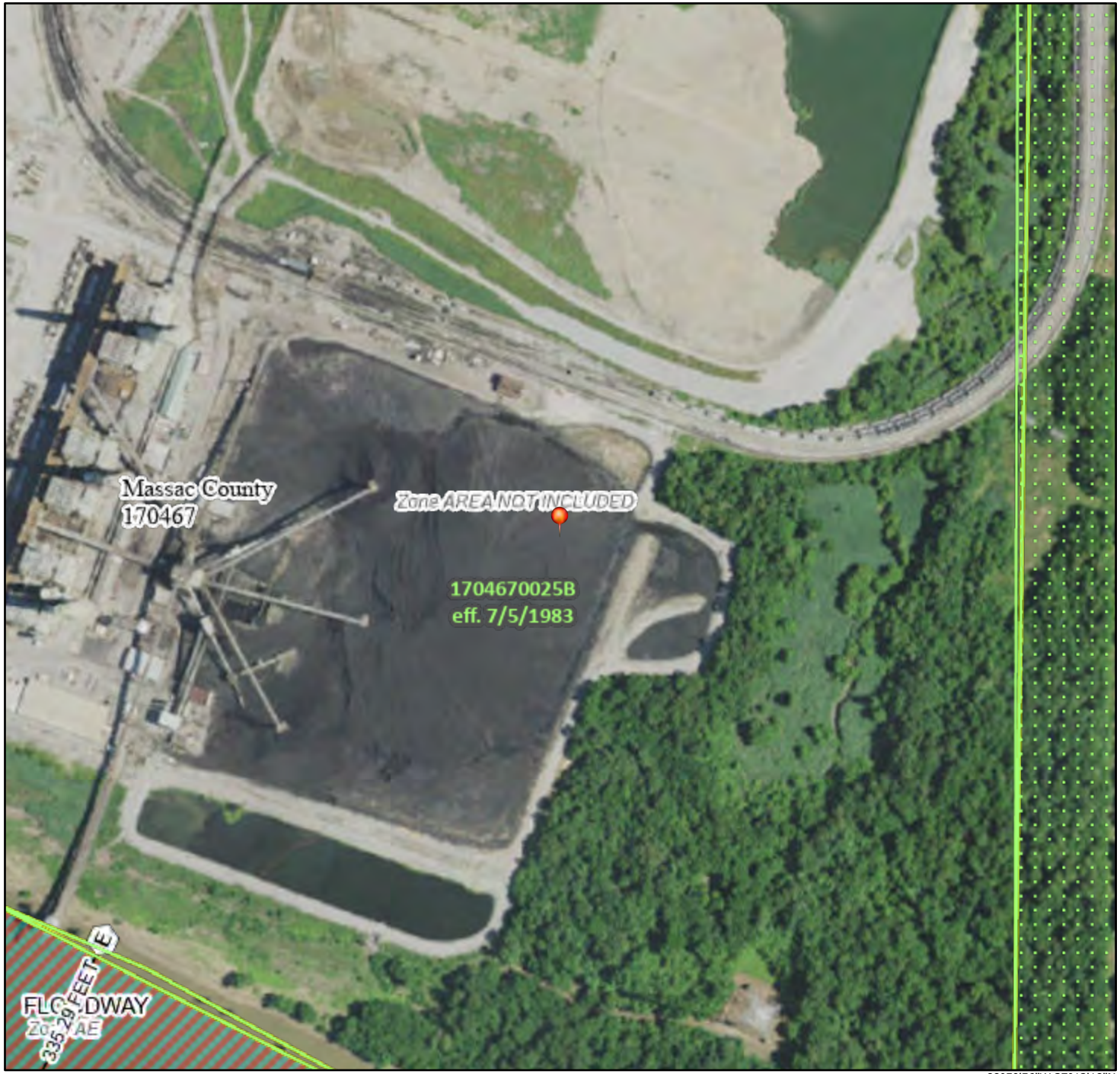
The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 8/31/2021 at 10:52 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

National Flood Hazard Layer FIRMette

FEMA

88°51'34"W 37°12'47"N



88°50'56"W 37°12'18"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 8/31/2021 at 10:48 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Geosyntec
consultants

ATTACHMENT C

History of Construction Report

845.220(a)(1)

July 2022

Geosyntec consultants

1 McBride and Son Center Drive, Suite 202
Chesterfield, MO 63005
PH 636-812-0800
www.geosyntec.com

October 11, 2021

Electric Energy, Inc.
2100 Portland Road
Joppa, Illinois 62953

Subject: Periodic History of Construction Report Update Letter
USEPA Final CCR Rule, 40 CFR §257.73(c)
Joppa Power Plant
Joppa, Illinois

At the request of Electric Energy, Inc. (EEI), Geosyntec Consultants (Geosyntec) has prepared this Letter to documents updates to the Initial History of Construction (HoC) report for the Joppa Power Plant (JPP), also known as the Joppa Power Station (JOP). The Initial HoC report was prepared by AECOM in October of 2016 [1] in accordance with 40 Code of Federal Regulations (CFR) §257.73(c) of the United States Environmental Protection Agency (USEPA) Coal Combustion Residuals Rule, known as the CCR Rule [2]. This letter also includes information required by Section 845.220(a)(1)(B) (Design and Construction Plans) of the state-specific Illinois Environmental Protection Agency (IEPA) Part 845 CCR Rule [3] that is not expressly required by §257.73(c).

BACKGROUND

The CCR Rule required that, by October 17, 2016, Initial HoC reports to be compiled for existing CCR surface impoundments with: (1) a height of five feet or more and a storage volume of 20 acre-feet or more, or (2) a height of 20 feet or more. The Initial HoC report was required to contain, to the extent feasible, the information specified in 40 CFR §257.73(c)(1)(i)-(xii). The Initial HoC report for JPP, which included the existing CCR surface impoundment, the East Ash Pond (EAP), was prepared and subsequently posted to EEI's CCR Website prior to October 17, 2016.

The CCR Rule requires that Initial HoC to be updated if there is a significant change to any information complied in the Initial HoC report, as listed below:

§ 257.73(c)(2): If there is a significant change to any information complied under paragraph (c)(1) of this section, the owner or operator of the CCR unit must update the relevant information and place it in the facility's operating record as required by § 257.105(f)(9).

EEI retained Geosyntec to review the Initial HoC report, review reasonably and readily available information for the EAP generated since the Initial HoC report was prepared, and perform a site visit to JPP to evaluate if significant changes may have occurred since the Initial HoC report was prepared. This Letter contains the results of Geosyntec's evaluation and documents significant changes that have occurred at the EAP and JPP, as they pertain the requirements of §257.73(c)(1)(i)-(xii)

UPDATES TO HISTORY OF CONSTRUCTION REPORT

Geosyntec's evaluation for the JPP EAP determined that no known significant changes requiring updates to the information in the Initial HoC report pertaining to §257.73(c)(1)(ii)-(vi) and (xi)-(xii) of the CCR Rule had occurred since the Initial HoC report was developed.

However, Geosyntec's evaluation determined that significant changes at the JPP EAP pertaining to §257.73(c)(1)(i) and (vii)-(x) of the CCR Rule had occurred since the Initial HoC report had been developed. Additionally, information how long the CCR surface impoundments have been operating and the types of CCR in the surface impoundments, as required by Section 845.220(a)(1)(B) of the Part 845 Rule were not included in the Initial HoC report, as this information is not required by the CCR Rule. Each change and the subsequent updates to the Initial HoC report is described within this section.

Section 845.220(a)(1)(B): A statement of … how long the CCR surface impoundment has been in operation, and the types of CCR that have been placed in the surface impoundment.

East Ash Pond

The EAP is in operation since 1973 for a total of approximately 48 years [4].

CCR placed in the EAP is being used to store and dispose of sluiced bottom ash, fly ash, and dredged material from the coal pile runoff pond [4].

§ 257.73(c)(1)(i): The name and address of the person(s) owning or operating the CCR unit; the name associated with the CCR unit; and the identification number of the CCR unit if one has been assigned by the state.

A state identification numbers (IDs) for the EAP was assigned by the Illinois Environmental Protection Agency (IEPA). The ID is listed in **Table 1**.

Table 1 – IEPA ID Numbers

CCR Surface Impoundment	State ID
East Ash Pond (EAP)	W1270100004-02

§ 257.73(c)(1)(vii): At a scale that details engineering structures and appurtenances relevant to the design, construction, operation, and maintenance of the CCR unit, detailed dimensional drawings of the CCR unit, including a plan view and cross sections of the length and width of the CCR unit, showing all zones, foundation improvements, drainage provisions, spillways diversion ditches, outlets, instrument locations, and slope protection, in addition to the normal operating pool surface elevation and the maximum pool surface elevation following peak discharge from the inflow design flood, the expected maximum depth of CCR within the CCR surface impoundment, and any identifiable natural or manmade features that could adversely affect operation of the CCR unit due to malfunction or mis-operation.

A wet area was observed at the toe of the eastern perimeter dike of the EAP in 2020. The wet area was repaired with geotextile, sand, and crushed stone in 2020, based on engineering drawings. Drawings for this repair are provided in **Attachment A**.

§ 257.73(c)(1)(viii): A description of the type, purpose, and location of existing instrumentation.

Several piezometers were abandoned, have stopped working, or are no longer being read due health and safety concerns related with poor accessibility that have developed since 2016. These piezometers include:

- JOP-P001, JOP-P002, JOP-P003, JOP-P010, JOP-P015, JOP-P017, JOP-P018, JOP-P019, JOP-P021, JOP-P022, B1, and B2.

§ 257.73(c)(1)(ix): Area-capacity curves for the CCR unit.

Updated area-capacity curves were prepared for the north and south sub-basins of the EAP in 2021. These curves are provided in **Figures 1** and **2**.

Figure 1 – Area-Capacity Curve for East Ash Pond – North Sub-Basin

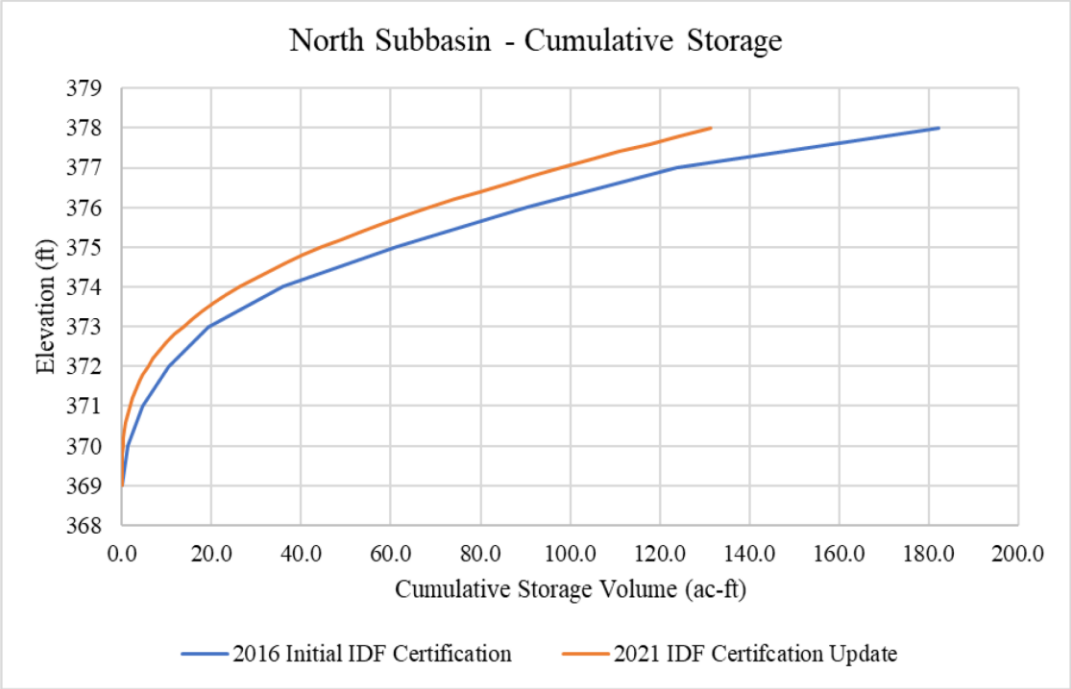
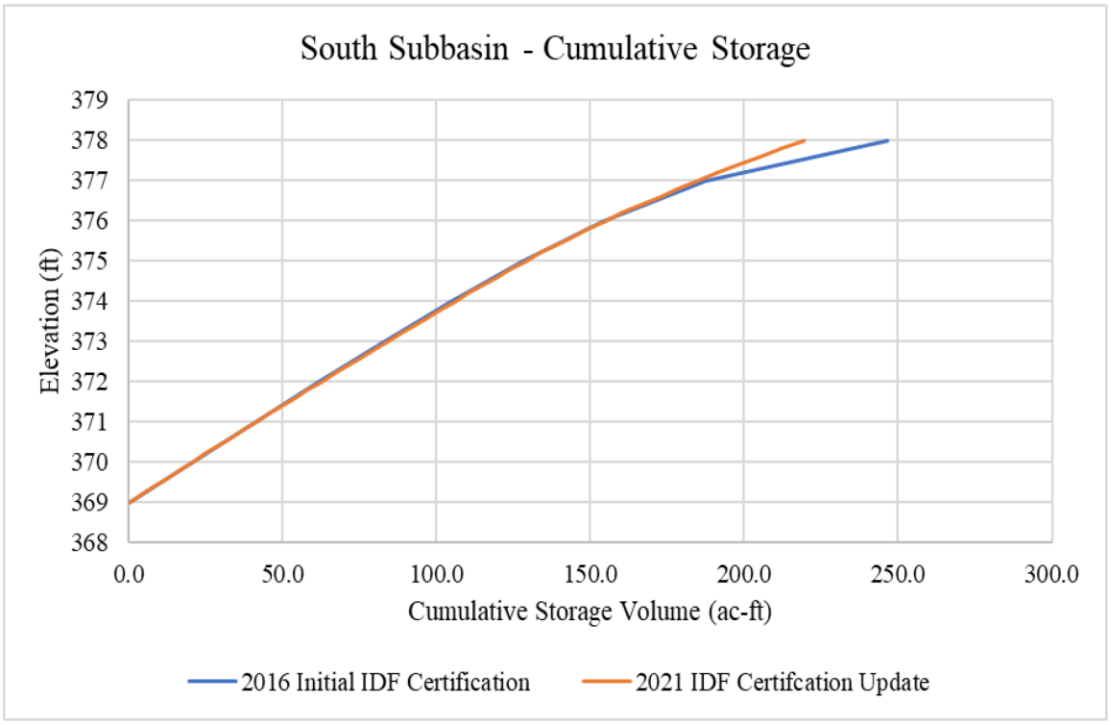


Figure 2 – Area-Capacity Curve for East Ash Pond – South Sub-Basin



§ 257.73(c)(1)(x): A description of each spillway and diversion design features and capacities and calculations used in their determination.

Updated discharge capacity calculations for the existing spillways were prepared in 2021 using HydroCAD 10 modeling software. The calculations indicate that the EAP has sufficient storage capacity and will not overtop the embankments during the Probable Maximum Precipitation (PMP), 24-hour, storm event. The results of the calculations are provided in **Table 2**.

Table 2 – Results of Updated Discharge Capacity Calculations

	North Sub-Basin	South Sub-Basin
Approximate Berm Minimum Elevation[1], ft	378.0	378.0
Approximate Emergency Spillway Elevation[1], ft	Not Applicable	Not Applicable
Starting Water Surface Elevation[1] (SWSE), ft	370.0	373.5
Peak Water Surface Elevation[1] (PWSE), ft	375.95	377.29
Time to Peak, hr	12.6	15.5
Surface Area[2], ac	26.8	33.6
Storage[3], ac-ft	67.3	99.4

Notes:
[1]Elevations are based on the NAVD88 datum
[2] Surface Area is defined as the water surface area at the PWSE
[3]Storage is defined as the volume between the SWSE and PWSE

CLOSING

This letter has been prepared to document Geosyntec's evaluation of changes that have occurred at the EAP at the JPP since the Initial HoC was developed, based on reasonably and readily available information provided by EEI, observed by Geosyntec during the site visit, or generated by Geosyntec as part of subsequent calculations.

Sincerely,

Lucas P. Carr, P.E.
Senior Engineer

John Seymour, P.E.
Senior Principal

REFERENCES

[1] AECOM, "History of Construction, USEPA 40 CFR § 257.73(c), Joppa Power Station, Joppa, Illinois," October 2016.

[2] United Stated Environmental Protection Agency, "40 CFR Parts 257 and 261, Hazardous and Solid Waste Management System, Disposal of Coal Combustion Residuals from Electric Utilities, Final Rule, 2015," 2015.

[3] Illinois Environmental Protection Agency, "35 Ill. Adm. Code Part 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments," Springfield, IL, 2021.

[4] AECOM, "History of Construction, USEPA Final CCR Rule, 40 CFR § 257.73(c), Hennepin Power Station, Hennepin, Illinois," October 2016.

APPENDICES

Appendix A Drawings for 2020 EAP Wet Area Repair

AECOM

October 2016

Electric Energy, Inc.
1500 Eastport Plaza Drive
Collinsville, IL 62234

RE: History of Construction
USEPA Final CCR Rule, 40 CFR § 257.73(c)
Joppa Power Station
Joppa, Illinois

On behalf of Electric Energy, Inc., AECOM has prepared the following history of construction for the East Ash Pond at the Joppa Power Station in accordance with 40 CFR § 257.73(c).

BACKGROUND

40 CFR § 257.73(c)(1) requires the owner or operator of an existing coal combustion residual (CCR) surface impoundment that either (1) has a height of five feet or more and a storage volume of 20 acre-feet or more, or (2) has a height of 20 feet or more to compile a history of construction by October 17, 2016 that contains, to the extent feasible, the information specified in 40 CFR § 257.73(c)(1)(i)–(xii).

The history of construction presented herein was compiled based on existing documentation, to the extent that it is reasonably and readily available (see 80 Fed. Reg. 21302, 21380 [April 17, 2015]), and AECOM's site experience. AECOM's document review included record drawings, geotechnical investigations, etc. for the East Ash Pond at the Joppa Power Station.

AECOM

HISTORY OF CONSTRUCTION

§ 257.73(c)(1)(i): The name and address of the person(s) owning or operating the CCR unit; the name associated with the CCR unit; and the identification number of the CCR unit if one has been assigned by the state.

Owner: Electric Energy, Inc.

Address: 1500 Eastport Plaza Drive
Collinsville, IL 62234

CCR Unit: East Ash Pond

The East Ash Pond does not have a state assigned identification number.

§ 257.73(c)(1)(ii): The location of the CCR unit identified on the most recent USGS $7^1/_2$ or 15 minute topographic quadrangle map or a topographic map of equivalent scale if a USGS map is not available.

The location of the East Ash Pond has been identified on an USGS 7-1/2 minute topographic quadrangle map in **Appendix A**.

§ 257.73(c)(1)(iii): A statement of the purpose for which the CCR unit is being used.

The East Ash Pond is being used to store and dispose of sluiced bottom ash, fly ash, and dredged material from the coal pile runoff pond and to clarify other plant process wastewaters prior to discharge in accordance with the station's NPDES permit.

§ 257.73(c)(1)(iv): The name and size in acres of the watershed where the CCR unit is located.

The East Ash Pond and the Joppa Power Station are located in the Bayou Creek-Ohio River Watershed with a 12-digit Hydrologic Unit Code (HUC) of 051402060701 and a drainage area of 47,283 acres (USGS, 2016).

§ 257.73(c)(1)(v): A description of the physical and engineering properties of the foundation and abutment materials on which the CCR unit is constructed.

The foundation materials consist of foundation clay and foundation sand layers. These layers are of Pleistocene origin and in the same geologic formation. The physical properties of the foundation clay layer for the East Ash Pond are described as lean clay and sandy clay with a generally stiff consistency. Some of these clay soils exhibit a dilative behavior while a limited amount of the clay soils exhibit a contractive behavior. The soils are highly interbedded; however, the contractive clay is generally identified in deeper stratum and is less prevalent in surficial and shallow foundation clays. Soft to very soft dark brown to brown clay with some organics is present in several locations immediately below the embankment. These areas are generally isolated and are generally located in areas of historic drainages. The physical properties of the foundation sand layer for the East Ash Pond are described as

dense silty sand and poorly graded sand with some gravel. An available summary of the engineering properties of the foundation materials is presented in **Table 1** below.

In 2016, the soils located below the East Ash Pond southeast corner embankment were improved using the Deep Mixing Method (DMM). An available summary of the engineering properties of the foundation materials is presented in **Table 1** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 1. Summary of Material Engineering Properties

Material	Unit Weight (pcf)	Drained Strength		Peak Undrained Strength S_u (psf)	Post-Earthquake Strength S_u[1] (psf)
		Cohesion (psf)	Friction Angle[1] (deg)		
Embankment Clay [Fill]	131	Non-linear strength envelope. See Table 1A below.		$\sigma'_{fc} < 0.5$ ksf: $S_u = 600$ psf $\sigma'_{fc} \geq 0.5$ ksf: $S_u/\sigma'_{fc} = 0.65$ and $c_o = 274$ psf	Peak undrained strength. Cyclic softening is not expected due to stiff nature of soil.
Foundation Clay	128	0	α > 5°: 33 -5° ≤ α ≤ 5°: 29 α < -5°: 33	$S_u/\sigma'_{fc} = 0.41$ $c_o = 700$ psf	
Foundation Sand	130	0	35	Drained Strength	Drained Strength
Soft Clay (Miscellaneous Fill)[2]	125	0	24	$S_u/\sigma'_{fc} = 0.25$, min $S_u = 500$ psf	$S_u/\sigma'_{fc} = 0.18$, min $S_u = 400$ psf
DMM Material (soil and cement)	125	Not Applicable		7200 psf	Peak Undrained

1. Where applicable, α represents the failure plane angle measured from horizontal.

Table 1A: Embankment Clay [Fill] Non-linear Drained Strength Failure Envelope

Normal Effective Stress on Failure Plane (s'_{ff}), psf	Shear Strength (t_{ff}), psf
0	0
585.2	561
1308.6	1050.4
1497.4	1124.6
2000	1400.4
10000	7002.1

The East Ash Pond is an enclosed impoundment with embankments and does not have abutments.

§ 257.73(c)(1)(vi): A statement of the type, size, range, and physical and engineering properties of the materials used in constructing each zone or stage of the CCR unit; the

method of site preparation and construction of each zone of the CCR unit; and the approximate dates of construction of each successive stage of construction of the CCR unit.

Physical properties for the original embankment construction are described as over-consolidated, silty clay and sandy clay with a general stiff consistency. Some isolated soft clay (dark brown in color) layers are presented. In 2016, the soils located within the East Ash Pond southeast corner embankment were improved using the Deep Mixing Method (DMM). An available summary of the engineering properties of the construction materials is presented in **Table 1** above. The engineering properties are based on previous geotechnical explorations and laboratory testing.

The method of site preparation and construction of the East Ash Pond is not reasonably and readily available.

The approximate dates of construction of each successive stage of construction of the East Ash Pond are provided in **Table 2** below.

Table 2. Approximate dates of construction of each successive stage of construction.

Date	Event
1973	Construction of the northern portion of the East Ash Pond
1977-1985	Construction of the southern portion of the East Ash Pond
1992	New outlet structure installed in the southern portion of East Ash Pond
1998	Changed the outlet from a high-density polyethylene (HDPE) tee drain to a ductile iron pipe (DIP) tee drain in the southern portion of East Ash Pond
2011	Perimeter berm repairs at select locations and rip-rap placement at select locations of the perimeter embankment.
2016	Ground improvement along the southeastern portion of the East Ash Pond using the wet soil cement deep mixing method (DMM)

§ 257.73(c)(1)(vii): At a scale that details engineering structures and appurtenances relevant to the design, construction, operation, and maintenance of the CCR unit, detailed dimensional drawings of the CCR unit, including a plan view and cross sections of the length and width of the CCR unit, showing all zones, foundation improvements, drainage provisions, spillways, diversion ditches, outlets, instrument locations, and slope protection, in addition to the normal operating pool surface elevation and the maximum pool surface elevation following peak discharge from the inflow design flood, the expected maximum depth of CCR within the CCR surface impoundment, and any identifiable natural or manmade features that could adversely affect operation of the CCR unit due to malfunction or mis-operation.

Drawings that contain items pertaining to the requested information for the Ash Pond are listed in **Table 3** below. Items marked as "Not Available" are items not found during a review of the reasonably and readily available record documentation.

Table 3. List of drawings containing items pertaining to the information requested in § 257.73(c)(1)(vii).

	East Ash Pond
Dimensional plan view (all zones)	EE-AP-1, C-106, 4229-8211
Dimensional cross sections	C-106, 4229-8211
Foundation Improvements	C-100 to C-106
Drainage Provisions	EE-AP-2, C-107, 02199 (sheets 2 to 8)
Spillways and Outlets	02199 (sheets 2 to 8)
Diversion Ditches	Not Applicable
Instrument Locations	Plate 2, Fig. No. 2A
Slope Protection	Not Available
Normal Operating Pool Elevation	C-107, 02199 (sheet 8)
Maximum Pool Elevation	Not Available
Approximate Maximum Depth of CCR in 2016	52 feet

All drawings referenced in **Table 3** above can be found in **Appendix B** and **Appendix C**.

Based on the review of the drawings listed above, no natural or manmade features that could adversely affect operation of this CCR unit due to malfunction or mis-operation were identified.

§ 257.73(c)(1)(viii): A description of the type, purpose, and location of existing instrumentation.

Existing instrumentation at the East Ash Pond include vibrating-wire and open-standpipe piezometers. The purpose of the piezometers is to measure the pore water pressures within and around the impoundment. Two (2) existing open-standpipe piezometers (B-1 and B-4) were installed in 2010 and the locations are presented on Plate 2 in **Appendix C**. Eighteen (18) vibrating-wire piezometers were installed in 2015 and the locations are presented on Figure 2A in **Appendix C**.

§ 257.73(c)(1)(ix): Area-capacity curves for the CCR unit.

The area-capacity curves for the East Ash Pond are presented in **Figures 1** and **2** below. "Area-capacity curves", as defined by 40 CFR § 257.53, "means graphic curves which readily show the reservoir water surface area, in acres, at different elevations from the bottom of the reservoir to the maximum water surface, and the capacity or volume, in acre-feet, of the water contained in the reservoir at various elevations."

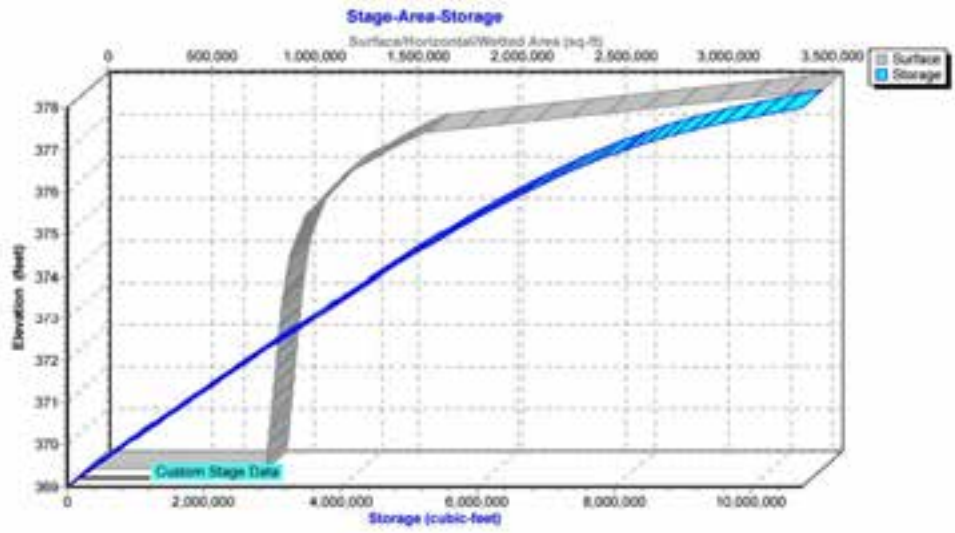


Figure 1. Area-capacity curve for East Ash Pond - south sub-basin

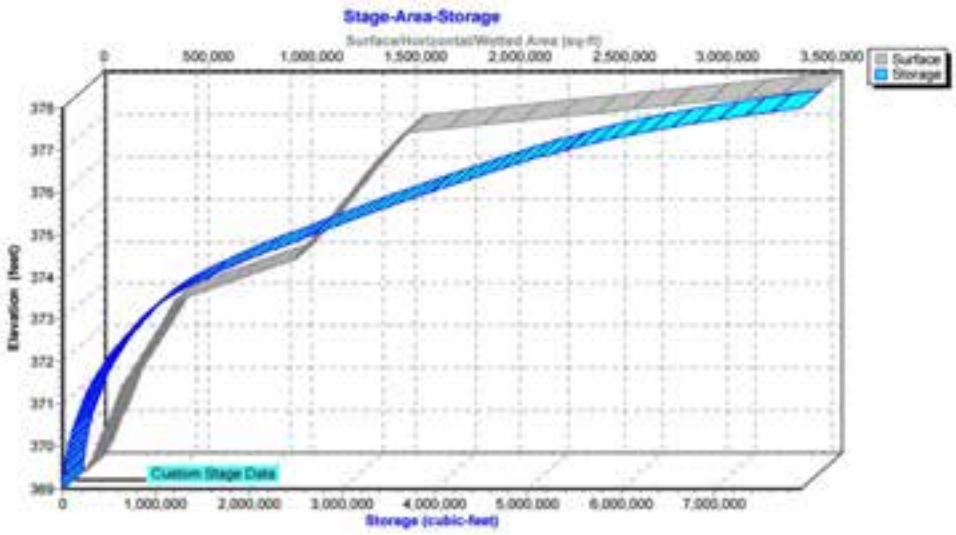


Figure 2. Area-capacity curve for East Ash Pond - north sub-basin

§ 257.73(c)(1)(x): A description of each spillway and diversion design features and capacities and calculations used in their determination.

The northern portion of the East Ash Pond contains stacked 48-inch diameter (dia.) concrete pipe sections seated on a 72-inch dia. precast manhole. The structure discharges water through a 48-inch-dia. reinforced concrete pipe (RCP) to the effluent control basin. The southern portion of the East Ash Pond contains a 24-inch dia. ductile iron tee pipe drain located on the east side of the impoundment. The tee pipe drains into a 26-inch outer-dia. high-density polyethylene (HDPE) pipe that transports the water to the 48-inch-dia. RCP discharge line from the northern portion of the East Ash Pond. The East Ash Pond also contains an internal 36-inch-dia. corrugated HDPE pipe culvert to allow for water to flow from the southern portion of the pond to the northern portion. The East Ash Pond's discharge capability was evaluated using HydroCAD 10 software modeling a 1,000-year, 24-hour rainfall event. The model results indicate that the East Ash Pond has enough storage capacity and will not overtop the embankment during the 1,000-year, 24-hour storm event. The results of the HydroCAD 10 analysis are presented below in **Table 4**.

The East Ash Pond includes a north sub-basin and a south sub-basin which is surrounded by a continuous perimeter embankment. The two sub-basins are separated by a common embankment and were modeled individually.

Table 4. Results of HydroCAD 10 analysis

	North Sub-Basin	South Sub-Basin
Approximate Berm Elevation[1] (ft)	378.0	378.0
Approximate Emergency Spillway Elevation[1] (ft)	Not Applicable	Not Applicable
Starting Pool Elevation[1] (ft)	370.0	373.2
Peak Elevation[1] (ft)	376.2	377.6
Time to Peak (hr)	14.0	15.4
Surface Area (ac)	31.8	63.4
Storage[2] (ac-ft)	93.9	129.9

Note: 1. Elevations are based on NAVD88 datum
2. Storage given is from Starting Pool Elevation to Peak Elevation.

§ 257.73(c)(1)(xi): The construction specifications and provisions for surveillance, maintenance, and repair of the CCR unit.

Drawings for the East Ash Pond refer to construction specification *Specifications for Construction of Waste Treatment Facilities*, but those specifications are not reasonably and readily available.

The operations and maintenance plan for the East Ash Pond is currently being prepared by Electric Energy, Inc.

§ 257.73(c)(1)(xii): Any record or knowledge of structural instability of the CCR unit.

In 2011, eight (8) separate surficial movements occurred along the downstream slope of the perimeter embankment. The soil movements were investigated by Hanson Professional Services (Hanson) and were believed to be caused by recent heavy rains and sliding along the interface of the original embankment and the subsequently placed ash materials. The surficial movements were recompacted with replacement material and portions of the south embankment were rock lined. Information about this event can be found in the 2011 letter by Hanson presented in **Appendix D**. Photos of the repaired slopes are presented in **Appendix E**.

There is no record or knowledge of any other structural instability of the East Ash Pond at Joppa Power Station.

AECOM

LIMITATIONS

The signature of AECOM's authorized representative on this document represents that to the best of AECOM's knowledge, information and belief in the exercise of its professional judgment, it is AECOM's professional opinion that the aforementioned information is accurate as of the date of such signature. Any recommendation, opinion or decisions by AECOM are made on the basis of AECOM's experience, qualifications and professional judgment and are not to be construed as warranties or guaranties. In addition, opinions relating to environmental, geologic, and geotechnical conditions or other estimates are based on available data and that actual conditions may vary from those encountered at the times and locations where data are obtained, despite the use of due care.

Sincerely,

Claudia Prado
Project Manager

Victor Modeer, P.E., D.GE
Senior Project Manager

REFERENCES

United States Environmental Protection Agency (USEPA). (2015). *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule.* 40 CFR Parts 257 and 261, 80 Fed. Reg. 21302, 21380 April 17, 2015.

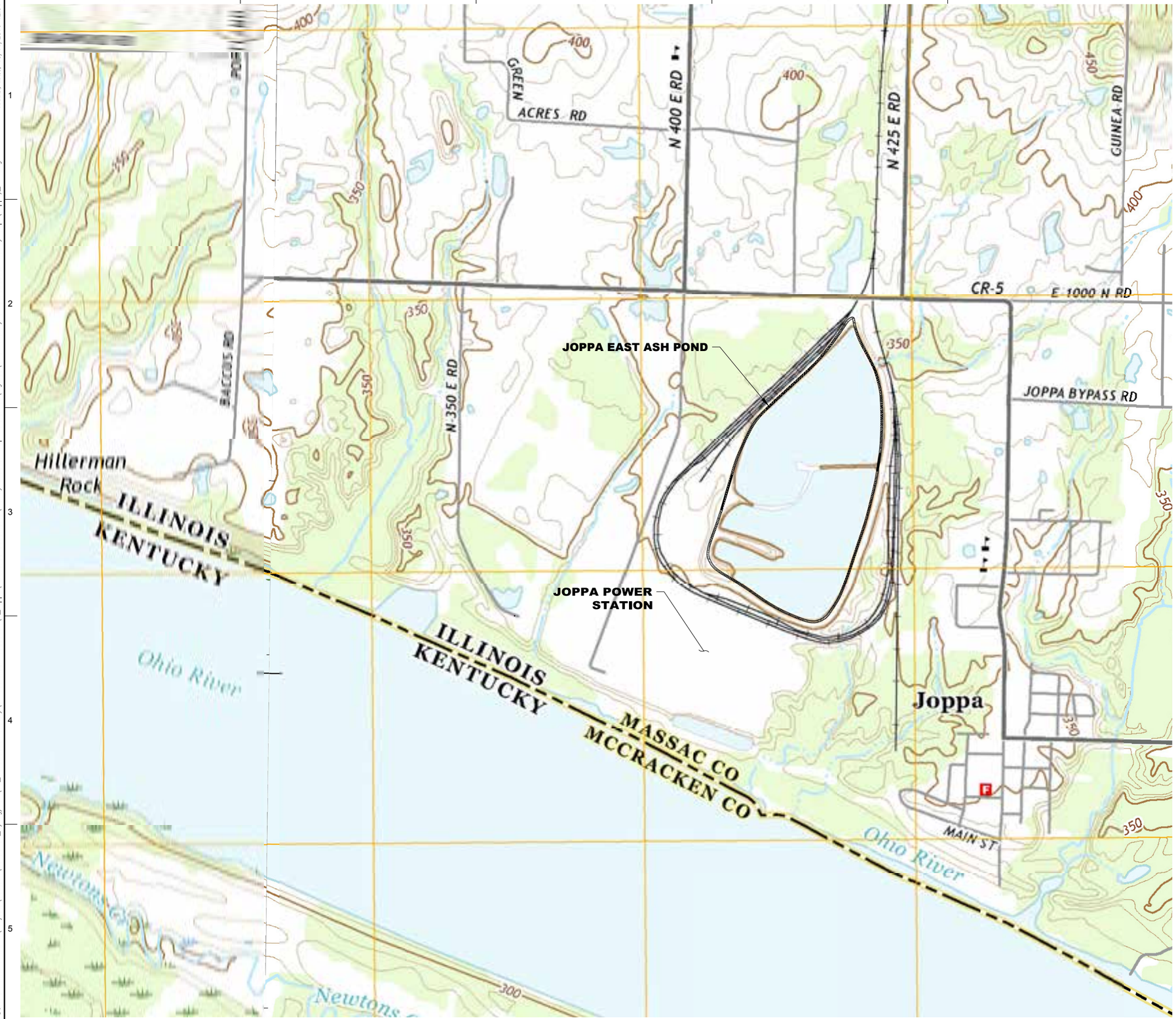
United States Geological Survey (USGS). (2016). The National Map Viewer. http://viewer.nationalmap.gov/viewer/. USGS data first accessed in March of 2016.

APPENDICES

Appendix A: History of Construction Vicinity Map
Appendix B: Joppa Power Station Drawings
Appendix C: Joppa East Ash Pond Piezometer and Boring Locations
Appendix D: Ash Pond Embankment Instability, Hanson Professional Services Inc. (2011)
Appendix E: Photos of Slope Repairs

AECOM

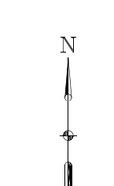
Appendix A: History of Construction Vicinity Map



LEGEND

CCR UNITS

SOURCE:
MAP PROVIDED FROM ELECTRONIC USGS DIGITAL RASTER GRAPHIC 7.5 MINUTE TOPOGRAPHIC MAP OF BANDANA, ILLINOIS AND JOPPA, ILLINOIS, REVISED 2015.



QUADRANGLE LOCATION

N

0 600 1200 1800

SCALE IN FEET

AECOM
1001 Highlands Plaza Drive, Suite 300
St. Louis, Mo. 63110
314 429-0100 (phone)
314-429-0462 (fax)

ELECTRIC ENERGY, INC.

2100 Portland Road,
Joppa, IL 62953

HISTORY OF CONSTRUCTION

JOPPA POWER STATION
JOPPA, ILLINOIS

ISSUED FOR BIDDING DATE BY

ISSUED FOR CONSTRUCTION DATE BY

REVISIONS

NO.	DESCRIPTION	DATE

AECOM PROJECT NO:	60489731
DRAWN BY:	DJD
DESIGNED BY:	DJD
CHECKED BY:	MN
DATE CREATED:	2016-04-13
PLOT DATE:	
SCALE:	1" = 600'
ACAD VER:	2014

SHEET TITLE

HISTORY OF CONSTRUCTION VICINITY MAP

01

AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\13_Construction History\04 Technical Production\8_Joppa\Reference Documents\Vicinity Location Map References\Figures\C-01 History of Construction Vicinity Map (Joppa)_ZAF.dwg NANAK, MATT, 10/11/2016 12:04 PM

Appendix B: Joppa Power Station Drawings

1. “Proposed East Ash Pond”, Drawing No. EE-AP-1, Revision 3, 7 December, 1972, Wapora Inc.
2. “East Ash Pond Sulfuric Acid Storage Tanks and pH Control System”, Drawing No. EE-AP-2, Revision 0, 24 May, 1973, Wapora Inc.
3. “East Ash Pond, Plan, Sections and Details”, Drawing No. C-106, Revision 5, 11 September, 1973, Wapora Inc.
4. “East Ash Pond, Sulfuric Acid Storage Tanks and pH Control System, Plan, Sections and Details”, Drawing No. C-107, Revision 4, 14 July, 1975, Wapora Inc.
5. “East Ash Pond, Plan”, Drawing No. 4229-8211, Revision 4, 13 June, 1986, Wapora Inc.
6. “Plan and Profile”, Drawing No. 02199 sh. 2, March, 1992, Keuffel & Esser Company.
7. “Plan and Profile”, Drawing No. 02199 sh. 3, March, 1992, Keuffel & Esser Company.
8. “Cross-Sections”, Drawing No. 02199 sh. 4, March, 1992, Keuffel & Esser Company.
9. “Cross-Sections”, Drawing No. 02199 sh. 5, March, 1992, Keuffel & Esser Company.
10. “Cross-Sections”, Drawing No. 02199 sh. 6, March, 1992, Keuffel & Esser Company.
11. “Cross-Sections”, Drawing No. 02199 sh. 7, March, 1992, Keuffel & Esser Company.
12. “Ash Lagoon Overflow, Miscellaneous Details”, Drawing No. 02199 sh. 8, 10 March, 1992, Brown, Roffmann & Roberts, Inc.
13. “Overall Site Plan”, Drawing No. C-100, Revision 1, 2 June, 2016, AECOM.
14. “Pre-DMM Site Clearing Plan”, Drawing No. C-101, Revision 1, 2 June, 2016, AECOM.
15. “Pre-DMM Site Plan”, Drawing No. C-102, Revision 1, 2 June, 2016, AECOM.
16. “Pre-DMM Cross Sections”, Drawing No. C-103, Revision 1, 2 June, 2016, AECOM.
17. “Pre-DMM Details”, Drawing No. C-104, Revision 1, 2 June, 2016, AECOM.
18. “Post-DMM Site Restoration Plan”, Drawing No. C-105, Revision 1, 2 June, 2016, AECOM.
19. “Post-DMM Details”, Drawing No. C-106, Revision 1, 2 June, 2016, AECOM.

LEGEND:

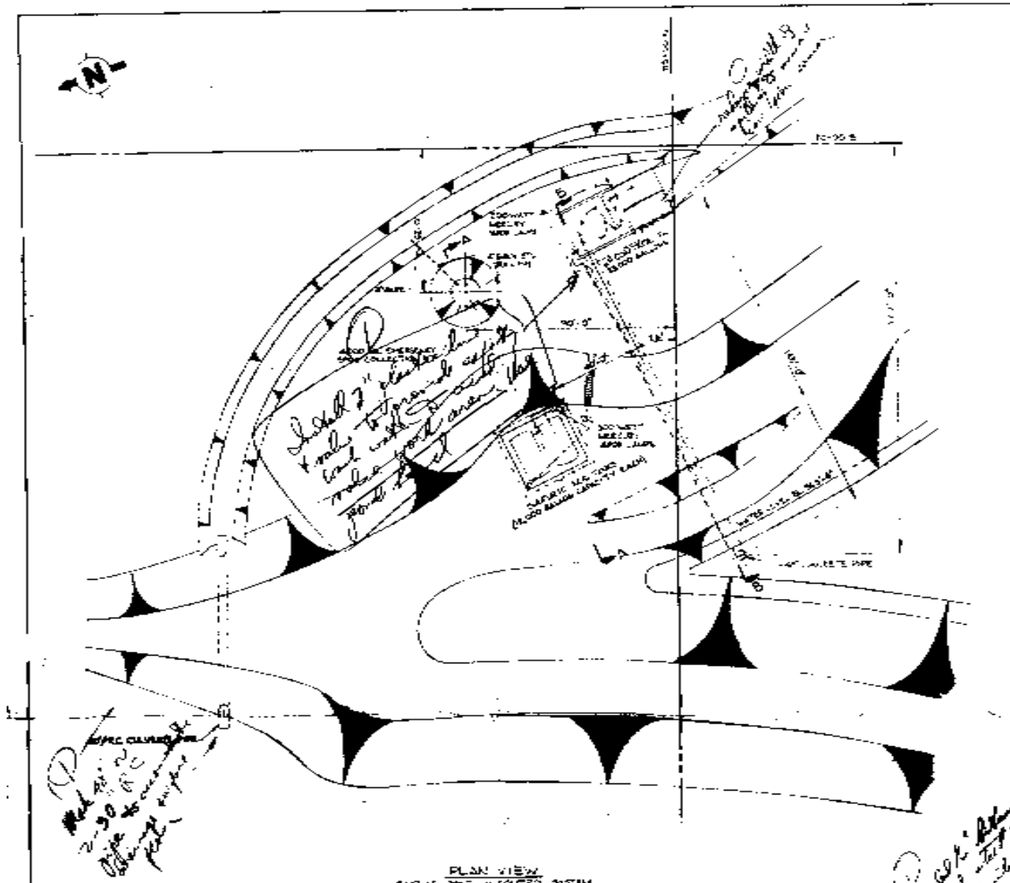
WAPORA INC.

PROPOSED EAST ASH POND

FOR ELECTRIC ENERGY INC.

EE-AP-1

4229-08208



PLAN VIEW
EAST ASH POND pH CONTROL SYSTEM
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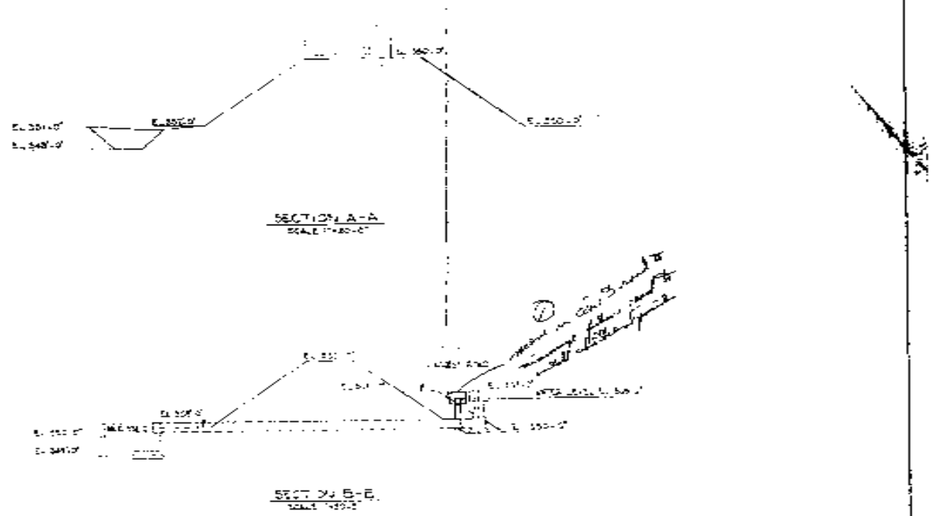

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SECTION B-B
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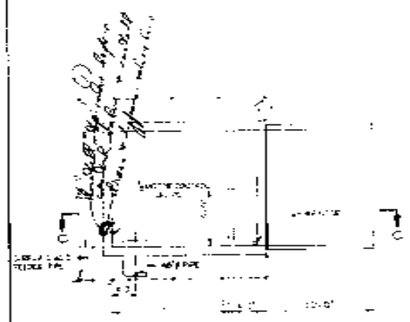

PLAN VIEW
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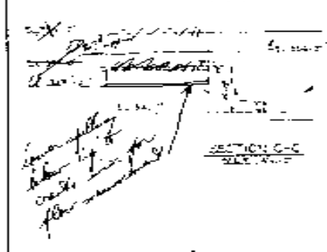
PLAN VIEW
SCALE 1"=10'-0"



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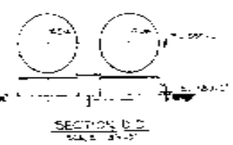

SECTION D-D
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Revised per 1/31/73

Revised per

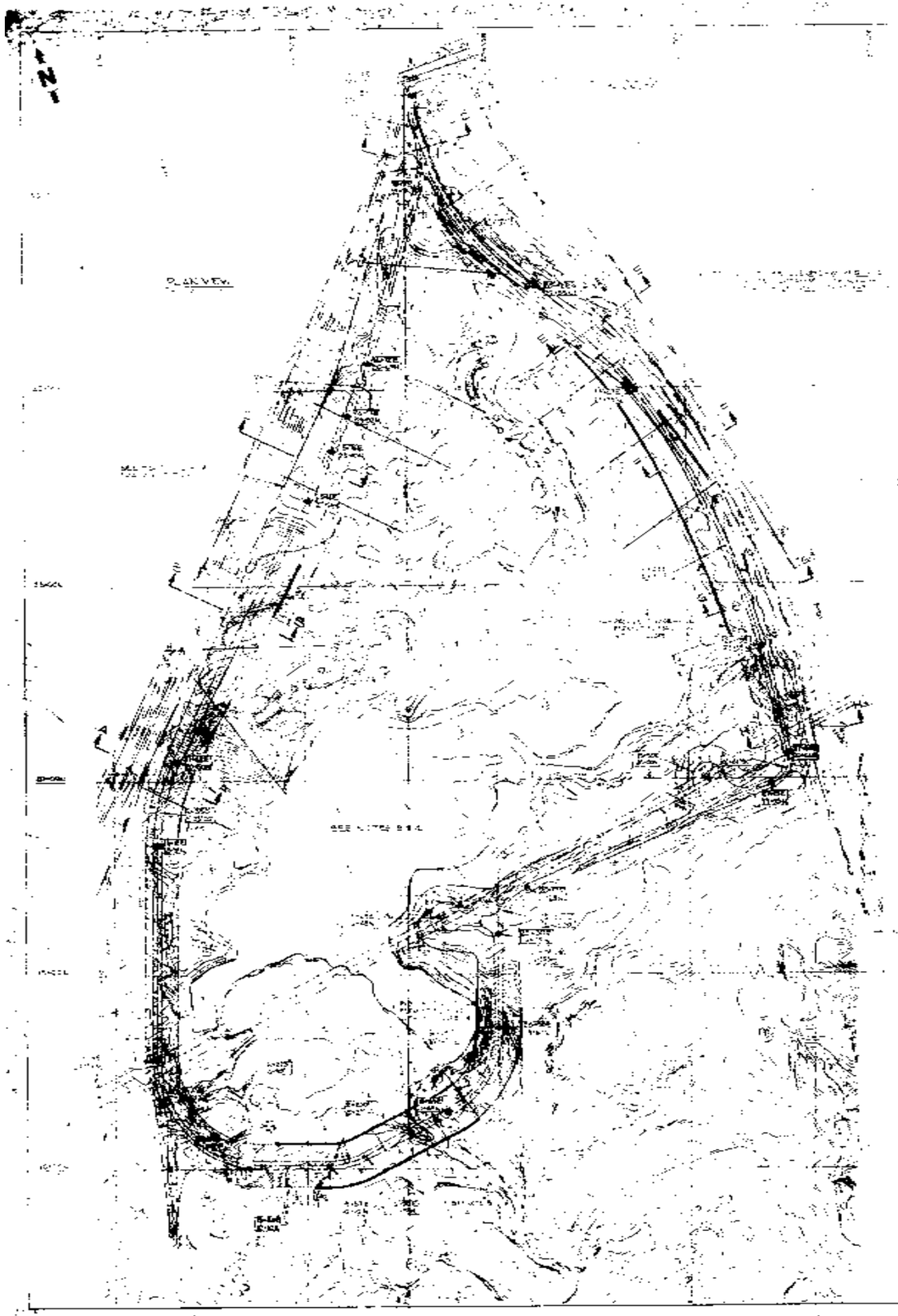
		ISSUED FOR APPROVAL	

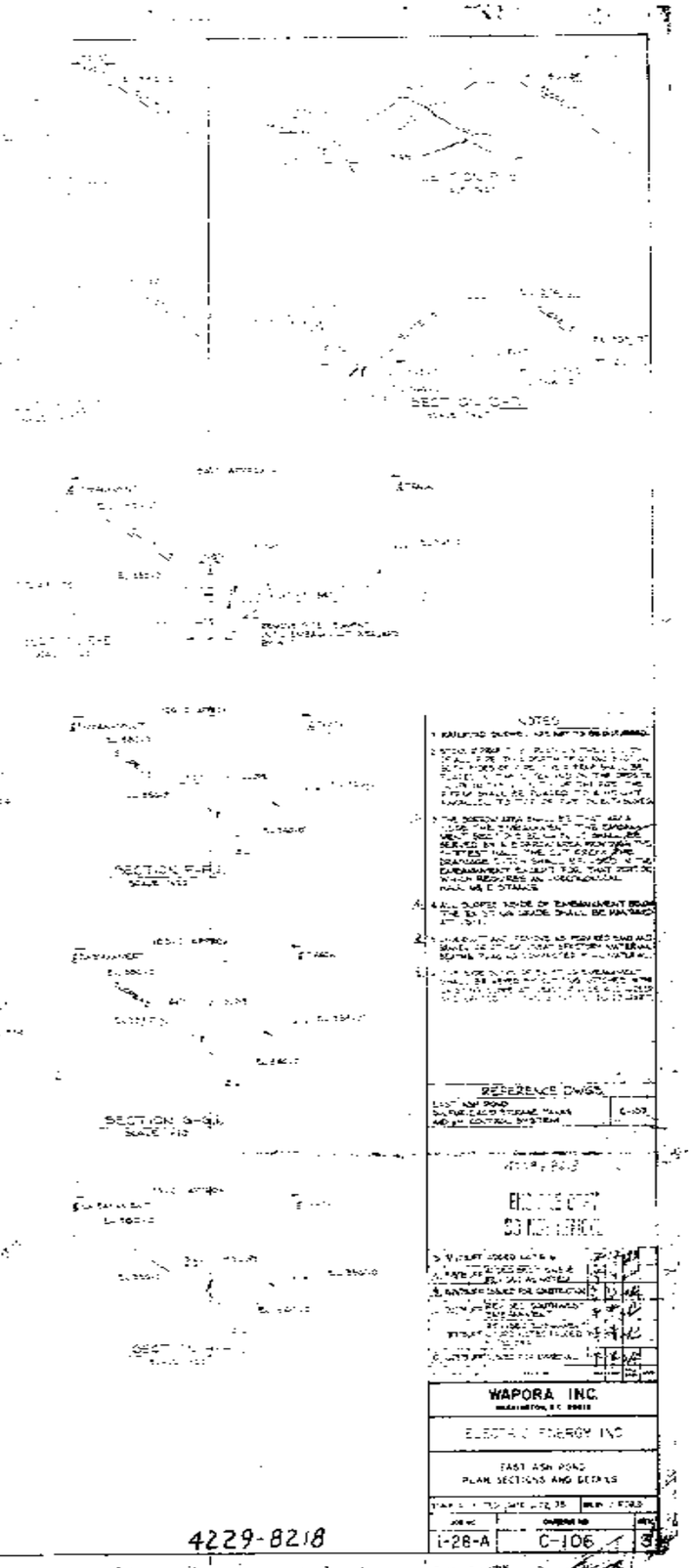
WAPORA, INC.
WASHINGTON, D.C. OFFICE

ELECTRIC ENERGY INC.

EAST ASH POND
SULFURIC ACID STORAGE TANK
AND pH CONTROL SYSTEM

SCALE AS NOTED	DATE 3/26/73	DRAWN J. POND
JOB NO. 1-26-4	DRAWING NO. EE-AP-2	REV. 0





NOTES

REFERENCE DWGS.

WAPORA INC.

ELECTRIC ENERGY INC

EAST ASH POND
PLAN, SECTIONS AND DETAILS

JOB NO.	DRAWING NO.	REV.
I-28-A	C-106	3

4229-8218

REVISED AS PER E.E.I. DWG. AP-A104

PLAN VIEW

PLAN VIEW

PLAN VIEW

PARTIAL PLAN

SECTION A-A

SECTION B-B

SECTION C-C

SECTION D-D

SECTION E-E

SECTION F-F

NOTES

4229-8221

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WAPORA INC.

ELECTRIC ENERGY INC.

EAST ASH POND SULFURIC ACID STORAGE TANKS AND UNLOADING SYSTEM PLAN, SECTIONS AND DETAILS

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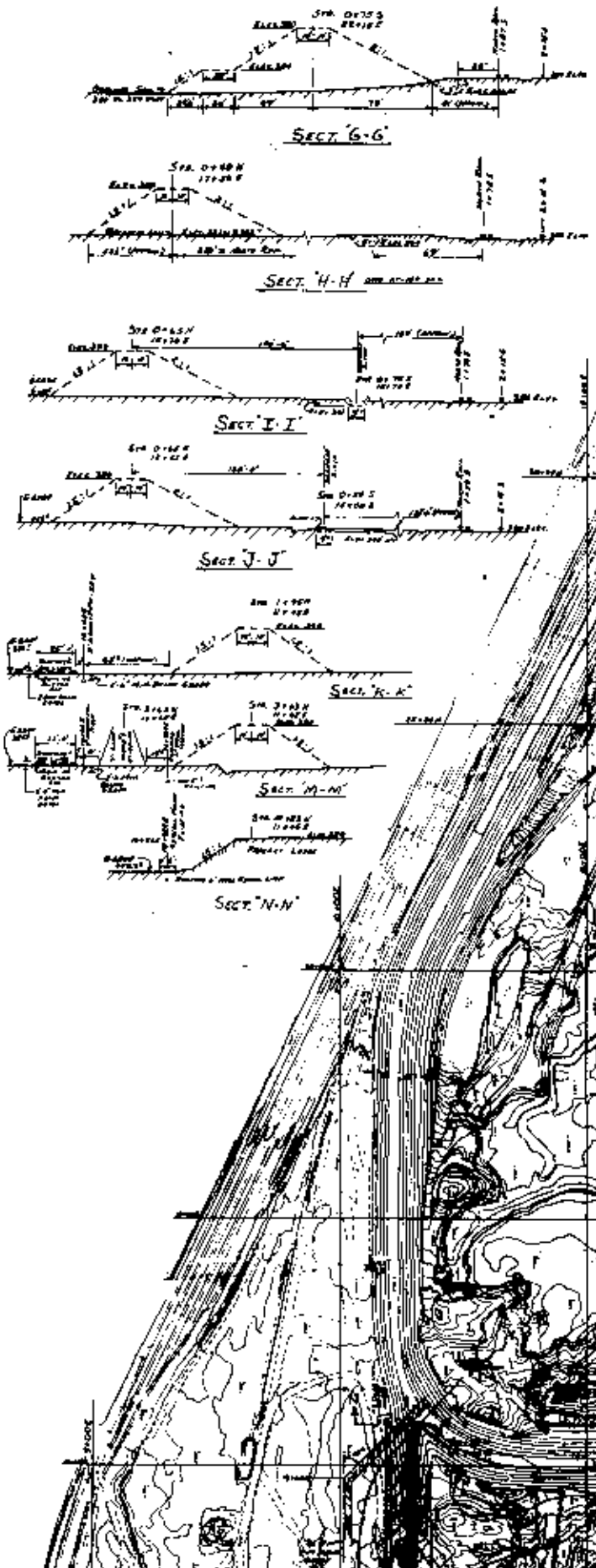
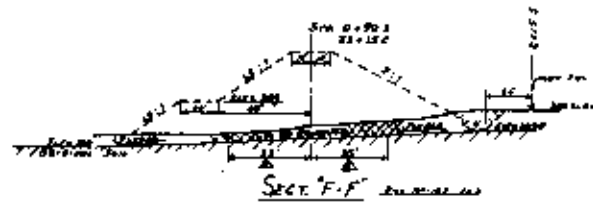
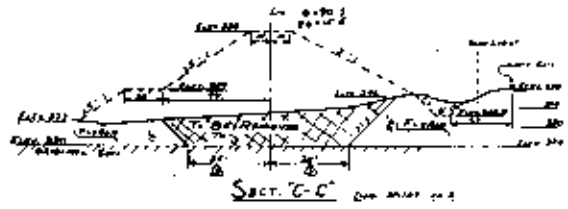
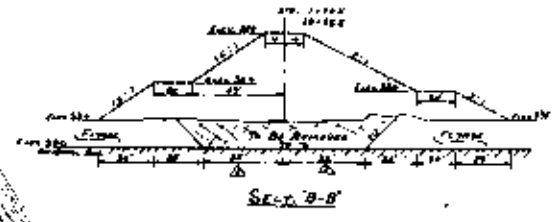
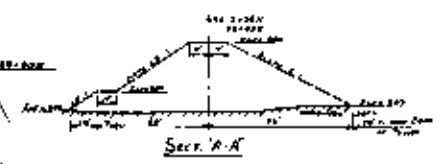
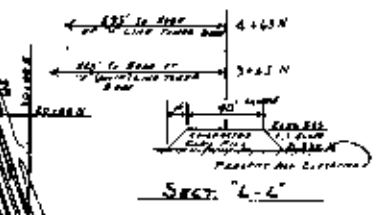












ELECTRIC ENERGY, INC.
JOPPA, IL.
EAST ASH POND
4229-8211

N

0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00

Existing 6'x6' Conc. Box Culvert w/ headwalls
i.e. = 339.18

Top of Bank
Toe of Slope
Ditch ℄
Existing pH Control Tank
Existing 48" RCP i.e. = 346.71
Existing 48" RCP (inlet) i.e. = 352.09
Cut into Existing 48" RCP and Pour Concrete Collar
PROPOSED 26" O.D. HDPE
i.e. = 341.19
Existing 24" RCP
i.e. = 340.80
℄ Swale
Toe of Slope
Top of Bank
PROPOSED 26" O.D. HDPE

Typical Section at Creek Crossings

3"+ Limestone
Mixed Ash Backfill
4' Minimum
2'
26" O.D. HDPE

Key
PROPOSED
Existing Drainage Structure
℄ of Ditch / Swale
Toe of Slope
Top of Bank

Scale
Horiz. 1" = 40'
Vert. 1" = 40'

PLAN — A/A — T-32 — NOTEBOOK — No. 87

PROFILE — A/A — T-32 — NOTE BOOK — No. 87

Horiz. 1" = 40'
Vert. 1" = 8'

370 365 360 355 350 345 340 335

MOUND DIRT OVER PIPE TO OBTAIN THREE FEET OF COVER

STATIC WATER LEVEL = 353.9

Profile Existing Ground Elevation

MAXIMUM TOP OF PIPE ELEV. = 353.00

PROPOSED 26" O.D. HDPE

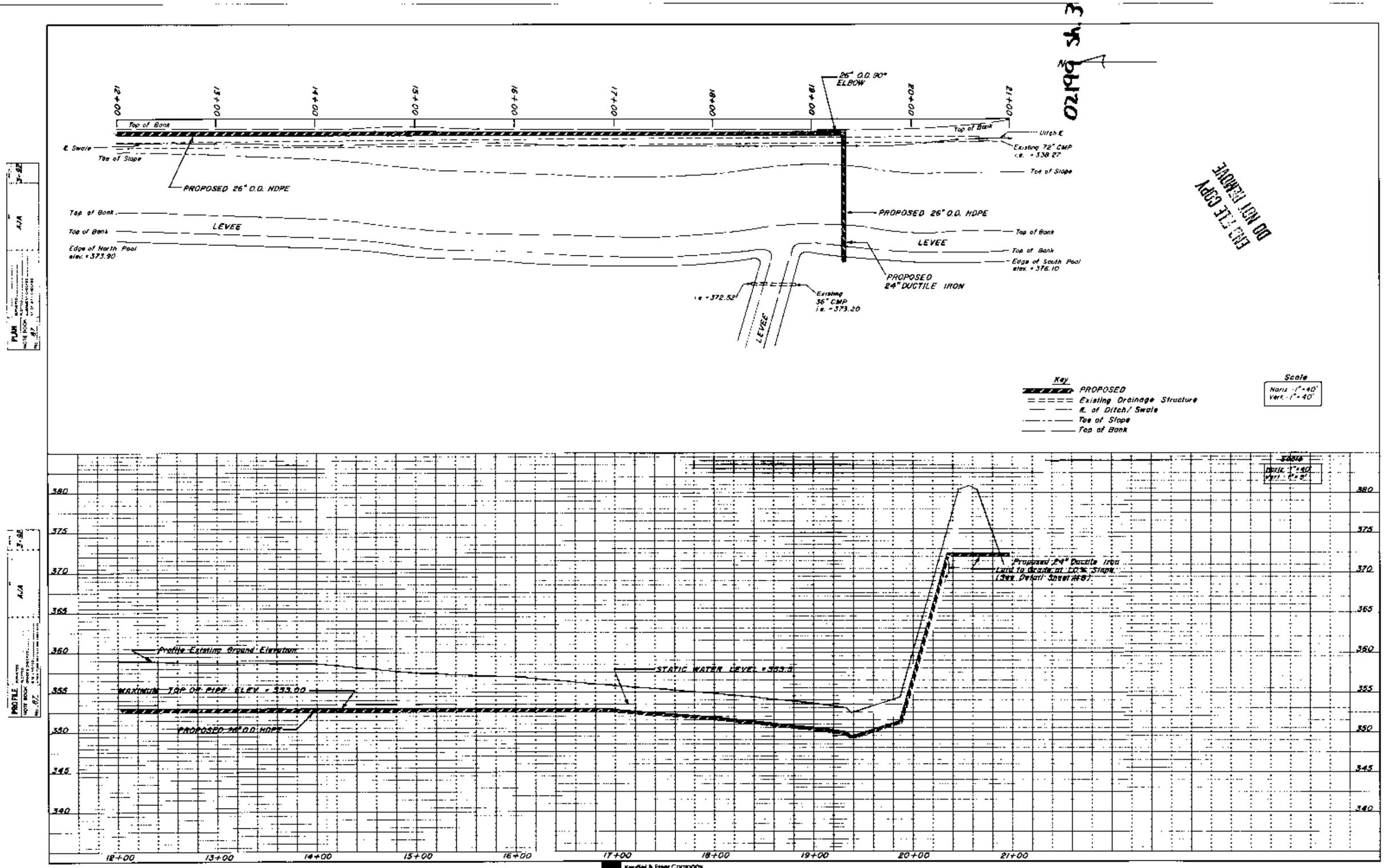
Proposed 26" O.D. HDPE

0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00

ENG. FILE COPY DO NOT REMOVE

0219 sh. 2

Roy F. Weston Company



ENG FILE COPY
DO NOT REMOVE

02199 Sh. 3

PLAN NOTE BOOK No. 87 AJA 3-92

PROFILE NOTE BOOK No. 87 AJA 3-92

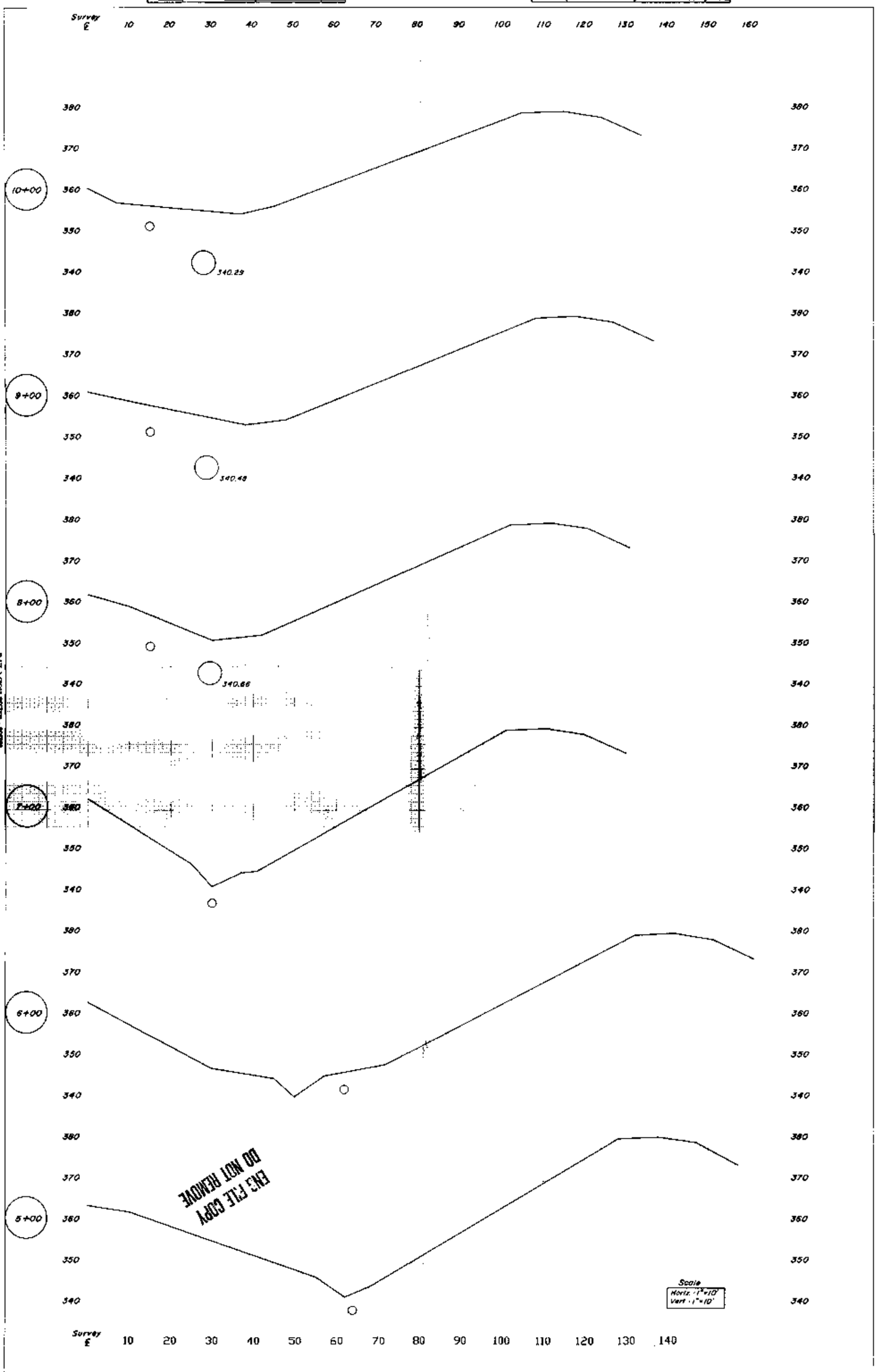
Keuffel & Esser Company

92-031

4+00
3+00
2+00
1+00
Survey

ORIGINAL SURVEY		BY	DATE
NOTE BOOK NO. 87	SURVEYED / PLOTTED / TEMPLATE / AREAS / AREAS CHECKED	AJA	3-92

FINAL SURVEY		BY	DATE
NOTE BOOK NO.	SURVEYED / PLOTTED / TEMPLATE / AREAS / AREAS CHECKED		



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DO NOT REMOVE

Cross-Sections

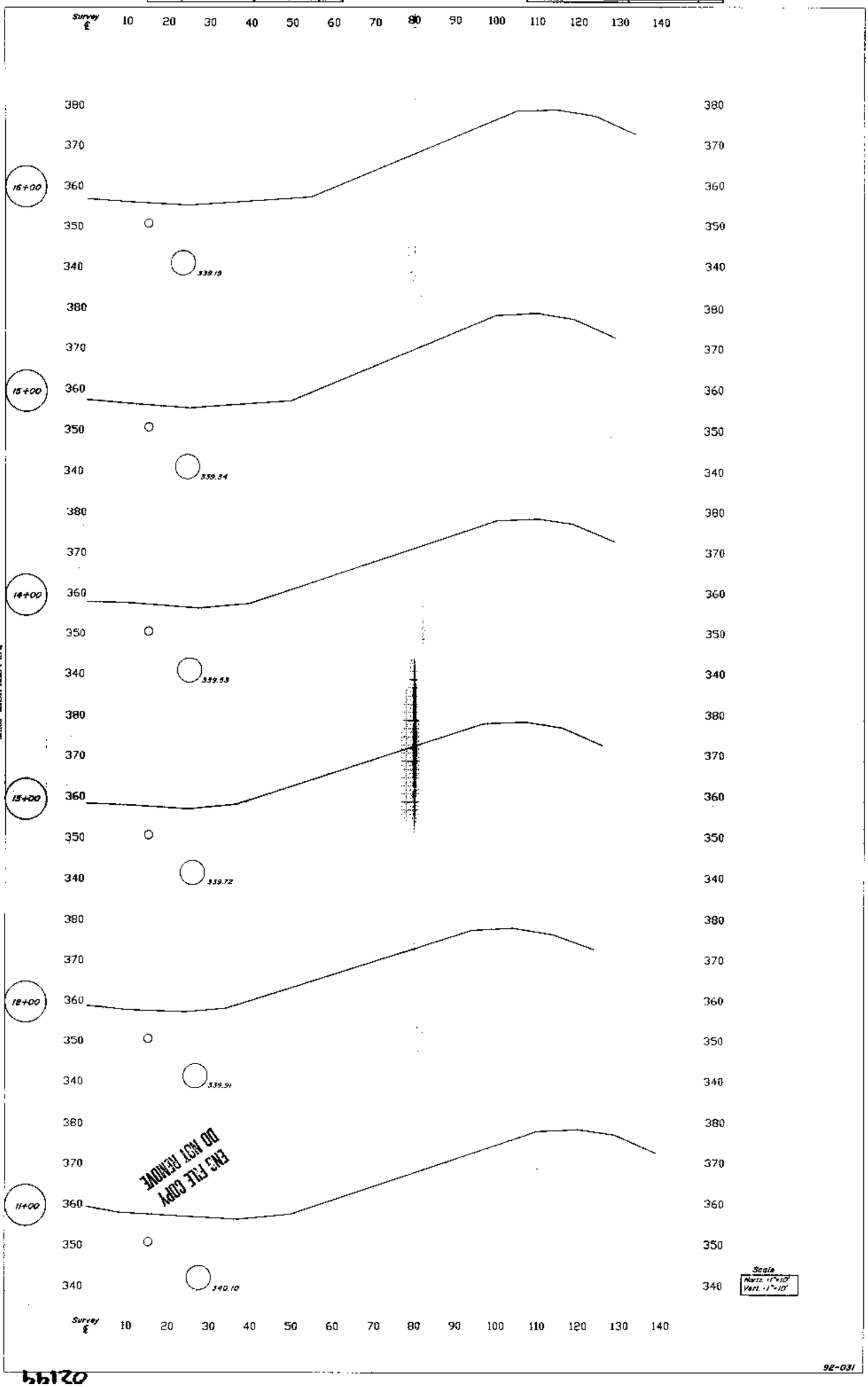
Sheet 5 of 8

92-031

02144 Sh. 5

ORIGINAL SURVEY		BY	DATE
	SURVEYED		
	PLOTTED		
NOTE BOOK	TEMPLATE		
NO. 87	AREAS		
	AREAS CHECKED		

FINAL SURVEY		BY	DATE
	SURVEYED		
	PLOTTED		
NOTE BOOK	TEMPLATE		
NO.	AREAS		
	AREAS CHECKED		



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Cross-Sections

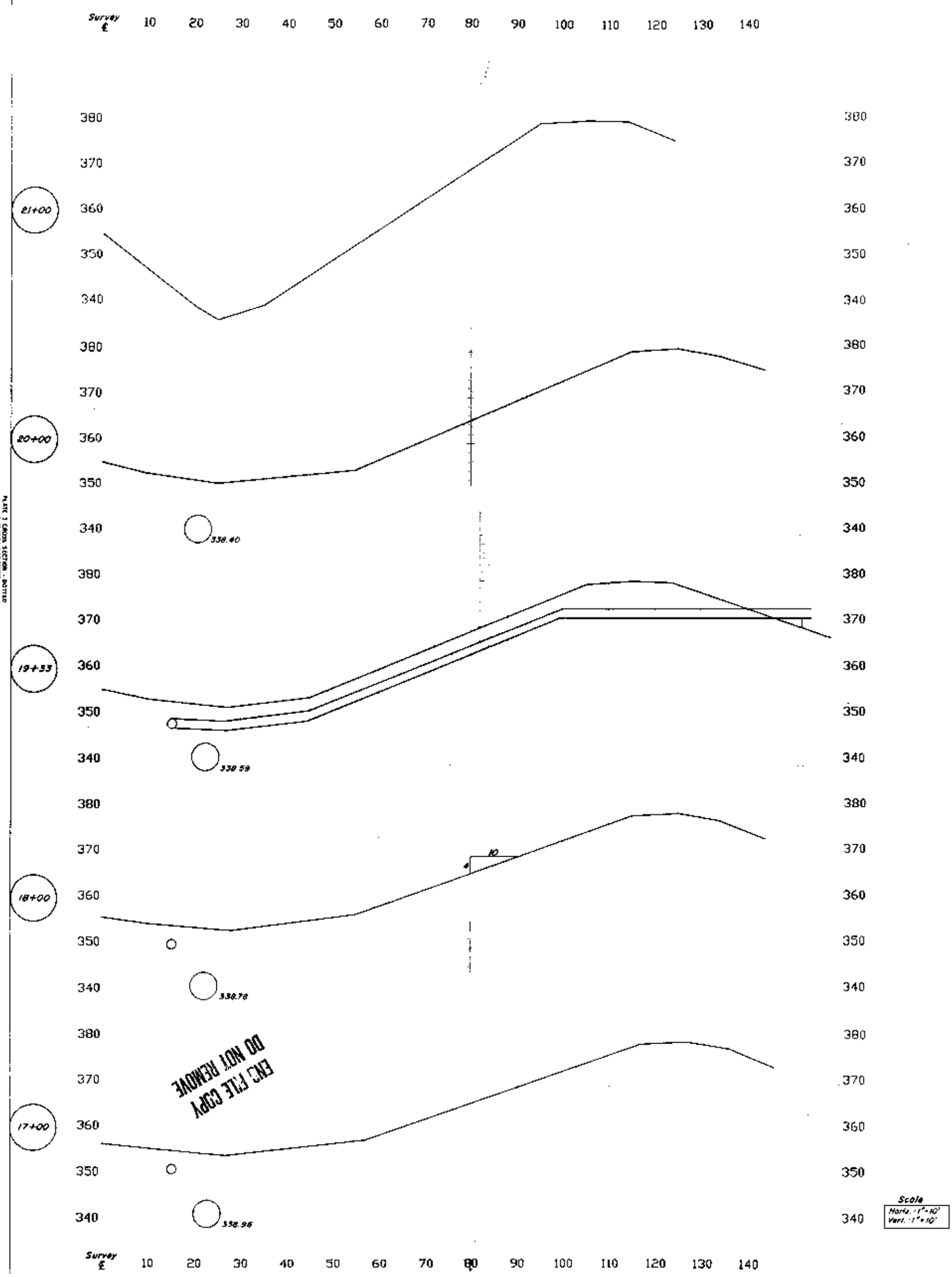
Sheet 6 of 8

92-031

9.45 66120

ORIGINAL SURVEY		BY	DATE
NOTE BOOK NO. 87	SURVEYED		
	PLOTTED	AJA	3-92
	TEMPLATE		
	AREAS		
	AREAS CHECKED		

FINAL SURVEY		BY	DATE
NOTE BOOK NO.	SURVEYED		
	PLOTTED		
	TEMPLATE		
	AREAS		
	AREAS CHECKED		



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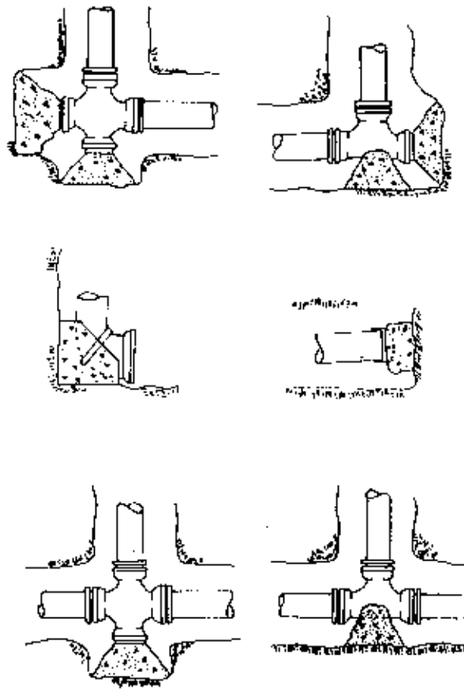
Cross-Sections

Sheet 7 of 8

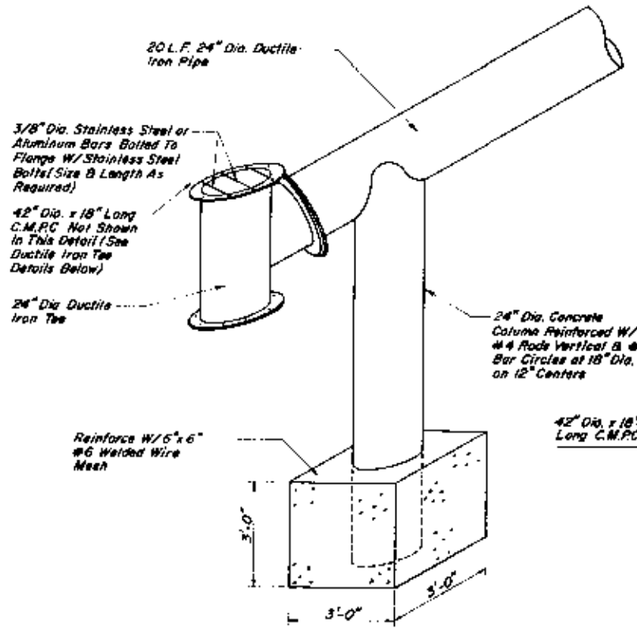
02199 SH 7

92-031



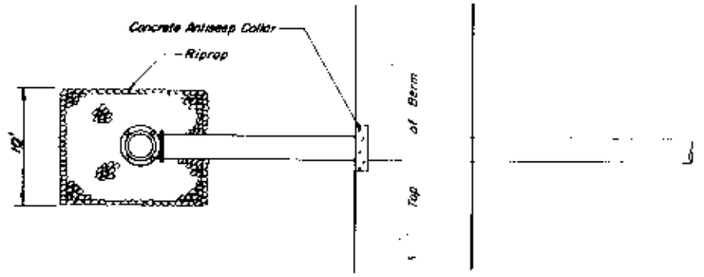
Typical Thrust Block Installation

ALL THRUST BLOCKING SHALL BE READY-MIX CONCRETE POURED AGAINST UNDISTURBED EARTH AT ALL LOCATIONS ILLUSTRATED ABOVE

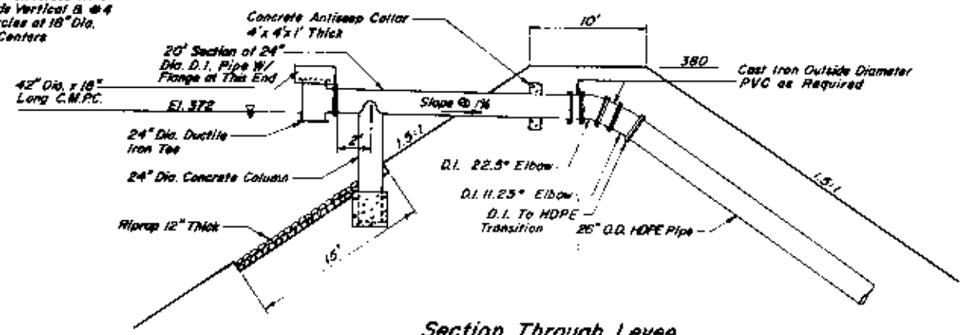


Section at Pipe Support

No Scale

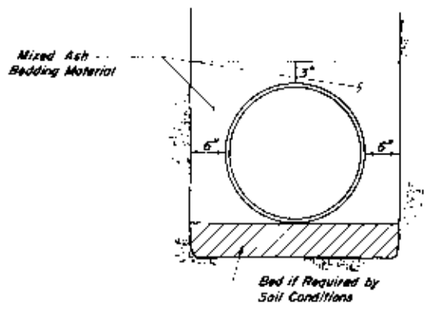


Plan



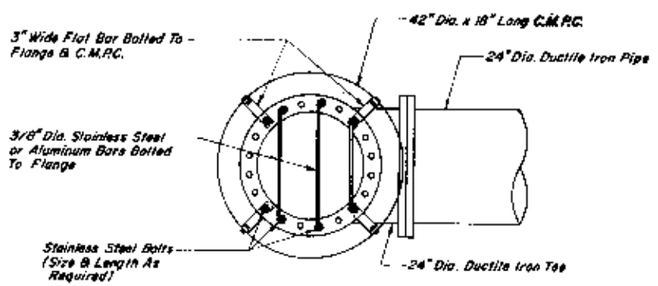
Section Through Levee

No Scale



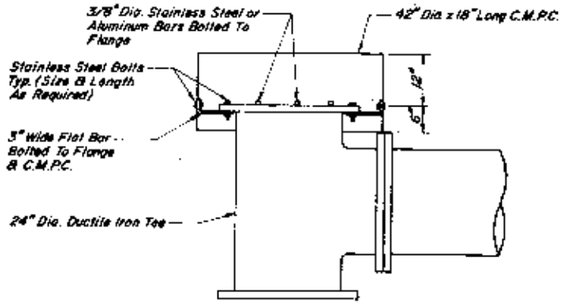
Typical Bedding Detail

No Scale



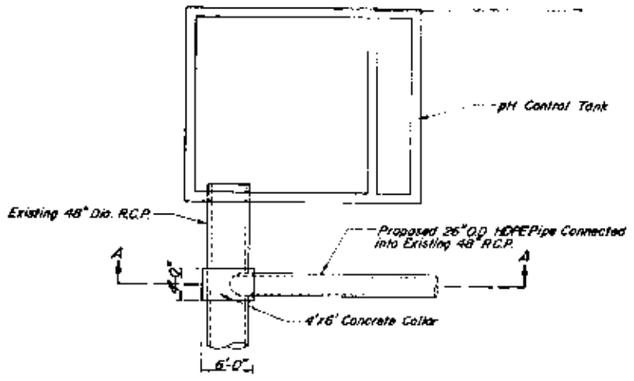
Plan View - Ductile Iron Tee

No Scale

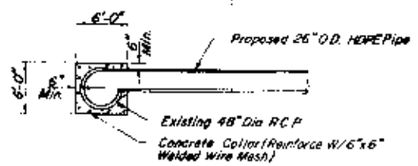


Elevation - Ductile Iron Tee

No Scale



Plan at pH Control Tank



Section A-A

No Scale

ENG FILE COPY
DO NOT REMOVE

BROWN, ROFFMANN & ROBERTS, INC.
CONSULTING ENGINEERS AND LAND SURVEYORS
500 W. POPLAR ST. HARRISBURG, IL 62946 (618) 252-8111

ELECTRIC ENERGY, INC.
ASH LAGOON OVERFLOW
Miscellaneous Details

Drawn By: H.J.F. | Checked By:
Revisions
Item | Date | By
Scale: As Shown | Field Book: H-1
Job Number: 90 01K | Date: 5/10/91
Sheet: 8 of 8

02169-48

CARUSO, MICHAEL, 6/2/2016 9:33 AM

LEGEND:

- GROUNDWATER MONITORING WELL
- SURVEY CONTROL POINT

AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\Joppa Remediation\CAD Files from SLC\JOP-SITE PLAN.dwg

AECOM
1001 Highlands Plaza
Drive West, Suite 300
St. Louis, MO 63110-1337
314-429-0100 (phone)
314-429-0462 (fax)

ELECTRIC ENERGY, INC.
2100 PORTLAND ROAD
JOPPA, IL 62953

WORK PAD AND SITE RESTORATION
EAST ASH POND

ISSUED FOR CONSTRUCTION

ISSUED FOR BIDDING	DATE	BY
ISSUED FOR CONSTRUCTION	05/24/16	VAM

REVISIONS

NO.	DESCRIPTION	DATE
1	ADDED TRAFFIC PLAN	6/2/2016

AECOM PROJECT NO:	60440155
DRAWN BY:	MJC
DESIGNED BY:	MJC
CHECKED BY:	LPC
DATE CREATED:	4/13/2016
PLOT DATE:	6/2/2016
SCALE:	1" = 40'
ACAD VER:	2014

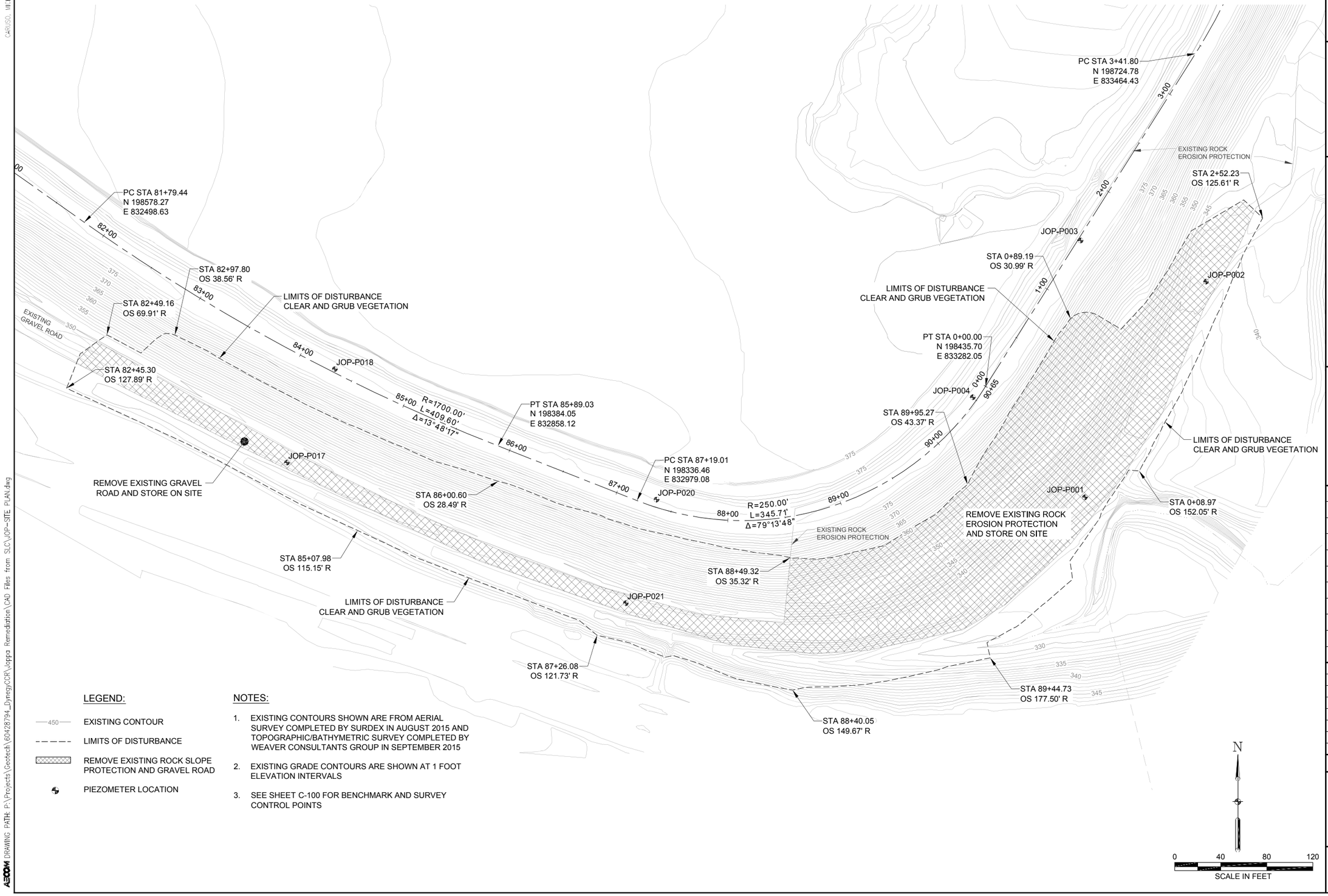
SHEET TITLE

OVERALL SITE PLAN

C-100

SHEET 4 OF 14

CARUSO, MICHAEL, 6/2/2016 9:33 AM



LEGEND:

- 450 — EXISTING CONTOUR
- LIMITS OF DISTURBANCE
- REMOVE EXISTING ROCK SLOPE PROTECTION AND GRAVEL ROAD
- PIEZOMETER LOCATION

NOTES:

1. EXISTING CONTOURS SHOWN ARE FROM AERIAL SURVEY COMPLETED BY SURDEX IN AUGUST 2015 AND TOPOGRAPHIC/BATHYMETRIC SURVEY COMPLETED BY WEAVER CONSULTANTS GROUP IN SEPTEMBER 2015
2. EXISTING GRADE CONTOURS ARE SHOWN AT 1 FOOT ELEVATION INTERVALS
3. SEE SHEET C-100 FOR BENCHMARK AND SURVEY CONTROL POINTS

N

0 40 80 120
SCALE IN FEET

AECOM
1001 Highlands Plaza
Drive West, Suite 300
St. Louis, MO 63110-1337
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314-429-0462 (fax)

ELECTRIC ENERGY, INC.
2100 PORTLAND ROAD
JOPPA, IL 62953

WORK PAD AND SITE
RESTORATION
EAST ASH POND

ISSUED FOR
CONSTRUCTION

ISSUED FOR BIDDING	DATE	BY
ISSUED FOR CONSTRUCTION	05/24/16	VAM

REVISIONS

NO.	DESCRIPTION	DATE
1	ADDED TRAFFIC PLAN	6/2/2016

AECOM PROJECT NO:	60440155
DRAWN BY:	MJC
DESIGNED BY:	MJC
CHECKED BY:	LPC
DATE CREATED:	4/13/2016
PLOT DATE:	6/2/2016
SCALE:	1" = 40'
ACAD VER:	2014

SHEET TITLE

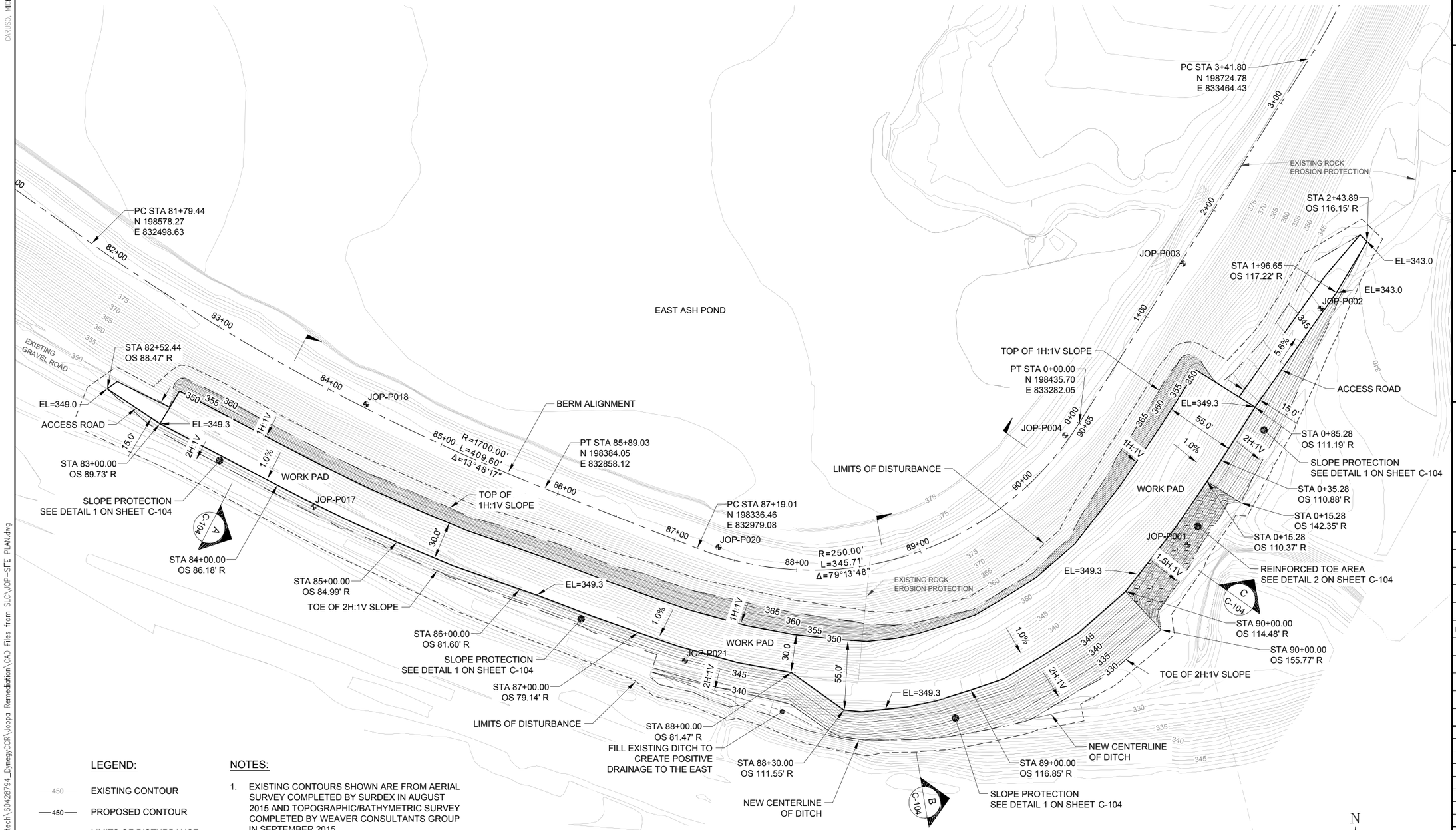
PRE-DMM SITE
CLEARING PLAN

C-101

SHEET 5 OF 14

AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\Joppa Remediation\CAD Files from SLC\JOP-SITE PLAN.dwg

CARUSO, MICHAEL, 6/2/2016 9:33 AM



LEGEND:

- 450 EXISTING CONTOUR
- 450 PROPOSED CONTOUR
- LIMITS OF DISTURBANCE
- CATCHLINES
- NEW DITCH
- REINFORCED TOE AREA
- PIEZOMETER LOCATION

NOTES:

1. EXISTING CONTOURS SHOWN ARE FROM AERIAL SURVEY COMPLETED BY SURDEX IN AUGUST 2015 AND TOPOGRAPHIC/BATHYMETRIC SURVEY COMPLETED BY WEAVER CONSULTANTS GROUP IN SEPTEMBER 2015
2. EXISTING AND PROPOSED GRADE CONTOURS ARE SHOWN AT 1 FOOT ELEVATION INTERVALS
3. SEE SHEET C-100 FOR BENCHMARK AND SURVEY CONTROL POINTS

N

0 40 80 120
SCALE IN FEET

AECOM
1001 Highlands Plaza
Drive West, Suite 300
St. Louis, MO 63110-1337
314-429-0100 (phone)
314-429-0462 (fax)

ELECTRIC ENERGY, INC.
2100 PORTLAND ROAD
JOPPA, IL 62953

WORK PAD AND SITE
RESTORATION
EAST ASH POND

ISSUED FOR
CONSTRUCTION

ISSUED FOR BIDDING	DATE	BY
ISSUED FOR CONSTRUCTION	05/24/16	VAM

REVISIONS

NO.	DESCRIPTION	DATE
1	ADDED TRAFFIC PLAN	6/2/2016

AECOM PROJECT NO:	60440155
DRAWN BY:	MJC
DESIGNED BY:	MJC
CHECKED BY:	LPC
DATE CREATED:	4/13/2016
PLOT DATE:	6/2/2016
SCALE:	1" = 40'
ACAD VER:	2014

SHEET TITLE

PRE-DMM SITE PLAN

C-102

SHEET 6 OF 14

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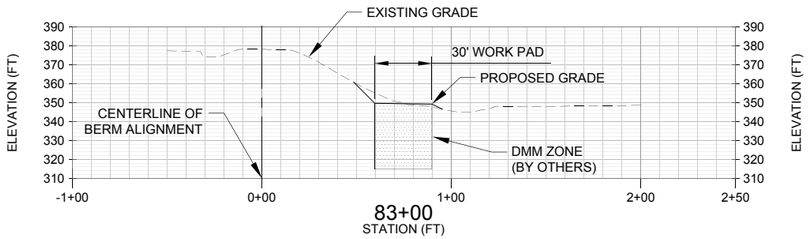

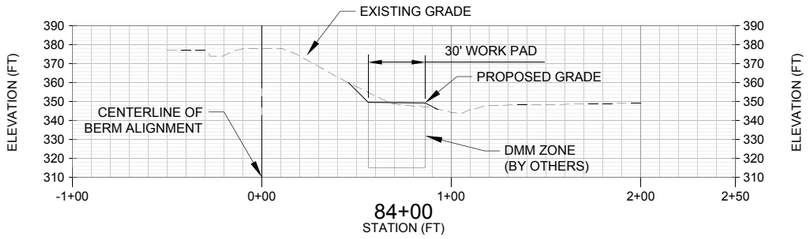

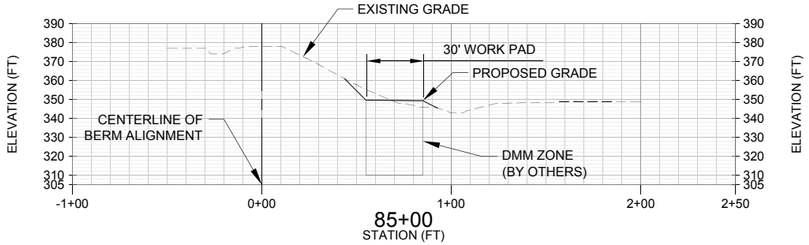

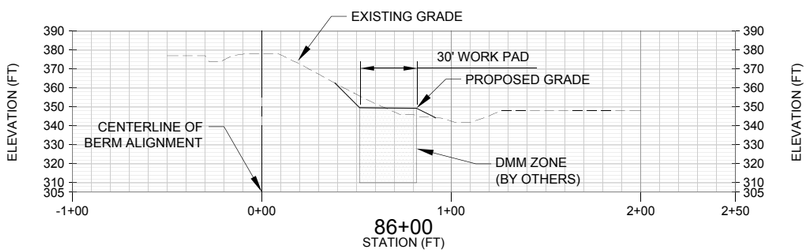

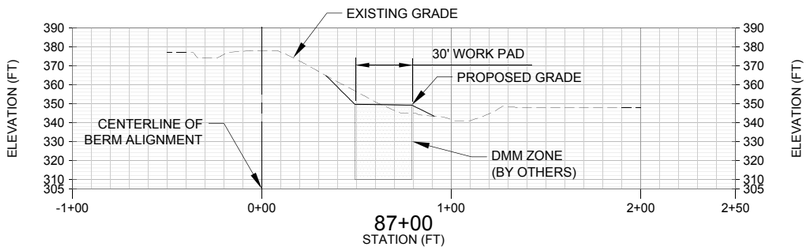

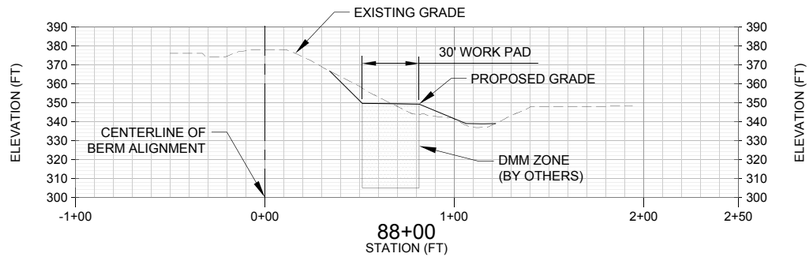

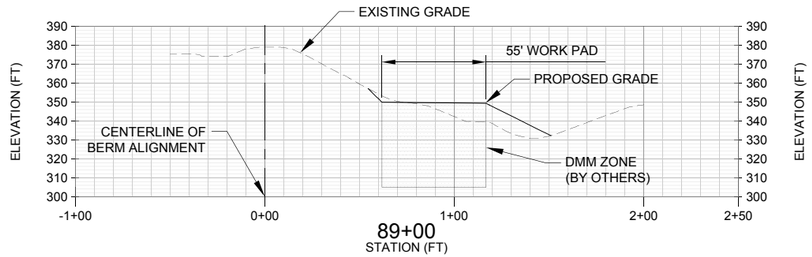

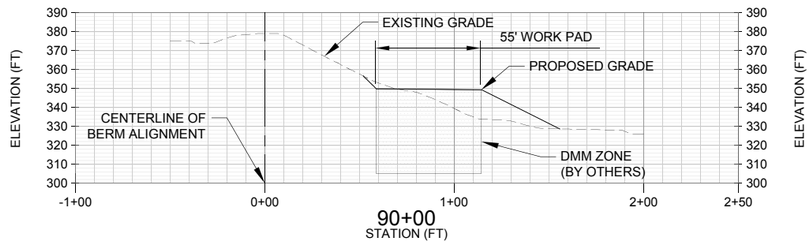

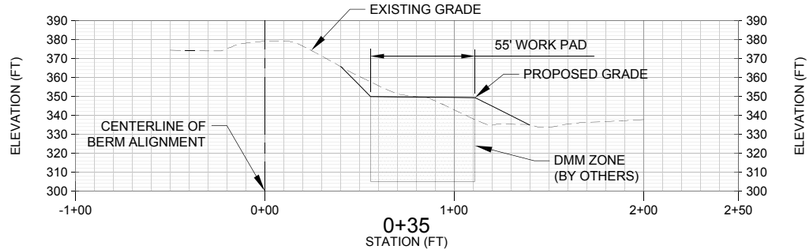

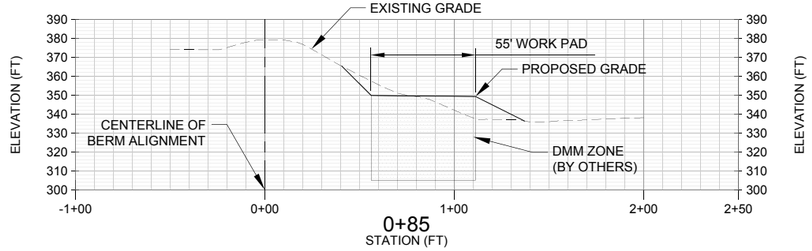

AECOM
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314-429-0100 (phone)
314-429-0462 (fax)

ELECTRIC ENERGY, INC.
2100 PORTLAND ROAD
JOPPA, IL 62953

WORK PAD AND SITE RESTORATION
EAST ASH POND

ISSUED FOR CONSTRUCTION

ISSUED FOR BIDDING		DATE BY
ISSUED FOR CONSTRUCTION	05/24/16	VAM

REVISIONS

NO.	DESCRIPTION	DATE
1	ADDED TRAFFIC PLAN	6/2/2016

AECOM PROJECT NO:	60440155
DRAWN BY:	MJC
DESIGNED BY:	MJC
CHECKED BY:	TLE
DATE CREATED:	04/13/16
PLOT DATE:	6/2/2016
SCALE:	1" = 40'
ACAD VER:	2014

SHEET TITLE

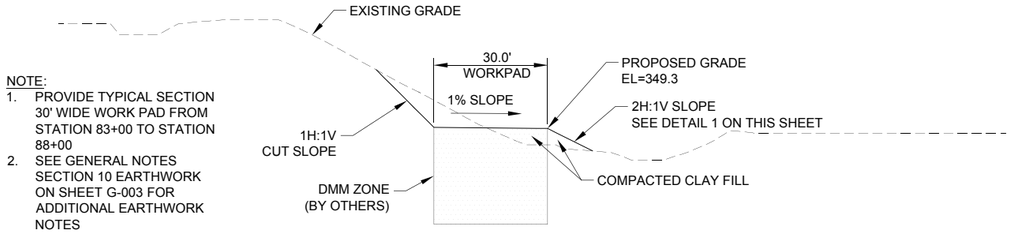
PRE-DMM CROSS SECTIONS

C-103

SHEET 7 OF 14

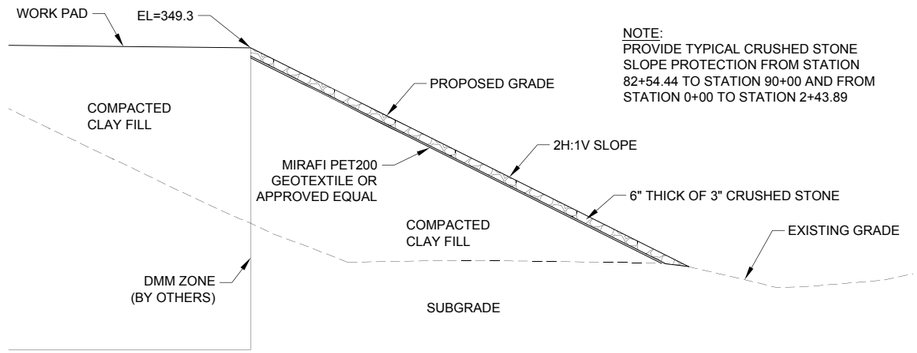
CARUSO, MICHAEL, 6/2/2016 9:34 AM
AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\Joppa Remediation\CAD Files from SLC\C3D\C3D-JOP-DESIGN.dwg

CARUSO, MICHAEL, 6/2/2016 9:34 AM



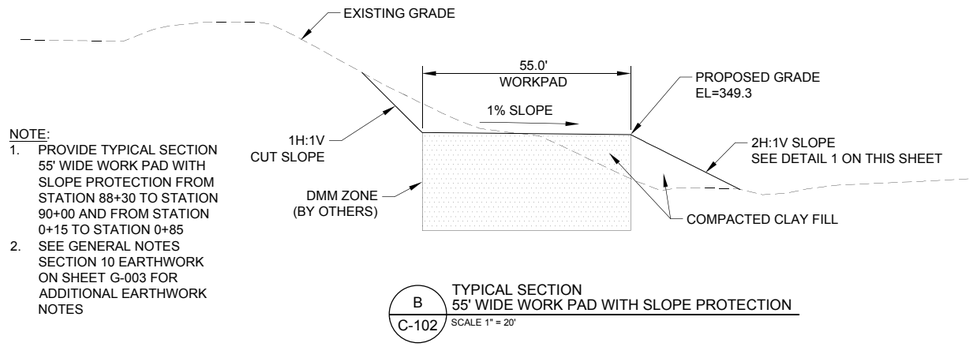
NOTE:
1. PROVIDE TYPICAL SECTION 30' WIDE WORK PAD FROM STATION 83+00 TO STATION 88+00
2. SEE GENERAL NOTES SECTION 10 EARTHWORK ON SHEET G-003 FOR ADDITIONAL EARTHWORK NOTES

A / C-102 TYPICAL SECTION
30' WIDE WORK PAD WITH SLOPE PROTECTION
SCALE 1" = 20'



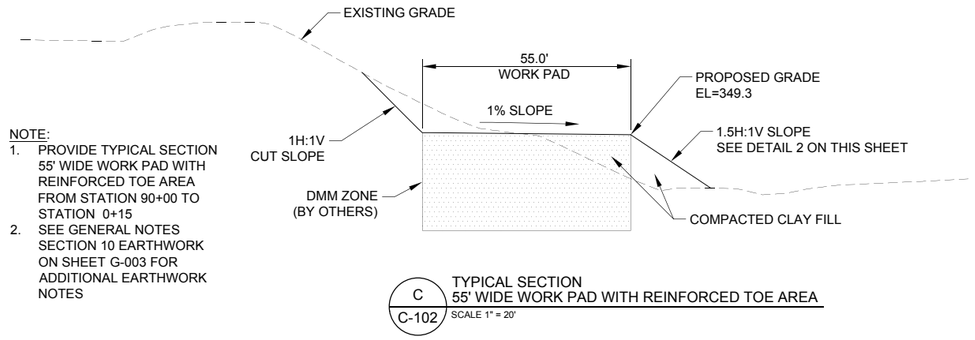
NOTE:
PROVIDE TYPICAL CRUSHED STONE SLOPE PROTECTION FROM STATION 82+54.44 TO STATION 90+00 AND FROM STATION 0+00 TO STATION 2+43.89

1 / C-102 TYPICAL PRE-DMM SLOPE PROTECTION
SCALE 1" = 5'



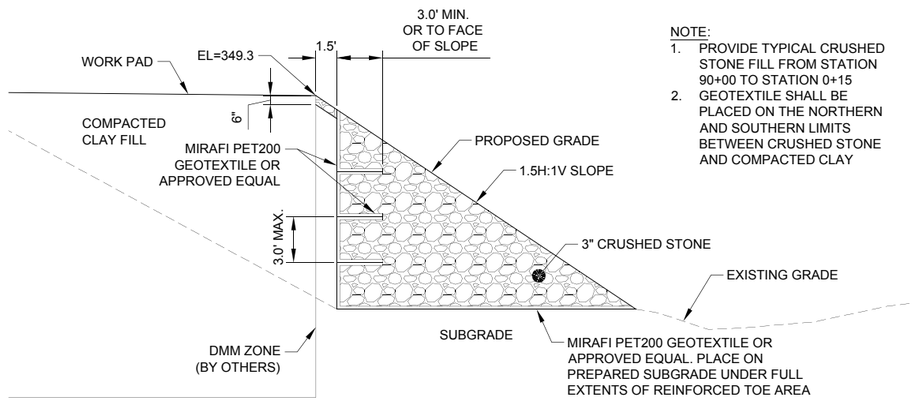
NOTE:
1. PROVIDE TYPICAL SECTION 55' WIDE WORK PAD WITH SLOPE PROTECTION FROM STATION 88+30 TO STATION 90+00 AND FROM STATION 0+15 TO STATION 0+85
2. SEE GENERAL NOTES SECTION 10 EARTHWORK ON SHEET G-003 FOR ADDITIONAL EARTHWORK NOTES

B / C-102 TYPICAL SECTION
55' WIDE WORK PAD WITH SLOPE PROTECTION
SCALE 1" = 20'



NOTE:
1. PROVIDE TYPICAL SECTION 55' WIDE WORK PAD WITH REINFORCED TOE AREA FROM STATION 90+00 TO STATION 0+15
2. SEE GENERAL NOTES SECTION 10 EARTHWORK ON SHEET G-003 FOR ADDITIONAL EARTHWORK NOTES

C / C-102 TYPICAL SECTION
55' WIDE WORK PAD WITH REINFORCED TOE AREA
SCALE 1" = 20'



NOTE:
1. PROVIDE TYPICAL CRUSHED STONE FILL FROM STATION 90+00 TO STATION 0+15
2. GEOTEXTILE SHALL BE PLACED ON THE NORTHERN AND SOUTHERN LIMITS BETWEEN CRUSHED STONE AND COMPACTED CLAY

2 / C-102 TYPICAL PRE-DMM REINFORCED TOE AREA
SCALE 1" = 5'

AECOM
1001 Highlands Plaza
Drive West, Suite 300
St. Louis, MO 63110-1337
314-429-0100 (phone)
314-429-0462 (fax)

ELECTRIC ENERGY, INC.
2100 PORTLAND ROAD
JOPPA, IL 62953

WORK PAD AND SITE RESTORATION
EAST ASH POND

ISSUED FOR CONSTRUCTION

	DATE	BY
ISSUED FOR BIDDING		
ISSUED FOR CONSTRUCTION	05/24/16	VAM

REVISIONS

NO.	DESCRIPTION	DATE
1	ADDED TRAFFIC PLAN	6/2/2016

AECOM PROJECT NO:	60440155
DRAWN BY:	MJC
DESIGNED BY:	MJC
CHECKED BY:	LPC
DATE CREATED:	4/13/2016
PLOT DATE:	6/2/2016
SCALE:	AS SHOWN
ACAD VER:	2014

SHEET TITLE

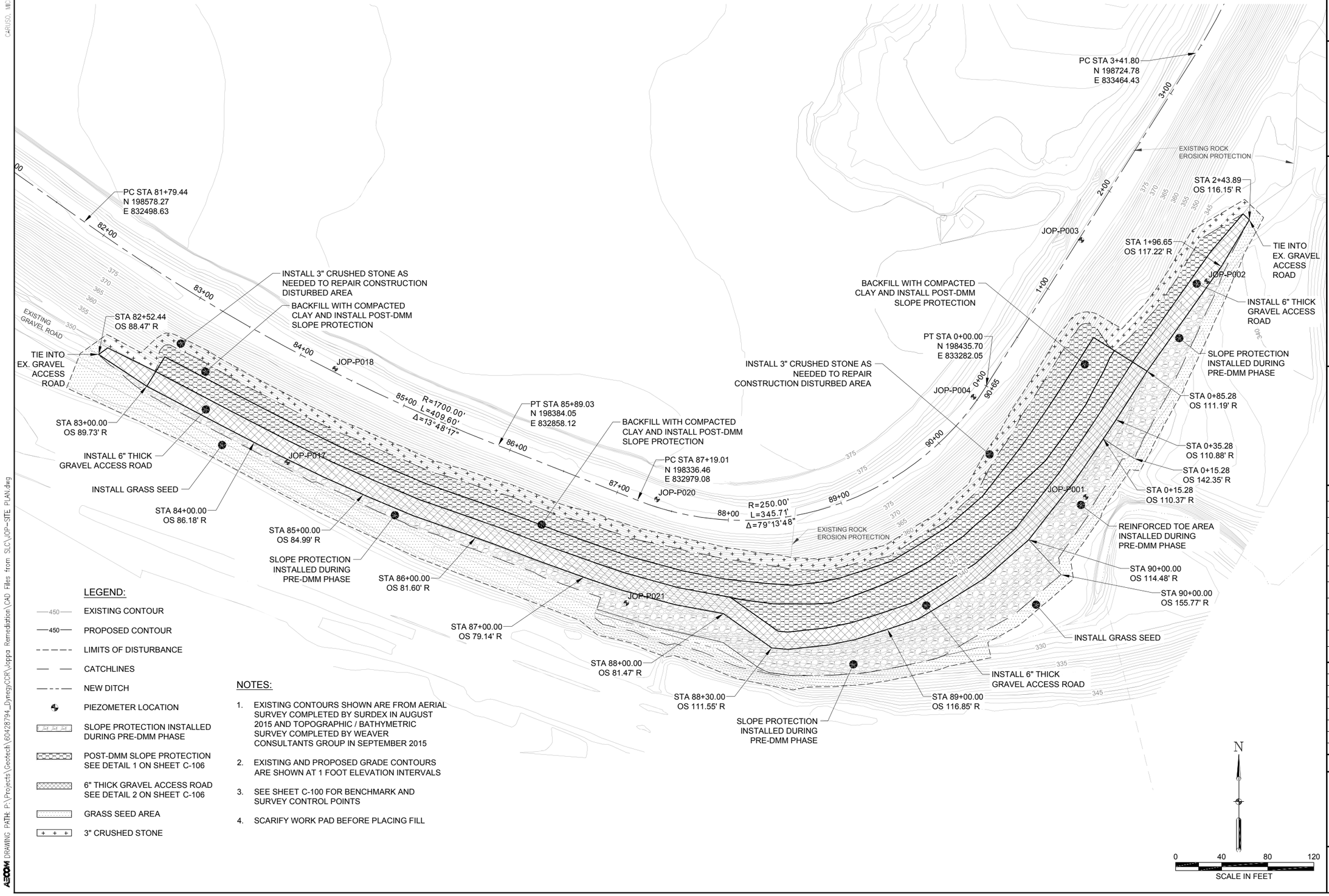
PRE-DMM DETAILS

C-104

SHEET 8 OF 14

AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\Joppa Remediation\CAD Files from SLC\JOP-DETAILS.dwg

CARUSO, MICHAEL, 6/2/2016 9:35 AM



LEGEND:

- 450 EXISTING CONTOUR
- 450 PROPOSED CONTOUR
- LIMITS OF DISTURBANCE
- CATCHLINES
- NEW DITCH
- PIEZOMETER LOCATION
- SLOPE PROTECTION INSTALLED DURING PRE-DMM PHASE
- POST-DMM SLOPE PROTECTION SEE DETAIL 1 ON SHEET C-106
- 6" THICK GRAVEL ACCESS ROAD SEE DETAIL 2 ON SHEET C-106
- GRASS SEED AREA
- 3" CRUSHED STONE

NOTES:

1. EXISTING CONTOURS SHOWN ARE FROM AERIAL SURVEY COMPLETED BY SURDEX IN AUGUST 2015 AND TOPOGRAPHIC / BATHYMETRIC SURVEY COMPLETED BY WEAVER CONSULTANTS GROUP IN SEPTEMBER 2015
2. EXISTING AND PROPOSED GRADE CONTOURS ARE SHOWN AT 1 FOOT ELEVATION INTERVALS
3. SEE SHEET C-100 FOR BENCHMARK AND SURVEY CONTROL POINTS
4. SCARIFY WORK PAD BEFORE PLACING FILL

AECOM
1001 Highlands Plaza
Drive West, Suite 300
St. Louis, MO 63110-1337
314-429-0100 (phone)
314-429-0462 (fax)

ELECTRIC ENERGY, INC.
2100 PORTLAND ROAD
JOPPA, IL 62953

WORK PAD AND SITE RESTORATION
EAST ASH POND

ISSUED FOR CONSTRUCTION

ISSUED FOR BIDDING		DATE BY
ISSUED FOR CONSTRUCTION	05/24/16	VAM

REVISIONS

NO.	DESCRIPTION	DATE
1	ADDED TRAFFIC PLAN	6/2/2016

AECOM PROJECT NO:	60440155
DRAWN BY:	MJC
DESIGNED BY:	MJC
CHECKED BY:	LPC
DATE CREATED:	4/13/2016
PLOT DATE:	6/2/2016
SCALE:	1" = 40'
ACAD VER:	2014

SHEET TITLE

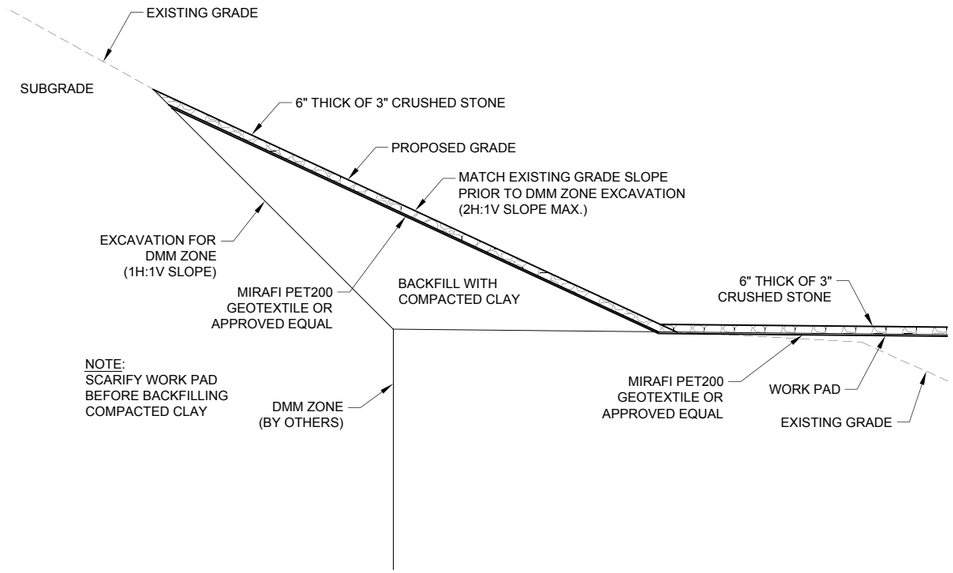
POST-DMM SITE RESTORATION PLAN

C-105

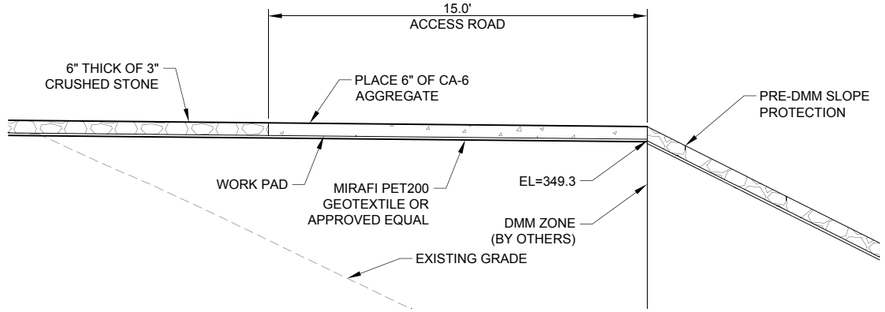
SHEET 9 OF 14

AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\Joppa Remediation\CAD Files from SLC\JOP-SITE PLAN.dwg

CARUSO, MICHAEL, 6/2/2016 9:36 AM



1 / C-105 TYPICAL POST-DMM SLOPE PROTECTION
SCALE 1" = 5'



2 / C-105 TYPICAL ACCESS ROAD
SCALE 1" = 3'

AECOM
1001 Highlands Plaza
Drive West, Suite 300
St. Louis, MO 63110-1337
314-429-0100 (phone)
314-429-0462 (fax)

ELECTRIC ENERGY, INC.
2100 PORTLAND ROAD
JOPPA, IL 62953

WORK PAD AND SITE
RESTORATION
EAST ASH POND

ISSUED FOR
CONSTRUCTION

	DATE	BY
ISSUED FOR BIDDING		
ISSUED FOR CONSTRUCTION	05/24/16	VAM

REVISIONS

NO.	DESCRIPTION	DATE
1	ADDED TRAFFIC PLAN	6/2/2016

AECOM PROJECT NO:	60440155
DRAWN BY:	MJC
DESIGNED BY:	MJC
CHECKED BY:	LPC
DATE CREATED:	4/25/2016
PLOT DATE:	6/2/2016
SCALE:	AS SHOWN
ACAD VER:	2014

SHEET TITLE

POST-DMM DETAILS

C-106

SHEET 10 OF 14

AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\Joppa Remediation\CAD Files from SLC\JOP-DETAILS.dwg

AECOM

Appendix C: Joppa East Ash Pond Piezometer and Boring Locations

NOTES

1. Plan adapted from an aerial photograph courtesy of Google Earth.

LEGEND

Boring Location

A A' Slope Stability Cross Section

N

0 180 360

SCALE IN FEET

Drawn By: SLC	Ck'd By: SLC	App'vd By: RSP
Date: 08-12-10	Date: 09/20/10	Date: 9/20/10

GEOTECHNOLOGY INC.
ENGINEERING AND ENVIRONMENTAL SERVICES
ST. LOUIS • COLLINSVILLE • KANSAS CITY

Electric Energy Inc. Facility
Joppa, Illinois

AERIAL PHOTOGRAPH OF SITE AND BORING LOCATIONS

Project Number J017150.02	PLATE 2

XXX-X### — EXPLORATION METHOD (B=BORING, C=CPT, P=PIEZOMETER); ID NUMBER; STATION ABBREVIATION

LEGEND

PIEZOMETER LOCATION

CCR UNIT BERM ALIGNMENT

SOURCE:
MAP PROVIDED BY GOOGLE EARTH PRO 2015

0 300

APPROXIMATE SCALE FEET

N

Electric Energy, Inc.

PROJECT NO. 60440155

AECOM

DRN. BY: djd October 2015
DSGN. BY: eg
CHKD. BY: eg

Joppa East Ash Pond Piezometer Locations

FIG. NO. 2A

File: P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\04TASKS\00 PROGRAM TASKS\1.0 TASK 1 INITIAL UNIT ASSESSMENT\CCR FACT SHEETS\SITE MAPS\FIGURE 2A PIEZOMETER LOCATION PLAN (JOPPA).DWG Last edited: NOV. 04, 15 @ 1:20 p.m. by: david_deguire

AECOM

Appendix D: Ash Pond Embankment Instability, Hanson Professional Services Inc. (2011)

HANSON
Engineering | Architecture | Planning | Allied Services

Hanson Professional Services Inc.
1525 South 6th Street
Springfield, IL 62703
(217) 788-2450
Fax: (217) 788-5241
www.hanson-inc.com

April 29, 2011

Mr. Mike Mercer
Electric Energy Inc.
P.O. Box 158
Joppa, Illinois 62953

RE: Ash Pond Embankment Instability
Joppa Ash Pond
Hanson No. 11E0054

Dear Mr. Mercer:

On April 26, 2011 the Joppa ash pond embankment was inspected by James Knutelski, P.E. from Hanson, and Mike Mercer from Electric energy Inc. (EEI) after instability in several areas of the downstream embankment slope was observed on April 25, 2011 by EEI personnel. The locations of the areas of instability that were observed during the April 26, 2011 inspection are shown on the aerial photograph that is attached to this letter. We understand that storms produced 4.75 in. of rain at the Joppa Power Station between April 22 and April 25, 2011.

Existing drawing indicate that the embankment was originally constructed in 1985 using local cohesive soils (ML or CL materials) with 1.5H:1.0V and 2.0H:1.0V exterior slopes. The embankment height varies between 15 ft and 40 ft. The design crest width was 20 ft. EEI employees reported that the completed embankment crest width was less than 20 ft and on the order of 10 ft or less in some areas. Between 1985 and 2011, the configuration of the embankment has been changed using flyash produced at the Joppa Power Station. Generally, fly ash has been placed over the downstream slope from the embankment crest in order to widen the embankment crest width in some areas. At some locations as much as 3 ft of additional embankment (flyash) has reportedly been added to the downstream embankment slope.

There have been previous reports of instability of the pond embankment on the northern portion of the west embankment. These areas of instability were repaired using riprap materials in a bench arrangement in order to provide more resistance to sliding in the affected areas. These areas appeared to be stable during the April 26, 2011 inspection.

During the inspection, sloughs at eight areas of instability were observed. The areas of instability are shown on the attached photographs. The sloughs appeared to be relatively shallow. The length of scarp varied from as little as 25 ft in length to as much as 150 ft in length. The scarps generally began at the top of the slope and extended to between one-half of the embankment height and the full embankment height. The embankment soils exposed by the slide were observed to be firm to hard at a shallow depth (less than 1 ft in most instances) when probed with a thin steel rod (drain tile probe).

The sloughs observed on the northern ash pond (#1 through #6) and one of two slough areas on the southern ash pond (area #7) appeared to be mainly due to sliding at the interface between ash materials apparently added to the downstream embankment slope and the original cohesive soil embankment constructed in 1985. Water infiltration through the ash materials that did not infiltrate the cohesive soils appears to have reduced the friction between these materials and caused sloughing. The sloughed material appeared to be composed of partially hydrated flyash and was generally hard and brittle.

Slide area #8 was observed on the southern portion of the eastern embankment. It appeared to be a shallow failure about 50 ft long with a scarp about 8 in. deep. In general, the slide appeared to consist of only topsoil and organic material. Infiltration of water through the topsoil that was trapped between the topsoil and cohesive embankment probably provided the failure mechanism in this area. There were no observations made that would indicate why this area failed and other areas with similar surface condition and slope did not.

Until more favorable weather conditions exist, the areas of instability may continue to slough, sloughs may propagate into areas adjacent to existing sloughs, and new sloughs may develop.

Repair of these areas may be completed using local cohesive soils, or riprap materials similar to those used to repair other areas of sliding. The use of local cohesive soil for repair will probably be the more economic alternative if repairs are made, but will require more favorable weather conditions and soil moisture control as described below.

Repair of the embankment with local cohesive soil should consist of stripping the affected area of all sloughing soil, ash, and vegetative cover; placement of new compacted soil embankment; and establishment of vegetative cover on the repaired embankment. Repair of these areas with soil should not be started until weather conditions allow compaction of thin lifts (8 in. maximum compacted thickness) of soil to be placed and compacted to 95% of the maximum dry density obtained using ASTM Test Method D648 (Standard Compaction Test).

The new embankment materials should be constructed by benching into the existing embankment deep enough to remove all soft or wet soils encountered. The maximum vertical bench height should be limited to 2 ft. The average slope of the benched area within the existing embankment should be no steeper than 1.5H:1.0V during construction of repairs. In order to construct repairs and maintain stability of the existing embankment materials, it will probably be necessary to increase the width of the embankment toe and construct a slope flatter than the 1.5H:1.0 V and 2.0H:1.0V slopes that were originally constructed. It is recommended that slopes no steeper than 2.5H:1.0V be constructed for repairs with local cohesive soils since one area of instability in the 2.0H:1.0V existing slope was observed during the inspection. A typical soil repair section is shown on the attached sheet.

Repair of the embankment with riprap material should consist of stripping the affected area of all sloughing soil, ash, and vegetative cover and placement of riprap materials.

The riprap materials should be constructed by benching into the existing embankment deep enough to remove all soft or wet soils encountered. The average slope of the benched area within the existing embankment should be no steeper than 1.5H:1.0V during construction of repairs. The maximum vertical bench height should be limited to 2 ft. The riprap materials may be placed in a single slope configuration or benched. The riprap should be placed in lifts not exceeding 2 ft in height and tracked in with the equipment used for construction. The single slope should be no steeper than 2.5H:1.0V. For a benched slope, the average slope of the

riprap materials should be no steeper than 2.5H:1.0V. The slope of the benches should match the slope of the adjacent embankment materials. A typical benched riprap slope is shown on the attached sheet.

The above repair recommendations should also be considered for areas of the pond embankment that have not experienced instability in order to prevent instability under similar wet weather conditions in the future. The ash materials that have been placed on the embankment slope appear to have created a mechanism for failure by trapping water between the ash and embankment soil. In addition, flattening the slope of the embankment where ash materials are not present should be considered since instability of the slope under extremely wet weather conditions has been experienced.

As discussed, an alternative to the above repair recommendations is to discontinue use of the pond for water detention. The risk of a breach in the embankment would be greatly reduced if water detention and storage were eliminated. This could be accomplished by grading the ash materials within the pond to drain to a low point (either the existing outfall structure, or a designed breach within the perimeter embankment). One requirement for this alternative would be that the ash be graded to be able to discharge runoff from the pond interior to the pond outlet with minimal water detention.

We have been pleased to provide the information within this letter. Feel free to call me at (217) 747-9437 if you have any questions.

Sincerely,

HANSON PROFESSIONAL SERVICES INC.

James P. Knutelski, PE
Geotechnical Engineer

jpk

Enclosures

41
42
43
44
36
37
38
35

Slide Area #1

Slide Area #2

Slide Area #3

Slide Area #4

Slide Area #5

Slide Area #6

Slide Area #7

Slide Area #8

By: JPK Date: 4/27/11

Checked by: _____ Date: _____

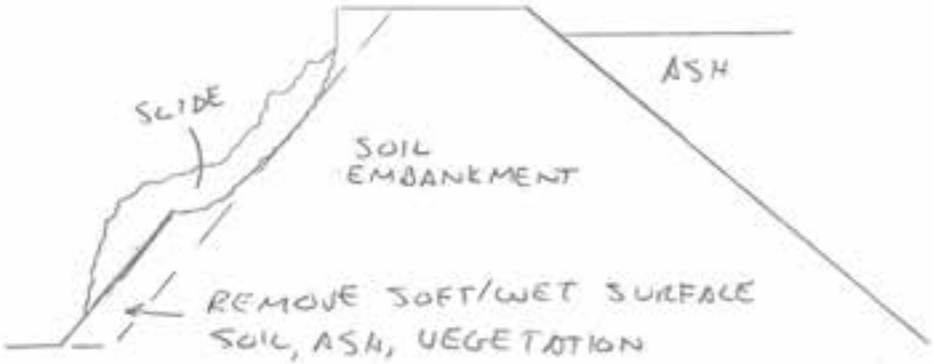
HANSON
Engineering | Architecture | Planning | Allied Services

Sheet No.: 1 of: _____

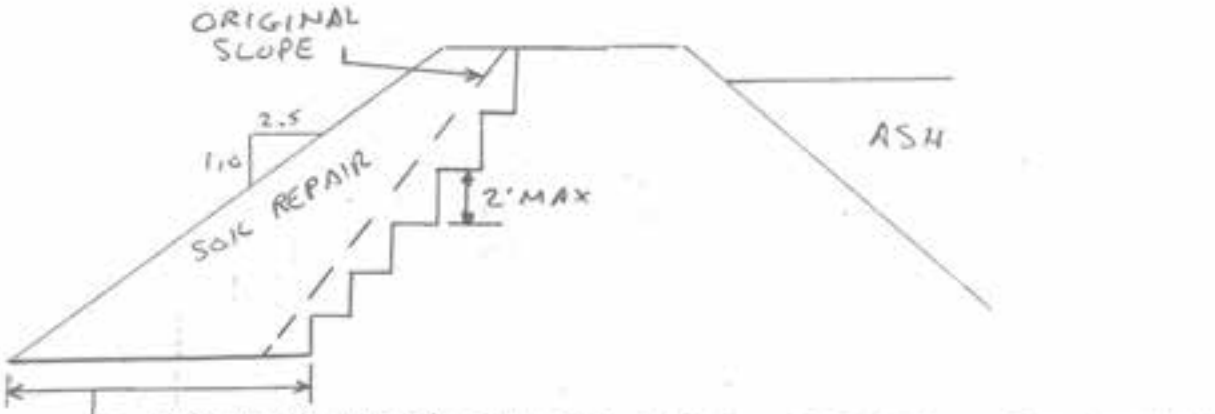
Project No.: 11E0054

JOPPA ASH POND - SHALLOW FAILURE REPAIR

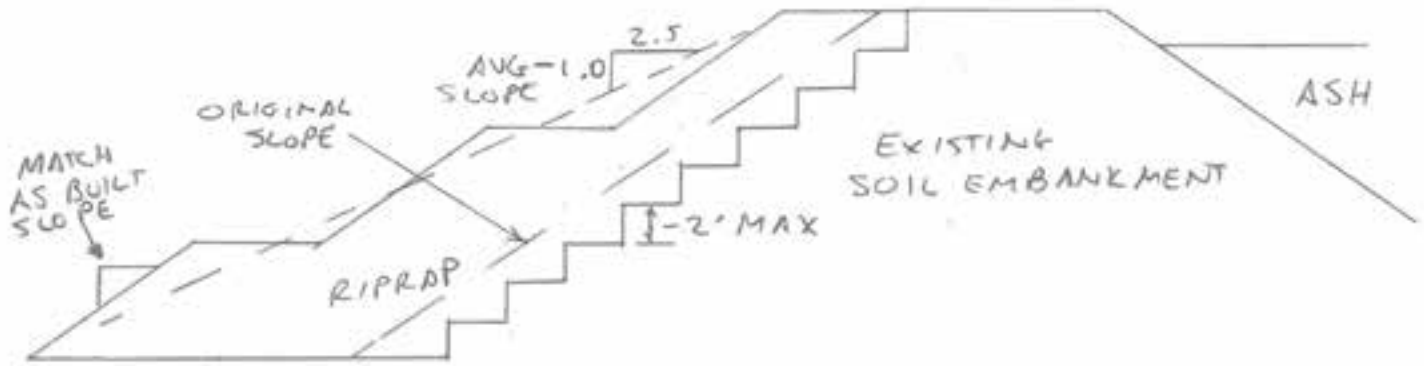
TYPICAL SHALLOW SLIDE



SOIL REPAIR



RIPRAP REPAIR



AECOM

Appendix E: Photos of Slope Repairs

Figure E.1: Photo of stripping the affected area of all sloughing soil, ash, and vegetative cover.

Figure E.2: Photo of benching into the existing embankment.

Geosyntec
consultants

ATTACHMENT D

Types of CCR and Chemical Constituents

845.220(a)(2)(A)

July 2022

Joppa Power Plant - East Ash Pond's Chemical Constituents

In accordance with 35 I.A.C. 845.230(d)(2)(C), EEI is submitting available/existing analyses of "the chemical constituents of all waste streams, chemical additives and sorbent materials entering or contained in" the CCR impoundment, East Ash Pond.

A list of the chemical constituents' analyses contained in the EEI surface impoundment can be found in Appendix A. As determined through antidegradation studies, this list contains chemical constituents found in the surface free liquid and the subsurface free liquids. EEI is also including a list of chemical additives, sorbent materials and waste streams that were submitted in the facility's NPDES permit applications to IEPA within the past ten years at a minimum and/or listed in the current NPDES permit (IL0001554) in Appendix B.

Appendix A: Chemical Constituents Contained in the Ash Pond

Pollutant	Units	Surface Free Liquids Average Concentration	Subsurface Free Liquids Average Concentration
Ammonia	mg/L	< 0.10	3.3
Arsenic	mg/L	0.0014	0.189
Barium	mg/L	0.1585	0.45
Boron	mg/L	0.208	9.0
Cadmium	mg/L	< 0.0005	0.0007
Chloride	mg/L	20.6	11.7
Chromium	mg/L	0.00395	0.00024
Chromium (hexavalent)	mg/L	0.00315	0.0182
Copper	mg/L	0.00305	0.0260
Cyanide	mg/L	< 0.005	< 0.0050
Fluoride	mg/L	< 0.12	0.28
Iron	mg/L	0.2114	0.62
Iron, Dissolved	mg/L	< 0.05	6.7
Lead	mg/L	0.0007	0.039
Manganese	mg/L	0.0084	0.278
Mercury	mg/L	2.7E-06	0.000063
Nickel	mg/L	0.0014	0.0223
Nitrate as N	mg/L	1.2	0.09
Oil and Grease	mg/L	< 1.85	6.1
pH*	SU	8.8	8.3
Phenols	mg/L	< 0.05	< 0.05
Selenium	mg/L	< 0.0005	1.52
Silver	mg/L	< 0.0005	0.0063
Sulfate	mg/L	59.55	0.0004
TDS	mg/L	238	848.9
TSS	mg/L	9.9	1726
Zinc	mg/L	< 0.01	65

*Used https://calstormcompliance.com/ph-averaging-tool

Appendix B: List of Chemical Additives, Waste Streams and Sorbent Materials

Chemical Additives
Buckman 8812 or equivalent -- Anti Scalant
Calcium Bromide*
Bualab 5494 – Dust Suppression*
Sulfuric acid (93%)
Sodium hydroxide (50%)
Buckman 8862 or equivalent -- Biocide
Buckman 8854 or equivalent – high pH Cleaner
Buckman 8893 or equivalent – low pH Cleaner

* Only a very small percentage of these chemicals would enter the ash pond. A high majority of the product would be consumed in the combustion process. Varying products may be used.

Waste Streams and Sorbent Materials*
Bottom Ash & Fly Ash Sluice water
Demineralizer Regeneration Waste
Central Water Treatment Bldg Floor Drains
Settling Lagoon and Intake Dredging
Air Heater Wash Water
Reverse Osmosis and Demineralizer System Blowdown
Non-Chemical Metal Cleaning Waste

*No sorbent materials

DYNEGY

Safety Data Sheet

Section 1
Identification of the Substance and of the Supplier

1.1 Product Identifier

Product Name/Identification:	ASTM Class C Fly Ash
Synonyms:	Coal Fly Ash, Pozzolan
Formula:	UVCB Substance

1.2 Relevant Identified Uses of the Substance or Mixture and Uses Advices Against

Relevant Identified Uses:	Component of wallboard, concrete, roofing material, bricks, cement kiln feed.
Uses Advised Against:	None known.

1.3 Details of the Supplier of the SDS

Manufacturer/Supplier:	Dynegy, Inc.
Street Address:	601 Travis Street, Suite 1400
City, State and Zip Code:	Houston, TX 77002
Customer Service Telephone:	800-633-4704

Section 2
Hazards Identification

2.1 Classification of the Substance

GHS Classification(s) according to OSHA Hazard Communication Standard (29 CFR 1910.1200):

- Eye Irritant, Category 2A
- STOT-SE, Category 3 (Respiratory Irritation)
- Carcinogen, Category 1A
- STOT-RE, Category 1 (Lungs)
- Toxic to Reproduction, Category 2

2.2 Label Elements

Labelling according to 29 CFR 1910.1200 Appendices A, B and C*	
Hazard Pictogram(s):	
Signal word:	**DANGER**
Hazard Statement(s):	*Causes serious eye irritation.* *May cause damage to lungs after repeated/prolonged exposure via inhalation.* *May cause respiratory irritation.* *May cause cancer of the lung.* *Suspected of damaging fertility or the unborn child.*
Precautionary Statement(s):	*Obtain special instructions before use.* *Do not handle until all safety precautions have been read and understood.* *Avoid breathing dust.* *Wear protective gloves/protective clothing/eye protection/face protection.* *Wash thoroughly after handling.* *Do not eat drink or smoke when using this product.* *Use outdoors or in a well-ventilated area.* *If exposed or concerned: Get medical advice/attention.* *Store in a secure area.* *Dispose of product in accordance with local/national regulations.*

** Fly ash and other coal combustion products (CCPs) are UVCB substances (unknown or variable composition or biological). Various CCPs, noted as ashes/ash residuals; Ashes, residues, bottom; Bottom ash; Bottom ash residues; Waste solids, ashes under TSCA are defined as: "The residuum from the burning of a combination of carbonaceous materials. The following elements may be present as oxides: aluminum, calcium, iron, magnesium, nickel, phosphorus, potassium, silicon, sulfur, titanium, and vanadium." Ashes including fly ash and fluidized bed combustion ash are identified by CAS number 68131-74-8. The exact composition of the ash is dependent on the fuel source and flue additives composed of many constituents. The*

classification of the final substance is dependent on the presence of specific identified oxides as well as other trace elements.

2.3 Other Hazards

Listed Carcinogens:

-Respirable Crystalline Silica

IARC: [Yes] **NTP:** [Yes] **OSHA:** [Yes] **Other:** **(ACGIH)** [Yes]

Section 3
Composition/Information on Ingredients

Substance	***CAS No.***	***Percentage (%)***	***GHS Classification***
Crystalline Silica	*14808-60-7*	*30 - 60%*	*Repeat Dose STOT, Category 1* *Carcinogen, Category 1A*
Silica, crystalline respirable (RCS)	*14808-60-7*	***See Footnote 1***	*Repeat Dose STOT, Category 1* *Carcinogen, Category 1A*
Aluminosilicates	*71243-67-9* *1327-36-2*	*30 - 60%*	*Single Exposure STOT, Category 3*
Iron oxide	*1309-37-1*	*1 - 10%*	*Not Classified*
Calcium oxide (CaO)	*1305-78-8*	*20 - 30%*	*Skin Irritant, Category 2* *Eye Irritant, Category 1* *Single Exposure STOT, Category 3*
Magnesium oxide	*1309-48-4*	*2 - 10%*	*Not Classified*
Phosphorus pentoxide (P_2O_5)	*1314-56-3*	*≤2%*	*Skin Irritant, Category 2* *Eye Irritant, Category 2B*
Sodium oxide	*1313-59-3*	*1-8%*	*Not Classified*
Potassium oxide (K_2O)	*12136-45-7*	*≤1%*	*Skin Irritant, Category 2* *Eye Irritant, Category 2B*
Titanium dioxide (TiO_2)	*13463-67-7*	*<3%*	*Not Classified*
Bromide salt (calcium)	*7789-41-5*	*See Footnote 2*	*Toxic to Reproduction, Category 2*

Footnote 1: *The percentage of respirable crystalline silica has not been determined. Therefore, a GHS classification of Carcinogen, Category 1A has been assigned.*

Footnote 2: *Analytical data are not available to demonstrate that the concentration of bromide salt is <0.1%; therefore, a GHS classification of Toxic to Reproduction, Category 2 has been assigned.*

Section 4
First Aid Measures

4.1 Description of First Aid Measures

Inhalation:	If product is inhaled and irritation of the nose or coughing occurs, remove person to fresh air. Get medical advice/attention if respiratory symptoms persist.
Skin Contact:	If skin exposure occurs, wash with soap and water.
Eye Contact:	If product gets into the eye, rinse copiously with water for several minutes. Remove contact lenses, if present and easy to do. Seek medical attention/advice if irritation occurs or persists.
Ingestion:	No specific first aid measures are required.

4.2 Most Important Health Effects, Both Acute and Delayed

Acute Effects: Direct exposure may cause respiratory irritation, eye irritation and skin irritation. The product dust can dry and irritate the skin and cause dermatitis and can irritate eyes and skin through mechanical abrasion.

Chronic Effects: Chronic exposure may cause lung damage from repeated exposure. Prolonged inhalation of respirable crystalline silica above certain concentrations may cause lung diseases, including silicosis and lung cancer. Repeated exposure to dusts containing inorganic bromide salts may affect fertility and/or result in effects to the unborn child.

4.3 Indication of Any Immediate Medical Attention and Special Treatment Needed

Seek first aid or call a doctor or Poison Control Center if contact with eyes occurs and irritation remains after rinsing. Get medical advice if inhalation occurs and respiratory symptoms persist.

Section 5
Firefighting Measures

5.1 Extinguishing Media

Suitable Extinguishing Media:	Product is not flammable. Use extinguishing media appropriate for surrounding fire.
Unsuitable Extinguishing Media:	Not applicable, the product is not flammable.

5.2 Special Hazards Arising from the Substance or Mixture

Hazardous Combustion Products:	None known.

5.3 Advice for Firefighters

Special Protective Equipment and Precautions for Firefighters:	As with any fire, wear self-contained breathing apparatus (NIOSH approved or equivalent) and full protective gear.

Section 6
Accidental Release Measures

6.1 Personal Precautions, Protective Equipment and Emergency Procedures

Personal precautions/Protective Equipment:	See Section 8.2.2 Individual Protective Measures. For concentrations exceeding Occupational Exposure Levels (OELs), use a self-contained breathing apparatus (SCBA).
Emergency procedures:	Use scooping, water spraying/flushing/misting or ventilated vacuum cleaning systems to clean up spills. Do not use pressurized air.

6.2 Environmental Precautions

Environmental precautions:	Prevent contamination of drains or waterways and dispose according to local and national regulations.

6.3 Methods and Material for Containment and Cleaning Up

Methods and materials for containment and cleaning up:	Do not use brooms or compressed air to clean surfaces. Use dust collection vacuum and extraction systems. Large spills of dry product should be removed by a vacuum system. Dampened material should be removed by mechanical means and recycled or disposed of according to local and national regulations.

See Sections 8 and 13 for additional information on exposure controls and disposal.

Section 7
Handling and Storage

7.1 Precautions for Safe Handling

Practice good housekeeping. Use adequate exhaust ventilation, dust collection and/or water mist to maintain airborne dust concentrations below permissible exposure limits (note: respirable crystalline silica dust may be in the air without a visible dust cloud).

Do not permit dust to collect on walls, floors, sills, ledges, machinery, or equipment. Maintain and test ventilation and dust collection equipment. In cases of insufficient ventilation, wear a NIOSH approved respirator for silica dust when handling or disposing dust from this product. Avoid contact with skin and eyes. Wash or vacuum clothing that has become dusty. Avoid eating, smoking, or drinking while handling the material.

7.2 Conditions for Safe Storage, Including any Incompatibilities

Minimize dust produced during loading and unloading.

Section 8
Exposure Controls/Personal Protection

8.1 Control Parameters

OCCUPATIONAL EXPOSURE LIMITS					
SUBSTANCE		**OSHA PEL TWA (mg/m^3)**	**NIOSH REL TWA (mg/m^3)**	**ACGIH TLV TWA (mg/m^3)**	**CA - OSHA PEL (mg/m^3)**
Calcium oxide		5	2	2	2
Particulates Not Otherwise Regulated	Total	15	15	10	10
	Respirable	5	5	3	5
Respirable Crystalline Silica	Respirable Crystalline Silica	0.05	0.05	0.025	0.05
Titanium dioxide	Total	15	2.4 (fine) 0.3 (ultrafine)	10	10
Manganese dioxide (as manganese compounds)	Total	5 (Ceiling)	1 3 (STEL)	0.1	0.2
	Respirable	-	-	0.02	-

8.2 Exposure Controls

8.2.1 Engineering Controls

Provide ventilation to maintain the ambient workplace atmosphere below the occupational exposure limit(s). Use general and local exhaust ventilation and dust collection systems as necessary to minimize exposure.

8.2.2 Personal Protective Equipment (PPE)

Respiratory protection:	Wear a NIOSH approved particulate respirator if exposure to airborne particulates is unavoidable and where occupational exposure limits may be exceeded. If airborne exposures are anticipated to exceed applicable PELs or TLVs, a self-contained breathing apparatus or airline respirator is recommended.
Eye and face protection:	If eye contact is possible, wear protective glasses with side shields. Avoid contact lenses.
Hand and skin protection:	Wear gloves and protective clothing. Wash hands with soap and water after contact with material.

Section 9
Physical and Chemical Properties

9.1 Information on Basic Physical and Chemical Properties

Property: Value	Property: Value
Appearance (physical state, color, etc.): Fine tan/ gray particulate	**Upper/lower flammability or explosive limits:** Not applicable
Odor: Odorless[1]	**Vapor Pressure (Pa):** Not applicable
Odor threshold: Not applicable	**Vapor Density:** Not applicable
pH (25 °C) (in water): Not Determined	**Specific gravity or relative density:** 2.2 – 2.9
Melting point/freezing point (°C): Not applicable	**Water Solubility:** Slight
Initial boiling point/boiling range (°C): NA	**Partition coefficient: n-octane/water:** NA
Flash point (°C): Not determined	**Auto ignition temperature (°C):** Not applicable
Evaporation rate: Not applicable	**Decomposition temperature (°C):** Not determined
Flammability (solid, gas): Not combustible	**Viscosity:** Not applicable

[1] The use of urea or aqueous ammonia injected into the flue gas to reduce nitrogen oxides (NOx) emissions may result in the presence of ammonium sulfate or ammonium bisulfate in the ash at less than 0.1%. When ash containing these substances becomes wet under high pH (>9), free ammonia gas may be released resulting in objectionable/nuisance ammonia odor and potential exposure to ammonia gas especially in confined spaces.

Section 10
Stability and Reactivity

10.1 Reactivity:	The material is an inert, inorganic material primarily composed of elemental oxides.
10.2 Chemical stability:	The material is stable under normal use conditions.
10.3 Possibility of hazardous reactions:	The material is a relatively stable, inert material; however, when ash containing ammonia becomes wet under high pH (>9), free ammonia gas may be released resulting in an objectionable/nuisance ammonia odor and potential exposure to ammonia gas especially in confined spaces. Polymerization will not occur.
10.4 Conditions to avoid:	Product can become airborne in moderate winds. Dry material should be stored in silos. Materials stored out of doors should be covered or maintained in a damp condition.
10.5 Incompatible materials:	None known.
10. 6 Hazardous decomposition products:	None known.

Section 11
Toxicological Information

11.1 Information on Toxicological Effects

Endpoint	Data
Acute oral toxicity	LD50 > 2000 mg/kg
Acute dermal toxicity	LD50 > 2000 mg/kg
Acute inhalation toxicity	LD50 > 5.0 mg/L
Skin corrosion/irritation	Does not meet the classification criteria but may cause slight skin irritation. Product dust can dry the skin which can result in irritation.
Eye damage/irritation	Causes serious eye irritation. Positive scores for conjunctiva irritation and chemosis in 2/3 animals based on average of 24, 48 and 72-hour scores with irritation clearing within 21 days; No corneal or iritis effects observed.
Respiratory/skin sensitization	Not a respiratory or dermal sensitizer.
Germ cell mutagenicity	Not mutagenic in in-vitro and in-vivo assays with or without metabolic activation.
Carcinogenicity	Not available. Respirable crystalline silica has been identified as a carcinogen by OSHA, NTP, ACGIH and IARC.
Reproductive toxicity	No developmental toxicity was observed in available animal studies. Reproductive studies on CCPs showed either no reproductive effects, or some effects on male and female reproductive organs and parameters but without a clear dose response. Inorganic bromide salts have been shown to have adverse effects on reproductive parameters in some animal studies.
STOT-SE	CCPs when present as a nuisance dust may result in respiratory irritation.
STOT-RE	In a 180-day inhalation study with fly ash dust, no effects were observed at the highest dose tested. NOEC = 4.2 mg/m^3; it is not possible to assess the level at which toxicologically significant effects may occur. Repeated inhalation exposures to high levels of respirable crystalline silica may result in lung damage (i.e., silicosis).
Aspiration Hazard	Not applicable based product form.

Section 12
Ecological Information

12.1 Toxicity

Fly Ash C (CAS# 68131-74-8)	
Toxicity to Fish	LC50 > 100 mg/L
Toxicity to Aquatic Invertebrates	Data indicates that the test substance is not toxic to *Daphnia magna* (EC50 undetermined).
Toxicity to Aquatic Algae and Plants	EC50 = 10 mg/L

Calcium oxide CAS# 1305-78-8	
Toxicity to Fish	LC50 = 50.6 mg/L The findings were closely related to the pH of the test solutions; therefore, pH is considered to be the main reason for the effects.
Toxicity to Aquatic Invertebrates	EC50 = 49.1 mg/L The findings were closely related to the pH of the test solutions; therefore, pH is considered to be the main reason for the effects.
Toxicity to Aquatic Algae and Plants	NOEC =48 mg/L @ 72 hours based on $Ca(OH)_2$ The initial pH of the test medium was not directly related to the biologically relevant effects. The formation of precipitates is likely the result of the reaction between CO_2 dissolved in the medium.

12.2 Persistence and Degradability

Not relevant for inorganic materials.

12.3 Bioaccumulative Potential

This material does not contain any compounds that would bioaccumulate up the food chain.

12.4 Mobility in Soil

No data available.

12.5 Results of PBT and vPvB Assessment

This material does not contain any compounds classified as “persistent, bioaccumulative or toxic” nor as “very persistent/very bioaccumulative”.

12.6 Other Adverse Effects

None known.

Section 13

Disposal Considerations

See Sections 7 and 8 above for safe handling and use, including appropriate industrial hygiene practices.

Dispose of all waste product and containers in accordance with federal, state and local regulations.

Section 14
Transport Information

Regulatory entity: U.S. DOT	Shipping Name:	Not Regulated
	Hazard Class:	Not Regulated
	ID Number:	Not Regulated
	Packing Group:	Not Regulated

Section 15
Regulatory Information

15.1 Safety, Health and Environmental Regulations/Legislation Specific for the Mixture

- TSCA Inventory Status

  All components are listed on the TSCA Inventory.

- California Proposition 65.

  The following substances are known to the State of California to be carcinogens and/or reproductive toxicants:

  - Respirable crystalline silica

- State Right-to-Know (RTK)

Component	CAS	MA[1,2]	NJ[3,4]	PA[5]	RI[6]
Ammonium bisulfate	7803-63-6	No	Yes	No	No
Ammonium sulfate	7783-20-2	Yes	No	Yes	No
Calcium oxide	1305-78-8	Yes	Yes	Yes	No
Iron oxide	1309-37-1	Yes	Yes	Yes	No
Magnesium oxide	1309-48-4	No	Yes	No	No
Manganese oxide-as manganese compounds	1313-13-9; Various	No	No	Yes	Yes
Phosphorus pentoxide (or phosphorus oxide)	1314-56-3	Yes	Yes	Yes	No
Potassium oxide	12136-45-7	No	Yes	No	No
Silica-crystalline (SiO2), quartz	14808-60-7	Yes	Yes	Yes	No
Sodium oxide	1313-59-3	No	Yes	No	No
Titanium dioxide	13463-67-7	Yes	Yes	Yes	Yes

[1] Massachusetts Department of Public Health, no date
[2] 189th General Court of The Commonwealth of Massachusetts, no date
[3] New Jersey Department of Health and Senior Services, 2010a
[4] New Jersey Department of Health, 2010b
[5] Pennsylvania Code, 1986
[6] Rhode Island Department of Labor and Training, no date

Section 16
Other Information, Including Date of Preparation or Last Revision

16.1 Indication of Changes

Date of preparation or last revision: February 23, 2018

16.2 Abbreviations and Acronyms

- ACGIH: American Conference of Industrial Hygienists
- CA: California
- CAS: Chemical Abstract Services
- CCP: Coal Combustion Product
- CFR: Code of Federal Regulations
- EPA: Environmental Protection Agency

- GHS: Globally Harmonized System of Classification and Labelling
- IARC: International Agency for Research on Cancer
- LC50: Concentration resulting in the mortality of 50 % of an animal population
- LD50: Dose resulting in the mortality of 50 % of an animal population
- MA: Massachusetts
- NA: Not Applicable
- NJ: New Jersey
- NOEC: No observed effect concentration
- NIOSH: National Institute of Occupational Safety and Health
- NOx: Nitrogen oxides
- NTP: US National Toxicology Program
- OEL: Occupational Exposure Limit
- OSHA: Occupational Safety and Health Administration
- PA: Pennsylvania
- PBT: Persistent, Toxic and Bioaccumulative
- PEL: Permissible exposure limit
- PPE: Personal Protective Equipment
- REL: Recommended exposure limit
- RI: Rhode Island
- RCS: Respirable Crystalline Silica
- RTK: Right-to-Know
- SCBA: Self-contained breathing apparatus
- SDS: Safety Data Sheet
- STEL: Short-term exposure limit
- STOT-RE: Specific target organ toxicity-repeated exposure
- STOT-SE: Specific target organ toxicity-single exposure
- TLV: Threshold limit value
- TSCA: Toxic Substances Control Act
- TWA: Time-weighted average
- UEL: Upper explosive limit
- UVCB: Unknown or Variable Composition/Biological
- U.S.: United States
- U.S. DOT: United States of Department of Transportation

16.3 Other Hazards

Hazardous Materials Identification System (HMIS) Degree of hazard (0= low, 4 = extreme)							
Health:	2*	**Flammability:**	0	**Physical Hazards:**	0	**Personal protection:****	

** Chronic Health Effects*
*** Appropriate personal protection is defined by the activity to be performed.*
See Section 8 for additional information.

DISCLAIMER:

This SDS has been prepared in accordance with the Hazard Communication Rule 29 CFR 1910.1200. Information herein is based on data considered to be accurate as of date prepared. No warranty or representation, express or implied, is made as to the accuracy or completeness of this data and safety information. No responsibility can be assumed for any damage or injury resulting from abnormal use, failure to adhere to recommended practices, or from any hazards inherent in the nature of the product.

DYNEGY

Safety Data Sheet

Section 1
Identification of the Substance and of the Supplier

1.1 Product Identifier

Product Name/Identification:	ASTM Bottom Ash
Synonyms:	Ash; Ashes; Ash residues; Ashes, residues, bottom; Bottom ash; Bottom ash residues; Coal Fly Ash; Pozzolan; Waste solids.
Formula:	UVCB Substance

1.2 Relevant Identified Uses of the Substance or Mixture and Uses Advices Against

Relevant Identified Uses:	Component of wallboard, concrete, roofing material, bricks, cement kiln feed.
Uses Advised Against:	None known.

1.3 Details of the Supplier of the SDS

Manufacturer/Supplier:	Dynegy, Inc.
Street Address:	601 Travis Street, Suite 1400
City, State and Zip Code:	Houston, TX 77002
Customer Service Telephone:	800-633-4704

Section 2
Hazards Identification

2.1 Classification of the Substance

GHS Classification(s) according to OSHA Hazard Communication Standard (29 CFR 1910.1200):

- Eye Irritant, Category 2A
- STOT-SE, Category 3 (Respiratory Irritation)
- Carcinogen, Category 1A
- STOT-RE, Category 1 (Lungs)
- Toxic to Reproduction, Category 2

2.2 Label Elements

Labelling according to 29 CFR 1910.1200 Appendices A, B and C*	
Hazard Pictogram(s):	
Signal word:	**DANGER**
Hazard Statement(s):	*Causes serious eye irritation.* *May cause respiratory irritation.* *May cause damage to lungs after repeated/prolonged exposure via inhalation.* *May cause cancer of the lung.* *Suspected of damaging fertility or the unborn child.*
Precautionary Statement(s):	*Obtain special instructions before use.* *Do not handle until all safety precautions have been read and understood.* *Avoid breathing dust.* *Wash thoroughly after handling.* *Do not eat drink or smoke when using this product.* *Wear protective gloves/protective clothing/eye protection/face protection.* *Use outdoors or in a well-ventilated area.* *If exposed or concerned: Get medical advice/attention.* *Store in a secure area.* *Dispose of product in accordance with local/national regulations.*

** Fly ash and other coal combustion products (CCPs) are UVCB substances (unknown or variable composition or biological). Various CCPs, noted as ashes/ash residuals; Ashes, residues, bottom; Bottom ash; Bottom ash residues; Waste solids, ashes under TSCA are defined as: "The residuum from the burning of a combination of carbonaceous materials. The following elements may be present as oxides: aluminum, calcium, iron, magnesium, nickel, phosphorus, potassium, silicon, sulfur, titanium, and vanadium." Ashes including fly ash and fluidized bed combustion ash are identified by CAS number 68131-74-8. The exact composition of the ash is dependent on the fuel source and flue additives composed of many constituents. The classification of the final substance is dependent on the presence of specific identified oxides as well as other trace elements.*

2.3 Other Hazards

Listed Carcinogens:

-Respirable Crystalline Silica

IARC: [Yes] **NTP:** [Yes] **OSHA:** [Yes] **Other:** **(ACGIH)** [Yes]

Section 3
Composition/Information on Ingredients

Substance	*CAS No.*	*Percentage (%)*	*GHS Classification*
Crystalline Silica	*14808-60-7*	*20 - 40%*	*Repeat Dose STOT, Category 1* *Carcinogen, Category 1A*
Silica, crystalline respirable (RCS)	*14808-60-7*	*See Footnote 1*	*Repeat Dose STOT, Category 1* *Carcinogen. Category 1A*
Aluminosilicates[2]	*Various, see Footnote 2*	*10 - 60%*	*Single Exposure STOT, Category 3*
Calcium oxide (CaO)	*1305-78-8*	*10 - 30%*	*Skin Irritant, Category 2* *Eye Irritant, Category 1* *Single Exposure STOT, Category 3*
Iron oxide	*1309-37-1*	*1 - 10%*	*Not Classified*
Manganese dioxide (MnO_2)	*1313-13-9*	*<2%*	*Skin Irritant, Category 2* *Eye Irritant, Category 2B*
Magnesium oxide	*1309-48-4*	*2 - 10%*	*Not Classified*
Phosphorus pentoxide (P_2O_5)	*1314-56-3*	*≤2%*	*Skin Irritant, Category 2* *Eye Irritant, Category 2B*
Sodium oxide	*1313-59-3*	*1 - 10%*	*Not Classified*
Potassium oxide (K_2O)	*12136-45-7*	*≤1%*	*Skin Irritant Category 2* *Eye Irritant Category 2B*
Titanium dioxide (TiO_2)	*13463-67-7*	*<3%*	*Not Classified*

[1]The percentage of respirable crystalline silica has not been determined. Therefore, a GHS classification of Carcinogen 1A has been assigned.

[2]Aluminosilicates (CAS# 1327-36-2) may be in the form of mullite (CAS# 1302-93-8); aluminosilicate glass; pozzolans (CAS# 71243-67-9); or calcium aluminosilicates such as tricalcium aluminate (C3A), or calcium sulfoaluminate (C4A3S). The form is dependent on the source of the coal and or the process used to create the CCP. Pulverized coal combustion would be more likely to create high levels of pozzolans. Aluminosilicates may have inclusions of calcium, titanium, iron, potassium, phosphorus, magnesium and other metal oxides.

Section 4
First Aid Measures

4.1 Description of First Aid Measures

Inhalation:	If product is inhaled and irritation of the nose or coughing occurs, remove person to fresh air. Get medical advice/attention if respiratory symptoms persist.
Skin Contact:	If skin exposure occurs, wash with soap and water.
Eye Contact:	If product gets into the eye, rinse copiously with water for several minutes. Remove contact lenses, if present and easy to do. Seek medical attention/advice if irritation occurs or persists.
Ingestion:	No specific first aid measures are required.

4.2 Most Important Health Effects, Both Acute and Delayed

Acute Effects: Direct exposure may cause respiratory irritation, eye irritation and skin irritation. The product dust can dry and irritate the skin and cause dermatitis and can irritate eyes and skin through mechanical abrasion.

Chronic Effects: Chronic exposure may cause lung damage from repeated exposure. Prolonged inhalation of respirable crystalline silica above certain concentrations may cause lung diseases, including silicosis and lung cancer.

4.3 Indication of Any Immediate Medical Attention and Special Treatment Needed

Seek first aid or call a doctor or Poison Control Center if contact with eyes occurs and irritation remains after rinsing. Get medical advice if inhalation occurs and respiratory symptoms persist.

Section 5
Firefighting Measures

5.1 Extinguishing Media

Suitable Extinguishing Media:	Product is not flammable. Use extinguishing media appropriate for surrounding fire.
Unsuitable Extinguishing Media:	Not applicable, the product is not flammable.

5.2 Special Hazards Arising from the Substance or Mixture

Hazardous Combustion Products:	None known.

5.3 Advice for Firefighters

Special Protective Equipment and Precautions for Firefighters:	As with any fire, wear self-contained breathing apparatus (NIOSH approved or equivalent) and full protective gear.

Section 6
Accidental Release Measures

6.1 Personal Precautions, Protective Equipment and Emergency Procedures

Personal precautions/Protective Equipment:	See Section 8.2.2 Individual Protective Measures. For concentrations exceeding Occupational Exposure Levels (OELs), use a self-contained breathing apparatus (SCBA).
Emergency procedures:	Use scooping, water spraying/flushing/misting or ventilated vacuum cleaning systems to clean up spills. Do not use pressurized air.

6.2 Environmental Precautions

Environmental precautions:	Prevent contamination of drains or waterways and dispose according to local and national regulations.

6.3 Methods and Material for Containment and Cleaning Up

Methods and materials for containment and cleaning up:	Do not use brooms or compressed air to clean surfaces. Use dust collection vacuum and extraction systems. Large spills of dry product should be removed by a vacuum system. Dampened material should be removed by mechanical means and recycled or disposed of according to local and national regulations.

See Sections 8 and 13 for additional information on exposure controls and disposal.

Section 7
Handling and Storage

7.1 Precautions for Safe Handling

Practice good housekeeping. Use adequate exhaust ventilation, dust collection and/or water mist to maintain airborne dust concentrations below permissible exposure limits (note: respirable crystalline silica dust may be in the air without a visible dust cloud).

Do not permit dust to collect on walls, floors, sills, ledges, machinery, or equipment. Maintain and test ventilation and dust collection equipment. In cases of insufficient ventilation, wear a NIOSH approved respirator for silica dust when handling or disposing dust from this product. Avoid contact with skin and eyes. Wash or vacuum clothing that has become dusty. Avoid eating, smoking, or drinking while handling the material.

7.2 Conditions for Safe Storage, Including any Incompatibilities

Minimize dust produced during loading and unloading.

Section 8
Exposure Controls/Personal Protection

8.1 Control Parameters

OCCUPATIONAL EXPOSURE LIMITS					
SUBSTANCE		**OSHA PEL TWA (mg/m^3)**	**NIOSH REL TWA (mg/m^3)**	**ACGIH TLV TWA (mg/m^3)**	**CA - OSHA PEL (mg/m^3)**
Calcium oxide		5	2	2	2
Particulates Not Otherwise Regulated	Total	15	15	10	10
	Respirable	5	5	3	5
Respirable Crystalline Silica	Respirable	0.05	0.05	0.025	0.05
Manganese dioxide (as manganese compounds)	Total	5 (Ceiling)	1 3 (STEL)	0.1	0.2
	Respirable	-	-	0.02	-

8.2 Exposure Controls

8.2.1 Engineering Controls

Provide ventilation to maintain the ambient workplace atmosphere below the occupational exposure limit(s). Use general and local exhaust ventilation and dust collection systems as necessary to minimize exposure.

8.2.2 Personal Protective Equipment (PPE)

Respiratory protection:	Wear a NIOSH approved particulate respirator if exposure to airborne particulates is unavoidable and where occupational exposure limits may be exceeded. If airborne exposures are anticipated to exceed applicable PELs or TLVs, a self-contained breathing apparatus or airline respirator is recommended.
Eye and face protection:	If eye contact is possible, wear protective glasses with side shields. Avoid contact lenses.
Hand and skin protection:	Wear gloves and protective clothing. Wash hands with soap and water after contact with material.

Section 9
Physical and Chemical Properties

9.1 Information on Basic Physical and Chemical Properties

Property: Value	Property: Value
Appearance (physical state, color, etc.): Fine tan/ gray particulate	**Upper/lower flammability or explosive limits:** Not applicable
Odor: Odorless[1]	**Vapor Pressure (Pa):** Not applicable
Odor threshold: Not applicable	**Vapor Density:** Not applicable
pH (25 °C) (in water): 8 - 11	**Specific gravity or relative density:** 2.2 – 2.9
Melting point/freezing point (°C): Not applicable	**Water Solubility:** Slight
Initial boiling point and boiling range (°C): Not applicable	**Partition coefficient: n-octane/water:** Not determined
Flash point (°C): Not determined	**Auto ignition temperature (°C):** Not applicable
Evaporation rate: Not applicable	**Decomposition temperature (°C):** Not determined
Flammability (solid, gas): Not combustible	**Viscosity:** Not applicable

[1] The use of urea or aqueous ammonia injected into the flue gas to reduce nitrogen oxides (NOx) emissions may result in the presence of ammonium sulfate or ammonium bisulfate in the ash at less than 0.1%. When ash containing these substances becomes wet under high pH (>9), free ammonia gas may be released resulting in objectionable/nuisance ammonia odor and potential exposure to ammonia gas especially in confined spaces.

Section 10
Stability and Reactivity

10.1 Reactivity:	The material is an inert, inorganic material primarily composed of elemental oxides.
10.2 Chemical stability:	The material is stable under normal use conditions.
10.3 Possibility of hazardous reactions:	The material is a relatively stable, inert material; however, when ash containing ammonia becomes wet under high pH (>9), free ammonia gas may be released resulting in an objectionable/nuisance ammonia odor and potential exposure to ammonia gas especially in confined spaces. Polymerization will not occur.
10.4 Conditions to avoid:	Product can become airborne in moderate winds. Dry material should be stored in silos. Materials stored out of doors should be covered or maintained in a damp condition.
10.5 Incompatible materials:	None known.
10. 6 Hazardous decomposition products:	None known.

Section 11
Toxicological Information

11.1 Information on Toxicological Effects

Endpoint	Data
Acute oral toxicity	LD50 > 2000 mg/kg
Acute dermal toxicity	LD50 > 2000 mg/kg
Acute inhalation toxicity	LD50 > 5.0 mg/L
Skin corrosion/irritation	Does not meet the classification criteria but may cause slight skin irritation. Product dust can dry the skin which can result in irritation.
Eye damage/irritation	Causes serious eye irritation. Positive scores for conjunctiva irritation and chemosis in 2/3 animals based on average of 24, 48 and 72-hour scores with irritation clearing within 21 days; no corneal or iritis effects observed.
Respiratory/skin sensitization	Not a respiratory or dermal sensitizer.
Germ cell mutagenicity	Not mutagenic in in-vitro and in-vivo assays with or without metabolic activation.
Carcinogenicity	Not available. Respirable crystalline silica has been identified as a carcinogen by OSHA, NTP, ACGIH and IARC.
Reproductive toxicity	No developmental toxicity was observed in available animal studies. Reproductive studies on CCPs showed either no reproductive effects, or some effects on male and female reproductive organs and parameters but without a clear dose response.
STOT-SE	CCPs when present as a nuisance dust may result in respiratory irritation.
STOT-RE	In a 180-day inhalation study with fly ash dust, no effects were observed at the highest dose tested. NOEC = 4.2 mg/m^3; it is not possible to assess the level at which toxicologically significant effects may occur. Repeated inhalation exposures to high levels of respirable crystalline silica may result in lung damage (i.e., silicosis).
Aspiration Hazard	Not applicable based product form.

Section 12
Ecological Information

12.1 Toxicity

Fly Ash (CAS# 68131-74-8)	
Toxicity to Fish	LC50 > 100 mg/L
Toxicity to Aquatic Invertebrates	Data indicates that the test substance is not toxic to *Daphnia magna* (EC50 undetermined)
Toxicity to Aquatic Algae and Plants	EC50 = 10 mg/L
Calcium oxide CAS# 1305-78-8	
Toxicity to Fish	LC50 = 50.6 mg/L The findings were closely related to the pH of the test solutions; therefore, pH is considered to be the main reason for the effects.
Toxicity to Aquatic Invertebrates	EC50 = 49.1 mg/L The findings were closely related to the pH of the test solutions; therefore, pH is considered to be the main reason for the effects.
Toxicity to Aquatic Algae and Plants	NOEC =48 mg/L @ 72 hours based on $Ca(OH)_2$ The initial pH of the test medium was not directly related to the biologically relevant effects. The formation of precipitates is likely the result of the reaction between CO_2 dissolved in the medium.

12.2 Persistence and Degradability

Not relevant for inorganic materials.

12.3 Bioaccumulative Potential

This material does not contain any compounds that would bioaccumulate up the food chain.

12.4 Mobility in Soil

No data available.

12.5 Results of PBT and vPvB Assessment

This material does not contain any compounds classified as “persistent, bioaccumulative or toxic” nor as “very persistent/very bioaccumulative”.

12.6 Other Adverse Effects

None known.

Section 13
Disposal Considerations

See Sections 7 and 8 above for safe handling and use, including appropriate industrial hygiene practices.

Dispose of all waste product and containers in accordance with federal, state and local regulations.

Section 14
Transport Information

Regulatory entity: U.S. DOT	Shipping Name:	Not Regulated
	Hazard Class:	Not Regulated
	ID Number:	Not Regulated
	Packing Group:	Not Regulated

Section 15
Regulatory Information

15.1 Safety, Health and Environmental Regulations/Legislation Specific for the Mixture

- TSCA Inventory Status

  All components are listed on the TSCA Inventory.

- California Proposition 65

  The following substances are known to the State of California to be carcinogens and/or reproductive toxicants:

  - Respirable crystalline silica
  - Titanium dioxide

- State Right-to-Know (RTK)

Component	CAS	MA[1,2]	NJ[3,4]	PA[5]	RI[6]
Ammonium bisulfate	7803-63-6	No	Yes	No	No
Ammonium sulfate	7783-20-2	Yes	No	Yes	No
Calcium oxide	1305-78-8	Yes	Yes	Yes	No
Iron oxide	1309-37-1	Yes	Yes	Yes	No
Magnesium oxide	1309-48-4	No	Yes	No	No
Phosphorus pentoxide (or phosphorus oxide)	1314-56-3	Yes	Yes	Yes	No
Potassium oxide	12136-45-7	No	Yes	No	No
Silica-crystalline (SiO_2), quartz	14808-60-7	Yes	Yes	Yes	No
Sodium oxide	1313-59-3	No	Yes	No	No
Titanium dioxide	13463-67-7	Yes	Yes	Yes	Yes

[1] Massachusetts Department of Public Health, no date
[2] 189th General Court of The Commonwealth of Massachusetts, no date
[3] New Jersey Department of Health and Senior Services, 2010a
[4] New Jersey Department of Health, 2010b
[5] Pennsylvania Code, 1986
[6] Rhode Island Department of Labor and Training, no date

Section 16
Other Information, Including Date of Preparation or Last Revision

16.1 Indication of Changes

Date of preparation or last revision: February 23, 2018

16.2 Abbreviations and Acronyms

- ACGIH: American Conference of Industrial Hygienists
- CA: California
- CAS: Chemical Abstract Services
- CCP: Coal Combustion Product
- CFR: Code of Federal Regulations
- EPA: Environmental Protection Agency
- GHS: Globally Harmonized System of Classification and Labelling
- IARC: International Agency for Research on Cancer
- LC50: Concentration resulting in the mortality of 50 % of an animal population
- LD50: Dose resulting in the mortality of 50 % of an animal population
- MA: Massachusetts
- NA: Not Applicable
- NJ: New Jersey
- NOEC: No observed effect concentration
- NIOSH: National Institute of Occupational Safety and Health
- NOx: Nitrogen oxides
- NTP: US National Toxicology Program
- OEL: Occupational Exposure Limit
- OSHA: Occupational Safety and Health Administration
- PA: Pennsylvania
- PBT: Persistent, Toxic and Bioaccumulative
- PEL: Permissible exposure limit
- PPE: Personal Protective Equipment
- REL: Recommended exposure limit
- RI: Rhode Island
- RCS: Respirable Crystalline Silica
- RTK: Right-to-Know
- SCBA: Self-contained breathing apparatus
- SDS: Safety Data Sheet
- STEL: Short-term exposure limit
- STOT-RE: Specific target organ toxicity-repeated exposure
- STOT-SE: Specific target organ toxicity-single exposure
- TLV: Threshold limit value
- TSCA: Toxic Substances Control Act
- TWA: Time-weighted average
- UEL: Upper explosive limit
- UVCB: Unknown or Variable Composition/Biological
- U.S.: United States
- U.S. DOT: United States of Department of Transportation

16.3 Other Hazards

Hazardous Materials Identification System (HMIS) Degree of hazard (0= low, 4 = extreme)							
Health:	2*	**Flammability:**	0	**Physical Hazards:**	0	**Personal protection:****	

** Chronic Health Effects*
******* *Appropriate personal protection is defined by the activity to be performed.*
See Section 8 for additional information.

DISCLAIMER:

This SDS has been prepared in accordance with the Hazard Communication Rule 29 CFR 1910.1200. Information herein is based on data considered to be accurate as of date prepared. No warranty or representation, express or implied, is made as to the accuracy or completeness of this data and safety information. No responsibility can be assumed for any damage or injury resulting from abnormal use, failure to adhere to recommended practices, or from any hazards inherent in the nature of the product.

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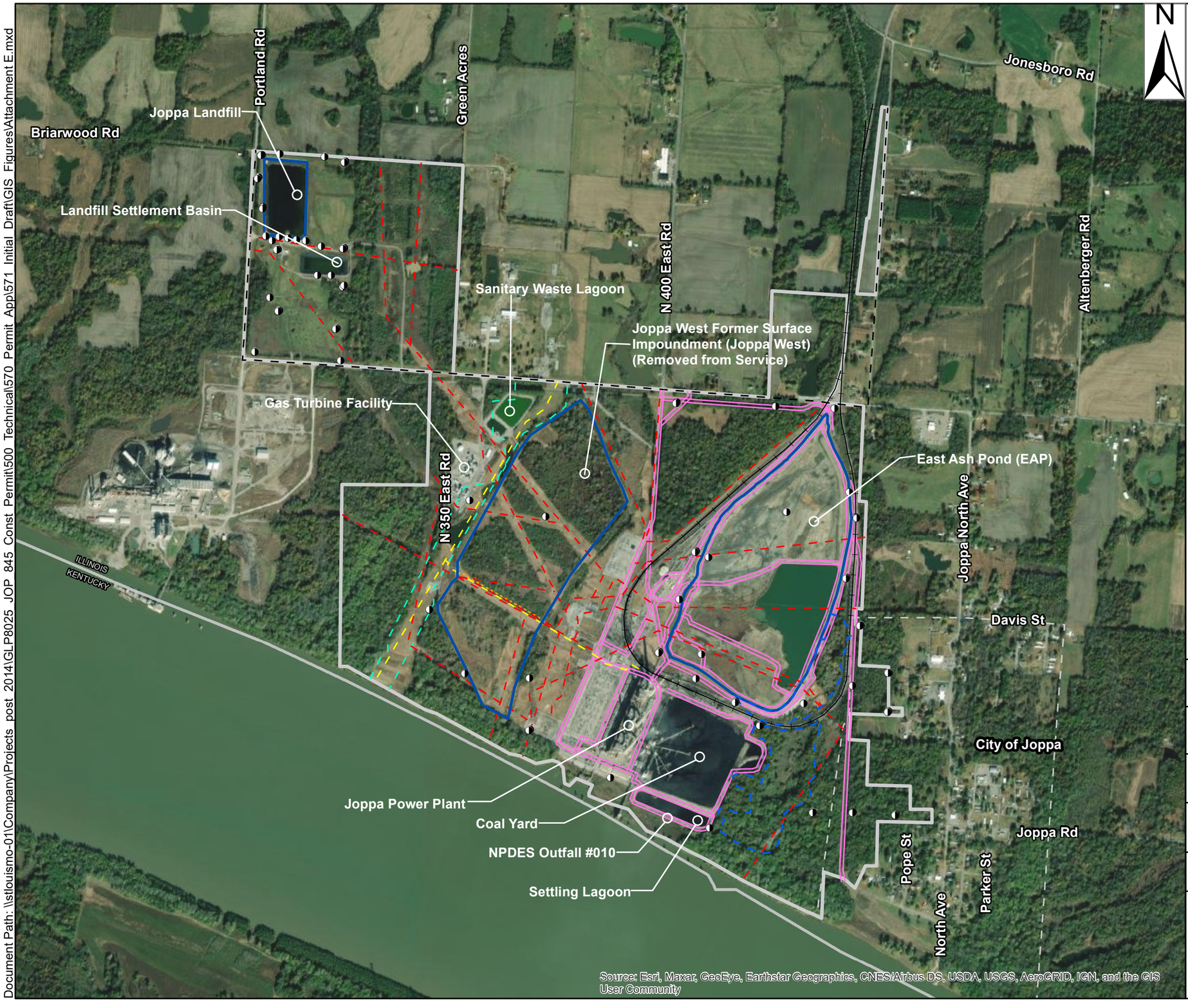
ATTACHMENT E

Site Plan Map and On-Site Transportation Plan

845.220(a)(4) and 845.220(a)(2)(E)

July 2022



N

Legend

- Union Pacific Rail Spur
- High Voltage Overhead Electric
- Buried Gas Line
- Gas Transmission Pipelines
- Hazardous Liquid Pipelines
- Onsite Transportation Routes
- Public Roadways
- Joppa City Limits
- Existing Monitoring Wells
- Approximate CCR Unit Limits
- Approximate CCR Outside of EAP
- EEI Property Boundary

NOTES:
CCR unit limits and Site boundary locations are approximate. All high-voltage electric line alignments, gas line alignments, and hazardous liquid pipeline alignments were based off available aerial imagery data and other data sources, should be considered approximate, may vary in the field, and should not be considered comprehensive. All private and public site utilities including, but not limited to, service electric lines, gas lines, hazardous liquid lines, water and sewer lines, telecommunication lines, plant utilities, and/or private utilities are not shown on this figure and shall be verified in the field prior to any site work.

Locations for CCR outside of the EAP limits are approximate and are subject to change based on ongoing investigations.

0 500 1,000 2,000
Feet

Joppa Power Plant

Electric Energy Inc.

East Ash Pond Construction Permit Application

Site Plan Map and Transportation Plan

GLP8025	JULY 2022

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ATTACHMENT E

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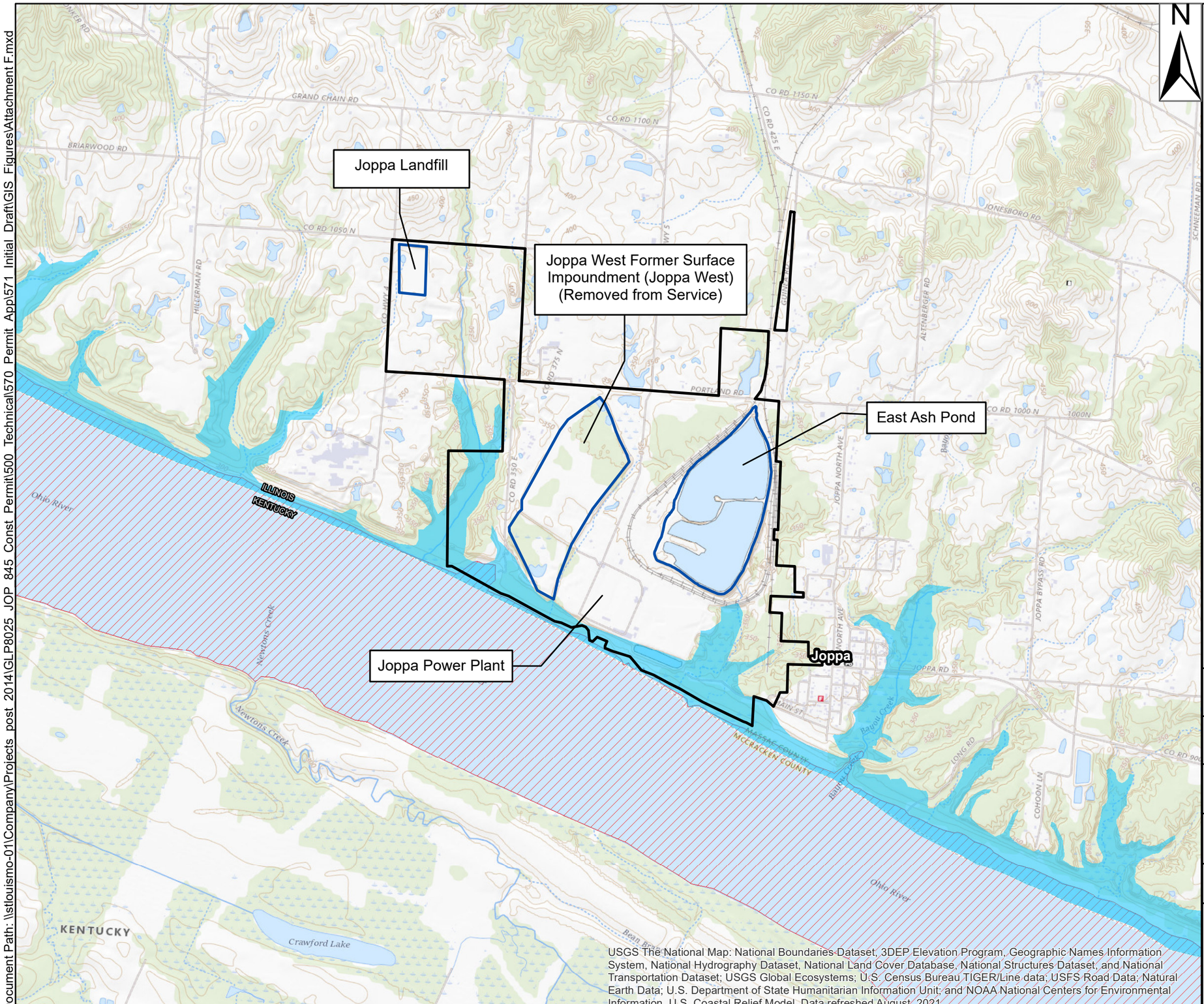
ATTACHMENT F

Site Location Maps

845.220(a)(3)

July 2022



Legend

- EEI Property Boundary
- Approximate CCR Unit Limits
- FEMA 100 Year Flood Zone
- Critical Habitat - Threatened Rabbitsfoot Mussel

NOTES:
The basemap for this figure includes the 2021 USGS US 7.5-minute series quadrangle map for Joppa, IL and 2019 USGS US 7.5-minute series quadrangle map for Bandana, KY.

Critical habitat for the threatened rabbitsfoot mussel (quadrula cylindrica) was obtained from the 2022 US Fish and Wildlife Critical Habitat for Threatened and Endangered Species online mapping application (https://ecos.fws.gov/ecp/report/table/critical-habitat.html). Critical Habitat was not identified for other threatened or endngered specites within 1,000 meters of the Site.

No Dedicated Illinois Nature Preserves or designated historic and archaeological sites per Illinois National Historic Preservation Act were listed within 1,000 meters of the Site (https://www2.illinois.gov/dnrhistoric/Preserve/Pages/HARGIS.aspx).

The FEMA 100-year Flood Zone boundaries were taken from the FEMA Flood Map Service Center (https://msc.fema.gov/portal/home). Only Portions of the flood zone within Illinois are shown.

The prevailing wind direction was taken as the highest frequency by direction for the Metropolis, IL Municipal Airport, from windhistory.com.

CCR unit and site property boundaries are approximate.

Prevailing Wind

0 750 1,500 3,000
Feet

USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed August, 2021.

Joppa Power Plant

Electric Energy Inc.

East Ash Pond Construction Permit Application

Site Location Map

GLP8025	JULY 2022
Geosyntec consultants	ATTACHMENT F

Document Path: \\stlouismo-01\Company\Projects post 2014\GLP8025 JOP 845 Const Permit\500 Technical\570 Permit App\571 Initial Draft\GIS Figures\Attachment F.mxd

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ATTACHMENT G

Final Closure Plan and Proposed Closure Schedule (including Closure Alternatives Analysis/ Preliminary Corrective Measures Assessment)

845.210, 845.220(a)(5-6), 845.720(b), 845.220(d)(2)

July 2022

Prepared for

Electric Energy, Inc.
2100 Portland Road
Joppa, Illinois 62953

CCR SURFACE IMPOUNDMENT

FINAL CLOSURE PLAN

JOPPA POWER PLANT
EAST ASH POND
(IEPA ID W1270100004-02)
Joppa, Illinois

Prepared by

Geosyntec consultants
engineers | scientists | innovators

600 Roselane Court
Farmington, Missouri 63640

Project Number GLP8025

Revision 0
July 28, 2022

Geosyntec consultants

TABLE OF CONTENTS

1. Introduction 3
   1.1. Selected Closure Method 3
   1.2. Organization of Final Closure Plan 3
2. Final Closure Plan 5
   2.1. Narrative Closure Description 5
      2.1.1. Closure Overview 5
      2.1.2. Closure Performance Features 7
      2.1.3. Closure Construction Narrative Sequencing 7
   2.2. Decontamination of CCR Surface Impoundment 13
   2.3. Final Cover System 14
   2.4. Maximum CCR Inventory 14
   2.5. Largest Surface Area Estimate 14
   2.6. Closure Completion Schedule 15
3. Amendments of Final Closure Plan 20
4. Closure with Final Cover System 21
   4.1. Minimization of Post-Closure Infiltration and Releases 21
   4.2. Preclusion of Future Impoundment 23
   4.3. Provisions for Preventing Instability, Sloughing and Movement 23
   4.4. Minimize the Need for Further Maintenance 24
   4.5. Be Completed in Shortest Amount of Time 25
   4.6. Drainage and Stabilization 25
   4.7. Final Cover System 26
      4.7.1. Low Permeability Layer - Geomembrane 27
      4.7.2. Standards for the Final Protective Layer 27
   4.8. Certification 29
   4.9. Uses of CCR in Closure 30
   4.10. Final Cover System Slopes 30
5. Additional Information 32
6. Proposed PV Solar Panel Array 33
7. Certification from a Qualified Professional Engineer 34

TABLE OF CONTENTS

8. References 35

TABLES

Table 1 Closure Completion Milestone Schedule
Table 2 CCR Final Closure Plan Revisions

ATTACHMENTS

Attachment A Closure Alternatives Analysis
Attachment B Preliminary Corrective Measures Assessment
Attachment C Final Closure Plan Drawings and Material Specifications
Attachment D CCR Investigation and Delineation Report
Attachment E Alternative Final Protective Layer Equivalency Demonstration
Attachment F Hydrologic and Hydraulic Design of Stormwater Management System
Attachment G Geotechnical Design of Slopes and Final Cover System

1. INTRODUCTION

Electric Energy, Inc. (EEI) is the owner of the coal-fired Joppa Power Plant (JPP), also referred to as the Joppa Power Station (JOP), in Joppa, Illinois. This closure plan is for the East Ash Pond (EAP). The EAP was present and operational prior to promulgation 35 Ill. Admin. Code 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845). The EAP has an Illinois Environmental Protection Agency (IEPA) identification number of W1270100004-02.

EEI intends to case the burning of coal and generation of electricity at JPP on September 1, 2022. The EPP Site is slated for re-development as a utility-scale solar facility if closure in place (CIP) is approved.

1.1. Selected Closure Method

Section 845.720(b)(3): The final closure plan must identify the proposed selected closure method and must include the information required in subsection (a)(1) and the closure alternatives analysis specified in Section 845.710.

Closure with a final cover system has been identified as the most appropriate closure method, also known as Closure-in-Place (CIP, per Section 845.740) based on the Closure Alternatives Analysis (CAA), provided in **Attachment A**. The CAA was prepared by Gradient Corporation (Gradient) to evaluate CIP versus Closure by Removal (CBR, per Section 845.750) and a hybrid closure alternative was selected as the most appropriate closure method for the EAP. All CCR from the 54-acre southeastern portion of the EAP and a 32-acre area outside of the EAP will be removed and placed into the northern and western portion of the EAP, which will be closed in accordance with Section 845.70. Under this hybrid approach, all CCR will be removed from approximately 42% of the current footprint of the impoundment. The proposed hybrid CIP alternative will control, minimize, or eliminate, as much as feasible "post-closure infiltration of liquids" and releases of CCR, leachate, or contaminated runoff as interpreted by the Illinois Environmental Protection Agency (EPA) in the Part 845 rulemaking.

Information developed by Geosyntec to support the Closure Alternatives Analysis is provided as an attachment to the CAA. A Preliminary Corrective Measures Assessment (CMA) developed by Geosyntec is provided in **Attachment B**.

1.2. Organization of Final Closure Plan

This Final Closure Plan is organized in the following manner:

- **Section 2** includes the Final Closure Plan, as required by Section 875.720(a)(1).

- **Section 3** includes a summary of amendments of the Closure Plan.
- **Section 4** includes a discussion of how the closure using a final cover system will comply with the performance and design requirements of Sections 845.720 and 845.750, in addition to a Certification from a Qualified Professional Engineer for the final cover system design.
- **Section 5** includes additional information regarding the closure.
- **Section 6** includes a Certification from a Qualified Professional Engineer for this Final Closure Plan.
- **Section 7** includes reference documents used in the development of this Final Closure Plan.

2. FINAL CLOSURE PLAN

Section 845.720(a)(1): *Content of the Preliminary Closure Plan. The owner or operator of a new CCR surface impoundment or an existing CCR surface impoundment not required to close under Section 845.700 must prepare a preliminary written closure plan that describes the steps necessary to close the CCR surface impoundment at any point during the active life of the CCR surface impoundment consistent with recognized and generally accepted engineering practices.*

This section includes the final closure plan for the EAP, as required by Section 845.720(a)(1). Specific requirements of the closure plan and the relevant regulatory citations are included in the following sections.

2.1. Narrative Closure Description

Section 845.720(a)(1)(A): A narrative description of how the CCR surface impoundment will be closed in accordance with this Part.

2.1.1. Closure Overview

The EAP will be closed in place and covered with a final cover compliant with 40 C.F.R. § 257.102(d)(3) and Section 845.750. Closure of the EAP will include a consolidate-and-cap approach, where the final footprint of the EAP will be reduced from approximately 128 acres to approximately 74 acres (the closure-in-place area). This will include removing all CCR some of the underlying subgrade materials, totaling approximately 1.8 million cubic yards (CY), from an approximately 54-acre closure-by-removal area inside the perimeter dikes to the consolidated footprint within the current EAP dikes.

Additionally, all CCR and some of the underlying subgrade materials from a 32-acre area outside of the perimeter dikes will also be removed and placed into the consolidated footprint. This is included within the 1.8 million CY removal volume. Solar panels will be established on the final cover system after closure is complete. Figures showing the location of each area of the EAP and the proposed solar layout are provided within the final closure drawings in **Attachment C**.

During the closure process, EEI will continue to assess off-site CCR beneficial use opportunities. Ash consolidation and closure-in-place with a combination of offsite beneficial use may result in a smaller footprint for the ultimate cap design along with a reduced construction schedule.

2.1.1.1. CCR and Soils to be Relocated

Specific areas and volumes that will be removed and placed into the closure-in-place area are described within this section.

- All CCR and up to one foot of the underlying subgrade soils, which are approximately 1.2 million CY in volume, will be removed from a 54-acre area inside the EAP (the closure-by-removal area) and placed into the closure-in-place area.

- All CCR and up to one foot of the underlying subgrade soils, which are approximately 580,000 CY in volume, will be removed from a 32-acre area outside of the EAP, to the south and southeast (the Southeast Area) and placed into the closure-in-place area.

    - The southeast area is further sub-divided into two areas, Southeast – North, located north of the rail loop, and Southeast – South, located south of the rail loop. The approximate boundaries of these areas are provided within the drawings in **Attachment C**. CCR in both areas was generated at the JPP and deposited between initial commissioning of the JPP in the 1950s and construction of the southern berms of the EAP in the 1970s and 1980s [1].

    - Additional information on this CCR, including subsurface investigation results, is included in the *CCR Investigation and Delineation Report* provided in **Attachment D**.

- Approximately 3,000-ft of the existing perimeter dikes will be removed from the closure-by-removal areas, as the dikes will no longer be retaining CCR during post closure conditions.

    - This will include relocating approximately 120,000 CY of dike soils and CCR beneath the dike soils (where present).

    - The dike soils, which are not impacted with CCR, will be used for protective cover soil.

CCR removal in all areas will include excavating all CCR and up to one foot of underlying native underlying subgrade materials beneath the CCR. The removal of CCR will be verified via visual observations performed during construction, and excavation depths will be adjusted, as needed to remove the CCR. The removed CCR and native soils will be placed within the closure-in-place area, over existing impounded CCR, as compacted fill to achieve final cover system subgrades.

2.1.1.2. New Soil Containment Berms and Final Cover System

As part of consolidation, a new soil containment berm and final cover system will be constructed within the closure-in-place area, as described below.

- Approximately 380,000 CY of onsite clay borrow soils will be utilized to construct a new compacted clay soil containment berm to separate the closure-by-removal portion of the EAP from the consolidate-and-cap portion.
    - The soil containment berm will be constructed along the eastern and southern boundary of the CIP portion of the EAP, in a accordance with the IDNR Part 3702 dam safety rules.
    - The soil containment berm will be founded on native foundation soils where the CCR has been removed. Any soft and/or saturated soils within the foundation of the EAP will be over-excavated and replaced with compacted fill.
    - The berm will have an approximate length of 2,700 ft, maximum height of 55-ft, and 3H:1V (horizontal to vertical) exterior slopes.
- An approximately 74-acre final cover system will be installed completely over the extents of consolidated CCR in plan.
    - The final cover system will consist of a geomembrane, protective cover soil, and vegetated topsoil. The final cover system will be keyed into the perimeter dikes and berms with an anchor trench.

2.1.2. Closure Performance Features

Therefore, closing the EAP with a consolidate-and-cap approach with a final cover will result in CCR within the consolidated EAP being:

- Encapsulated on the top, by the final cover system.
- Encapsulated on the sides by the existing soil dikes and new compacted clay soil containment berms.
- Encapsulated on the bottom, by existing native clay foundation soil which comprise the upper confining unit and have an estimated permeability on the order of 5×10^{-7} to 6×10^{-8} cm/sec [2].
- Not in contact with the uppermost aquifer.

2.1.3. Closure Construction Narrative Sequencing

Physical construction of the consolidate-and-cap closure of the EAP with a final cover system is expected to include the following tasks:

- The construction limits of disturbance will be established, and perimeter stormwater Best Management Practices (BMPs) will be installed, as and if needed.

- A temporary water management system will be constructed within the EAP, including ditches, sumps, pumps, discharge piping, and/or temporary stormwater detention basin(s), in order to manage surface water and liquid wastes. Free liquids will be removed from the Ash Pond via unwatering and dewatering and managed in accordance with the National Pollutant Discharge Elimination System (NPDES) permit for the facility [845.750(b)(1) and 845.750(b)(2)]. The methods by which free liquids will be removed may include drilled sumps, engineered trenches, and/or horizontal wells as discussed in **Section 4.6**. Free liquids will be routed into the stormwater management system.

    - The stormwater management system will remove the liquid waste in the EAP and maintain the EAP in an unwatered state by collecting contact stormwater during closure construction and prior to the installation of the cover system. Liquid waste flows will be pumped via the stormwater management system to the Settling Lagoon (a non-CCR surface impoundment) for ultimate discharge to the Ohio River at NPDES Outfall 010.

- Multiple powerlines and utility right-of-ways (ROWs) currently cross the EAP and Southeast Area, from east to west. These will be relocated around the EAP and Southeast Area, raised, or otherwise modified, as and if needed to allow for construction access. This will be performed either prior to the start of earthwork activities or in stages as the EAP closure is completed.

- Existing sluice pipes entering the EAP, and appurtenant structures such as pipe racks, will be demolished and disposed of beneath the final cover system of the EAP.

- The existing outflow structures and culverts connecting the EAP to the discharge channel east of the EAP that leads to the Ohio River will be abandoned, to reduce the risk of CCR from migrating through these conduits during post-closure conditions. Abandonment will consist of the following tasks:

    - Primary 48-inch diameter Reinforced Concrete Pipe (RCP) Spillway and pH Mixing Tank:

        - The concrete inlet structure wingwalls and pH mixing tank concrete basin and appurtenant at the outlier structures will be demolished and disposed of beneath the final cover system of the EAP.

        - The interior of the spillway will be cleaned via pressure washing and sealed by filling with cement-bentonite grout.

    - Secondary 26-inch diameter High-Density Polyethylene (HDPE) Culvert:

        - The catwalk, drop inlet structure, ductile iron tee, portions of the culvert within the closure-by-removal area, and portions of the culvert located above existing grades, near the pH mixing tank, will be demolished and disposed of beneath the final cover system of the EAP.

        - Portions of the culvert located above the existing grades, near the pH mixing tank, will be demolished and disposed of beneath the final cover system of the EAP.

        - Interior portions of the culvert within the perimeter dikes and outside of the closure-by-removal area will be cleaned via pressure washing and filled with cement-bentonite grout.

- All CCR and up to one foot of underlying native soils will be removed from the closure-by-removal portion of the EAP using mass mechanical excavation techniques. Excavations will be visually observed for CCR removal to verify that the CCR has been removed, and excavation depths may vary during this process. The material will be placed in the consolidate-and-cap portion of the EAP as compacted fill to provide a subgrade suitable for the construction of a final cover system. Dewatering will be performed as needed to support construction activity and excavation, using the temporary water management system.

    - Portions of the deep mixing method (DMM) stability buttress installed in 2016 that are higher than the surrounding closure-by-removal grades will also be removed and used as subgrade fill within the consolidate-and-cap portion of the EAP.

- CCR is located: (i) within the area between the southeastern corner of the EAP and the rail loop (Southeast Area – North), and (ii) in the natural stream valley that leads south of the rail loop to the Ohio River (Southeast Area – South).

    - Existing trees and dense vegetation within this area will be removed and the temporary water management system will be extended into this area to support the removal of all CCR.

    - All CCR and up to one foot of underlying native soils will be removed from this area using mass mechanical excavation techniques, similar to those used for the

closure-by-removal portion of the EAP. The material will be placed in the consolidate-and-cap portion of the EAP as compacted fill to provide a suitable subgrade for the construction of a final cover system.

- Dewatering and stormwater management will be performed, as needed to support construction activity and excavation, using the temporary water management system.

- The new soil containment berm will be constructed to separate the closure-by-removal footprint of the EAP from the consolidate-and-cap footprint. The soil containment berm will be founded on and inspected and prepared native clay soil subgrade and constructed using compacted clay fill obtained from an onsite borrow source. A shear key trench will be used at the base of the soil containment berm.

- The existing 72-inch diameter corrugated metal pipe (CMP) culvert, located along the eastern edge of the EAP, will be slip lined, to rehabilitate the culvert and reduce the potential for settlement or sinkholes at the dike toe caused by potential future culvert distress.

- An alternative cover system would be installed over the CCR that remains in the EAP. The cover would minimize vertical infiltration of precipitation into the basin [Part 845.750(a)(1)]. A solar facility atop the cover system is currently being designed. Components of the vegetative cover may change as details of the solar facility are finalized. However, any changes are expected to be protective of human health and the environment and meet the requirements of Section 845.750(c).

    - The alternate final cover system will be constructed over the entire footprint of the EAP that contains CCR, and will include, from bottom to top:

        - A 40-mil linear low-density polyethylene (LLDPE) geomembrane, placed on a prepared subgrade with rocks no larger than one inch in diameter, and other sharp objects will be removed prior to geomembrane placement.

        - A nonwoven geotextile, to protect the geomembrane from rocks and/or sharp objects in the cover soil.

        - Based on a demonstration included in **Attachment E**, pursuant to Section 845.750(C)(2), the final cover system will include an alternative 1.5-ft thick protective layer (e.g., cover soil) to protect

the geomembrane and 0.5 ft of topsoil capable of supporting vegetation, for a total cover soil thickness of 2 ft.

- The cover soil will be obtained from onsite borrow sources, including portions of the EAP perimeter dikes that are comprised of non-CCR impacted soil fill, and are within the closure-by-removal area.

- The final cover system would be gently sloped to direct surface water away from the impoundment. The final cover system grades will be approximately 2% over the majority of the EAP, although 10% (10 horizontal to 1 vertical [10H:1V]) grades will be used for heights of up to approximately 20 ft, to tie the final cover system into existing grades and reduce the overall height of the consolidated EAP. The final cover system will extend completely across the crest of the EAP dikes, and access roads will be constructed on top of the final cover system. Beyond the final cover system, channels will direct surface water away from the EAP to existing site drainages [Part 845.750(a)(2)].

- The final cover system will include an anchor trench for the geosynthetic materials along the entire perimeter of the EAP to secure the final cover system into existing grades. The anchor trench will be placed within the crests of the existing clay perimeter dikes and the new soil containment berm.

- Existing groundwater monitoring wells and standpipe piezometers present within the consolidated footprint will be retained and modified by extending the wells through the final cover system, sealing the penetration with a pipe boot, and constructing a new surface completion on top of the final cover.

- Some of the existing geotechnical vibrating-wire piezometers that are within the consolidate-and-cap footprint will be retained by extending the readout cable and constructing a new protective readout box on top of the final cover. Some or all of the vibrating-wire piezometers outside of the consolidated footprint will be abandoned by cutting the readout cable off at the ground surface.

- A post-closure non-contact stormwater management system will be constructed. The system will consist of:

  - Final Cover System

    - Stormwater diversion berms and channels will be constructed to convey stormwater off the EAP final cover system.

- Perimeter Dikes
    - Culverts will be installed to direct the stormwater flow through the EAP perimeter dikes, beneath perimeter access roadways and railroads. The culverts may use inlet and outlet structures such as drop inlets, headwalls, and/or other features.
    - Riprap energy dissipation structures will be placed at the outlet for each culvert to reduce erosion.
- Closure-by-Removal and Exterior Areas
    - Stormwater channels outside of the EAP footprint will be constructed, as necessary to direct the non-contact stormwater away from the EAP and route it to ultimate discharge at the Ohio River, via existing and new site stormwater channels. Some of these channels will be inside the closure-by-removal area, others will be outside of the original EAP footprint.
    - A channel will be excavated through the consolidate-and-cap portions of the EAP and southeast of the EAP, approximately where a creek channel was present prior to the construction of the EAP. The creek channel will direct stormwater flow from the eastern portion of the EAP final cover and from the closure-by-removal area to the Ohio River.
    - Stormwater detention pond(s) will be utilized within the closure-by-removal area, within a low area where CCR will be removed from the current EAP footprint and potentially within the Southeast Area. The pond(s) will provide attenuation for stormwater discharge to reduce the potential for downstream erosion..
    - The creek channel will utilize the existing culvert beneath the rail loop that surrounds the EAP, in order to allow stormwater to flow to the southeast.

- Vegetation will be established across the EAP and other disturbed areas, by:
    - Soils to be seeded will be fertilized, as needed to support vegetation establishment, based on agronomical soil tests.
    - The final cover system in the consolidate-and-cap area and the exterior surface of the new soil containment berm will be seeded with a suitable grass species for local climate and soil conditions.

- The closure-by-removal area and Southeast Area will be seeded with appropriate vegetation, including upland species (e.g., grasses) in most areas. However, appropriate species and/or trees capable of growing in wet areas may be utilized along the creek channel, and in the Southeast Area.
    - The closure-by-removal area will also include native pollinator plantings consistent with the Illinois Department of Natural Resources (IDNR) Solar Site Pollinator Scorecard [3], to the extent feasible given site conditions.
- Temporary BMPs such as mulch, erosion control blankets, turf reinforced mats, check dams, temporary settling basins, silt fences, and/or straw wattles, will be installed as necessary in accordance with a land disturbance permit to reduce the potential for soil erosion until vegetation is established.

- After vegetation is established on the final cover and in closure-by-removal areas, temporary BMPs will be removed, and closure construction will be considered complete.

- The JPP Site is slated for re-development as a utility-scale solar facility if CIP is approved. Additional information on the PV solar panel array is provided in **Section 6**.

Permit-level engineering drawings and material specifications for the closure are provided in **Attachment C**.

2.2. Decontamination of CCR Surface Impoundment

Section 845.720(a)(1)(B): If closure of the CCR surface impoundment will be accomplished through removal of CCR from the CCR surface impoundment, a description of the procedures to remove the CCR and decontaminate the CCR surface impoundment in accordance with Section 845.740.

The portions of the EAP that will be closed-by-removal and the Southeast Area will be decontaminated as part of closure. Decontamination will occur after all CCR has been removed and will include excavating up to one foot of native underlying subgrade materials (i.e., soils) beneath the CCR, similar to decontamination procedures completed and proposed for other CCR surface impoundments that have been closed-by-removal within Illinois. These excavated subgrade materials will be disposed of beneath the final cover system of the EAP. Decontamination will also include a visual inspection of the excavated subgrade to verify that all CCR has been removed, and excavation depths will be varied, as needed, until the removal of all CCR has been verified and documented.

Decontamination from other areas outside of the EAP and the Southeast Area will not be required because there have been no known releases within other areas.

2.3. Final Cover System

Section 845.720(a)(1)(C): If closure of the CCR surface impoundment will be accomplished by leaving CCR in place, a description of the final cover system, designed in accordance with Section 845.750, and the methods and procedures to be used to install the final cover. The closure plan must also discuss how the final cover system will achieve the performance standards specified in Section 845.750.

A description of the final cover system design, methods and procedures used for installation, and how the final cover system will achieve the Section 845.750 performance standards is provided in **Section 4** of this Closure Plan.

2.4. Maximum CCR Inventory

Section 845.720(a)(1)(D): An estimate of the maximum inventory of CCR ever on-site over the active life of the CCR surface impoundment.

The maximum inventory of CCR ever on-site within the EAP is approximately 5,870,000 cubic yards. An additional 530,000 cubic yards of CCR is estimated to be located outside of the limits of the EAP embankments (see **Section 2.1** and **Attachment D**). This CCR, and approximately 50,000 CY of underlying subgrade materials, will be excavated and utilized within the EAP as contouring fill to reach final cover system subgrades during closure. Therefore, this inventory will increase to approximately 6,500,000 CY during closure of the EAP.

2.5. Largest Surface Area Estimate

Section 845.720(a)(1)(E): An estimate of the largest area of the CCR surface impoundment ever requiring a final cover (see Section 845.750), at any time during the CCR surface impoundment's active life.

The largest surface area of the EAP, in plan, is approximately 128 acres [4]. The surface area in plan will be reduced to approximately 74 acres and the final cover system will extend completely across this consolidated area and beyond the limits of CCR in plan. This will provide a continuous encapsulation system consisting of the final cover on the top of the EAP, the clay perimeter dikes on the sides of the EAP, and the clay foundation soils beneath the EAP. Areas of the EAP that are closed-by-removal will not be capped with a final cover system, all CCR will have been removed from these areas after closure-by-removal is completed.

2.6. Closure Completion Schedule

Section 845.720(a)(1)(F): A schedule for completing all activities necessary to satisfy the closure criteria in this Section, including an estimate of the year in which all closure activities for the CCR surface impoundment will be completed. The schedule should provide sufficient information to describe the sequential steps that will be taken to close the CCR surface impoundment, including identification of major milestones such as coordinating with and obtaining necessary approvals and permits from other agencies, the dewatering and stabilization phases of CCR surface impoundment closure, or installation of the final cover system, and the estimated timeframes to complete each step or phase of CCR surface impoundment closure.

A milestone closure completion schedule has been prepared and is provided in **Table 1**. Key sequential phases and sub-tasks that will be completed as part of the closure will include:

- Agency Coordinating, Approvals, and Permitting
    - Approval of the closure Construction Permit Application by IEPA.
    - Obtaining a modification to the existing NPDES permit to allow the disposal of water generated from free liquid removal, unwatering, and dewatering operations to the Ohio River *via* the existing NPDES-permitted Outfall 010 for the Site.
    - Obtaining a Section 404/10 standard permit from the U.S. Army Corps of Engineers, Louisville District, for the removal of CCR from the southeast area, because this area is expected to be a Waters of the United States (WOTUS). This would include mitigation for any impacts to WOTUS.
        - This would include coordination with the United States Fish and Wildlife Service (USFWS) and Illinois Department of Natural Resources (IDNR) for potential impacts to listed species under the Endangered Species Act (Federal and State) within the area that will be disturbed.
        - Coordination with the Historical Preservation division of IDNR would be performed to evaluate potential impacts to cultural resources within the area that will be disturbed.
    - Obtaining a construction permit from the IDNR, Office of Water Resources (OWR), Dam Safety Program (DSP) to allow the embankment and spillways of the EAP to be modified as part of closure.

  - A general storm water permit for construction site activities through IEPA, including construction stormwater controls and other BMPs such as silt fences and other measures.

  - A joint water pollution control construction and operating permit (WPC Permit).

- Final Design and Bidding

  - Completion of final design investigations, calculations, design drawings, and specifications.

  - Bidding and selection of a closure construction contractor.

- Unwater, Dewater and Stabilize CCR, CCR Removal, Install Final Cover System

  - Closure contractor mobilization and material procurement.

  - Installing stormwater BMPs around the construction area, per the Land Disturbance Permit.

  - Clearing brush and trees in the work area.

  - Unwatering the EAP by pumping impounded water to the Polishing Pond, which is a non-CCR surface impoundment at JPP that currently discharges to the Ohio River via NPDES Outfall No. 010.

  - Abandoning existing outfall structures and culverts.

  - Stabilizing the subgrade through free liquid removal.

  - Removing all CCR from the closure-by-removal portions of the EAP, areas outside of the EAP (the Southeast Area), and all CCR below perimeter dikes (where present).

  - Constructing the new soil containment berm.

  - Grading up to design final cover subgrades.

  - Installing the final cover system geosynthetics and anchor trench.

  - Constructing the post-closure stormwater management system, including diversion berms and channels on the final cover system, then culverts, riprap energy dissipation structures, manholes, and new exterior stormwater channels.

- Removing the perimeter dikes of the in the closure-by-removal area for use as cover soil.

- Placing final protective layer including topsoil over the geosynthetics.

- Site Restoration

  - Seeding and stabilizing the surface of the final cover system and other disturbed areas and allowing the vegetation to become established.

  - Restoring the closure-by-removal areas by reconstructing creek channels and establishing vegetation.

  - Removing temporary stormwater BMPs and other temporary stabilization measures, after vegetation is established.

  - Closure contractor demobilization from the site.

The project is expected to be completed by August of 2028. Additional project schedule may be required if delays in permitting or significant weather delays occur. The JPP Site is slated for re-development as a utility-scale solar facility if closure in place (CIP) is approved. Additional information on the PV solar panel array is provided in **Section 6**. Installation of the PV solar array is not included within the closure construction schedule, as this is considered to be a post-closure activity initiated after the closure is otherwise complete.

Table 1 – Closure Completion Milestone Schedule

Milestone	Timeframe (Preliminary Estimates)
Final Closure Plan Submittal	August 2022
Joppa Power Plant Cessation of Coal Burning	September 2022
Agency Coordination, Approvals, and Permitting • Obtain state permits, as needed, for dewatering and free liquid removal, water discharge, modifications, land disturbance, and dam modifications. • Obtain a USACE Section 404 permits for removal of CCR from WOTUS.	6 to 12 months after Final Closure Plan Approval
Final Design and Bid Process • Complete final design of the closure and select a construction contractor.	12 to 16 months after Agency Coordination, Approvals, and Permitting
Dewater and Stabilize CCR, relocate CCR and consolidate, Install Final Cover System • Complete contractor mobilization, installation of stormwater BMPs, and unwatering of the EAP • Abandon outfall structures, stabilize the EAP, and remove free liquids (dewater and stabilize) • Remove all CCR from the closure-by-removal area and areas outside of the EAP embankments. • Construct the new soil containment berm. • Install the final cover system and stormwater downchutes.	24 to 38 months after Final Design and Bid Process
Site Restoration • Seed and stabilize the EAP and closure-by-removal areas. • Complete contractor demobilization.	2 to 8 months after the final cover system is complete
Timeframe to Complete Closure	March 2026 – October 2028 (4 to 6 years)
Note: Solar development will occur after closure is completed.	

Section 845.720(a)(1)(F) (Continued): When preparing the preliminary written closure plan, if the owner or operator of a CCR surface impoundment estimates that the time required to complete closure will exceed the timeframes specified in Section 845.760(a), the preliminary written closure plan must include the site-specific information, factors and considerations that would support any time extension sought under Section 845.760(b).

The time required to complete closure construction is not expected to exceed the timeframe specified in Section 845.760(a). Therefore, closure extensions for the EAP are not being sought at this time.

3. AMENDMENTS OF FINAL CLOSURE PLAN

Section 845.720(b)(4): If a final written closure plan revision is necessary after closure activities have started for a CCR surface impoundment, the owner or operator must submit a request to modify the construction permit within 60 days following the triggering event.

If revisions are required for this Final Closure Plan, the owner will submit a request to modify the construction permit within 60 days following the triggering event.

Table 2. CCR Final Closure Plan Revisions

Revision Number and Date	Pages or Section	Description of Revision	Professional Engineer Certifying Plan

4. CLOSURE WITH FINAL COVER SYSTEM

This section includes a description of the final closure with a final cover that will be completed for the EAP surface impoundment, including principal design and construction features, material specifications, and a discussion of how each feature is in accordance with the requirements of Section 845.750. Drawings showing each design feature and material specifications are provided in **Attachment C**.

The proposed CIP design will control, minimize, or eliminate as much as feasible "post-closure infiltration of liquids" and releases of CCR, leachate, or contaminated runoff as interpreted by Illinois EPA in the Part 845 rulemaking. Specifically, the Groundwater Modeling Report [5] shows that the closure design will result in a reduction of infiltration into the Ash Pond by 99.9% compared to pre-closure conditions. Additionally, within one year of closure completion, the Groundwater Modeling Report shows that CIP will result in a reduction of hydraulic flux into and out of the Ash Pond by 99.9% compared to pre-closure conditions [5]. Due to the reduction in the hydraulic flux out of the Ash Pond, the mass flux out of the Ash Pond will also be controlled or minimized as much as feasible as a result of CIP.

4.1. Minimization of Post-Closure Infiltration and Releases

Section 845.750(a)(1): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will: Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;

This performance standard will be met through:

- A 40-mil LLDPE geomembrane low-permeability layer will be placed on the prepared subgrade to control and minimize vertical infiltration, to the maximum extend feasible, into the surface impoundment. The geomembrane will be constructed on a subgrade that is free of sharp rocks or other debris and will be protected from damage by installing a nonwoven geotextile cushion and a total of two feet of cover soil and topsoil over the top of the geomembrane.

- Surface stormwater will be routed off the top of the final cover by the construction of a free-draining post-closure stormwater management system including diversion berms, letdown channels, culverts, and outlet energy dissipators. The stormwater management system will drain by gravity and preclude water impoundment on top of the final cover system, thereby minimizing post-closure infiltration into the CCR.

- CCR within the EAP will not be in direct contact with groundwater under post-closure conditions. Additionally, the CCR will be encapsulated on all sides, including laterally by compacted clay soil dikes and beneath the CCR by native clay upper confining unit soils with a permeability on the order of 5×10^{-7} to 6×10^{-8} cm/sec [5]. The CCR will be located at least 10 feet above the normal groundwater table [5] and at least 15 ft of separation above the uppermost aquifer will be provided [2]. Free liquids will be removed from the CCR as part of closure, and the potential for future accumulation of free liquids within the CCR will be reduced by the installation of a final cover system. These features will control the lateral migration of water into the unit and minimize any releases of CCR leachate into ground and surface waters.

    - The final cover system will tie into the existing perimeter dikes, by constructing a final cover anchor trench on the crest of the perimeter dikes. The final cover will therefore provide continuous encapsulation between the CCR and the surrounding environment on the top, bottom, and sides of the CCR, using the final cover, earthen perimeter dikes, and clay foundation soils.

    - This continuous encapsulation will result in the CCR being physically isolated from the surrounding environment on all sides, including the groundwater, surface water, and atmosphere and therefore minimize the releases of CCR, leachate, or contaminated run-off into the ground, surface waters, and atmosphere.

- Free liquid removal will significantly reduce the amount of leachate within the CCR prior to closure, and the final cover system will minimize infiltration and therefore the amount of leachate that accumulates within the CCR during post-closure.

- All existing culverts that penetrate the EAP dikes and connect them to adjacent areas will be sealed. Sealing will include cleaning of concrete and HDPE pipe culverts and filling with cement-bentonite grout, thereby removing potential flow paths that could otherwise allow leachate to be released after closure is completed.

- CCR within the consolidated-and-cap footprint of the EAP will not be in contact with the uppermost aquifer during post-closure conditions.

    - All CCR that is currently (e.g., under pre-closure conditions) expected to be in contact with or within close proximity to the uppermost aquifer, including CCR within the EAP and in the Southeast Area will be removed as part of closure. The removed CCR will be placed under the final cover system within the consolidated-can-capped EAP footprint, so that it is no longer in contact with groundwater.

Therefore, vertical infiltration will be minimized and the CCR will be physically isolated from and located above groundwater.

4.2. Preclusion of Future Impoundment

Section 845.750(a)(2): Preclude the probability of future impoundment of water, sediment, or slurry;

A final cover system will be installed on top of the EAP. All areas of the final cover system will be sloped to positively drain to the exterior of the EAP and preclude future impoundment of water, sediment, or slurry. This will include installing cross-slopes at approximately 2% grades, although slopes at up to 10% grades at the tie-in between the final cover system and existing grades. Stormwater will be directed into channels via diversion berms; the channels will allow stormwater to flow by gravity off the EAP footprint and into the surrounding area through culverts that will be installed in the perimeter dikes. Hydrologic and hydraulic calculations used to design the stormwater channels and other control features to preclude impoundment are provided in **Attachment F**.

4.3. Provisions for Preventing Instability, Sloughing and Movement

Section 845.750(a)(3): Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period;

The existing perimeter berms of the EAP are constructed out of compacted fill materials and are founded on medium stiff to stiff clay overlying dense to very dense sand and gravel. The foundation subgrade will be inspected prior to berm construction and any soft and/or wet areas will be over-excavated and backfilled with compacted fill. The new soil containment berms will also be constructed out of compacted fill and placed on similar foundation materials as the existing dikes. The stability of the existing and new soil containment berms have been evaluated by performing global slope stability analyses considering post-closure conditions. The resulting factors of safety exceed regulatory minimum values for static and seismic loading conditions for CCR surface impoundments [6]. Slope stability analyses are provided in **Attachment G**.

Sloughing and movement of the final cover system will be minimized by constructing the final cover system at relatively flat slopes, including 2% over most of the final cover and 10% slopes of up to 20 ft in height at the edges of the final cover, as necessary to tie into existing grades and limit the height of the consolidated EAP. The potential for sloughing and movement of the final cover system, including the 10% slopes, has been evaluated by performing veneer stability analyses for the various interfaces within the final cover system. The resulting factors of safety exceed typical minimum values for static and seismic loading conditions. Veneer stability analyses are provided in **Attachment G**.

4.4. Minimize the Need for Further Maintenance

Section 845.750(a)(4): Minimize the need for further maintenance of the CCR surface impoundment; and

Future maintenance needs will be minimized using the following design features:

- The final cover system will be installed at gentle 2% slopes over most of the final closure with 10% slopes in limited areas at the extents of the final cover, with maximum heights of 20 ft, as needed to tie into existing grades and limit the height of the consolidated EAP.
    - These relatively flat slopes will minimize erosion of the final cover soils and thereby minimize maintenance needs by reducing stormwater flow velocities relative to steeper slopes.
    - The relatively flat slopes will also facilitate routine mowing of vegetation of the final cover system by allowing tractor-based mowing equipment to operate on the slopes with a reduced risk of equipment flip-over.
- The final cover, outside of stormwater channels and diversion berms, will be stabilized by placing topsoil, fertilizing the topsoil, establishing vegetation using suitable grass species.
    - The vegetation will have a design seed mix suitable for the climate and need for robustness and longevity, and therefore will minimize erosion of the final cover system by stabilizing the topsoil.
    - The use of fertilizer and selection of a suitable grass species will minimize maintenance required to repair areas of poor vegetation establishment.
- Stormwater channels and diversion berms will be stabilized with erosion control blankets and straw wattles. The channels will transition to non-erodible culverts where they pass through the EAP east perimeter dike and flow into surrounding areas. Riprap or other types of energy dissipation will be placed at each culvert outlet. The erosion control blankets, non-erodible culverts, and energy dissipation will minimize post-closure erosion and associated maintenance for the stormwater management system.
    - Calculations used to design the stormwater channel stabilization and riprap armoring were based on the 100-year, 24-hour storm event. These calculations are provided in **Attachment F**.

4.5. Be Completed in Shortest Amount of Time

Section 845.750(a)(5): Be completed in the shortest amount of time consistent with recognized and generally accepted engineering practices.

Closure construction is expected to be completed within an amount of time that is consistent with recognized and generally accepted timeframes required to permit, design, bid, and construct a CCR impoundment final closure system of this size (i.e., approximately 2 million CY of CCR excavation and placement), with a consideration of other permits form multiple State and Federal agencies that are also required for the project. An estimated closure construction schedule is provided in **Section 2.6**. It should be noted that this schedule may change based on contractor, equipment, and material availability and actual weather conditions at the time at which closure occurs.

4.6. Drainage and Stabilization

Section 845.750(b): Drainage and Stabilization of CCR Surface Impoundments. The owner or operator of a CCR surface impoundment or any lateral expansion of a CCR surface impoundment must meet the requirements of this subsection (b) before installing the final cover system required by subsection (c).

Section 845.750(b)(1): Free liquids must be eliminated by removing liquid wastes or solidifying the remaining wastes and waste residues.

Section 845.750(b)(2): Remaining wastes must be stabilized sufficiently to support the final cover system.

Prior to installing the final cover system, free liquids will be eliminated by removing the liquid waste from the EAP. Free liquids are defined as liquids that readily separate from the solid portion of a waste under ambient temperature and pressure. Methods for free liquid removal may include, but are not limited to, the methods described below.

- Drilled Sumps
    - Drilled sumps typically consist of four to six-foot diameter borings drilled in CCR to depths of at least 10 ft. A perforated pipe is inserted into the boring and the annulus between the CCR and the pipe is backfilled with gravel. Free liquids are then allowed to flow into the pipe and are then removed via pumping.
    - A series of piezometers is typically installed near the sump to determine the corresponding drawdown in the phreatic surface in the CCR.

- The achieved drawdown will determine the required spacing of the sumps.

- Engineered Trenches
  - Excavated and sloped trenches may be used for CCR depths of less than 10 ft.
  - A series of piezometers is typically installed between excavated trenches to determine the corresponding drawdown in the phreatic surface in the CCR.
  - The trenches are sloped for a low point where free liquids are removed via pumping.

- Horizontal Wells
  - Horizontal wells may be directionally-drilled or installed using cut-and-cover techniques in CCR zones of low permeability that do not respond to free liquid removal using trenches drilled sumps or engineered trenches.
  - A series of piezometers is typically installed to determine the corresponding drawdown in the phreatic surface in the CCR.
  - Liquid waste is removed form the horizontal wells using a submersible pump.

Liquid waste obtained during free liquid removal will be discharged to the site's NPDES-permitted outfall. The removal of free liquids will result in the stabilization of the remaining CCR and will therefore allow the final cover to be placed on a stable subgrade.

4.7. Final Cover System

Section 845.750(c): If a CCR surface impoundment is closed by leaving CCR in place, the owner or operator must install a final cover system that is designed to minimize infiltration and erosion, and, at a minimum, meets the requirements of this subsection (c) unless the owner or operator demonstrates that another construction technique or material provides equivalent or superior performance to the requirements of this subsection (c) and is approved by the Agency. The final cover system must consist of a low permeability layer and a final protective layer. The design of the final cover system must be included in the preliminary and final written closure plans required by Section 845.720 and the construction permit application for closure submitted to the Agency.

An alternate final cover system has been designed consistent with the requirements of Section 845.720(c). The final cover will use a geomembrane as a low-permeability layer. The design of the final cover system is discussed within this section.

4.7.1. Low Permeability Layer - Geomembrane

Section 845.750(c)(1)(B): A geomembrane constructed in accordance with the following standards: i) The geosynthetic membrane must have a minimum thickness of 40 mil (0.04 inches) and, in terms of hydraulic flux, must be equivalent or superior to a three-foot layer of soil with a hydraulic conductivity of 1 x 10^{-7} cm/sec; ii) The geomembrane must have strength to withstand the normal stresses imposed by the waste stabilization process; and (iii) The geomembrane must be placed over a prepared base free from sharp objects and other materials that may cause damage.

The geomembrane will consist of a 40-mil linear low-density polyethylene (LLDPE) layer. Ramboll completed a Hydrologic Evaluation of Landfill Performance (HELP) [7] model to compare flux through the geomembrane cover to an equivalent cover system with 3 ft of 1×10^{-7} cm/sec clay, in order to demonstrate that the geomembrane final cover is superior to a soil-only final cover. The HELP modeling estimated a total infiltration of 0.016 in of water per year (in/yr) for the geomembrane final cover system, relative to 2.05 in/year for the cover system using 3 ft of 1×10^{-7} cm/sec clay. Therefore, the proposed geomembrane final cover system is superior to the three-foot, 1×10^{-7} cm/sec clay low-permeability layer, as infiltration is reduced by a factor of approximately 128.

The geomembrane will be installed on a prepared subgrade, after the underlying CCR has been stabilized. Therefore, additional normal stresses will not be imparted on the geomembrane due to the waste stabilization process.

The subgrade (e.g., base) for the geomembrane will be visually inspected and sharp objects such as rocks or debris that may damage the geomembrane will be removed, prior to deployment of the geomembrane.

4.7.2. Standards for the Final Protective Layer

An alternative final protective layer is proposed. The alternative final protective layer requirements are as follows:

Section 845.750(c)(2): The final protective layer must meet the following requirements…

A) Cover the entire low permeability layer;

B) Be at least three feet thick, be sufficient to protect the low permeability layer from freezing, and minimize root penetration of the low permeability layer;

C) Consist of soil material capable of supporting vegetation;

D) Be placed as soon as possible after placement of the low permeability layer; and

E) Be covered with vegetation to minimize wind and water erosion.

A final protective layer will be placed over and extend slightly beyond the entire geomembrane low-permeability layer in plan. Based on the demonstration included in **Attachment E**, pursuant to Section 845.750(c)(2), the protective layer will include, from bottom to top, a geotextile cushion, a 1.5-ft thick cover soil layer, and a 0.5-ft thick topsoil layer, for a total thickness of 2 ft.

The nonwoven geotextile cushion and 1.5-ft thick cover soil layer will protect the geomembrane from root penetration. Geomembranes are not susceptible to freeze damage, as discussed in **Attachment E**. The geotextile and cover soil will be placed as soon as practical after the geomembrane has been deployed and both quality assurance and quality control testing has been performed on the geomembrane seams.

The 0.5-ft thick topsoil layer will be fertilized, as necessary to support appropriate grass species, to vegetate the final protective layer.

Section 845.750(c)(3): The disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.

Settling and subsidence has been accounted for in the design of the final cover system as discussed in **Section 4.10**.

4.8. Certification

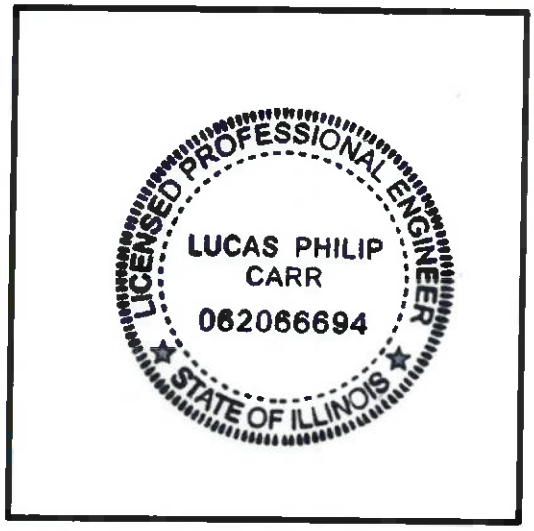
Section 845.750(c)(4): The owner or operator of the CCR surface impoundment must obtain and submit with its construction permit application for closure a written certification from a qualified professional engineer that the design of the final cover system meets the requirements of this section.

The undersigned qualified professional engineer registered in Illinois certifies that the design of the final cover system meets the requirements of Section 845.750.

Lucas P. Carr
Printed Name

Signature 7/28/2022
Date

062-066694 IL 11/30/2023
Registration Number State Expiration Date



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4.9. Uses of CCR in Closure

Section 845.750(d): *This subsection specifies the allowable uses of CCR in the closure of CCR surface impoundments closing under Section 845.700. Notwithstanding the prohibition on further placement in Section 845.700, CCR may be placed in these surface impoundments, but only for purposes of grading and contouring in the design and construction of the final cover system, if:*

1) The CCR placed was generated at the facility and is located at the facility at the time closure was initiated;

2) CCR is placed entirely above the elevation of CCR in the surface impoundment, following dewatering and stabilization (see subsection (b));

3) The CCR is placed entirely within the perimeter berms of the CCR surface impoundment;

Approximately 530,000 cubic yards of CCR is estimated to be located outside of the EAP, as discussed in **Section 2.1.1.1** and within **Attachment D**. This CCR was generated at the facility and will be located at the facility at the time that closure of the EAP is initiated.

All of the CCR and up to one foot of underlying native soils will be excavated from these areas and transported to the adjacent EAP to be beneficially used as compacted subgrade fill below the final cover system. This will support achieving design final cover system grades and maintaining final cover system slopes that promote positive stormwater drainage and preclude the impoundment of stormwater.

The CCR will be placed on top of the existing subgrade (i.e., existing elevation of CCR in the surface impoundment), following subgrade dewatering and stabilization via free liquid removal. CCR placement will only occur completely beneath the limits of the EAP final cover system and within the existing perimeter berms and new soil containment berms of the consolidated EAP footprint. This is in accordance with the Section 845.750(d) criteria.

4.10. Final Cover System Slopes

Section 845.750(d)(4): *The final cover system is constructed with either:*

A) A slope not steeper than 5% grade after allowance for settlement; or

B) At a steeper grade, if the Agency determines that the steeper slope is necessary, based on conditions at the site, to facilitate run-off and minimize erosion, and that side slopes are evaluated for erosion potential based on a stability analysis to evaluate possible erosion potential. The stability analysis, at a minimum, must evaluate the site geology; characterize soil shear strength; construct a slope stability model; establish groundwater and seepage conditions, if any; select

loading conditions; locate critical failure surface; and iterate until minimum factor of safety is achieved.

Final cover slopes will typically consist of 2% cross-slopes on the top of the EAP. However, slopes of up to 10% final cover slopes, up to 20 ft in height, will be used near the perimeter of the final cover, as needed to tie the final cover into the existing grades, as shown in the drawing package provided in **Attachment C**. Ten percent slopes will be utilized to limit the total height of the consolidated-and-cap EAP. This will reduce visual impacts associated with the closure.

The stability of the 10% final cover slopes has been evaluated both for the final cover system itself (e.g., veneer stability) and the global stability of the slope. These calculations included characterizing soil shear strength based on site geology, constructing slope stability models, establishing groundwater seepage conditions, selecting loading conditions, locating the critical failure surface, and iterating until minimum factors of safety were calculated. These calculations are provided in **Attachment G**. Resulting factors of safety exceed typical minimum factors of safety for both global and veneer stability.

Settlement analyses to evaluate the effects of compression of the underlying native foundation clay soil units on the final cover system have indicated that nominal settlements (e.g., less than four inches) are expected. These settlements are not expected to adversely impact final cover system drainage.

Subsidence is not expected to be a concern for the EAP as previous Unstable Area location restrictions reports, prepared in accordance with §257.64(a) of the USEPA CCR Rule [6] concluded that *"…karst topography or physiographic features such as sinkholes, vertical shafts, sinking streams, caves, large sprints, or blind valleys do not existing at the plant."* [8].

5. ADDITIONAL INFORMATION

Both the lateral migration of groundwater and vertical infiltration of liquids, and releases of CCR, and leachate, and contaminated run-off into and out of the EAP will be controlled, minimized or eliminated, to the maximum extent feasible, under post-closure conditions. A description of how this will be performed is provided below.

- All CCR in the Southeast Area located outside of the EAP will be excavated and placed beneath the final cover system in the EAP. This action will eliminate the potential for it to be susceptible to lateral and vertical groundwater and liquid migration, as well as inducing the potential for releases, leachate generation, and contaminated run-off.

- Free liquids will be removed from the EAP during closure, thereby reducing the amount of leachate and potential for contaminated runoff. Additionally, a final cover system will be installed to reduce the potential for future accumulation of free liquids within the CCR, as discussed in **Section 4.1**.

- The consolidated-and-capped EAP footprint will overly a native alluvial clay thickness (the upper confining unit) of 15 to 50 ft that is approximately 30 ft thick on average beneath the CCR, as shown within the figures in **Attachment C**.

    - The alluvial clay is expected to have a hydraulic conductivity on the order of 5×10^{-7} to 6×10^{-8} cm/sec [2].

    - A minimum of 10 feet of separation will be present between the base of CCR and the estimated normal groundwater table within the upper confining unit under post-closure conditions [5].

- CCR within the EAP is isolated laterally from surrounding areas by existing compacted clay soil dikes and a new compacted clay soil containment berm that will be constructed as part of closure, as discussed in **Section 2.1**.

- Closure of the EAP will include constructing a final cover system that ties into the existing soil dikes and berms, thereby completely encapsulating CCR within the EAP on the top, bottom, and sides, as discussed in **Section 4.1.**

- CCR within the EAP will not be contact with the uppermost aquifer during post-closure conditions.

6. PROPOSED PV SOLAR PANEL ARRAY

A solar facility atop the cover system is currently being designed with an estimated annual power generation of 25,300 watts. The solar array development is currently expected to be comprised of a 2V, fixed tilt ballasted system and associated electrical equipment. The PV racking system and electrical system will be placed on concrete foundations placed directly on the protective cover layer. Components of the vegetative cover may change as details of the solar facility are finalized. No foundation systems or other appurtenances of the solar array are currently proposed to penetrate through the geomembrane low-permeability barrier. The proposed layout of the PV solar array panels and details are included in **Attachment C**.

The racks and equipment will be placed to avoid interference with existing monitoring devices or and components of the stormwater management system. The final design of the PV solar array may be revised based on site conditions and the available equipment and technology available at the time of installation.

The ballast blocks will be designed to minimize the additional loading applied to the protective soil layer to avoid adverse impacts to the final cover system. The stormwater drainage system is not currently expected to be significantly altered by the proposed PV solar array, although this will be verified during final design of the PV solar array. If changes are proposed to the closure design, based on the proposed PV solar array, a revised closure plan will be submitted to IEPA for approval.

7. CERTIFICATION FROM A QUALIFIED PROFESSIONAL ENGINEER

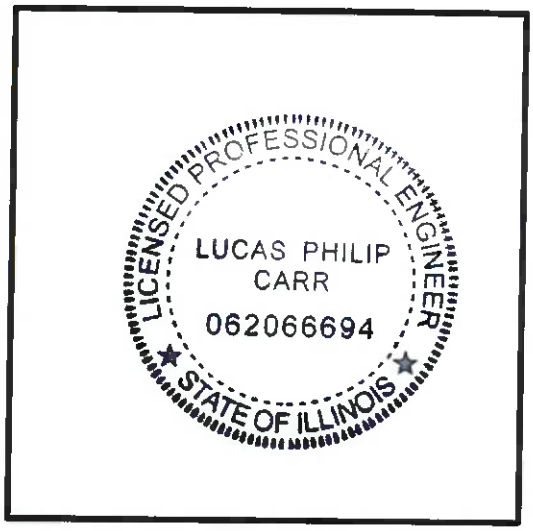
Section 845.720(b)(5): The owner or operator of the CCR surface impoundment must obtain and submit with its construction permit application for closure a written certification from a qualified professional engineer that the final written closure plan meets the requirements of this Part.

I, Lucas P. Carr, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this construction permit application has been prepared in accordance with the accepted practice of engineering and the requirements of Title 35, Subtitle G, Chapter I, Subchapter j, Section 845.720 of the Illinois Administrative Code.

Lucas P. Carr
Printed Name

Signature 7/22/2022
Date

062-066694 IL 11/30/2023
Registration Number State Expiration Date



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Geosyntec
consultants

ATTACHMENT A

Closure Alternatives Analysis

July 2022

Closure Alternatives Analysis for the East Ash Pond at the Joppa Power Plant, Joppa, Illinois

July 28, 2022

GRADIENT

www.gradientcorp.com
One Beacon Street, 17th Floor
Boston, MA 02108
617-395-5000

Table of Contents

Page

Summary of Findings S-1

1 Introduction 1
1.1 Site Description and History 1
1.1 Site Location and History 1
1.1.2 CCR Impoundment 1
1.1.3 Surface Water Hydrology 2
1.1.4 Hydrogeology 3
1.1.5 Site Vicinity 3
1.2 IAC Part 845 Regulatory Review and Requirements 4

2 Closure Alternatives Analysis 5
2.1 Closure Alternative Descriptions (IAC Section 845.710(c)) 5
2.1.1 Closure-in-Place 5
2.1.2 Closure-by-Removal with Off-Site CCR Disposal by Trucking 8
2.1.3 Closure-by-Removal with Off-Site CCR Disposal by Barging 10
2.2 Long- and Short-Term Effectiveness of the Closure Alternative (IAC Section 845.710(b)(1)) 12
2.2.1 Magnitude of Reduction of Existing Risks (IAC Section 845.710(b)(1)(A)) 12
2.2.2 Likelihood of Future Releases of CCR (IAC Section 845.710(b)(1)(B)) 12
2.2.3 Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (IAC Section 845.710(b)(1)(C)) 13
2.2.4 Short-Term Risks to the Community or the Environment During Implementation of Closure (IAC Section 845.710(b)(1)(D)) 13
2.2.4.1 Worker Risks 13
2.2.4.2 Community Risks 15
2.2.4.3 Environmental Risks 20
2.2.5 Time Until Groundwater Protection Standards Are Achieved (IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3)) 22
2.2.6 Potential for Exposure of Humans and Environmental Receptors to Remaining Wastes, Considering the Potential Threat to Human Health and the Environment Associated with Excavation, Transportation, Re-disposal, Containment, or Changes in Groundwater Flow (IAC Section 845.710(b)(1)(F)) 23
2.2.7 Long-Term Reliability of the Engineering and Institutional Controls (IAC Section 845.710(b)(1)(G)) 23

2.2.8 Potential Need for Future Corrective Action Associated with the Closure (IAC Section 845.710(b)(1)(H)) 24
2.3 Effectiveness of the Closure Alternative in Controlling Future Releases (IAC Section 845.710(b)(2)) 24
2.3.1 Extent to Which Containment Practices Will Reduce Further Releases (IAC Section 845.710(b)(2)(A)) 24
2.3.2 Extent to Which Treatment Technologies May Be Used (IAC Section 845.710(b)(2)(B)) 24
2.4 Ease or Difficulty of Implementing Closure Alternative (IAC Section 845.710(b)(3)) 24
2.4.1 Degree of Difficulty Associated with Constructing the Closure Alternative 24
2.4.2 Expected Operational Reliability of the Closure Alternative 25
2.4.3 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies 25
2.4.4 Availability of Necessary Equipment and Specialists 26
2.4.5 Available Capacity and Location of Needed Treatment, Storage, and Disposal Services 26
2.5 Impact of Closure Alternative on Waters of the State (IAC Section 845.710(d)(4)) 27
2.6 Concerns of Residents Associated with Closure Alternatives (IAC Section 845.710(b)(4)) 27
2.7 Class 4 Estimate (IAC Section 845.710(d)(1)) 28
2.8 Summary 28

References 29

Appendix A Human Health and Ecological Risk Assessment
Appendix B Supporting Information

List of Tables

Table S.1 Comparison of Proposed Closure Scenarios

Table 2.1 Key Parameters for the Closure-in-Place Scenario

Table 2.2 Key Parameters for the Closure-by-Removal with Off-Site CCR Disposal by Trucking Scenario

Table 2.3 Key Parameters for the Closure-by-Removal with Off-Site CCR Disposal by Barging Scenario

Table 2.4 Expected Number of On-Site Worker Accidents Under Each Closure Scenario

Table 2.5 Expected Number of Off-Site Worker Accidents Related to Off-Site Car and Truck Use Under Each Closure Scenario

Table 2.6 Expected Number of Worker Accidents Associated with Barge Transportation Under the Closure-by-Removal with Off-Site CCR Disposal by Barging Scenario

Table 2.7 Expected Number of Community Accidents Under Each Closure Scenario

List of Figures

Figure 1.1 Site Location Map

Figure 2.1 Environmental Justice Communities in the Vicinity of the Site and the Off-Site Landfill Under the Closure-by-Removal with Off-Site CCR Disposal by Trucking Scenario

Figure 2.2 Environmental Justice Communities in the Vicinity of the Site and the Off-Site Landfill Under the Closure-by-Removal with Off-Site CCR Disposal by Barging Scenario

Abbreviations

AACE	Association for the Advancement of Cost Engineering
BMP	Best Management Practice
CAA	Closure Alternatives Analysis
CAAA	Corrective Action Alternatives Analysis
CBR	Closure-by-Removal
CBR-Offsite-Barge	Closure-by-Removal with Off-Site CCR Disposal by Barging
CBR-Offsite-Truck	Closure-by-Removal with Off-Site CCR Disposal by Trucking
CCR	Coal Combustion Residual
CIP	Closure-in-Place
CFR	Code of Federal Regulations
CMA	Corrective Measures Assessment
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CY	Cubic Yard
EAP	East Ash Pond
EEI	Electric Energy, Inc.
EJ	Environmental Justice
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
GWPS	Groundwater Protection Standards
IAC	Illinois Administrative Code
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
Joppa West	Joppa West Former Surface Impoundment
LAU	Lower Aquifer Unit
LCU	Lower Confining Unit
LCFZ	Lusk Creek Fault Zone
LLDPE	Linear Low-Density Polyethylene
N_2O	Nitrous Oxide
NID	National Inventory of Dams
NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyl
PM	Particulate Matter
PMP	Potential Migration Pathway
SFWA	State Fish and Wildlife Area
TVA	Tennessee Valley Authority
UA	Uppermost Aquifer
UCU	Upper Confining Unit
US ACE	United States Army Corps of Engineers
US DOT	United States Department of Transportation
US EPA	United States Environmental Protection Agency
US FWS	United States Fish & Wildlife Service

USGS	United States Geological Survey
VOC	Volatile Organic Compound
WPC Permit	Water Pollution Control Construction and Operating Permit

Summary of Findings

Title 35, Part 845 of the Illinois Administrative Code (IAC; IEPA, 2021a) requires the development of a Closure Alternatives Analysis (CAA) prior to undertaking closure activities at certain surface impoundments containing coal combustion residuals (CCRs) in the State of Illinois. Pursuant to requirements under IAC Section 845.710, this report presents a CAA for the East Ash Pond (EAP) located on Electric Energy, Inc.'s (EEI) Joppa Power Plant property near the Village of Joppa, Illinois.

The goal of a CAA is to holistically evaluate potential closure scenarios with respect to a wide range of factors, including the efficiency, reliability, and ease of implementation of the closure scenario; its potential positive and negative short- and long-term impacts on human health and the environment; and its ability to address concerns raised by residents (IAC Part 845; IEPA, 2021a). Gradient evaluated three specific closure scenarios for the EAP: Closure-in-Place (CIP) with CCR excavation and consolidation, Closure-by-Removal with Off-Site CCR Disposal by Trucking (CBR-Offsite-Truck), and Closure-by-Removal with Off-Site CCR Disposal by Barging (CBR-Offsite-Barge). The CIP scenario entails excavating and consolidating CCRs from the EAP and CCRs located outside the limits of the EAP into one area, then capping these consolidated materials with a final cover system consisting of, from bottom to top, a geomembrane layer, a geotextile protective layer, and 24 inches of protective soil cover suitable for supporting vegetative growth. The two CBR-Offsite scenarios entail excavating all of the CCRs from the EAP, as well as from areas outside the EAP, and transporting it to an off-Site landfill for disposal either by truck (CBR-Offsite-Truck) or by a combination of barges and trucks (CBR-Offsite-Barge). Even though capping the entire EAP (without any excavation or consolidation) would be an acceptable closure approach based on IAC Section 845.710 (IEPA, 2021a), it was not evaluated in this CAA. EEI will also continue to evaluate potential opportunities for the beneficial re-use of CCRs excavated from the EAP as an alternative to disposal.

IAC Section 845.710(c)(2) requires CAAs to "[i]dentify whether the facility has an onsite landfill with remaining capacity that can legally accept CCR, and, if not, whether constructing an onsite landfill is possible" (IEPA, 2021a). There is an existing landfill (Joppa Landfill) located in the northwestern portion of the Joppa Power Plant property (Ramboll, 2021). However, the current landfill cell (Cell L1) is only 13.5 acres in size; an additional 13.5-acre cell (Cell L2) was permitted but never constructed (Appendix B). The capacity of the existing landfill is not sufficient to accommodate all of the CCRs that would be excavated from the EAP under a Closure-by-Removal (CBR) scenario (Appendix B). Due to the presence of other features in the immediate vicinity of the landfill, it cannot be expanded laterally to increase its capacity. In addition, vertical expansion of the landfill is not feasible, because such an expansion would potentially render the landfill unstable and would not be consistent with the permitted final cover slopes (Appendix B). Construction of a new on-Site landfill is not feasible due to conflicts related to the potential 100-year floodplain; existing infrastructure, including surface impoundments, utility corridors and Site roadways; as well as interference with planned future property uses, including the planned construction of a utility-scale battery energy storage facility, or EEI property boundaries (Appendix B). In summary, neither expansion of the existing on-Site landfill nor construction of a new on-Site landfill is a viable alternative at this Site.

Table S.1 summarizes the expected impacts of the CIP, CBR-Offsite-Truck, and CBR-Offsite-Barge closure scenarios with regard to each of the factors specified under IAC Section 845.710 (IEPA, 2021a). Based on this evaluation and the additional details provided in Section 2 of this report, CIP has been identified as the most appropriate closure scenario for the EAP. Key benefits of the CIP scenario relative

to the CBR-Offsite scenarios include the more rapid redevelopment of the Site for the installation of a solar facility on the capped impoundment and reduced impacts to workers, community members, and the environment during construction (*e.g.*, fewer constructed-related accidents, lower energy demands, less air pollution and greenhouse gas [GHG] emissions, reduced duration of traffic-related impacts, and potentially lower impacts to environmental justice [EJ] communities). Moreover, the CIP scenario will meet the required closure schedule (*i.e.*, closure completed by October 2028) defined in IAC Section 845.700(d)(2)(C)(ii) (IEPA, 2021a), whereas the CBR-Offsite scenarios will be unable to meet this required schedule.

Table S.1 Comparison of Proposed Closure Scenarios

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP	**CBR-Offsite-Truck**	**CBR-Offsite-Barge**
Closure Alternative Descriptions (Section 2.1; IAC Section 845.710(c))	CCRs from the EAP and CCRs located outside of the EAP would be excavated and consolidated into one area, then capped with a final cover system consisting of, from bottom to top, a geomembrane layer, a geotextile protective layer, and 24 inches of protective soil cover suitable for supporting vegetative growth. During the closure process, EEI will continue to evaluate potential opportunities for the beneficial re-use of CCRs excavated from the EAP as an alternative to disposal. Consolidation of the CCRs and CIP, in combination with off-Site beneficial re-use of some of the excavated CCRs, may result in a smaller footprint for the final cover system, along with a shorter construction duration.	All of the CCRs would be excavated from the EAP, as well as from areas outside the EAP, and transported *via* truck to an off-Site landfill for disposal. Expansion of the off-Site landfill may be necessary in order to accept all of the excavated CCRs.	All of the CCRs would be excavated from the EAP, as well as from areas outside the EAP, and transported *via* barge and truck to an off-Site landfill for disposal. Expansion of the off-Site landfill may be necessary in order to accept all of the excavated CCRs.
Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (Section 2.2.3; IAC Section 845.710(b)(1)(C))	Monitoring would be performed for 30 years post-closure or until GWPSs are achieved, whichever is longer. Additionally, the final cover system would undergo 30 years of annual inspections, mowing, and maintenance.	Monitoring would be performed for 3 years post-closure or until GWPSs are achieved, whichever is longer.	Monitoring would be performed for 3 years post-closure or until GWPSs are achieved, whichever is longer.
Magnitude of Reduction of Existing Risks (Section 2.2.1; IAC Sections 845.710(b)(1)(A) and 845.710(b)(1)(F))	There are no current unacceptable risks to any human or ecological receptors associated with the EAP for all pathways, with the potential exception of residents in the Village of Joppa who may use groundwater from the uppermost aquifer (UA) as a source of drinking water. For the drinking water pathway, conservatively estimated concentrations of several constituents exceed their respective screening-level benchmarks. For these constituents, further evaluation is being performed to determine if there are any receptors exposed *via* this pathway and to better characterize potential future exposure concentrations. This evaluation will be performed and addressed in the Corrective Action Alternatives Analysis (CAAA), because any future off-Site groundwater concentrations will decline over time both as a result of the planned closure of the EAP and the corrective actions that will be implemented at the Site. It should be noted that based on the results of a comprehensive well survey conducted within the Village of Joppa, we do not believe that there are any current residents who use groundwater from the UA as a source of drinking water.	There are no current unacceptable risks to any human or ecological receptors associated with the EAP for all pathways, with the potential exception of residents in the Village of Joppa who may use groundwater from the UA as a source of drinking water. For the drinking water pathway, conservatively estimated concentrations of several constituents exceed their respective screening-level benchmarks. For these constituents, further evaluation is being performed to determine if there are any receptors exposed *via* this pathway and to better characterize potential future exposure concentrations. This evaluation will be performed and addressed in the Corrective Action Alternatives Analysis (CAAA), because any future off-Site groundwater concentrations will decline over time both as a result of the planned closure of the EAP and the corrective actions that will be implemented at the Site. It should be noted that based on the results of a comprehensive well survey conducted within the Village of Joppa, we do not believe that there are any current residents who use groundwater from the UA as a source of drinking water.	There are no current unacceptable risks to any human or ecological receptors associated with the EAP for all pathways, with the potential exception of residents in the Village of Joppa who may use groundwater from the UA as a source of drinking water. For the drinking water pathway, conservatively estimated concentrations of several constituents exceed their respective screening-level benchmarks. For these constituents, further evaluation is being performed to determine if there are any receptors exposed *via* this pathway and to better characterize potential future exposure concentrations. This evaluation will be performed and addressed in the Corrective Action Alternatives Analysis (CAAA), because any future off-Site groundwater concentrations will decline over time both as a result of the planned closure of the EAP and the corrective actions that will be implemented at the Site. It should be noted that based on the results of a comprehensive well survey conducted within the Village of Joppa, we do not believe that there are any current residents who use groundwater from the UA as a source of drinking water.
Likelihood of Future Releases of CCR (Section 2.2.2; IAC Sections 845.710(b)(1)(B) and 845.710(b)(1)(F))	During closure, there would be minimal risk of dike failure occurring at the EAP (due to, *e.g.*, flooding or seismic activity) and minimal risk of dike overtopping during flood conditions. Post-closure, the risks of overtopping and dike failure would be even lower than they are currently, due to the installation of a protective soil cover and new stormwater control structures. The dikes, final cover, and stormwater control features have been designed to withstand earthquakes and storm events.	During closure, there would be minimal risk of dike failure occurring at the EAP (due to, *e.g.*, flooding or seismic activity) and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure. Changing geochemical conditions during an extended excavation can be a mechanism that results in mobilization and increased transport in groundwater for some constituents.	During closure, there would be minimal risk of dike failure occurring at the EAP (due to, *e.g.*, flooding or seismic activity) and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure. Changing geochemical conditions during an extended excavation can be a mechanism that results in mobilization and increased transport in groundwater for some constituents.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP	**CBR-Offsite-Truck**	**CBR-Offsite-Barge**
Worker Risks (Section 2.2.4.1; IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))	An estimated 0.006 worker fatalities and 0.91 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.007 worker fatalities and 0.5 worker injuries would be expected to occur off-Site due to vehicle accidents during hauling, labor and equipment mobilization and demobilization, and material deliveries. In total, 0.013 worker fatalities and 1.4 worker injuries would be expected to occur under this closure scenario. Overall, risks to workers would likely be highest under the CBR-Offsite-Truck scenario and lowest under the CIP scenario.	An estimated 0.105 worker fatalities and 16.1 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.19 worker fatalities and 9.8 worker injuries would be expected to occur off-Site due to vehicle accidents during hauling, labor and equipment mobilization and demobilization, and material deliveries. In total, 0.30 worker fatalities and 25.9 worker injuries would be expected to occur under this closure scenario. Overall, risks to workers would likely be higher under the two CBR-Offsite scenarios and lower under the CIP scenario.	An estimated 0.089 worker fatalities and 13.8 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.091 worker fatalities and 5.4 worker injuries would be expected to occur off-Site due to vehicle accidents during hauling, labor and equipment mobilization and demobilization, and material deliveries. An estimated 0.19 worker fatalities and 1.2 worker injuries would be expected to occur off-Site due to barge transportation. In total, 0.37 worker fatalities and 20.4 worker injuries would be expected to occur under this closure scenario. Overall, risks to workers would likely be higher under the two CBR-Offsite scenarios and lower under the CIP scenario.
Community Risks (Section 2.2.4.2; IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))			
▪ *Off-Site Impacts on Nearby Residents and EJ Communities*	Off-Site impacts on nearby residents and EJ communities (including accidents, traffic, noise, and air pollution) would be less under this closure scenario than under the two CBR-Offsite scenarios, because it would require less off-Site vehicle and equipment travel miles than the two CBR-Offsite scenarios. In total, an estimated 0.007 fatalities and 0.32 injuries would be expected to occur among community members due to off-Site activities under this scenario. No off-Site hauling of CCRs is required under the CIP scenario.	Off-Site impacts on nearby residents and EJ communities would be greater under the two CBR-Offsite closure scenarios than under the CIP scenario, because they would require significantly more off-Site vehicle and equipment travel miles. In total, an estimated 0.72 fatalities and 20.6 injuries would be expected to occur among community members due to off-Site activities under this scenario. With regard to traffic impacts, a haul truck could pass a location near the Site as frequently as once every 2.5 minutes on average during working hours for approximately 3,570 construction days under this scenario. Additionally, the transportation of CCRs to the off-Site landfill under this scenario could potentially require hauling CCRs through the EJ community near Johnston City, Illinois.	Off-Site impacts on nearby residents and EJ communities would be greater under the two CBR closure scenarios than under the CIP scenario, because they would require significantly more off-Site vehicle and equipment travel miles. In total, an estimated 0.26 fatalities and 7.8 injuries would be expected to occur among community members due to off-Site activities under this scenario. With regard to traffic impacts, a haul truck would be likely to pass a location near the barge unloading terminal and the off-Site landfill as frequently as once every 2.5 minutes on average during working hours for approximately 3,570 construction days under this scenario. In addition, the barge traffic on the Ohio River and Mississippi River would go through the buffer zones of several EJ communities, including Cairo, Illinois; Hickman, Kentucky; and New Madrid, Missouri.
▪ *Impacts on Scenic, Historical, and Recreational Value*	There are no notable scenic, historic, or recreational areas located in the immediate vicinity of the EAP or the on-Site borrow soil location. Construction activities at the Site are therefore not expected to have direct negative impacts on any scenic, historic, or recreational areas under any of the evaluated closure scenarios.	There are no notable scenic, historic, or recreational areas located in the immediate vicinity of the EAP or the on-Site borrow soil location. Construction activities at the Site are therefore not expected to have direct negative impacts on any scenic, historic, or recreational areas under any of the evaluated closure scenarios.	There are no notable scenic, historic, or recreational areas located in the immediate vicinity of the EAP or the on-Site borrow soil location. Construction activities at the Site are therefore not expected to have direct negative impacts on any scenic, historic, or recreational areas under any of the evaluated closure scenarios.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP	**CBR-Offsite-Truck**	**CBR-Offsite-Barge**
Environmental Risks (Section 2.2.4.3; IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))			
▪ *Impacts on Greenhouse Gas Emissions and Energy Consumption*	Total energy demands and GHG emissions would be lower under this closure scenario than under the two CBR-Offsite scenarios, because the total equipment and vehicle mileages required under this closure scenario would be less than those required under the two CBR-Offsite scenarios. The CIP scenario would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the final cover system. Construction of a utility-scale battery storage facility at the Site and the installation of a solar facility on the capped impoundment would help the state meet its goals of decarbonizing electricity generation and improve the overall reliability of the electricity grid. Redevelopment of the Site for the installation of a solar facility on the capped impoundment would occur more rapidly under the CIP scenario than under the two CBR-Offsite scenarios.	Total energy demands and GHG emissions would be greater under the two CBR-Offsite closure scenarios than under the CIP scenario, because the total equipment and vehicle mileages required under these closure scenarios would be greater than those required under the CIP scenario. If expansion of the off-Site landfill became necessary in order to accept all of the excavated CCRs, the CBR-Offsite scenarios would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the expanded landfill liner. Construction of a utility-scale battery storage facility at the Site would help the state meet its goals of decarbonizing electricity generation and improve the overall reliability of the electricity grid.	Total energy demands and GHG emissions would be greater under the two CBR-Offsite closure scenarios than under the CIP scenario, because the total equipment and vehicle mileages required under these closure scenarios would be greater than those required under the CIP scenario. This closure scenario would have an additional, unquantified carbon footprint due to the need to construct the loading and unloading terminals for barges at the Site and Port of Cates Landing, respectively. If expansion of the off-Site landfill became necessary in order to accept all of the excavated CCRs, then the CBR-Offsite scenarios would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the expanded landfill liner. Construction of a utility-scale battery storage facility at the Site would help the state meet its goals of decarbonizing electricity generation and improve the overall reliability of the electricity grid.
▪ *Impacts on Natural Resources and Habitat*	Construction may have short-term negative impacts on species located near the major construction locations associated with closure. Construction may also cause a long-term shift in the habitat type atop portions of these areas. Short-term impacts on natural resources and habitat would be smaller under the CIP scenario than under the two CBR-Offsite scenarios, because the overall duration of construction is shorter under the former scenario.	Construction may have short-term negative impacts on species located near the major construction locations associated with closure. Construction may also cause a long-term shift in the habitat type atop portions of these areas. Short-term impacts on natural resources and habitat would be greater under the two CBR-Offsite scenarios than under the CIP scenario, because the overall duration of construction is longer under the former scenarios.	Construction may have short-term negative impacts on species located near the major construction locations associated with closure. Construction may also cause a long-term shift in the habitat type atop portions of these areas. Short-term impacts on natural resources and habitat would be greater under the two CBR-Offsite scenarios than under the CIP scenario, because the overall duration of construction is longer under the former scenarios.
Time Until Groundwater Protection Standards Are Achieved (Section 2.2.5; IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3))	Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the EAP under each of the proposed closure alternatives (Ramboll, 2022). The model results demonstrate that the GWPSs in the UA will be achieved within approximately 14 years under both the CIP and CBR closure scenarios at the EAP monitoring wells where average boron concentrations have been observed exceeding the boron GWPS of 2 mg/L between 2015 and 2022. Additionally, the modeling indicates that GWPSs will be achieved at all well locations within approximately 24 years after closure under both the CIP and CBR closure scenarios.	Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the EAP under each of the proposed closure alternatives (Ramboll, 2022). The model results demonstrate that the GWPSs in the UA will be achieved within approximately 14 years after closure under both the CIP and CBR closure scenarios at the EAP monitoring wells where average concentrations have been observed exceeding the boron GWPS of 2 mg/L between 2015 and 2022. Additionally, the modeling indicates that GWPSs will be achieved at all well locations within approximately 24 years after closure under both the CIP and CBR closure scenarios. Additionally, changing geochemical conditions during an extended excavation can be a mechanism that results in mobilization and increased transport in groundwater for some constituents. This may result in GWPS exceedance durations in excess of the model predictions.	Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the EAP under each of the proposed closure alternatives (Ramboll, 2022). The model results demonstrate that the GWPSs in the UA will be achieved within approximately 14 years after closure under both the CIP and CBR closure scenarios at the EAP monitoring wells where average concentrations have been observed exceeding the boron GWPS of 2 mg/L between 2015 and 2022. Additionally, the modeling indicates that GWPSs will be achieved at all well locations within approximately 24 years after closure under both the CIP and CBR closure scenarios. Additionally, changing geochemical conditions during an extended excavation can be a mechanism that results in mobilization and increased transport in groundwater for some constituents. This may result in GWPS exceedance durations in excess of the model predictions.
Long-Term Reliability of the Engineering and Institutional Controls (Section 2.2.7; IAC Section 845.710(b)(1)(G))	CIP would be expected to be a reliable closure alternative over the long term.	CBR-Offsite-Truck would be expected to be a reliable closure alternative over the long term.	CBR-Offsite-Barge would be expected to be a reliable closure alternative over the long term.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP	**CBR-Offsite-Truck**	**CBR-Offsite-Barge**
Potential Need for Future Corrective Action Section 2.2.8; IAC Section 845.710(b)(1)(H))	Corrective action is expected at the Site. A Preliminary Corrective Measures Assessment (CMA) that presents and evaluates the corrective measures being considered at the Site, consistent with the requirements listed in IAC Section 845.660, is provided as an attachment to the Closure Plan (Geosyntec, 2022a).	Corrective action is expected at the Site. A Preliminary Corrective Measures Assessment (CMA) that presents and evaluates the corrective measures being considered at the Site, consistent with the requirements listed in IAC Section 845.660, is provided as an attachment to the Closure Plan (Geosyntec, 2022a).	Corrective action is expected at the Site. A Preliminary Corrective Measures Assessment (CMA) that presents and evaluates the corrective measures being considered at the Site, consistent with the requirements listed in IAC Section 845.660, is provided as an attachment to the Closure Plan (Geosyntec, 2022a).
Effectiveness of the Alternative in Controlling Future Releases (Section 2.3; IAC Section 845.710(b)(2)(A and B))	Due to the planned closure and corrective measures presented in this report that will be implemented at the Site, potential releases of CCR-related constituents will decline over time, and the migration of potentially impacted groundwater off Site will be mitigated as a result of closure and the corrective actions that will be implemented at the Site under all of the evaluated closure scenarios. Consequently, potential exposures to CCR-related constituents in the environment will also decline. During closure, there would be minimal risk of dike failure occurring and minimal risk of dike overtopping during flood conditions. Post-closure, the risks of overtopping and dike failure would be even lower than they are currently, due to the installation of a protective soil cover and new stormwater control structures. The dikes, final cover, and stormwater control features have been designed to withstand earthquakes and storm events.	Due to the planned closure and corrective measures presented in this report that will be implemented at the Site, potential releases of CCR-related constituents will decline over time, and the migration of potentially impacted groundwater off Site will be mitigated as a result of closure and the corrective actions that will be implemented at the Site under all of the evaluated closure scenarios. Consequently, potential exposures to CCR-related constituents in the environment will also decline. During closure, there would be minimal risk of dike failure occurring and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure.	Due to the planned closure and corrective measures presented in this report that will be implemented at the Site, potential releases of CCR-related constituents will decline over time, and the migration of potentially impacted groundwater off Site will be mitigated as a result of closure and the corrective actions that will be implemented at the Site under all of the evaluated closure scenarios. Consequently, potential exposures to CCR-related constituents in the environment will also decline. During closure, there would be minimal risk of dike failure occurring and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure.
Ease or Difficulty of Implementing the Alternative (Section 2.4; IAC Section 845.710(b)(3))			
▪ *Degree of Difficulty Associated with Construction*	CIP is a reliable and standard method for managing and closing waste impoundments. Dewatering saturated CCRs to construct a stabilized final cover system subgrade may present challenges during closure; however, these challenges are common to most CCR surface impoundment closures and are commonly addressed *via* surface water management and dewatering techniques.	Relative to CIP, the two CBR-Offsite scenarios pose additional implementation difficulties due to higher earthwork volumes, higher dewatering volumes, and longer construction schedules. Hauling the excavated CCRs to an off-Site landfill would be required under the CBR-Offsite-Truck scenario. Because the CCRs would be hauled on public roads under this scenario, this analysis assumes a haul truck capacity of 16.5 CY (*versus* haul trucks with a 34 CY capacity that could be used on Site). The CCRs being hauled would also need to be dewatered to a greater extent than would be necessary under the CIP scenario. Disposing of the excavated CCRs in an off-Site landfill would additionally require the development of a disposal plan and could raise issues related to the co-disposal of CCRs and other non-hazardous wastes. The off-Site landfill may also need to be expanded to receive all of the excavated CCRs.	Relative to CIP, the two CBR-Offsite scenarios pose additional implementation difficulties due to higher earthwork volumes, higher dewatering volumes, and longer construction schedules. Additionally, for the CBR-Offsite-Barge scenario, CCR loading and unloading terminals would need to be permitted and constructed at both the Site and the Port of Cates landing. Transporting the excavated CCRs to an off-Site landfill would be required under the CBR-Offsite-Barge scenario. Because the CCRs would be hauled from the barge unloading terminal to the off-Site landfill on public roads under this scenario, this analysis assumes a haul truck capacity of 16.5 CY (*versus* haul trucks with a 34-CY capacity that could be used on Site). The CCRs being transported would also need to be dewatered to a greater extent than would be necessary under the CIP scenario. Disposing of the excavated CCRs in an off-Site landfill would additionally require the development of a disposal plan and could raise issues related to the co-disposal of CCRs and other non-hazardous wastes. The off-Site landfill may also need to be expanded to receive all of the excavated CCRs.
▪ *Expected Operational Reliability*	Operational reliability would be expected under all of the evaluated closure scenarios.	Operational reliability would be expected under all of the evaluated closure scenarios.	Operational reliability would be expected under all of the evaluated closure scenarios.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP	**CBR-Offsite-Truck**	**CBR-Offsite-Barge**
▪ *Need for Permits and Approvals*	Permits required under all of the evaluated closure scenarios would include a modification to the existing NPDES permit, a construction permit from the IDNR Dam Safety Program to allow the embankment and spillways of the EAP to be modified as part of closure, a construction stormwater permit through IEPA, and a joint water pollution control construction and operating permit (WPC permit). A joint 404/401 permit will also be required from US ACE/ IEPA for the excavation of CCRs from the 32-acre area outside of the EAP.	Permits required under all of the evaluated closure scenarios would include a modification to the existing NPDES permit, a construction permit from the IDNR Dam Safety Program to allow the embankment and spillways of the EAP to be modified as part of closure, a construction stormwater permit through IEPA, and a joint water pollution control construction and operating permit (WPC permit). Additional permits and approvals may be required under this scenario if the off-Site landfill must be expanded to receive all of the excavated CCRs. A joint 404/401 permit will also be required from US ACE/IEPA for the excavation of CCRs from the 32-acre area outside of the EAP.	Permits required under all of the evaluated closure scenarios would include a modification to the existing NPDES permit, a construction permit from the IDNR Dam Safety Program to allow the embankment and spillways of the EAP to be modified as part of closure, a construction stormwater permit through IEPA, and a joint water pollution control construction and operating permit (WPC permit). Additional permits and approvals may be required under this scenario if the off-Site landfill must be expanded to receive all of the excavated CCRs and for the construction of CCR loading and unloading terminals at the Site and the Port of Cates landing. A joint 404/401 permit will also be required from US ACE/IEPA for excavation of the CCRs from the 32-acre area outside of the EAP.
▪ *Availability of Equipment and Specialists*	CIP and CBR rely on common construction equipment and materials and typically do not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under all of the evaluated closure scenarios if supply chain resilience does not improve by the time of construction. Due to the smaller earthwork volumes involved and a reduced need for construction equipment under the CIP scenario than under the two CBR-Offsite scenarios, shortages may cause fewer challenges under the CIP scenario than under the two CBR-Offsite scenarios.	CIP and CBR rely on common construction equipment and materials and typically do not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under all of the evaluated closure scenarios if supply chain resilience does not improve by the time of construction. Due to the higher earthwork volumes involved and a greater need for construction equipment under the two CBR-Offsite scenarios than under the CIP scenario, shortages may cause greater challenges under the two CBR-Offsite scenarios than under the CIP scenario. The current shortage of truck drivers, trucks, and trailers may be particularly impactful under the CBR-Offsite-Truck scenario, due to the large volumes of CCRs to be hauled from the Site to the off-Site landfill *via* haul trucks, as approximately 100 trucks would need to be dedicated to hauling CCRs on a full-time basis.	CIP and CBR rely on common construction equipment and materials and typically do not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under all of the evaluated closure scenarios if supply chain resilience does not improve by the time of construction. Due to the higher earthwork volumes involved and a greater need for construction equipment under the two CBR-Offsite scenarios than under the CIP scenario, shortages may cause greater challenges under the two CBR-Offsite scenarios than under the CIP scenario. The current shortage of truck drivers, trucks, trailers, tugboat operators, and barges may be particularly impactful under the CBR-Offsite-Barge scenario, due to the large volumes of CCRs to be hauled from the Site to the off-Site landfill *via* haul trucks and barge, as approximately 40 trucks would need to be dedicated to hauling CCRs on a full-time basis.
▪ *Available Capacity and Location of Treatment, Storage, and Disposal Services*	Under the CIP scenario, all of the CCRs currently within the EAP, as well as CCRs that were disposed of outside the EAP, would be stored within the existing footprint of the impoundment, in a smaller "CIP area." Treatment would consist of unwatering the EAP at the start of construction, performing dewatering to stabilize the CCRs subgrade, and managing stormwater inflow. Water from unwatering and dewatering of the EAP would be discharged in accordance with the NPDES permit for the facility.	The permitted capacity remaining at the chosen off-Site landfill (the West End Disposal Facility in Thompsonville, Illinois) would be sufficient to receive all of the CCRs in the EAP, as well as from areas outside the EAP. However, due to the relatively short period over which CCRs would be received at the landfill, vertical and/or lateral expansions of the landfill may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that would be received and the unique waste characteristics of CCRs. If expansion of the chosen off-Site landfill were found to be impractical or infeasible, an alternative landfill located farther from the Site would need to be identified. A likely alternative to the West End Disposal Facility is the Southern Illinois Regional Landfill in DeSoto, Illinois. Water from unwatering and dewatering of the EAP would be discharged in accordance with the NPDES permit for the facility.	The permitted capacity remaining at the chosen off-Site landfill (the ECM Landfill in Obion, Tennessee) would be sufficient to receive all of the CCRs in the EAP, as well as from areas outside the EAP. However, due to the relatively short period over which CCRs would be received at the landfill, vertical and/or lateral expansions of the landfill may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that would be received and the unique waste characteristics of CCRs. If expansion of the chosen off-Site landfill were found to be impractical or infeasible, an alternative landfill located farther from the Site would need to be identified. An alternative to the ECM Landfill is the North Milam Landfill, Illinois. Water from unwatering and dewatering of the EAP would be discharged in accordance with the NPDES permit for the facility.
Impact of Alternative on Waters of the State (Section 2.5; IAC Section 845.710(d)(4))	No current or future exceedances of any screening benchmarks for surface water would be expected under any of the evaluated closure scenarios.	No current or future exceedances of any screening benchmarks for surface water would be expected under any of the evaluated closure scenarios.	No current or future exceedances of any screening benchmarks for surface water would be expected under any of the evaluated closure scenarios.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP	**CBR-Offsite-Truck**	**CBR-Offsite-Barge**
Potential Modes of Transportation Associated with CBR (Section 2.1; IAC Section 845.710(c)(1)	This factor is not relevant for CIP.	IAC Section 845.710(c)(1) requires that CBR alternatives consider multiple methods for transporting CCRs off Site, including rail, barge, and trucks. Geosyntec evaluated the feasibility of transporting CCRs to the off-Site landfill *via* rail or barge and found that transportation by rail is not expected to be viable at this Site. Hauling by truck and transportation by a combination of barges and trucks have been identified as viable options for the transportation of CCRs to the off-Site landfill. The local availability and use of natural gas-powered trucks, or other low-polluting trucks, would be evaluated prior to the start of construction under the CBR-Offsite-Truck scenario.	IAC Section 845.710(c)(1) requires that CBR alternatives consider multiple methods for transporting CCRs off Site, including rail, barge, and trucks. Geosyntec evaluated the feasibility of transporting CCRs to the off-Site landfill *via* rail or barge and found that transportation by rail is not expected to be viable at this Site. Hauling by truck and transportation by a combination of barges and trucks have been identified as viable options for the transportation of CCRs to the off-Site landfill. The local availability and use of tugboats, natural gas-powered trucks, or other low-polluting trucks, would be evaluated prior to the start of construction under the CBR-Offsite-Barge scenario.
Concerns of Residents Associated with Alternatives (Section 2.6; IAC Section 845.710(b)(4))	Despite the preference for CBR that has been expressed by some nonprofits, CIP would effectively address residents' concerns regarding the potential risks of dike failure and the potential impacts to groundwater and surface water quality at the Site. Relative to the two CBR-Offsite closure scenarios, CIP also presents less risks to nearby residents and EJ communities in the form of accidents, traffic-related impacts, noise, and air pollution. Moreover, under the CIP scenario, the Site could be more rapidly redeveloped for the installation of a solar facility on the capped impoundment. A public meeting was held on June 30, 2022, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees were addressed at the meeting; subsequently, a written summary of the questions and responses was prepared.	Some nonprofits have expressed a preference for CBR over CIP. However, the two CBR-Offsite closure scenarios have several disadvantages with regard to potential community concerns. Relative to CIP, the CBR-Offsite scenarios present greater risks to nearby residents and EJ communities in the form of accidents, traffic-related impacts, noise, and air pollution. A public meeting was held on June 30, 2022, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees were addressed at the meeting; subsequently, a written summary of the questions and responses was prepared.	Some nonprofits have expressed a preference for CBR over CIP. However, the two CBR-Offsite closure scenarios have several disadvantages with regard to potential community concerns. Relative to CIP, the CBR-Offsite scenarios present greater risks to nearby residents and EJ communities in the form of accidents, traffic-related impacts, noise, and air pollution. A public meeting was held on June 30, 2022, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees were addressed at the meeting; subsequently, a written summary of the questions and responses was prepared.

Notes:
CBR = Closure-by-Removal; CBR-Offsite-Barge = Closure-by-Removal with Off-Site CCR Disposal by Barging; CBR-Offsite-Truck = Closure-by-Removal with Off-Site CCR Disposal by Trucking; CCR = Coal Combustion Residual; CIP = Closure-in-Place; CY = Cubic Yard; EAP = East Ash Pond; EEI = Electric Energy, Inc.; EJ = Environmental Justice; GHG = Greenhouse Gas; GWPS = Groundwater Protection Standard; IAC = Illinois Administrative Code; IDNR = Illinois Department of Natural Resources; IEPA = Illinois Environmental Protection Agency; NPDES = National Pollutant Discharge Elimination System; UA = Uppermost Aquifer; US ACE = United States Army Corps of Engineers.

1 Introduction

1.1 Site Description and History

1.1 Site Location and History

Electric Energy, Inc.'s (EEI) Joppa Power Plant is an electric power generating facility with coal-fired units located near the Village of Joppa, Illinois. The Joppa Power Plant Site is located along the northern bank of the Ohio River, which forms the border between Illinois and Kentucky. The Joppa Power Plant opened in 1953 and the generation of electricity at the plant will stop in 2022 (Ramboll, 2021; Vistra Corp., 2021).

1.1.2 CCR Impoundment

The Joppa Power Plant produces and stores coal combustion residuals (CCRs) as a part of its operations. The East Ash Pond (EAP; Vistra ID No. CCR Unit 401, Illinois Environmental Protection Agency [IEPA] ID No. W1270100004-02, and National Inventory of Dams [NID] ID No. IL50714), shown in Figure 1.1, is the subject of this report. A second CCR-containing surface impoundment, the Joppa West Former Surface Impoundment (Joppa West), is located on the property, to the west of the EAP (Figure 1.1). Joppa West is not the subject of this report.

The EAP is an unlined, 128-acre surface impoundment used for the management of bottom ash, fly ash, and other non-CCR waste generated by the facility. After electricity generation at the Joppa Power Plant ends in 2022, the EAP will no longer receive bottom ash or fly ash.

During normal operations, CCRs from the power plant are sluiced to the southwest corner of the EAP. A third-party recycling company periodically recovers a portion of the ash from the EAP for beneficial re-use. Decanted water discharged from the EAP is ultimately routed to the Ohio River *via* a National Pollutant Discharge Elimination System (NPDES)-permitted outfall (Geosyntec, 2021).

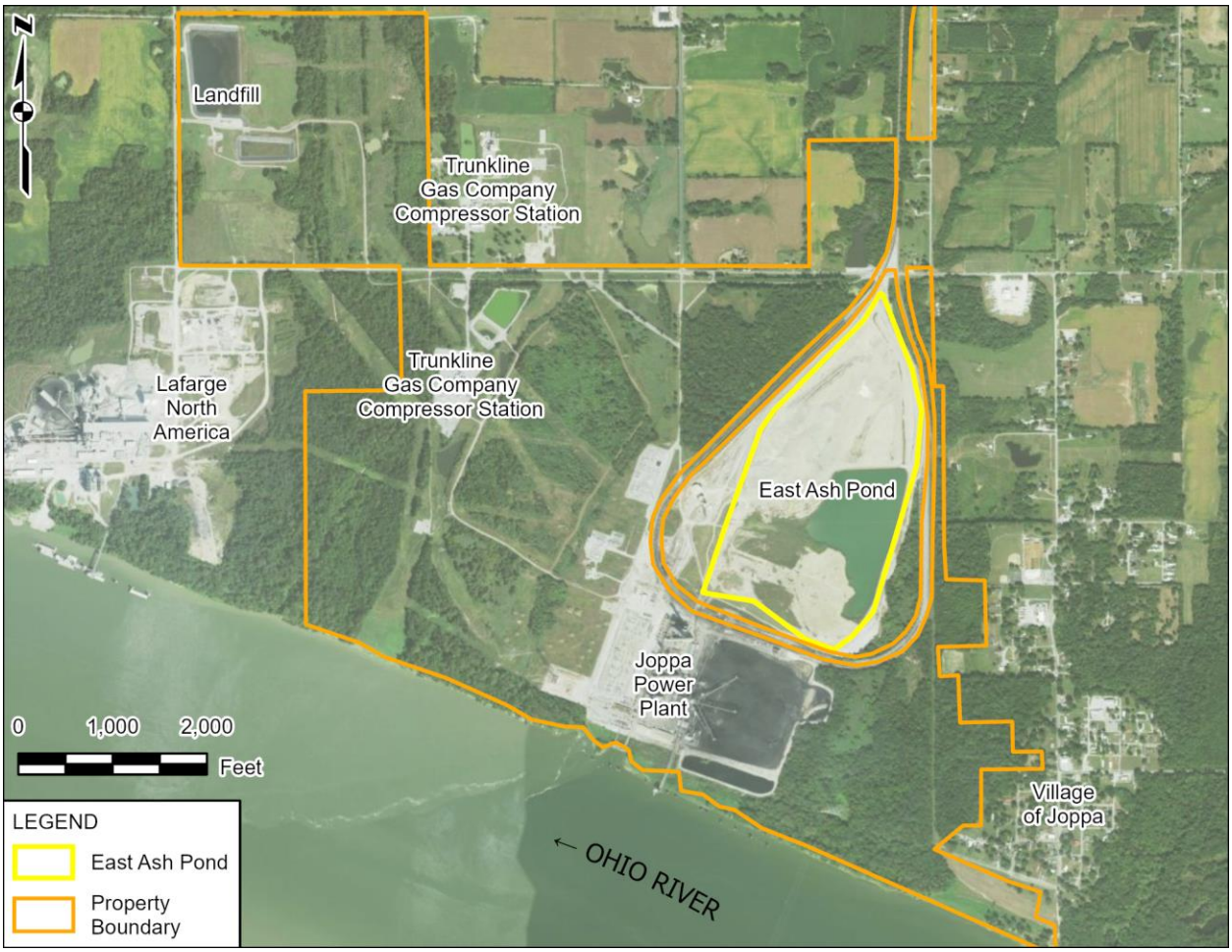

Figure 1.1 Site Location Map. Adapted from Ramboll (2021).

1.1.3 Surface Water Hydrology

The EAP is located within the Bayou Creek-Ohio River Watershed (12-digit Hydrologic Unit Code: 051402060701), which lies within the greater Lower Ohio River Watershed (8-digit Hydrologic Unit Code: 05140206) (AECOM, 2016a; Ramboll, 2021). The Ohio River, which is located approximately 1,600 ft south of the outer perimeter of the EAP, is the largest surface water body in the area. As described above (Section 1.1.2), decanted water discharged from the EAP is routed to the Ohio River *via* an NPDES-permitted outfall (Geosyntec, 2021). The 2020 Kentucky Section 303(d) List states that the segment of the Ohio River adjacent to the Site (Assessment Unit ID: KY-108) is impaired, specifically regarding fish consumption, due to dioxins and polychlorinated biphenyls (PCBs) (US EPA, 2020a). In addition to the Ohio River, several small ponds, streams, and wetlands are located in the vicinity of the EAP (Ramboll, 2021; US FWS, 2021). The closest named freshwater lake is Mermet Lake, which is located approximately 2 miles north of the EAP (Google LLC, 2022).

1.1.4 Hydrogeology

The geology underlying the Site in the vicinity of the EAP consists of four hydrostratigraphic units (Ramboll, 2021):

- **Upper Confining Unit (UCU):** The UCU underlies the CCR unit and consists of the low-permeability silts and clays of the Equality Formation, which are interbedded with thin sand lenses; the silts of the Peoria Silt, Roxana Silt, and Loveland Silt (the "Silt Unit"); and the clays and silts of the Metropolis Formation.
- **Uppermost Aquifer (UA):** The UA underlies the UCU and is comprised of the high-permeability sands and gravel of the Upper McNairy Formation. Discontinuous lenses of clay and silt were also encountered at isolated locations.
- **Lower Confining Unit (LCU):** The LCU underlies the UA and consists of the low-permeability clays and silts of the Lower McNairy Formation.
- **Lower Aquifer Unit (LAU):** The LAU underlies the LCU and consists of the Mississippian Salem Limestone bedrock, which is used as a potable and non-potable water supply in the vicinity of the Joppa Power Plant. The LAU is considered a potential migration pathway (PMP) at the Site.

In the vicinity of the EAP, groundwater migrates downward through the UCU into the UA. Further downward migration is limited by the LCU. Within the UA, groundwater flows generally to the south and southeast toward the Ohio River and the Village of Joppa. The Ohio River is the primary receiving body of water in the vicinity of the Site. Vertical gradients measured between the LAU and the UA indicate that groundwater migrates upward from the LAU to the UA and into the Ohio River.

During groundwater's interaction with surface water, CCR-related constituents may partition between sediments and the surface water column. It should be noted that many CCR-related constituents occur naturally in sediments and surface water (and can also arise from other industrial sources). As a result, their presence in the sediments and/or surface water of the Ohio River does not necessarily signify contributions from the EAP.

The "Hydrogeologic Site Characterization Report" prepared by Ramboll as part of the operating permit for the EAP includes an evaluation of groundwater data collected from EAP monitoring wells between 2015 and 2021 (Ramboll, 2021).

1.1.5 Site Vicinity

The Joppa Power Plant Site is bordered by the Ohio River to the south, the Village of Joppa to the east, a Portland cement plant (LaFarge North America) to the west, and a compressor station for a natural gas pipeline system (Trunkline Gas Company-Joppa Compressor) to the north and west. The Village of Joppa is located immediately to the east of the Joppa Power Plant Site boundary (Google LLC, 2022; US Census Bureau, 2021). The Joppa Public Boat Ramp is located less than 1 mile upstream of the Joppa Power Plant, along the Ohio River. The Mermet Lake State Fish and Wildlife Area (SFWA) and the Mermet Swamp Nature Preserve are both located approximately 2 miles north of the EAP (Google LLC, 2022).

Based on a review of the Illinois Department of Natural Resources (IDNR) Historic Preservation Division database and the Illinois State Archaeological Survey database, there are no historic sites located within 1,000 meters of the EAP (Ramboll, 2021). Based on a review of the IDNR Natural Heritage Database, there are similarly no natural areas or protected areas located within 1,000 meters of the EAP (Ramboll, 2021; Appendix B).

1.2 IAC Part 845 Regulatory Review and Requirements

Title 35, Part 845 of the Illinois Administrative Code (IAC; IEPA, 2021a) requires the development of a Closure Alternatives Analysis (CAA) prior to undertaking closure activities at certain CCR-containing surface impoundments in the State of Illinois. Section 2 of this report presents a CAA for the EAP pursuant to requirements under IAC Section 845.710. The goal of a CAA is to holistically evaluate each potential closure scenario with respect to a wide range of factors, including the efficiency, reliability, and ease of implementation of the closure scenario; its potential positive and negative short- and long-term impacts on human health and the environment; and its ability to address concerns raised by residents (IEPA, 2021a). A CAA is a decision-making tool that is designed to aid in the selection of an optimal closure alternative for the impoundment(s) at a site.

2 Closure Alternatives Analysis

2.1 Closure Alternative Descriptions (IAC Section 845.710(c))

This section of the report presents a CAA for the EAP pursuant to requirements under IAC Section 845.710 (IEPA, 2021a). The three closure scenarios evaluated in this CAA are Closure-in-Place (CIP) with CCR excavation and consolidation, Closure-by-Removal with Off-Site CCR Disposal by Trucking (CBR-Offsite-Truck), and Closure-by-Removal with Off-Site CCR Disposal by Barging (CBR-Offsite-Barge). Under the CIP scenario, all of the CCRs from the EAP, as well as CCRs that were disposed of outside the EAP, would be excavated and consolidated into one area, then capped with a final cover system. Under the CBR-Offsite scenarios, all of the CCRs would be excavated from the EAP, as well as areas outside the EAP, and transported to an off-Site landfill either by truck or by a combination of barges and trucks. EEI will also continue to evaluate potential opportunities for the beneficial re-use of CCRs excavated from the EAP as an alternative to disposal.

IAC Section 845.710(c)(2) requires CAAs to "[i]dentify whether the facility has an onsite landfill with remaining capacity that can legally accept CCR, and, if not, whether constructing an onsite landfill is possible" (IEPA, 2021a). There is an existing landfill (Joppa Landfill) located in the northwestern portion of the Joppa Power Plant property (Ramboll, 2021). The current landfill cell (Cell L1) is only 13.5 acres in size; an additional 13.5-acre cell (Cell L2) was permitted but never constructed (Appendix B). The capacity of the existing landfill is not sufficient to accommodate all of the CCRs that would be excavated from the EAP under a Closure-by-Removal (CBR) scenario (Appendix B). Due to the presence of other features in the immediate vicinity of the landfill, it cannot be expanded laterally to increase its capacity. In addition, vertical expansion of the landfill is not feasible, because such an expansion would potentially render the landfill unstable and would not be consistent with the permitted final cover slopes (Appendix B). Construction of a new on-Site landfill is not feasible due to conflicts related to the potential 100-year floodplain; existing infrastructure, including surface impoundments, utility corridors, and Site roadways; as well as interference with planned future property uses, including the planned construction of a utility-scale battery energy storage facility, or EEI property boundaries (Appendix B). Therefore, expansion of the on-site landfill is not feasible due to limited capacity and inability for expansion.

Sections 2.1.1, 2.1.2, and 2.1.3 provide detailed descriptions of the CIP, CBR-Offsite-Truck, and CBR-Offsite-Barge closure scenarios. These scenarios are based on information and analyses provided to Gradient by Geosyntec, which are attached to this report as Appendix B.

2.1.1 Closure-in-Place

Under the CIP scenario, the CCRs within the EAP and CCRs that were disposed of outside the EAP would be excavated and consolidated into one area, then capped with a final cover system. This scenario includes the following work elements (Geosyntec, 2022a):

- Construction of a temporary water management system, including ditches, sumps, pumps, and/or detention basin(s), within the EAP to collect and discharge stormwater during construction associated with closure. Collected flows will be managed in accordance with the NPDES permit for the Site.

- Elimination of free liquids by solidifying waste residues, as needed, or by removing liquid waste, including *via* pumping and the construction of drilled sumps, engineered trenches, and/or horizontal wells. Water will be managed in accordance with the NPDES permit for the Site.
- Contouring and grading to manage stormwater.
- Relocation and/or modification of existing on-Site powerlines to allow access for construction.
- Demolition and disposal of existing outflow structures and culverts from the EAP to the discharge channel east of EAP that flows to the Ohio River.
- Excavation and consolidation of CCRs from a 54-acre area within the EAP and CCRs located in a 32-acre area outside the EAP into the consolidate-and-cap portion of the EAP. The excavation and consolidation of CCRs will result in CCRs being separated from underlying groundwater during the simulated post-closure conditions by at least 10 feet (Ramboll, 2022).
- Construction of a new soil containment berm to separate the CBR portion within the EAP from the consolidate-and-cap portion.
- Construction of an alternative cover system consisting of a 40-mil linear low-density polyethylene (LLDPE) geomembrane layer, a geotextile protective layer, and 24 inches of protective soil cover suitable for supporting vegetative growth. An alternative cover performance demonstration has been submitted to IEPA for approval pursuant to IAC Section 845.750(c)(2) (Geosyntec, 2022b). A solar facility to be installed atop the cover system is currently being designed. Components of the vegetative cover may change as details of the solar facility are finalized. However, any changes to the cover are expected to be protective of human health and the environment and meet the requirements of IAC Section 845.750(c).
- Long-term (post-closure) monitoring and maintenance, including at least 30 years of groundwater monitoring at the EAP, or until such time as groundwater protection standards (GWPSs) are achieved, whichever is longer. Additionally, 30 years of post-closure care would be undertaken for the final cover system, including annual cap inspections, mowing, and maintenance.

This CIP closure plan meets all closure requirements of IAC Part 845.750 (IEPA, 2021a). Key closure elements that address the Part 845 closure requirements are summarized below. Further details are provided in the Closure Plan (Geosyntec 2022a).

- An alternative cover system would be installed over the consolidated CCRs in the EAP. The cover, consisting of a 40-mil LLDPE geomembrane layer, a geotextile protective layer, and 24 inches of protective soil cover suitable for supporting vegetative growth, would minimize vertical infiltration of precipitation into the basin (IAC Section 845.750(a)(1)) (Geosyntec, 2022b). A solar facility to be installed atop the cover system is currently being designed. Components of the vegetative cover may change as details of the solar facility are finalized. However, any changes are expected to be protective of human health and the environment and meet the requirements of IAC Section 845.750(c).
- The final cover system would be gently sloped to direct surface water away from the EAP. Beyond the final cover system, channels would direct surface water away from the EAP to existing site drainage points (IAC Section Part 845.750(a)(2)).
- Impounded water would be removed from the EAP and managed in accordance with the NPDES permit for the Site (IAC Sections 845.750(b)(1) and 845.750(b)(2)).
- Free liquids in the CCRs would be eliminated by removing liquid wastes or solidifying the remaining wastes. Trenches would facilitate gravity drainage of liquid wastes in the CCRs and direct the liquid wastes to sumps. Other engineering measures, such as drilled sumps and/or

horizontal wells, may also be considered to facilitate the removal of liquid wastes and the stabilization of wastes. Liquid wastes will be managed in accordance with the NPDES permit for the Site (IAC Sections 845.750(b)(1) and 845.750(b)(2)).

- The proposed CIP design will control, minimize, or eliminate, as much as feasible, post-closure infiltration of liquids and releases of CCR, leachate, or contaminated runoff as interpreted by IEPA in the Part 845 rulemaking. Specifically, CIP will result in a reduction of infiltration into the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022). Additionally, CIP will result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022). Due to the reduction in the hydraulic flux out of the EAP, the mass flux out of the EAP will also be controlled or minimized as much as feasible as a result of CIP.

Furthermore, during the closure process, EEI will continue to evaluate potential opportunities for the beneficial re-use of the CCRs excavated at the EAP as an alternative to disposal. Consolidation of the CCRs and CIP, in combination with off-Site beneficial re-use of some of the excavated CCRs, may result in a smaller footprint for the final cover system, along with a shorter construction duration.

A total of approximately 1,900,000 cubic yards (CY) of CCRs from a 54-acre area within the EAP and CCRs disposed of in a 32-acre area outside EAP would be relocated into a "CIP area" under this scenario (Appendix B). The assumed travel distance for the relocation of these materials is 0.5 miles (Appendix B). Construction of the new berm and the final cover system would require approximately 657,000 CY of borrow soil to be hauled from an on-Site source area located within 0.5 miles of the "CIP area." A capacity of 34 CY is assumed for the haul trucks transporting CCRs and borrow soil on Site (Appendix B). Under the CIP scenario, the overall expected duration of construction and earthwork activities is approximately 2.0-3.3 years (24-39 months) (Appendix B). The CIP scenario will meet the required closure schedule (*i.e.*, closure completed by October 2028) defined in IAC Section 845.700(d)(2)(C)(ii) (IEPA, 2021a). Key parameters for the CIP scenario are shown in Table 2.1.

Table 2.1 Key Parameters for the Closure-in-Place Scenario

Parameter	Value
Surface Area of the EAP	128 acres
Surface Area of Final Cover System	74 acres
Volume of CCRs to Be Relocated	1,900,000 CY[a]
Travel Distance for Relocation of CCRs	0.5 mile
Required Volume of Borrow Soil	657,000 CY
Distance to On-Site Borrow Soil Site	0.5 mile
Duration of Construction	2.0-3.3 years
Labor Hours	
Total On-Site Labor	79,200 hours
Total Off-Site Labor	4,680 hours
30% Contingency	25,200 hours
Total Labor Hours:	109,000 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	18,400 miles
Equipment On-Site	501,000 miles
On-Site Haul Trucks (Unloaded + Loaded)	79,100 miles
Labor Mobilization	764,000 miles
Equipment Mobilization (Unloaded + Loaded)	46,800 miles
Off-Site Haul Trucks (Unloaded + Loaded)	113,000 miles
Material Deliveries (Unloaded + Loaded)	200,000 miles
Total On-Site Vehicle and Equipment Travel Miles:	599,000 miles
Total Off-Site Vehicle and Equipment Travel Miles:	1,120,000 miles
Total Vehicle and Equipment Travel Miles:	1,720,000 miles

Notes:
CCR = Coal Combustion Residual; CY = Cubic Yard; EAP = East Ash Pond.
Source: Appendix B.
(a) Due to the expansion that will occur during excavation, the relocation volume is slightly larger than the *in-situ* volume.

2.1.2 Closure-by-Removal with Off-Site CCR Disposal by Trucking

Under the CBR-Offsite-Truck scenario, all of the CCRs would be excavated from the EAP, as well as areas outside the EAP, and transported to an off-Site landfill for disposal. Landfill capacity and permitted use must be taken into consideration for each landfill considered for off-Site disposal of CCRs. For example, a municipal landfill is often designed and permitted to accept waste from the local community at a specific rate. The landfill owner relies on this information to determine the remaining life of a landfill and determine when it will be necessary to expand or close the landfill. Due to the lengthy permitting and construction process, a landfill would need to continue accepting its current waste streams and ash for a significant period of time to be a viable option, assuming the landfill owner and state approve of the landfill choice. Furthermore, given the volume of ash that would need to be transported, it is important to evaluate impacts to communities that will be affected by the increase in truck traffic to and from the landfill. The nearest operating landfill that meets these criteria is the West End Disposal Facility in Thompsonville, Illinois (1710 McFarland Road), which is located approximately 58 road miles from the Site (Appendix B). CCRs would be hauled to the off-Site landfill using haul trucks with an assumed capacity of 16.5 CY. As described below in Section 2.4.5, it is possible that the West End Disposal Facility would have to be expanded in order to accept all of the CCRs excavated from the EAP and areas outside the EAP.

IAC Section 845.710(c)(1) requires that CBR alternatives consider multiple methods for transporting CCRs off-Site, including rail, barge, and trucks. Geosyntec evaluated the feasibility of transporting CCRs to the off-Site landfill *via* rail or barge and found that transportation by rail is not expected to be viable at this Site (Appendix B). There is an established rail terminal and rail spur at the Joppa Power Plant property, but the terminal would require modification for CCR transportation. In addition, a new rail unloading terminal near the off-Site landfill would need to be constructed. Both modification of the existing infrastructure and the new construction necessary would require in coordination with the railroad and additional permitting, which could negatively impact the project schedule. In addition, trucks would still be needed to haul CCRs to and from the rail terminals, and additional CCR exposures could occur during the loading and unloading of CCRs into trucks and rail cars. Moreover, because there is no direct rail route from the Site to the off-Site landfill, the transport of CCRs to the off-Site landfill would require 84 miles of rail transport on tracks owned by three separate rail lines (Appendix B). Therefore, transportation of CCRs by rail to the off-Site landfill is unlikely to be a viable option for this Site. However, Geosyntec found that hauling by truck and transportation by a combination of barges and trucks are viable options for the transportation of CCRs to the off-Site landfill. The latter transportation method is evaluated under the CBR-Offsite-Barge scenario (Section 2.1.3)

The CBR-Offsite-Truck scenario includes the following work elements (Appendix B):

- Dewatering and unwatering to remove liquids from the EAP *via* methods such as pumping. Water would be managed in accordance with the NPDES permit for the facility.
- Construction of a temporary water management system, including ditches, sumps, pumps, and/or detention basin(s), within the EAP to collect and discharge stormwater during construction associated with closure. Collected flows will be managed in accordance with the NPDES permit for the Site.
- Relocation and/or modification of existing on-Site powerlines to allow access for construction.
- Excavation of CCRs from the EAP, as well as areas outside the EAP, and transportation of these materials to the off-Site landfill.
- Reconstruction of a surface creek channel southeast of the EAP, including the removal of sections of the EAP perimeter dike and deep mixing method foundation to clear the surface water flow path.
- Excavation of soils within the EAP embankments to be used as backfill to provide surface water drainage.
- Site restoration, including the placement of 6 inches of topsoil along the side slopes and bottom of the EAP and revegetation with native grasses.
- Monitoring for 3 years post-closure or until such time as GWPSs are achieved, whichever is longer.

A total of approximately 7,120,000 CY of CCRs from areas within the EAP and outside EAP would be hauled to an off-Site landfill under this scenario. To backfill portions of the EAP, 403,000 CY of borrow soil would need to be hauled from an on-Site source area located within 0.5 miles of the impoundment. A capacity of 16.5 CY is assumed for the haul trucks transporting CCRs to the off-Site landfill, and a capacity of 34 CY is assumed for the haul trucks transporting borrow soil on Site (Appendix B). The overall duration of construction and earthwork activities under this closure scenario is approximately 13.9-20.6 years (167-247 months) (Appendix B). The CBR-Offsite-Truck scenario will not meet the required closure schedule (*i.e.*, closure completed by October 2028) defined in IAC Section

845.700(d)(2)(C)(ii) (IEPA, 2021a). Key parameters for the CBR-Offsite-Truck scenario are shown in Table 2.2.

Table 2.2 Key Parameters for the Closure-by-Removal with Off-Site CCR Disposal by Trucking Scenario

Parameter	Value
Surface Area of the EAP	128 acres
Hauled Volume of CCRs	7,120,000 CY[a]
Distance to the Off-Site Landfill	58 miles
Hauled Volume of Borrow Soil	403,000 CY
Distance to the On-Site Borrow Soil Site	0.5 miles
Duration of Construction Activities	13.9-20.6 years
Labor Hours	
Total On-Site Labor	1,400,000 hours
Total Off-Site Labor	42,800 hours
30% Contingency	432,000 hours
Total Labor Hours:	1,870,000 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	137,000 miles
Equipment On-Site	3,940,000 miles
On-Site Haul Trucks (Unloaded + Loaded)	220,000 miles
Labor Mobilization	5,000,000 miles
Equipment Mobilization (Unloaded + Loaded)	428,000 miles
Off-Site Haul Trucks (Unloaded + Loaded)	51,900,000 miles
Material Deliveries (Unloaded + Loaded)	200,000 miles
Total On-Site Vehicle and Equipment Travel:	4,300,000 miles
Total Off-Site Vehicle and Equipment Travel:	57,500,000 miles
Total Vehicle and Equipment Travel:	61,800,000 miles

Notes:
CCR = Coal Combustion Residual; CY = Cubic Yard; EAP = East Ash Pond.
Source: Appendix B.
(a) Due to the expansion that will occur during excavation, the haul volume is slightly larger than the *in-situ* volume.

2.1.3 Closure-by-Removal with Off-Site CCR Disposal by Barging

Under the CBR-Offsite-Barge scenario, all of the CCRs would be excavated from the EAP, as well as areas outside the EAP, and transported to an off-Site landfill for disposal by a combination of barging and trucking (*i.e.*, for trucking, between the unloading terminal and the off-Site landfill). The Joppa Power Plant is located along the Ohio River, and there is an unloading terminal and wharf at the Site that was used to receive coal shipments by barge in the past. The terminal would need to be reconstructed for the loading of CCRs into barges. The preferred landfill for the off-Site disposal of CCRs under this scenario is the ECM Landfill in Obion, Tennessee (2633 Inman Hollow Road), which is located approximately 17 miles from the Port of Cates Landing on the Mississippi River, near Tiptonville, Tennessee, and the Port of Cates landing is located approximately 81 river miles from the Site (Appendix B). CCRs would need to be hauled by truck from the unloading terminal to the off-Site landfill, using haul trucks with an assumed capacity of 16.5 CY.

The major work elements included in the CBR-Offsite-Barge scenario are the same as those discussed in Section 2.1.2 for the CBR-Offsite-Truck scenario, with the exception of the additional requirement that the barge loading and unloading facilities may need to be reconstructed and/or modified.

A total of 7,120,000 CY of CCRs from areas within the EAP and outside EAP would be hauled to an off-Site landfill under this scenario. The CCRs would be transported by a tugboat assumed to be towing nine barges per trip, with each barge assumed to be carrying 1,400 CY of CCRs. To backfill portions of the EAP, 403,000 CY of borrow soil would need to be hauled from an on-Site source area located within 0.5 miles of the impoundment. A capacity of 16.5 CY is assumed for the haul trucks transporting CCRs from the barge unloading terminal to the off-Site landfill, and a capacity of 34 CY is assumed for the haul trucks transporting borrow soil on Site (Appendix B). The overall duration of construction and earthwork activities under this closure scenario is approximately 13.9-20.6 years (167-247 months) (Appendix B). The CBR-Offsite-Barge scenario will not meet the required closure schedule (*i.e.*, closure completed by October 2028) defined in IAC Section 845.700(d)(2)(C)(ii) (IEPA, 2021a). Key parameters for the CBR-Offsite-Barge scenario are shown in Table 2.3.

Table 2.3 Key Parameters for the Closure-by-Removal with Off-Site CCR Disposal by Barging Scenario

Parameter	Value
Surface Area of the EAP	128 acres
Hauled Volume of CCRs	7,120,000 CY[a]
Distance Between Barge Loading and Unloading Terminals (*i.e.*, River Miles)	81 miles
Distance Between Barge Unloading Terminal to the off-Site Landfill	17 miles
Hauled Volume of Borrow Soil	403,000 CY
Distance to the on-Site Borrow Soil Site	0.5 miles
Duration of Construction Activities	13.9-20.6 years
Labor Hours	
Total On-Site Labor	1,190,000 hours
Total Off-Site Labor	42,800 hours
30% Contingency	370,000 hours
Total Labor Hours:	1,600,000 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	137,000 miles
Equipment On-Site	3,940,000 miles
On-Site Haul Trucks (Unloaded + Loaded)	220,000 miles
Labor Mobilization	5,000,000 miles
Equipment Mobilization (Unloaded + Loaded)	428,000 miles
Off-Site Haul Trucks (Unloaded + Loaded)	17,300,000 miles
Barge Miles on River (Unloaded + Loaded)	93,800 miles
Material Deliveries (Unloaded + Loaded)	200,000 miles
Total On-Site Vehicle and Equipment Travel:	4,300,000 miles
Total Off-Site Vehicle and Equipment Travel:	23,000,000 miles
Total Vehicle and Equipment Travel:	27,300,000 miles

Notes:
CCR = Coal Combustion Residual; CY = Cubic Yard; EAP = East Ash Pond.
Source: Appendix B.
(a) Due to the expansion that will occur during excavation, the haul volume is slightly larger than the *in-situ* volume.

2.2 Long- and Short-Term Effectiveness of the Closure Alternative (IAC Section 845.710(b)(1))

2.2.1 Magnitude of Reduction of Existing Risks (IAC Section 845.710(b)(1)(A))

This section of the report addresses the potential risks to human and ecological receptors due to exposure to CCR-associated constituents in groundwater or surface water. Gradient has performed a Human Health and Ecological Risk Assessment for the Site (Appendix A of this report), which provides a detailed evaluation of the magnitude of existing risks to human and ecological receptors associated with the EAP. There are no current unacceptable risks to any human or ecological receptors associated with the EAP for all pathways and receptors, with the potential exception of residents in the Village of Joppa who may use groundwater from the UA as a source of drinking water. For the drinking water pathway, conservatively estimated concentrations of several constituents exceed their respective screening-level benchmarks (Appendix A). For these constituents, further evaluation is being conducted to determine if there are any receptors and to better characterize potential future exposure concentrations. This evaluation will be performed and addressed in the Corrective Action Alternatives Analysis (CAAA), because any future off-Site groundwater concentrations will decline over time both as a result of the planned closure of the EAP and the corrective actions that will be implemented at the Site. It should be noted that based on the results of the windshield survey conducted within the Village of Joppa, we do not believe that there are any current residents who use groundwater from the UA as a source of drinking water.

2.2.2 Likelihood of Future Releases of CCR (IAC Section 845.710(b)(1)(B))

This section of the report quantifies the risk of future releases of CCRs that may occur during dike failure and storm-related events.

Storm-Related Releases and Dike Failure During Flood Conditions

Based on the effective Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map for the Site, the EAP is not located within the 100-year flood zone for the Ohio River (AECOM, 2016b; FEMA, 1983). Engineering analyses show that the risk of overtopping occurring during flood conditions is also minimal under current conditions. Specifically, AECOM and Geosyntec evaluated the risk of flood overtopping occurring at the EAP and found that the impoundment can adequately manage flow during peak discharge from a calculated probable maximum flood event, thus preventing overtopping (AECOM, 2016b; Geosyntec, 2021). Additionally, engineering analyses show that the EAP dikes are expected to remain stable under static, seismic, and flood conditions (AECOM, 2016c; Geosyntec, 2021). Prior to closure (*i.e.*, under current conditions), the risk of dike failure occurring during floods or other storm-related events is therefore minimal. Post-closure, the risks of overtopping and dike failure occurring due to floods or other storm-related events would be even lower than they are currently. Under the CIP scenario, a new cover system would be installed, which would include 24 inches of soil and a geomembrane liner, as well as new stormwater control structures. Relative to current conditions, this cover system would provide increased protection against berm and surface erosion, precipitation infiltration, and other adverse effects that could potentially trigger a dike slope failure event. Under the two CBR-Offsite scenarios, all of the CCRs in the EAP would be excavated and relocated to an off-Site landfill, eliminating the risk of a CCR release from the impoundment occurring post-closure. In summary, there is minimal current or future risk of sudden CCR releases occurring under any of the evaluated closure scenarios either during or following closure.

Dike Failure Due to Seismicity

Sites in Illinois may be subject to seismic risks arising from the Wabash Valley Seismic Zone and the New Madrid Seismic Zone (IEMA, 2020). Although the Joppa Power Plant property is located within a seismic impact zone, as defined in 40 Code of Federal Regulations (CFR) Section 257.53 and IAC Section 845.120, all structural components of the EAP embankments have been evaluated and were found to be able to resist the maximum horizontal acceleration in lithified earth material estimated to occur for a 2% probability of an exceedance in 50 years for the Site. The EAP therefore meets the seismic safety requirements of 40 CFR Section 257.63(a) and IAC Section 845.330(a), and the overall risk of dike failure due to seismicity is expected to be low (Haley & Aldrich, Inc., 2018a; Ramboll, 2021). Additionally, the EAP does not lie within 200 ft of an active fault or fault damage zone at which displacement has occurred within the current geological epoch (*i.e.*, within the last ~11,650 years; Haley & Aldrich, Inc., 2018b). The nearest known fault is located approximately 0.2 miles northwest of the EAP, within the Lusk Creek Fault Zone (LCFZ). Faults within the LCFZ do not have known recent activity (Haley & Aldrich, Inc., 2018b). Thus, the risk of dike failure occurring during or following closure activities due to seismic activity is exceedingly low at the EAP.

2.2.3 Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (IAC Section 845.710(b)(1)(C))

The long-term operation and management plans for the EAP under each closure scenario are described in Section 2.1 (Closure Alternatives Descriptions). In summary, under the CIP scenario, the EAP would undergo monitoring for 30 years post-closure, or until such time as GWPSs are achieved. Under the two CBR-Offsite scenarios, the EAP would undergo monitoring for 3 years post-closure, or until such time as GWPSs are achieved. The post-closure care plan for the CIP scenario would additionally include annual inspections, mowing, and maintenance of the final cover system.

2.2.4 Short-Term Risks to the Community or the Environment During Implementation of Closure (IAC Section 845.710(b)(1)(D))

2.2.4.1 Worker Risks

Best practices would be employed during construction in order to ensure worker safety and comply with all relevant regulations, permit requirements, and safety plans. However, it is impossible to completely eliminate the risk of accidents occurring during construction activities, both on and off Site. On-Site accidents include injuries and deaths arising from the use of heavy equipment and/or earthmoving operations during construction activities. Off-Site accidents include injuries and deaths due to vehicle accidents during labor and equipment mobilization/demobilization, material deliveries, and the hauling of CCRs.

As shown in Tables 2.1 through 2.3, Geosyntec estimates that the CIP scenario would require 79,200 on-Site labor hours (Appendix B). The CBR-Offsite-Truck scenario would require approximately 1,400,000 on-Site labor hours, and the CBR-Offsite-Barge scenario would require approximately 1,190,000 on-Site labor hours. The US Bureau of Labor Statistics (US DOL, 2020a,b) provides an estimate of the hourly fatality and injury rates for construction workers. Based on the accident rates reported by the US Bureau of Labor Statistics and the on-Site labor hours reported in Appendix B, we estimate that approximately 0.91 worker injuries and 0.006 worker fatalities would occur on Site under the CIP scenario; approximately 16.1 worker injuries and 0.105 worker fatalities would occur on Site under the CBR-

Offsite-Truck scenario; and approximately 13.8 worker injuries and 0.089 worker fatalities would occur on Site under the CBR-Offsite-Barge scenario (Table 2.4). The rate of on-Site worker accidents is therefore expected to be highest under the CBR-Offsite-Truck scenario and lowest under the CIP scenario.

Table 2.4 Expected Number of On-Site Worker Accidents Under Each Closure Scenario

Closure Scenario	Injuries	Fatalities
CIP	0.91	0.006
CBR-Offsite-Truck	16.1	0.105
CBR-Offsite-Barge	13.8	0.089

Notes:
CBR-Offsite-Barge = Closure-by-Removal with Off-Site CCR Disposal by Barging; CBR-Offsite-Truck = Closure-by-Removal with Off-Site CCR Disposal by Trucking; CCR = Coal Combustion Residual; CIP = Closure-in-Place.

Off-Site, a greater number of haul truck miles, labor and equipment mobilization/demobilization miles, and material delivery miles would be required under the two CBR-Offsite scenarios than would be required under the CIP scenario (Tables 2.1 through 2.3). Under the CBR-Offsite-Truck scenario, 57,500,000 total off-Site vehicle and equipment travel miles would be required; under the CBR-Offsite-Barge scenario, 23,000,000 total off-Site vehicle and equipment travel miles (including 22,900,000 road miles for car and haul truck use, and 93,800 river miles for barge use) would be required (Appendix B). In contrast, under the CIP scenario, only 1,120,000 total off-Site vehicle and equipment travel miles would be required (Appendix B). The United States Department of Transportation (US DOT, 2020) provides estimates of the expected number of fatalities and injuries "per vehicle mile driven" for drivers and passengers of large trucks and passenger vehicles. Table 2.5 shows the expected number of off-Site accidents under each closure scenario due to all categories of off-Site vehicle usage. For these calculations, it was assumed that labor mobilization/demobilization would rely upon passenger vehicles (cars or light trucks, including pickups, vans, and sport utility vehicles) and that hauling, equipment mobilization/demobilization, and material deliveries would rely upon large trucks. Based on US DOT's accident statistics and the mileage estimates in Appendix B, an estimated 0.52 worker injuries and 0.007 worker fatalities would be expected to occur due to off-Site activities under the CIP scenario; an estimated 9.8 worker injuries and 0.19 worker fatalities would be expected to occur due to off-Site activities under the CBR-Offsite-Truck scenario; and an estimated 5.4 worker injuries and 0.091 worker fatalities would be expected to occur due to off-Site activities under the CBR-Offsite-Barge scenario.

Table 2.5 Expected Number of Off-Site Worker Accidents Related to Off-Site Car and Truck Use Under Each Closure Scenario

Off-Site Vehicle Use Category	CIP		CBR-Offsite-Truck		CBR-Offsite-Barge	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
Hauling	0.014	0.00033	6.6	0.15	2.2	0.050
Labor Mobilization/Demobilization	0.47	0.006	3.1	0.039	3.1	0.039
Equipment Mobilization/Demobilization	0.006	0.00014	0.055	0.00124	0.055	0.0012
Material Deliveries	0.026	0.00058	0.026	0.00058	0.026	0.00058
Total:	0.52	0.007	9.8	0.19	5.4	0.091

Notes:
CBR-Offsite-Barge = Closure-by-Removal with Off-Site CCR Disposal by Barging; CBR-Offsite-Truck = Closure-by-Removal with Off-Site CCR Disposal by Trucking; CCR = Coal Combustion Residual; CIP = Closure-in-Place.

In addition to risks associated with haul trucks and other vehicle use, accidents could also happen during barge transportation of CCRs. The US DOT Bureau of Transportation Statistics provides estimates of the expected number of fatalities and injuries related to total freight weight for domestic waterborne transportation[1] (US DOT, 2021). Table 2.6 shows the additional expected number of accidents associated with barge transport under the CBR Off-Site-Barge scenario. Based on the US DOT Bureau of Transportation Statistics's accident statistics and the total weight of the CCRs expected to be hauled by barge (Appendix B), an estimated 1.2 worker injuries and 0.19 worker fatalities would be expected to occur due to vessel casualties and non-vessel-related accidents,

Table 2.6 Expected Number of Worker Accidents Associated with Barge Transportation Under the Closure-by-Removal with Off-Site CCR Disposal by Barging Scenario

Accident Type	Number
Injuries	1.2
Fatalities	0.19

Note:
CCR = Coal Combustion Residual.

Overall, taking into account accidents occurring both on and off Site, as well as accidents occurring specifically during barge transportation (under the CBR-Offsite-Barge scenario), 1.4 worker injuries and 0.013 worker fatalities would be expected to occur under the CIP scenario; 25.9 worker injuries and 0.30 worker fatalities would be expected to occur under the CBR-Offsite-Truck scenario; and 20.4 worker injuries and 0.37 worker fatalities would be expected to occur under the CBR-Offsite-Barge scenario. Thus, overall risks to workers would be higher under the two CBR-Offsite scenarios and lower under the CIP scenario.

In summary, risks to workers due to accidents would be expected to be greater under the two CBR-Offsite scenarios and lower under the CIP scenario. Differences in worker risks between the three scenarios would largely be driven by off-Site activities.

2.2.4.2 Community Risks

Accidents

Vehicle accidents that occur off Site can result in injuries or fatalities among community members as well as workers. Based on the accident statistics reported by US DOT (2020) and the off-Site travel mileages reported in Appendix B, off-Site vehicle accidents could result in an estimated 0.32 injuries and 0.007 fatalities among community members (*i.e.*, people involved in haul truck accidents that are neither haul truck drivers nor passengers, including pedestrians, drivers of other vehicles, *etc*.) under the CIP scenario (Table 2.6). Under the CBR-Offsite-Truck scenario, off-Site vehicle accidents could result in an estimated 20.6 community injuries and 0.72 community fatalities. Under the CBR-Offsite-Barge scenario, off-Site vehicle accidents could result in an estimated 7.8 community injuries and 0.26 community fatalities.

[1] The injuries and fatalities that result from slips, falls, and electrocutions are classified as non-vessel-related incidents, and the injuries and fatalities that result from groundings, collision, fires, and explosions are classified as vessel-related incidents (US DOT, 2021).

Table 2.7 Expected Number of Community Accidents Under Each Closure Scenario

Off-Site Vehicle Use Category	CIP		CBR-Offsite-Truck		CBR-Offsite-Barge	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
Hauling	0.041	0.0015	19	0.69	6.36	0.23
Labor Mobilization/Demobilization	0.19	0.0024	1.2	0.016	1.24	0.016
Equipment Mobilization/Demobilization	0.017	0.00062	0.16	0.0057	0.16	0.0057
Material Deliveries	0.07	0.0027	0.073	0.0027	0.07	0.0027
Total:	0.32	0.007	20.6	0.72	7.8	0.26

Notes:
CBR-Offsite-Barge = Closure-by-Removal with Off-Site CCR Disposal by Barging; CBR-Offsite-Truck = Closure-by-Removal with Off-Site CCR Disposal by Trucking; CCR = Coal Combustion Residual; CIP = Closure-in-Place.

Traffic

Haul routes would be expected to use major arterial roads and highways wherever possible, which would reduce the incidence of traffic. However, the heavy use of local roads for construction operations may result in traffic near the Site and the off-Site landfill, as well as in communities along the haul route. Traffic could potentially cause travel delays on local roads and also cause damage to local roadways.

Traffic may increase temporarily around the Site under all of the evaluated closure scenarios due to the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. However, these impacts would be expected to largely occur at the beginning or end of each work day (for the arrival/departure of the work force), at the beginning or end of the construction period (for equipment mobilization/demobilization), and at specific times throughout the construction period (for material deliveries). These impacts would therefore likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site due to CCR hauling. Under the CBR-Offsite-Truck scenario, hauling-related construction activities would be expected to take approximately 3,570 working days and require approximately 431,000 truckloads of CCRs to be transported from the Site to the off-Site Landfill (Appendix B). Assuming 10-hour work days, a haul truck transporting CCRs would need to pass a given location near the Site as frequently as once every 2.5 minutes[2] on average for approximately 3,570 working days under this closure scenario. Similarly, the CBR-Offsite-Barge scenario requires approximately 431,000 truckloads of CCRs to be transported from the barge unloading terminal to the off-Site landfill, which, assuming 10-hour work days, would result in a haul truck needing to pass a given location near the unloading terminal and the off-Site landfill as frequently as once every 2.5 minutes for approximately 3,570 working days. No off-Site hauling of CCRs is required under the CIP scenario.

Noise

Construction would generate a great deal of noise both in the vicinity of the Site and along haul routes. In a closure impact analysis performed by the Tennessee Valley Authority (TVA, 2015), the authors found that "typical noise levels from construction equipment used for closure are expected to be 85 dBA or less when measured at 50 ft. These types of noise levels would diminish with distance… at a rate of approximately 6 dBA per each doubling of distance and therefore would be expected to attenuate to the recommended EPA noise guideline of 55 dBA at 1,500 ft." As identified in Google Maps (Google LLC, 2022), several residences are located within 1,500 ft of the EAP to the north (along Portland Road) and to the east (in the nearby Village of Joppa). The Joppa Junior & Senior High School is also located within 1,500 ft of the EAP (Google LLC, 2022). Residents, students, and others that live, work, study, or play

[2] This traffic calculation is based on 16.5-CY trucks traveling to (empty) and from (full) the Site, transporting 7,120,000 CY of CCR for 3,570 construction days that are each 10 hours long.

within 1,500 ft of the EAP may be adversely impacted by noise pollution under all of the evaluated closure scenarios. The duration of noise impacts in the vicinity of the EAP would be greater under the two CBR-Offsite scenarios than under the CIP scenario, because the expected duration of construction under both CBR scenarios is expected to be longer (13.9-20.6 years [167-247 months]) than under the CIP scenario (2.0-3.3 years [24-39 months]).

In addition to impacts in the immediate vicinity of planned construction areas at the Site, local roads near the Site and the off-Site landfill (under the CBR-Offsite scenarios only) may also experience noise pollution due to high volumes of truck traffic. As described above (Traffic), the construction schedule for the CBR-Offsite-Truck scenario requires haul trucks to pass by a given location as frequently as once every 2.5 minutes on average for 10 hours each day for approximately 3,570 working days. The construction schedule for the CBR-Offsite-Barge scenario requires haul trucks to pass a given location as frequently as once every 2.5 minutes on average for 10 hours each day for approximately 3,570 days. Dump trucks generate significant noise pollution, with noise levels of approximately 88 decibels or higher expected within a 50-ft radius of the truck (Exponent, 2018). This noise level is similar to the noise level of a gas-powered lawnmower or leaf blower (CDC, 2019). Decibel levels above 80 can damage hearing after 2 hours of exposure (CDC, 2019).

In addition to haul truck impacts, noise pollution may also arise from the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. These impacts would be expected to largely occur at the beginning or end of each work day (for the arrival/departure of the work force), at the beginning or end of the construction period (for equipment mobilization/demobilization), and at specific times throughout the construction period (for material deliveries). These impacts would likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site. In addition, reconstruction/modification of the barge loading and unloading terminals at the Joppa Power Plant Site and Port of Cates Landing, respectively, would also increase the level of noise pollution under the CBR-Offsite-Barge scenario. In summary, noise impacts are likely to be greater under the two CBR-Offsite scenarios and lower under the CIP scenario.

Air Quality

Construction can adversely impact air quality. Air pollution can occur both on Site and off Site (*e.g.*, along haul routes), potentially impacting workers as well as community members. With regard to construction activities, two categories of air pollution are of particular concern: equipment emissions and fugitive dust. The equipment emissions of greatest concern are those found in diesel exhaust. Most construction equipment is diesel-powered, including the dump trucks that would be used to haul material to and from the Site. Diesel exhaust contains numerous air pollutants, including nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs; Hesterberg *et al.*, 2009; Mauderly and Garshick, 2009). Fugitive dust, another major air pollutant at construction sites, is generated by earthmoving operations and other soil- and CCR-handling activities. Along haul routes, an additional source of fugitive dust is road dust along unpaved dirt roads. Careful planning and the use of Best Management Practices (BMPs) such as wet suppression are used to minimize and control fugitive dust during construction activities; however, it is not possible to prevent dust generation entirely.

On Site, emissions would be higher under the CBR-Offsite-Truck and CBR-Offsite-Barge scenarios than under the CIP scenario, due to the greater amount of on-Site vehicle and equipment travel miles required under these scenarios (599,000 total on-Site travel miles under the CIP scenario *vs.* 4,300,000 total on-Site travel miles under both the CBR-Offsite-Truck and the CBR-Offsite-Barge scenarios; Tables 2.1 through 2.3). Off Site, emissions would similarly be higher under the two CBR-Offsite scenarios than under the CIP scenario, due to the greater amount of off-Site vehicle and equipment travel miles required

under these scenarios (1,120,000 total off-Site travel miles under the CIP scenario *vs.* 57,500,000 total off-Site travel miles under the CBR-Offsite-Truck scenario *vs.* 22,900,000[3] total off-Site travel miles under the CBR-Offsite-Barge scenario; Tables 2.1 through 2.3). In addition to off-Site truck emissions, barge transportation would lead to additional emissions under the CBR-Offsite-Barge scenario, which requires travel over a total of 93,800 river miles. However, it is well known that inland barge transportation generates much fewer emissions per ton of cargo moved compared to transportation by truck (NWF, 2022).

Environmental Justice

The State of Illinois defines environmental justice (EJ) communities to be those communities with a minority population above twice the state average and/or a total population below twice the state poverty rate (IEPA, 2019).

IEPA's EJ Start mapping tool (IEPA, 2019) uses income and demographics data collected by the US Census Bureau to map all of the EJ communities throughout the state. In order to extend the boundaries of the EJ Start tool into the neighboring states of Kentucky, Tennessee, and Missouri that may be impacted by the barging of CCRs, Gradient used US Census Bureau data reported in the national-level EJScreen tool (US EPA, 2020b) to create a new EJ community mapping tool that was identical to EJ Start for communities in Illinois but also included EJ communities located in Kentucky, Tennessee, and Missouri.

Gradient's analysis demonstrated that the outer perimeter of the 1-mile buffer zone for the nearest EJ community lies over 7 miles southeast of the EAP, near Metropolis, Illinois (Figure 2.1). As described above (Noise), significant noise impacts due to construction are expected to be limited to potential receptors located within 1,500 ft (0.28 miles) of the Site. Similarly, the air quality impacts of construction are expected to be limited to potential receptors located within 1,000 ft (0.19 miles) of the Site (CARB, 2005; BAAQMD, 2017). Along heavily trafficked roadways, air quality impacts are expected to be limited to potential receptors located within 600 ft of the roadway (0.11 miles; US EPA, 2014). Thus, the EJ community near Metropolis is unlikely to be directly impacted by on-Site air emissions, noise pollution, or other negative impacts arising at the Site. However, it may be impacted by off-Site impacts, including CCR hauling (under the CBR-Offsite-Truck scenario), labor and equipment mobilization/demobilization, and material deliveries. Off-Site impacts due to labor and equipment mobilization/demobilization and material deliveries would be expected to be diffuse (*i.e.*, to span a wide range of transport routes originating over a wide area). Additionally, these impacts would be expected to largely occur at the beginning/end of each work day (for the arrival/departure of the work force), at the beginning/end of the construction period (for equipment mobilization/demobilization), and at specific times throughout the construction period (for material deliveries). Hauling, in contrast, would likely rely on a single transport route (which would be a different route under the two different CBR-Offsite closure scenarios) that would be in continuous use throughout the entire excavation period. Off-Site hauling is therefore more likely to have a significant impact on EJ communities than other types of off-Site vehicle use.

Under the CBR-Offsite scenarios, EJ communities located along the haul routes to the off-Site landfills or near the off-Site landfills may be negatively impacted throughout the excavation period by the air pollution, noise, traffic, and accidents generated by CCR-hauling activities. A review of the EJ communities in Illinois and surrounding states (Figures 2.1 and 2.2) reveals that the preferred off-Site landfills (*i.e.*, the West End Disposal Facility in Thompsonville, Illinois, under the CBR-Offsite-Truck scenario and the ECM Landfill in Obion, Tennessee, under the CBR-Offsite-Barge scenario) are not

[3] This value only includes off-Site road miles for car and haul truck use.

located within the 1-mile buffer zone of an EJ community. However, two of the three major haul routes suggested by Google Maps (Google LLC, 2022) for transporting CCRs to the West End Disposal Facility under the CBR-Offsite-Truck scenario would require hauling CCRs through the buffer zone of the EJ community near Johnston City and Marion, Illinois. The preferred haul truck route (Appendix B) for transporting CCRs from the barge unloading terminal at Port of Cates Landing to the ECM Landfill under the CBR-Offsite-Barge scenario does not require hauling CCRs through the buffer zone of an EJ community. However, the barge traffic from the Site to the unloading terminal on the Ohio River and Mississippi River would go through the buffer zone of several EJ communities including Cairo, Illinois; Hickman, Kentucky; and New Madrid, Missouri, under the CBR-Offsite-Barge scenario (Appendix B; Figure 2.2).

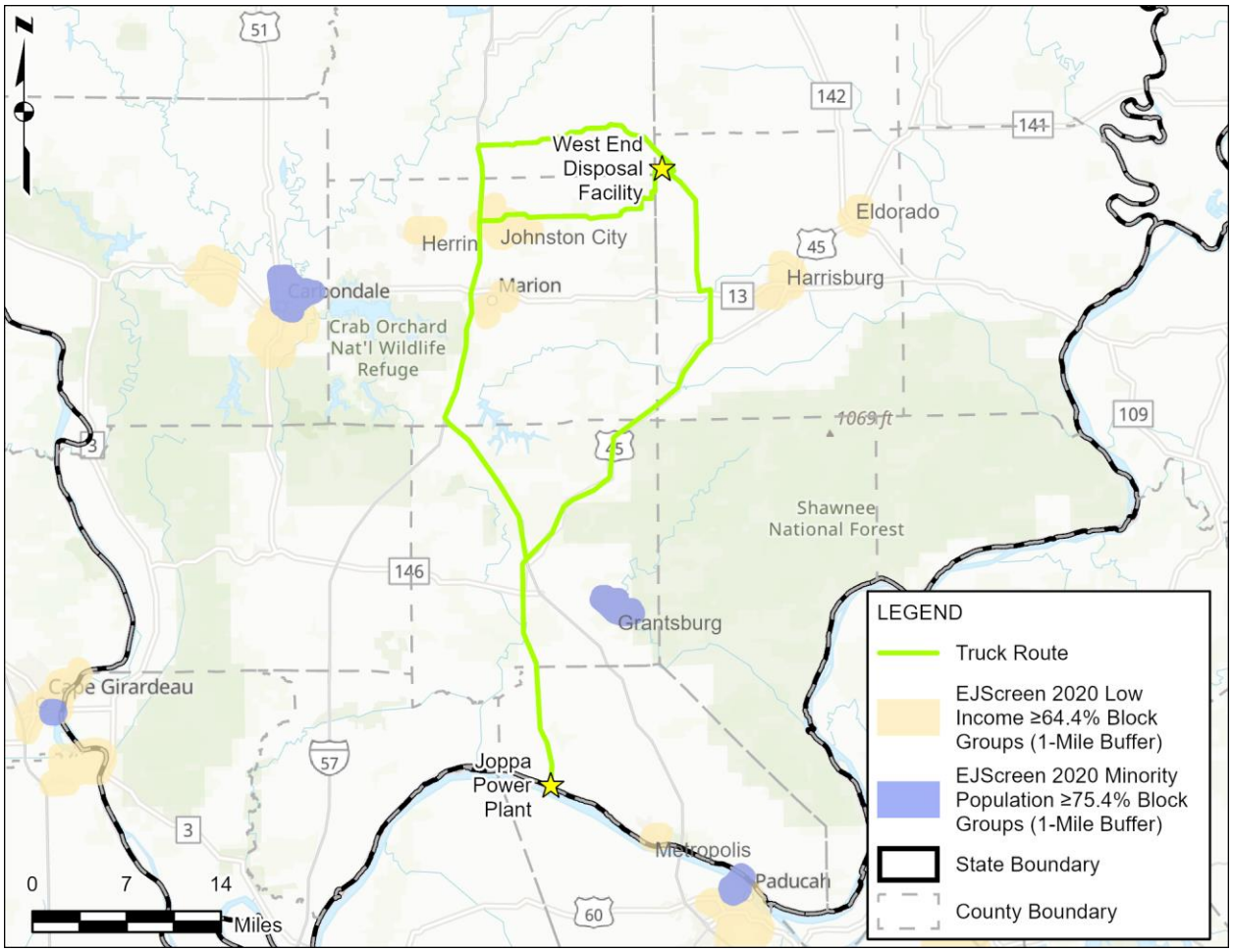

Figure 2.1 Environmental Justice Communities in the Vicinity of the Site and the Off-Site Landfill Under the Closure-by-Removal with Off-Site CCR Disposal by Trucking Scenario. Sources: IEPA (2019); US EPA (2020b); Google LLC (2022).

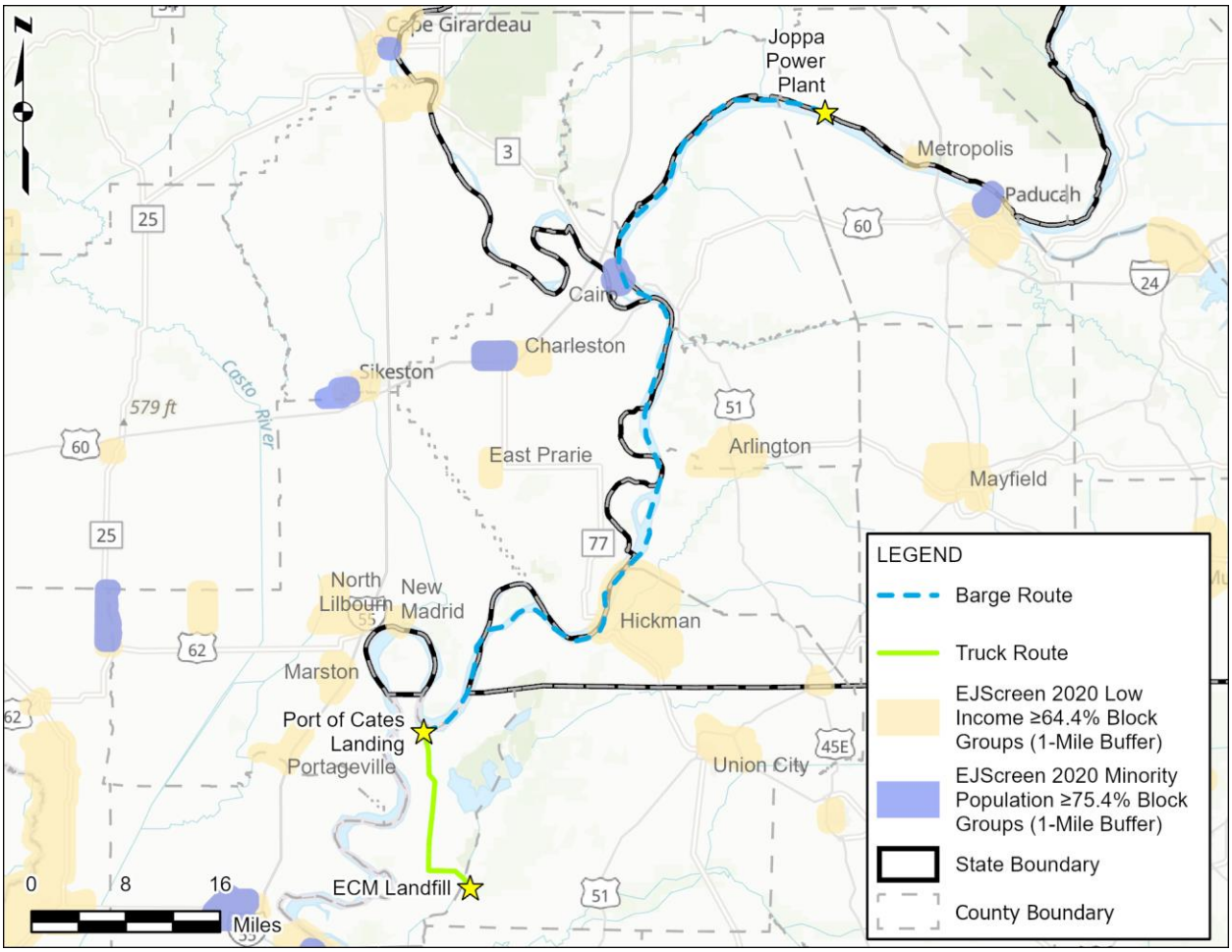

Figure 2.2 Environmental Justice Communities in the Vicinity of the Site and the Off-Site Landfill Under the Closure-by-Removal with Off-Site CCR Disposal by Barging Scenario. Sources: IEPA (2019); US EPA (2020b); Appendix B.

Scenic, Historical, and Recreational Value

There are no notable scenic, historic, or recreational areas located within 1,500 ft of the EAP or the on-Site borrow soil location (Ramboll, 2021). The nearest identified scenic, recreational, or historic areas are the Mermet SFWA and the Mermet Swamp Nature Preserve, which are both located approximately 2 miles north of the EAP (Google LLC, 2022). We therefore do not expect construction activities at the Site to have any direct negative impacts on the scenic, historic, or recreational value of the areas immediately surrounding the Site (due to, *e.g.*, noise, obstructions of the view, or restricted access) under any of the evaluated closure scenarios.

2.2.4.3 Environmental Risks

Greenhouse Gas Emissions

In addition to the air pollutants listed above in Section 2.2.4.2, construction equipment emits greenhouse gases (GHGs), including carbon dioxide (CO_2) and possibly nitrous oxide (N_2O). The potential impact of each closure scenario on GHG emissions is proportional to the potential impact of each closure scenario

on other emissions from construction vehicles and equipment, as described above in Section 2.2.4.2. In summary, GHG emissions from construction equipment and vehicles would be greater under the CBR-Offsite-Truck and CBR-Offsite-Barge scenarios than under the CIP scenario, because the total on-Site and off-Site vehicle and equipment travel miles required under the two CBR-Offsite scenarios (61,800,000 total vehicle and equipment travel miles for the CBR-Offsite-Truck scenario and 27,300,000[4] total vehicle and equipment travel miles for the CBR-Offsite-Barge scenario) are greater than those required under the CIP scenario (1,720,000 total vehicle and equipment travel miles; Tables 2.1 through 2.3).

We did not quantify the carbon footprint of the approximately 74 acres of 40-mil LLDPE geomembrane liner required for the final EAP cover system under the CIP scenario. The carbon footprint of this geomembrane (*i.e.*, the fossil fuel emissions required to manufacture it) is an additional source of GHG emissions at the Site under the CIP scenario. Reconstruction/modification of the barge loading and unloading terminals under the CBR-Offsite-Barge scenario and the potential expansion of the off-Site landfills under both of the CBR-Offsite scenarios would have additional, unquantified carbon footprints due to the manufacture of geomembranes used in the expanded landfill liners and other materials for the terminal reconstruction/modification.

Energy Consumption

Energy consumption at a construction site is synonymous with fossil fuel consumption, because the energy to power construction vehicles and equipment comes from the burning of fossil fuels. Fossil fuel demands considered in this analysis include the burning of diesel fuel during construction activities and the carbon footprint of manufacturing geomembrane textiles. Because GHG emission impacts and energy consumption impacts both arise from the same sources at construction sites, the trends discussed above with respect to GHG emissions also apply to the evaluation of energy demands. Specifically, the energy demands of construction equipment and vehicles would be greater under the two CBR-Offsite scenarios than under the CIP scenario. We did not quantify the energy demands of the reconstruction/modification of the barge loading and unloading terminals under the CBR-Offsite-Barge scenario, the geomembranes required for the construction of the final cover system under the CIP scenario, or, potentially, the geomembranes required for expansion of the off-Site landfills under both of the CBR-Offsite scenarios.

The Joppa Power Plant Site is slated for redevelopment as a utility-scale battery energy storage facility and for the installation of a solar facility on the capped impoundment. The proposed battery storage facility and solar facility will provide additional tax revenue to the local community, create jobs, benefit the reliability of the electrical grid, and support Illinois's path toward 100% clean energy by 2050. The CIP scenario would result in more rapid redevelopment of the Site for the installation of a solar facility on the capped impoundment – and, hence, the more rapid realization of grid-scale solar energy benefits – than the two CBR-Offsite scenarios.

Natural Resources and Habitat

During closure, major construction activities such as the construction of the barge loading and unloading terminals (under the CBR-Offsite-Barge scenario only), the excavation of the EAP and areas outside the EAP, the excavation of the borrow soil area, and, potentially, the expansion of the off-Site landfills (under both of the CBR-Offsite scenarios) may require the destruction of some existing habitat atop portions of these construction areas, resulting in negative impacts to natural resources and habitat within the footprint of these areas. Construction may also have indirect negative impacts on the natural resources and habitat in the immediate vicinity of these locations by causing alarm and escape behavior in nearby wildlife (*e.g.*,

[4] This value includes both haul truck miles and barge river miles.

due to noise disturbances). The duration of time over which various short-term negative habitat impacts might occur due to construction would be longer under the CBR-Offsite-Truck and CBR-Offsite-Barge scenarios than under the CIP scenario, due to the longer expected duration of construction activities (2.0-3.3 years for the CIP scenario *vs.* 13.9-20.6 years for both CBR scenarios). Thus, negative short-term impacts to natural resources and habitat due to closure activities would likely be greater under the two CBR-Offsite scenarios than under the CIP scenario.

The EAP is separated spatially from the Ohio River by the Joppa Power Plant (a buffer distance of at least 1,600 ft; Figure 1.1). For this reason, construction activities at the EAP are unlikely to have a significant negative impact on aquatic species found in the Ohio River (due to, *e.g.*, erosion and sediment runoff). According to the United States Fish & Wildlife Service's (US FWS) National Wetlands Inventory, however, there are some small, discontiguous wetland areas and ponds in the vicinity of the EAP (US FWS, 2021). Wetland and aquatic species in these areas could potentially be subjected to temporary, minor disturbances as a result of closure activities. Terrestrial species located near the EAP could also potentially be temporarily impacted by closure activities. According to the IDNR Natural Heritage Database and the US FWS Environmental Conservation Online System, there are 41 endangered species and 20 threatened species within Massac County (Ramboll, 2021). To our knowledge, however, no threatened or endangered species have been identified at the Site. Based on the information that is currently available, we do not expect construction activities to have negative impacts on any threatened or endangered species.

In addition to the short-term negative habitat impacts caused by construction activities, closure may also result in long-term shifts in the habitat types overlying the major construction locations associated with closure (the EAP, the borrow soil area, and the off-Site landfills). This assessment does not make any value judgments regarding the relative value of the habitat types currently overlying these locations and the habitat types that could potentially overlie these locations post-closure under the various closure scenarios. For example, we did not attempt to determine whether the conversion of open water to grassland within the footprint of the EAP would constitute a positive or negative long-term change with regard to factors such as biodiversity, ecosystem services, or the preferences of recreators/sightseers.

2.2.5 Time Until Groundwater Protection Standards Are Achieved (IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3))

As described above in Section 1.1.4 (Hydrogeology), groundwater and dissolved constituents migrate downward through the UCU in the vicinity of the EAP until they reach the UA. Further downward migration is limited by the LCU. Within the UA, groundwater flows generally southwards towards the Ohio River, with seasonal variations to the southeast and southwest. The Ohio River is the primary receiving body of water in the vicinity of the Site. Vertical gradients measured between the LAU and the UA indicate that groundwater migrates upward from the LAU to the UA and into the Ohio River.

Groundwater elevations near the Joppa Power Plant are primarily controlled by surface water elevations in the Ohio River. Although elevations in the Ohio River can exceed groundwater elevations during flood conditions, periodic flooding of the river has not been observed to result in a reversal of the groundwater flow direction beneath the EAP. Due to seasonal variation, groundwater elevations may fluctuate by approximately 10 ft in the vicinity of the Site (Ramboll, 2021).

Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the EAP under each of the proposed closure scenarios (Ramboll, 2022). The model results demonstrate that the GWPSs in the UA will be achieved within approximately 14 years after closure under both the CIP and CBR closure scenarios at the EAP monitoring wells where average concentrations have been observed

exceeding the boron GWPS of 2 mg/L between 2015 and 2022 (Ramboll, 2022). Additionally, the modeling indicates that GWPSs will be achieved at all UA monitoring well locations within approximately 24 years after closure under both the CIP and CBR closure scenarios (Ramboll, 2022). Because the estimated duration of construction activities for the CBR-Offsite scenarios is so much longer than the duration of construction activities for CIP (2.0-3.3 years for the CIP scenario compared to 13.9-20.6 years for the CBR-Offsite-Truck and CBR-Offsite-Barge scenarios; Section 2.1), CIP may actually achieve the GWPSs faster than either of the CBR-Offsite scenarios.

Additionally, changing geochemical conditions during an extended excavation, like the one associated with the CBR-Offsite scenarios, can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents. This may result in GWPS exceedance durations in excess of the model predictions for the CBR-Offsite scenarios.

2.2.6 Potential for Exposure of Humans and Environmental Receptors to Remaining Wastes, Considering the Potential Threat to Human Health and the Environment Associated with Excavation, Transportation, Re-disposal, Containment, or Changes in Groundwater Flow (IAC Section 845.710(b)(1)(F))

Section 2.2.1 evaluates potential risks to human and ecological receptors arising from the leaching of CCR-associated constituents into groundwater during closure activities and following the closure of the EAP. Section 2.2.2 evaluates the potential for CCR releases to occur due to dike failure or overtopping during floods or other storm-related events. Due to the planned closure and corrective measures presented in this report that will be implemented at the Site, potential releases of CCR-related constituents will decline over time, and the migration of potentially impacted groundwater off Site will be mitigated as a result of closure and the corrective actions that will be implemented at the Site under all of the evaluated closure scenarios. Additionally, there is minimal current or future risk of overtopping occurring at the embankments due to flood conditions at the Site. Dike failure due to, *e.g.*, seismic activity and storm-related events is also exceedingly unlikely.

Section 2.2.4 evaluates several potential risks to human health and the environment during closure activities, including risks of accidents occurring among workers; risks to nearby residents and EJ communities related to accidents, traffic-related impacts, noise, and air pollution; and risks to natural resources and wildlife. The findings from this section of the text are summarized in Table S.1 (Summary of Findings).

2.2.7 Long-Term Reliability of the Engineering and Institutional Controls (IAC Section 845.710(b)(1)(G))

Post-closure, there is minimal risk of engineering or institutional failures leading to sudden releases of CCRs from the EAP under the CIP scenario. There is no post-closure risk of engineering or institutional failures under the two CBR scenarios (see Section 2.2.2 above). Moreover, reliable engineering and institutional controls (*e.g.*, a bottom liner, a leachate management system, and groundwater monitoring) would be implemented at the off-Site landfills under both of the CBR-Offsite scenarios. All of the evaluated closure scenarios are therefore reliable with respect to long-term engineering and institutional controls.

2.2.8 Potential Need for Future Corrective Action Associated with the Closure (IAC Section 845.710(b)(1)(H))

Corrective action is expected at the Site. A Preliminary CMA that presents and evaluates the corrective measures being considered at the Site, consistent with the requirements in IAC Section 845.660, is provided as an attachment to the Closure Plan (Geosyntec, 2022a).

2.3 Effectiveness of the Closure Alternative in Controlling Future Releases (IAC Section 845.710(b)(2))

2.3.1 Extent to Which Containment Practices Will Reduce Further Releases (IAC Section 845.710(b)(2)(A))

Due to the planned closure and corrective measures presented in this report that will be implemented at the Site, potential releases of CCR-related constituents will decline over time, and the migration of potentially impacted groundwater off Site will be mitigated as a result of closure and the corrective actions that will be implemented at the Site under all of the evaluated closure scenarios.

Section 2.2.2 discusses the potential for dike failure or overtopping to occur during or following closure activities, resulting in a sudden release of CCRs. That analysis showed that there is minimal risk of sudden CCR releases occurring during or following closure under any of the evaluated closure scenarios.

2.3.2 Extent to Which Treatment Technologies May Be Used (IAC Section 845.710(b)(2)(B))

Under all three closure scenarios evaluated herein, water generated during the dewatering and unwatering of the EAP would be treated, if necessary, prior to disposal. Following treatment, water from the unwatering and dewatering processes would be discharged to the Ohio River, in accordance with the NPDES permit for the Site.

2.4 Ease or Difficulty of Implementing Closure Alternative (IAC Section 845.710(b)(3))

2.4.1 Degree of Difficulty Associated with Constructing the Closure Alternative

The final cover system that would be used under the CIP scenario is a reliable and standard method for managing and closing impoundments that relies on common construction activities. Dewatering saturated CCRs to construct a stabilized final cover system subgrade can present challenges during closure; however, these challenges are common to most CCR surface impoundment closures and are commonly addressed *via* surface water management and dewatering techniques.

Excavation and landfilling of CCRs is also a reliable and standard method for closing impoundments. However, relative to the CIP scenario, the two CBR-Offsite scenarios pose additional implementation difficulties due to the higher earthwork and dewatering volumes involved, as well as the longer construction schedules required. As described in Section 2.2.4.2 (Community Risks), off-Site hauling of excavated CCRs may also have detrimental impacts due to increased incidences of vehicle accidents, truck traffic, noise, and air pollution.

In addition to off-Site hauling, off-Site landfilling of the excavated CCRs under the CBR-Offsite scenarios may pose particular challenges. A disposal plan would need to be developed by EEI and the owner/operator of the third-party landfill in order to outline acceptable waste conditions upon delivery, daily waste production rates, and the expected duration of the project. Off-Site landfilling may additionally raise issues related to the co-disposal of CCRs and other non-hazardous wastes. Finally, the construction schedule for excavation may be negatively impacted if, during the course of closure, it is determined that the off-Site landfill must be expanded in order to receive all of the materials excavated from the EAP.

The CBR-Offsite-Barge scenario would entail an additional challenge, because it would require the construction of a CCR loading and unloading barge terminal.

2.4.2 Expected Operational Reliability of the Closure Alternative

There is no post-closure risk of operational failures leading to sudden releases of CCRs from the EAP under the two CBR-Offsite scenarios. There is minimal post-closure risk of sudden CCR releases occurring under the CIP scenario, because: (1) the final cover system will be constructed and maintained in accordance with all relevant state and federal safety regulations, and (2) the dikes, final cover, and stormwater control features have all been designed to withstand earthquakes and storm events (see Section 2.2.2 above). Moreover, appropriate operational controls are expected to be implemented at the off-Site landfills under the two CBR-Offsite scenarios. As such, operational reliability would be expected under all of the evaluated closure scenarios.

2.4.3 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies

Permits and approvals would be needed under all of the closure scenarios evaluated herein. Components of the three closure scenarios evaluated herein that would be expected to require a permit include:

- A modification to the existing NPDES permit through IEPA to allow the disposal of water generated from unwatering and dewatering operations to the Ohio River *via* the existing NPDES-permitted outfall for the Site;
- A construction permit from the IDNR Office of Water Resources Dam Safety Program to allow the embankment and spillways of the EAP to be modified as part of closure;
- A construction stormwater permit through IEPA, including construction stormwater controls and other BMPs such as silt fences and other measures;
- A joint water pollution control construction and operating permit (WPC permit); and
- A joint 404/401 permit from the United States Army Corps of Engineers (US ACE)/IEPA for the excavation of CCR from the 32-acre area located outside of the EAP.

As discussed below in Section 2.4.5, under both of the CBR-Offsite scenarios, it may similarly be necessary to expand the off-Site landfills. Additional permitting may be required under these scenarios for the transport of the CCRs and to expand the off-Site landfills. It may also be necessary to modify the operating plan for the off-Site landfills in order to accommodate the increased rate of filling of the landfills and the likely need for additional equipment and personnel to manage the receipt and disposal of the CCRs.

2.4.4 Availability of Necessary Equipment and Specialists

CIP and CBR are reliable and standard methods for managing waste that rely on common construction equipment and materials and typically do not require the use of specialists, outside of typical construction labor and equipment operators. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be some shortages in construction equipment under all of the evaluated closure scenarios, if supply chain resilience does not improve by the time of construction. Alternatively, extended downtime may be required for equipment repairs and maintenance. A national shortage of truck drivers has also developed during the COVID-19 pandemic. Due to the higher earthwork volumes involved and the longer construction duration required under the two CBR-Offsite scenarios than under the CIP scenario, shortages in construction equipment may cause greater challenges under the former two scenarios than under the CIP scenario. The current shortage of truck drivers, trucks, trailers, tugboat operators, and barges may be particularly impactful under the two CBR-Offsite scenarios, due to the large volume of CCRs to be hauled from the Site by truck or by a combination of trucks and barges. If sufficient trucks, truck drivers, vessels, and tugboat operators are not available, the construction schedule at the Site may lengthen based on hauling-related delays. Approximately 100 trucks would be required to transport CCR under the CBR-Truck scenario and approximately 40 trucks would be required to transport CCR under the CBR-Barge scenario; the required quantity of trucks and drivers may not be available in the local area and may cause project delays.

The availability of critical materials such as metal, wood, and electronic chips has also been impacted by the COVID-19 pandemic. However, geomembrane liner materials have generally been available during 2021 and early 2022 for landfill development and closure projects.

2.4.5 Available Capacity and Location of Needed Treatment, Storage, and Disposal Services

Under the CIP scenario, all of the CCRs currently within the EAP, as well as CCRs disposed of outside the EAP, would be stored within the existing footprint of the EAP, in a smaller "CIP area." Treatment would consist of unwatering the EAP at the start of construction, performing limited dewatering to stabilize the CCRs subgrade, and managing stormwater inflow. Water from unwatering and dewatering of the EAP would be discharged in accordance with the NPDES permit for the Site. Under the two CBR-Offsite scenarios, water treatment would similarly consist of unwatering and dewatering the EAP at the start of construction and discharging water from unwatering/dewatering in accordance with the NPDES permit for the Site. Due to the need for dewatering prior to CCR hauling, a higher volume of water would be expected to be generated during dewatering under the two CBR-Offsite scenarios than under the CIP scenario.

For the two CBR-Offsite scenarios, 7,120,000 CY of CCRs would be excavated from the EAP and areas outside the EAP and require disposal. The closest nearby third-party landfill with the ability to receive and dispose of CCRs from the Site is the West End Disposal Facility in Thompsonville, Illinois (Appendix B; IEPA, 2021b). This facility has 12,200,000 CY of remaining capacity in its current permitted footprint. It receives 136,000 CY of waste annually, and is located 58 miles from the Site by road. The West End Disposal Facility therefore has sufficient capacity to receive CCRs from the EAP and areas outside the EAP. However, the closure of the EAP would increase the annual waste receipt rate at the off-Site landfill. Due to the short timeframe over which CCRs would be received at the landfill, vertical and/or lateral expansions of the landfill may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that would be received and the unique waste characteristics of CCRs. Elements of this disposal plan might include

increasing daily operational capacity and procedures, expediting planned airspace construction, and potentially expediting the expansion of the landfill. If expansion of the West End Disposal Facility is impractical or infeasible, an alternative landfill located farther from the Site would need to be identified. A likely alternative to the West End Disposal Facility is the Southern Illinois Regional Landfill in DeSoto, Illinois. It has 18,100,000 CY of remaining capacity in its current permitted footprint, receives 430,000 CY of waste annually, and is located 62 road miles from the Site (Appendix B; IEPA, 2021b).

Similarly, the preferred off-Site landfill (the ECM Landfill in Obion, Tennessee) under the CBR-Offsite-Barge scenario has 21,600,000 CY of remaining capacity in its current permitted footprint. It receives 24,700 CY of waste annually, and is located 17 road miles from the barge unloading terminal at Port of Cates Landing, which is about 81 miles by river from the Site (Appendix B; TDEC, 2021). The ECM Landfill therefore has sufficient capacity to receive CCRs from the EAP and areas outside the EAP. However, the closure of the EAP would increase the annual waste receipt rate at the off-Site landfill. Due to the short timeframe over which CCRs would be received at the landfill, vertical and/or lateral expansions of the landfill may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that would be received and the unique waste characteristics of CCRs. Elements of this disposal plan might include increasing daily operational capacity and procedures, expediting planned airspace construction, and potentially expediting the expansion of the landfill. If expansion of the ECM Landfill is impractical or infeasible, then an alternative landfill located farther from the Site would need to be identified. An alternative to the ECM Landfill is the North Milam Landfill in East St. Louis, Illinois. It has 11,000,000 CY of remaining capacity in its current permitted footprint, receives 756,000 CY of waste annually, and is located approximately 6 road miles from an commercial bulk material handling terminal, which is 205 miles by river from the Site (Appendix B; IEPA, 2021b)

2.5 Impact of Closure Alternative on Waters of the State (IAC Section 845.710(d)(4))

As demonstrated in Gradient's Human Health and Ecological Risk Assessment (Appendix A), both modeled and measured surface water concentrations in the Ohio River are all lower than the relevant human health and ecological screening benchmarks. Surface water concentrations of CCR-associated constituents would be expected to decline over time under all of the evaluated closure scenarios. Thus, no current or future exceedances of any human health or ecological screening benchmarks for surface water would be anticipated under any closure scenario.

The lined landfills that would receive the CCRs excavated from the EAP and areas outside the EAP under the CBR-Offsite scenarios would be managed to ensure that no surface water impacts would occur in the vicinity of the off-Site landfills. In summary, no impacts on any waters of the state would be expected under any of the evaluated closure scenario.

2.6 Concerns of Residents Associated with Closure Alternatives (IAC Section 845.710(b)(4))

Several nonprofits representing community interests near the Site have raised concerns regarding the potential for dike failure to occur at the EAP, as well as the potential impacts of the EAP on groundwater and surface water quality (Earthjustice *et al*., 2018; Lydersen, 2017; Sierra Club and CIHCA, 2014; Sierra Club, 2021). These parties generally prefer CBR to CIP, citing fears that allowing CCRs to remain in place "allows the widespread groundwater contamination to continue indefinitely" (Earthjustice *et al*.,

2018). However, it is not the case that closing the EAP *via* CIP rather than CBR would result in undue risks to groundwater and surface water post-closure. The combination of closure and corrective actions will cause groundwater concentrations to decline over time under all of the closure scenarios evaluated. There is also a nominal risk of future CCR releases occurring due to dike failure under any of the evaluated closure scenarios (Section 2.2.2). Furthermore, groundwater modeling conducted at the Site demonstrated that the GWPSs in the UA will be achieved within similar timeframes under both the CIP and CBR closure scenarios (Ramboll, 2022). All three of the evaluated closure scenarios are therefore responsive to residents' concerns regarding impacts to groundwater and surface water quality.

The CIP scenario has several advantages over the two CBR-Offsite scenarios regarding likely community concerns. Notably, the CIP scenario presents fewer risks to workers, nearby residents, and EJ communities during construction in the form of accidents, traffic-related impacts, noise, and air pollution (Section 2.2.4 above). Closure would also be achieved more rapidly under the CIP scenario than under the two CBR-Offsite scenarios, due to the shorter duration of the required construction activities. Finally, the Site can be more rapidly redeveloped for the installation of a solar facility on the capped impoundment under the CIP scenario than under the two CBR-Offsite scenarios. Redevelopment of the Site for use in energy storage and as a solar facility would bring new jobs to the community and help the state meet its goals of decarbonizing electricity generation.

A public meeting was held on June 30, 2022, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees were addressed at the meeting; subsequently, a written summary of the questions and responses was prepared.

2.7 Class 4 Estimate (IAC Section 845.710(d)(1))

Analyses in the Final Closure Plan were prepared consistent with Class 4 estimates based on the Association for the Advancement of Cost Engineering (AACE) Classification Standard (or a comparable classification practice as provided in the AACE Classification Standard), as required by IAC Section 845.710 (IEPA, 2021a).

2.8 Summary

Table S.1 (Summary of Findings) summarizes the expected impacts of the CIP, CBR-Offsite-Truck, and CBR-Offsite-Barge closure scenarios with regard to each of the factors specified under IAC Section 845.710 (IEPA, 2021a). Based on this evaluation and the details provided in Section 2 above, CIP has been identified as the most appropriate closure scenario for the EAP. Key benefits of the CIP scenario relative to the two CBR-Offsite scenarios include more rapid redevelopment of the Site for the installation of a solar facility on the capped impoundment and greatly reduced impacts to workers, community members, and the environment due to construction activities (*e.g.*, fewer constructed-related accidents, lower energy demands, less air pollution and GHG emissions, reduced duration of traffic-related impacts, and lower impacts to EJ communities). Moreover, the CIP scenario will meet the required closure schedule (*i.e.*, closure completed by October 2028) defined in IAC Section 845.700(d)(2)(C)(ii) (IEPA, 2021a), whereas the CBR-Offsite scenarios will be unable to meet this required schedule.

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Appendix A

Human Health and Ecological Risk Assessment

Human Health and Ecological Risk Assessment
East Ash Pond
Joppa Power Plant
Joppa, Illinois

July 28, 2022

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www.gradientcorp.com
One Beacon Street, 17th Floor
Boston, MA 02108
617-395-5000

Table of Contents

Page

1 Introduction 1

2 Site Overview 3
- 2.1 Site Description 3
- 2.2 Geology/Hydrogeology 4
- 2.3 Conceptual Site Model 4
- 2.4 Groundwater Monitoring 4

3 Risk Evaluation 8
- 3.1 Risk Evaluation Process 8
- 3.2 Human and Ecological Conceptual Exposure Models 9
  - 3.2.1 Human Conceptual Exposure Model 10
    - 3.2.1.1 Groundwater as a Drinking Water/Irrigation Source 11
    - 3.2.1.2 Surface Water as a Drinking Water/Irrigation Source 14
    - 3.2.1.3 Recreational Exposures 14
  - 3.2.2 Ecological Conceptual Exposure Model 14
- 3.3 Identification of Constituents of Interest 15
  - 3.3.1 Human Health Constituents of Interest 15
  - 3.3.2 Ecological Constituents of Interest 16
  - 3.3.3 Surface Water and Sediment Modeling 18
- 3.4 Human Health Risk Evaluation 21
  - 3.4.1 Residents Using Groundwater as Drinking Water 21
  - 3.4.2 Residents Using Groundwater as an Irrigation Source 23
  - 3.4.3 Recreators Exposed to Surface Water 24
  - 3.4.4 Recreators Exposed to Sediment 26
- 3.5 Ecological Risk Evaluation 27
  - 3.5.1 Ecological Receptors Exposed to Surface Water 27
  - 3.5.2 Ecological Receptors Exposed to Sediment 28
  - 3.5.3 Ecological Receptors Exposed to Bioaccumulative Constituents of Interest 29
- 3.6 Uncertainties and Conservatisms 29

4 Summary and Conclusions 32

References 34

Appendix A Surface Water and Sediment Modeling
Appendix B Screening Benchmarks
Appendix C Well Survey Results

List of Tables

Table 2.1 Groundwater Monitoring Wells Related to the East Ash Pond

Table 2.2 Groundwater Data Summary

Table 3.1 Human Health Constituents of Interest

Table 3.2 Ecological Constituents of Interest

Table 3.3 Groundwater and Surface Water Properties Used in Modeling

Table 3.4 Sediment Properties Used in Modeling

Table 3.5 Surface Water and Sediment Modeling Results

Table 3.6 Risk Evaluation for Residents Using Groundwater as Drinking Water

Table 3.7 Refined Screening Evaluation for Drinking Water Pathway

Table 3.8 Refined Risk Evaluation for Residents Using Groundwater as Drinking Water

Table 3.9 Risk Evaluation for Residents Using Private Well Water as an Irrigation Source

Table 3.10 Risk Evaluation for Recreators Exposed to Surface Water

Table 3.11 Risk Evaluation for Recreators Exposed to Sediment

Table 3.12 Risk Evaluation for Ecological Receptors Exposed to Surface Water

Table 3.13 Risk Evaluation for Ecological Receptors Exposed to Sediment

List of Figures

Figure 2.1 Site Location Map

Figure 2.2 Monitoring Well Locations and Groundwater Elevation Contours for the UA

Figure 3.1 Overview of Risk Evaluation Methodology

Figure 3.2 Human Conceptual Exposure Model

Figure 3.3 2021 Well Survey Results

Figure 3.4 Ecological Conceptual Exposure Model

Abbreviations

ADI	Acceptable Daily Intake
BCF	Bioconcentration Factor
BCG	Biota Concentration Guide
CAA	Closure Alternatives Assessment
CCR	Coal Combustion Residual
CEM	Conceptual Exposure Model
COI	Constituent of Interest
COPC	Constituent of Potential Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CWS	Community Water Supply
DWW	Drinking Water Watch
EAP	East Ash Pond
EEI	Electric Energy, Inc.
ESV	Ecological Screening Value
GWPS	Groundwater Protection Standard
GWQS	Groundwater Quality Standard
HTC	Human Threshold Criteria
HQ	Hazard Quotient
IAC	Illinois Administrative Code
IEPA	Illinois Environmental Protection Agency
ILWATER	Illinois Water and Related Wells
ISGS	Illinois State Geological Survey
JPP	Joppa Power Plant
K_d	Equilibrium Partition Coefficient
LAU	Lower Aquifer Unit
LOAEL	Lowest Observed Adverse Effect Level
LCU	Lower Confining Unit
MCL	Maximum Contaminant Level
NGWMN	National Groundwater Monitoring Network
NRWQC	National Recommended Water Quality Criteria
ORNL RAIS	Oak Ridge National Laboratory's Risk Assessment Information System
pCi	Picocurie
PMP	Potential Migration Pathway
PRG	Preliminary Remediation Goal
PWS	Public Water System
RAGS	Risk Assessment Guidance for Superfund
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SDWIS	Safe Drinking Water Information System
SI	Surface Impoundment
SWQS	Surface Water Quality Standards

TEC	Threshold Effect Concentration
UA	Uppermost Aquifer
UCU	Upper Confining Unit
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1 Introduction

Electric Energy, Inc. (EEI), a subsidiary of Vistra Corp., owns and operates the Joppa Power Plant (JPP), a coal-fired power generating facility in Joppa, Illinois. The facility began operations in 1955 and is currently in operation. EEI plans to retire the JPP by September 2022 (Vistra Corp, 2021). The JPP has two surface impoundments (SIs) for the storage of coal combustion residuals (CCR). The East Ash Pond (EAP), which is the subject of this report, is an "unlined CCR SI used to manage CCR and non-CCR waste streams at the JPP" (Ramboll, 2021). The West Ash Pond, known as Joppa West, is inactive (Ramboll, 2021).

This report presents the results of an evaluation that characterizes potential risk to human and ecological receptors that may be exposed to CCR constituents in environmental media potentially impacted by the EAP. This risk evaluation was performed to support the Closure Alternatives Assessment (CAA) for the EAP in accordance with the requirements outlined in Title 35, Part 845 of the Illinois Administrative Code (IAC) (IEPA, 2021). Human and ecological risks were evaluated for Site-specific constituents of interest (COIs). The conceptual site model (CSM) assumed that Site-related COIs may impact groundwater and migrate to the Ohio River and affect surface water and sediment in the vicinity of the Site.

Consistent with United States Environmental Protection Agency (US EPA) guidance (US EPA, 1989), this report used a tiered approach to evaluate potential risks, which included the following steps:

1. Identify complete exposure pathways and develop a conceptual exposure model (CEM).
2. Identify Site-related COIs: A constituent detected in groundwater was considered a COI if its maximum detected concentration over the period of 2015-2021 exceeded a groundwater protection standard (GWPS) identified in Section 845.600 (IEPA, 2021), or a relevant surface water quality standard (SWQS) (IEPA, 2019; US EPA Region IV, 2018).
3. Perform screening-level risk analysis: Compare maximum measured or modeled COI concentrations in surface water and sediment to conservative, health-protective benchmarks to identify constituents of potential concern (COPCs).
4. Perform refined risk analysis: If COPCs are identified, perform a refined analysis to evaluate potential risks associated with the COPCs.
5. Formulate risk conclusions and discuss any associated uncertainties.

This assessment relies on a conservative (*i.e.*, health-protective) approach and is consistent with the risk approaches outlined in US EPA guidance. Specifically, Gradient considered evaluation criteria detailed in Illinois Environmental Protection Agency (IEPA) guidance documents (*e.g.*, IEPA, 2013, 2019), incorporating principles and assumptions consistent with the Federal CCR Rule (US EPA, 2015a) and US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals," referred to herein as the US EPA CCR risk assessment (US EPA, 2014a).

US EPA has established acceptable risk metrics. Risks above these US EPA-defined metrics are termed potentially "unacceptable risks." Even though there are no known current risks associated with exposure to groundwater at the Site, an unacceptable risk was identified for the potential future residential use of shallow groundwater as source of drinking water. No other unacceptable risks to human or ecological receptors resulting from CCR exposures associated with the EAP were identified. Specific risk assessment results include the following:

- Residential use of groundwater from the Uppermost Aquifer (UA) as drinking water was identified as a potential human health risk. However, based on a windshield survey within the Village of Joppa, Gradient does not believe that there are any current residential users of groundwater from the UA.
- No unacceptable risks were identified for residents using groundwater for irrigation of homegrown produce.
- No unacceptable risks were identified for recreators swimming or boating in the Ohio River adjacent to the Site.
- No unacceptable risks were identified for recreators exposed to sediment in the Ohio River adjacent to the Site.
- No unacceptable risks were identified for anglers consuming locally caught fish.
- No unacceptable risks were identified for ecological receptors exposed to surface water or sediment at the Site.
- No bioaccumulative ecological risks were identified.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk. Moreover, due to the planned closure and corrective measures that will be implemented at the Site, future risks are anticipated to be lower than current risks for all receptors and exposure pathways, because potential releases of CCR-related constituents will decline over time and impacted groundwater will be intercepted before it can migrate off Site. Consequently, potential exposures to CCR-related constituents in the environment will also decline.

2 Site Overview

2.1 Site Description

The JPP is located in Massac County, Illinois, west of the Village of Joppa and northeast of the Ohio River, in a predominantly agricultural area (Ramboll, 2021). The JPP Site "is bordered by the LaFarge North America cement plant to the west, the Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south" (Ramboll, 2021) (Figure 2.1). The EAP is located on the eastern portion of the JPP property, "and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa" (Ramboll, 2021).

As stated in Ramboll (2021), "the EAP was built in two phases." The northern portion (Phase I) was completed in late 1973, while the southern portion (Phase II) was completed in late 1985. The northern and southern portions "are separated by a dividing dike (*i.e.*, Central Dike) and were referred to as the Northern and Southern Ponds" (Ramboll, 2021). Both the Northern and Southern Ponds are diked earthen embankment structures with dike heights varying "from approximately 15 to 45 ft above" their outboard toe, and the "Northern Pond is diked over the length of its perimeter" (Ramboll, 2021).

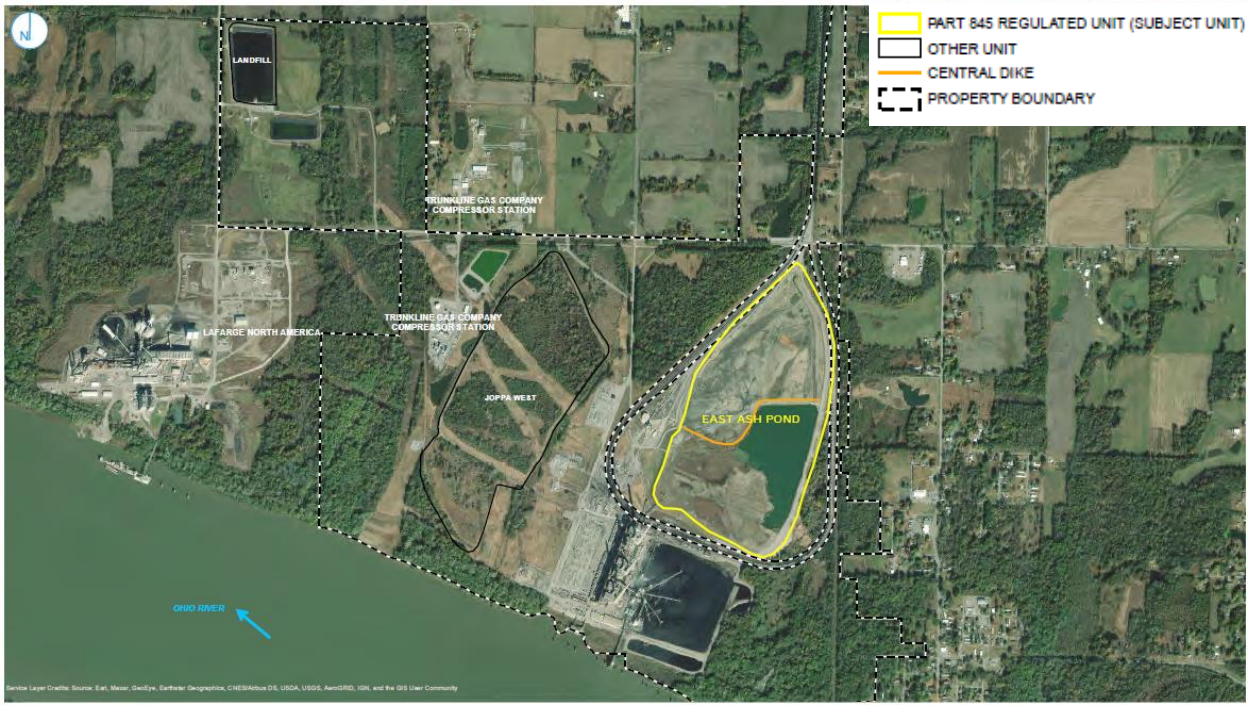

Figure 2.1 Site Location Map. Source: Ramboll (2021).

2.2 Geology/Hydrogeology

The geology underlying the Site in the vicinity of the EAP primarily consists of three hydrostratigraphic layers of unlithified deposits underlain by bedrock (Ramboll, 2021). From the top down, the three unlithified hydrostratigraphic units are the Upper Confining Unit (UCU), consisting of low-permeability silt and clay; the Uppermost Aquifer (UA), consisting of high-permeability sand with gravel and minor silt/clay; and the Lower Confining Unit (LCU), consisting of low-permeability clay and silt (Ramboll, 2021). The lowermost bedrock unit, or Lower Aquifer Unit (LAU), is comprised of limestone. The LAU is "used as a potable and non-potable water supply in the vicinity of the JPP" (Ramboll, 2021).

The UCU consists of the silt and clay of the Equality Formation (14-28 ft thick) and the Metropolis Formation (5-40 ft thick). The average thickness of the UCU is approximately 41 ft (Ramboll, 2021). The UA consists of the sands and gravels of the Upper McNairy Formation, with isolated lenses of silt and clay. Horizontal hydraulic conductivity for the Upper McNairy Formation at the Site is variable, with a geometric mean of 3.1×10^{-3} cm/sec (Ramboll, 2021). The UA is about 58 ft thick and is underlain by the LCU. The LCU overlies the bedrock and consists of the clay and silt of the Lower McNairy Formation, with a maximum thickness of about 14 ft. The LAU is composed of a 200- to 500-ft-thick limestone of the Salem Formation. The LAU was identified as a potential migration pathway (PMP) (Ramboll, 2021). The geometric mean horizontal hydraulic conductivity for the LAU at the Site is 4×10^{-4} cm/sec (Ramboll, 2021). The LAU is transmissive and can support production from the JPP wells.

As stated in Ramboll (2021), "The EAP is located upgradient of the Ohio River." Groundwater in the UA generally flows to the south and southeast toward the Ohio River (Figure 2.2; Ramboll, 2021). Some constituents in groundwater associated with the EAP may have migrated off Site into the areas east of the JPP property, including the Village of Joppa.

2.3 Conceptual Site Model

A CSM describes sources of contamination, the hydrogeological units, and the physical processes that control the transport of water and solutes. In this case, the CSM describes how groundwater underlying the EAP migrates and potentially interacts with surface water and sediment in the adjacent Ohio River. The CSM was developed using available hydrogeologic data specific to the EAP (Ramboll, 2021), including information on groundwater flow and surface water characteristics. Groundwater (and CCR-related constituents) originating from the EAP may migrate vertically downward through the silts and clays of the UCU into the sands and gravels of the UA and ultimately flow to the south and southeast toward the Village of Joppa and the Ohio River. Dissolved constituents in groundwater may partition between river sediments and Ohio River surface water.

2.4 Groundwater Monitoring

A total of 31 wells have been used to monitor groundwater quality near and downgradient of the EAP. Of these, 26 wells are screened in the UA, 4 are screened in the UCU, and 1 is screened in the LAU (Table 2.1) (Ramboll, 2021). The analyses presented in this report relied on all the available data from the 31 wells collected between 2015 and 2022, which is the period subsequent to the promulgation of the Federal CCR Rule. Groundwater samples were analyzed for a suite of total metals, specified in the Illinois CCR Rule, Section 845.600 (IEPA, 2021).[1] A summary of the groundwater data used in this risk evaluation is

[1] Samples were analyzed for a longer list of inorganic constituents and general water quality parameters (chloride, fluoride, sulfate, and total dissolved solids), but these constituents were not evaluated in the risk evaluation.

presented in Table 2.2. The EAP well locations are shown in Figure 2.2, along with the groundwater contour elevations for the UA. The use of groundwater data in this risk evaluation does not imply that any detected constituents are associated with the EAP or that potential groundwater exceedances of any detected constituents have been identified.

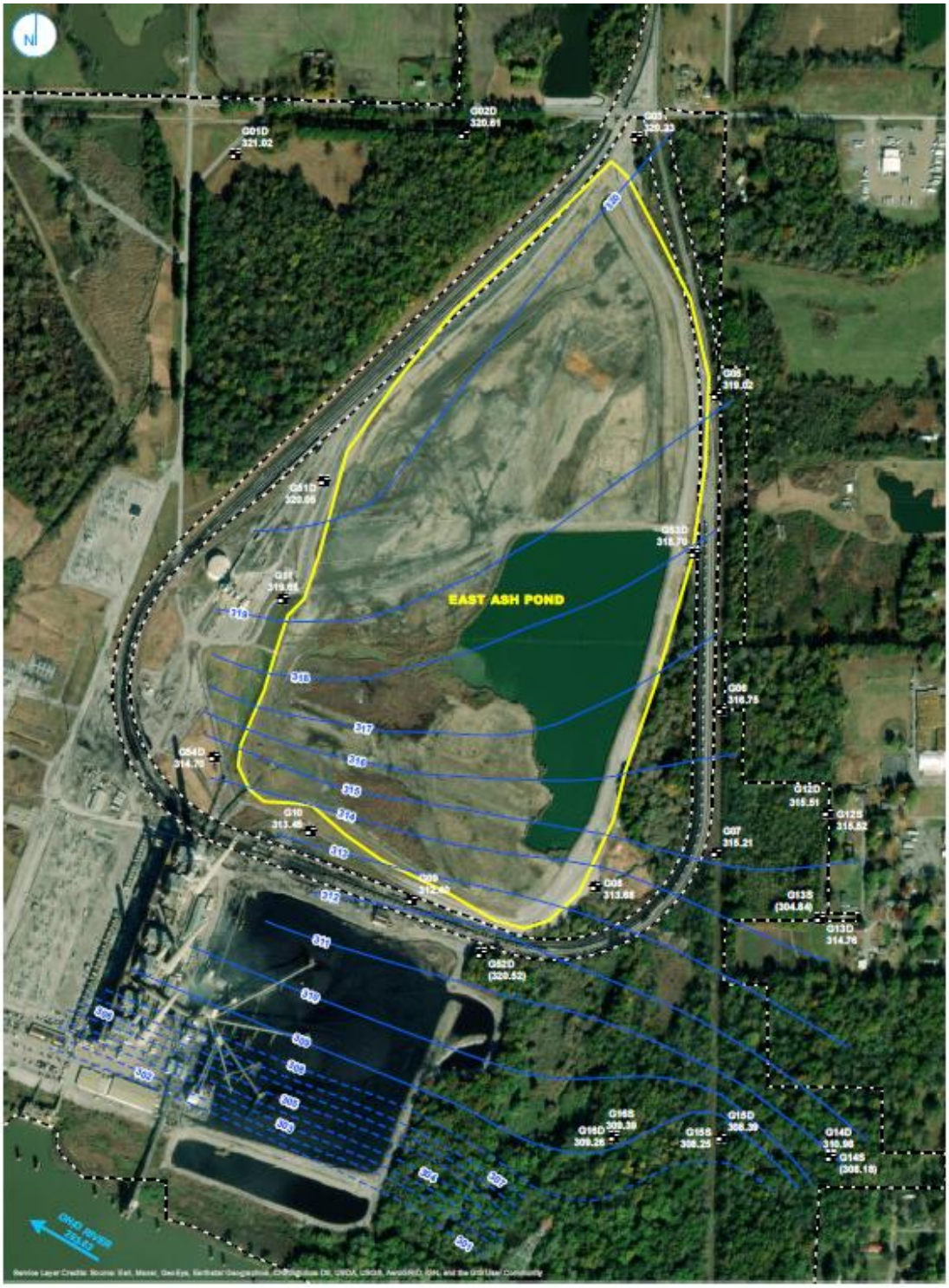

Figure 2.2 Monitoring Well Locations and Groundwater Elevation Contours for the UA. Source: Ramboll (2022a).

Table 2.1 Groundwater Monitoring Wells Related to East Ash Pond

Well	Hydrogeologic Unit	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth (ft bgs)
G01D	UA	08/14/2015	54.2	63.9	64.4
G02D	UA	08/13/2015	62.2	71.8	72.4
G03	UA	02/02/2021	55.0	65.0	65.0
G04	UA	02/02/2021	50.0	60.0	60.0
G05	UA	02/01/2021	50.0	60.0	60.0
G06	UA	01/29/2021	75.0	85.0	85.0
G06S	UA	01/28/2021	30.0	40.0	40.0
G07	UA	01/29/2021	50.0	60.0	60.0
G08	UA	01/28/2021	75.0	85.0	85.0
G09	UA	01/31/2021	59.5	69.5	69.5
G09M	LAU	01/28/2021	145.0	155.0	155.0
G10	UA	02/01/2021	60.3	70.3	70.3
G11	UA	01/19/2021	55.7	65.7	65.7
G12D	UA	09/23/2021	80.0	90.0	90.0
G12S	UA	09/23/2021	60.0	70.0	70.0
G13D	UA	09/23/2021	80.0	90.0	90.0
G13S	UA	09/23/2021	50.0	60.0	60.0
G14D	UA	09/16/2021	120.0	130.0	130.0
G14S	UA	09/16/2021	53.0	63.0	63.0
G15D	UA	09/15/2021	83.0	93.0	93.0
G15S	UA	09/15/2021	50.0	60.0	60.0
G16D	UA	09/14/2021	98.0	108.0	108.0
G16S	UA	09/14/2021	50.0	60.0	60.0
G51D	UA	08/18/2015	49.6	59.3	59.9
G52D	UA	08/19/2015	69.9	79.6	80.0
G53D	UA	08/21/2015	47.3	56.9	57.3
G54S	UCU	01/22/2021	34.7	44.7	44.7
G54D	UA	08/11/2015	70.0	79.7	80.1
G151	UCU	06/19/2010	31.7	41.7	41.7
G152[a]	UCU	06/21/2010	14.7	24.7	24.7
G152B	UCU	01/30/2013	34.4	44.4	44.6
G153	UCU	06/18/2010	29.7	39.7	39.7

Notes:
ft bgs = Feet Below Ground Surface; LAU = Lower Aquifer Unit; UA = Uppermost Aquifer; UCU = Upper Confining Unit.
Sources: Ramboll (2021, 2022a).
(a) No analytical data were available for Well G152.

Table 2.2 Groundwater Data Summary

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	195	ND	ND	0.0010
Arsenic	72	219	0.0010	0.0098	0.0010
Barium	219	219	0.011	0.59	0.0040
Beryllium	2	195	0.0011	0.0012	0.0010
Boron	174	225	0.016	7.2	0.10
Cadmium	2	195	0.0010	0.0018	0.0010
Chromium	225	225	22	178	0.50
Cobalt	84	219	0.0011	0.023	0.0015
Lead	151	219	0.0010	0.0268	0.0010
Lithium	30	219	0.0010	0.0066	0.0010
Mercury	123	219	0.0011	0.010	0.0030
Molybdenum	0	195	ND	ND	0.00020
Selenium	59	195	0.0010	0.0062	0.0015
Thallium	4	195	0.0020	0.0033	0.0020
Radionuclides (pCi/L)					
Radium-226+228	219	219	0	5.9	2.0
Other (mg/L)					
Chloride	223	225	1.0	45	25
Fluoride	205	225	0.10	0.98	0.10
Sulfate	221	225	10	761	500
Total Dissolved Solids	225	225	146	1,200	20

Notes:
ND = Not Detected; pCi/L = Picocuries Per Liter.
Source: Ramboll (2021, 2022a).

3 Risk Evaluation

3.1 Risk Evaluation Process

A risk evaluation was conducted to determine whether constituents present in groundwater underlying and downgradient of the EAP have the potential to pose adverse health effects to human and ecological receptors. The risk evaluation is consistent with the principles of risk assessment established by US EPA and has considered evaluation criteria detailed in Illinois guidance documents (*e.g.*, IEPA, 2013, 2019).

The general risk evaluation approach is summarized in Figure 3.1 and discussed below.

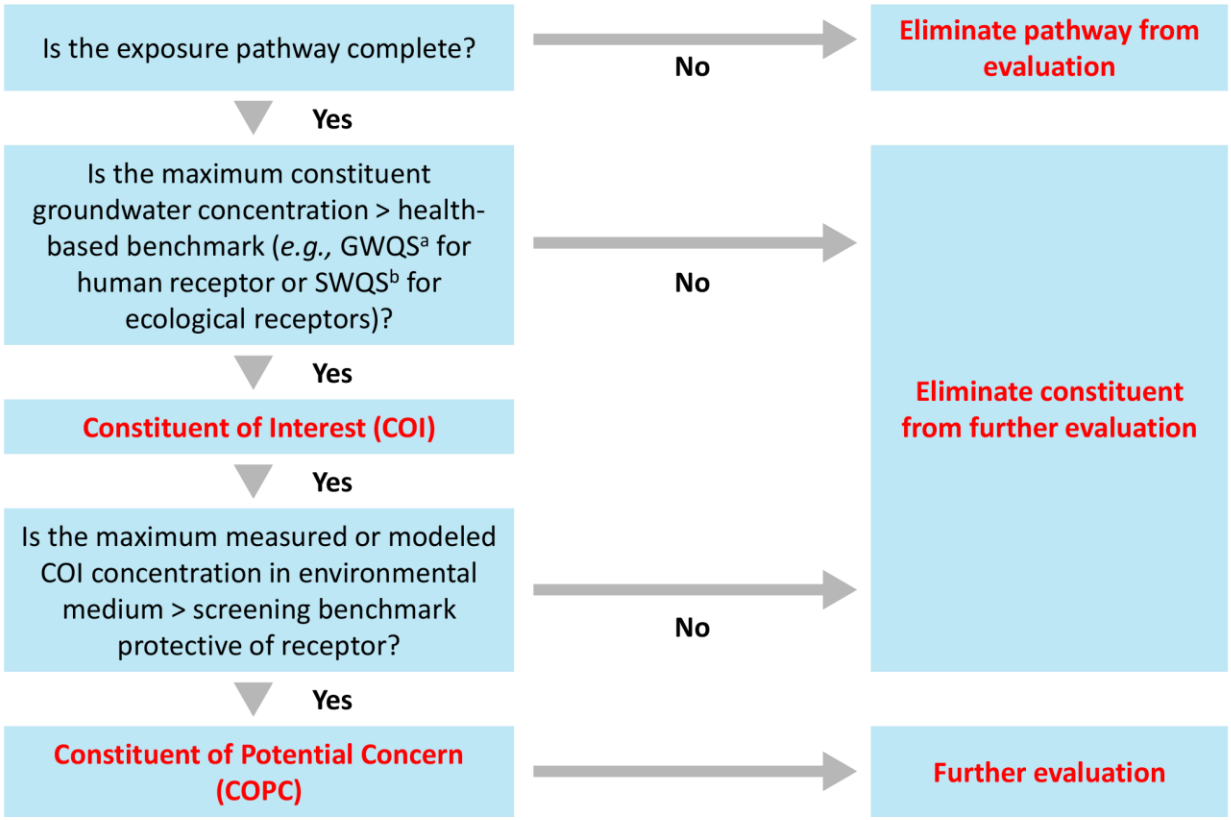

Figure 3.1 Overview of Risk Evaluation Methodology. GWQS = Groundwater Quality Standard; IEPA = Illinois Environmental Protection Agency; SWQS = Surface Water Quality Standard; US EPA = United States Environmental Protection Agency. (a) The IEPA Part 845 GWPS were used to identify COIs. (b) IEPA SWQS protective of chronic exposures to aquatic organisms were used to identify ecological COIs. In the absence of SWQSs, US EPA Region IV Ecological Screening Values (ESV) were used.

The first step in the risk evaluation was to develop the CEMs and identify complete exposure pathways. All potential receptors and exposure pathways based on groundwater use and surface water use in the vicinity of the Site were considered. Exposure pathways that are incomplete were excluded from the evaluation.

Groundwater data were used to identify COIs. COIs were identified as constituents with maximum concentrations in groundwater in excess of groundwater quality standards (GWQS)[2] for human receptors and SWQS for ecological receptors.

To evaluate the drinking water pathway, groundwater COI concentrations were compared to screening benchmarks for drinking water developed by US EPA. Concentrations that exceeded a conservative screening benchmark were identified as COPCs requiring further evaluation. To evaluate the use of groundwater for irrigation of homegrown produce, Gradient modeled the COI concentrations in soil resulting from irrigation with groundwater. The modeled soil concentrations were compared to soil screening benchmarks protective of consumption of homegrown produce. COIs with concentrations above the screening benchmark were identified as COPCs requiring further evaluation.

Surface water and sediment samples have not been collected from the Ohio River adjacent to the Site. Gradient modeled the potential migration of COIs from groundwater to surface water and sediment to evaluate potential risks to receptors (see Section 3.3.3). Gradient modeled the COI concentrations in surface water and sediment based on the groundwater data from the EAP-related wells. The modeled COI concentrations in surface water and sediment were compared to conservative, generic risk-based screening benchmarks for human health and ecological receptors. These generic screening benchmarks rely on default assumptions with limited consideration of site-specific characteristics. Human health benchmarks are receptor-specific values calculated for each pathway and environmental medium that are designed to be protective of human health. Ecological benchmarks are medium-specific values designed to be protective of all potential ecological receptors exposed to surface water. Ecological and human health screening benchmarks are inherently conservative because they are intended to screen out chemicals that are of no concern with a high level of confidence. Therefore, a modeled COI concentration exceeding a screening benchmark does not indicate an unacceptable risk; it only indicates that further risk evaluation is warranted. COIs with maximum concentrations exceeding a conservative screening benchmark are identified as COPCs requiring further evaluation.

As described in more detail below, the results of the screening assessment demonstrate that constituents present in groundwater underlying the EAP do not pose an unacceptable human health or ecological risk for exposure to surface water or sediment. The use of groundwater for irrigation of homegrown produce does not present an unacceptable risk. The residential use of groundwater from the UA as drinking water was identified as a potential human health risk for boron and cobalt, thus further assessment is warranted.

3.2 Human and Ecological Conceptual Exposure Models

A CEM provides an overview of the receptors and exposure pathways requiring risk evaluation. The CEM describes the source of the contamination, the mechanism that may lead to a release of contamination, the environmental media to which a receptor may be exposed, the route of exposure (exposure pathway), and the types of receptors that may be exposed to these environmental media.

[2] As discussed further in Section 3.3.2, groundwater quality standards are protective of human health and not necessarily of ecological receptors. While ecological receptors are not exposed to groundwater, groundwater can potentially enter into the adjacent surface water and impact ecological receptors. Therefore, two sets of COIs were identified: one for humans and another for ecological receptors.

3.2.1 Human Conceptual Exposure Model

The human CEM for the Site depicts the relationships between the off-Site environmental media potentially impacted by constituents in groundwater and the human receptors that could be exposed to these media. Figure 3.2 presents a human CEM for the Site. It considers human receptors who could be exposed to COIs hypothetically released from the EAP into groundwater, surface water, sediment, and fish. The following human receptors and exposure pathways were evaluated for inclusion in the Site-specific CEM:

- Residents – Exposure to groundwater/surface water as drinking water.
- Residents – Exposure to groundwater/surface water used for irrigation.
- Recreators in the river near the Site:
  - Boaters – Exposure to surface water and sediment while boating.
  - Swimmers – Exposure to surface water and sediment while swimming.
  - Anglers – Exposure to surface water and sediment and consumption of locally caught fish.

All of these exposure pathways were considered to be complete at the Site, except for surface water used for drinking water. Section 3.2.1.1 discusses the potential use of groundwater as a drinking water or irrigation source. Section 3.2.1.2 explains why surface water is not used for drinking water adjacent to the Site. Section 3.2.1.3 provides additional description of the recreational exposures.

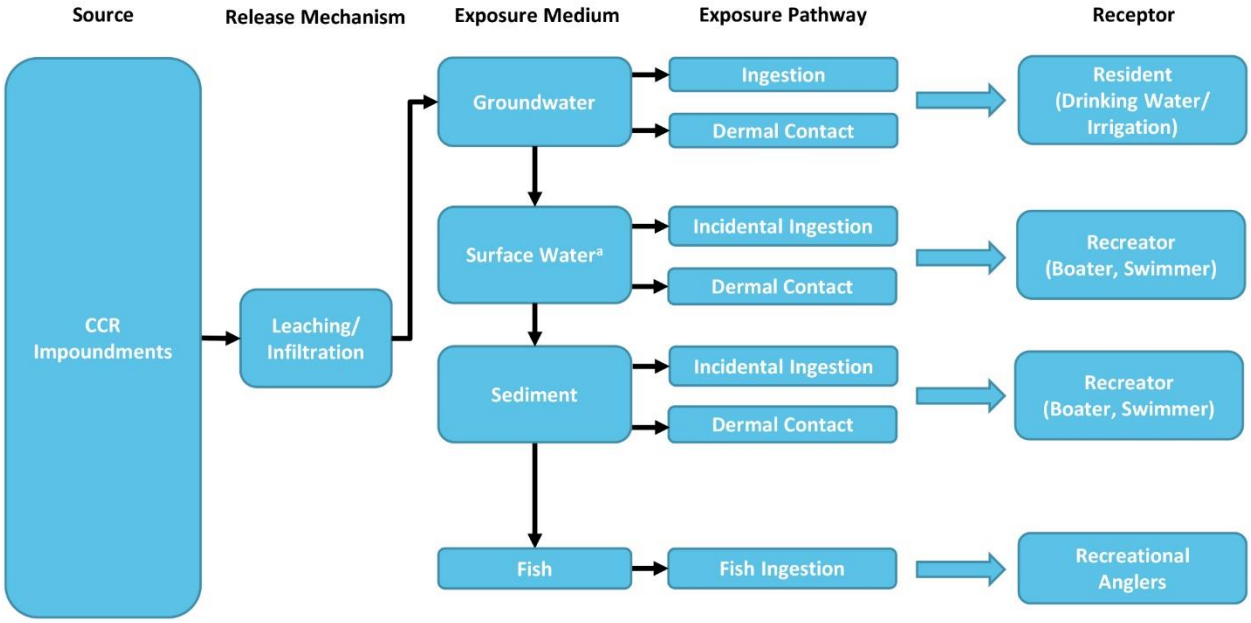

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residual. (a) Surface water is not used as a drinking water source adjacent to the Site.

3.2.1.1 Groundwater as a Drinking Water/Irrigation Source

Receptor surveys have been performed between 2013 and 2021 to identify potential users of groundwater in the vicinity of the EAP (Ramboll, 2021). Federal and state databases were reviewed as part of these surveys to identify nearby pumping wells and potential drinking water receptors in the vicinity of the EAP (Ramboll, 2021). Specific sources that were reviewed in these surveys include the United States Geological Survey (USGS) National Groundwater Monitoring Network (NGWMN),[3] the Illinois State Geological Survey (ISGS) Illinois Water and Related Wells (ILWATER) Map,[4] the US EPA Safe Drinking Water Information System (SDWIS),[5] and the IEPA Illinois Drinking Water Watch (DWW)[6] (Ramboll, 2021).

The most recent receptor survey, conducted in 2021 (Ramboll, 2021), identified six potential groundwater wells within 300 meters of the JPP property boundary. Three of the identified wells were located downgradient of the EAP, and three were located sidegradient of the EAP (Figure 3.3) (Ramboll, 2022b). The well survey results are presented in Appendix C, and are summarized as follows (Ramboll, 2022b):

- Two potential downgradient wells (121270005500 and 121270005400) have depths of 65 and 137 feet below ground surface (ft bgs), respectively. One of these wells (121270005400) is located on the JPP property.
- One potential downgradient well (121272094200) has a depth of 90 ft bgs. EEI is listed as the owner of this well.
- Three potential sidegradient wells (121270003100, 121270003000, and 121270005200) have depths ranging from 138 to 156 ft bgs.

A windshield survey (site visit) was completed in February 2022 to confirm the existence of the wells identified in the well survey, and to assess whether there may be other wells within the Village of Joppa (Ramboll, 2022b). No wells were identified at the potential locations cited in the 2021 receptor survey. Two other potential wells were identified during the windshield survey (located at 235 Main Street and 234 Pope Avenue). However, based on further in-person inquiries conducted in May and June 2022, it was confirmed that the features that were identified were not groundwater wells (Ramboll, 2022b). EEI also sent a letter to all residents of the Village of Joppa to request that residents "with a private irrigation or drinking water well contact EEI to have their well tested"; however, no responses have been received as of the end of June 2022 (Ramboll, 2022b). Based on the results of the windshield survey and the follow-up inquiries, and the fact that the Village of Joppa is serviced by a municipal water supply, Gradient has concluded that there are no current private users of groundwater within the Village of Joppa.

A search of the US EPA SDWIS and IEPA Illinois DWW databases for drinking water intakes in the vicinity of the EAP identified a community water supply (CWS) well for the Village of Joppa. The Joppa CWS Well #2 (Water System ID IL1270100) is located approximately 1,070 m to the southeast and downgradient of the EAP and provides drinking water supply for 462 residents (Figure 3.3). This well is screened at a depth of 240 ft within the LAU and separated from the UA by an approximately 14-ft-thick clay/silt layer of the LCU that prevents groundwater from flowing between the units. Furthermore, there is an upward flow gradient from the LAU toward the UA, so to the extent that there is any hydraulic

[3] USGS NGWMN: https://cida.usgs.gov/ngwmn/index.jsp
[4] ISGS ILWATER Map: https://prairieresearch.maps.arcgis.com/apps/webappviewer/index.html?id=e06b64ae0c814ef3a4e43a191cb57f87
[5] US EPA SDWIS: https://www.epa.gov/enviro/sdwis-search
[6] IEPA Illinois DWW: http://water.epa.state.il.us/dww/index.jsp

connection between the LAU and the UA, flow would be going from the deeper unit to the shallower unit (Ramboll, 2022a).

The Joppa CWS Well #2 was sampled by Ramboll on May 23, 2022. The samples were analyzed for a range of inorganic constituents (antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, fluoride, iron, lead, lithium, mercury, molybdenum, selenium, sulfate, thallium, and total dissolved solids). The constituent concentrations did not exceed the Illinois Class I groundwater protection standards (35 Ill. Admin. Code Part 620.410) (Ramboll, 2022b); therefore, the results indicate there are no well impacts related to the EAP. The CWS well will be resampled in September 2022 to confirm these results. In addition, groundwater monitoring wells installed "as part of off-site plume delineation activities within the Village of Joppa are scheduled for testing in July, September, and October 2022" (Ramboll, 2022b).

In summary, the well survey did not identify any downgradient potable water wells, and sampling results indicate that the Joppa CWS well is not impacted by the EAP (Ramboll, 2022b). However, because there is a possibility that a resident of Joppa could install a private well in the UA and use the water for drinking water or irrigation, this exposure pathway was considered to be potentially complete and was retained for evaluation in this risk assessment.

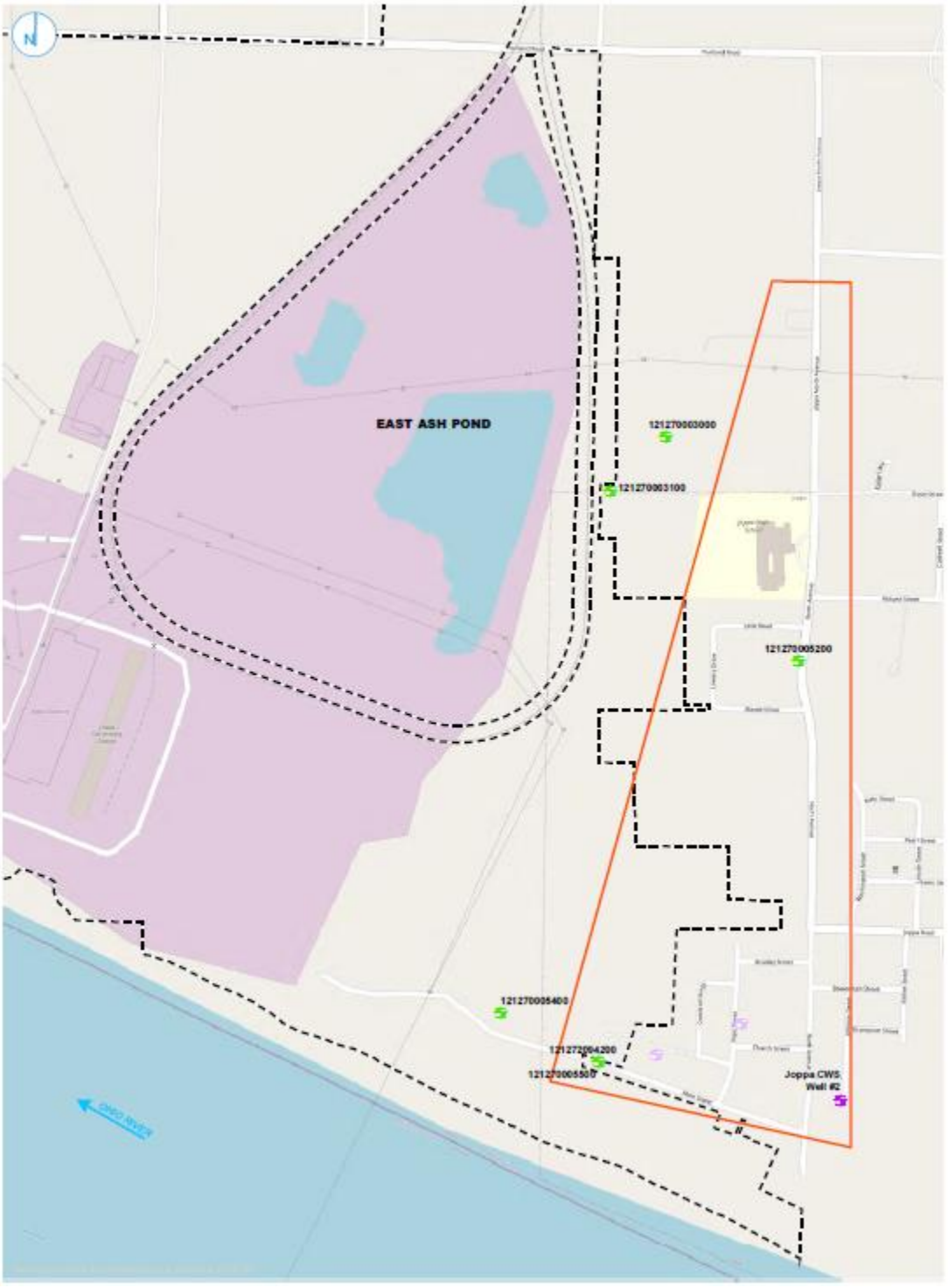

Figure 3.3. 2021 Well Survey Results. Source: Ramboll (2022b).

3.2.1.2 Surface Water as a Drinking Water/Irrigation Source

The Ohio River is not used as a public water supply adjacent to the Site. Gradient searched the US EPA SDWIS database to identify the public water systems for the four counties that border the Ohio River within 10 miles of the Site (*i.e.*, Massac County, Illinois; Pulaski County, Illinois; Ballard County, Kentucky; and McCracken County, Kentucky) (US EPA, 2022a). The public water systems in Massac, Pulaski, and Ballard Counties use groundwater as their water source, and thus do not obtain water from the Ohio River. In McCracken County, the city of Paducah, Kentucky, obtains a portion of its water supply from the Ohio River (Paducah Water, 2021); however, this location is approximately 15 miles upstream of the Site.

3.2.1.3 Recreational Exposures

The Site is located on the north bank of the Ohio River, which flows to the west past the Site. Recreational exposure to surface water and sediment may occur during activities such as swimming, boating, or fishing in the river. Exposure estimates for swimmers provide a health-protective means to evaluate exposure during other recreational activities. Recreational anglers may also consume locally caught fish from the Ohio River.

3.2.2 Ecological Conceptual Exposure Model

The ecological CEM for the Site depicts the relationships between off-Site environmental media (surface water and sediment) potentially impacted by COIs in groundwater and ecological receptors that may be exposed to these media. The ecological risk evaluation considered both direct toxicity as well as secondary toxicity *via* bioaccumulation. Figure 3.4 presents the ecological CEM for the Site.

The following ecological receptor groups and exposure pathways were considered:

- **Ecological Receptors Exposed to Surface Water:**
  - Aquatic plants, amphibians, reptiles, and fish.
- **Ecological Receptors Exposed to Sediment:**
  - Benthic invertebrates (*e.g.*, insects, crayfish, mussels).
- **Ecological Receptors Exposed to Bioaccumulative COIs:**
  - Higher-trophic-level wildlife (avian and mammalian) *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of prey (*e.g.*, plants, invertebrates, small mammals, fish).

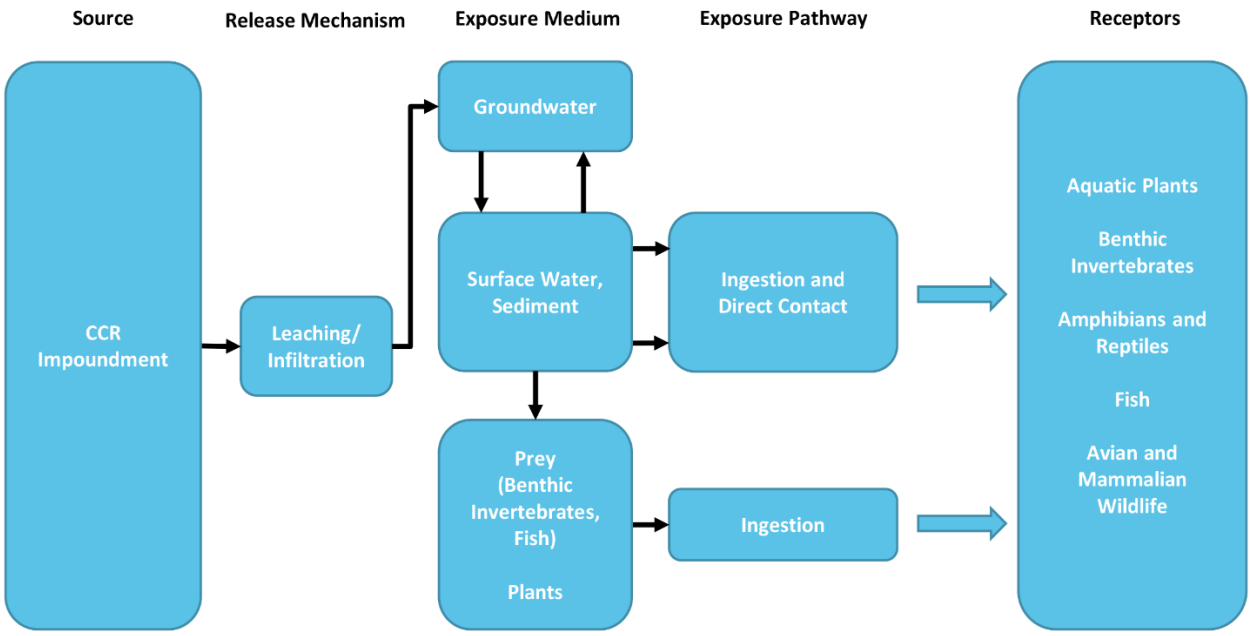

Figure 3.4 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residual.

3.3 Identification of Constituents of Interest

Risks were evaluated for COIs. A constituent was considered a COI if the maximum detected constituent concentration in groundwater exceeded a health-based benchmark. According to US EPA risk assessment guidance (US EPA, 1989), this screening step is designed to reduce the number of constituents carried through the risk evaluation that are anticipated to have a minimal contribution to the overall risk. Identified COIs are the constituents that are most likely to pose a risk concern in the surface water adjacent to the Site.

3.3.1 Human Health Constituents of Interest

For the human health risk evaluation, COIs were conservatively identified as constituents with maximum concentrations in groundwater above the GWPS listed in the Illinois CCR Rule Section 845.600 (IEPA, 2021). To determine the COIs for the surface water pathway, Gradient used the maximum detected concentrations from groundwater samples collected from all of the EAP-associated wells, regardless of hydrostratigraphic unit. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with the EAP. Using this approach, four COIs (boron, cobalt, thallium, and radium-226+228) were identified for the human health risk evaluation (Table 3.1). The maximum detected groundwater concentration of sulfate exceeded the GWPS; however, sulfate was not included in the risk evaluation, because the GWPS is based on aesthetic quality (*i.e.*, the US EPA secondary maximum contaminant level [MCL] for sulfate [250 mg/L] is based on salty taste; US EPA, 2021a). Given that sulfate is not likely to pose a human health risk concern, it was not considered to be a human health COI.

Table 3.1 Human Health Constituents of Interest

Constituent[a]	Maximum Concentration	GWPS[b]	Human Health COI[c]
Total Metals (mg/L)			
Antimony	ND	0.0060	No
Arsenic	0.0098	0.010	No
Barium	0.59	2.0	No
Beryllium	0.0012	0.0040	No
Boron	7.2	2.0	Yes
Cadmium	0.0018	0.0050	No
Chromium	0.023	0.10	No
Cobalt	0.027	0.0060	Yes
Lead	0.0066	0.0075	No
Lithium	0.010	0.040	No
Mercury	ND	0.0020	No
Molybdenum	0.0058	0.10	No
Selenium	0.033	0.050	No
Thallium	0.0033	0.0020	Yes
Radionuclides (pCi/L)			
Radium-226+228	5.9	5.0	Yes
Other (mg/L)			
Chloride	45	200	No
Fluoride	0.98	4.0	No
Sulfate	761	400	No[d]
Total Dissolved Solids	1,200	1,200	No

Notes:
COI = Constituent of Interest; GWPS = Groundwater Protection Standard; MCL = Maximum Contaminant Level; pCi/L = Picocuries Per Liter.
Shaded = Compound identified as a COI.
(a) The constituents are those listed in Illinois Section 845.600 (IEPA, 2021).
(b) The Illinois Section 845.600 GWPS (IEPA, 2021) were used to identify COIs.
(c) COIs are constituents for which the maximum detected concentration in groundwater exceeds the GWPS.
(d) This constituent is not likely to pose a human health risk concern due to the absence of studies regarding its toxicity to human health. Therefore, this constituent is not considered a COI.

3.3.2 Ecological Constituents of Interest

The Illinois GWPS, as defined in IEPA's guidance, were developed to protect human health but not necessarily ecological receptors. While ecological receptors are not exposed to groundwater, groundwater can potentially migrate into the adjacent surface water and impact ecological receptors. Therefore, to identify ecological COIs, the maximum concentrations of constituents detected in groundwater were compared to ecological surface water benchmarks protective of aquatic life.

The surface water screening benchmarks for freshwater organisms were obtained from the following hierarchy of sources:

- IEPA (2019) SWQS. IEPA SWQS are health-protective benchmarks for aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). The SWQS for several metals are hardness dependent (cadmium, chromium, copper, lead, manganese, nickel, and zinc). Screening

benchmarks for these constituents were calculated assuming US EPA's default hardness of 100 mg/L (US EPA, 2022b).[7]

- US EPA Region IV (2018) surface water Ecological Screening Values (ESVs) for hazardous waste sites.

Benchmarks from a United States Department of Energy (US DOE) guidance document ("A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota") were used for radium (US DOE, 2019). US DOE presents benchmarks for radium-226 and radium-228 (4 and 3 picocuries per liter [pCi/L], respectively). Given that radium concentrations are expressed as total radium (radium-226+228, *i.e.*, the sum of radium-226 and radium-228), Gradient used the lower of the two benchmarks (3 pCi/L for radium-228) to evaluate total radium concentrations.

Consistent with the human health risk evaluation, Gradient used the maximum detected concentrations from groundwater samples collected from all of the EAP-associated wells (regardless of hydrostratigraphic unit) without considering spatial or temporal representativeness for ecological receptor exposures. The use of the maximum constituent concentrations in this evaluation is designed to conservatively identify COIs that warrant further investigation. Cadmium, cobalt, and radium-226+228 were identified as COIs for ecological receptors (Table 3.2).

[7] Hardness data are available from the Ohio River at Olmsted, Illinois (USGS Station 03612600), about 12 miles downstream of the Site. Based on the available data (103 samples, collected from 2014 to 2021), hardness ranges from 91 to 171 mg/L, with a mean of 122 mg/L (USGS, 2022a). However, the US EPA (2022b) default hardness of 100 mg/L was used in this assessment. The use of a higher hardness value would result in less stringent screening values, thus the use of the US EPA default hardness value is conservative

Table 3.2 Ecological Constituents of Interest

Constituent[a]	Maximum Groundwater Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Metals (mg/L)				
Antimony	ND	0.19	US EPA R4 ESV	No
Arsenic	0.0098	0.19	IEPA SWQC	No
Barium	0.59	5.0	IEPA SWQC	No
Beryllium	0.0012	0.064	US EPA R4 ESV	No
Boron	5.3	7.6	IEPA SWQC	No
Cadmium	0.0018	0.0011	IEPA SWQC	Yes
Chromium	0.023	0.21	IEPA SWQC	No
Cobalt	0.027	0.019	US EPA R4 ESV	Yes
Lead	0.0066	0.020	IEPA SWQC	No
Lithium	0.010	0.44	US EPA R4 ESV	No
Mercury	ND	0.0011	IEPA SWQC	No
Molybdenum	0.0058	7.2	US EPA R4 ESV	No
Selenium	0.033	1.0	IEPA SWQC	No
Thallium	0.0033	0.0060	US EPA R4 ESV	No
Radionuclides (pCi/L)				
Radium-226+228	5.9	3.0	US DOE	Yes
Other (mg/L)				
Chloride	45	500	IEPA SWQC	No
Fluoride	0.98	4.0	IEPA SWQC	No
Sulfate	761	NA	NA	NA
Total Dissolved Solids	1,200	NA	NA	NA

Notes:
COI = Constituent of Interest; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; NA = Not Available; ND = Not Detected; pCi/L = Picocuries Per Liter; SWQC = Surface Water Quality Criteria; US DOE = United States Department of Energy; US EPA R4 = United States Environmental Protection Agency Region IV.
Shaded = Compound identified as a COI.
(a) The constituents are those listed in Illinois Section 845.600 (IEPA, 2021).
(b) Ecological benchmarks are from the hierarchy of sources discussed in Section 3.3.2: IEPA SWQC = IEPA (2019); US EPA R4 = US EPA Region IV "Ecological Risk Assessment Supplemental Guidance" (US EPA Region IV, 2018); and US DOE = US DOE guidance document "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).
(c) Constituents with maximum detected concentrations exceeding a benchmark protective of surface water exposure are considered ecological COIs.

3.3.3 Surface Water and Sediment Modeling

No surface water sampling has been conducted in the Ohio River adjacent to the Site. To estimate the potential contribution to surface water (and sediment) from groundwater specifically associated with the EAP, Gradient modeled concentrations in the Ohio River surface water and sediment from groundwater that may flow to the Ohio River for the detected human and ecological COIs (boron, cadmium, cobalt, thallium, and radium-226+228). The constituents detected in groundwater above a ecological or health-based benchmark are most likely to pose a risk concern in the adjacent surface water. Gradient modeled human health and ecological COI concentrations in the surface water and sediment using a mass balance calculation based on the surface water and groundwater mixing. The model assumes a well-mixed groundwater-surface water location.

The maximum detected concentrations in groundwater (regardless of well location) from 2015 to 2021 were conservatively used to model COI concentrations in surface water and sediment. The metals in groundwater were measured as total metals. Use of the total metal concentration for these COIs may overestimate surface water concentrations, because dissolved concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow to and mix with surface water.

The modeling approach does not account for geochemical transformations that may occur when groundwater mixes with surface water. Gradient assumed that predicted surface water concentrations were influenced only by the physical mixing of groundwater as it enters the surface water and were not further influenced by the geochemical reactions in the water and sediment, such as precipitation. In addition, the model only predicts surface water and sediment concentrations as a result of the potential migration of COI concentrations in EAP-related groundwater and does not account for background concentrations in surface water or sediment.

For this evaluation, Gradient adapted a simplified and conservative form of US EPA's indirect exposure assessment methodology (US EPA, 1998) that was used in US EPA's CCR risk assessment (US EPA, 2014a). The model is a mass-balance calculation based on surface water and groundwater mixing and the concept that the dissolved and sorbed concentrations can be related through an equilibrium partition coefficient (K_d). The model assumes a well-mixed groundwater-surface water location, with partitioning among total suspended solids, the dissolved water column, sediment pore water, and solid sediments.

Sorption to soil and sediment is highly dependent on the surrounding geochemical conditions. To be conservative, Gradient ignored the natural attenuation capacity of soil and sediment and estimated the surface water concentrations based only on the physical mixing of groundwater and surface water (*i.e.*, dilution).

The aquifer and surface water properties used to estimate the volume of groundwater flowing to the Ohio River and surface water COI concentrations are presented in Table 3.3. The COI concentrations in sediment were modeled using the COI-specific sediment-to-water partitioning coefficients and the sediment properties presented in Table 3.4. In the absence of Site-specific information for the Ohio River, Gradient used default assumptions (*e.g.*, depth of the upper benthic layer and bed sediment porosity) to model sediment COI concentrations. The modeled surface water and sediment COI concentrations are presented in Table 3.5. These modeled concentrations reflect conservative contributions from groundwater. A description of the modeling and the detailed results are presented in Appendix A.

Table 3.3 Groundwater and Surface Water Properties Used in Modeling

Parameter	Value	Unit	Notes/Source
Groundwater			
COI Concentration	Constituent specific	mg/L	Maximum detected concentration in groundwater.
Cross Section Area for the UA[a]	14,672	m^2	The length of the groundwater discharge zone was assumed to be equal to the maximum width of the EAP (*i.e.*, approximately 830 m). The thickness of the discharge zone was assumed to be equal to the maximum thickness of the UA (17.7 m) (Ramboll, 2021).
Hydraulic Gradient	0.0053	m/m	Maximum average horizontal hydraulic gradient determined for the UA (Ramboll, 2021).
Hydraulic Conductivity of the UA	0.0031	cm/s	Geometric mean horizontal hydraulic conductivity for all UA wells (Ramboll, 2021).
Surface Water			
Surface Water Flow Rate	9.6×10^{13}	L/year	Representative low-flow (10th percentile) discharge rate for the Ohio River at USGS Olmsted, Illinois gauging station (USGS Station 03612600) (USGS, 2022b).
Total Suspended Solids (TSS)	62	mg/L	Median of 2014-2021 suspended solids data for Ohio River at USGS Olmsted, Illinois gauging station (USGS 03612600) (USGS, 2022a).
Depth of the Water Column	8.23	m	Average water depth of Ohio River near JPP (Bist LLC, 2022).
Suspended Sediment to Water Partition Coefficient	Constituent specific	mg/L	Values based on US EPA (2014a).

Notes:
COI = Constituent of Interest; EAP = East Ash Pond; JPP = Joppa Power Plant; UA = Uppermost Aquifer; USGS = United States Geological Survey.
(a) The cross-sectional area represents the area through which groundwater flows from the UA to the Ohio River.

Table 3.4 Sediment Properties Used in Modeling

Parameter	Value	Unit	Notes/Source
Depth of Upper Benthic Layer	0.03	m	Default (US EPA, 2014a).
Depth of Water Body	8.26	m	Depth of water column (8.23 m) in Ohio River (Bist LLC, 2022) plus depth of upper benthic layer (0.03 m) (US EPA, 2014a).
Bed Sediment Particle Concentration	1	g/cm^3	Default (US EPA, 2014a).
Bed Sediment Porosity	0.6	–	Default (US EPA, 2014a).
Total Suspended Solids (TSS) Mass Per Unit Area	0.51	kg/m^2	Depth of water column × TSS × conversion factors (10^{-6} kg/mg and 1,000 L/m^3).
Sediment Mass Per Unit Area	30	kg/m^2	Depth of upper benthic layer × bed sediment particulate concentration × conversion factors (0.001 kg/g and 10^6 cm^3/m^3).
Sediment to Water Partitioning Coefficients	Constituent specific	mg/L	Values based on US EPA (2014a).

Table 3.5 Surface Water and Sediment Modeling Results

COI	Groundwater Concentration (mg/L or pCi/L)	Mass Discharge Rate (mg/year or pCi/year)	Total Water Column Concentration (mg/L or pCi/L)	Concentration Sorbed to Bottom Sediments (mg/kg or pCi/kg)
Metals				
Boron	7.24	5.5E+08	5.8E-06	2.4E-05
Cadmium	0.0018	1.4E+05	1.4E-09	4.8E-07
Cobalt	0.027	2.0E+06	2.1E-08	5.5E-06
Thallium	0.0033	2.5E+05	2.6E-09	3.0E-08
Radionuclides				
Radium-226+228	5.9	4.5E+08	4.7E-06	2.4E-02

Notes:
COI = Constituent of Concern; pCi/L = Picocuries Per Liter; pCi/kg = Picocuries Per Kilogram.

3.4 Human Health Risk Evaluation

The section below presents the results of the human health risk evaluation for residents using groundwater as drinking water, residents using groundwater for the irrigation of homegrown produce, and recreators (boaters, swimmers and anglers) along the Ohio River adjacent to the Site. Risks for recreators were assessed using the maximum modeled COI concentrations in surface water.

3.4.1 Residents Using Groundwater as Drinking Water

Screening Exposures: Although there are no known current residential users of groundwater, residents to the east of the JPP could be exposed to groundwater from the UA used as drinking water if they install a private well in the UA. The maximum COI concentrations in groundwater were used as conservative upper-end estimates of the COI concentrations to which a resident might be exposed through drinking water.

Screening Benchmarks: The US EPA Regional Screening Levels (RSLs) for tap water were used as the screening benchmarks values for the risk evaluation. US EPA developed the RSLs using generic default assumptions for a resident designed to identify constituents that warrant further investigation (US EPA, 2021b). The RSLs are based on a target hazard quotient (HQ) of 1, or a target cancer risk of 1×10^{-6}, based on US EPA's "Risk Assessment Guidance for Superfund" (RAGS; US EPA, 1989). The screening benchmarks for Ra-226 and Ra-228 were obtained from the US EPA Preliminary Remediation Goal (PRG) calculator (US EPA, 2020). The tap water PRG was 2.84E-02 for Ra-226, and 1.03E-02 for Ra-228. The PRG for Ra-228 was used as the screening benchmark because it is the lower of the two PRG values.

Screening Risk Evaluation: Risks from residential use of groundwater as drinking water were evaluated by comparing the maximum COI concentration to the US EPA tap water RSL (or PRG). The maximum detected concentrations of all four COIs were higher than their respective benchmarks, indicating they are COPCs that require further evaluation (Table 3.6).

Further Evaluation: Gradient evaluated data for the four COPCs from a subset of the EAP monitoring wells that included 10 monitoring wells (five nested pairs) along the eastern and southeastern JPP property boundary (G12S/D, G13S/D, G14S/D, G15S/D, and G16S/D). These wells are screened in the UA (Ramboll, 2022a). The data from these wells were used for this additional drinking water risk evaluation because this data could be representative of groundwater conditions in the UA if someone were to install a private well just east of the property boundary. In this dataset, boron and cobalt were the only constituents (of the four COPCs) that were considered COIs for the drinking water exposure pathway (Table 3.7). In

the refined risk evaluation, maximum boron and cobalt concentrations exceeded the US EPA RSL benchmarks and were considered to be COPCs requiring further evaluation (Table 3.8). The boron concentration exceeded the RSL by a factor of 2, and the cobalt concentration exceeded the RSL by a factor of 4; thus, these constituents present a potential unacceptable risk for residents using groundwater as drinking water. However, it should be noted that the boron and cobalt levels in groundwater are well below levels that cause adverse health effects (see Section 3.6).

Although this risk evaluation includes some refinement, EEI is currently in the process of determining the nature and extent of COIs in any wells potentially used for drinking water east of the JPP. Once that information is available, the risk evaluation could be further refined.

Table 3.6 Risk Evaluation for Residents Using Groundwater as Drinking Water

COI	Maximum Concentration	Human Health Residential Benchmark[a] (mg/L)	COPC
Metals (mg/L)			
Boron	7.2	4	Yes
Cobalt	0.027	0.006	Yes
Thallium	0.0033	0.0002	Yes
Radionuclides (pCi/L)			
Radium-226+228	5.9	0.01	Yes

Notes:
COI = Constituent of Interest; PRG = Preliminary Remediation Goal; RSL = Regional Screening Level.
(a) Screening benchmark is the US EPA RSL for tap water (US EPA, 2021b) or the US EPA PRG (for radium) (US EPA 2020).

Table 3.7 Refined Screening Evaluation for Drinking Water Pathway

Constituent	Maximum Concentration	GWPS	Human Health COI
Metals (mg/L)			
Boron	7.2	2	Yes
Cobalt	0.024	0.006	Yes
Thallium	<0.002	0.002	No
Radionuclides (pCi/L)			
Radium-226+228	1.1	5	No

Notes:
COI = Constituent of Interest; GWPS = Groundwater Protection Standard; NA = Not Available.
< = The constituent was not detected, and the value reported is the detection limit.
Shaded = Compound identified as a COI.
This table includes data from 10 monitoring wells along the eastern and southeastern property boundary (G12S/D, G13S/D, G14S/D, G15S/D, and G16S/D).
Source: Ramboll (2022a).

Table 3.8 Refined Risk Evaluation for Residents Using Groundwater as Drinking Water

COI	Maximum Concentration	Human Health Residential Benchmark[a] (mg/L)	COPC
Metals (mg/L)			
Boron	7.2	4	Yes
Cobalt	0.024	0.006	Yes

Note:
(a) Screening benchmark is the US EPA Regional Screening Level (RSL) for tap water (US EPA, 2021b).

3.4.2 Residents Using Groundwater as an Irrigation Source

Screening Exposures: Gradient evaluated hypothetical risks to downgradient residents who may consume homegrown produce irrigated with water from a private well that could potentially be impacted by COIs related to the EAP. The exposure concentrations used for this risk evaluation were the maximum detected concentrations of the groundwater COIs. Gradient used the conservative assumption that there was no dilution or attenuation of COI concentrations between the monitoring wells on the JPP property and a potential downgradient private well.

The COI concentrations in soil resulting from irrigation with well water were estimated by modeling the equilibrium partitioning expected as CCR-impacted groundwater mixes with surface soil during irrigation. The K_d varies by source and soil characteristics (*e.g.*, soil pH, moisture content). The K_d values are from US EPA's CCR risk assessment (US EPA, 2014a). Gradient used 50th-percentile K_d values for unsaturated soils, which would be similar to the surface soil used for residential gardens. The maximum groundwater COI concentrations, K_d values, and modeled soil concentrations are presented in Table 3.9.

Screening Benchmarks: US EPA does not have a soil RSL protective of residents consuming homegrown produce. Therefore, screening benchmarks were calculated using the recommended approach described in US EPA's RAGS (US EPA, 1989) and US EPA's CCR risk assessment (US EPA, 2014a). As recommended by the CCR beneficial use risk assessments conducted by US EPA (2014b), benchmarks were calculated using a target HQ of 1 (US EPA, 2014b, 2015a). Soil screening levels were calculated for five types of homegrown produce (exposed fruit, exposed vegetables, protected fruit, protected vegetables, and root vegetables) that could be exposed to constituents in soil *via* root uptake when using groundwater as an irrigation source. Produce ingestion rates used by US EPA in its CCR risk assessment (US EPA, 2014a) were used in this analysis. Child residents were assumed to ingest 1.5, 1.2, 2.0, 1.2, and 0.5 g/kg-day of exposed fruit, exposed vegetables, protected fruit, protected vegetables, and root vegetables, respectively (US EPA, 2014a). Adult residents were assumed to ingest 0.9, 0.8, 1.5, 0.6, and 0.6 g/kg-day of exposed fruit, exposed vegetables, protected fruit, protected vegetables, and root vegetables, respectively (US EPA, 2014a). Soil benchmarks protective of the consumption of all five types of homegrown produce were calculated using US EPA-recommended assumptions (*i.e.*, exposure duration, body weight, averaging time) and toxicity reference values (*i.e.*, reference doses [RfDs]). Non-cancer benchmarks were calculated only for a child resident, because it is the most sensitive of the two age groups (*i.e.*, child and adult).

Appendix B, Table B.1 presents the calculations of soil screening benchmarks protective of residents consuming homegrown produce watered with potentially impacted groundwater. The soil screening benchmarks for this pathway are presented in Table 3.9.

Screening Risk Evaluation: The modeled soil concentrations of all COIs were lower than their respective soil benchmarks (Table 3.9). Thus, the residential use of groundwater from private wells potentially impacted by constituents related to the EAP as an irrigation source for homegrown produce does not pose a risk concern.

Table 3.9 Risk Evaluation for Residents Using Private Well Water as an Irrigation Source

COI	Maximum Groundwater Concentration (mg/L)	Soil-Water Partitioning Coefficient (K_d)[b] (L/kg)	Modeled Soil Concentration[c] (mg/kg)	Gardening Soil Benchmark[d] (mg/kg)	COPC
Boron	7.24	0.11	0.80	101	No
Cobalt	0.0238	3.7	0.088	38	No
Thallium	0.0033	0.2	0.00066	11	No
Radium-226+228	5.9	1.0	0.0059	0.13	No

Notes:
COI = Constituent of Interest; K_d = Equilibrium Partitioning Coefficient.
(b) K_d values are from US EPA (2014a).
(c) Modeled soil concentrations were calculated as the maximum groundwater concentration multiplied by the K_d value.
(d) The calculated soil benchmarks are protective of gardeners consuming homegrown produce watered with potentially impacted groundwater.

3.4.3 Recreators Exposed to Surface Water

Screening Exposures: Recreators could be exposed to surface water *via* incidental ingestion and dermal contact while swimming or boating. In addition, anglers could consume fish caught in the Ohio River. The maximum modeled COI concentrations in surface water were used as conservative upper-end estimates of the COI concentrations to which a recreator might be exposed directly (incidental ingestion of COIs in surface water while swimming) and indirectly (consumption of locally caught fish exposed to COIs in surface water).

Screening Benchmarks: The Illinois surface water criteria known as human threshold criteria (HTC) (IEPA, 2019) are based on incidental exposure through direct contact with or ingestion of small volumes of water while swimming or during other recreational activities, as well as the consumption of fish. HTC values are calculated using the following equation (IEPA, 2019):

$$\mathrm{HTC} = \frac{\mathrm{ADI}}{\mathrm{W} + (\mathrm{F} \times \mathrm{BCF})}$$

where:

HTC = Human threshold criterion (mg/L)
ADI = Acceptable daily intake (mg/day)
W = Water consumption rate (L/day)
F = Fish consumption rate (kg/day)
BCF = Bioconcentration factor (L/kg-tissue)

Illinois defines the acceptable daily intake (ADI) as the "maximum amount of a substance which, if ingested daily for a lifetime, results in no adverse effects to humans" (IEPA, 2019). US EPA defines its chronic RfD as an "estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure for a chronic duration (up to a lifetime) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (US EPA, 2011a). Illinois lists methods to derive an ADI from the primary literature (IEPA, 2019). In accordance with Illinois guidance, Gradient derived an ADI by multiplying the MCL by the default water ingestion rate of 2 L/day (IEPA, 2019). In the absence of an MCL, Gradient applied the RfD used by US EPA to derive its Regional Screening Levels (RSLs) (US EPA, 2021b) as a conservative estimate of the ADI. The RfDs are given in mg/kg-day, while the ADIs are given in mg/day; thus, Gradient multiplied the RfD by a standard adult body

weight of 70 kg to obtain the ADI in mg/day. The calculation of the HTC values is shown in Appendix B, Table B.2.

Gradient used bioconcentration factors (BCFs) from a hierarchy of sources. The primary BCFs were those that US EPA used to calculate the National Recommended Water Quality Criteria (NRWQC) for human health (US EPA, 2002). Other sources included BCFs used in the US EPA CCR risk assessment (US EPA, 2014a) and BCFs reported by Oak Ridge National Laboratory's Risk Assessment Information System (ORNL RAIS) (ORNL, 2020).[8]

Illinois recommends a fish consumption rate of 0.020 kg/day (20 g/day) for an adult weighing 70 kg (IEPA, 2019). Illinois recommends a water consumption rate of 0.01 L/day for "incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities" (IEPA, 2019). Appendix B, Table B.2 presents the calculated HTC for fish and water and for fish consumption only.

The HTC for fish consumption for radium-226+228 was calculated as follows:

$$\mathrm{HTC} = \frac{\mathrm{TCR}}{(\mathrm{SF} \times \mathrm{BAF} \times \mathrm{F})}$$

where:

HTC	=	Human threshold criterion (pCi/L)
TCR	=	Target cancer risk (1×10^{-5})
SF	=	Food ingestion slope factor (risk/pCi)
BAF	=	Bioaccumulation factor (L/kg-tissue)
F	=	Fish consumption rate (kg/day)

The food ingestion slope factor (lifetime excess total cancer risk per unit exposure, in risk/pCi) used to calculate the HTC was the highest value of those for radium-226 (Ra-226), radium-228 (Ra-228), and "Ra-228+D" (US EPA, 2001). According to US EPA (2001), "+D" indicates that "the risks from associated short-lived radioactive decay products (*i.e.*, those decay products with radioactive half-lives less than or equal to 6 months) are also included."

Screening Risk Evaluation: The maximum modeled COI concentrations in surface water were compared to the calculated Illinois HTC values (Table 3.10). All the modeled surface water concentrations were below their respective benchmarks. The HTC are protective of recreational exposure *via* water and/or fish ingestion and do not account for dermal exposures to COIs in surface water while swimming. However, given that the modeled surface water concentrations are orders of magnitude below the HTC protective of water and/or fish ingestion, dermal exposures to COIs are not expected to pose a risk concern. Moreover, the dermal uptake of metals is considered to be minimal and represent only a small proportion of ingestion exposures. Thus, none of the COIs evaluated would be expected to pose an unacceptable risk to recreators exposed to surface water while swimming and anglers consuming fish caught in the Ohio River.

[8] Although recommended by US EPA (2015b), US EPA Epi Suite version 4.1 (US EPA, 2019) was not used as a source of BCFs, because inorganic compounds are outside the estimation domain of the program.

Table 3.10 Risk Evaluation for Recreators Exposed to Surface Water

COI	Maximum Modeled Surface Water Concentration	HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC
Total Metals (mg/L)					
Boron	5.8E-06	467	1,400	700	No
Cobalt	2.1E-08	0.0035	2.1	0.0035	No
Thallium	2.6E-09	0.0017	0.40	0.0017	No
Radionuclides (pCi/L)					
Radium-226+228	4.7E-06	1,000	1,000	87,413	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; pCi/L = Picocuries Per Liter.

3.4.4 Recreators Exposed to Sediment

Recreational exposure to sediment may occur during boating and swimming activity along the Ohio River. Recreational exposure to sediment may occur through incidental ingestion and dermal contact.

Screening Exposures: COIs in impacted groundwater flowing into the river can sorb to sediments. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations.

Screening Benchmarks: There are no established recreator RSLs that are protective of recreational exposures to sediment (US EPA, 2021c). Therefore, benchmarks that are protective of recreational exposures to sediment *via* incidental ingestion and dermal contact were calculated using US EPA's RSL guidance (US EPA, 2021c). These benchmarks were calculated using the recommended assumptions (*i.e.*, oral bioavailability, body weights, averaging time) and toxicity reference values (*i.e.*, RfD and cancer slope factor [CSF]), with the following changes. Recreators were assumed to be exposed to sediment while recreating 60 days a year (or two weekend days per week for 30 weeks a year, from April to October). The exposure duration was assumed for a child 6 years of age and an adult 20 years of age, per US EPA guidance (US EPA, 2014c). The daily recommended residential soil ingestion rates are 200 mg/day for a child and 100 mg/day for an adult, based on an all-day exposure to residential soils (US EPA, 2014c, 2011b). Because recreational exposures to sediment are assumed to occur for less than 4 hours per day, one-third of the daily residential soil ingestion amount (*i.e.*, 67 mg/day for a child and 33 mg/day for an adult) was used as a conservative assumption. For dermal exposures, recreators were assumed to be exposed to sediment on their lower legs and feet (with a skin surface area 1,026 cm^2 for the child and 3,026 cm^2 for the adult, based on the age-weighted skin surface areas reported in US EPA, 2011b). While other body parts may be exposed to sediment, the contact time will likely be very short, as the sediment would wash off in the surface water. Gradient used US EPA's recommended soil adherence factor of 0.2 mg/cm^2 based on child exposure to wet soil (US EPA, 2004a, 2014c), which was used in the US EPA RSL user's guide for a child recreator exposed to soil or sediment (US EPA, 2021c). The sediment screening benchmarks were calculated based on a target HQ of 1 or a target cancer risk of 1×10^{-5}. Appendix B, Table B.3 presents the calculations of screening benchmarks protective of recreational exposures to sediment. The recreator sediment screening benchmark for radium-226+228 was based on soil PRGs calculated for radium-226 and radium-228 using US EPA's PRG calculator (US EPA, 2020). The lower of the two values was used as the recreator sediment screening benchmark for radium-226+228 (Appendix B, Table B.4).

Screening Risk Evaluation: The modeled sediment concentrations were all well below their respective recreator sediment screening benchmarks (Table 3.11). Therefore, exposure to sediment is not expected to pose an unacceptable risk to recreators while swimming or boating.

Table 3.11 Risk Evaluation for Recreators Exposed to Sediment

COI[a]	Modeled Sediment Concentration	Recreator Sediment Screening Benchmark	COPC
Total Metals (mg/kg)			
Boron	2.4E-05	2.7E+05	No
Cobalt	5.5E-06	4.1E+02	No
Thallium	3.0E-08	1.4E+01	No
Radionuclides (pCi/kg)			
Radium-226+228	2.4E-02	7.9E+03	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; pCi/kg = Picocuries Per Kilogram.

3.5 Ecological Risk Evaluation

Based on the ecological CEM (Figure 3.4), ecological receptors could be exposed to surface water and dietary items (*i.e.*, prey and plants) potentially impacted by identified COIs (cadmium, cobalt, and radium-226+228).

3.5.1 Ecological Receptors Exposed to Surface Water

Screening Exposures: The ecological evaluation considered aquatic communities in the Ohio River potentially impacted by the identified ecological COIs. Modeled surface water concentrations were compared to risk-based ecological screening benchmarks.

Screening Benchmarks: Surface water screening benchmarks protective of aquatic life were obtained from the following hierarchy of sources:

- IEPA SWQS (IEPA, 2019), which are regulatory standards that are intended to protect aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). For cadmium, the surface water benchmark is hardness dependent and was calculated using a default hardness of 100 mg/L (US EPA, 2022b).[9]
- US EPA Region IV (2018) surface water ESVs for hazardous waste sites.
- US DOE benchmarks from the guidance document, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).

Risk Evaluation: The maximum modeled COI concentrations in surface water were compared to the benchmarks protective of aquatic life (Table 3.12). The modeled surface water concentrations were below their respective benchmarks. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in the Ohio River.

[9] Conservatisms associated with using a default hardness value are discussed in Section 3.6.

Table 3.12 Risk Evaluation for Ecological Receptors Exposed to Surface Water

COI	Maximum Modeled Surface Water Concentration	Ecological Freshwater Benchmark	Basis	COPC
Total Metals (mg/L)				
Cadmium	1.4E-09	0.0011	IEPA (2019)	No
Cobalt	2.1E-08	0.019	US EPA Region IV (2018)	No
Radionuclides (pCi/L)				
Radium-226+228	4.7E-06	3.0	US DOE (2019)	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; pCi/L = Picocuries Per Liter.

3.5.2 Ecological Receptors Exposed to Sediment

Screening Exposures: COIs in impacted groundwater flowing to the Ohio River can sorb to sediments *via* chemical partitioning. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations. Therefore, the modeled COI sediment concentrations reflect the potential maximum Site-related sediment concentration from groundwater.

Screening Benchmarks: Sediment screening benchmarks were obtained from US EPA Region IV (2018). The majority of the sediment ESVs are based on threshold effect concentrations (TECs) from MacDonald *et al.* (2000), which provide consensus values that identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. In the absence of an ESV for radium-226+228, a sediment screening value of 90,000 pCi/kg was used, based on the biota concentration guide (BCG) for radium-228 (US DOE, 2019).[10] The benchmarks used in this evaluation are listed in Table 3.13.

Screening Risk Results: The maximum modeled COI sediment concentrations were below their respective sediment screening benchmarks (Table 3.13). The modeled sediment concentrations attributed to potential contributions from Site groundwater for all COIs were well below 0.01% of the sediment screening benchmark. Therefore, the modeled sediment concentrations attributed to potential contributions from Site groundwater are not expected to significantly contribute to ecological exposures in the Ohio River adjacent to the Site.

Table 3.13 Risk Evaluation for Ecological Receptors Exposed to Sediment

COI	Modeled Sediment Concentration	ESV	COPC	% of Benchmark
Total Metals (mg/kg)				
Cadmium	4.8E-07	0.99[a]	No	0.00005%
Cobalt	5.5E-06	50[a]	No	0.00001%
Radionuclides (pCi/kg)				
Radium-226+228	2.4E-02	90,000[b]	No	0.00003%

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; pCi/g = Picocuries Per Gram; pCi/kg = Picocuries Per Kilogram.
(a) ESV from US EPA Region IV (2018).
(b) ESV from US DOE (2019) was converted from 90 pCi/g to 90,000 pCi/kg.

[10] The biota concentration guide (BCG) for sediment is 90 pCi/g for Ra-228 and 100 pCi/g for Ra-226; the lower of the two values was used for Ra-226+228 and converted to pCi/kg (US DOE, 2019).

3.5.3 Ecological Receptors Exposed to Bioaccumulative Constituents of Interest

Screening Exposures: COIs with bioaccumulative properties can impact higher-trophic-level wildlife exposed to these COIs *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, and fish).

Screening Benchmark: US EPA Region IV (2018) and IEPA SWQS (IEPA, 2019) guidance were used to identify constituents with potential bioaccumulative effects.

Risk Evaluation: The ecological COIs (cadmium, cobalt, and radium-226+228) were not identified as having potential bioaccumulative effects. Therefore, these COIs are not considered to pose an ecological risk *via* bioaccumulation.

3.6 Uncertainties and Conservatisms

A number of uncertainties and their potential impact on the risk evaluation are discussed below. Wherever possible, conservative assumptions were used in an effort to minimize uncertainties and overestimate, rather than underestimate, risks.

Exposure Estimates:

- The risk evaluation included the Illinois Section 845.600 constituents detected in groundwater samples collected from wells associated with the EAP. However, it is possible that not all of the detected constituents are related specifically to the EAP.
- The human health and ecological risk characterizations were based on the maximum measured or modeled COI concentrations, rather than on averages. Thus, the variability in exposure concentrations was not considered. Assuming continuous exposure to the maximum concentration overestimates human and ecological exposures, given that receptors are mobile and concentrations change over time. For example, US EPA guidance states that risks should be estimated using average exposure concentrations as represented by the 95% upper confidence limit on the mean (US EPA, 1992).
- Only constituents detected in groundwater were used to identify COIs. The measured groundwater concentrations were used to model COI concentrations in surface water and sediment. For the constituents that were not detected in the EAP groundwater, the detection limits were below the Illinois Section 845.600 GWPS for these constituents, thus, they do not require further evaluation.
- COI concentrations in surface water were modeled using the maximum detected total metal concentrations in groundwater. Modeling surface water concentrations using total metal concentrations may overestimate surface water concentrations, because dissolved metal concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow to and mix with surface water.
- The COIs identified in this evaluation also occur naturally in the environment. Contributions to exposure from natural or other non-EAP-related sources of these constituents were not considered in the evaluation of modeled concentrations; only exposure contributions potentially attributable to Site groundwater mixing with surface water were evaluated. While not quantified, exposures from potential EAP-related groundwater contributions are likely to represent only a small fraction of the overall human and ecological exposure to COIs that also have natural or non-EAP-related sources.

- Screening benchmarks for human health were developed using exposure inputs based on US EPA's recommended values for reasonable maximum exposure (RME) assessments (US EPA, 2014c). RME is defined as "the highest exposure that is reasonably expected to occur at a site but that is still within the range of possible exposures" (US EPA, 2004a). US EPA states the "intent of the RME is to estimate a conservative exposure case (*i.e.*, well above the average case) that is still within the range of possible exposures" (US EPA, 1989). US EPA also notes that this high-end exposure "is the highest dose estimated to be experienced by some individuals, commonly stated as approximately equal to the 90th percentile exposure category for individuals" (US EPA, 2015c). Thus, most individuals will have lower exposures than those presented in this risk assessment.

Toxicity Benchmarks:

- Screening-level ecological benchmarks were compiled from IEPA and US EPA guidance and are designed to be protective of the majority of site conditions, leaving the option for site-specific refinement. In some cases, these benchmarks may not be representative of the specific conditions or receptors found at the Site, or may not accurately reflect concentration-response relationships encountered at the Site. For example, the ecological benchmark for cadmium is hardness dependent. Gradient relied on US EPA's default hardness of 100 mg/L. Hardness data are available from the Ohio River at Olmsted, Illinois (USGS Station 03612600), about 12 miles downstream of the Site. Based on the available data (103 samples, collected from 2014 to 2021), hardness ranges from 91 to 171 mg/L, with a mean of 122 mg/L (USGS, 2022a). Increasing the hardness from 100 to 122 mg/L would increase the cadmium SWQS, because benchmarks increase (*i.e.*, become less stringent) with higher levels of hardness. Regardless of the hardness, the maximum modeled cadmium concentration is orders of magnitude below the SWQS.
- In addition, for the ecological evaluation, Gradient conservatively assumed all constituents to be 100% bioavailable. Modeled COI concentrations in surface water are considered total metal concentrations. US EPA recommends using dissolved metal concentrations as a measure of ecological receptors' exposure to metals, because they represent the bioavailable fraction of metals in water (US EPA, 1993). Therefore, the modeled surface water concentrations may be an overestimation of exposure concentrations for ecological receptors.
- In general, it is important to appreciate that the human health toxicity factors used in this risk evaluation are developed to account for uncertainties, such that safe exposure levels used as benchmarks are often many times lower (even orders of magnitude lower) than the levels that cause effects that have been observed in human or animal studies. For example, toxicity factors incorporate a 10-fold safety factor to protect sensitive subpopulations. This means that a risk exceedance does not necessarily equate to actual harm.
- Boron and cobalt were identified as COPCs for the drinking water pathway. However, exceedance of a risk-based benchmark does not mean that an adverse health effect will occur, due to the conservative assumptions used in their derivation. The drinking water scenario assumes that a person drinks the maximum groundwater concentration every day for 30 years, which is unlikely to occur. In addition, the toxicity benchmarks used to calculate the RSLs, such as US EPA's chronic oral RfD, are also conservative. US EPA's RfD of 0.2 mg/kg-day for boron is based on decreased fetal body weight in rats observed at 13.3 mg/kg-day, which is a dose almost 60 times higher than the dose from drinking the maximum concentration of boron in groundwater measured at the Site (US EPA, 2004b). It is noteworthy that this effect has been observed only in animal studies, with no convincing evidence in humans. US EPA's chronic, provisional oral RfD of 3E-04 mg/kg-day for cobalt is based on decreased iodine uptake in the thyroid in human subjects. The lowest observed adverse effect level (LOAEL) determined in the study (1 mg/kg-day) is almost 1,700 times higher than the dose from drinking the maximum concentration of cobalt in groundwater

measured at the site (US EPA, 2008). The RfD includes a composite uncertainty factor of 3,000, which is highly conservative. It should be noted that the basis of the LOAEL (decreased iodine uptake by the thyroid) was described by US EPA as "reversible following relatively short-term exposure in humans" (US EPA, 2008).

4 Summary and Conclusions

A screening-level risk evaluation was performed for Site-related constituents in groundwater at the JPP, located in Massac County, Illinois, west of the Village of Joppa and northeast of the Ohio River. The CSM developed for the Site indicates that groundwater beneath the EAP flows into the Ohio River adjacent to the Site and may potentially impact surface water and sediment.

CEMs were developed for human and ecological receptors. The complete exposure pathways for humans include residential use of groundwater for drinking water or irrigation, recreators in the Ohio River who are exposed to surface water and sediment (boaters and swimmers), and anglers who consume locally caught fish. The complete exposure pathways for ecological receptors include aquatic life (including aquatic and marsh plants, amphibians, reptiles, and fish) exposed to surface water; benthic invertebrates exposed to sediment; and avian and mammalian wildlife exposed to bioaccumulative COIs in surface water, sediment, and dietary items.

Groundwater data collected from 2015 to 2022 were used to estimate exposures. For groundwater constituents retained as COIs, surface water and sediment concentrations were modeled using the maximum detected groundwater concentrations. Surface water and sediment exposure estimates were screened against benchmarks protective of human health and ecological receptors for this risk evaluation.

US EPA has established acceptable risk metrics. Risks above these US EPA-defined metrics are termed potentially "unacceptable risks." Based on the evaluation presented in this report, an unacceptable risk was identified for the potential future residential use of groundwater as a source of drinking water; however, there were no other unacceptable risks to human or ecological receptors resulting from CCR exposures associated with the EAP. Specific risk assessment results include the following:

- For the potential residential use of groundwater from the UA for drinking water, the maximum groundwater concentrations for boron and cobalt exceeded risk-based screening benchmarks. Therefore, the residential use of groundwater from the UA for drinking water poses a potential unacceptable risk to residents and requires further evaluation. It should be noted that based on the results of the windshield survey, Gradient does not believe that there are any current residents that use groundwater from the UA as a source of drinking water.
- For the potential residential use of groundwater from the UA for the irrigation of homegrown produce, the maximum COI concentrations were below their respective conservative risk-based screening benchmarks. Therefore, the use of groundwater from the UA for irrigation of homegrown produce is not expected to pose an unacceptable risk to residents.
- For recreators (boaters and swimmers) exposed to surface water, the modeled surface water concentrations for all COIs were below their respective conservative risk-based screening benchmarks. Therefore, none of the COIs evaluated in surface water are expected to pose an unacceptable risk to recreators boating or swimming in the Ohio River adjacent to the Site.
- For recreators exposed to sediment *via* incidental ingestion and dermal contact, the modeled sediment concentrations were below their respective health-protective sediment benchmarks. Therefore, none of the COIs evaluated in sediment are expected to pose an unacceptable risk to recreators exposed to sediment in the Ohio River adjacent to the Site.

- For anglers consuming locally caught fish, the modeled COI concentrations in surface water were below their respective conservative benchmarks protective of fish consumption. Therefore, none of the COIs evaluated for this pathway are expected to pose an unacceptable risk to recreators consuming fish caught in the Ohio River.
- Ecological receptors exposed to surface water include aquatic and marsh plants, amphibians, reptiles, and fish. The risk evaluation showed that none of the modeled COI concentrations in surface water exceeded their respective protective screening benchmarks. Ecological receptors exposed to sediment include benthic invertebrates. The modeled COI concentrations in sediment did not exceed their respective conservative screening benchmarks; therefore, none of the COIs evaluated in sediment are expected to pose an unacceptable risk to ecological receptors.
- Ecological receptors were also evaluated for exposure to bioaccumulative COIs. This evaluation considered higher-trophic-level wildlife with direct exposure to surface water and sediment and secondary exposure through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, fish). None of the ecological COIs were identified as having potential bioaccumulative effects. Overall, this evaluation demonstrated that none of the COIs evaluated are expected to pose an unacceptable risk to ecological receptors.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk. The risk evaluation was based on the maximum measured or modeled COI concentrations; however, US EPA guidance states that risks should be based on a representative average concentration, such as the 95% upper confidence limit on the mean. Thus, using the maximum concentration tends to overestimate exposure. Although the COIs identified in this evaluation also occur naturally in the environment, the contributions to exposure from natural background sources and nearby industry were not considered; thus, CCR-related exposures were likely overestimated. The exposure estimates also assumed 100% metal bioavailability, which likely results in overestimates of exposure and risks from the metals COIs. Lastly, exposure estimates were based on inputs to evaluate the RME; thus, most receptors will have lower exposures than those estimated in this risk assessment.

Finally, due to the planned closure and corrective measures that will be implemented at the Site, future risks are anticipated to be lower than current risks for all receptors and exposure pathways, because potential releases of CCR-related constituents will decline over time and impacted groundwater will be intercepted before it can migrate off Site. Consequently, potential exposures to CCR-related constituents in the environment will also decline.

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Appendix A

Surface Water and Sediment Modeling

Gradient modeled concentrations of constituents of interest (COIs) in the Ohio River surface water and sediment based on available groundwater data. First, we estimated the flow rate of COIs discharged to the Ohio River *via* groundwater. Then, we adapted United States Environmental Protection Agency (US EPA) indirect exposure assessment methodology (US EPA, 1998) in order to model surface water and sediment water concentrations in the Ohio River.

Model Overview

The groundwater flow to the river is represented by a one-dimensional, steady-state model. In this model, the groundwater plume migrates horizontally in the Uppermost Aquifer (UA) prior to flowing to the Ohio River. The groundwater flow entering the river is the flow going through a cross-sectional area that has a length equal to the maximum width of the East Ash Pond (EAP) and a width equal to the maximum saturated thickness of the UA. It was assumed that all the groundwater flowing through the UA would ultimately discharge to the Ohio River. The length of the groundwater discharge zone was estimated using Google Earth Pro (Google, LLC, 2022).

The groundwater flow to the Ohio River mixes with the surface water in the river. The COIs entering the river *via* groundwater can dissolve into the water column, sorb to suspended sediments, or sorb to benthic sediments. Using US EPA's indirect exposure assessment methodology (US EPA, 1998), the model evaluates the surface water and sediment COI concentrations at a location downstream of the groundwater discharge point, assuming a well-mixed water column.

Groundwater Discharge Rate

The groundwater discharge rate was evaluated using conservative assumptions. Gradient conservatively assumed that the groundwater concentrations were uniformly equal to the maximum detected concentration of each individual COI. Further, Gradient ignored adsorption by subsurface soil and assumed that all the groundwater flowing through the UA was discharged into the river.

For each groundwater unit, the groundwater flow rate into the river was derived using Darcy's Law:

$$Q = K \times i \times A$$

where:

- Q = Groundwater flow rate (m^3/s)
- K = Hydraulic conductivity (m/s)
- i = Hydraulic gradient (m/m)
- A = Cross-sectional area (m^2)

For each COI, the mass discharge rate into the river was then calculated by:

$$m_c = C_c \times Q \times CF$$

where:

- m_c = Mass discharge rate of the COI (mg/year)
- C_c = Maximum groundwater concentration of the COI (mg/L)
- Q = Groundwater flow rate (m^3/s)
- CF = Conversion factors: 1,000 L/m^3 and 31,557,600 s/year

The values of the aquifer parameters used for these calculations are provided in Table A.1. The calculated mass discharge rates were then used as inputs for the surface water and sediment partitioning model.

The cross-sectional area for the UA was 14,672 m^2. The length of the discharge zone was estimated to be approximately 830 m. The height of the discharge zone was assumed to be the maximum thickness of the UA (17.7 m) (Ramboll, 2021). The hydraulic gradient was 0.0053 m/m, based on the average horizontal hydraulic gradient determined for the UA (Ramboll, 2021). The hydraulic conductivity of the UA was 0.0031 cm/sec, based on the geometric mean horizontal hydraulic conductivity for the UA (Ramboll, 2021).

Surface Water and Sediment Concentration

Groundwater discharged into the river will be diluted in the surface water flow. Constituents transported by groundwater into the surface water migrate into the water column and the bed sediments. The surface water model Gradient used to estimate the surface water and sediment concentrations is a steady-state model described in US EPA's indirect exposure assessment methodology (US EPA, 1998) and also used in US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals," referred to herein as the coal combustion residual (CCR) risk assessment (US EPA, 2014). This model describes the partitioning of constituents between surface water, suspended sediments, and benthic sediments based on equilibrium partition coefficients (K_d values). It estimates the concentrations of constituents in surface water, suspended sediments, and benthic sediments at steady-state equilibrium at a theoretical location downstream of the discharge point after complete mixing of the water column. In our analysis, we used the K_d values provided in the US EPA CCR risk assessment for all of the COIs (US EPA, 2014, Table J-1). These coefficients are presented in Table A.2.

To be conservative, Gradient assumed that the constituents were not affected by dissipation or degradation once they entered the water body. The total water body concentration of the COI was calculated as follows (US EPA, 1998):

$$C_{wtot} = \frac{m_c}{V_f \times f_{water}}$$

where:

C_{wtot} = Total water body concentration of the COI (mg/L)
m_c = Mass discharge rate of the COI (mg/year)
V_f = Water body annual flow (L/year)
f_{water} = Fraction of the COI in the water column (unitless)

For the Ohio River annual flow rate, Gradient conservatively used the low-flow (10th percentile) discharge rate of about 10,7000 cubic feet per second (cfs), or 9.6×10^{13} L/year, based on the daily mean discharge rates measured at the United States Geological Survey (USGS) gauging station at Olmsted, Illinois (USGS Station 03612600) between 2013 and 2021 (USGS, 2022a). The surface water parameters are presented in Table A.3.

The fraction of COIs in the water column was calculated for each COI using the sediment/water and suspended solids/water partition coefficients (US EPA, 2014). The fraction of COIs in the water column is defined as follows (US EPA, 2014):

$$f_{water} = \frac{(1 + [K_{dsw} \times TSS \times 0.000001]) \times \frac{d_w}{d_z}}{\left([1 + (K_{dsw} \times TSS \times 0.000001)] \times \frac{d_w}{d_z}\right) + ([bsp + K_{dbs} \times bsc] \times \frac{d_b}{d_z})}$$

where:

K_{dsw}	=	Suspended sediment-water partition coefficient (mL/g)
K_{dbs}	=	Sediment-water partition coefficient (mL/g)
TSS	=	Total suspended solids in the surface water body (mg/L). Set equal to 62 mg/L based on the median suspended sediment concentration measured at the USGS gauging station at Olmsted, Illinois (USGS Station 03612600) between 2014 and 2021 (USGS, 2022b).
0.000001	=	Units conversion factor
d_w	=	Depth of the water column (m). The depth of the water column was estimated as 8.23 m, based on bathymetry data for the Ohio River near the Joppa Power Plant (JPP) (Bist LLC, 2022).
d_b	=	Depth of the upper benthic layer (m). Set equal to 0.03 m (US EPA, 2014).
d_z	=	Depth of the water body (m). Calculated as $d_w + d_b$. Set equal to 8.26 m.
bsp	=	Bed sediment porosity (unitless), set equal to 0.6 (US EPA, 2014)
bsc	=	Bed sediment particle concentration (g/cm^3). Set equal to 1.0 g/cm^3 (US EPA, 2014).

The fraction of COIs dissolved in the water column (f_d) is calculated as follows (US EPA 2014):

$$f_d = \frac{1}{1 + K_{dsw} \times TSS \times 0.000001}$$

The values for the fraction of COI in the water column and other calculated parameters are presented in Table A.4.

The total water column concentration (C_{wcTot}) of the COIs, comprising both the dissolved and suspended sediment phases, is then calculated as follows (US EPA, 2014):

$$C_{wcTot} = C_{wtot} \times f_{water} \times \frac{d_z}{d_w}$$

Finally, the dissolved water column concentration (C_{dw}) for the COIs is calculated as follows (US EPA, 2014):

$$C_{dw} = f_d \times C_{wcTot}$$

The dissolved water column concentration was then used to calculate the concentration of COIs sorbed to suspended solids in the water column (US EPA, 1998):

$$C_{sw} = C_{dw} \times K_{dsw}$$

where:

C_{sw}	=	Concentration sorbed to suspended solids (mg/kg)
C_{dw}	=	Concentration dissolved in the water column (mg/L)
K_{dsw}	=	Suspended solids/water partition coefficient (mL/g)

In the same way, using the total water body concentration and the fraction of COI in the benthic sediments, the model derives the total concentration in benthic sediments (US EPA, 2014):

$$C_{bstot} = f_{benth} \times C_{wtot} \times \frac{d_z}{d_b}$$

where:

C_{bstot} = Total COI concentration in bed sediment (mg/L or g/m^3)
C_{wtot} = Total water body COI concentration (mg/L)
f_{benth} = Fraction of COI in benthic sediments (unitless)
d_b = Depth of the upper benthic layer (m)
d_z = Depth of the water body (m). Calculated as $d_w + d_b$.

This value can be used to calculate dry weight sediment concentration as follows:

$$C_{sed\text{-}dw} = \frac{C_{bstot}}{bsc}$$

where:

$C_{sed\text{-}dw}$ = Dry weight sediment concentration (mg/kg)
C_{bstot} = Total sediment concentration (mg/L)
bsc = Bed sediment bulk density. Used the default value of 1 g/cm^3 from US EPA (2014).

The total sediment concentration is composed of the sum of the COI concentration dissolved in the bed sediment pore water (equal to the concentration dissolved in the water column) and the COI concentration sorbed to benthic sediments (US EPA, 1998).

The COI concentration sorbed to benthic sediments was calculated as follows (US EPA, 1998):

$$C_{sb} = C_{dbs} \times K_{dbs}$$

where:

C_{sb} = Concentration sorbed to bottom sediments (mg/kg)
C_{dbs} = Concentration dissolved in the sediment pore water (mg/L)
K_{dbs} = Sediments/water partition coefficient (mL/kg)

For each COI, the modeled total water column concentration, dry weight sediment concentration, and concentration sorbed to sediment are presented in Table A.5.

Table A.1 Parameters Used to Estimate Groundwater Discharge to Surface Water

Groundwater Unit	Parameter	Name	Value	Unit
UA	A	Cross-Sectional Area	14,672	m^2
UA	i	Hydraulic Gradient	0.0053	m/m
UA	K	Hydraulic Conductivity	0.0031	cm/s

Notes:
UA = Uppermost Aquifer.
Source: Hydraulic gradient and hydraulic conductivity values from Ramboll (2021).
Cross-sectional area was estimated from Ramboll (2021).

Table A.2 Partition Coefficients

Constituent	Mean Sediment-Water Partition Coefficient (K_{dbs})		Mean Suspended Sediment-Water Partition Coefficient (K_{dsw})	
	Value (log_{10}) (mL/g)	Value (mL/g)	Value (log_{10}) (mL/g)	Value (mL/g)
Metals				
Boron	0.8	6.31E+00	3.9	7.94E+03
Cadmium	3.3	2.00E+03	4.9	7.94E+04
Cobalt	3.1	1.26E+03	4.8	6.31E+04
Thallium	1.3	2.00E+01	4.1	1.26E+04
Radionuclides				
Radium-226+228	–	7.40E+03	–	7.40E+03

Note:
Source: US EPA (2014).

Table A.3 Surface Water Parameters

Parameter	Name	Value	Unit
TSS	Total Suspended Solids	62	mg/L
V_{fx}	Surface Water Flow Rate	9.6×10^{13}	L/year
d_b	Depth of Upper Benthic Layer (default)	0.03	m
d_w	Depth of Water Column	8.2	m
d_z	Depth of Water Body	8.23	m
bsc	Bed Sediment Bulk Density (default)	1	g/cm^3
bsp	Bed Sediment Porosity (default)	0.6	–
M_{TSS}	TSS Mass per Unit Area[a]	0.51	kg/m^2
M_S	Sediment Mass per Unit Area[b]	30	kg/m^2

Notes:
Source of default values: US EPA (2014).
(a) Determined by multiplying TSS by d_w.
(b) Determined by multiplying d_b by bsc.

Table A.4 Calculated Parameters

COI	Fraction of COI in the Water Column (f_{water})	Fraction of COI in the Benthic Sediments ($f_{benthic}$)	Fraction of COI Dissolved in the Water Column ($f_{dissolved}$)
Metals			
Boron	0.98	0.02	0.67
Cadmium	0.45	0.55	0.17
Cobalt	0.52	0.48	0.20
Thallium	0.96	0.04	0.56
Radionuclides			
Radium-226+228	0.05	0.95	0.69

Note:
COI = Constituent of Concern.

Table A.5 Surface Water and Sediment Modeling Results

COI	Groundwater Concentration (mg/L or pCi/L)	Mass Discharge Rate (mg/year or pCi/year)	Total Water Column Concentration (mg/L or pCi/L)	Concentration Sorbed to Bottom Sediments (mg/kg or pCi/kg)
Metals				
Boron	7.24	5.5E+08	5.8E-06	2.4E-05
Cadmium	0.0018	1.4E+05	1.4E-09	4.8E-07
Cobalt	0.027	2.0E+06	2.1E-08	5.5E-06
Thallium	0.0033	2.5E+05	2.6E-09	3.0E-08
Radionuclides				
Radium-226+228	5.9	4.5E+08	4.7E-06	2.4E-02

Notes:
COI = Constituent of Concern; pCi/kg = Picocuries Per Kilogram; pCi/L = Picocuries Per Liter.

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Appendix B

Screening Benchmarks

Table B.1 Soil Screening Benchmarks for Produce Ingestion

COI	Bioconcentration Factor (BCF)					Cancer						Cancer Benchmark	Non-cancer						Non-cancer Benchmark
						CSF	Cancer SL (mg/kg)							RfD	Non-cancer SL (mg/kg)					
	Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg	(mg/kg-day)$^{-1}$	Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg	(mg/kg)	(mg/kg-day)	Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg	(mg/kg)
Boron	2.0E+00	4.0E+00	2.0E+00	2.0E+00	4.0E+00	NC	NC	NC	NC	NC	NC	NC	2.0E-01	4.4E+02	5.2E+02	5.1E+02	4.3E+02	7.2E+02	101
Cobalt	7.0E-03	2.0E-02	7.0E-03	7.0E-03	2.0E-02	NC	NC	NC	NC	NC	NC	NC	3.0E-04	1.9E+02	1.5E+02	2.2E+02	1.8E+02	2.1E+02	38
Thallium	4.0E-04	4.0E-03	4.0E-04	4.0E-04	4.0E-03	NC	NC	NC	NC	NC	NC	NC	1.0E-05	1.1E+02	2.6E+01	1.3E+02	1.1E+02	3.6E+01	11

COI	Half-life (year)	Cancer											Cancer $SL_{produce-soil}$ (pCi/g)
		CSF (risk/pCi)	Cancer $SL_{Produce}$ (pCi/g)					Cancer SL_{soil} (pCi/g)					
			Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg	Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg	
Radium-226+228	1.6E+03	5.1E-10	3.5E-02	3.9E-02	2.2E-02	4.9E-02	5.2E-02	1.9E+00	1.3E+00	1.3E+00	2.9E+00	3.1E+00	0.36
Radium-226	1.6E+03	5.1E-10	3.5E-02	3.9E-02	2.2E-02	4.9E-02	5.2E-02	1.9E+00	1.3E+00	1.3E+00	2.9E+00	3.1E+00	0.36
Radium-228	5.8E+00	1.4E-09	1.3E-02	1.4E-02	8.0E-03	1.8E-02	1.9E-02	6.8E-01	4.6E-01	4.7E-01	1.0E+00	1.1E+00	0.13

Notes:

BCF = Bioconcentration Factor; CCR = Coal Combustion Residual; COC = Constituent of Concern; CSF = Cancer Slope Factor; Fruit-exp = Fruit-Exposed; Fruit-pro = Fruit-Protected; NA = Not Applicable; NC = No Criterion Available; RfD = Reference Dose; Root Veg = Root Vegetable; RSL = Regional Screening Level; SL = Screening Level; US EPA = United States Environmental Protection Agency; Veg-exp = Vegetable-Exposed; Veg-pro = Vegetable-Protected.

BCFs are values US EPA used in its CCR risk assessment (US EPA, 2014a).

$$Benchmark_{produce-soil} = \frac{1}{\frac{1}{SL_{fruit}} + \frac{1}{SL_{vegetable}}}$$

$$Cancer\ SL_{fruit} = \frac{TR}{Intake * BCF * CSF} \qquad Non\text{-}cancer\ SL_{fruit} = \frac{THQ * RfD}{Intake * BCF * (100/100\text{-}W)}$$

$$Cancer\ SL_{vegetable} = \frac{TR}{Intake * BCF * CSF} \qquad Non\text{-}cancer\ SL_{vegetable} = \frac{THQ * RfD}{Intake * BCF * (100/100\text{-}W)}$$

Target Cancer Risk (TR)= 1E-05

Target Hazard Quotient (THQ) = 1

W = Water content (%)				
Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg
85	92	90	80	87

Exposed Fruit Ingestion

$$\text{Intake} = \frac{\text{IR x EF x ED x CF1 x CF2 x TAF}}{\text{BW x AT}} =$$

		Non-cancer	Cancer		Basis
		1.5E-03	1.3E-04	2.6E-04	
		(Child)	(Child)	(Adult)	
IR	Ingestion Rate (g/kg-day)	1.5	1.5	0.9	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	23	23	73	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Exposed Vegetable Ingestion

$$\text{Intake} = \frac{\text{IR x EF x ED x CF1 x CF2 x TAF}}{\text{BW x AT}} =$$

		Non-cancer	Cancer		Basis
		1.2E-03	1.0E-04	2.4E-04	
		(Child)	(Child)	(Adult)	
IR	Ingestion Rate (g/kg-day)	1.2	1.2	0.8	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	18	18	67	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Protected Fruit Ingestion

$$\text{Intake} = \frac{\text{IR x EF x ED x CF1 x CF2 x TAF}}{\text{BW x AT}} =$$

		Non-cancer	Cancer		Basis
		2.0E-03	1.7E-04	4.2E-04	
		(Child)	(Child)	(Adult)	
IR	Ingestion Rate (g/kg-day)	2.0	2.0	1.5	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	29	29	116	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Protected Vegetable Ingestion

$$\text{Intake} = \frac{\text{IR x EF x ED x CF1 x CF2 x TAF}}{\text{BW x AT}} =$$

		Non-cancer	Cancer		Basis
		1.2E-03	1.0E-04	1.8E-04	
		(Child)	(Child)	(Adult)	
IR	Ingestion Rate (g/kg-day)	1.2	1.2	0.6	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	18	18	51	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Root Vegetable

$$\text{Intake} = \frac{\text{IR} \times \text{EF} \times \text{ED} \times \text{CF1} \times \text{CF2} \times \text{TAF}}{\text{BW} \times \text{AT}} =$$

		Non-cancer	Cancer		Basis
		5.4E-04 (Child)	4.6E-05 (Child)	1.8E-04 (Adult)	
IR	Ingestion Rate (g/kg-day)	0.5	0.5	0.6	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	8	8	51	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Table B.2 Calculated Water Quality Standards Protective of Incidental Ingestion and Fish Consumption

Human Health COI	BCF[a] (L/kg-tissue)	Basis	MCL (mg/L)	RfD (mg/kg-day)	ADI[b] (mg/day)	Human Threshold Criteria		
						Water & Fish (mg/L)	Water Only (mg/L)	Fish Only (mg/L)
Total Metals								
Boron	1	(c)	NC	0.20	14	467	1,400	700
Cobalt	300	ORNL (2020)	NC	0.00030	0.021	0.0035	2.1	0.0035
Thallium	116	NRWQC (2002)	0.0020	0.000010	0.0040	0.0017	0.40	0.0017

Human Health COI	BAF (L/kg-tissue)		MCL (pCi/L)	ADI (pCi/day)	Food Ingestion Slope Factor[d] (risk/pCi)	Human Threshold Criteria		
	SW-Fish	Basis				Water & Fish (pCi/L)	Water Only (pCi/L)	Fish Only (pCi/L)
Radium-226+228	4.0	ORNL (2020)	5	10	1.43E-09	1,000	1,000	87,413

Notes:

ADI = Acceptable Daily Intake; BAF = Bioaccumulation Factor; BCF = Bioconcentration Factor; COI = Constituent of Interest; IEPA = Illinois Environmental Protection Agency; MCL = Maximum Contaminant Level; NC = No Criterion Available; NRWQC = National Recommended Water Quality Criteria; ORNL = Oak Ridge National Laboratory; pCi = Picocurie; Ra = Radium; RfD = Reference Dose; US EPA = United States Environmental Protection Agency.

(a) BCFs are from the following hierarchy of sources:

NRWQC (US EPA, 2002). "National Recommended Water Quality Criteria: 2002. Human Health Criteria Calculation Matrix."

US EPA (2014a). "Human and Ecological Risk Assessment of Coal Combustion Residuals."

ORNL RAIS (ORNL, 2020). "Risk Assessment Information System (RAIS) Toxicity Values and Chemical Parameters."

(b) An ADI based on the MCL is calculated as the MCL (mg/L) multiplied by a water ingestion rate of 2 L/day. In the absence of an MCL, the ADI was calculated as the RfD (mg/kg-day) multiplied by adult body weight (70 kg).

(c) A BCF of 1 was used as a conservative assumption, due to the lack of a published BCF.

(d) Food ingestion slope factors for Ra-226+D and Ra-228+D were compared and the higher factor (Ra-228+D) was selected. The "+D" indicates that the risks from "associated short-lived radioactive decay products are also included" (US EPA, 2001).

Equations from IEPA (2019):

Consumption of Water and Fish:

$$HTC = \frac{ADI}{W + (F \times BCF)}$$

Incidental Consumption of Water Only:

$$HTC = \frac{ADI}{W}$$

Consumption of Fish Only:

$$HTC = \frac{ADI}{F \times BCF}$$

Where:

Human Threshold Criteria (HTC)	Chemical specific	mg/L
Acceptable Daily Intake (ADI)	Chemical specific	mg/day
Fish Consumption Rate (F)	0.02	kg/day
Bioconcentration Factor (BCF)/ Bioaccumulation Factor (BAF)	Chemical specific	L/kg-tissue
Water Consumption Rate (W)	0.01	L/day
Body Weight	70	kg
Target Cancer Risk (TCR)	1.0E-05	

Radium-226+228:

$$HTC = \frac{TCR}{(SF \times BAF \times F)}$$

Table B.3 Recreator Exposure to Sediment

COI	Relative Bioavailability (unitless)	Dermal Absorption Fraction (unitless)	Cancer				Cancer SL (mg/kg)	Non-Cancer								Recreator RSL Sediment (mg/kg)	Basis[a]
			TRV		Child + Adult			TRV		Child		Adult		Child	Adult		
			CSF (mg/kg-day)$^{-1}$	Dermal CSF (mg/kg-day)$^{-1}$	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)		RfD (mg/kg-day)	Dermal RfD (mg/kg-day)	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)	Non-cancer SL (mg/kg)			
Total Metals																	
Boron	1	NA	NC	NC	NC	NC	NC	2.0E-01	2.0E-01	2.7E+05	NA	2.9E+06	NA	2.7E+05	2.9E+06	2.7E+05	nc
Cobalt	1	NA	NC	NC	NC	NC	NC	3.0E-04	3.0E-04	4.1E+02	NA	4.4E+03	NA	4.1E+02	4.4E+03	4.1E+02	nc
Thallium	1	NA	NC	NC	NC	NC	NC	1.0E-05	1.0E-05	1.4E+01	NA	1.5E+02	NA	1.4E+01	1.5E+02	1.4E+01	nc
Radionuclides																**Total Soil PRG (pCi/kg)**	
Radium-226+228																7.9E+03	

Notes:

COI = Constituent of Interest; CSF = Cancer Slope Factor; NC = No Criterion Available; pCi = Picocurie; PRG = Preliminary Remediation Goal; RfD = Reference Dose; RSL = Regional Screening Level; SL = Screening Level; TRV = Toxicity Reference Value; US EPA = United States Environmental Protection Agency.

(a) Screening benchmark defined as the lower of the SLs for cancer and non-cancer. nc = Benchmark is based on a non-cancer endpoint.

Equations for Screening Benchmark and Screening Levels:

$$\text{Screening Benchmark} = \frac{1}{\frac{1}{SL_{ing}} + \frac{1}{SL_{derm}}}$$

$$\text{Non-cancer } SL_{ing} = \frac{THQ * RfD}{Intake} \qquad \text{Cancer } SL_{ing} = \frac{TR}{Intake * CSF}$$

$$\text{Non-cancer } SL_{derm} = \frac{THQ * RfD}{Intake * ABS} \qquad \text{Cancer } SL_{derm} = \frac{TR}{Intake * ABS * CSF}$$

Where:

Target Risk (TR)	1E-05	
Target Hazard Quotient (THQ)	1	
Reference Dose (RfD)	Chemical-specific	mg/kg-day
Dermal Absorption Fraction (ABS)	Chemical-specific	
Cancer Slope Factor (CSF)	Chemical-specific	mg/kg
Incidental Ingestions Screening Level (SL_{ing})	Chemical-specific	mg/kg
Dermal Contact Screening Level (SL_{derm})	Chemical-specific	mg/kg

Sediment – Ingestion (Chemical)

Intake Factor (IF) = $\frac{IR \times EF \times ED \times CF}{BW \times AT}$ =

		Non-Cancer		Cancer		
		7.3E-07 Child	6.8E-08 Adult	6.3E-08 Child	2.0E-08 Adult	Basis
IR	Ingestion Rate (mg/day)	67	33	67	33	One-third of US EPA residential soil ingestion rate (Professional Judgment)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and October, when air temperature is >70°F (Professional Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2021b)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2021b)
AT	Averaging Time (days)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2021b)

Sediment – Dermal Contact (Chemical)

Intake Factor (IF) = $\frac{SA \times AF \times EF \times ED \times CF}{BW \times AT}$ =

		Non-Cancer		Cancer		
		2.2E-06 Child	1.2E-06 Adult	1.9E-07 Child	3.6E-07 Adult	Basis
SA	Surface Area Exposed to Sediment (cm²/day)	1,026	3,026	1,026	3,026	Age-weighted SA for lower legs and feet (US EPA, 2011b)
AF	Sediment Skin Adherence Factor (mg/cm²)	0.2	0.2	0.2	0.2	Age-weighted AF for children exposed to sediment (US EPA, 2011b)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and October, when air temperature is >70°F (Professional Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2021b)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2021b)
AT	Averaging Time (days)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2021b)

Table B.4.1 Recreator PRGs for Soil, Input Values

Variable	Recreator Soil Default Value	Form-Input Value
A (PEF dispersion constant)	16.2302	16.8653
B (PEF dispersion constant)	18.7762	18.7848
City (climate zone)	Default	Chicago, IL (7)
C (PEF dispersion constant)	216.108	215.0624
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
$CF_{rec\text{-}fowl}$ (fowl contaminated fraction) unitless	1	1
$CF_{rec\text{-}game}$ (game contaminated fraction) unitless	1	1
ED_{rec} (exposure duration - recreator) years		26
EF_{rec} (exposure frequency - recreator) days/year		60
$f_{p\text{-}fowl}$ (fowl on-site fraction) unitless	1	1
$f_{p\text{-}game}$ (land game on-site fraction) unitless	1	1
$f_{s\text{-}fowl}$ (fraction of year fowl is on site) unitless	1	1
$f_{s\text{-}game}$ (fraction of year land game is on site) unitless	1	1
$MLF_{pasture}$ (pasture plant mass loading factor) unitless	0.25	0.25
t_{rec} (time - recreator) years		26
TR (target risk) unitless	0.000001	0.000001
F(x) (function dependent on U_m/U_t) unitless	0.194	0.182
PEF (particulate emission factor) m^3/kg	1,359,344,438	1,560,521,177
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77	98.431
A_s (acres)	0.5	0.5
Site area for ACF (area correction factor) m^2	1,000,000 m^2	1,000 m^2
ED_{rec} (exposure duration - recreator) years		26
$ED_{rec\text{-}a}$ (exposure duration - recreator adult) years		20
$ED_{resc\text{-}c}$ (exposure duration - recreator child) years		6
EF_{rec} (exposure frequency - recreator) days/year		60
$EF_{rec\text{-}a}$ (exposure frequency - recreator adult) days/year		60
$EF_{rec\text{-}c}$ (exposure frequency - recreator child) days/year		60
ET_{rec} (exposure time - recreator) hours/day		8
$ET_{rec\text{-}a}$ (exposure time - recreator) hours/day		8
$ET_{rec\text{-}c}$ (exposure time - recreator) hours/day		8
$IFA_{rec\text{-}adj}$ (age-adjusted inhalation rate - recreator) m^3		9,200
$IFS_{rec\text{-}adj}$ (age-adjusted soil intake rate - recreator) mg		63,720
$IRA_{rec\text{-}a}$ (inhalation rate - recreator adult) m^3/day	20	20
$IRA_{rec\text{-}c}$ (inhalation rate - recreator child) m^3/day	10	10
$IRS_{rec\text{-}a}$ (soil intake rate - recreator adult) mg/day	100	33
$IRS_{rec\text{-}c}$ (soil intake rate - recreator child) mg/day	200	67
t_{rec} (time - recreator) years		26
TR (target risk) unitless	0.000001	0.000001
U_m (mean annual wind speed) m/s	4.69	4.65
U_t (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

Notes:

IL = Illinois; PRG = Preliminary Remediation Goal.

Table B.4.2 Recreator PRGs for Soil, Ra-226

Isotope	ICRP Lung Absorption Type	Soil Ingestion Slope Factor (risk/pCi)	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/year per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Lambda (1/year)	Half-Life (years)	1,000 m^2 Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Particulate Emission Factor (m^3/kg)	Dry Soil-to-Plant Transfer Factor (pCi/g-fresh plant per pCi/g-dry soil)	Beef Transfer Factor (pCi/kg per pCi/day)	Poultry Transfer Factor (pCi/kg per pCi/day)	Ingestion PRG TR = 1.0E-06 (pCi/g)	Inhalation PRG TR = 1.0E-06 (pCi/g)	External Exposure PRG TR = 1.0E-06 (pCi/g)	Total PRG TR = 1.0E-06 (pCi/g)	Total PRG TR = 1.0E-06 (mg/kg)	Total PRG TR = 1.0E-06 (pCi/kg)
Ra-226	S	6.77E-10	2.82E-08	2.50E-08	5.14E-10	4.33E-04	1.60E+03	6.85E-01	1.00E+00	1.56E+09	1.95E-02	1.70E-03	-	2.32E+01	6.02E+03	4.10E+01	1.48E+01	1.50E-05	1.48E+04

Notes:
ICRP = International Commission on Radiological Protection; pCi = Picocurie; PRG = Preliminary Remediation Goal; Ra = Radium; S = Slow; TR = Target Risk.

Table B.4.3 Recreator PRGs for Soil, Ra-228

Isotope	ICRP Lung Absorption Type	Soil Ingestion Slope Factor (risk/pCi)	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/year per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Lambda (1/year)	Half-Life (year)	1,000 m^2 Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Particulate Emission Factor (m^3/kg)	Dry Soil-to-Plant Transfer Factor (pCi/g-fresh plant per pCi/g-dry soil)	Beef Transfer Factor (pCi/kg per pCi/day)	Poultry Transfer Factor (pCi/kg per pCi/day)	Ingestion PRG TR = 1.0E-06 (pCi/g)	Inhalation PRG TR = 1.0E-06 (pCi/g)	External Exposure PRG TR = 1.0E-06 (pCi/g)	Total PRG TR = 1.0E-06 (pCi/g)	Total PRG TR = 1.0E-06 (mg/kg)	Total PRG TR = 1.0E-06 (pCi/kg)
Ra-228	S	1.98E-09	4.37E-08	3.43E-11	1.42E-09	1.21E-01	5.75E+00	1.00E+00	1.00E+00	1.56E+09	1.95E-02	1.70E-03	-	7.93E+00	3.89E+03	2.04E+04	7.91E+00	2.90E-08	7.91E+03

Notes:

ICRP = International Commission on Radiological Protection; pCi = Picocurie; PRG = Preliminary Remediation Goal; Ra = Radium; S = Slow; TR = Target Risk.

Appendix C

Well Survey Results

RAMBOLL

ENVIRONMENT
& HEALTH

Phil Morris, PE
Senior Director, Environmental
Electric Energy, Inc.
Joppa Power Plant
2100 Portland Road
Joppa, IL 62960

Village of Joppa Well Survey and Community Water Supply Results
Joppa Power Plant, Joppa, Illinois

June 28, 2022

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this letter to document the activities and results of the well survey and Village of Joppa Community Water Supply sampling completed for the Joppa Power Plant (JPP).

Specifically, this document summarizes the results of the following tasks:

- Communication and coordination with the Village of Joppa to characterize and sample Joppa Community Water Supply (CWS) Well #2
- Investigation of potential water supply locations off-site including:
  - Evaluation of potential private well locations identified during windshield survey
  - Discussion with Village of Joppa personnel to evaluate whether potable water wells exist within village limits
  - Additional investigation, survey, and mail inquiries to identify potential private well locations
  - If private wells are confirmed downgradient within the potential extent of boron concentrations, sample private well locations. Note that no private wells were confirmed, and no sampling was completed.

Ramboll
234 W. Florida Street
Fifth Floor
Milwaukee, WI 53204
USA

T +1 414 837 3607
F +1 414 837 3608
https://ramboll.com

Ref. 1940102417

BACKGROUND

On April 19, 2022, Electric Energy Inc. (EEI) met with representatives of the Village of Joppa to discuss potential well installation locations and sampling of the CWS. Following discussion and completion of an access agreement, the Joppa CWS Well #2 was sampled by Ramboll on May 23, 2022. The sampling was completed while the well was operating and collected from a sample tap located at the wellhead. Three sets of field parameters (pH, temperature, and specific conductance) were measured and recorded to provide an indication of water quality and stability prior to sampling. The sample (and a duplicate) were collected following the measurement of field parameters and sent to Teklab, Inc. in Collinsville, Illinois (IEPA Certification Number [No.] 100226) for analysis of the following parameters: antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, fluoride, iron, lead, lithium, mercury, molybdenum, selenium, sulfate, thallium, and total dissolved solids.

The results are included in **Table 1**, and laboratory reports are attached (**Attachment 1**). Based on the results there are no exceedances of Illinois Class I groundwater protection standards (35 Ill. Admin. Code Part 620.410). These results will be confirmed with another sample event currently planned for September 2022.

WELL SURVEYS

Previous water well surveys have been completed in the vicinity of the JPP to identify possible receptors and evaluate the potential for impacts from Joppa East Ash Pond (EAP). Results have been included in the following reports:

- Kelron Environmental, 2013. *Memorandum: Visual Well Survey and Interviews with Village of Joppa and Fort Massac Water District Officials*. July 12, 2013.
- Natural Resource Technology, Inc. (NRT), 2013. *Phase I Hydrogeological Assessment Report, Coal Combustion Product Impoundments, Joppa Generating Station, Joppa, Illinois*. July 23, 2013.
- Ramboll US Corporation (Ramboll), 2020. *Well/Water Supply Survey and Evaluation, Coal-Fired Power Plants in Illinois*. September 24, 2020.
- Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021. *Hydrogeologic Site Characterization Report, included as Attachment H to Part 845 Operating Permit Application. East Ash Pond, Joppa Power Plant, Joppa, Illinois*. October 25, 2021.

The most recent potable water well inventory was completed utilizing federal and state databases to identify nearby pumping wells, drinking water receptors, and other uses of water in the vicinity of the EAP as provided in Section 5.1 of the Hydrogeologic Site Characterization Report (Ramboll, 2021).

In addition to the Village of Joppa CWS, three potential water wells within 300-meters of the JPP property boundary were identified downgradient and three potential wells were identified side-gradient of the EAP (**Figure 1**). The well IDs and depths of the wells is summarized as follows:

- Two potential downgradient wells (121270005500 and 121270005400) were identified to have depths of 65 feet and 137 feet bgs.
- One well (121272094200, downgradient) has Electric Energy Inc. listed as the owner and a depth of 90 feet bgs. This location is listed as Well 3, but this well is actually located on the JPP property, therefore, the location shown in the state database is not accurate.
- Three potential side-gradient wells (121270003100, 121270003000, and 121270005200) were identified to have depths ranging from 138 to 156 feet bgs.

WINDSHIELD SURVEY AND IN-PERSON INQUIRIES

A windshield survey (site visit) was completed on February 1, 2022 to confirm the locations of the wells identified in the well survey provided in Hydrogeologic Site Characterization Report (Ramboll, 2021) and identify whether any additional locations had potential wells (**Attachment 2**). Well-like features were observed at two locations (235 Main Street and 234 Pope Ave) and are depicted on **Figure 1**. Geosyntec visited the identified locations to inquire whether or not the observed features were groundwater wells. The results of their interactions are as follows:

- 234 Pope Ave – Geosyntec visited the property on May 4, 2022. The owner was present and indicated that the feature was not a well, and she only receives water from the village supply.
- 235 Main Street – An initial attempt by Geosyntec to speak with the owner on May 4, 2022 was unsuccessful. On June 2, 2022 Geosyntec again knocked on the door in an attempt to discuss the feature with the owner and/or resident. While waiting for a response at the door, a man, who lived several

houses to the west, stated that he was a nephew of the owner, and that the feature was a sewer clean out, not a well.

Based on the information gathered during the inquiries these features are not groundwater wells.

MAIL INQUIRIES

In addition to the database review, windshield survey, and in-person inquiries, EEI prepared and distributed a letter to all residents of the Village of Joppa (**Attachment 3**). The purpose of the letter was to identify wells that may not have been identified using previous methods and stated the following: "we ask that any property owner in the Village of Joppa with a private irrigation or drinking water well contact EEI to have their well tested." As of the date of this letter no residents downgradient of the EAP have responded.

NEXT STEPS

Based on the results of the well survey and subsequent inquiries, no downgradient potable water wells have been identified. Sampling analytical data results from Joppa CWS Well #2 indicate there are no impacts related to the EAP. Another sampling event is planned for September 2022 to confirm these results. Groundwater monitoring wells completed as part of off-site plume delineation activities within the Village of Joppa are scheduled for testing in July, September, and October 2022.

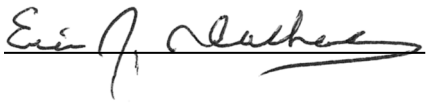
Documentation and interpretation of the data collected for the delineation activities are ongoing and will be submitted to IEPA when complete.

LICENSED PROFESSIONAL CERTIFICATIONS

I, Brian G. Hennings, a qualified professional geologist in good standing in the State of Illinois, certify that the Village of Joppa's Community Water Supply Well #2 was sampled on May 24, 2022 and the groundwater analytical results as reported by the laboratory for all the parameters tested were below the Illinois Class I groundwater protection standards (35 Ill. Admin. Code Part 620.410).

Brian G. Hennings
Professional Geologist
196-001482
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: June 28, 2022

I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the Village of Joppa's Community Water Supply Well #2 was sampled on May 24, 2022 and the groundwater analytical results as reported by the laboratory for all the parameters tested were below the Illinois Class I groundwater protection standards (35 Ill. Admin. Code Part 620.410).

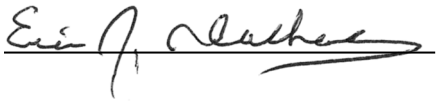


Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: June 28, 2022

I, Brian G. Hennings, a qualified professional geologist in good standing in the State of Illinois, certify that to the best of my knowledge based on (i) State of Illinois database searches, (ii) windshield surveys looking for private wells, (iii) letters mailed to all known owners and/or occupants within the Village of Joppa seeking information about private wells, and (iv) in-person interviews with two homeowners that confirmed they did not have a private well on their property, there are no known private water wells, for drinking water or non-potable use, identified within the Village of Joppa or within the area served by the community water system.

Brian G. Hennings
Professional Geologist
196-001482
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: June 28, 2022

I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that to the best of my knowledge based on (i) State of Illinois database searches, (ii) windshield surveys looking for private wells, (iii) letters mailed to all known owners and/or occupants within the Village of Joppa seeking information about private wells, and (iv) in-person interviews with two homeowners that confirmed they did not have a private well on their property, there are no known private water wells, for drinking water or non-potable use, identified within the Village of Joppa or within the area served by the community water system.



Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: June 28, 2022

FIGURES (ATTACHED)

Figure 1 Well Survey Results

TABLES (ATTACHED)

Table 1 Joppa CWS Well #2 Analytical Results

ATTACHMENTS

Attachment 1 Laboratory Analytical Report for Joppa CWS Well #2 Sampling
Attachment 2 Windshield Survey Notes and Photographs
Attachment 3 Vistra's April 26, 2022 Letter to Residents of Joppa Village

cc:

TABLES

TABLE 1. Joppa CWS WELL #2 ANALYTICAL RESULTS

VILLAGE OF JOPPA WELL SURVEY AND COMMUNITY WATER SUPPLY RESULTS

JOPPA POWER PLANT

JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Iron, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 620.410(a)	N/A	0.006	0.010	2.0	0.004	2.0	0.005	--	200.0	0.1	1.0	4.0	5.0	0.0075	--	0.002	--	6.5 - 9.0	0.05	400.0	0.002	1200
Joppa CWS Well #2	05/24/2022	<0.0010	0.0037	0.349	<0.0010	<0.0250	<0.0010	74.6	5	<0.0015	0.0013	0.28	1.32	0.0010	0.0111	<0.00020	0.0015	7.3	<0.0010	<10	<0.0020	270
DUP-01	05/24/2022	<0.0010	0.0037	0.349	<0.0010	<0.0250	<0.0010	75.4	6	<0.0015	0.0014	0.27	1.39	0.0008	0.011	<0.00020	0.0006	7.3	<0.0010	<10	<0.0020	266

[O: CJC 06/23/2022; C: EJT 06/24/2022]

Notes:

Detected at concentration greater than 35 I.A.C. 620.410(a) standard

-- = data not available

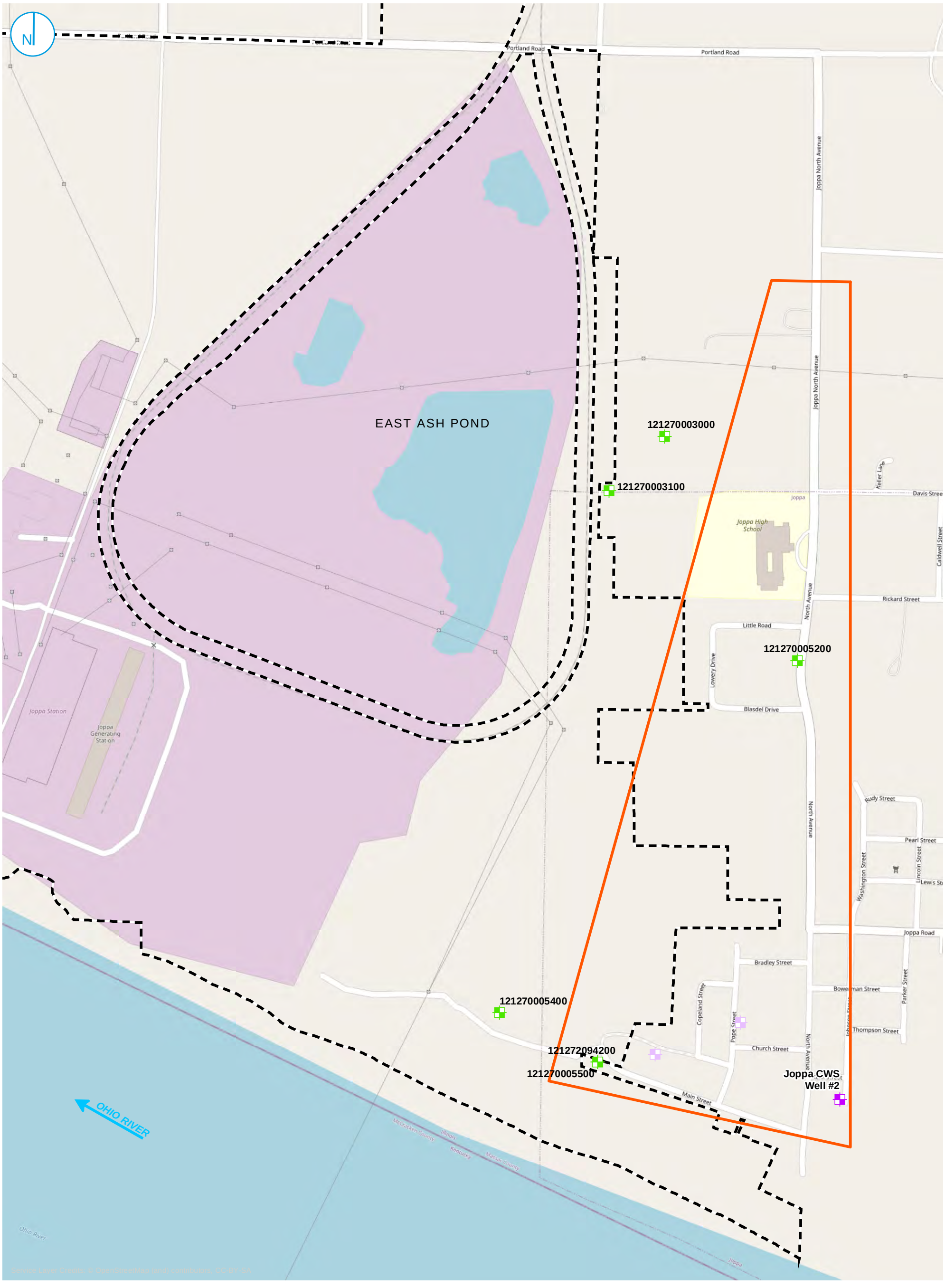
mg/L = milligrams per liter

SU = standard units

< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method. Estimated concentrations below the reporting limit and associated qualifiers are not provided.

35 I.A.C. 620.410(a) = Groundwater Quality Standards for Class I: Potable Resource Groundwater

FIGURES



COMMUNITY WATER SUPPLY
POTENTIAL PRIVATE WELL (DOES NOT EXIST)
PRIVATE WELL (PRESENCE NOT CONFIRMED)
AREA OF WINDSHIELD SURVEY PROPERTY
BOUNDARY

0 275 550
Feet

WELL SURVEY RESULTS

JOPPA GENERATING STATION
ELECTRIC ENERGY INC.
JOPPA, ILLINOIS

FIGURE 1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

ATTACHMENT 1
Laboratory Analytical Report for Joppa CWS Well #2 Sampling

June 07, 2022

Eric Plante
Ramboll
300 S. Wacker Drive
Suite 130
Chicago, IL 60606
TEL: (414) 837-3687
FAX: (414) 837-3608

Illinois	100226
Kansas	E-10374
Louisiana	05002
Louisiana	05003
Oklahoma	9978

RE: Joppa Groundwater **WorkOrder:** 22051610

Dear Eric Plante:

TEKLAB, INC received 4 samples on 5/25/2022 8:18:00 AM for the analysis presented in the following report.

Samples are analyzed on an as received basis unless otherwise requested and documented. The sample results contained in this report relate only to the requested analytes of interest as directed on the chain of custody. NELAP accredited fields of testing are indicated by the letters NELAP under the Certification column. Unless otherwise documented within this report, Teklab Inc. analyzes samples utilizing the most current methods in compliance with 40CFR. All tests are performed in the Collinsville, IL laboratory unless otherwise noted in the Case Narrative.

All quality control criteria applicable to the test methods employed for this project have been satisfactorily met and are in accordance with NELAP except where noted. The following report shall not be reproduced, except in full, without the written approval of Teklab, Inc.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Elizabeth A. Hurley
Project Manager
(618)344-1004 ex 33
ehurley@teklabinc.com

Client: Ramboll
Work Order: 22051610
Client Project: Joppa Groundwater
Report Date: 07-Jun-22

This reporting package includes the following:

Cover Letter	1
Report Contents	2
Definitions	3
Case Narrative	5
Accreditations	6
Laboratory Results	7
Sample Summary	9
Dates Report	10
Quality Control Results	11
Receiving Check List	17
Chain of Custody	Appended

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

Abbr Definition

*	Analytes on report marked with an asterisk are not NELAP accredited
CCV	Continuing calibration verification is a check of a standard to determine the state of calibration of an instrument between recalibration.
CRQL	A Client Requested Quantitation Limit is a reporting limit that varies according to customer request. The CRQL may not be less than the MDL.
DF	Dilution factor is the dilution performed during analysis only and does not take into account any dilutions made during sample preparation. The reported result is final and includes all dilution factors.
DNI	Did not ignite
DUP	Laboratory duplicate is a replicate aliquot prepared under the same laboratory conditions and independently analyzed to obtain a measure of precision.
ICV	Initial calibration verification is a check of a standard to determine the state of calibration of an instrument before sample analysis is initiated.
IDPH	IL Dept. of Public Health
LCS	Laboratory control sample is a sample matrix, free from the analytes of interest,spiked with verified known amounts of analytes and analyzed exactly like a sample to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.
LCSD	Laboratory control sample duplicate is a replicate laboratory control sample that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MBLK	Method blank is a sample of a matrix similar to the batch of associated sample (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences should present at concentrations that impact the analytical results for sample analyses.
MDL	"The method detection limit is defined as the minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results."
MS	Matrix spike is an aliquot of matrix fortified (spiked) with known quantities of specific analytes that is subjected to the entire analytical procedures in order to determine the effect of the matrix on an approved test method's recovery system. The acceptable recovery range is listed in the QC Package (provided upon request).
MSD	Matrix spike duplicate means a replicate matrix spike that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MW	Molecular weight
NC	Data is not acceptable for compliance purposes
ND	Not Detected at the Reporting Limit
NELAP	NELAP Accredited
PQL	Practical quantitation limit means the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operation conditions.
RL	The reporting limit the lowest level that the data is displayed in the final report. The reporting limit may vary according to customer request or sample dilution. The reporting limit may not be less than the MDL.
RPD	Relative percent difference is a calculated difference between two recoveries (ie. MS/MSD). The acceptable recovery limit is listed in the QC Package (provided upon request).
SPK	The spike is a known mass of target analyte added to a blank sample or sub-sample; used to determine recovery deficiency or for other quality control purposes.
Surr	Surrogates are compounds which are similar to the analytes of interest in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples.
TIC	Tentatively identified compound: Analytes tentatively identified in the sample by using a library search. Only results not in the calibration standard will be reported as tentatively identified compounds. Results for tentatively identified compounds that are not present in the calibration standard, but are assigned a specific chemical name based upon the library search, are calculated using total peak areas from reconstructed ion chromatograms and a response factor of one. The nearest Internal Standard is used for the calculation. The results of any TICs must be considered estimated, and are flagged with a "T". If the estimated result is above the calibration range it is flagged "ET"
TNTC	Too numerous to count (> 200 CFU)

Definitions

Client: Ramboll
Work Order: 22051610
Client Project: Joppa Groundwater
Report Date: 07-Jun-22

Qualifiers

- # - Unknown hydrocarbon
- B - Analyte detected in associated Method Blank
- C - RL shown is a Client Requested Quantitation Limit
- E - Value above quantitation range
- H - Holding times exceeded
- I - Associated internal standard was outside method criteria
- J - Analyte detected below quantitation limits
- M - Manual Integration used to determine area response
- ND - Not Detected at the Reporting Limit
- R - RPD outside accepted recovery limits
- S - Spike Recovery outside recovery limits
- T - TIC(Tentatively identified compound)
- X - Value exceeds Maximum Contaminant Level

Case Narrative

http://www.teklabinc.com/

Client: Ramboll
Client Project: Joppa Groundwater

Work Order: 22051610
Report Date: 07-Jun-22

Cooler Receipt Temp: 5.4 °C

This report was revised on June 7, 2022 per Eric Bauer's request. The reason for the revision is to include Mercury analysis (omitted in error at sample receipt). Please replace report dated June 3, 2022 with this report. EAH 6/7/22

Locations

Collinsville

Address 5445 Horseshoe Lake Road
Collinsville, IL 62234-7425
Phone (618) 344-1004
Fax (618) 344-1005
Email jhriley@teklabinc.com

Springfield

Address 3920 Pintail Dr
Springfield, IL 62711-9415
Phone (217) 698-1004
Fax (217) 698-1005
Email KKlostermann@teklabinc.com

Kansas City

Address 8421 Nieman Road
Lenexa, KS 66214
Phone (913) 541-1998
Fax (913) 541-1998
Email jhriley@teklabinc.com

Collinsville Air

Address 5445 Horseshoe Lake Road
Collinsville, IL 62234-7425
Phone (618) 344-1004
Fax (618) 344-1005
Email EHurley@teklabinc.com

Chicago

Address 1319 Butterfield Rd.
Downers Grove, IL 60515
Phone (630) 324-6855
Fax
Email arenner@teklabinc.com

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

State	Dept	Cert #	NELAP	Exp Date	Lab
Illinois	IEPA	100226	NELAP	1/31/2023	Collinsville
Kansas	KDHE	E-10374	NELAP	4/30/2023	Collinsville
Louisiana	LDEQ	05002	NELAP	6/30/2023	Collinsville
Louisiana	LDEQ	05003	NELAP	6/30/2023	Collinsville
Oklahoma	ODEQ	9978	NELAP	8/31/2022	Collinsville
Arkansas	ADEQ	88-0966		3/14/2023	Collinsville
Illinois	IDPH	17584		5/31/2023	Collinsville
Kentucky	UST	0073		1/31/2023	Collinsville
Missouri	MDNR	00930		5/31/2023	Collinsville
Missouri	MDNR	930		1/31/2025	Collinsville

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

Lab ID: 22051610-001 **Client Sample ID:** CWS-Well-2

Matrix: GROUNDWATER **Collection Date:** 05/24/2022 9:30

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
STANDARD METHODS 2540 C (DISSOLVED) 1997, 2011								
Total Dissolved Solids	NELAP	20		**270**	mg/L	1	05/26/2022 10:25	R312565
SW-846 9036 (TOTAL)								
Sulfate	NELAP	10		**< 10**	mg/L	1	05/26/2022 18:23	R312492
SW-846 9214 (TOTAL)								
Fluoride	NELAP	0.10		**0.28**	mg/L	1	06/02/2022 11:32	R312705
SW-846 9251 (TOTAL)								
Chloride	NELAP	1		**5**	mg/L	1	05/26/2022 18:23	R312493
SW-846 3005A, 6010B, METALS BY ICP (TOTAL)								
Lithium	NELAP	0.0050		**0.0111**	mg/L	1	06/02/2022 11:57	193089
SW-846 3005A, 6020A, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:24	193089
Arsenic	NELAP	0.0010		**0.0037**	mg/L	5	05/27/2022 13:24	193089
Barium	NELAP	0.0010		**0.349**	mg/L	5	05/27/2022 13:24	193089
Beryllium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:24	193089
Boron	NELAP	0.0250		**< 0.0250**	mg/L	5	05/27/2022 13:24	193089
Cadmium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:24	193089
Calcium	NELAP	0.125		**74.6**	mg/L	5	05/31/2022 13:49	193089
Chromium	NELAP	0.0015		**< 0.0015**	mg/L	5	05/27/2022 13:24	193089
Cobalt	NELAP	0.0010		**0.0013**	mg/L	5	05/27/2022 13:24	193089
Iron	NELAP	0.0250		**1.32**	mg/L	5	05/31/2022 13:49	193089
Lead	NELAP	0.0010	J	**0.0010**	mg/L	5	05/27/2022 13:24	193089
Molybdenum	NELAP	0.0015	J	**0.0015**	mg/L	5	05/27/2022 13:24	193089
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:24	193089
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	05/27/2022 13:24	193089
LCS recovered outside upper control limits for B and Se. Sample results are below the reporting limit. Data is reportable per the TNI Standard.								
SW-846 7470A (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	06/07/2022 10:08	193373

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

Lab ID: 22051610-002 **Client Sample ID:** DUP-01

Matrix: GROUNDWATER **Collection Date:** 05/24/2022 0:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
STANDARD METHODS 2540 C (DISSOLVED) 1997, 2011								
Total Dissolved Solids	NELAP	20		**266**	mg/L	1	05/26/2022 10:26	R312565
SW-846 9036 (TOTAL)								
Sulfate	NELAP	10		**< 10**	mg/L	1	05/26/2022 18:44	R312492
SW-846 9214 (TOTAL)								
Fluoride	NELAP	0.10		**0.27**	mg/L	1	06/02/2022 11:34	R312705
SW-846 9251 (TOTAL)								
Chloride	NELAP	1		**6**	mg/L	1	05/26/2022 18:44	R312493
SW-846 3005A, 6010B, METALS BY ICP (TOTAL)								
Lithium	NELAP	0.0050		**0.0110**	mg/L	1	06/02/2022 11:59	193089
SW-846 3005A, 6020A, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:30	193089
Arsenic	NELAP	0.0010		**0.0037**	mg/L	5	05/27/2022 13:30	193089
Barium	NELAP	0.0010		**0.349**	mg/L	5	05/27/2022 13:30	193089
Beryllium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:30	193089
Boron	NELAP	0.0250		**< 0.0250**	mg/L	5	05/27/2022 13:30	193089
Cadmium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:30	193089
Calcium	NELAP	0.125	S	**75.4**	mg/L	5	05/31/2022 15:24	193089
Chromium	NELAP	0.0015		**< 0.0015**	mg/L	5	05/27/2022 13:30	193089
Cobalt	NELAP	0.0010		**0.0014**	mg/L	5	06/02/2022 12:22	193089
Iron	NELAP	0.0250		**1.39**	mg/L	5	05/31/2022 15:24	193089
Lead	NELAP	0.0010	J	**0.0008**	mg/L	5	05/27/2022 13:30	193089
Molybdenum	NELAP	0.0015	J	**0.0006**	mg/L	5	05/27/2022 13:30	193089
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:30	193089
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	05/27/2022 13:30	193089

Matrix spike control limits for Ca are not applicable due to high sample/spike ratio.

LCS recovered outside upper control limits for B and Se. Sample results are below the reporting limit. Data is reportable per the TNI Standard.

SW-846 7470A (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	06/07/2022 10:11	193373

Client: Ramboll
Client Project: Joppa Groundwater

Work Order: 22051610
Report Date: 07-Jun-22

Lab Sample ID	Client Sample ID	Matrix	Fractions	Collection Date
22051610-001	CWS-Well-2	Groundwater	3	05/24/2022 9:30
22051610-002	DUP-01	Groundwater	3	05/24/2022 0:00
22051610-003	Extra Set 1	Groundwater	3	05/24/2022 0:00
22051610-004	Extra Set 2	Groundwater	3	05/24/2022 0:00

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

Sample ID	Client Sample ID	Collection Date	Received Date		
	Test Name			**Prep Date/Time**	**Analysis Date/Time**
22051610-001A	CWS-Well-2	05/24/2022 9:30	05/25/2022 8:18		
	SW-846 9036 (Total)				05/26/2022 18:23
	SW-846 9214 (Total)				06/02/2022 11:32
	SW-846 9251 (Total)				05/26/2022 18:23
22051610-001B	CWS-Well-2	05/24/2022 9:30	05/25/2022 8:18		
	Standard Methods 2540 C (Dissolved) 1997, 2011				05/26/2022 10:25
22051610-001C	CWS-Well-2	05/24/2022 9:30	05/25/2022 8:18		
	SW-846 3005A, 6010B, Metals by ICP (Total)			05/26/2022 7:36	06/02/2022 11:57
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	05/27/2022 13:24
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	05/31/2022 13:49
	SW-846 7470A (Total)			06/06/2022 13:00	06/07/2022 10:08
22051610-002A	DUP-01	05/24/2022 0:00	05/25/2022 8:18		
	SW-846 9036 (Total)				05/26/2022 18:44
	SW-846 9214 (Total)				06/02/2022 11:34
	SW-846 9251 (Total)				05/26/2022 18:44
22051610-002B	DUP-01	05/24/2022 0:00	05/25/2022 8:18		
	Standard Methods 2540 C (Dissolved) 1997, 2011				05/26/2022 10:26
22051610-002C	DUP-01	05/24/2022 0:00	05/25/2022 8:18		
	SW-846 3005A, 6010B, Metals by ICP (Total)			05/26/2022 7:36	06/02/2022 11:59
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	05/27/2022 13:30
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	05/31/2022 15:24
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	06/02/2022 12:22
	SW-846 7470A (Total)			06/06/2022 13:00	06/07/2022 10:11

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

STANDARD METHODS 2540 C (DISSOLVED) 1997, 2011

Batch R312565 **SampType:** MBLK Units **mg/L**
SampID: MBLK

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Total Dissolved Solids		20		**< 20**	16.00	0	0	-100	100	05/26/2022
Total Dissolved Solids		20		**< 20**	16.00	0	0	-100	100	05/26/2022

Batch R312565 **SampType:** LCS Units **mg/L**
SampID: LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Total Dissolved Solids		20		**952**	1000	0	95.2	90	110	05/26/2022
Total Dissolved Solids		20		**952**	1000	0	95.2	90	110	05/26/2022

Batch R312565 **SampType:** DUP Units **mg/L** RPD Limit: **5**
SampID: 22051610-001BDUP

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Total Dissolved Solids		20		**262**				270.0	3.01	05/26/2022

SW-846 9036 (TOTAL)

Batch R312492 **SampType:** MBLK Units **mg/L**
SampID: ICB/MBLK

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Sulfate		10		**< 10**	6.140	0	0	-100	100	05/26/2022

Batch R312492 **SampType:** LCS Units **mg/L**
SampID: ICV/LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Sulfate		10		**21**	20.00	0	107.4	90	110	05/26/2022

Batch R312492 **SampType:** MS Units **mg/L**
SampID: 22051610-001AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Sulfate		10		**20**	20.00	0	98.4	85	115	05/26/2022

Batch R312492 **SampType:** MSD Units **mg/L** RPD Limit: **10**
SampID: 22051610-001AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Sulfate		10		**20**	20.00	0	100.8	19.68	2.36	05/26/2022

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

SW-846 9214 (TOTAL)

Batch R312705 **SampType:** MBLK Units **mg/L**
SampID: MBLK

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Fluoride		0.10		**< 0.10**	0.0370	0	0	-100	100	06/02/2022

Batch R312705 **SampType:** LCS Units **mg/L**
SampID: LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Fluoride		0.10		**1.01**	1.000	0	100.7	90	110	06/02/2022

Batch R312705 **SampType:** MS Units **mg/L**
SampID: 22051610-002AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Fluoride		0.10		**2.43**	2.000	0.2710	108.2	75	125	06/02/2022

Batch R312705 **SampType:** MSD Units **mg/L** RPD Limit: **15**
SampID: 22051610-002AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Fluoride		0.10		**2.46**	2.000	0.2710	109.2	2.434	0.90	06/02/2022

SW-846 9251 (TOTAL)

Batch R312493 **SampType:** MBLK Units **mg/L**
SampID: ICB/MBLK

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Chloride		1		**< 1**	0.5000	0	0	-100	100	05/26/2022

Batch R312493 **SampType:** LCS Units **mg/L**
SampID: ICV/LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Chloride		1		**22**	20.00	0	108.8	90	110	05/26/2022

Batch R312493 **SampType:** MS Units **mg/L**
SampID: 22051610-001AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Chloride		1		**26**	20.00	5.250	102.0	85	115	05/26/2022

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

SW-846 9251 (TOTAL)

Batch R312493 **SampType:** MSD Units **mg/L** RPD Limit: **15**

SampID: 22051610-001AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Chloride		1		**25**	20.00	5.250	100.8	25.66	0.94	05/26/2022

SW-846 3005A, 6010B, METALS BY ICP (TOTAL)

Batch 193089 **SampType:** MBLK Units **mg/L**

SampID: MBLK-193089

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Lithium	*	0.0050		**< 0.0050**	0.0019	0	0	-100	100	06/01/2022
Lithium		0.0050		**< 0.0050**	0.0019	0	0	-100	100	06/02/2022

Batch 193089 **SampType:** LCS Units **mg/L**

SampID: LCS-193089

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Lithium		0.0050		**0.552**	0.5000	0	110.3	85	115	06/02/2022

Batch 193089 **SampType:** MS Units **mg/L**

SampID: 22051610-002CMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Lithium		0.0050		**0.569**	0.5000	0.01100	111.6	75	125	06/02/2022

Batch 193089 **SampType:** MSD Units **mg/L** RPD Limit: **20**

SampID: 22051610-002CMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Lithium		0.0050		**0.562**	0.5000	0.01100	110.1	0.5689	1.31	06/02/2022

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

SW-846 3005A, 6020A, METALS BY ICPMS (TOTAL)

Batch 193089 **SampType:** MBLK Units **mg/L**

SampID: MBLK-193089

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**< 0.0010**	0.0004	0	0	-100	100	05/27/2022
Arsenic		0.0010		**< 0.0010**	0.0004	0	0	-100	100	05/27/2022
Barium		0.0010		**< 0.0010**	0.0007	0	0	-100	100	05/27/2022
Beryllium		0.0010		**< 0.0010**	0.0002	0	0	-100	100	05/27/2022
Boron		0.0250		**< 0.0250**	0.0093	0	0	-100	100	05/27/2022
Cadmium		0.0010		**< 0.0010**	0.0001	0	0	-100	100	05/27/2022
Calcium		0.125		**< 0.125**	0.0700	0	0	-100	100	05/31/2022
Chromium		0.0015		**< 0.0015**	0.0007	0	0	-100	100	05/27/2022
Cobalt		0.0010		**< 0.0010**	0.0001	0	0	-100	100	05/27/2022
Iron		0.0250		**< 0.0250**	0.0120	0	0	-100	100	05/31/2022
Lead		0.0010		**< 0.0010**	0.0006	0	0	-100	100	05/27/2022
Molybdenum		0.0015		**< 0.0015**	0.0006	0	0	-100	100	05/27/2022
Selenium		0.0010		**< 0.0010**	0.0006	0	0	-100	100	05/27/2022
Thallium		0.0020		**< 0.0020**	0.0010	0	0	-100	100	05/27/2022

Batch 193089 **SampType:** LCS Units **mg/L**

SampID: LCS-193089

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**0.593**	0.5000	0	118.7	80	120	05/27/2022
Arsenic		0.0010		**0.543**	0.5000	0	108.7	80	120	06/01/2022
Barium		0.0010		**2.08**	2.000	0	103.9	80	120	06/01/2022
Beryllium		0.0010		**0.0531**	0.0500	0	106.1	80	120	06/01/2022
Boron		0.0250	S	**0.614**	0.5000	0	122.7	80	120	05/27/2022
Cadmium		0.0010		**0.0531**	0.0500	0	106.1	80	120	06/01/2022
Calcium		0.125		**2.59**	2.500	0	103.7	80	120	05/31/2022
Chromium		0.0015		**0.237**	0.2000	0	118.3	80	120	05/27/2022
Cobalt		0.0010		**0.524**	0.5000	0	104.8	80	120	06/01/2022
Iron		0.0250		**2.11**	2.000	0	105.4	80	120	05/31/2022
Lead		0.0010		**0.589**	0.5000	0	117.7	80	120	05/27/2022
Molybdenum		0.0015		**0.519**	0.5000	0	103.7	80	120	06/01/2022
Selenium		0.0010	S	**0.601**	0.5000	0	120.2	80	120	05/27/2022
Thallium		0.0020		**0.286**	0.2500	0	114.4	80	120	05/27/2022

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

SW-846 3005A, 6020A, METALS BY ICPMS (TOTAL)

Batch 193089 **SampType:** MS Units **mg/L**

SampID: 22051610-002CMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**0.576**	0.5000	0	115.1	75	125	05/27/2022
Arsenic		0.0010		**0.611**	0.5000	0.003729	121.4	75	125	05/27/2022
Barium		0.0010		**2.74**	2.000	0.3494	119.6	75	125	05/27/2022
Beryllium		0.0010		**0.0605**	0.0500	0	121.1	75	125	05/27/2022
Boron		0.0250		**0.586**	0.5000	0	117.2	75	125	05/27/2022
Cadmium		0.0010		**0.0588**	0.0500	0	117.6	75	125	05/27/2022
Calcium		0.125	S	**74.7**	2.500	75.43	-27.9	75	125	05/31/2022
Chromium		0.0015		**0.225**	0.2000	0	112.3	75	125	05/27/2022
Cobalt		0.0010		**0.619**	0.5000	0.001389	123.5	75	125	06/02/2022
Iron		0.0250		**3.48**	2.000	1.389	104.3	75	125	05/31/2022
Lead		0.0010		**0.565**	0.5000	0.0007580	112.8	75	125	05/27/2022
Molybdenum		0.0015		**0.595**	0.5000	0.0006209	118.9	75	125	05/27/2022
Selenium		0.0010		**0.575**	0.5000	0	114.9	75	125	05/27/2022
Thallium		0.0020		**0.282**	0.2500	0	112.9	75	125	05/27/2022

Batch 193089 **SampType:** MSD Units **mg/L** RPD Limit: **20**

SampID: 22051610-002CMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Antimony		0.0010		**0.539**	0.5000	0	107.8	0.5757	6.56	05/27/2022
Arsenic		0.0010		**0.569**	0.5000	0.003729	113.1	0.6106	7.02	05/27/2022
Barium		0.0010		**2.52**	2.000	0.3494	108.7	2.742	8.28	05/27/2022
Beryllium		0.0010		**0.0571**	0.0500	0	114.1	0.06054	5.92	05/27/2022
Boron		0.0250		**0.569**	0.5000	0	113.8	0.5860	2.93	05/27/2022
Cadmium		0.0010		**0.0556**	0.0500	0	111.1	0.05881	5.69	05/27/2022
Calcium		0.125	S	**77.1**	2.500	75.43	68.5	74.73	3.17	05/31/2022
Chromium		0.0015		**0.212**	0.2000	0	106.0	0.2246	5.78	05/27/2022
Cobalt		0.0010		**0.593**	0.5000	0.001389	118.3	0.6191	4.36	06/02/2022
Iron		0.0250		**3.50**	2.000	1.389	105.6	3.476	0.75	05/31/2022
Lead		0.0010		**0.530**	0.5000	0.0007580	105.9	0.5648	6.34	05/27/2022
Molybdenum		0.0015		**0.550**	0.5000	0.0006209	109.9	0.5953	7.86	05/27/2022
Selenium		0.0010		**0.544**	0.5000	0	108.8	0.5747	5.47	05/27/2022
Thallium		0.0020		**0.264**	0.2500	0	105.7	0.2823	6.61	05/27/2022

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

SW-846 7470A (TOTAL)

Batch 193373 **SampType:** MBLK Units **mg/L**

SampID: MBLK-193373

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**< 0.00020**	0.0001	0	0	-100	100	06/07/2022

Batch 193373 **SampType:** LCS Units **mg/L**

SampID: LCS-193373

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00497**	0.0050	0	99.5	85	115	06/07/2022

Batch 193373 **SampType:** MS Units **mg/L**

SampID: 22051610-002CMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00496**	0.0050	0	99.3	75	125	06/07/2022

Batch 193373 **SampType:** MSD Units **mg/L** RPD Limit: **15**

SampID: 22051610-002CMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Mercury		0.00020		**0.00487**	0.0050	0	97.3	0.004965	2.02	06/07/2022

Receiving Check List

http://www.teklabinc.com/

Client: Ramboll
Work Order: 22051610
Client Project: Joppa Groundwater
Report Date: 07-Jun-22

Carrier: FedEx
Received By: RMW

Completed by: Payton Yoch
On: 25-May-22

Reviewed by: Elizabeth A. Hurley
On: 25-May-22

Pages to follow: Chain of custody 1 Extra pages included 0

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐	Temp °C 5.4
Type of thermal preservation?	None ☐	Ice ☑	Blue Ice ☐	Dry Ice ☐
Chain of custody present?	Yes ☑	No ☐		
Chain of custody signed when relinquished and received?	Yes ☑	No ☐		
Chain of custody agrees with sample labels?	Yes ☐	No ☑		
Samples in proper container/bottle?	Yes ☑	No ☐		
Sample containers intact?	Yes ☑	No ☐		
Sufficient sample volume for indicated test?	Yes ☑	No ☐		
All samples received within holding time?	Yes ☑	No ☐		
Reported field parameters measured:	Field ☐	Lab ☐	NA ☑	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐		
When thermal preservation is required, samples are compliant with a temperature between 0.1°C - 6.0°C, or when samples are received on ice the same day as collected.				
Water – at least one vial per sample has zero headspace?	Yes ☐	No ☐	No VOA vials ☑	
Water - TOX containers have zero headspace?	Yes ☐	No ☐	No TOX containers ☑	
Water - pH acceptable upon receipt?	Yes ☑	No ☐	NA ☐	
NPDES/CWA TCN interferences checked/treated in the field?	Yes ☐	No ☐	NA ☑	

Any No responses must be detailed below or on the COC.

pH strip 78198 - pyoch - 5/25/2022 10:55:30 AM

Two extra sample sets were received but not identified on the container labels or chain of custody. Eric Plante was notified via work order summary. CET/EAH 5/25/22

CHAIN OF CUSTODY

pg. 1 of 1 Work order # 22051610

TEKLAB, INC. 5445 Horseshoe Lake Road - Collinsville, IL 62234 - Phone: (618) 344-1004 - Fax: (618) 344-1005

Client: Ramboll
Address: 300 S. Wacker Drive
City / State / Zip Chicago, IL 60606
Contact: Erin Plante **Phone:** (414) 837-3607
E-Mail: eric.plante@obg.com **Fax:**

Samples on: [X] ICE [ ] BLUE ICE [ ] NO ICE 5.4 °C LTG# 3
Preserved in: [ ] LAB [X] FIELD **FOR LAB USE ONLY**
Lab Notes phd 78 PTS. CET 5/25/2022
Recieved extra samples w/o sample ids. ☆

Client Comments:
ICP/MS: Sb As Ba Be B Cd Ca Cr Co Fe Pb Mo Se Tl
ICP: Li

Are these samples known to be involved in litigation? If yes, a surcharge will apply [ ] Yes [ ] No
Are these samples known to be hazardous? [ ] Yes [X] No
Are there any required reporting limits to be met on the requested analysis?. If yes, please provide limits in the comment section. [ ] Yes [ ] No

Project Name/Number: Joppa Groundwater
Sample Collector's Name: SAMMY MALLOW

Results Requested: [X] Standard [ ] 1-2 Day (100% Surcharge) [ ] Other ____ [ ] 3 Day (50% Surcharge)
Billing Instructions:

Lab Use Only	Sample Identification	Date/Time Sampled	UNPRES	HNO3	NaOH	H2SO4	HCL	MeOH	NaHSO4	OTHER	Aqueous	Drinking Water	Soil	Sludge	Special Waste	Groundwater	Chloride	Dissolved TDS	Fluoride	Mercury	Sulfate	Total Metals by ICP	Total Metals by ICP/MS
22051610-001	CWS-WELL-2	5-24-22/0930	2	1												X	X	X	X	X	X	X	X
002	DUP-01	———	2	1												X	X	X	X	X	X	X	X
003	Extra Set 1 ☆																						
004	Extra Set 2 ☆																						

Relinquished By	Date/Time	Received By	Date/Time
SAMUEL MALLOW [signature]	5-24-22 / 1130	FED EX	5-24-22
		Reannan Willis (Fedex)	5/25/22 8:18

The individual signing this agreement on behalf of the client, acknowledges that he/she has read and understands the terms and conditions of this agreement, and that he/she has the authority to sign on behalf of the client. See www.teklabinc.com for terms and conditions.

BottleOrder: 72433

CET 5/25/2022

ATTACHMENT 2
Windshield Survey Notes and Photographs

Daily Field Report

Project and Site Information

Client: Vistra	**Project No.:** GLP8030	**Date:** December 10, 2021
Project: Joppa Well Survey	**Location:** Joppa, IL	**Phase No.**: 02
Survey Performed By: Zachary Fallert, P.E. (Geosyntec)		
Weather: PM: 55°F, Partly Cloudy		
Distribution List: Vistra: Stuart Cravens, Vic Modeer, Geosyntec: Allison Kreinberg, Lucas Carr, Zachary Fallert, Ramboll: Brian Hennings, Nathaniel Keller		

Geosyntec Onsite Personnel

Name	Position	Arrival	Departure	Hours
Zachary Fallert (ZF)	Engineer	1230	1500	2.5

Description of Work

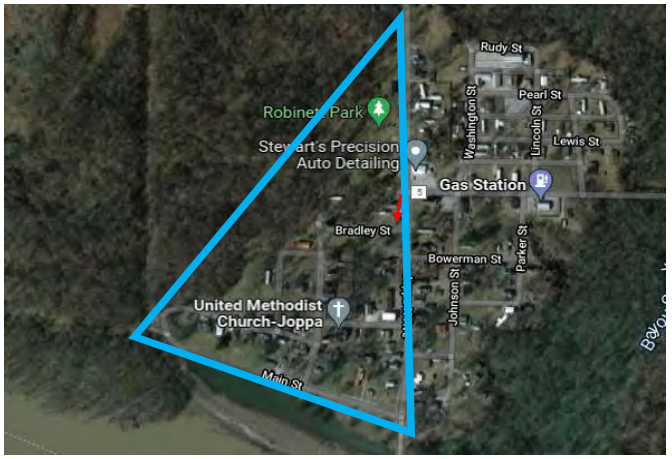
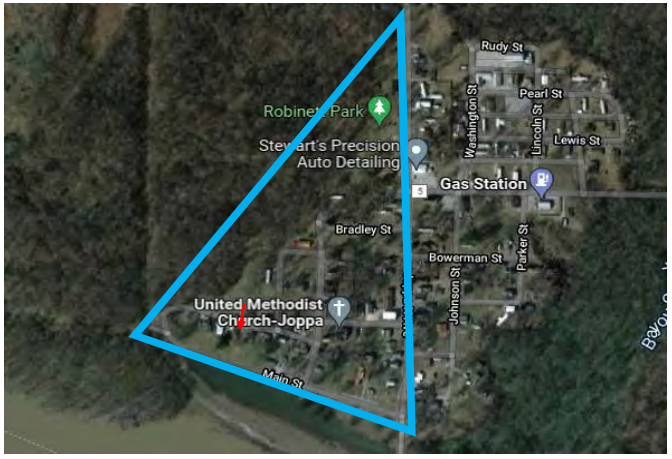
- ZF performed a "windshield survey" by driving most of the streets within the designated survey area (shown in blue in the attached photolog).
- ZF then parked on Blasdel Dr. and walked Blasdel Dr., Lowery Dr., and Little Rd.
    a. ZF observed two PVC stickups along this route. These stickups are approximately 6 in. diameter PVC with a threaded cap. Both appeared to be relatively new.
- ZF then parked at the Joppa Post Office and walked the southern designated survey area including Bradley St., Pope St., Copeland St., Main St., and Joppa N. Ave.
    a. ZF observed four PVC stickups similar to those noted previously. Exposed soil and straw around one indicated further that they are recent additions.
    b. ZF observed one stickup beneath a decorative windmill. From the road, it could not be discerned what the stickup was.
    c. ZF observed one stickup in a yard that had a spicket and garden hose attached.
    d. ZF spoke with one resident and informed him that this was part of a well survey. The resident informed ZF that he did not think any wells would be found as most people had cisterns prior to the public water supply coming online in the 1950s.
- ZF walked Kern St., turned south, and came to the water treatment facility. North of the facility, ZF observed a small structure that appeared to be a well house for the public water supply.
- No wells, except for the public supply well, listed by the Illinois Department of Natural Resources database were observed.
- ZF left Joppa.

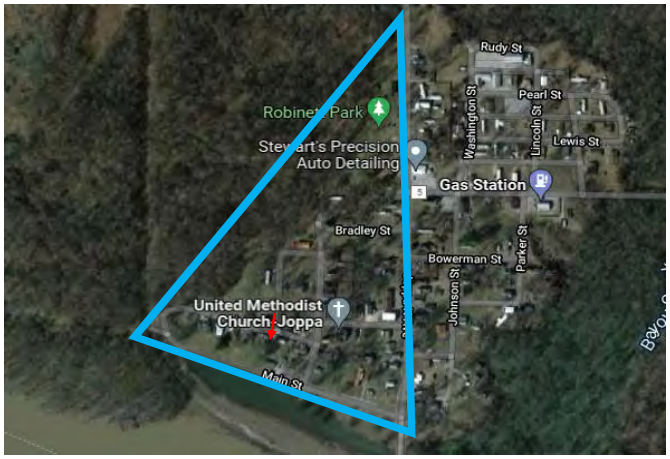
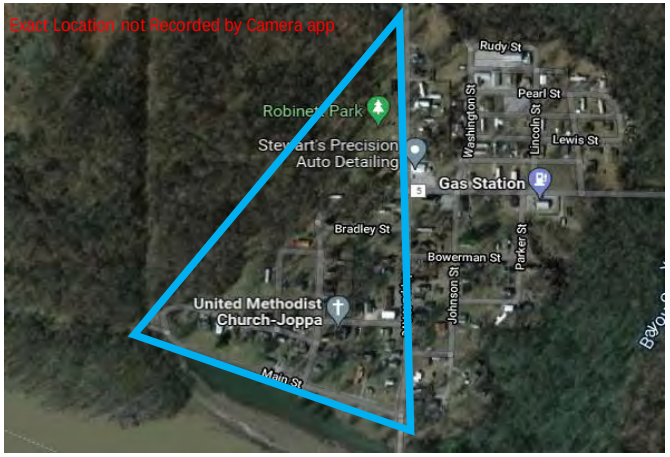
Review and Approval

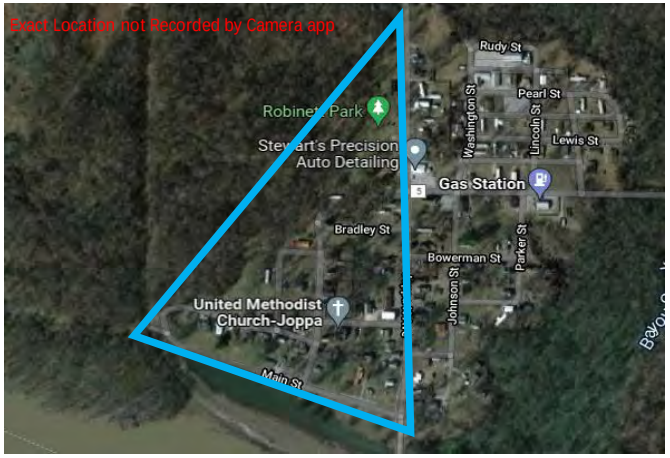
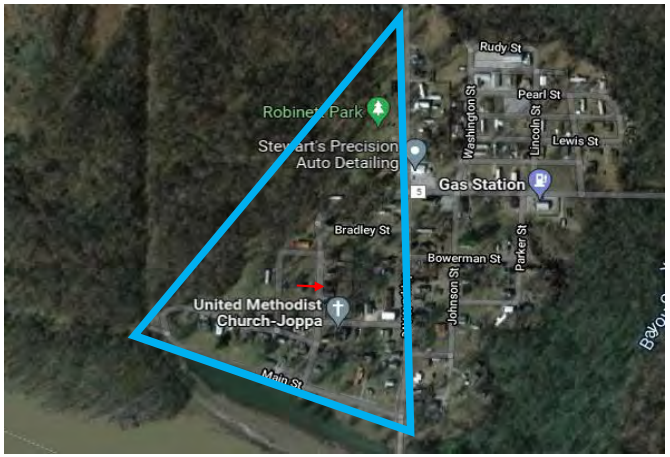
Report Prepared By	Signature	Date
Zachary Fallert, P.E.		February 2, 2022

Date:	2/1/2022
Direction:	South
Approximate Location:	West end of Blasdel Dr.
Description:	PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.

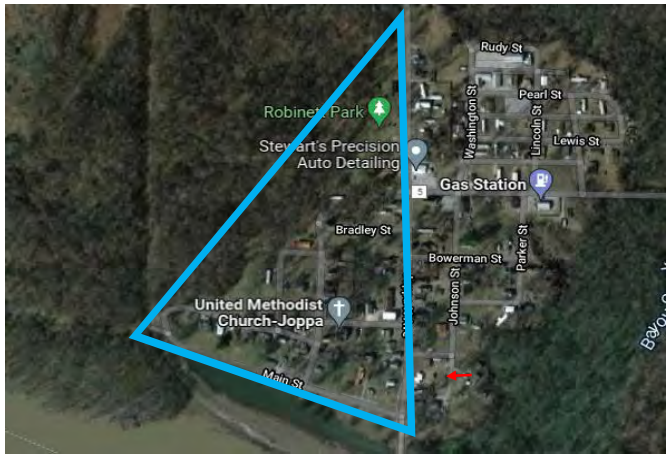
Date:	2/1/2022
Direction:	North
Approximate Location:	West end of Little Rd.
Description:	PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.

Date:	2/1/2022		
Direction:	South		
Approximate Location:	Corner of Joppa N Ave. and Bradley St.		
Description:	PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.		
Date:	2/1/2022		
Direction:	South		
Approximate Location:	Main St. west of Copeland		
Description:	Possible well location. Uknown stickup beneath decorative windmill.		

Date: 2/1/2022 **Direction:** South **Approximate Location:** Main St. west of Copeland **Description:** PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.		
Date: 2/1/2022 **Direction:** Unknown **Approximate Location:** Within blue boundary to right. **Description:** PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.		

Date:	2/1/2022		
Direction:	Unknown		
Approximate Location:	Within blue boundary to right.		
Description:	PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.		
Date:	2/1/2022		
Direction:	East		
Approximate Location:	Pope St. between the two ends of Copeland St.		
Description:	Stickup in yard. Has spicket with hose attached. Likely just water line stick up.		

Date:	2/1/2022
Direction:	West
Approximate Location:	Johnson St. north of water treatment plant and south of Kern St.
Description:	Suspected public water supply well house.



ATTACHMENT 3
Vistra's April 26, 2022 Letter to Residents of Joppa Village

April 26, 2022

VIA U.S. MAIL

Dear Neighbor:

Last year, Vistra Corp. and Electric Energy Inc. (EEI), the entity that owns the Joppa Power Plant, announced that the Joppa Power Plant would close no later than Sept. 1, 2022. The accelerated retirement schedule was part of a settlement to resolve a complaint initiated by the Illinois Sierra Club in 2018. We're committed to an orderly and responsible plant retirement and to transforming the site into a battery energy storage center. We also remain committed to the Village of Joppa and the community and will have a presence here for decades to come.

Retirement Update

The hardest decision we make in our business is to retire a facility because we know it impacts our dedicated energy workers and creates ripples across our plant communities. Since announcing the accelerated closure date, we have been assisting our plant workers and preparing them for what's next. To that end, we recently reached a comprehensive separation agreement in partnership with the local union employee group, Operating Engineers Local 148.

We do not have a finalized retirement date yet, but the plant will retire later this summer.

Environmental Update

We are committed to being a good steward of our property and to retiring the facility in an environmentally responsible manner. As part of our diligence, groundwater monitoring stations recently installed in accordance with the Illinois coal ash rule near the plant's property boundary have detected elevated levels of boron in groundwater.

The detected levels of boron at our property's edge exceed the applicable state groundwater standard of 2.0 milligrams per liter (mg/L) and range from 3.4 mg/L to 6.94 mg/L. EEI has already briefed local, regional, and state officials, including the Illinois EPA. Our immediate priority is to notify our neighbors of this development and let you know the next steps we will take.

Boron is a naturally occurring element found in fruits, vegetables, and seawater. Many everyday items such as cosmetics, dietary supplements, and cleaning products also contain boron. While boron is naturally occurring, studies have been conducted to determine if ingestion of boron in high concentrations adversely impacts human health.

Excess boron consumption can potentially cause health impacts, but the current detected levels of boron in the upper aquifer at the property boundary are *significantly less* than the concentrations associated with health impacts in various studies.

Further, there is no evidence that groundwater in the lower aquifer, which supplies the Village's public water supply well, has been impacted. However, out of an abundance of caution, EEI is working with the Village to test the water supply to ensure that it remains unimpacted.

EEI is also working to gather additional data, including installing monitoring stations that will collect further data samples and develop a detailed understanding of the extent of boron exceedances. Again, out of an abundance of caution and to assist with data collection, *we ask that any property owner in the Village of Joppa with a private irrigation or drinking water well contact EEI to have their well tested*. We will cover the cost of the testing and will provide the test results to the well owner.

We have proposed to place additional monitoring stations at strategic locations on municipal property. This data collection and analysis will be complete by late summer, and we will share the results with the community.

We understand that you may have questions after receiving this letter. To provide you with additional resources and easy access to government-created resources on the health impacts of boron, we've created a webpage with briefings, infographics, and hyperlinks to trusted resources. Please visit **www.renewillinoispower.com/joppa** for more information.

You can also submit a request to have your private well tested or sign up for ongoing email updates on this webpage.

What We're Doing About This Development

We have already begun evaluating mitigation measures. EEI is in the process of implementing a study to evaluate the extraction of groundwater to help redirect it before it potentially moves off the plant's property. This system would collect the extracted water and then manage it appropriately. All corrective measures we take will be reviewed and permitted by Illinois EPA.

By June 1, the company will publish the draft closure documents for the East Ash Pond in accordance with state regulations governing the management and disposal of coal combustion residuals in surface impoundments known as "Part 845."

Documents associated with that process will be available at **https://www.luminant.com/ccr/illinois-ccr.**

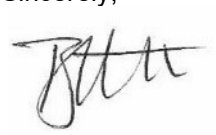
Joppa's Future As An Energy Storage Center

State officials included the *Illinois Coal to Solar and Energy Storage Initiative* in comprehensive energy legislation passed last year. Vistra proposed the framework to facilitate the redevelopment of retired or to-be-retired coal plant sites like Joppa Power Plant.

Vistra submitted an application to the Department of Commerce and Economic Opportunity to facilitate the development of a 37-megawatt battery energy storage center at the site. We expect to hear from state officials in early summer and are continuing to work on receiving all necessary regulatory approvals needed for the project. We currently project the battery energy storage center will enter commercial service in 2025.

Please reach out to us if you have questions or concerns about our Joppa Power Plant.

Sincerely,



Brad Watson
Sr. Director, Community Affairs
EEI Community Relations Department
2100 Portland Rd.
Joppa, IL 62953
214-812-5777
joppa@renewillinoispower.com
www.renewillinoispower.com/joppa

Appendix B

Supporting Information for the Closure Alternatives Analysis – East Ash Pond at the Joppa Power Plant

Prepared for

Electric Energy, Inc.
2100 Portland Road
Joppa, Illinois 62953

CLOSURE ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT

JOPPA POWER PLANT
EAST ASH POND
(IEPA ID W1270100004-02)
Joppa, Illinois

Prepared by

Geosyntec consultants
engineers | scientists | innovators

600 Roselane Court
Farmington, Missouri 63640
Project Number GLP8025

Revision 0

July 28, 2022

TABLE OF CONTENTS

1. Introduction and Background 3
1.1. Report Contents 3

2. Closure-by-Removal Information 4
2.1. Evaluation of Onsite Landfill Options 4
2.1.1. Existing Joppa CCR Landfill 4
2.1.2. Feasibility of New Onsite Landfill Construction 4
2.2. Potential CBR-Offsite Receiving Landfills 8
2.2.1. Kentucky Landfills 9
2.2.2. Illinois Landfills 9
2.2.3. Tennessee Landfills 10
2.3. Potential CBR-Offsite Transportation Methods 10
2.3.1. Transportation by Rail 10
2.3.2. Transportation by Barge 11
2.3.3. Transportation by Truck 12

3. Closure Description Narratives 14
3.1. CIP 14
3.2. CBR-Offsite 14

4. Construction Schedules 16
4.1. CIP 16
4.2. CBR-Offsite 16

5. Material, Quantity, Labor, and Mileage Estimates 17

6. References 18

FIGURES

Figure 1 Potential Onsite Landfill Locations
Figure 2 Offsite Landfill Locations and Transportation Routes

TABLES

Table 1 Offsite Landfill Information
Table 2 Construction Schedule – CBR-Offsite
Table 3 Material Quantity Estimate – CIP
Table 4 Labor, Equipment, and Mileage Estimate – CIP
Table 5 Material Quantity Estimate – CBR-Offsite-Barge
Table 6 Labor, Equipment, and Mileage Estimate – CBR-Offsite-Barge
Table 7 Material Quantity Estimate – CBR-Offsite-Truck
Table 8 Labor, Equipment, and Mileage Estimate – CBR-Offsite-Truck

1. INTRODUCTION AND BACKGROUND

Electric Energy, Inc. (EEI) is the owner of the coal-fired Joppa Power Plant (JPP), also referred to as Joppa Power Station, in Joppa, Illinois. The JPP is currently active, although EEI intends to cease the generation of electricity by September of 2022. EEI intends to complete closure of the East Ash Pond (EAP) at the JPP (IEPA ID No. W1270100004-02, EEI CCR Unit ID 401, and National Inventory of Dams Number IL50714). Closure of the EAP will be performed under the relevant Illinois Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845) [1] and the United States Environmental Protection Agency (USEPA) CCR Rule [2].

Part 845 requires a Closure Alternatives Analysis (CAA) to be completed, pursuant to the requirements of Section 854.710, to support the Closure Plan prepared pursuant to Section 845.720. The CAA for the JPP EAP will be performed by Gradient Corporation (Gradient). Geosyntec has prepared this Closure Alternatives Analysis Supporting Information Report (Report) to provide information requested by Gradient to support their preparation of the CAA.

1.1. Report Contents

The following information is contained within this report:

- **Section 1** includes the Introduction and Background;
- **Section 2** includes information related to closure-by-removal (CBR) including:
    - A feasibility evaluation of CBR using an onsite landfill (CBR-Onsite);
    - An evaluation of potential offsite landfills to receive the CCR for CBR-Offsite; and
    - A feasibility evaluation of CCR transportation for CBR-Offsite using over-the-road trucks, rail, and barges.
- **Section 3** includes an overview of construction activities that would occur for both CIP and CBR-Offsite;
- **Section 4** includes a project schedule for both CIP and CBR-Offsite; and
- **Section 5** includes estimates for construction material quantities, labor, vehicle miles, and equipment miles, for both CIP and CBR-Offsite.

2. CLOSURE-BY-REMOVAL INFORMATION

Section 845.710(c)(1) requires the evaluation of complete removal of CCR (e.g., CBR), and Section 845.710(d)(2) requires the CAA to identify if the Power Plant has a landfill that can accept the CCR, or if constructing an onsite landfill of sufficient capacity is feasible. Additionally, Section 845.710(c)(1) requires the evaluation of multiple modes of transportation of CCR, including rail, barge, and truck. This section includes evaluation of onsite landfill options, potential offsite landfills, and potential methods for transporting CCR to offsite landfills.

2.1. Evaluation of Onsite Landfill Options

2.1.1. Existing Joppa CCR Landfill

An existing CCR landfill, the Joppa Landfill (Landfill), was constructed on EEI property near the JPP in 2009 and was never used to store waste and remains inactive and void of any CCR waste materials. The existing landfill cell (Cell L1) is approximately 13.5 acres, although an additional 13.5-acre cell (Cell L2) was permitted it was never constructed [3]. Permitting documents indicate the landfill was designed with an anticipated disposal volume of 1.5 million cubic yards (CY) of CCR with 4 horizontal to 1 vertical (H:V) side slopes on the final cover. The bottom is lined with a 60-mil HDPE geomembrane underlain by three feet of compacted clay [3].

The EAP and areas outside the EAP, contain approximately a combined 6.5 million CY of CCR and underlying native subgrade materials that would be removed as part of closure-by-removal, as estimated by Geosyntec [4]. Placing all CCR from the EAP within the Landfill would require the Landfill to be constructed to a height of approximately 400 feet with 0.7H:1V side-slopes. A landfill of this geometry is unlikely to be stable from a geotechnical perspective and is not consistent with the permitted 4H:1V final cover side slopes.

The landfill is bounded on the west side by the Ohio River Scenic Byway (Portland Road), on the north by farmland beyond the plant/Landfill property boundary, on the south side by the landfill detention pond and high-voltage electric lines, and on the east side by multiple high-voltage electric lines. Any lateral expansions to the landfill would require the purchase of multiple tracts of land and/or moving multiple high-voltage electric lines. The location of the Landfill and surrounding Site features is provided in **Figure 1**.

Therefore, using the existing onsite landfill at the JPP is not feasible due to the limited capacity and inability of the landfill to be expanded without impacting existing utilities.

2.1.2. Feasibility of New Onsite Landfill Construction

Areas inside the JPP Site boundaries were evaluated for suitable areas for the construction of a new onsite landfill for disposing of the approximately 6.5 million CY of CCR within and outside

of the EAP. The Site was divided into multiple areas, Area 1 through Area 8, as shown in **Figure 1**. The potential feasibility of constructing a new landfill in each area is described below:

- Area 1 is approximately 160 acres in size and is located northwest of the JPP.
    - The northwest corner of Area 1 is occupied by the existing 27-acre Joppa Landfill and the Landfill sediment basin.
    - The remaining area is intersected by multiple utility service right-of-ways (ROWs) for four high voltage electric lines leading to the switchyard at the JPP. These electric lines will likely remain in-service after the JPP is closed. Construction of a landfill in this area would likely require relocation of the utilities.
    - Areas in between utility corridors and the Landfill are limited to a maximum size of approximately 26 acres; this would require a landfill height of approximately 470 ft and 1.2H:1V side slopes, which is unlikely to be stable from a geotechnical perspective.
    - Therefore, there are no feasible locations for constructing a landfill within Area 1, due to lack of capacity, utility conflicts, and conflicts with the existing landfill and detention pond.
- Area 2 is approximately 105 acres in size and is located west of the JPP and west of the inactive Joppa West Former Surface Impoundment (Joppa West).
    - Area 2 contains multiple utility service ROWs, including five high-voltage electric lines leading to the switchyard at the JPP, a natural gas line and valve station, and one hazardous liquid pipeline. These utilities are active and some are expected to remain active after electricity generation is ceased at JPP. Construction of a landfill in this area would likely require negotiations with the ROW holder and relocation of the utilities.
    - Approximately 54 acres of Area 2 is within the 100-year floodplain of the Ohio River.
    - Therefore, there are no feasible locations for constructing a landfill within Area 2, due to lack of capacity, existing utility ROWs, and potential 100-year floodplain impacts.
- Area 3 is approximately 145 acres in size and is located immediately west adjacent to and includes the JPP.

- Construction of a landfill in this area would require the demolition of the JPP and/or multiple switchyards. The switchyards are expected to remain active after the JPP is closed.

- Remaining areas not occupied by structures, parking lots, or switchyards, are intersected by multiple utilities including no less than six high-voltage electric line ROWs and one natural gas line ROW. Construction of a landfill would require negotiations with the ROW holders and relocation of the utilities.

- Therefore, there are no feasible locations for constructing a landfill within Area 2, due to lack of capacity, conflicts with existing infrastructure and multiple utilities ROWs, most of which are expected to remain in service after electricity generation is ceased at JPP.

- Area 4 is approximately 155 acres in size and is located immediately west of the JPP.

  - Area 4 contains multiple utility service corridors and ROWs, including eight high-voltage electric lines leading to the switchyard at the JPP, two natural gas lines, and one hazardous liquid pipeline. These utilities extend across the existing Joppa West former CCR surface impoundment. These utilities are still active and all except one gas line are expected to remain active after the JPP is closed. Construction of a landfill in this area would require negotiations with the ROW holders and relocation of the utilities.

  - Approximately 106 acres of this area is occupied by the Joppa West former CCR surface impoundment (Joppa West). Constructing a landfill in this area would require construction over existing CCR within Joppa West and would require a landfill height of approximately 45 ft and 4H:1V side slopes. There are multiple technical, environmental, and regulatory challenges associated with designing, permitting, and constructing a landfill over the top of a former CCR surface impoundment.

  - This area immediately to the west contains a gas turbine facility, which EEI intends to cease operations at by September 2022. The turbine facility would need to be demolished to construct a landfill.

  - This area contains the sanitary wastewater treatment ponds that handle all sanitary sewage from the JPP, which EEI intends to cease operations of by September 2022. These ponds would have to be decommissioned, along with sanitary sewage lines, to construct a landfill in this area.

  - Therefore, there are no feasible locations for constructing a landfill within Area 4 due to conflicts with existing infrastructure, utility ROWs, challenges involved with

constructing over the top of a former CCR impoundment, and only 49 acres of space remaining outside of the former CCR impoundment.

- Area 5 is approximately 80 acres and is location north of the JPP and immediately west of the EAP.
    - Area 5 is bounded on the north by the Ohio River Scenic By-way (Portland Road), on the east by the BNSF Railway rail spur that surrounds the EAP, and on the west Joppa West.
    - This area is intersected by the plant entrance road and other minor access routes.
    - This area has been designated as soil borrow for future construction activities at Joppa and would need to be reserved for soil borrow for the construction of an onsite landfill.
    - The area between the plant entrance road, Portland Road, and the EAP is approximately 45 acres; this would require a landfill height of approximately 270 ft and 3H:1V side slopes, which may present geotechnical stability challenges given the seismic hazards at the Site. The landfill would also be visible from much of the surrounding area and village of Joppa.
    - Therefore, there are no feasible locations for constructing a landfill within Area 5, due to the need to preserve the area for future soil borrow and the area being of insufficient size to support a single landfill with adequate capacity to retain the volume of CCR within the EAP.
- Area 6 is approximately 25 acres in size and is located immediately west of the EAP and within the rail spur that surrounds the EAP.
    - Area 6 is too small to contain the volume of CCR within the EAP.
    - This area contains facilities related to the recycling of CCR for cement production.
    - This area is intersected by multiple roadways that provide access around the EAP and to storage areas.
    - Therefore, there are no feasible location to construct a landfill in Area 6 due to size limitations and conflicts with existing infrastructure.
- Area 7 consists of six small areas (Area 7A thorough 7F) totaling approximately 65 acres in size. These areas are located along the eastern side of EEI property.

- Each area's size is limited by property boundaries, public roadways, the rail spur that surround the EAP, or the EAP. The areas range in size from approximately 2 acres (Area 7D) to 30 acres (Area 7B).
    - The largest area is Area 7B, which is approximately 30 acres; this would require a landfill height of approximately 220 ft and 1H:1V side slopes, which is unlikely to be stable from a geotechnical perspective. This structure would also be visible from much of the surrounding area and village of Joppa.
- Therefore, none of these areas are feasible for construction a landfill, due to being insufficient in size.

- Area 8 is approximately 100 areas in size and is located immediately east of the JPP.
    - Approximately 45 acres of Area 8, including the western and southern portions, lie within the 100-year floodplain of the Ohio River.
    - Approximately 40 acres of Area 8 is above the 100-flood plain of the Ohio River. Due to EEI property boundaries, this would require a complex landfill geometry and height of approximately 230 ft with 1.5H:1V side slopes, which is unlikely to be stable from a geotechnical perspective. This structure would also be visible from much of the surrounding area and the village of Joppa

In summary, there are no feasible locations for constructing a landfill within the existing JPP Site boundary. Each evaluated location has multiple conflicts related to potential 100-year floodplain impacts, former CCR surface impoundments, existing utility corridors and Site roadways, planned future property uses, and/or EEI property boundaries.

2.2. Potential CBR-Offsite Receiving Landfills

Potential offsite landfills suitable for disposing of the approximately 6.5 million CY of CCR within and outside of the EAP were evaluated for landfills within Illinois, Kentucky, Tennessee, and Missouri, due to JPP's location in southern Illinois near the borders of four other states. Information on the landfills were obtained from IEPA's online Illinois Disposal Capacity Report [5], the Kentucky Energy and Environment Cabinet Solid Waste Branch's Annual Survey Report [6], the Missouri Department of Natural Resources' Solid Waste Management Map [7], and the Tennessee Department of Environment and Conservation's 2021 Annual Engineering Report [8].

The two closest landfills in Illinois, by road and rail miles, are the West End Disposal Facility (owned by Waste Connections), and the Southern Illinois Regional Landfill (owned by Republic Services), and the two closest landfills in Kentucky, by road miles, are the West KY Landfill

(owned by Jones Sanitation, LLC) and the Waste Path Sanitary Landfill (owned by Waste Path Sanitary Landfill, LLC).

The two most suitable options for transport by barge, based on proximity to the Site and nearby commercial or public barge terminals, include the North Milam Landfill in Illinois (owned by Waste Management) and the ECM Landfill in Tennessee (owned by ECM of Ridgely, LLC).

Landfills within Missouri were also evaluated at a cursory level; however, the closest landfill is approximately 78 miles from JPP (Lemons Landfill in Dexter, MO), versus 39 to 62 road miles for the evaluated landfills in Kentucky and Illinois. No landfills in Missouri were located near the Mississippi River. Therefore, Missouri landfills were excluded from additional evaluation.

These six landfills in Illinois, Kentucky, and Tennessee were evaluated for potential use as receiving landfills for CBR-Offsite.

2.2.1. Kentucky Landfills

The closest landfill is the Waste Path Sanitary Landfill in Calvert City, Kentucky which is 39 road miles or 30 river miles from the Site. However, this landfill does not accept CCR and only has 572,049 CY of remaining permitted capacity; this is insufficient to accept the 6.5 million CY CCR contained within and outside of the EAP.

The next closest landfill is the West KY Landfill in Mayfield, Kentucky, which is 46 road miles from the Site. This landfill accepts CCR; however, this landfill only has 5,013,470 CY of remaining permitted capacity, which is insufficient to accept the 6.5 million CY of CCR contained within and outside of the EAP.

Therefore, neither of the evaluated landfills within Kentucky are viable options for disposal of the CCR material within the EAP.

2.2.2. Illinois Landfills

The West End Disposal Facility, located in Thompsonville, Illinois, and the Southern Illinois Regional Landfill, located in Desoto, Illinois, have 12,201,455 and 18,125,391 CY of remaining permitted capacity, respectively, which is sufficient to dispose of the 6.5 million CY of CCR from the EAP. Out of the two landfills, the West End Disposal Facility was selected as the preferred landfill because it is closer to the JPP at 58 miles vs. 62 one-way road miles, thereby resulting in reduced hauling mileage. Both landfills are within approximately two miles of existing rail lines; however, neither location has an existing rail terminal capable of unloading CCR.

For evaluating the feasibility of barge transport of CCR (discussed in **Section 2.3.2**), landfills near navigable waterways and commercial or public port facilities were also evaluated. The North Milam Landfill in East St. Louis, Illinois was found to be nearest to a navigable river and an

existing commercial bulk material handling terminal (Cahokia Marine Terminal), at approximately 6 miles by road from the Mississippi River and 205 miles by the Ohio and Mississippi Rivers from the JPP. The North Milam Landfill has 11,035,000 CY of remaining permitted capacity, which is sufficient to dispose of the 6.5 million CY of CCR from the EAP.

2.2.3. Tennessee Landfills

Landfills in Tennessee were evaluated for feasibility of barge transport (discussed in **Section 2.3.2**). The ECM Landfill, located in Obion, Tennessee, was found to be nearest to a navigable river and existing commercial port facility (Port of Cates Landing) at approximately 17 road miles from the Mississippi River and 81 river miles from the JPP via the Ohio and Mississippi Rivers. The ECM Landfill has 21,557,475 CY of remaining permitted capacity, which is sufficient to dispose of the 6.5 million CY of CCR from the EAP. Landfills in Tennessee were not evaluated for potential transport via trucks or rail, as the landfills in Illinois are closer to the JPP for these transportation methods.

Information on all evaluated landfills is provided in **Table 1** and the location of each landfill relative to the JPP is provided in **Figure 2**.

2.3. Potential CBR-Offsite Transportation Methods

Section 845.710(c)(1) requires CBR to consider multiple methods for transporting removed CCR, including using rail, barge, and trucks. An evaluation of each method is included within this section.

2.3.1. Transportation by Rail

The JPP currently has an established rail terminal and rail spur which borders the EAP and JPP. This spur and terminal are currently used for transporting coal to the JPP and unloading coal at the coal yard. For CCR to be transported by rail, the terminal would have to modified to construct a loading facility on the EAP side of the rail spur/terminal, which would increase the project schedule due to the need to coordinate with the railroad, complete design, permitting, and construction of the terminal. CCR would still need to be hauled by off-road haul trucks to the new onsite loading terminal and loaded into rail cars.

While both the West End Disposal Facility and Southern Illinois Regional Landfill are located within approximately one and two miles of existing rail lines, respectively, an existing terminal suitable for the unloading of CCR is not present near either landfill. A CCR unloading rail terminal would need to be constructed which would increase the project schedule due to the need to acquire land for the terminal, coordinate with the railroad, complete design and permitting, and construct the terminal. Additionally, CCR would need to be hauled by truck from the new offsite unloading terminal to the landfill resulting in additional CCR handling and exposure to the surrounding environment near the offsite receiving landfill.

Furthermore, a direct rail route from the JPP to either landfill does not exist. Hauling CCR to the West End Disposal Facility or Southern Illinois Regional Landfill would involve approximately 84 and 92 miles, respectively, of hauling by rail on tracks owned by three separate rail lines (BNSF, Union Pacific Railroad [UP], and Canadian National Railways [CN]), as shown on **Figure 2**. The ability of CCR to be hauled over multiple lines and transferred from line to line is currently unknown.

Therefore, transporting CCR by rail is unlikely to be a viable option for the JPP EAP, due to the need to design, permit, and construct additional loading and unloading infrastructure, resulting in corresponding project schedule delays, and the distance and number of rail lines which the CCR would need to be transported over.

2.3.2. Transportation by Barge

2.3.2.1. CCR Loading at JPP

The JPP is located along the Ohio River and formerly received coal shipments by barge, which were unloaded at an unloading terminal and wharf. The coal unloading terminal includes a clamshell unloading bucket that was utilized for removing coal from barges and placing the coal into a conveyor system that transported to the former coal pile at the JPP. This terminal is not currently suitable for the loading of CCR into barges as it was designed and constructed for unloading, rather than loading. The clamshell is unlikely to be suitable for the loading of CCR without potentially releasing some amount of CCR dust from the clamshell into the surrounding environment. Additionally, the terminal has not been used for over 20 years, and the functionality of the terminal is currently unknown. For CCR to be hauled by barge from the JPP a new loading terminal would need to be constructed, thereby increasing the project schedule due to the need to complete design, permitting, and construction.

Another barge terminal is located at the Lafarge-Joppa Cement Plant, which is offsite and located approximately two miles from the JPP. Use of this terminal would require negotiating an agreement with the terminal owner and/or operator. It is unknown if this terminal is suitable for the loading of CCR. If the terminal is not suitable, use of the terminal may require the design, permitting, and construction of improvements to allow CCR to be unloaded, thereby increasing the project schedule. CCR would still need to be hauled by truck to the loading terminal and unloaded, resulting in additional CCR handling and exposure to the surrounding environment.

2.3.2.2. CCR Unloading Near Receiving Landfills

The West End Disposal Facility, Southern Illinois Regional Landfill, and the West KY Landfill, are not located near a river, thereby making transporting CCR to any of them by barge infeasible.

The North Milam Landfill is located approximately six miles from an existing commercial bulk material handling terminal on the Mississippi River (Cahokia Marine Terminal) in East St. Louis,

Illinois, which is approximately 205 miles by river from the JPP, as shown in **Figure 2**. To utilize the Cahokia Marine Terminal, an agreement would need to be negotiated with the terminal owner. It is unknown if this terminal is suitable for the unloading of CCR. If the terminal is not suitable, it would require design, permitting, and construction of improvements to allow CCR to be unloaded. Unloading and trucking of CCR at this location may also result in CCR exposure within an urban environment that is located within a community designated by the Illinois EPA to be an Environmental Justice Area [9]. Therefore, this landfill was not considered a feasible option for disposal of CCR and impacted soils within the JPP EAP.

The ECM Landfill is located approximately 17 road miles from the Port of Cates Landing on the Mississippi River near Tiptonville, Tennessee, which is approximately 81 miles by river from the JPP, as shown in **Figure 2**. To utilize the Port of Cates Landing, an agreement would need to be negotiated with the terminal owner and an unloading terminal would need to be designed, permitted, and constructed at the port.

Transporting CCR by barge would still require that CCR be hauled by truck from the unloading terminal to the landfill and unloaded, resulting in additional CCR handling and exposure to the surrounding environment and communities. Additionally, transporting CCR by truck will incur significant amounts of additional truck traffic on the public roads between the port and the chosen offsite landfill (approximately 17 miles one-way). To complete the closure within a timeframe of 15 to 23 years, the frequency of trucks leaving and entering the port could be as rapid one truck leaving every 1.7 minutes and one truck returning every 1.7 minutes (approximately one truck per minute on public roadways).

Because of the relatively short barging distance, and proximity of an existing port to the landfill, transporting CCR by barge was considered to be a viable option for disposal of CCR and underlying subgrade soils within the JPP EAP and was evaluated further, as discussed in **Sections 4** and **5**, below.

2.3.3. Transportation by Truck

The JPP borders the Ohio River Scenic Byway (Portland Road) and intersects County Road 400E, both of which are suitable for accommodating truck hauling traffic. County Road 400E links the JPP to IL-169E which links to US-45N and routinely receive truck traffic associated with adjacent industrial facilities and the JPP. Potential travel routes between the JPP and West End Disposal Facility and the Southern Illinois Regional Landfill are provided in **Figure 2**.

Transporting CCR by truck will not require the construction of additional loading or unloading infrastructure at either the receiving landfill or the JPP. CCR would be loaded into truck using heavy equipment at the EAP. CCR will then be unloaded at the receiving landfill by the truck directly. However, truck transportation may require upgrades or other infrastructure improvements to local roadways in order to accommodate increased traffic volumes (i.e., site entrances, signals,

signage), both near JPP and near the receiving landfill. Because of ability to initiate trucking with installing a limited amount of new loading and unloading infrastructure at JPP and the receiving landfill relative to other options, transporting CCR by truck was considered to be a viable option for disposal of CCR and soils within the JPP EAP and was evaluated further, as discussed in **Sections 4** and **5**, below.

Transporting CCR by truck will result in significant amounts of additional truck traffic on the public roads between the Site and the offsite landfill (approximately 58 miles one-way). Similar to transportation by barge, the rate of trucks entering or leaving the Site may be as rapid as approximately one truck per minute.

3. CLOSURE DESCRIPTION NARRATIVES

Section 845.720(a)(1)(A) requires narrative description of CCR impoundment closures to be prepared. Narrative descriptions have been prepared for both CIP and CBR-Offsite and are included within this section.

3.1. CIP

A narrative description of how the EAP will be closed in place is provided in Section 2.1 of the JPP Closure Plan [10].

3.2. CBR-Offsite

A description of how CBR-Offsite alternative will be completed is as follows:

- The EAP will be unwatered by pumping free surface water to the nearby non-CCR Settling Lagoon (non-CCR surface impoundment displayed in **Figure 2**) for ultimate discharge at NPDES Outfall 010.

- A temporary water management system will be constructed within the EAP, including ditches, sumps, and/or temporary stormwater detention basin(s). The system will maintain the EAP in an unwatered state by collecting contact stormwater during closure construction. Unwatering flows will be pumped to the Settling Lagoon for ultimate discharge at NDPES Outfall 010.

- Multiple active powerlines currently cross the EAP from west to east. These will be either relocated around the EAP, raised, or otherwise modified, as needed to allow for construction access, prior to start of excavation or across the EAP in stages as portions of the EAP are fully excavated.

- CCR will be removed from the EAP using mass mechanical excavation techniques. Some of the CCR is expected to be saturated or nearly saturated, so mass excavation will include the use of dewatering trenches or other forms of passive dewatering (i.e., rim ditching or windrowing), as and if needed to lower the moisture content of the CCR via free liquid removal prior to handling. Dewatering flows will be pumped to the Settling Lagoon for ultimate discharge at NPDES Outfall 010.

- The EAP bottom and side-slopes will be decontaminated by removing all visible CCR and up to one foot of native soils beneath the CCR.

- CCR and excavated native soils will be loaded into either barges or over-the-road dump trucks and hauled to the offsite receiving landfill. If the CCR is excessively dry prior to

loading, it may be moisture-conditioned by spraying with water to reduce the potential for fugitive dust emissions at the barge unloading terminal and/or receiving landfill.

- Any observed CCR along the southeastern EAP boundary will also be excavated. Up to one foot of native soils beneath the CCR will be excavated. Both the CCR and native soils will be disposed of in the offsite receiving landfill.

- A creek channel and stormwater detention pond(s) will be excavated through the former footprint of the EAP and southeast of the EAP. The creek channel will follow the approximate alignment of the pre-construction creek channel that was present prior to construction of the EAP. This will require removing sections of the EAP perimeter dike and deep mixing method (DMM) foundation improvement zone that would otherwise impede surface water flow to the south.

- Soils within the existing EAP embankments will be excavated and used as backfill within the closure-by-removal footprint of the EAP to provide surface water drainage to the Ohio River, as and if needed. Remaining portions of the perimeter dikes that are not utilized as borrow material will remain in-place.

- Post-closure stormwater flows from the EAP area will continue to flow through an existing culvert beneath the rail loop that surrounds the EAP.

- Disturbed areas that are not utilized as detention ponds with permanent water pools will be restored by fertilizing and establishing vegetation. Vegetation will include upland species (e.g., grasses) in most areas, although species capable of growing in wet environments, and/or trees, may be required along the creek channel, and in the area southeast of the EAP where CCR will be removed.

- Temporary stormwater best management practices (BMPs) such as erosion control blankets, straw wattles, detention basins, and/or check dams, will be used, as needed to reduce erosion during vegetation establishment.

- After vegetation is established, BMPs will be removed, and closure construction will be considered completed.

4. CONSTRUCTION SCHEDULES

Section 845.720(a)(1)(F) requires a schedule including all activities necessary to complete closure to be prepared. Schedules have been prepared for both CIP and CBR-Offsite and are included within this section. Schedules were prepared using estimates of task durations based on Geosyntec's experience, typical weather conditions at the site, likely production rates in CCR excavation and hauling based on site-specific considerations, and expected construction rates relative to estimated construction quantities.

4.1. CIP

The proposed closure completion schedule for CIP is provided in Section 2.6 of the JPP Closure Plan [10].

4.2. CBR-Offsite

The proposed closure construction schedule for CBR-Offsite is provided in **Table 2**. The same schedule was utilized for transportation using trucks and barges, as the construction duration is primarily based on daily production rates for onsite earthwork.

5. MATERIAL, QUANTITY, LABOR, AND MILEAGE ESTIMATES

Estimates of material quantities, total labor hours, and mileage were prepared for each alternative to support Gradient in preparing the CAA. Estimates for CIP, CBR-Offsite using trucks, and CBR-Offsite using barges, were prepared utilizing the following approach:

- Major construction components and line-items were identified, in accordance with the narrative closure description (**Section 3**).
- Construction quantities were estimated based on volume estimates, area estimates, and proposed construction schedules (**Section 4**).
- Soil fill was assumed to come from an onsite borrow source located immediately northwest of the EAP.
- RSMeans Heavy Construction Cost Data [11] (RS Means) was used to estimate the crew size, equipment description, and daily output associated with each line-item.
- For line-items where RSMeans data was not available, the crew size, equipment description, and daily output were estimated based on Geosyntec's experience, information from contractors, and/or information from material suppliers.
- Daily labor mobilization miles were estimated assuming an average one-way commute of 35 miles for each individual working onsite. The number of working days were estimated from the construction schedules (**Section 4**).
- Estimates of haul truck mileage were based on the assumed round-trip haul distance and dump truck size. All dump trucks were assumed to be filled to capacity.
- Estimates of barge/tugboat mileage were based on the assumed round trip haul distance and assumed capacity of 1,400 cubic yards per barge. Barges were assumed to be transported in groups of nine (i.e., nine barges being loaded and transported per trip from the Site to the unloading terminal) and filled to capacity.
- Estimates of material delivery miles were prepared based on Geosyntec's experience.

The detailed quantity, labor, and mileage estimates for CIP are provided in **Tables 3** and **4**, respectively. Similar information for CBR-Offsite with barges is provided in **Tables 5** and **6**, and for CBR-Offsite with trucks in **Tables 7** and **8**.

6. REFERENCES

[1] Illinois Environmental Protection Agency, "35 Ill. Adm. Code Part 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments," Springfield, IL, 2021.

[2] United Stated Environmental Protection Agency, "40 CFR Parts 257 and 261, Hazardous and Solid Waste Management System, Disposal of Coal Combustion Residuals from Electric Utilities, Final Rule, 2015," 2015.

[3] Hanson Professional Services, Inc., "Initial Facility Report - Coal Combustion By-Product Management Facility - Joppa, Massac County, Illinois," 2009.

[4] Geosyntec Consultants, "Construction Permit Application, Joppa Power Plant, East Ash Pond," St. Louis, 2022.

[5] Illinois Environmental Protection Agency, "Illinois Landfill Disposal Capacity Report," August 2021.

[6] Kentucky Energy and Environment Cabinet Solid Waste Brance, "Annual Survey Report," 2021.

[7] Missouri Department of Natural Resources, "Missouri Solid Waste Management Map," [Online]. Available: https://modnr.maps.arcgis.com/apps/webappviewer/index.html?id=f261c6069e324f48a8cbc6ce74343f41. [Accessed 2022].

[8] Tennessee Department of Environment and Conservation, "2021 Annual Engineering Report - Class I Disposal Facilities," 2021.

[9] Illinois Environmental Protection Agency, "Illinois EPA Environmental Justice Tracker," 2020. [Online]. Available: https://illinois-epa.maps.arcgis.com/apps/webappviewer/index.html?id=f154845da68a4a3f837cd3b880b0233c. [Accessed 2022].

[10] Geosyntec Consultants, "CCR Surface Impoundment Final Closure Plan, Joppa Power Plant, East Ash Pond," St. Louis, 2022.

[11] RSMeans, "Heavy Construction Costs with RSMeans Data," Gordian, 2022.

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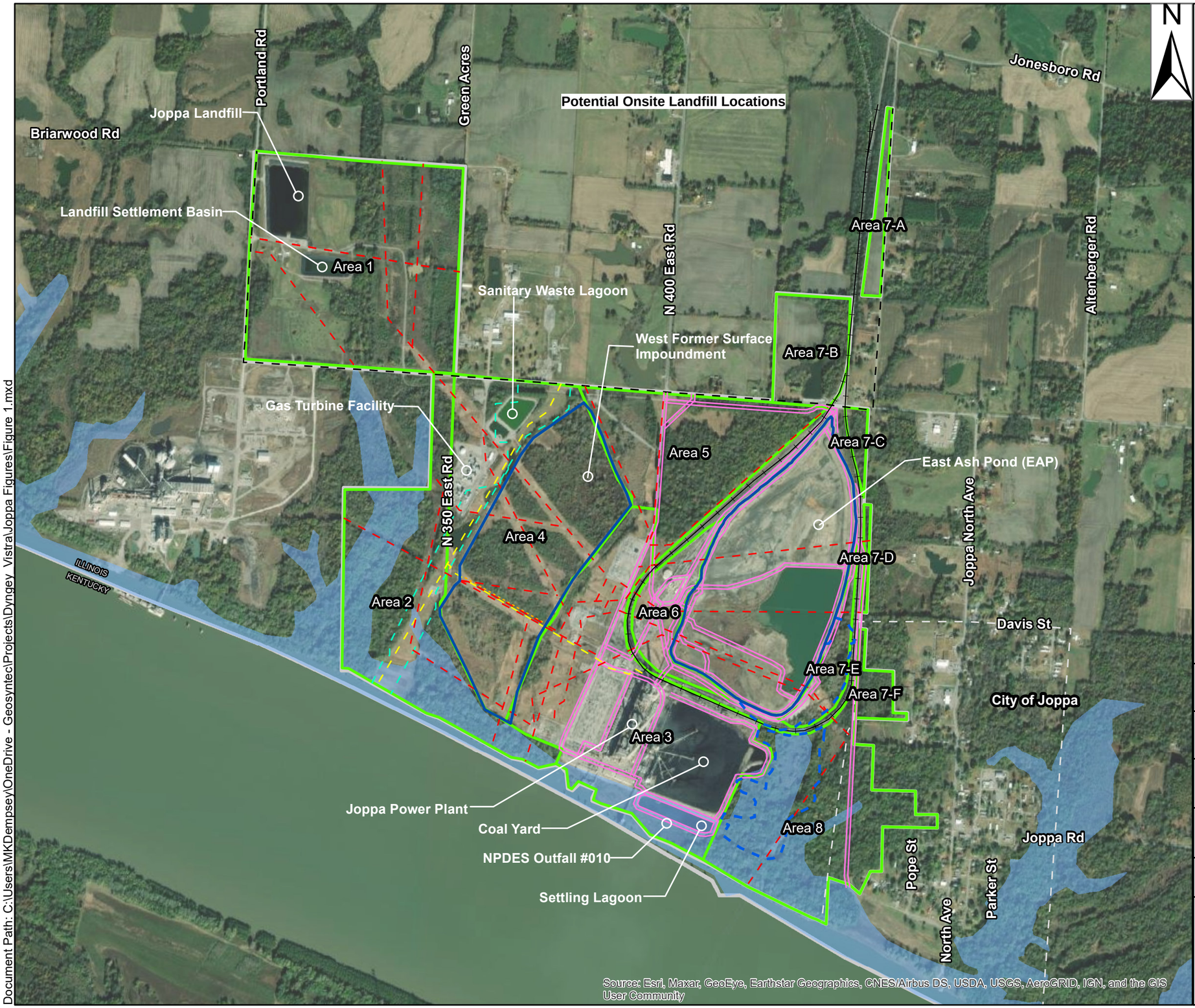
FIGURES

July 2022



N

Legend

- Union Pacific Rail Spur
- High Voltage Overhead Electric
- Buried Gas Line
- Gas Transmission Pipelines
- Hazardous Liquid Pipelines
- Onsite Transportation Routes
- Public Roadways
- Joppa City Limits
- Potential Landfill Areas
- Approximate CCR Unit Limits
- Approximate CCR Outside of EAP
- EEI Property Boundary
- FEMA 100 Year Flood Zone

NOTES:
1. CCR unit limits and Site boundary locations are approximate. All high-voltage electric line alignments, gas line alignments, and hazardous liquid pipeline alignments were based off available aerial imagery data and other data sources, should be considered approximate, may vary in the field, and should not be considered comprehensive.
2. All private and public site utilities including, but not limited to, service electric lines, gas lines, hazardous liquid lines, water and sewer lines, telecommunication lines, plant utilities, and/or private utilities are not shown on this figure and shall be verified in the field prior to any site work.

Prevailing Wind

0 500 1,000 2,000
Feet

Joppa Power Plant

Electric Energy Inc.

East Ash Pond Construction Permit Application

Potential Onsite Landfill Locations

GLP8025	APRIL 2022

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FIGURE 1

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North Milam Landfill
St. Louis
East St. Louis
Cahokia Marine Terminal
Mt Vernon
Canadian National Railways
Canadian National Railways
Illinois
Union Pacific Rail Line
West End Disposal Facility
Southern Illinois Regional Landfill
Evansville
Union Pacific Rail Line
Burlington Northern & Santa Fe Rail Line
Joppa Power Plant
Missouri
Waste Path Sanitary Landfill
Paducah
Poplar Bluff
Mayfield
West KY Landfill
Kentucky
Port of Cates Landing
Arkansas
Tennessee
ECM Landfill
Cape Giardeau
Carbondale
Marion
MISSISSIPPI RIVER
OHIO RIVER
OHIO RIVERxt
MISSOURI
SHAWNEE NATIONAL FOREST
MARK TWAIN NATIONAL FOREST
Baldwin Power Plant Cooling Lake
Rend Lake
Kinkaid Lake
Crab Orchard Lake
Lake of Egypt
Reelfoot Lake
Lake Wappapello
Horseshoe Lake

USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, Na Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Cens Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S Coastal Relief Model. Data refreshed August, 2021.

0 12.5 25 50
Miles

Legend

- Exsisting Barge Terminal
- Potential Offsite Landfill
- Joppa Power Plant
- Potential Rail Haul Route
- Potential Barge Haul Route
- Potential Truck Haul Route
- Minority Population & Low Income
- Minority Population >= 75.4%
- Low Income >= 63.4%

NOTES:
Some railroad right-of-ways no longer contain tracks. The potential rail haul route was selected to include right-of-ways with existing tracks, based on an evaluation of Google Earth imagery.

OFFSITE LANDFILL LOCATIONS AND TRANSPORTATION ROUTES

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FIGURE 2

GLP8025 | APRIL 2022

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TABLES

July 2022

Table 1: Offsite Landfill Information

Landfill Name	Owner	Location	One-Way Distance from Site (Miles)			Volume (in-place CY)	
			By Road	By Rail	By Barge	2020 Five-Year Average Disposal [5]	Remaining Capacity Reported [5], [6], [8]
West KY Landfill (Formerly Freedom Waste Services Landfill)	Jones Sanitation, LLC.	Mayfield, KY	46	NE[1]	NE[1]	Not Reported	5,013,470
Waste Path Sanitary Landfill, LLC.	Waste Path Sanitary Landfill, LLC.	Calvert City, KY	39	NE[1]	NE[1]	Not Reported	572,049 CY *(Does not accept CCR)*
West End Disposal Facility	Waste Connections	Thompsonville, IL	58	84	NE[2]	135,506	12,201,455
Southern Illinois Regional Landfill, Inc.	Republic Services	Desoto, IL	62	92	NE[2]	429,668	18,125,391
North Milam Landfill	Waste Management	East St. Louis, IL	5[4]	NE[3]	205	756,360	11,035,000
ECM Landfill	ECM of Ridgely, LLC	Obion, TN	17[4]	NE[3]	81	Not Reported	21,557,475

Notes:
[1]Not Evaluated due to insufficient disposal capacity.
[2]Not Evaluated due to infeasible distance from river.
[3]Not Evaluated due to closer options by rail.
[4]Road distance is from barge terminal or port to the landfill.

Table 2 – Construction Schedule – CBR-Offsite

Milestone	Timeframe (Preliminary Estimates)
Agency Coordination, Approvals, and Permitting • Obtain state permits, as needed, for dewatering, water discharge, land disturbance, wetlands modifications, stream restoration, and dam modifications	6 to 12 months after Final Closure Plan Approval
Final Design and Bid Process • Complete final design of the closure and select a construction contractor.	12 to 16 months after Agency Coordination, Approvals, and Permitting

Dewater and Excavate CCR, Decontaminate CCR Unit
• Complete contractor mobilization, installation of stormwater BMPs, and unwatering of the EAP.
• Complete mass excavation of CCR and decontamination of the EAP and area southeast of the EAP.
  • It is assumed that no work will be performed for 17 weeks of each year due to holidays, weather, winter shutdowns, etc.
  • Haul CCR to offsite receiving landfill[1].
• Reconstruct creek channel through the EAP and area southeast of the EAP.
	13 to 20 years after necessary permits are issued[1]

Site Restoration • Seed and stabilize the EAP. • Complete contractor demobilization.	6 to 9 months after backfill is complete
Timeframe to Complete Closure	August 2037 – September 2045 (15 to 23 years)

Note: [1]This schedule assumes that CCR hauling to the offsite landfill may occur during weather delays that preclude excavation but do not preclude hauling.

Table 3 - Material Quantity Estimate - CIP (1 of 2)

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QUANTITY, LABOR, AND EQUIPMENT HOURS ESTIMATE
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CONSOLIDATE AND CAP-IN-PLACE OF EAST ASH POND

ITEM NO.	PRE-CONSTRUCTION	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
1	Mobilization and De-Mobilization	LS	1	-	-	-	-	Based on experience
	PRE-CONSTRUCTION ESTIMATED SUBTOTAL							
ITEM NO.	**SITE PREPARATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
2	Mow Vegetation in East Ash Pond	MSF	526	B84	22	191	191	320190191660: Mowing, mowing brush, light density, tractory with rotary mower
3	Clear Vegetation in Impacted Areas Outside of EAP	Acre	55	-	-	3,567	2,478	Removal of dense vegatation and trees for areas outsdie of the EAP where CCR will be removed.
	Unit Costs							
	Clear Trees	Acre	48	B7	0.7	3,266	2,177	311110100200: Clear and Grub Site, cut and ship medium trees to 12"diameter.
	Heavy Vegetation	MSF	339	B84	9	301	301	320190191680: Mowing, mowing brush, tractor with rotary mower, heavy density.
4	Construction Soil Erosion & Sediment Controls	-	-	-	-	2,641	882	Installation of silt fence, rock check dams, and straw wattles for temporary soil erosion and sediment control during construction.
	Unit Costs							
	Silt Fence	LF	#REF!	B62	650	2,511	837	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Quantity assumes all silt fence is replaced two times/year.
	Rock Check Dams	CY	40	Sump Install	62	10	5	313713100100: Riprap, riprap and rock lining, random, broken stone, machine placed for slope protection. Crew altered based on experience. Assume 20 check dams constructed with 2 CY per check dam. Assume material not purchased but pulled from stockpiled material from existing slopes.
	Straw Wattles	LF	5,000	A2	1000	120	40	312514160705: Sediment Log, Filter Sock, 9". Quantity assumed 3/acre (based on experience) for entire disturbed area and each being 30 ft long.
5	Construction Facilities	MO - in use	30	-	-	-	-	Includes monthly costs associated with three office trailers, 10 storage trailers, and 8 portable toilets.
	Unit Costs							
	Office Trailer (x2)	MO - in use	30	-	-	-	-	015213200350: Office trailer, furnished, no hookups, 32' x 8', rent per month
	Storage Trailers (x5)	MO - in use	30	-	-	-	-	015213201350: Storage boxes, 40' x 8', rent per month
	Portable Toilet (x8)	MO - in use	30	-	-	-	-	015433406410: Rent toilet, portable chemical
6	Construct New Access Ramp at North End and East Side of EAP	CY	3,860	-	-	330	309	Construction of two new access ramps for entry/exit of the EAP.
	Unit Costs							
	Purchase of Material	TON	5,800	-	-	-	-	
	Hauling of Material	CY	3,860	B34C	116	266	266	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Spreading of Material	CY	3,860	B10B	1000	46	31	312323170020: Spread dumped material, no compaction, by dozer
	Compaction of Material	CY	3,860	B10F	2600	18	12	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
7	Construct New Access Road to South East Area (Outside of Rail Loop)	CY	19,000	-	-	1,626	1,521	Construction of a new access road to the west of the rail spur from Portland Rd. to the SE Area.
	Unit Costs							
	Purchase of Material	TON	28,300	-	-	-	-	
	Hauling of Material	CY	19,000	B34C	116	1,310	1,310	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Spreading of Material	CY	19,000	B10B	1000	228	152	312323170020: Spread dumped material, no compaction, by dozer
	Compaction of Material	CY	19,000	B10F	2600	88	58	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
8	Extend Piezometers and Monitoring Wells	EA	7	Grout/Concrete	4	42	14	Crew and Daily Output based on experience.
9	Dust Control	DAY	195	B59	1	1,560	1,560	312323202510: Dust control, heavy; utilizing truck tractor and water tank trailer per RSMeans Crew B59. Quantity is assumed to be half of working days will need dust control. Daily Output assumed to 1, based on experience.
10	Haul Road Maintenance	DAY	78	B86A	1	624	624	312323202600: Haul road maintenance Quantity is assumed to be 1 day/week.
	SITE PREPARATION ESTIMATED SUBTOTAL					**10,580**	**7,580**	
ITEM NO.	**FREE LIQUIDS REMOVAL, UNWATERING, AND STORMWATER MANAGEMENT**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
11	Free Liquids Removal Trench Drain	LF	5,400	-	-	4,192	3,379	Installation of one-pass trench drain. Deep trenches are assumed to be 50 ft deep and shallow trenches are assumed to be 20 ft deep.
	Unit Costs							
	Installation of Deep System (including pipe)	LF	5,400	Trench	400	540	216	Crew and daily output provided by trench drain specialty contractor.
	Installation of Deep Sumps	EA	6	Trench	1	240	96	Crew and daily output provided by trench drain specialty contractor.
	Installation of Shallow System (including pipe)	LF	1,600	Trench	300	213	85	Crew and daily output provided by trench drain specialty contractor.
	Purchase of Backfill Sand	TON	26,100	-	-	-	-	
	Purchase of Backfill Gravel	TON	26,100	-	-	-	-	
	Hauling of Backfill Material to Stockpile	CY	30,300	B34C	116	2,090	2,090	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Mixing of Sand and Gravel	CY	30,300	B10T	1120	325	216	312316421601: Excavating, bulk bank measure, common earth piled, front end loader, wheel mounted, 3 C.Y. cap. = 140 C.Y./hr.
	Loading Backfill Material at Stockpile	CY	30,300	B10T	1120	325	216	312316421601: Excavating, bulk bank measure, common earth piled, front end loader, wheel mounted, 3 C.Y. cap. = 140 C.Y./hr.
	Hauling of Backfill Material to Installation Site	CY	30,300	B34G	997	243	243	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile.
	Loading Backfill Material Into Hopper	CY	30,300	Hopper	1120	216	216	312316420300: Excavating bulk bank measure, common earth piled, excavator, hydraulic, crawler mtd., 3 C.Y. cap. = 260 C.Y./hr. Crew modified based on experience. Daily output modified to match hauling operation.
12	Pumping Free Liquids from Trench Drain	DAY	730	B10I	8			312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" discharge pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose. 312319200670: Add per additional pump - 7 additional pumps added. Quantity assumes pumping occurs 7 days per week for two years.
	Unit Costs							
	Additional HDPE Piping	LF	3,300	-	-	-	-	221113780074: Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 4" diameter, DR11, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting, or digging equipment.
13	Unwatering, and Stormwater Management for the East Ash Pond	DAY	599	B10K	2	3,594	2,396	312319201100: Dewatering, pumping 8 hours, attended 2 hours per day, 6" discharge pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose. Daily Output multiplied by 2 for 2 pumps. Quantity assumes pumping everyday for 1 year before construction and average of 3 days/week during construction.
	Unit Costs							
	Additional HDPE Piping	LF	15,700	-	-	-	-	221113780098: Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 10" diameter, DR11, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting, or digging equipment.
14	Construct Temporary Stormwater Detention Basin	CY - in place	48,400	-	-	555	512	Assume 3 are constructed throughout the construction life of project. Each assumed to be 2 acres and 5 ft deep.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	53,240	B14B	5000	128	85	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	53,240	B34G	997	427	427	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
15	Slipline Existing 72-inch CMP	LF	2,000	Pipe Liner	200	400	160	Crew and Daily Output assumed based on experience.
	FREE LIQUIDS REMOVAL, UNWATERING, AND STORMWATER MANAGEMENT ESTIMATED SUBTOTAL					**8,700**	**6,400**	
ITEM NO.	**EAST ASH POND CLOSURE**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
16	Relocation of Power Lines	LS	4					Approximate cost.
17	Demolish and Dispose of Facilities at North End of EAP in EAP	LS	1	B14B	1.0	12	8	Crew and Daily Output based on experience.
18	Excavation and Placement of CCR + 1 ft overdig within Consolidation Area	CY - in place	1,187,600	-	-	23,247	18,850	Quantity based on surface to surface calculation performed in AutoCAD. Quantity excavated in Detention Basin Construction subtracted.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	1,253,120	B14B	5000	3,007	2,005	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping within EAP for Moisture Conditioning	CY - as excavated	1,253,120	B34G	997	10,055	10,055	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
	Spreading/ Drying Moisture Conditioning	CY - as excavated	653,180	B10B	5000	1,568	1,045	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience. Quantity assumes 50% of volume requires moisture conditioning.
	Spreading Lifts	CY - as excavated	1,306,360	B10B	5000	3,135	2,090	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Material	CY - in place	1,187,600	B10F	2600	5,481	3,654	312323235060: Compaction; Riding, vibrating roller, 12" lifts, 2 passes. RSMeans Crew is B10Y; altered to B10F based on experience.
19	Demolish/Excavate and Dispose of DMM	CY	13,350	-	-	716	632	Demolish/Excavate DMM in southeast corner of EAP. Material to be buried in EAP.
	Unit Costs							
	Demolish/Excavate and Load Material	CY - in place	13,350	B13K	640	334	334	312316350130: Hydraulic rock breaking and loading, solid rock mass excavation, excavator/breaker and excavator/bucket (into trucks), 110 HP excavator w/ 4,000 ft lb. breaker, mobilization 2/20 ton, 6,000 psi rock. Quantity obtained from DMM design drawings.
	Hauling and Dumping in EAP	CY - as excavated	16,020	B34G	997	129	129	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
	Spreading Lifts	CY - as excavated	16,020	B10B	1000	192	128	312323170020: Spread dumped material, no compaction, by dozer
	Compaction of Material	CY - in place	13,350	B10F	2600	62	41	312323235060: Compaction; Riding, vibrating roller, 12" lifts, 2 passes. RSMeans Crew is B10Y; altered to B10F based on experience.
20	Excavation and Placement of CCR and Impacted Soils Outside of EAP	CY - in place	585,548	-	-	12,045	9,753	Quantity within rail loop based on surfaces (Top and Bottom of CCR - Southeast) developed by Geosyntec plus one foot of overdig.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	644,103	B14B	5000	1,546	1,031	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping in EAP for Moisture Conditioning	CY - as excavated	644,103	B34G	997	5,168	5,168	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
	Spreading/ Drying Moisture Conditioning	CY - as excavated	450,872	B10B	5000	1,082	721	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience. Quantity assumes 70% of volume requires moisture conditioning.
	Spreading Lifts	CY - as excavated	644,103	B10B	5000	1,546	1,031	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Material	CY - in place	585,548	B10F	2600	2,703	1,802	312323235060: Compaction; Riding, vibrating roller, 12" lifts, 2 passes. RSMeans Crew is B10Y; altered to B10F based on experience.
21	Removal and Stockpiling of Dike Riprap for Onsite Use	CY - in place	12,600	-	-	162	141	Remove existing riprap facing on EAP dikes and stockpile onsite for future use.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	12,600	B14B	5000	30	20	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material to Onsite Stockpile	CY - as excavated	12,600	B34G	997	101	101	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
	Stockpiling of Material	CY - as excavated	12,600	B10B	5000	30	20	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
22	Contruct New Soil Containment Berm	CY - in place	375,700	-	-	7,034	5,795	Construct compacted soil berm along proposed alignment for the reduced EAP footprint.
	Unit Costs							
	Excavation and Loading of Material from Onsite Source	CY - as excavated	413,270	B14B	5000	992	661	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material	CY - as excavated	413,270	B34G	997	3,316	3,316	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
	Spreading of Material	CY - as excavated	413,270	B10B	5000	992	661	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Material	CY - in place	375,700	B10F	2600	1,734	1,156	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
23	Contruct Geosynthetic Cover	SF - in place	2,834,100	-	-	1,561	260	Install geomembrane and geotextile cushion.
	Unit Costs							
	Geomembrane	SF - in place	2,834,100	B63B	87120	1,041	260	310519531200: Pond and reservoir liners, membrane lining systems HDPE, 100,000 S.F. or more, 60 mil thick, per S.F. Daily output edited based on experience.
	Geotextile	SF - in place	2,834,100	2 Clab	87120	520	0	312319161550: Geotextile soil stabilization; non-woven 120 lb. tensile strength. Daily output edited based on experience.
24	Install Anchor Trench	LF	9,500	-	-	635	425	Install anchor trench for anchoring geosynthetics.
	Unit Costs							
	Excavation of Material	CY - as excavated	3,325	B11C	150	355	177	312316130050: Excavating, Trench or continuous footing, common earth with no sheeting or dewatering included, 1' to 4' deep, 3/8 C.Y. excavator
	Backfilling Material	CY - as excavated	3,325	B10R	400	100	67	312316133020: Backfill trench, F.E. Loader, wheel mtd., 1 C.Y. bucket, minimal haul
	Compacting Material	CY - in place	3,167	A1D	140	181	181	312323237040: Compaction, walk behind, vibrating plate 18" wide, 6" lifts, 4 passes
25	Placement of Onsite Protective Cover Soil	CY - in place	157,450	-	-	2,221	1,944	Place 18 inches of cover soil over geotextile cushion. Material assumed to come from onsite borrow/clean existing dike fill.
	Unit Costs							
	Excavation and Loading of Material from Onsite Source	CY - as excavated	173,195	B14B	5000	416	277	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material	CY - as excavated	173,195	B34G	997	1,390	1,390	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
	Spreading of Material for Regrading /Drainage	CY - as excavated	173,195	B10B	5000	416	277	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
26	Placement of Onsite Vegetative Soil	CY - in place	52,483	-	-	740	648	Place 6 inches of vegetative soil. Material assumed to come from onsite borrow.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	57,732	B14B	5000	139	92	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material	CY - as excavated	57,732	B34G	997	463	463	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
	Spreading of Material	CY - as excavated	57,732	B10B	5000	139	92	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
27	Reconstruct Creek Channel	CY - in place	33,800	-	-	477	417	Excavation of a creek channel along a similar alignment as prior to construction of the EAP. Also includes placement of the excavated material in CBR EAP to promote drainage towards the creek channel/Ohio River.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	37,180	B14B	5000	89	59	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material	CY - as excavated	37,180	B34G	997	298	298	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait.
	Spreading of Material for Regrading /Drainage	CY - as excavated	37,180	B10B	5000	89	59	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
28	Regrade Consolidated Area	CY - in place	128,700	B10L	220	7,020	4,680	Regrade/place fill, in consolidated area to promote drainage to creek channel.
	EAST ASH POND CLOSURE ESTIMATED SUBTOTAL					**55,900**	**43,600**	

Table 3 - Material Quantity Estimate - CIP (2 of 2)

Geosyntec consultants

ITEM NO.	SITE RESTORATION	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
29	Establish Access Roads	LF	9,000	-	-	245	230	Construct gravel access roads on top of the final cover. Assumed to extend around entire cover perimeter.
	Unit Costs							
	Purchasing of Material	TON	4,500	-	-	-	-	Quantity assumes material is 125 pcf.
	Hauling of Material	CY	2,667	B34C	116	184	184	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Spreading and Compacting Material	SY	8,000	B32	4200	61	46	321123230400: Base course drainage layers, aggregate base course for roadways and large paved areas, bank run gravel, spread and compacted, 12" deep
30	Install Stormwater Chute Culverts	EA	20	-	-	434	130	Install HDPE culverts to carry stormwater through dike.
	Unit Costs							
	Excavate Trench	CY - in place	593	B12F	270	35	18	312316130062: Excavating, trench, or continuous footing, common earth with no sheeting or dewatering included, 1' to 4' deep, 3/4 C.Y. excavator. Assume trench is 4 ft wide by 2 ft deep
	Install Pipes	LF	2,000	B21	180	311	44	334211501090: Piping, drainage & sewage, corrugated HDPE Type S, not including excavation and backfill, bell and spigot, with gaskets, 36" diameter. Assume each chute requires 100ft of pipe.
	Backfill Trench	CY - as excavated	652	B12F	270	39	19	Assumed same crew and output as for trench excavation. Assume 10% fluff factor from ground to excavated.
	Compact Backfill in Trench	CY - in place	593	A1F	97	49	49	312323238050: Compaction, Rammer tamper, 6" to 11", 4" lifts, 3 passes
31	Install Stormwater Catch Basins	EA	20	-	-	189	74	Install catch basins, or drop inlets, to collect and transmit stormwater.
	Unit Costs							
	Excavate	CY - in place	160	B12F	270	9	5	312316130062: Excavating, trench, or continuous footing, common earth with no sheeting or dewatering included, 1' to 4' deep, 3/4 C.Y. excavator. Assume excavation is 6 ft wide square and 6 ft deep.
	Purchase of Bedding	CY	27	-	-	-	-	Assume bedding is 1 ft deep.
	Haul Bedding	CY	27	B34C	116	2	2	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Place Bedding	CY	27	B12F	270	2	1	Assumed same crew and output as for excavation.
	Purchase and Install 48 inch Diameter Catch Basin	EA	20	B6	3	160	53	334233132200: Utility aera drain, catch basins or manholes catch basins or manhole frames and covers, cast iron, heavy traffic, 36" diameter, 1,150 lb., excluding footing and excavation.
	Backfill Trench	CY - as excavated	117	B12F	270	7	3	Assumed same crew and output as for excavation. Assume 10% fluff factor from ground to excavated.
	Compact Backfill in Trench	CY - in place	117	A1F	97	10	10	312323238050: Compaction, Rammer tamper, 6" to 11", 4" lifts, 3 passes
32	Riprap Stormwater Chutes	SF - in place	40,000	-	-	280	228	Install rip rap and geotextile in all stormwater chutes for erosion protection. Each chute assumed to be 100 ft long and 20 ft wide.
	Unit Costs							
	Purchase of Material	TON	4,400	-	-	-	-	
	Hauling of Material	CY - as excavated	2,963	B34C	116	204	204	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Geotextile Placement	SF - in place	40,000	2 Clab	22500	28	0	313219161550: Geotextile soil stabilization; non-woven 120 lb. tensile strength.
	Rip Rap Placement	CY - as excavated	2,963	B12S	1000	47	24	312316130620: Excvating, trench, common earth with no sheeting or dewatering included, 6' to 10' deep, 2-1/2 C.Y. excavator. Assumed this item for placing rip rap due to no reasonable RS Means lines.
33	Placement of Erosion Control Blankets (ECBs)	SF - in place	696,960	ECB	22500	743	248	Crew based on experience. Daily Output based on 312514160100: Rolled erosion control mats and blankets, plastic netting, stapled, 2" x 1" mesh, 20 mil. Quantity assumed to be 10% of disturbed area multiplied by 0.5 based on experience.
34	Straw Wattle Ditch Checks	LF - in place	14,400	A2	1000	346	115	312514160705: Sediment Log, Filter Sock, 9". Quantity assumed 3/acre (based on experience) for entire disturbed area and each being 30 ft long.
35	Placement of Turf Reinforcement Mats (TRMs) in Creek Channel	SY - in place	31,200	ECB	11250	67	22	Crew and output based on ECB parameters. Output halved from ECB output to account for level of difficulty.
36	Place Rip Rap and Geotextile Along Creek Channel and Around Culvert Entry/Exit	CY - in place	3,150	-	-	298	242	Quantity assumes 25% of rip rap excavated from dike face is used.
	Unit Costs							
	Purchase of Material	TON	4,678	-	-	-	-	
	Hauling of Material	CY - as excavated	3,150	B34C	116	217	217	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Geotextile Placement	SF - in place	42,525	2 Clab	22500	30	0	313219161550: Geotextile soil stabilization; non-woven 120 lb. tensile strength. Assumed rip rap volume placed 2 ft thick to get area.
	Rip Rap Placement	CY - as excavated	3,150	B12S	1000	50	25	312316130620: Excvating, trench, common earth with no sheeting or dewatering included, 6' to 10' deep, 2-1/2 C.Y. excavator. Assumed this item for placing rip rap due to no reasonable RS Means lines.
37	Seed, Mulch, and Maintain Vegetated Surfaces	AC	160	-	-	1,462	1,462	Includes soil ammendments, upland seeding, and wetland planting for all disturbed areas.
	Unit Costs							
	Lime	MSF	6,970	B66	700	80	80	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader.
	Fertilizer	MSF	6,970	B66	700	80	80	329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader.
	Wetland Mix	MSF	348	B66	26	107	107	Daily output and crew based on experience. Quantity assumes 8 acres of disturbed area outside of EAP.
	Grassland Mix	MSF	5,532	B66	52	851	851	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quanity all disturbed areas minus wetland area, pollinator area, and 15-acre pond in consolidated area.
	Pollinator Mix	MSF	436	B66	26	134	134	Daily output and crew based on experience. Quantity assumes 10 acres of disturbed area outside of EAP.
	Mulch	MSF	6,970	B65	530	210	210	329113160350: Mulching, Hay, 1" deep, power mulcher, large
					SITE RESTORATION ESTIMATED SUBTOTAL	**4,060**	**2,750**	

ITEM NO.	ENGINEERING AND CONSTRUCTION SUPPORT TASKS	Units	Quantity	Crew	Output	Labor Hours	Equipment Hours	Notes
38	Engineering Support and CQA During Construction	LS	1	Eng	60 hrs/week	4,680	1,560	Crew and Output based on experience.
					ENGINEERING AND PERMITTING ESTIMATED SUBTOTAL	**4,680**	**1,560**	

NOTES:
1. LS = Lump Sum, AC = Acre, LF = Linear Foot, EA = Each, SY = Square Yard, MO = Month, YR = Year, CY = Cubic Yard, MSF = Thousand Sqaure Feet
2. RS Means refers to the 2022 online edition of RS Means Commercial New Construction.
3. See schedule (Table 2) for assumptions regarding schedule for time unit quantities.

Table 4 - Labor, Equipment, and Mileage Estimate - CIP (1 of 2)

Geosyntec consultants

					Project Total	
Crew	**Labor**	**Daily Labor Hours**	**Equipment**	**Daily Equipment Hours**	**Labor Hours**	**Equipment Hours**
B84	Operator x1	8	Rotary Mower/Tractor	8	492	492
B62	Laborer x2 Operator x 1	24	Loader, Skid Steer, 30 H.P.	8	2,511	837
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	1,560	1,560
B86A	Operator x1	8	Grader, 30,000 lbs	8	624	624
B10K	Operator x1 Laborer x0.5	12	Centr. Water Pump, 6"	8	3,594	2,396
B14B	Operator x1 Laborer x0.5	12	Hyd. Excavator, 6 C.Y.	8	6,359	4,239
B10L	Operator x1 Laborer x0.6	12	Dozer, 80 H.P.	8	7,020	4,680
B21	Labor Foreman x 1 Skilled Worker x 1 Laborer x 1 Operator (crane) 0.5	28	S.P. Crane, 4x4, 5 ton	4	311	44
B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	9,463	6,309
B12F	Operator (crane) x 1 Laborer x 1	16	Hyd. Excavator, 0.75 C.Y.	8	92	46
B6	Laborer x 2 Operator (light) x 1	24	Backhoe Loader, 48 H.P.	8	160	53
A1D	Laborer x 1	8	Vibrating Plate, Gas, 18"	8	181	181
B10T	Laborer x 0.5 Operator (med.) x1	12	F.E. Loader W.M. 2.5 C.Y.	8	649	433
B10R	Laborer x 0.5 Operator (med) x 1	12	F.E. Loader W.M., 1 C.Y.	8	100	67
B63B	Labor Foreman x1 Laborer x2 Operator (light) x1	32	Loader, Skid Steer, 78 H.P.	8	1,041	260
B32	Laborer x1 Operator (med) x3	32	Grader, 30,000 lbs Tandem Roller, 10 ton Dozer, 200 H.P.	24	61	46
2 Clab	Laborer x2	16	None	0	579	0
B12S	Equip. Oper. (crane) x 1 Laborer x 1	16	Hyd. Excavator, 2.5 C.Y.	8	98	49
A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	466	155
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	1,252	1,252
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	210	210
A1F	Laborer x 1	8	Rammer/Tamper, Gas, 8"	8	59	59
B11C	Laborer x1 Operator (med) x1	16	Backhoe Loader, 48 H.P.	8	355	177
B13K	Operators (crane) x 2	16	Hyd. Excavator, .75 C.Y. x 2 Hyd. Hammer, 4000 ft-lb	16	334	334
B34G	Truck Driver x1	8	Dump Truck, Off Hwy., 50 ton	8	21,591	21,591
ECB	Laborer x3	24	Tractor	8	810	270
Hopper	Operator x1	8	Hyd. Excavator, 3.5 C.Y.	8	216	216
Sump Install	Laborer x1 Operator x1	16	Hyd. Excavator, 4.5 C.Y.	8	10	5
Trench	Laborer x3 Operator x2	40	Front End Loader, 10 C.Y. Dewind Machine 1000 H.P.	16	993	0
Grout/Concrete	Laborer x2 Truck Driver x1	24	Concrete Truck	8	42	14
Eng	Engineering Staff x1.2	10	Side by Side x1	4	4,680	1,560
B10F	Operator (med) x1 Laborer x0.5	12	Tandem Roller, 10, Ton	8	10,085	6,723
B10I	Operator (med) x1 Laborer x0.5	12	Diaphragm Water Pump, 4"	8	Not Used	Not Used
B34C	Truck Driver (heavy) x 1	8	Truck Tractor, 6x4, 380 H.P. x 1 Dump Trailer, 16.5 CY x 1	8	4,274	4,274
Pipe Liner	Laborer x 4 Operator x 1	40	Hyd. Excavator, 3.5 C.Y. Grouting Pump	16	400	160
B11L	Operator (med.) x 1 Laborer x 1	16	Grader, 30,000 lbs	8	Not Used	Not Used
B10W	Operator (med.) x 1 Laborer x 0.5	12	Dozer, 105 H.P.	8	Not Used	Not Used
B7	Laborer x 5 Operator (med) x 1	48	Brush Chipper, 12", 130 H.P Crawler Loader, 3 C.Y. Chain Saws, Gas, 36" Long x 2	32	3,266	2,177
B45	Operator (med) x1 Truck Driver(heavy) x 1	16	Tanker, 3000 gal Truck Tractor, 6x4, 380 H.P.	8	Not Used	Not Used
Note: Blue crew names were created by Geosyntec based on experience (not pulled from RSMeans).				**Totals**	83,900	61,500

Table 4 - Labor, Equipment, and Mileage Estimate - CIP (2 of 2)

Geosyntec consultants

Item	Quantity	Assumptions
Labor Total Hours	83,900	Per projected subtotal in cost estimate (Does not include contingency)
Duration of Onsite Construction in Days	390	Per Construction Schedule
Average Daily Crew Size	28	10 hour days (5 days per week)
Daily Labor Mobilization Miles	764,400	Average of 70 miles round trip per day
Vehicles Miles Onsite	18,447	1 mile round trip from gate to parking 5 miles per day for 2 CQA techs and Construction Supervisor 10% Contingency for site visitors (client and engineering support)
Equipment Mobilization Miles - Unloaded	23,400	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	23,400	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Daily Equipment Miles Onsite	500,760	Average of 21 of 28 crew members running equipment Assume 60 miles per piece of equipment 40 miles per day used for water truck 20 miles per day used for grader
Onsite Haul Truck Miles - Unloaded	39,570	34 CY Off Road Dump Truck 1 mile round trip per load
Onsite Haul Truck Miles - Loaded	39,570	34 CY Off Road Dump Truck 1 mile round trip per load
Offsite Haul Truck Miles - Unloaded	56,309	16.5 CY Dump Truck 30 mi cycle for imported materials
Offsite Haul Truck Miles - Loaded	56,309	16.5 CY Dump Truck 30 mi cycle for imported materials
Material Delivery Miles - Unloaded	100,000	100 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete - source 1000 miles away average
Material Delivery Miles - Loaded	100,000	100 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete - source 1000 miles away average

Table 5 - Material Quantity Estimate - CBR-Offsite-Barge Transportation (1 of 1)

Geosyntec consultants

QUANTITY, LABOR, AND EQUIPMENT HOURS ESTIMATE
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CLOSURE-BY-REMOVAL OF EAST ASH POND - OFFSITE BARGE TRANSPORTATION

ITEM NO.	PRE-CONSTRUCTION	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
1	Mobilization and De-Mobilization	LS	1	-	-	-	-	
	PRE-CONSTRUCTION ESTIMATED SUBTOTAL							
ITEM NO.	**SITE PREPARATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
2	Mow Vegetation in East Ash Pond	MSF	526	B84	22	191	191	320190191660: Mowing, mowing brush, light density, tractory with rotary mower
3	Clear Vegetation in Impacted Areas Outside of EAP	Acre	55	-	-	3,567	2,478	Removal of dense vegatation and trees for areas outsdie of the EAP where CCR will be removed.
	Unit Costs							
	Clear Trees	Acre	48	B7	0.7	3,266	2,177	311110100200: Clear and Grub Site, cut and ship medium trees to 12"diameter.
	Heavy Vegetation	MSF	339	B84	9	301	301	320190191680: Mowing, mowing brush, tractor with rotary mower, heavy density.
4	Construction Soil Erosion & Sediment Controls	-	-	-	-	20,819	6,941	Installation of silt fence, rock check dams, and straw wattles for temporary soil erosion and sediment control during construction.
	Unit Costs							
	Silt Fence	LF	560,320	B62	650	20,689	6,896	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Quantity assumes all silt fence is replaced two times/year.
	Rock Check Dams	CY	40	Sump Install	62	10	5	313713100100: Riprap, riprap and rock lining, random, broken stone, machine placed for slope protection. Crew altered based on experience. Assume 20 check dams constructed with 2 CY per check dam. Assume material not purchased but pulled from stockpiled material from existing slopes.
	Straw Wattles	LF	5,000	A2	1000	120	40	312514160705: Sediment Log, Filter Sock, 9". Quantity assumed 3/acre (based on experience) for entire disturbed area and each being 30 ft long.
5	Construction Facilities	MO - in use	247	-	-	-	-	Includes monthly costs associated with three office trailers, 10 storage trailers, and 8 portable toilets.
	Unit Costs							
	Office Trailer (x3)	MO - in use	247	-	-	-	-	015213200350: Office trailer, furnished, no hookups, 32' x 8', rent per month
	Storage Trailers (x10)	MO - in use	247	-	-	-	-	015213201350: Storage boxes, 40' x 8', rent per month
	Portable Toilet (x8)	MO - in use	247	-	-	-	-	015433406410: Rent toilet, portable chemical
6	Construct New Access Ramp at North End and West Side of EAP	CY	3,860	-	-	477	309	Construction of two new access ramps for entry/exit of the EAP.
	Unit Costs							
	Purchase of Material	TON	6,000	-	-	-	-	
	Hauling of Material	CY	3,860	B34C	116	266	266	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Spreading of Material	CY	3,860	B10B	1000	193	31	312323170020: Spread dumped material, no compaction, by dozer
	Compaction of Material	CY	3,860	B10F	2600	18	12	312322235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
7	Construct New Access Road to South East Area (Outside of Rail Loop)	CY	22,200	-	-	2,829	1,834	Construction of a new access road to the west of the rail spur from Portland Rd. to the SE Area.
	Unit Costs							
	Clear Trees	Acre	1.25	B7	0.7	86	57	311110100200: Clear and Grub Site, cut and ship medium trees to 12"diameter.
	Purchase of Material	TON	34,500	-	-	-	-	
	Hauling of Material	CY	22,200	B34C	116	1,531	1,531	312323203070: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Spreading of Material	CY	22,200	B10B	1000	1,110	178	312323170020: Spread dumped material, no compaction, by dozer
	Compaction of Material	CY	22,200	B10F	2600	102	68	312322235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
8	Abandonment of Piezometers and Monitoring Wells	EA	3	Grout/Concrete	4	18	6	Crew and Daily Output based on experience.
9	Dust Control	DAY	1,785	B59	1	14,280	14,280	312323202510: Dust control, heavy; utlizing truck tractor and water tank trailer per RSMeans Crew B59. Quantity is assumed to be half of working days will need dust control. Daily Output assumed to 1, based on experience.
10	Haul Road Maintenance	DAY	714	B86A	1	5,712	5,712	312323202600: Haul road maintenance Quantity is assumed to be 1 day/week.
	SITE PREPARATION ESTIMATED SUBTOTAL					**47,890**	**31,750**	
ITEM NO.	**DEWATERING, UNWATERING, AND STORMWATER MANAGEMENT**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
11	Dewatering, Unwatering, and Stormwater Management for the East Ash Pond	DAY	2,507	B10K	4	7,521	5,014	312319201100: Dewatering, pumping 8 hours, attended 2 hours per day, 6" discharge pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose. 312319201100: Add per additional pump - 3 additional pumps added. Quantity assumes 1 year of pumping prior to excavation and average of 3 days/week during construction.
	Unit Costs							
	Additional HDPE Piping	LF	15,700	-	-	-	-	221113780098: Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 10" diameter, DR11, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting, or digging equipment.
12	Construct Temporary Stormwater Detention Basin	CY - in place	96,800	-	-	1,258	1,173	Assume 6 are constructed throughout the construction life of project. Each assumed to be 2 acres and 5 ft deep.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	106,480	B14B	5000	256	170	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	106,480	B34G	850	1,002	1,002	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
13	Dewatering Sumps Installation	EA - in place	300	Sump Install	4	1,200	600	Crew and Daily Output based on experience. Materials include 24" corrugated HDPE pipe with geotextile wrapping, and 1 C.Y. of gravel backfill.
	DEWATERING, UNWATERING, AND STORMWATER MANAGEMENT ESTIMATED SUBTOTAL					**10,000**	**6,800**	
ITEM NO.	**EAST ASH POND CLOSURE**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
14	Relocation of Power Lines	LS	4					
15	Demolish and Dispose of Facilities at North End of EAP in Receiving Landfill	LS	1	B14B	1.0	12	8	Crew and Daily Output based on experience.
16	Construct Loading Terminal Onsite	LS	1					
17	Construct Unloading Terminal at Port of Cates Landing	LS	1					
18	Excavation of CCR + 1 ft overdig within EAP Boundaries	CY - in place	5,869,600	-	-	1,014,291	960,848	Quantity based on surface to surface calculation performed in AutoCAD. Quantity excavated in Detention Basin Construction subtracted.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	6,350,080	B14B	5000	15,240	10,160	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	6,350,080	B34G	850	59,765	59,765	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Spreading/ Drying Moisture Conditioning	CY - as excavated	3,228,280	B10B	5000	32,283	5,165	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience. Quantity assumes 50% of volume requires moisture conditioning.
	Dust Control Moisture Conditioning Prior to Loading	CY - as excavated	968,484	B45	1888	8,207	4,104	312323239000: Water, 3000 gal. truck, 3 mile haul. Assume 30% of volume will need to be wetted.
	Demolish/Excavate and Load DMM in Southeast corner of EAP	CY - as excavated	13,350	B13K	640	334	334	312316350130: Hydraulic rock breaking and loading, solid rock mass excavation, excavator/breaker and excavator/bucket (into trucks), 110 HP excavator w/ 4,000 ft lb. breaker, mobilization 2/20 ton, 6,000 psi rock. Quantity obtained from DMM design drawings and 50% of volume assumed to be excavated. Assume 20% fluff from ground to excavated.
	Loading of Material onto Terminal	CY - as excavated	6,472,580	B14K	5130	15,141	10,094	312316432550: Excavating, large volume projects; restricted loading trucks, loader, 95% fill factor, 10 C.Y. bucket (assume 10% fluff factor from ground to excavated)
	Hauling of Material by Barge	DAY	4,500	Barge	5130	323,999	323,999	Quantity assumes enough working days to keep up with two excavation crews, working five days per week- also assumes barges are reserved for all other non-working days.
	Unloading Material from Barge	CY - as excavated	6,472,580	B14C	5510	14,096	9,398	312316435430:Excavating, large volume projects, various materials, minimum project size 200,000 B.C.Y, excavation with truck loading, excavator, 95% fill factor, 7 C.Y. bucket. 312316424000: for soft soil or sand, deduct.
	Unloading Assistance in Barge	CY - as excavated	3,236,290	B10L	5510	7,048	4,699	312323142000: Backfill, structural, sand and gravel, 80 HP dozer, 50' haul, from existing stockpile, excludes compaction. Line item for piece of equipment pushing material in loaded barges to center - assumes only half the volume must be handled. Daily output altered to match unloading.
	Loading of Material onto Trucks	CY - as excavated	6,472,580	B14K	5130	15,141	10,094	312316432550: Excavating, large volume projects; restricted loading trucks, loader, 95% fill factor, 10 C.Y. bucket (assume 10% fluff factor from ground to excavated)
	Hauling of Material to Landfill by Truck	CY - as excavated	6,472,580	B34C	99	523,037	523,037	312323203084: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 40 MPH, cycle 40 miles.
	Landfill Quantity	TON	7,427,286	-	-	-	-	
19	Excavation of CCR and Impacted Soils Outside of EAP	CY - in place	585,548	-	-	102,671	96,090	Quantity within rail loop based on surfaces (Top and Bottom of CCR - Southeast) developed by Geosyntec plus one foot of overdig.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	644,103	B14B	5000	1,546	1,031	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	644,103	B34G	850	6,062	6,062	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Spreading/ Drying Moisture Conditioning	CY - as excavated	450,872	B10B	5000	4,509	721	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience. Quantity assumes 70% of volume requires moisture conditioning.
	Dust Control Moisture Conditioning Prior to Loading	CY - as excavated	135,262	B45	1888	1,146	573	312323239000: Water, 3000 gal. truck, 3 mile haul. Assume 30% of volume will need to be wetted.
	Loading of Material onto Terminal	CY - as excavated	644,103	B14K	5130	1,507	1,004	312316432550: Excavating, large volume projects; restricted loading trucks, loader, 95% fill factor, 10 C.Y. bucket (assume 10% fluff factor from ground to excavated)
	Hauling of Material by Barge	DAY	448	Barge	5130	32,242	32,242	Quantity assumes enough working days to keep up with two excavation crews, working five days per week- also assumes barges are reserved for all other non-working days.
	Unloading Material from Barge onto Trucks	CY - as excavated	644,103	B14C	5510	1,403	935	312316435430:Excavating, large volume projects, various materials, minimum project size 200,000 B.C.Y, excavation with truck loading, excavator, 95% fill factor, 7 C.Y. bucket. 312316424000: for soft soil or sand, deduct.
	Unloading Assistance in Barge	CY - as excavated	322,052	B10L	5510	701	468	312323142000: Backfill, structural, sand and gravel, 80 HP dozer, 50' haul, from existing stockpile, excludes compaction. Line item for piece of equipment pushing material in loaded barges to center - assumes only half the volume must be handled. Daily output altered to match unloading.
	Loading of Material onto Trucks	CY - as excavated	644,103	B14K	5130	1,507	1,004	312316432550: Excavating, large volume projects; restricted loading trucks, loader, 95% fill factor, 10 C.Y. bucket (assume 10% fluff factor from ground to excavated)
	Hauling of Material to Landfill by Truck	CY - as excavated	644,103	B34C	99	52,049	52,049	312323203084: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 40 MPH, cycle 40 miles.
	Landfill Quantity	TON	739,108	-	-	-	-	
20	Removal and Stockpiling of Dike Riprap for Onsite Use	CY - in place	38,300	-	-	2,367	728	Remove existing riprap facing on EAP dikes and stockpile onsite for future use.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	38,300	B14B	5000	92	61	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor
	Hauling of Material to Onsite Stockpile	CY - as excavated	38,300	B34G	850	360	360	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Stockpiling of Material	CY - as excavated	38,300	B10B	1000	1,915	306	312323170020: Spread dumped material, no compaction, by dozer
21	Movement of Dike Fill for Regrading/Drainage	CY - in place	331,700	-	-	9,489	5,622	Excavation of clean dike fill and placement of fill in CBR EAP to promote drainage towards the creek channel/Ohio River.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	364,870	B14B	5000	876	584	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material	CY - as excavated	364,870	B34G	850	3,434	3,434	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Spreading of Material	CY - as excavated	364,870	B10B	5000	3,649	584	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Material	CY - in place	331,700	B10F	2600	1,531	1,021	312322235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
22	Reconstruct Creek Channel	CY - in place	47,850	-	-	1,148	664	Excavation of a creek channel along a similar alignment as prior to construction of the EAP. Also includes placement of the excavated material in CBR EAP to promote drainage towards the creek channel/Ohio River.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	52,635	B14B	5000	126	84	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material	CY - as excavated	52,635	B34G	850	495	495	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Spreading of Material for Regrading /Drainage	CY - as excavated	52,635	B10B	5000	526	84	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	EAST ASH POND ESTIMATED SUBTOTAL					**1,129,980**	**1,063,960**	
ITEM NO.	**SITE RESTORATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
23	Placement of Erosion Control Blankets (ECBs)	SF - in place	696,960	ECB	22500	743	248	Crew based on experience. Daily Output based on 312514160100: Rolled erosion control mats and blankets, plastic netting, stapled, 2" x 1" mesh, 20 mil. Quantity assumed to be 10% of disturbed area multiplied by 0.5 based on experience.
24	Straw Wattle Ditch Checks	LF - in place	14,400	A2	1000	346	115	312514160705: Sediment Log, Filter Sock, 9". Quantity assumed 3/acre (based on experience) for entire disturbed area and each being 30 ft long.
25	Placement of Turf Reinforcement Mats (TRMs) in Creek Channel	SY - in place	40,167	ECB	11250	86	29	Crew and output based on ECB parameters. Output halved from ECB output to account for level of difficulty.
26	Place Rip Rap and Geotextile Along Creek Channel and Around Culvert Entry/Exit.	CY - in place	19,150	-	-	716	364	Quantity assumes half of rip rap excavated from dike face is used.
	Unit Costs							
	Loading of Stockpiled Material	CY - as excavated	19,150	B14B	5000	46	31	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor
	Hauling of Material	CY - as excavated	19,150	B34G	850	180	180	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Geotextile Placement	SF - in place	258,525	2 Clab	22500	184	0	313219161550: Geotextile soil stabilization; non-woven 120 lb. tensile strength. Assumed rip rap volume placed 2 ft thick to get area.
	Rip Rap Placement	CY - as excavated	19,150	B12S	1000	306	153	312316130620: Excvating, trench, common earth with no sheeting or dewatering included, 6' to 10' deep, 2-1/2 C.Y. excavator. Assumed this item for placing rip rap due to no reasonable RS Means lines.
27	Seed, Mulch, and Maintain Vegetated Surfaces	AC	160	-	-	1,509	1,509	Includes soil ammendments, upland seeding, and wetland planting for all disturbed areas.
	Unit Costs							
	Lime	MSF	6,970	B66	700	80	80	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader.
	Fertilizer	MSF	6,970	B66	700	80	80	329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader.
	Wetland Mix	MSF	871	B66	26	268	268	Daily output and crew based on experience. Quantity assumes 20acres of disturbed area.
	Grassland Mix	MSF	3,920	B66	52	603	603	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quanity all disturbed areas minus wetland area, pollinator area, and 30 acres of ponds in EAP area.
	Pollinator Mix	MSF	871	B66	26	268	268	Daily output and crew based on experience. Quantity assumes 20 acres of distubed area.
	Mulch	MSF	6,970	B65	530	210	210	329113160350: Mulching, Hay, 1" deep, power mulcher, large
	SITE RESTORATION ESTIMATED SUBTOTAL					**3,400**	**2,260**	
ITEM NO.	**ENGINEERING AND CONSTRUCTION SUPPORT TASKS**	**Units**	**Quantity**	**Crew**	**Output**	**Labor Hours**	**Equipment Hours**	**Notes**
29	Engineering Support and CQA During Construction	LS	1	Eng	60 hrs/week	42,840	14,280	Crew and Output based on experience.
	ENGINEERING AND PERMITTING ESTIMATED SUBTOTAL					**42,840**	**14,280**	

NOTES:
1. LS = Lump Sum, AC = Acre, LF = Linear Foot, EA = Each, SY = Square Yard, MO = Month, YR = Year, CY = Cubic Yard, MSF = Thousand Sqaure Feet
2. RS Means refers to the 2022 online edition of RS Means Commercial New Construction.
3. See schedule (Table 2) for assumptions regarding schedule for time unit quantities.

Table 6 - Labor, Equipment, and Mileage Estimate
CBR-Offsite-Barge Transportation
(1 of 2)

Geosyntec consultants

Crew	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Project Total	
					Labor Hours	Equipment Hours
B84	Operator x1	8	Rotary Mower/Tractor	8	492	492
B62	Laborer x2 Operator x 1	24	Loader, Skid Steer, 30 H.P.	8	20,689	6,896
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	14,280	14,280
B86A	Operator x1	8	Grader, 30,000 lbs	8	5,712	5,712
B10K	Operator x1 Laborer x0.5	12	Centr. Water Pump, 6"	8	7,521	5,014
B14B	Operator x1 Laborer x0.5	12	Hyd. Excavator, 6 C.Y.	8	18,193	12,129
1 Clab	Laborer x1	8	None	0	Not Used	Not Used
B34F	Truck Driver x1	8	Dump Truck, Off Hwy., 35 ton	8	Not Used	Not Used
B10B	Operator x1 Laborer x5	50	Dozer, 200 H.P.	8	44,185	7,070
Barge	Tug Captain x 1 Mates, Engineers, & Seamen x 5	72	Diesel Tugboat, 6,000 HP	12	356,241	356,241
B34D	Truck Driver (heavy) x 1	8	Truck Tractor, 6x4, 380 H.P. x 1 Dump Trailer, 20 CY x 1	8	Not Used	Not Used
B21C	Labor Foreman x1 Laborer x4 Operator (crane) x1 Operator (oiler) x1	56	Cutting Torches x2 Sets of Gasses x2 Lattice Boom Crane, 90 ton	8	Not Used	Not Used
B69	Labor Foreman x1 Laborer x3 Operator (crane) x1 Operator (oiler) x1	48	Hyd. Crane, 80 ton	8	Not Used	Not Used
C14A	Carpenter Foreman x1 Carpenters x16 Rodmen x4 Laborers x2 Cement Finisher x1 Operator (medium) x1	200	Gas Engine Vibrator Concrete Pump (small)	16	Not Used	Not Used
B10L	Laborer x 0.5 Operator (med) x1	12	Dozer, 80 H.P.	8	7,750	5,166
B32	Laborer x1 Operator (med) x3	32	Grader, 30,000 lbs Tandem Roller, 10 ton Dozer, 200 H.P.	24	Not Used	Not Used
2 Clab	Laborer x2	16	None	0	184	0
B12S	Equip. Oper. (crane) x 1 Laborer x 1	16	Hyd. Excavator, 2.5 C.Y.	8	306	153
A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	466	155
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	1,299	1,299
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	210	210
B63	Laborer x4 Operator (light) x1	40	Loader, Skid Steer, 30 H.P.	8	Not Used	Not Used
B11C	Laborer x1 Operator (med) x1	16	Backhoe Loader, 48 H.P.	8	Not Used	Not Used
B13K	Operators (crane) x 2	16	Hyd. Excavator, .75 C.Y. x 2 Hyd. Hammer, 4000 ft-lb	16	334	334
B34G	Truck Driver x1	8	Dump Truck, Off Hwy., 50 ton	8	71,300	71,300
ECB	Laborer x3	24	Tractor	8	829	276
Dewater	Laborer x1	8	8" Diesel Pump	2	Not Used	Not Used
Sump Install	Laborer x1 Operator x1	16	Hyd. Excavator, 4.5 C.Y.	8	1,210	605
Grout/Concrete	Laborer x2 Truck Driver x1	24	Concrete Truck	8	18	6
Eng	Engineering Staff x1.2	10	Side by Side x1	4	42,840	14,280
B10F	Operator (med) x1 Laborer x0.5	12	Tandem Roller, 10, Ton	8	1,651	1,101
B14K	Operator (med) x1 Laborer x0.5	12	Front End Loader, 10 C.Y.	8	16,647	11,098
B34C	Truck Driver (heavy) x 1	8	Truck Tractor, 6x4, 380 H.P. x 1 Dump Trailer, 16.5 CY x 1	8	576,883	576,883
B14C	Operator (crane) x 1 Laborer x 0.5	12	Hyd. Excavator, 7 C.Y.	8	15,499	10,333
B11L	Operator (med.) x 1 Laborer x 1	16	Grader, 30,000 lbs	8	Not Used	Not Used
B10W	Operator (med.) x 1 Laborer x 0.5	12	Dozer, 105 H.P.	8	Not Used	Not Used
B7	Laborer x 5 Operator (med) x 1	48	Brush Chipper, 12", 130 H.P Crawler Loader, 3 C.Y. Chain Saws, Gas, 36" Long x 2	32	3,352	2,234
B45	Operator (med) x1 Truck Driver(heavy) x 1	16	Tanker, 3000 gal Truck Tractor, 6x4, 380 H.P.	8	9,354	4,677
Note: Blue crew names were created by Geosyntec based on experience (not pulled from RSMeans).				**Totals**	1,217,400	1,107,900

Table 6 - Labor, Equipment, and Mileage Estimate
CBR-Offsite-Barge Transportation
(2 of 2)

Geosyntec consultants

Item	Quantity	Assumptions
Labor Total Hours	1,234,100	Per projected subtotal in cost estimate (Does not include contingency)
Duration of Onsite Construction in Days	3,570	Per Construction Schedule
Average Daily Crew Size	20	10 hour days (5 days per week)
Daily Labor Mobilization Miles	4,998,000	Average of 70 miles round trip per day
Vehicles Miles Onsite	137,445	1 mile round trip from gate to parking 5 miles per day for 2 CQA techs and Construction Supervisor 10% Contingency for site visitors (client and engineering support)
Equipment Mobilization Miles - Unloaded	214,200	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	214,200	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Daily Equipment Miles Onsite	3,941,280	Average of 18 of 20 crew members running equipment Assume 60 miles per piece of equipment 40 miles per day used for water truck 20 miles per day used for grader
Onsite Haul Truck Miles - Unloaded	109,840	34 CY Off Road Dump Truck 1 mile round trip per load
Onsite Haul Truck Miles - Loaded	109,840	34 CY Off Road Dump Truck 1 mile round trip per load
Tugboat Miles on River - Unloaded	46,894	9 barges per trip (at 1400 CY per barge) 162 mile cycle (increased by 2.5% to account for maneuvering, rearranging, etc. at docks)
Tugboat Miles on River - Loaded	46,894	9 barges per trip 162 mile cycle (increased by 2.5% to account for maneuvering, rearranging, etc. at docks)
Offsite Haul Truck Miles - Unloaded	8,657,870	16.5 CY Dump Truck 40 mi cycle for exported CCR
Offsite Haul Truck Miles - Loaded	8,657,870	16.5 CY Dump Truck 40 mi cycle for exported CCR
Material Delivery Miles - Unloaded	100,000	100 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete - source 1000 miles away average
Material Delivery Miles - Loaded	100,000	100 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete - source 1000 miles away average

Table 7 - Material Quantity Estimate - CBR-Offsite-Truck Transportation (1 of 1)

Geosyntec consultants

QUANTITY, LABOR, AND EQUIPMENT HOURS ESTIMATE
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CLOSURE-BY-REMOVAL OF EAST ASH POND

ITEM NO.	PRE-CONSTRUCTION	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
1	Mobilization and De-Mobilization	LS	1	-	-	-	-	
	PRE-CONSTRUCTION ESTIMATED SUBTOTAL							
ITEM NO.	**SITE PREPARATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
2	Mow Vegetation in East Ash Pond	MSF	526	B84	22	191	191	320190191660: Mowing, mowing brush, light density, tractory with rotary mower
3	Clear Vegetation in Impacted Areas Outside of EAP	Acre	55	-	-	3,567	2,478	Removal of dense vegatation and trees for areas outsdie of the EAP where CCR will be removed.
	Unit Costs							
	Clear Trees	Acre	48	B7	0.7	3,266	2,177	311110100200: Clear and Grub Site, cut and ship medium trees to 12"diameter.
	Heavy Vegetation	MSF	339	B84	9	301	301	320190191680: Mowing, mowing brush, tractor with rotary mower, heavy density.
4	Construction Soil Erosion & Sediment Controls	-	-	-	-	20,819	6,941	Installation of silt fence, rock check dams, and straw wattles for temporary soil erosion and sediment control during construction.
	Unit Costs							
	Silt Fence	LF	560,320	B62	650	20,689	6,896	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Quantity assumes all silt fence is replaced two times/year.
	Rock Check Dams	CY	40	Sump Install	62	10	5	313713100100: Riprap, riprap and rock lining, random, broken stone, machine placed for slope protection. Crew altered based on experience. Assume 20 check dams constructed with 2 CY per check dam. Assume material not purchased but pulled from stockpiled material from existing slopes.
	Straw Wattles	LF	5,000	A2	1000	120	40	312514160705: Sediment Log, Filter Sock, 9". Quantity assumed 3/acre (based on experience) for entire disturbed area and each being 30 ft long.
5	Construction Facilities	MO - in use	245	-	-	-	-	Includes monthly costs associated with three office trailers, 10 storage trailers, and 8 portable toilets.
	Unit Costs							
	Office Trailer (x3)	MO - in use	245	-	-	-	-	015213200350: Office trailer, furnished, no hookups, 32' x 8', rent per month
	Storage Trailers (x10)	MO - in use	245	-	-	-	-	015213201350: Storage boxes, 40' x 8', rent per month
	Portable Toilet (x8)	MO - in use	245	-	-	-	-	015433406410: Rent toilet, portable chemical
6	Construct New Access Ramp at North End and West Side of EAP	CY	3,860	-	-	330	309	Construction of two new access ramps for entry/exit of the EAP.
	Unit Costs							
	Purchase of Material	TON	6,000	-	-	-	-	
	Hauling of Material	CY	3,860	B34C	116	266	266	312323203070: Hauling: no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Spreading of Material	CY	3,860	B10B	1000	46	31	312323170020: Spread dumped material, no compaction, by dozer
	Compaction of Material	CY	3,860	B10F	2600	18	12	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
7	Construct New Access Road to South East Area (Outside of Rail Loop)	CY	22,200	-	-	1,986	1,834	Construction of a new access road to the west of the rail spur from Portland Rd. to the SE Area.
	Unit Costs							
	Clear Trees	Acre	1.25	B7	0.7	86	57	311110100200: Clear and Grub Site, cut and ship medium trees to 12"diameter.
	Purchase of Material	TON	34,500	-	-	-	-	
	Hauling of Material	CY	22,200	B34C	116	1,531	1,531	312323203070: Hauling: no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 35 MPH, cycle 30 miles
	Spreading of Material	CY	22,200	B10B	1000	266	178	312323170020: Spread dumped material, no compaction, by dozer
	Compaction of Material	CY	22,200	B10F	2600	102	68	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
8	Abandonment of Piezometers and Monitoring Wells	EA	3	Grout/Concrete	4	18	6	Crew and Daily Output based on experience.
9	Dust Control	DAY	1,785	B59	1	14,280	14,280	312323202510: Dust control, heavy; utilizing truck tractor and water tank trailer per RSMeans Crew B59. Quantity is assumed to be half of working days will need dust control. Daily Output assumed to 1, based on experience.
10	Haul Road Maintenance	DAY	714	B86A	1	5,712	5,712	312323202600: Haul road maintenance Quantity is assumed to be 1 day/week.
	SITE PREPARATION ESTIMATED SUBTOTAL					**46,900**	**31,750**	
ITEM NO.	**DEWATERING, UNWATERING, AND STORMWATER MANAGEMENT**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
11	Dewatering, Unwatering, and Stormwater Management for the East Ash Pond	DAY	2,507	B10K	4	7,521	5,014	312319201100: Dewatering, pumping 8 hours, attended 2 hours per day, 6" discharge pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose. 312319201100: Add per additional pump - 3 additional pumps added. Quantity assumes 1 year of pumping prior to excavation and average of 3 days/week during construction.
	Unit Costs							
	Additional HDPE Piping	LF	15,700	-	-	-	-	221113780098: Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 10" diameter, DR11, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting, or digging equipment.
12	Construct Temporary Stormwater Detention Basin	CY - in place	96,800	-	-	1,258	1,173	Assume 6 are constructed throughout the construction life of project. Each assumed to be 2 acres and 5 ft deep.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	106,480	B14B	5000	256	170	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	106,480	B34G	850	1,002	1,002	312323206170: Hauling: no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
13	Dewatering Sumps Installation	EA - in place	300	Sump Install	4	1,200	600	Crew and Daily Output based on experience. Materials include 24" corrugated HDPE pipe with geotextile wrapping, and 1 C.Y. of gravel backfill.
	DEWATERING, UNWATERING, AND STORMWATER MANAGEMENT ESTIMATED SUBTOTAL					**10,000**	**6,800**	
ITEM NO.	**EAST ASH POND CLOSURE**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
14	Relocation of Power Lines	LS	4					
15	Demolish and Dispose of Facilities at North End of EAP in Receiving Landfill	LS	1	B14B	1.0	12	8	Crew and Daily Output based on experience.
16	Excavation of CCR + 1 ft overdig within EAP Boundaries	CY - in place	5,869,600	-	-	1,204,296	1,187,483	Quantity based on surface to surface calculation performed in AutoCAD. Quantity excavated in Detention Basin Construction subtracted.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	6,350,080	B14B	5000	15,240	10,160	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	6,350,080	B34G	850	59,765	59,765	312323206170: Hauling: no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Spreading/ Drying Moisture Conditioning	CY - as excavated	3,228,280	B10B	5000	7,748	5,165	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Dust Control Moisture Conditioning Prior to Loading	CY - as excavated	968,484	B45	1888	8,207	4,104	312323239000: Water, 3000 gal. truck, 3 mile haul. Assume 30% of volume will need to be wetted.
	Demolish/Excavate and Load DMM in Southeast corner of EAP	CY - as excavated	13,350	B13K	640	334	334	312316350130: Hydraulic rock breaking and loading, solid rock mass excavation, excavator/breaker and excavator/bucket (into trucks), 110 HP excavator w/ 4,000 ft lb. breaker, mobilization 2/20 ton, 6,000 psi rock. Quantity obtained from DMM design drawings and 50% of volume assumed to be excavated. Assume 20% fluff from ground to excavated.
	Loading of Material	CY - as excavated	6,472,580	B14K	5130	15,141	10,094	312316432550: Excavating, large volume projects; restricted loading trucks, loader, 95% fill factor, 10 C.Y. bucket (assume 10% fluff factor from ground to excavated)
	Hauling of Material Offiste	CY - as excavated	6,472,580	B34C	47	1,097,861	1,097,861	312323203086: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 40 MPH, cycle 50 miles. RS Means daily output extrapolated for longer 116 mile cycle.
	Landfill Quantity	TON	7,427,286	-	-	-	-	
17	Excavation of CCR and Impacted Soils Outside of EAP	CY - in place	585,548	-	-	120,594	118,643	Quantity within rail loop based on surfaces (Top and Bottom of CCR - Southeast) developed by Geosyntec plus one foot of overdig.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	644,103	B14B	5000	1,546	1,031	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	644,103	B34G	850	6,062	6,062	312323206170: Hauling: no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Spreading/ Drying Moisture Conditioning	CY - as excavated	450,872	B10B	5000	1,082	721	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience. Quantity assumes 70% of volume requires moisture conditioning.
	Dust Control Moisture Conditioning Prior to Loading	CY - as excavated	135,262	B45	1888	1,146	573	312323239000: Water, 3000 gal. truck, 3 mile haul. Assume 30% of volume will need to be wetted.
	Loading of Material	CY - as excavated	644,103	B14K	5130	1,507	1,004	312316432550: Excavating, large volume projects; restricted loading trucks, loader, 95% fill factor, 10 C.Y. bucket (assume 10% fluff factor from ground to excavated)
	Hauling of Material Offiste	CY - as excavated	644,103	B34C	47	109,251	109,251	312323203086: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y.truck, 15 min wait/ld/uld., 40 MPH, cycle 50 miles. RS Means daily output extrapolated for longer 116 mile cycle.
	Landfill Quantity	TON	739,108	-	-	-	-	
18	Removal and Stockpiling of Dike Riprap for Onsite Use	CY - in place	38,300	-	-	912	728	Remove existing riprap facing on EAP dikes and stockpile onsite for future use.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	38,300	B14B	5000	92	61	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor
	Hauling of Material to Onsite Stockpile	CY - as excavated	38,300	B34G	850	360	360	312323206170: Hauling: no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Stockpiling of Material	CY - as excavated	38,300	B10B	1000	460	306	312323170020: Spread dumped material, no compaction, by dozer
19	Movement of Dike Fill for Regrading/Drainage	CY - in place	331,700	-	-	8,396	6,462	Excavation of clean dike fill and placement of fill in CBR EAP to promote drainage towards the creek channel/Ohio River.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	364,870	B14B	5000	876	584	312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 C.Y. bucket, 95% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material	CY - as excavated	364,870	B34G	850	3,434	3,434	312323206170: Hauling: no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Spreading of Material	CY - as excavated	364,870	B10B	5000	876	584	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Finish Grading of Material	SY	934,122	B11L	8900	1,679	840	312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience.
	Compaction of Material	CY - in place	331,700	B10F	2600	1,531	1,021	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
20	Reconstruct Creek Channel	CY - in place	47,850	-	-	1,041	847	Excavation of a creek channel along a similar alignment as prior to construction of the EAP. Also includes placement of the excavated material in CBR EAP to promote drainage towards the creek channel/Ohio River.
	Unit Costs							
	Excavation and Loading of Material	CY - as excavated	52,635	B14B	5000	126	84	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated)
	Hauling of Material	CY - as excavated	52,635	B34G	850	495	495	312323206170: Hauling: no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Spreading of Material for Regrading /Drainage	CY - as excavated	52,635	B10B	5000	126	84	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Finish Grading Surface	SY	40,167	B11L	8900	72	36	312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience.
	Compaction of Material	CY - in place	47,850	B10F	2600	221	147	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
	EAST ASH POND ESTIMATED SUBTOTAL					**1,335,250**	**1,314,170**	
ITEM NO.	**SITE RESTORATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
21	Placement of Erosion Control Blankets (ECBs)	SF - in place	696,960	ECB	22500	743	248	Crew based on experience. Daily Output based on 312514160100: Rolled erosion control mats and blankets, plastic netting, stapled, 2" x 1" mesh, 20 mil. Quantity assumed to be 10% of disturbed area multiplied by 0.5 based on experience.
22	Straw Wattle Ditch Checks	LF - in place	14,400	A2	1000	346	115	312514160705: Sediment Log, Filter Sock, 9". Quantity assumed 3/acre (based on experience) for entire disturbed area and each being 30 ft long.
23	Placement of Turf Reinforcement Mats (TRMs) in Creek Channel	SY - in place	40,167	ECB	11250	86	29	Crew and output based on ECB parameters. Output halved from ECB output to account for level of difficulty.
24	Place Rip Rap and Geotextile Along Creek Channel and Around Culvert Entry/Exit.	CY - in place	19,150	-	-	716	364	Quantity assumes half of rip rap excavated from dike face is used.
	Unit Costs							
	Loading of Stockpiled Material	CY - as excavated	19,150	B14B	5000	46	31	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor
	Hauling of Material	CY - as excavated	19,150	B34G	850	180	180	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 1 mile
	Geotextile Placement	SF - in place	258,525	2 Clab	22500	184	0	313219161550: Geotextile soil stabilization; non-woven 120 lb. tensile strength. Assumed rip rap volume placed 2 ft thick to get area.
	Rip Rap Placement	CY - as excavated	19,150	B12S	1000	306	153	312316130620: Excvating, trench, common earth with no sheeting or dewatering included, 6' to 10' deep, 2-1/2 C.Y. excavator. Assumed this item for placing rip rap due to no reasonable RS Means lines.
25	Seed, Mulch, and Maintain Vegetated Surfaces	AC	160	-	-	1,509	1,509	Includes soil ammendments, upland seeding, and wetland planting for all disturbed areas.
	Unit Costs							
	Lime	MSF	6,970	B66	700	80	80	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader.
	Fertilizer	MSF	6,970	B66	700	80	80	329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader.
	Wetland Mix	MSF	871	B66	26	268	268	Daily output, crew based on experience. Quantity assumes 20acres of disturbed area.
	Grassland Mix	MSF	3,920	B66	52	603	603	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quanity all disturbed areas minus wetland area, pollinator area, and 30 acres of ponds in EAP area.
	Pollinator Mix	MSF	871	B66	26	268	268	Daily output, crew based on experience. Quantity assumes 20 acres of distubed area.
	Mulch	MSF	6,970	B65	530	210	210	329113160350: Mulching, Hay, 1" deep, power mulcher, large
	SITE RESTORATION ESTIMATED SUBTOTAL					**3,400**	**2,260**	
ITEM NO.	**ENGINEERING AND CONSTRUCTION SUPPORT TASKS**	**Units**	**Quantity**	**Crew**	**Output**	**Labor Hours**	**Equipment Hours**	**Notes**
27	Engineering Support and CQA During Construction	LS	1	Eng	60 hrs/week	42,840	14,280	Crew and Output based on experience.
	ENGINEERING AND PERMITTING ESTIMATED SUBTOTAL					**42,840**	**14,280**	

NOTES:
1. LS = Lump Sum, AC = Acre, LF = Linear Foot, EA = Each, SY = Square Yard, MO = Month, YR = Year, CY = Cubic Yard, MSF = Thousand Sqaure Feet
2. RS Means refers to the 2022 online edition of RS Means Commercial New Construction.
3. See schedule (Table 2) for assumptions regarding schedule for time unit quantities.

Table 8 - Labor, Equipment, and Mileage Estimate
CBR-Offsite-Truck Transportation
(1 of 2)

Geosyntec consultants

Crew	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Project Total	
					Labor Hours	Equipment Hours
B84	Operator x1	8	Rotary Mower/Tractor	8	492	492
B62	Laborer x2 Operator x 1	24	Loader, Skid Steer, 30 H.P.	8	20,689	6,896
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	14,280	14,280
B86A	Operator x1	8	Grader, 30,000 lbs	8	5,712	5,712
B10K	Operator x1 Laborer x0.5	12	Centr. Water Pump, 6"	8	7,521	5,014
B14B	Operator x1 Laborer x0.5	12	Hyd. Excavator, 6 C.Y.	8	18,193	12,129
1 Clab	Laborer x1	8	None	0	Not Used	Not Used
B34F	Truck Driver x1	8	Dump Truck, Off Hwy., 35 ton	8	Not Used	Not Used
B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	10,604	7,070
B10G	Operator x1 Laborer x0.5	12	Sheepsfoot Roller, 240 H.P.	8	Not Used	Not Used
B34D	Truck Driver (heavy) x 1	8	Truck Tractor, 6x4, 380 H.P. x 1 Dump Trailer, 20 CY x 1	8	Not Used	Not Used
B21C	Labor Foreman x1 Laborer x4 Operator (crane) x1 Operator (oiler) x1	56	Cutting Torches x2 Sets of Gasses x2 Lattice Boom Crane, 90 ton	8	Not Used	Not Used
B69	Labor Foreman x1 Laborer x3 Operator (crane) x1 Operator (oiler) x1	48	Hyd. Crane, 80 ton	8	Not Used	Not Used
C14A	Carpenter Foreman x1 Carpenters x16 Rodmen x4 Laborers x2 Cement Finisher x1 Operator (medium) x1	200	Gas Engine Vibrator Concrete Pump (small)	16	Not Used	Not Used
B63B	Labor Foreman x1 Laborer x2 Operator (light) x1	32	Loader, Skid Steer, 78 H.P.	8	Not Used	Not Used
B32	Laborer x1 Operator (med) x3	32	Grader, 30,000 lbs Tandem Roller, 10 ton Dozer, 200 H.P.	24	Not Used	Not Used
2 Clab	Laborer x2	16	None	0	184	0
B12S	Equip. Oper. (crane) x 1 Laborer x 1	16	Hyd. Excavator, 2.5 C.Y.	8	306	153
A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	466	155
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	1,299	1,299
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	210	210
B25B	Laborers x 8 Operators x 4	96	Asphalt Paver x 130 H.P. Tandem Rollers 10 ton x 2 Pneumatic Roller 12 ton	32	Not Used	Not Used
B10M	Laborer x.5 Operator (med) x1	12	Dozer, 300 H.P.	8	Not Used	Not Used
B13K	Operators (crane) x 2	16	Hyd. Excavator, .75 C.Y. x 2 Hyd. Hammer, 4000 ft-lb	16	334	334
B34G	Truck Driver x1	8	Dump Truck, Off Hwy., 50 ton	8	71,300	71,300
ECB	Laborer x3	24	Tractor	8	829	276
Dewater	Laborer x1	8	8" Diesel Pump	2	Not Used	Not Used
Sump Install	Laborer x1 Operator x1	16	Hyd. Excavator, 4.5 C.Y.	8	1,210	605
Grout/Concrete	Laborer x2 Truck Driver x1	24	Concrete Truck	8	18	6
Eng	Engineering Staff x1.2	10	Side by Side x1	4	42,840	14,280
B10F	Operator (med) x1 Laborer x0.5	12	Tandem Roller, 10, Ton	8	1,872	1,248
B14K	Operator (med) x1 Laborer x0.5	12	Front End Loader, 10 C.Y.	8	16,647	11,098
B34C	Truck Driver (heavy) x 1	8	Truck Tractor, 6x4, 380 H.P. x 1 Dump Trailer, 16.5 CY x 1	8	1,208,909	1,208,909
B14B	Operator (crane) x 1 Laborer x 0.5	12	Hyd. Excavator, 6 C.Y.	8	18,193	12,129
B11L	Operator (med.) x 1 Laborer x 1	16	Grader, 30,000 lbs	8	1,752	876
B10W	Operator (med.) x 1 Laborer x 0.5	12	Dozer, 105 H.P.	8	Not Used	Not Used
B7	Laborer x 5 Operator (med) x 1	48	Brush Chipper, 12", 130 H.P Crawler Loader, 3 C.Y. Chain Saws, Gas, 36" Long x 2	32	3,352	2,234
B45	Operator (med) x1 Truck Driver(heavy) x 1	16	Tanker, 3000 gal Truck Tractor, 6x4, 380 H.P.	8	9,354	4,677
Note: Blue crew names were created by Geosyntec based on experience (not pulled from RSMeans).				**Totals**	1,456,600	1,381,400

Table 8 - Labor, Equipment, and Mileage Estimate
CBR-Offsite-Truck Transportation
(2 of 2)

Geosyntec consultants

Item	Quantity	Assumptions
Labor Total Hours	1,438,400	Per projected subtotal in cost estimate (Does not include contingency)
Duration of Onsite Construction in Days	3,570	Per Construction Schedule
Average Daily Crew Size	20	10 hour days (5 days per week)
Daily Labor Mobilization Miles	4,998,000	Average of 70 miles round trip per day
Vehicles Miles Onsite	137,445	1 mile round trip from gate to parking 5 miles per day for 2 CQA techs and Construction Supervisor 10% Contingency for site visitors (client and engineering support)
Equipment Mobilization Miles - Unloaded	214,200	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	214,200	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Daily Equipment Miles Onsite	3,941,280	Average of 18 of 20 crew members running equipment Assume 60 miles per piece of equipment 40 miles per day used for water truck 20 miles per day used for grader
Onsite Haul Truck Miles - Unloaded	109,840	34 CY Off Road Dump Truck 1 mile round trip per load
Onsite Haul Truck Miles - Loaded	109,840	34 CY Off Road Dump Truck 1 mile round trip per load
Offsite Haul Truck Miles - Unloaded	25,973,611	16.5 CY Dump Truck 120 mi cycle for exported CCR
Offsite Haul Truck Miles - Loaded	25,973,611	16.5 CY Dump Truck 120 mi cycle for exported CCR
Material Delivery Miles - Unloaded	100,000	100 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete - source 1000 miles away average
Material Delivery Miles - Loaded	100,000	100 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete - source 1000 miles away average

Geosyntec
consultants

ATTACHMENT B

Preliminary Corrective Measures Assessment

July 2022

Prepared for

Electric Energy, Inc.
2100 Portland Road
Joppa, Illinois 62953

Preliminary Corrective Measures Assessment for the East Ash Pond (EAP) Joppa Power Plant Joppa, Illinois

Prepared by

Geosyntec consultants

engineers | scientists | innovators

Project Number GLP8030

Revision 0
July 28, 2022

TABLE OF CONTENTS

SECTION 1 INTRODUCTION 1-1
1.1 Overview 1-1
1.2 Potential Groundwater Protection Standard Exceedance Review 1-1
1.3 Corrective Measure Assessment Introduction 1-2
1.4 Source Control 1-3
1.5 Interim Remedial Measures 1-3
SECTION 2 Preliminary Corrective Measures Assessment 2-1
2.1 Corrective Measure Alternative Descriptions 2-1
2.1.1 Monitored Natural Attenuation (MNA) 2-2
2.1.2 Groundwater Extraction (GE) 2-2
2.1.3 Groundwater Collection Trench (GCT) 2-3
2.1.4 Cutoff Wall 2-3
2.1.5 Permeable Reactive Barrier (PRB) 2-4
2.1.6 Wellhead Treatment 2-4
2.2 Performance, Reliability, Ease of Implementation, and Potential Impacts of the Corrective Measure Alternative (IAC Section 845.660(c)(1)) 2-5
2.2.1 Performance of the Corrective Measure Alternative – Controlling the Source (IAC Section 845.660(c)(1)) 2-5
2.2.2 Performance of the Corrective Measure Alternative – Likelihood of Future Releases of CCR (IAC Section 845.660(c)(1)) 2-6
2.2.3 Performance of the Corrective Measure Alternative – Long-Term Management (IAC Section 845.660(c)(1)) 2-7
2.2.4 Reliability of the Corrective Measure Alternative – Engineering and Institutional Controls (IAC Section 845.660(c)(1)) 2-8
2.2.5 Reliability of the Corrective Measure Alternative - Potential Need for Replacement of the Corrective Measure (IAC Section 845.660(c)(1)) 2-9
2.2.6 Ease of Implementation (IAC Section 845.660(c)(1)) 2-10
2.2.7 Potential Impacts – Risks to the Community or the Environment During Implementation of Remedy (IAC Section 845.660(c)(1)) 2-11
2.3 The Time Required to Begin and Complete the Corrective Action Plan (IAC Section 845.660(c)(2)) 2-14
2.4 State or Local Permit Requirements or Other Environmental or Public Health Requirements that May Substantially Affect Implementation of the Corrective Action Plan (IAC Section 845.660(c)(3)) 2-14

2.5 Summary.....2-14
SECTION 3 REFERENCES.....3-1

LIST OF TABLES

Table 1 Corrective Measures Alternatives Summary Table

LIST OF FIGURES

Figure 1 Site Map

LIST OF ACRONYMS AND ABBREVIATIONS

CAA	Closure Alternatives Analysis
CAAA	Corrective Action Alternative Analysis
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
CIP	Closure-in-Place
CMA	Corrective Measures Assessment
CW	Cutoff Wall
EAP	East Ash Pond
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
GCT	Groundwater Collection Trench
GE	Groundwater Extraction
GHG	Greenhouse Gas
GWPS	Groundwater Protection Standard
IAC	Illinois Administrative Code
IEPA	Illinois Environmental Protection Agency
JPP	Joppa Power Plant
LCU	Lower Confining Unit
mg/L	milligrams per liter
MNA	Monitored Natural Attenuation
NID	National Inventory of Dams
NPDES	National Pollutant Discharge Elimination System
OSWER	Office of Solid Waste and Emergency Response
PRB	Permeable Reactive Barrier
RCRA	Resource Conservation and Recovery Act
SU	Standard Units
UAU	Uppermost Aquifer Unit
WT	Wellhead Treatment

SECTION 1

INTRODUCTION

1.1 Overview

Geosyntec Consultants, Inc. (Geosyntec) has prepared this corrective measures assessment (CMA) to holistically evaluate proposed corrective measures in order to remediate groundwater and achieve compliance with groundwater protection standards (GWPSs) specified in Illinois Administrative Code (IAC) Section 845.600 (Illinois Environmental Protection Agency [IEPA], 2021a). This CMA has been prepared on behalf of the Joppa Power Plant (JPP), which is operated by Electric Energy, Inc.

This CMA will apply specifically to the coal combustion residual (CCR) unit referred to as the East Ash Pond (EAP; Vistra ID No. CCR Unit 401, IEPA ID No. W1270100004-02, and National Inventory of Dams [NID] ID No. IL50714), shown in Figure 1. The EAP is a 128-acre existing unlined CCR surface impoundment used to manage CCR and non-CCR waste streams at the JPP. After the generation of electricity at JPP is ceased in 2022, the EAP will no longer receive bottom ash or fly ash.

1.2 Potential Groundwater Protection Standard Exceedance Review

An evaluation of the history of potential GWPS exceedances was completed for the EAP Operating Permit application in October 2021 (Burns & McDonnell, 2021). Groundwater concentrations from 2015 to 2021 were evaluated for potential exceedances in accordance with the Statistical Analysis Plan proposed in the Operating Permit application. Potential exceedances are summarized below:

- Boron at monitoring wells G06, G07, G08, and G10. The boron statistical results ranged from 3.0 milligrams per liter (mg/L) to 4.2 mg/L, which exceed the Part 845 GWPS (2.0 mg/L).

- pH (field) at monitoring wells G06S, G07, G11, G51D, and G151. The pH statistical results ranged from 5.4 to 5.9 standard units (SU) and individually exceed their Part 845 GWPS (ranging from 6/0/9.0 to 6.2/9.0) for the identified wells.

- Sulfate at monitoring well G11. The sulfate statistical result of 443 mg/L exceeds the Part 845 GWPS (400 mg/L).

A review of groundwater, porewater, soil, and ash data indicates that the potential exceedances of pH are not related to the EAP (Ramboll, 2022). Thus, the groundwater corrective measures were evaluated in regard to potential exceedances of boron and sulfate at the Site.

1.3 Corrective Measure Assessment Introduction

This CMA was prepared to assess proposed corrective measures based on a wide range of factors, including the performance, reliability, and ease of implementation of the corrective measure; its potential impacts on human health and the environment; and its ability to address concerns raised by residents in accordance with IAC Section 845.660. The CMA provides a high-level screening of potential corrective measures. This analysis determines which corrective measures are potentially viable at a site and thus subject to further evaluation in the Corrective Action Alternatives Analysis (CAAA), which will be prepared in accordance with IAC Section 845.670(e). Following the acquisition of additional subsurface and Site data, the final CMA will further evaluate and consider the viability of each corrective measure technology identified within this preliminary CMA. The CAAA, which will be prepared at a later date, will provide a more detailed analysis of the potentially viable measures identified in the final CMA.

It is important to note that many CCR sites are located in complex groundwater environments where remedial actions will inherently take many years to complete. While no formal definition of a complex groundwater environment exists, most would agree that there are a number of common characteristics at complex groundwater sites, including the following (National Research Council, 2013):

- Highly heterogeneous subsurface environments;
- Large source zones;
- Multiple, recalcitrant constituents; and
- Long timeframes over which releases occurred.

Each of these characteristics are common at CCR sites. Surface impoundments are often tens to hundreds of acres in size and many have operated for decades, leading to large source zones and prolonged releases. Furthermore, CCR surface impoundments are often located in alluvial geologic settings where sands are interbedded with silts and clays. This results in a heterogeneous environment where constituent mass may persist for many years in low-permeability deposits. Finally, the constituents that are most common at CCR sites include metals and inorganics that do not naturally biodegrade. The combination of these factors results in a complex groundwater environment where remediation, even under the best of circumstances, may take many years to achieve GWPSs. It is for these reasons that US EPA refused to specify what is a reasonable *versus* an unreasonable timeframe for groundwater corrective actions at CCR sites, stating that "EPA was truly unable to establish an outer limit on the necessary timeframes—including even a presumptive outer bound" (US EPA, 2015a).

1.4 Source Control

Source control, which at a CCR surface impoundment could include either capping or excavation, is generally considered to be one of the more effective remedial action approaches. Source control involves removing the hydraulic head from an impoundment (*e.g.*, free liquid removal, which is also known as unwatering and dewatering) and preventing further downward migration of constituents. US EPA has found that "releases from surface impoundments [to groundwater] drop dramatically after closure" (US EPA, 2014). As a result, the implementation of source control often has a more substantial and more immediate effect on groundwater quality improvements than other groundwater corrective measures.

In this preliminary CMA, source control is paired with other additional groundwater remediation strategies. The Closure Alternatives Analysis (CAA) prepared for the Site (Gradient, 2022) identified Closure-in-Place (CIP) as the most appropriate closure scenario. Under the CIP scenario, the CCRs within the 128-acre EAP and CCRs located in an approximately 32-acre area outside of the EAP would be consolidated into one approximately 74-acre area, then capped with a geomembrane and soil final cover system. This will result in a total footprint reduction of 54%. Closure activities associated with CIP will serve as source control at the Site.

Because the impacts of the closure activities on human health and the environment, engineering reliability, and other factors were already evaluated in the CAA (Gradient, 2022), they were not re-evaluated in this preliminary CMA. Additionally, because the selected closure alternative would occur under all the corrective measure alternatives, the impacts of source control will be the same under all the alternatives. We have therefore omitted discussion of the impacts of the closure-related activities from this preliminary CMA.

1.5 Interim Remedial Measures

Additional data is needed to evaluate available technologies for groundwater corrective action, including a better understanding of groundwater flow rates. A pilot pumping well will be installed to evaluate groundwater flow rates and groundwater capture zones in the uppermost aquifer unit (UAU). The pilot pumping well will consist of a six-inch continuously slotted stainless-steel screen from approximately 50 to 80 feet below ground surface (ft bgs). Aquifer testing, including a 72-hour constant rate test and step drawdown test, will be completed to evaluate UAU characteristics and the effectiveness and feasibility of potential corrective measures.

Following completion of the aquifer testing, the pilot well will be converted to an extraction well and begin operation (once approved by IEPA) to contain groundwater flow within the UAU to the extent practicable along the eastern boundary of the EAP. The interim extraction system is expected to be operational in late 2022 to early 2023.

The interim extraction system will be operated prior to closure, and until a final corrective action is determined or the interim extraction system is no longer required. Because implementation of the interim measure would occur under all the corrective measure alternatives, the impacts of the

interim measure will be the same under all the alternatives. We have therefore omitted discussion of the impacts of the interim measure from this preliminary CMA.

SECTION 2

PRELIMINARY CORRECTIVE MEASURES ASSESSMENT

2.1 Corrective Measure Alternative Descriptions

Six potential corrective measures were selected for evaluation in the preliminary CMA for this Site. Each corrective measure includes source control based on the CIP scenario, as evaluated and selected in the CAA (Gradient, 2022). Corrective measures considered in the preliminary CMA include:

- Monitored Natural Attenuation (MNA),
- Groundwater Extraction (GE),
- Groundwater Collection Trench (GCT),
- a Cutoff Wall (CW),
- a Permeable Reactive Barrier (PRB), and
- Wellhead Treatment (WT).

Each of these corrective measures was evaluated in the preliminary CMA for its potential viability at the Site. Under the MNA alternative, groundwater concentrations of dissolved constituents would attenuate *via* naturally occurring physical and chemical processes at the Site; active monitoring would be performed to verify and document the remediation processes. Under the GE alternative, groundwater extraction wells would be installed in order to extract potentially impacted groundwater from the aquifer, helping to contain the contaminant plume and prevent further lateral migration of constituents. Under the GCT alternative, a groundwater collection trench would be installed in order to extract potentially impacted groundwater from the aquifer, helping to contain the contaminant plume and prevent further lateral migration of constituents. Under the CW alternative, a trench would be excavated and filled with a soil-bentonite or cement-bentonite mixture, creating a low-permeability subsurface barrier to the lateral migration of constituents. Under the PRB alternative, a subsurface barrier of reactive materials would be placed in the path of groundwater flow downgradient of the EAP in order to promote the *in situ* transformation and/or immobilization of CCR-associated constituents. Under the WT alternative, treatment systems would be installed and maintained at each potentially impacted municipal and private groundwater well identified based on the results of analytical sampling. There are no municipal wells that extract groundwater from the UAU within the Village of Joppa. To date, no private groundwater wells which extract groundwater from the UAU and thus have the potential to be impacted have been identified.

This report evaluates the potential performance, reliability, and impacts of the various corrective measures, but does not make any judgments regarding the need for these corrective measures. The performance of each of these corrective measures is influenced by the closure activities described above in Section 1.4 and in greater detail in the Closure Plan, including capping and dewatering of the CCR impoundment (Geosyntec, 2022).

2.1.1 Monitored Natural Attenuation (MNA)

The United States Environmental Protection Agency (US EPA, 1999) defines MNA as "[t]he reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods." MNA relies on naturally occurring physical and chemical processes to immobilize potentially problematic constituents in groundwater and attenuate dissolved concentrations of those constituents. Chemical processes that naturally promote the attenuation of dissolved inorganic constituent concentrations in groundwater include sorption, precipitation, and redox reactions. Physical processes that promote attenuation include dispersion and dilution (US EPA, 2015b). US EPA has determined that MNA can be a viable alternative at sites impacted by inorganic constituents such as metals and metalloids, especially when implemented alongside source control measures (US EPA, 1999, 2015b).

The MNA alternative may be a promising alternative for the Site, depending on the results of additional Site investigation efforts to understand plume stability, contaminant immobilization, and exposure to potential receptors. Because MNA relies on natural processes, implementation of the MNA alternative does not require the installation, operation, or maintenance of any engineered systems or structures other than maintenance of the monitoring well network. Groundwater monitoring would continue until GWPSs are achieved. Following the completion of source control measures, the MNA remedy would require 1 to 2 years to design, construct, and implement, which includes any additional investigations required to characterize Site conditions, including completion of a tiered evaluation consistent with US EPA guidance (US EPA, 1999; US EPA, 2015b) and additional work related to the design and installation of the groundwater monitoring system.

2.1.2 Groundwater Extraction (GE)

Under the GE alternative, the interim extraction well would continue operation along with the installation of additional extraction wells. The GE system would extract potentially impacted groundwater from the UAU. Extraction would help contain the contaminant plume and prevent the lateral migration of constituents. If groundwater monitoring reveals a need for treatment of extracted groundwater prior to discharge, then a treatment system would be designed and implemented at the Site. Under this scenario, groundwater captured by the GE system would be discharged to the Ohio River *via* one of the facility's NPDES-permitted outfalls. Water treatment, if needed, would be completed to achieve discharge compliant with the facility’s NPDES permit.

Aquifer homogeneity and hydrogeologic properties are favorable for implementation of GE at the Site. However, property access may limit the placement and installation of extraction wells and associated piping downgradient of the Site. Additional testing would be required to estimate the number of extraction wells, well spacing, screened intervals, and well extraction rates for capture of impacted groundwater. Following the completion of source control measures, the GE remedy would require 1 to 2 years to design and construct. Long-term management of the GE system would include periodic inspections and routine maintenance, including the replacement of worn or damaged parts. Monitoring would also be undertaken to evaluate whether the GE system is working as intended and would continue until GWPSs are achieved.

2.1.3 Groundwater Collection Trench (GCT)

Under the GCT alternative, a collection trench and associated pumps would be installed to extract potentially impacted groundwater from the aquifer. Collection and extraction of groundwater via the trench system would help prevent the lateral migration of constituents. If groundwater monitoring reveals a need for treatment of extracted groundwater prior to discharge, then a treatment system would be designed and implemented at the Site. Under this scenario, groundwater captured by the GCT system would be discharged to the Ohio River *via* one of the facility's NPDES-permitted outfalls. Water treatment, if needed, would be completed to achieve discharge compliant with the facility's NPDES permit.

Aquifer homogeneity and hydrogeologic properties are favorable for implementation of a GCT at the Site. However, property access issues and inconvenience to the Village of Joppa makes implementation of this alternative difficult downgradient of the Site. Following the completion of source control measures, the GCT remedy would require 2 to 3 years to design and construct. Long-term management of the GCT system would include periodic inspections and routine maintenance. Monitoring would also be undertaken to evaluate whether the GCT system is working as intended and would continue until GWPSs are achieved.

2.1.4 Cutoff Wall

Under the CW alternative, a trench would be excavated and filled with a soil-bentonite or cement-bentonite mixture. This process would create a low-permeability subsurface barrier to mitigate lateral migration of constituents. The cutoff wall would extend down to the underlying Lower Confining Unit (LCU), creating a barrier to constituent transport across the vertical extent of the UAU.

In the absence of additional hydraulic controls, a CW can unintentionally function as a subsurface dam, routing groundwater around the wall rather than preventing its lateral migration. It may be necessary to install a series of hydraulic control wells in the vicinity of the CW to prevent this from occurring, in which case the interim extraction well could be repurposed as a hydraulic control well. These wells would serve as a "hydraulic gradient control system" to prevent groundwater mounding adjacent to the CW. If groundwater monitoring reveals a need for treatment of extracted groundwater prior to discharge, then a treatment system would be designed

and implemented at the Site. Water treatment, if needed, would be completed to achieve discharge compliant with the facility's NPDES permit.

Aquifer homogeneity and hydrogeologic properties may be favorable for implementation of a CW at the Site. However, property access issues and inconvenience to the Village of Joppa makes implementation of this alternative difficult downgradient of the Site. Site investigations and engineering analyses would be required prior to designing a CW system. In total, following the completion of source control measures, the CW remedy would require 2 to 3 years to design, construct, and implement. Long-term management under the CW alternative would include periodic inspections and routine maintenance of the CW and, if needed, operation and maintenance of a hydraulic gradient control system. Monitoring would also be undertaken to evaluate whether the corrective measure is working as intended and would continue until GWPSs are achieved.

2.1.5 Permeable Reactive Barrier (PRB)

Under the PRB alternative, a subsurface barrier of reactive materials would be placed in the path of groundwater flow in order to promote the *in situ* transformation and/or immobilization of CCR-associated constituents. A permeable barrier is used so that the barrier does not hinder groundwater flow. At the Site, the PRB would extend down to the LCU. Laboratory testing has identified PRB media which were highly effective (>90%) at removing boron from groundwater. However, the testing indicated that the duration of the media effectiveness was too short to be practical in a field application (EPRI, 2006). Testing to identify an effective media for a PRB to remove boron from groundwater is ongoing.

The feasibility of the PRB alternative would likely be limited by the availability of an appropriate media for boron removal, as well as implementation depths and mass flux, which, if high enough, could necessitate replacement of reactive media over time. Additionally, property access issues and inconvenience to the Village of Joppa make implementation of this alternative difficult downgradient of the Site.

Site investigations and engineering analyses would be required prior to designing a PRB. In total, following the completion of source control measures, the PRB remedy would require 3 to 5 years to design, construct, and implement. Long-term management under the PRB alternative would include periodic maintenance and possibly replacement of the reactive media in order to extend the life of the PRB. Monitoring would also be undertaken to evaluate whether the corrective measure is working as intended and would continue until GWPSs are achieved.

2.1.6 Wellhead Treatment

The Wellhead Treatment (WT) alternative would consist of treatment systems installed and maintained at each potentially impacted municipal and private groundwater well. The WT alternative is only applicable downgradient of the Site; wells that extract groundwater for potable use are not present at the Site. There are no municipal wells that extract groundwater from the UAU within the Village of Joppa. To date, no private groundwater wells which extract

groundwater from the UAU and thus have the potential to be impacted have been identified. WT may be used in combination with additional institutional controls to prevent the installation of future wells which could require treatment.

The location of municipal and private groundwater wells downgradient of the Site would be conducted through local records searches, windshield surveys, and communication with local property owners. Following location of potentially impacted groundwater wells, laboratory testing of water would occur to further understand potential impacts and treatability. The treatment technology may consist of an ion exchange resin or other commercially available technology.

2.2 Performance, Reliability, Ease of Implementation, and Potential Impacts of the Corrective Measure Alternative (IAC Section 845.660(c)(1))

2.2.1 Performance of the Corrective Measure Alternative – Controlling the Source (IAC Section 845.660(c)(1))

"Primary source control" means the prevention of CCR-associated constituents leaching from the impoundments into underlying groundwater. Because source control will be undertaken at the Site prior to the implementation of any corrective measures, all corrective measure alternatives will minimize the potential for CCR within the impoundments to impact groundwater. As part of the planned source control measures, the consolidated CCR material will not be in proximity with the uppermost aquifer (Geosyntec, 2022). Thus, all of the corrective measure alternatives would be equally and fully protective with regard to primary source control. However, impacted soils underlying the impoundment can potentially act as a secondary source of CCR-associated impacts to groundwater even after free liquids have been removed from the primary source (CCR) and the CCR has been capped. The effectiveness of each remedy is discussed below with respect to its expected performance in conjunction with source control measures.

The effectiveness of the various corrective measure alternatives with respect to secondary source control are summarized as follows:

- Under the MNA alternative, the attenuation of dissolved constituent concentrations remaining after source control would be achieved through natural processes. MNA is likely to be most effective in the source area as an additional measure following source control, interim measures, and an active remedy. Some attenuation will occur in this area due to natural processes regardless of the selected remedy; thus, monitoring the effects following an active remedy will further expand the understanding of constituent presence, migration, and attenuation at the Site.

- Under the GE alternative, GE would be used to capture dissolved constituent concentrations released from secondary source areas and prevent lateral migration. Pumping as part of the GE alternative may induce a higher gradient through the secondary source area, potentially accelerating the rate of mass reduction from the secondary source area (i.e., increased flushing). GE is a widely used corrective measure. However, its

performance can vary from site to site. Although good performance would generally be expected for this alternative, additional Site investigations and engineering analyses may be required to design the GE system.

- Under the GCT alternative, a collection trench would be used to capture dissolved constituent concentrations released from secondary source areas and prevent lateral migration. Pumping as part of the GCT alternative may induce a higher gradient through the secondary source area, potentially accelerating the rate of mass reduction from the secondary source area (i.e., increased flushing). Collection trenches are a proven corrective measure. However, the performance of a GCT is dependent on Site characteristics. Good performance would generally be expected for this alternative, although additional Site investigations and engineering analyses may be required to design the GCT.

- Under the CW alternative, a low-permeability subsurface barrier would prevent the lateral migration of constituents downgradient. This barrier, which would extend down to the LCU, is expected to be highly effective at preventing lateral constituent migration. If a hydraulic gradient control system is needed, pumping from that system may induce a higher gradient through the secondary source area, potentially accelerating the rate of mass reduction from the secondary source area (i.e., increased flushing). Additional Site investigations and engineering analyses may be required to design the CW and associated hydraulic control system.

- Under the PRB alternative, a PRB would be placed into the path of groundwater flow in order to promote the transformation and immobilization of constituents. The ability of this barrier to prevent the lateral migration of constituents would depend on Site-specific factors, such as Site hydrogeology and geochemical conditions. PRBs generally have limited success at treating boron in groundwater, for example, which may limit the effectiveness of PRB at the Site. Although the PRB would not be designed to promote the attenuation of dissolved constituent concentrations within the secondary source area, some attenuation would nonetheless occur in this area due to natural processes. Additional Site investigations and engineering analyses may be required to design the PRB.

- Under the WT alternative, control of constituent migration is disregarded in favor of removing constituents from groundwater at its point of extraction. Thus, WT is not effective at controlling the secondary source at the Site.

2.2.2 Performance of the Corrective Measure Alternative – Likelihood of Future Releases of CCR (IAC Section 845.660(c)(1))

All corrective measure alternatives include source control. The implementation of an engineered closure design (CIP), including capping, dewatering, and stormwater management, creates minimal risk of future releases of CCR.

2.2.3 Performance of the Corrective Measure Alternative – Long-Term Management (IAC Section 845.660(c)(1))

The type and degree of long-term management under each corrective measure alternative are summarized as follows:

- The MNA alternative would not require the installation, operation, or maintenance of any engineered systems or structures, other than maintenance of the monitoring well network. Long-term management associated with groundwater sampling would continue until GWPSs had been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d).

- The GE alternative would require the management and discharge of extracted groundwater. Treatment may also be required prior to discharge. Operations and maintenance (O&M) under this scenario would include routine groundwater sampling and hydraulic gradient monitoring to evaluate whether the GE system is working as intended. O&M would continue until GWPSs had been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d). If extraction wells were installed at the EAP, the GE and (if necessary) treatment systems would also need to be regularly inspected and maintained to prevent fouling and scaling issues from impacting the effectiveness of the remedy. Any sediments generated by the treatment system, if one is required, would periodically have to be removed and brought to a solid waste landfill for disposal. Once the remedy is complete, the system would need to be decommissioned in a manner that meets applicable regulatory standards.

- The GCT alternative would require periodic maintenance of the trench as well as management and discharge of extracted groundwater. Pumps used for groundwater extraction would need to be regularly inspected and maintained to prevent fouling and scaling issues from impacting the effectiveness of the remedy. Any sediments generated by the treatment system, if one is required, would periodically have to be removed and brought to a solid waste landfill for disposal. Extracted groundwater may need to be treated prior to discharge. Once the remedy is complete, the system would need to be decommissioned in a manner that meets applicable regulatory standards.

- Long-term O&M efforts under the CW scenario would include periodic maintenance of the CW and, if needed, the hydraulic gradient control system and management and discharge of groundwater extracted by the hydraulic gradient control system. Extracted groundwater may need to be treated prior to discharge. Once the cutoff wall is constructed and the necessary extraction well installations are complete, O&M would include long-term groundwater flow monitoring and periodic inspections and routine maintenance of the hydraulic gradient control system, including the replacement of worn or damaged parts. Any sediments generated by the treatment system, if one is required, would periodically have to be removed and brought to a solid waste landfill for disposal. For extraction wells

installed as part of the hydraulic gradient control system, regular inspection and maintenance to prevent fouling and scaling issues from impacting the effectiveness of the remedy would be necessary. Routine groundwater sampling would also need to be performed downgradient of the CW until GWPSs had been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d). Once the remedy is complete, the system would need to be decommissioned in a manner that meets applicable regulatory standards.

- Long-term O&M efforts under the PRB scenario would include routine groundwater sampling downgradient of the PRB until GWPSs had been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d). The PRB would also be monitored for treatment efficacy. If necessary, the PRB media may be amended or exchanged to extend the life of the PRB.

- The WT alternative would require regular inspection and maintenance of the installed technology, as well as regular testing of treated water to evaluate treatment effectiveness. Over time, replacement of the technology may be required to maintain the treatment objectives.

2.2.4 Reliability of the Corrective Measure Alternative – Engineering and Institutional Controls (IAC Section 845.660(c)(1))

The long-term reliability of the corrective measure alternatives is summarized as follows:

- The MNA alternative would be expected to be reliable over the long term at this Site, because it would rely on natural processes, rather than the installation, operation, and maintenance of engineered systems or structures. Under this alternative, engineering failure would not occur and no O&M activities would be required to ensure the success of the alternative (other than those required for groundwater monitoring).

- The GE alternative would be expected to be reliable over the long term at this Site, as long as the system is designed and constructed for Site-specific conditions. The long-term reliability of this alternative would depend on the management and maintenance of the GE system and (if necessary) the treatment system for extracted groundwater. However, maintenance of these systems would most likely be relatively straightforward to implement and therefore would be unlikely to have a negative impact on the reliability of this alternative.

- The GCT alternative would be expected to be reliable over the long term at this Site, as long as the trench is designed and constructed for Site-specific conditions. The long-term reliability of this treatment system would depend on the management and maintenance of the GCT and (if necessary) the treatment system for extracted groundwater. Maintenance

of this system would be expected to be relatively straightforward to implement and therefore would be unlikely to have a negative impact on the reliability of the alternative.

- The CW alternative would be expected to be reliable over the long term at this Site, as long as the system is designed and constructed for Site-specific conditions. Because implementation of the CW may require the installation of hydraulic controls via a GE system, the long-term reliability of this alternative may also depend on the management and maintenance of the GE system and (if necessary) the treatment system for extracted groundwater. However, maintenance of these systems would be expected to be relatively straightforward to implement and therefore would be unlikely to have a negative impact on the reliability of this alternative.

- The PRB alternative may not be reliable over the long term at this Site. The reliability of this alternative would depend on Site-specific groundwater hydraulics and geochemical conditions, including the behavior of the constituents of concern. PRBs generally have limited success at treating boron in groundwater. The effectiveness of the PRB would also decrease over time, resulting in a potential need for the eventual replacement of the remedy.

- The WT alternative would be expected to be reliable over the long term at this Site, as long as the system is designed and constructed properly. Additionally, consistent, proper inspection and maintenance, as well as regular testing of treated water, would be required to evaluate the long-term reliability of the selected technology for wellhead treatment.

2.2.5 Reliability of the Corrective Measure Alternative - Potential Need for Replacement of the Corrective Measure (IAC Section 845.660(c)(1))

The potential need for the eventual replacement of each corrective measure alternative is summarized as follows:

- MNA would rely on natural processes to achieve reductions in groundwater concentrations to below GWPSs. Without the installation, operation, and maintenance of engineered systems or structures, it would be unlikely that the MNA remedy would need to be replaced. US EPA guidance for implementation of MNA recommends that a contingency plan is developed that would identify the circumstances under which replacement of the remedy may be appropriate (US EPA, 2015); if the MNA alternative is selected, such a contingency plan will be developed.

- For the GE alternative, implementation of the GE system would rely on physical management of the groundwater flow path. If extraction wells were installed at the EAP, fouling of the well screens may reduce the system effectiveness and create a need for the replacement of extraction wells over time. Replacement of pumps would also be likely under this alternative, because groundwater hydraulic controls would need to be maintained on a long-term basis. However, it is unlikely that the entire remedy would need

to be replaced; this would only be necessary if groundwater flow conditions changed significantly at the Site.

- The GCT alternative would rely on the effectiveness of a collection trench and associated pumps to extract captured groundwater. Over the long term, maintenance of the trench system may be required, although, if designed to Site-specifications, needed maintenance would be expected to be limited. Replacement of extraction pumps would be expected over the long term, but would not be expected to impact the overall performance of the system. It is unlikely that the entire remedy would need to be replaced; this would only be necessary if groundwater flow conditions changed significantly at the Site.

- Like the GE alternative, the CW alternative would rely on physical management of the groundwater flow path. If groundwater hydraulic control is needed as part of the CW remedy, replacement of individual GE wells and pumps would likely be necessary under this alternative. However, it would be unlikely that the entire remedy would need to be replaced; this would only be necessary if groundwater flow conditions changed significantly at the Site.

- PRBs would rely on the chemical treatment of groundwater along the flow path. Given the low effectiveness of PRBs for boron, replacement of the PRB remedy would be likely. Replacement of this remedy would also be necessary if the effectiveness of the PRB declined over time or if groundwater flow conditions changed at the Site.

- For the WT alternative, maintenance of the treatment technology/medium would be expected regularly over the life of the corrective actions. In conjunction with regular testing of treated water, a bench-scale study is needed to better understand the expected replacement frequency prior to implementation. However, it would be unlikely that the entire remedy would need to be replaced; this would only potentially be necessary if a change in groundwater use or extraction rate occurred in the Village of Joppa.

2.2.6 Ease of Implementation (IAC Section 845.660(c)(1))

The expected degree of difficulty associated with implementing the corrective measure alternatives is summarized as follows:

- The MNA alternative would rely entirely on natural processes and therefore should not pose any significant construction challenges at the Site. This alternative would only require the installation of monitoring wells.

- Construction under the GE alternative would be limited to the installation of the GE system and monitoring wells. Installation of extraction and monitoring wells should not pose significant challenges at the Site. However, transport of extracted water to the designated outfall or potential treatment facility may pose a challenge due to the length of transport necessary. Design of this remedy would also require a good understanding of groundwater

flow conditions at the Site, including an evaluation of the ability to capture groundwater effectively and an evaluation of the interconnectivity between groundwater and the Ohio River, especially variability in groundwater flow with river stage. Additional testing would be required to estimate the number of extraction wells, well spacing, well screen intervals, and extraction rates for capture of impacted groundwater.

- Construction of the GCT may be difficult due to the required length and depth needed to capture potentially impacted groundwater. If needed, a downgradient off-Site location would add to the difficulty of installation due to property access restrictions. Construction of the GCT, which would be on the order of 50 to 140 feet deep, would entail excavating into the target aquifer zone and then installing the collection trench system. Specialized equipment would be required. A treatment system for extracted groundwater may also be required and would add to implementation complexity.

- Construction of a CW, which would be on the order of 50 to 140 feet deep, would entail excavating into the low-permeability LCU and then backfilling the excavated trench. Specialized equipment would be required to excavate to the required depths. If needed, the design of a hydraulic gradient control system would also require a detailed understanding of groundwater flow conditions at the Site, including an evaluation of the ability to contain groundwater effectively and an evaluation of the interconnectivity between groundwater and the Ohio River. If needed, a downgradient off-Site location would add to the difficulty of installation due to property access restrictions.

- Construction of the PRB may be difficult due to the required length and depth of the PRB. If needed, a downgradient off-Site location would add to the difficulty of installation due to issues with property access. The PRB may need to be extended down to the LCU, which is approximately 140 ft bgs.

- Implementation of the WT alternative is not expected to pose any significant technical challenges. There is potential for challenges to arise in obtaining access to private and/or municipal water supply wells both for initial installation and future testing, maintenance, and inspection.

2.2.7 Potential Impacts – Risks to the Community or the Environment During Implementation of Remedy (IAC Section 845.660(c)(1))

Safety Impacts

Best practices will be employed during construction in order to promote worker safety and comply with relevant regulations, permit requirements, and safety plans. It should be noted that it is not possible to completely eliminate risks to workers during construction activities. For example, injuries and fatalities can occur due to truck accidents or equipment malfunctions. Truck accidents

that occur off-Site can also result in injuries or fatalities to community members. The safety impacts of construction under each corrective measure alternative are summarized as follows:

- The MNA alternative would not require the construction of any engineered systems or structures other than monitoring wells. Construction activity would not be expected to result in any significant negative safety impacts under this alternative.

- A moderate level of construction activity would be required under the GE alternative. Construction activities under this alternative would include the construction of the GE system and monitoring wells. Therefore, the construction-related safety impacts of this alternative would be modest. Impacts would largely be limited to workers, rather than community members, because construction activities would largely be limited to the Site.

- The construction requirements of the GCT alternative would be considerable due to the planned extent of construction activities (i.e., excavation, installation, and backfilling of an approximately 50 to 140 foot deep earthen trench). The GCT alternative therefore would pose higher construction-related safety risks to workers relative to other alternatives. The negative impacts of construction activities would largely be limited to workers at the Site. Due to increased safety risk, construction of a GCT downgradient of the Site is not feasible.

- The construction requirements of the CW alternative would be considerable due to the planned extent of construction activities (i.e., excavation and backfilling of an approximately 50 to 140 foot deep earthen trench). The CW alternative therefore would pose higher construction-related safety risks to workers relative to other alternatives. The negative impacts of construction activities would largely be limited to workers at the Site. Due to increased safety risk, construction of a CW downgradient of the Site is not feasible.

- The construction requirements of the PRB alternative would be similar to those of the CW alternative. Relatively intensive construction activities would be required, including the excavation of an approximately 50 to 140 foot deep earthen trench. The CW scenario therefore would pose higher construction-related safety risks to workers relative to other alternatives. The negative impacts of construction activities would largely be limited to workers in the Site. Due to increased safety risk, construction of a CW downgradient of the Site is not feasible.

- The WT alternative would require the installation of the selected treatment technology at the point of use, which is not expected to include major construction of installation activities. Thus, no significant negative safety impacts are expected under this alternative.

Cross-Media Impacts to Air

Diesel emissions are a major source of air pollutants and greenhouse gas (GHG) emissions at construction sites. Corrective measures that require a greater level of construction activity would

result in larger overall air impacts in the form of diesel emissions. The MNA alternative would be expected to have minimal air impacts, because it would not require the construction of engineered systems or structures (other than monitoring wells). Similarly, installation of the WT alternative would be expected to have minimal air impacts because it does not require the construction of large-scale engineered systems. The GE alternatives would be expected to have moderate air impacts, because they would have modest construction requirements. The GCT, CW, and PRB alternatives would be expected to have the most considerable air impacts among the corrective measure alternatives, because they would have the most significant construction requirements.

Cross-Media Impacts to Surface Water and Sediments

Due to erosion and runoff, construction can have short-term negative impacts on surface water and sediment quality immediately adjacent to a site. These impacts may be of concern at the Site, due to the proximity of the EAP to the Ohio River. Minimal surface water or sediment impacts due to erosion and runoff during construction would be expected under the MNA and WT alternatives, because they would not require the construction of significant engineered systems or structures. In contrast, the GE, GCT, CW, and PRB alternatives may have short-term negative impacts on the Ohio River due to erosion and sediment runoff during construction. These impacts would be greater under the GCT, CW, and PRB alternatives, due to the greater extent and duration of construction activities required (*i.e.*, excavation of a 50 to 140 foot deep earthen trench).

Under the GE, GCT, and potentially the CW alternatives, extracted groundwater would be discharged to the Ohio River *via* one of the facility's NPDES-permitted outfalls. If necessary, extracted groundwater would be treated prior to discharge to comply with water quality standards. Thus, surface water or sediment impacts would not be expected for the corrective measure alternatives that discharge of extracted groundwater into the Ohio River.

Control of Exposure to Any Residual Contamination During Implementation of the Remedy

Source control would be undertaken at the Site prior to the implementation of any of the corrective measure alternatives. Thus, no residual CCR exposures would be expected to occur during the implementation of the corrective measure alternatives considered. However, impacted soils and groundwater underlying the impoundments can act as a secondary source of CCR-associated constituent exposures for workers even after the primary source (CCR) has been capped and dewatered. Risks to workers arising from potential contact with secondary sources during construction, operation, and maintenance activities (*e.g.*, contact with impacted groundwater extracted by the GE or GCT systems) would be managed through the use of rigorous safety protocols and personal protective equipment.

Other Identified Impacts

In addition to safety impacts, cross-media impacts, and the potential for workers to be exposed to residual contamination, construction activities can have significant energy demands and can cause

nuisance impacts such as traffic and noise. Moreover, construction activities can negatively impact natural resources and habitat near the Site, as well as scenic, historical, and recreational value. There are no historic sites, high-quality natural areas, or recreational areas in the immediate vicinity of the former impoundment. The magnitude of construction-related impacts would be expected to increase with the duration and intensity of construction activities. Additionally, any alternative implemented Off-Property poses the additional impact of disturbing residents of the Village of Joppa. Because the MNA and WT alternatives would not require any significant construction activity, the construction-related impacts listed above would not be a concern for these alternatives. In contrast, moderate construction-related impacts would be expected under the GE alternative. The most significant construction-related impacts would be expected to occur under the GCT, CW, and PRB alternatives, all of which would require excavation of an approximately 50 to 140 foot deep earthen trench.

2.3 The Time Required to Begin and Complete the Corrective Action Plan (IAC Section 845.660(c)(2))

IAC Section 845.670 states that a Corrective Action Plan must be submitted to the Agency within 1 year of submission of a CMA. A draft version of this preliminary CMA was completed on May 27, 2022 and provided to the public *via* DMG's CCR Rule Compliance Data and Information website as a component of the Draft Final Closure Plan for the EAP (Geosyntec, 2022). The CMA will be updated and finalized following collection of additional subsurface and Site data. The Corrective Action Plan will be submitted within one year of completion of the final CMA.

2.4 State or Local Permit Requirements or Other Environmental or Public Health Requirements that May Substantially Affect Implementation of the Corrective Action Plan (IAC Section 845.660(c)(3))

All of the corrective measure alternatives would require regulatory approvals prior to implementation. The GE, GCT, and CW alternatives may also require modifications to the Site's existing NPDES permit in order to manage groundwater extracted by the GE or GCT systems or extracted by the hydraulic gradient control system, if needed. However, these requirements would not be expected to substantially affect the implementation of the Corrective Action Plan.

2.5 Summary

Table 1 evaluates the six corrective measures included in this preliminary CMA with regards to each of the factors specified under IAC Section 845.660(c) (IEPA, 2021). Each of the six corrective measures would be paired with source control and groundwater extraction as an interim measure. Following the collection of additional subsurface and Site information, the CMA will be revised to further evaluate and consider the viability of each corrective measure technology identified within this preliminary CMA.

SECTION 3

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TABLES

TABLE 1 – Corrective Measures Alternatives Summary Table
Joppa Power Plant – East Ash Pond

Evaluation Factor (Report Section; Part 845 Section)	Corrective Measures Alternative					
	MNA	**GE**	**GCT**	**CW**	**PRB**	**WT**
Corrective Measure Alternative Descriptions (Section 2.1)	MNA would rely on naturally occurring physical and chemical processes to immobilize and attenuate concentrations of CCR-associated constituents in groundwater in the EAP areas. Active groundwater monitoring would be performed to ensure that the remedy is working as intended.	Under GE, a system comprised of groundwater pumping wells would be installed to extract potentially impacted groundwater and prevent the lateral migration of constituents. The interim extraction well would be incorporated into the GE system under this alternative. Groundwater captured by the GE system would be treated, if necessary, and discharged to the Ohio River *via* one of the facility's NPDES-permitted outfalls. Monitoring would be performed to ensure that the remedy is working as intended.	Under GCT, a system comprised of a groundwater collection trench and associated extraction pumps would be installed to capture and extract potentially impacted groundwater and prevent lateral migration of constituents. Groundwater captured by the GCT would be treated, if necessary, and discharged to the Ohio River *via* one of the facility's NPDES-permitted outfalls. Monitoring would be performed to ensure that the remedy is working as intended.	Under CW, a trench would be dug and filled with a soil-bentonite mixture, creating a low-permeability subsurface barrier that would prevent the lateral migration of constituents. Hydraulic control wells may be required to prevent groundwater mounding behind the CW. Groundwater captured by the hydraulic control wells would be treated, if necessary, and discharged to the Ohio River *via* one of the facility's NPDES-permitted outfalls. Monitoring would be performed to ensure that the remedy is working as intended.	Under PRB, a subsurface barrier of reactive materials would be placed in the path of groundwater flow in order to promote the *in-situ* transformation and/or immobilization of CCR-associated constituents. Monitoring would be performed to ensure that the remedy is working as intended.	Under WT, treatment systems would be installed and maintained at each potentially impacted municipal and private groundwater well. Monitoring would be performed to ensure that the remedy is working as intended.
Performance – Controlling the Source (Section 2.2.1; IAC Section 845.660(c)(1))	All of the alternatives would be protective with regard to primary source control. MNA would also likely be effective with regard to secondary source control.	All of the alternatives would be protective with regard to primary source control. Pumping as part of the GE alternative may induce a higher gradient through the secondary source area, potentially accelerating the rate of mass reduction from the secondary source area (i.e., increased flushing). GE would also likely be effective with regard to secondary source control, although GE system performance can vary from site-to-site.	All of the alternatives would be protective with regard to primary source control. Pumping as part of the GCT alternative may induce a higher gradient through the secondary source area, potentially accelerating the rate of mass reduction from the secondary source area (i.e., increased flushing). GCT would also likely be effective with regard to secondary source control, although GCT system performance can vary from site-to-site.	All of the alternatives would be protective with regard to primary source control. While the CW would not be designed to address secondary source control, it is likely to be effective due to natural processes. If a hydraulic gradient control system is needed, pumping associated with that system may induce a higher gradient through the secondary source area, potentially accelerating the rate of mass reduction from the secondary source area (i.e., increased flushing).	All of the alternatives would be protective with regard to primary source control. PRB would also likely be effective with regard to secondary source control due to *in-situ* treatment, which would promote the attenuation of constituent concentrations at the PRB.	All of the alternatives would be protective with regard to primary source control. WT would not be protective with regard to secondary source control but would treat any constituents in groundwater at the point of extraction.
Performance – Likelihood of Future Releases of CCR (Section 2.2.2; IAC Section 845.660(c)(1))	There would be minimal likelihood of CCR releases occurring post-closure under any of the alternatives due to the implementation of an engineered closure design.	There would be minimal likelihood of CCR releases occurring post-closure under any of the alternatives due to the implementation of an engineered closure design.	There would be minimal likelihood of CCR releases occurring post-closure under any of the alternatives due to the implementation of an engineered closure design.	There would be minimal likelihood of CCR releases occurring post-closure under any of the alternatives due to the implementation of an engineered closure design.	There would be minimal likelihood of CCR releases occurring post-closure under any of the alternatives due to the implementation of an engineered closure design.	There would be minimal likelihood of CCR releases occurring post-closure under any of the alternatives due to the implementation of an engineered closure design.

TABLE 1 – Corrective Measures Alternatives Summary Table
Joppa Power Plant – East Ash Pond

Evaluation Factor (Report Section; Part 845 Section)	Corrective Measures Alternative					
	MNA	**GE**	**GCT**	**CW**	**PRB**	**WT**
Performance – Long-Term Management (Section 2.2.3; IAC Section 845.660(c)(1))	Minimal long-term O&M efforts would be required for MNA, because it would not require the installation, operation, or maintenance of any engineered systems or structures other than monitoring wells. Groundwater sampling would continue until GWPSs have been achieved.	Long-term O&M efforts required under GE would include the monitoring and maintenance of the GE system and the management and discharge of extracted groundwater. Treatment of extracted water may be required prior to discharge. If extraction wells are installed at the EAP, fouling could create a need for the replacement of extraction wells over time. Groundwater sampling would continue until GWPSs have been achieved. Once the remedy is complete, the system would be decommissioned in a manner that meets applicable regulatory standards.	Long-term O&M efforts required under the GCT would include the monitoring and maintenance of the GCT system and the management and discharge of extracted groundwater. Treatment of extracted water may be required prior to discharge. If the trench system is installed, fouling of the capture system and extraction pumps could create the need for the replacement or cleaning of the system over time. Groundwater sampling would continue until GWPSs have been achieved. Once the remedy is complete, the system would be decommissioned in a manner that meets applicable regulatory standards.	Long-term O&M efforts required under CW would include the monitoring and maintenance of the CW and, if needed, the hydraulic gradient control system and the management and discharge of extracted groundwater. If groundwater is extracted, treatment may be required prior to discharge. If extraction wells are installed as part of the hydraulic gradient control system, fouling of the well screens could occur, which would require maintenance and potentially create a need for replacement of the wells over time. Groundwater sampling would continue until GWPSs have been achieved. Once the remedy is complete, the system would be decommissioned in a manner that meets applicable regulatory standards.	Long-term O&M efforts required under PRB would include regular groundwater sampling downgradient of the PRB until GWPSs are achieved. The PRB would also be monitored for treatment efficacy. If necessary, the PRB media may be amended or exchanged to extend the life of the PRB.	Long-term O&M efforts required under the WT would include regular sampling of treated water to ensure the remedy is performing as required. If necessary, the WT technology may be exchanged, cleaned, or replaced.
Reliability - Engineering and Institutional Controls (Section 2.2.4; IAC Section 845.660(c)(1))	High long-term reliability would be expected for MNA, because this alternative would rely on natural processes, rather than the installation, operation, and maintenance of engineered systems or structures.	Long-term reliability would be expected for GE, as long as the system is designed and constructed for Site-specific conditions.	Long-term reliability would be expected for the GCT, as long as the system is designed and constructed for Site-specific conditions.	Long-term reliability would be expected for a CW, as long as the system is designed and constructed for Site-specific conditions.	PRB may not be reliable over the long term with respect to engineering and institutional controls, because PRBs generally have limited success at treating boron in groundwater. The effectiveness of the PRB would also decrease over time, resulting in a potential need for the eventual replacement of the remedy.	Long-term reliability would be expected for WT, as long as the system is operated and maintained appropriately.

TABLE 1 – Corrective Measures Alternatives Summary Table
Joppa Power Plant – East Ash Pond

Evaluation Factor (Report Section; Part 845 Section)	Corrective Measures Alternative					
	MNA	**GE**	**GCT**	**CW**	**PRB**	**WT**
Reliability - Potential Need for Replacement of the Corrective Measure (Section 2.2.5; IAC Section 845.660(c)(1))	Without the installation, operation, and maintenance of engineered systems or structures, it would be unlikely that the MNA remedy would need to be replaced. If MNA is selected as the remedy, a contingency plan will be developed that will identify the circumstances under which replacement of the remedy may be appropriate in accordance with US EPA guidance.	Unless groundwater flow conditions change significantly at the Site, replacement of the entire remedy would be unlikely under GE. If extraction wells were installed at the EAP, fouling may reduce the system effectiveness and create a need for the replacement of extraction wells over time. Replacement pumps may also be necessary, because groundwater hydraulic controls would need to be maintained on a long-term basis.	Unless groundwater flow conditions change significantly at the Site, replacement of the entire remedy would be unlikely under GCT. Replacement of individual extraction pumps may be necessary due to fouling.	Unless groundwater flow conditions change significantly at the Site, replacement of the entire remedy would be unlikely under CW. If hydraulic controls are needed, replacement of individual hydraulic control wells may be necessary on a long-term basis because fouling may occur.	Given the low effectiveness of PRBs for boron in groundwater, replacement of the PRB remedy would likely be necessary., particularly if the effectiveness of the PRB declines over time.	Replacement of the WT remedy would be unlikely, as long as the system is operated and maintained appropriately. There may be a need for replacement, exchange, or cleaning of the system, depending on the selected technology.
Ease of Implementation (Section 2.2.6; IAC Section 845.660(c)(1))	MNA would rely on natural processes and active monitoring and therefore would not pose any significant construction challenges.	Installation of extraction and monitoring wells under GE should not pose any significant challenges, regardless of the defined zone. However, transport of extracted water to the designated outfall or potential treatment facility may pose a challenge due to the length of transport necessary..	Construction of the GCT may be difficult due to the required location, length, and depth needed to extract groundwater from the target aquifer. If needed, a downgradient off-Site location would add to the difficulty of installation due to property access restrictions.	Construction of the CW may be difficult due to the required location, length, and depth of the CW. If needed, a downgradient off-Site location would add to the difficulty of installation due to property access restrictions.	Construction of the PRB may be difficult due to the required location, length and depth of the PRB. If needed, a downgradient off-Site location would add to the difficulty of installation due to property access restrictions.	Installation of WT technology would likely not pose any significant challenges. Coordination with the Village of Joppa, private residents, or other stakeholders would be necessary prior to installation.
Potential Impacts – Risks to the Community or the Environment During Implementation of Remedy (Section 2.2.7; IAC Section 845.660(c)(1))	Minimal impacts to worker safety, air quality, and surface water and sediment quality would be expected under MNA, due to the minimal nature of the construction activities required under this alternative.	Modest impacts to worker safety, air quality, and surface water and sediment quality would be expected under GE, due to the modest construction activities required for the installation of the GE system.	Relatively large impacts to worker safety, air quality, and surface water and sediment quality would be expected under GCT, due to the substantial construction activities required for the installation of the GCT.	Relatively large impacts to worker safety, air quality, and surface water and sediment quality would be expected under CW, due to the substantial construction activities required for the installation of the CW.	Relatively large impacts to worker safety, air quality, and surface water and sediment quality would be expected under PRB, due to the substantial construction activities required for the installation of the PRB.	Minimal impacts to worker safety, air quality, and surface water and sediment quality would be expected under WT. Construction would be limited to groundwater extraction points.
The Time Required to Begin and Complete the Corrective Action Plan (Section 2.3; IAC Section 845.660(c)(2))	This report is a preliminary CMA. Following the collection of additional subsurface and site data, all alternatives will be further evaluated, and a final CMA will be prepared. The Corrective Action Plan will be prepared within one year of the final CMA.	This report is a preliminary CMA. Following the collection of additional subsurface and site data, all alternatives will be further evaluated, and a final CMA will be prepared. The Corrective Action Plan will be prepared within one year of the final CMA.	This report is a preliminary CMA. Following the collection of additional subsurface and site data, all alternatives will be further evaluated, and a final CMA will be prepared. The Corrective Action Plan will be prepared within one year of the final CMA.	This report is a preliminary CMA. Following the collection of additional subsurface and site data, all alternatives will be further evaluated, and a final CMA will be prepared. The Corrective Action Plan will be prepared within one year of the final CMA.	This report is a preliminary CMA. Following the collection of additional subsurface and site data, all alternatives will be further evaluated, and a final CMA will be prepared. The Corrective Action Plan will be prepared within one year of the final CMA.	This report is a preliminary CMA. Following the collection of additional subsurface and site data, all alternatives will be further evaluated, and a final CMA will be prepared. The Corrective Action Plan will be prepared within one year of the final CMA.

TABLE 1 – Corrective Measures Alternatives Summary Table
Joppa Power Plant – East Ash Pond

Evaluation Factor (Report Section; Part 845 Section)	Corrective Measures Alternative					
	MNA	**GE**	**GCT**	**CW**	**PRB**	**WT**
State or Local Permit Requirements or Other Environmental or Public Health Requirements that May Substantially Affect Implementation of the Corrective Action Plan (Section 2.4; IAC Section 845.660(c)(3))	MNA would require regulatory approval prior to implementation. The approval process would not be expected to substantially affect the implementation of the Corrective Action Plan.	GE would require regulatory approval prior to implementation and may require modifications to the Site's NPDES permit. The approval process and, if needed, NPDES permit modification would not be expected to substantially affect the implementation of the Corrective Action Plan.	GCT would require regulatory approval prior to implementation and may require modifications to the Site's NPDES permit. The approval process and, if needed, NPDES permit modification would not be expected to substantially affect the implementation of the Corrective Action Plan.	CW would require regulatory approval prior to implementation and may require modifications to the Site's NPDES permit. The approval process and, if needed, NPDES permit modification would not be expected to substantially affect the implementation of the Corrective Action Plan.	PRB would require regulatory approval prior to implementation. The approval process would not be expected to substantially affect the implementation of the Corrective Action Plan.	WT would require regulatory approval prior to implementation. The approval process would not be expected to substantially affect the implementation of the Corrective Action Plan.

Notes:
MNA - Monitored Natural Attenuation
GE – Groundwater Extraction
GCT – Groundwater Collection Trench
CW – Cutoff Wall
PRB – Permeable Reactive Barrier
WT – Wellhead Treatment

FIGURES

Ohio River

Legend

- Joppa Power Station
- East Ash Pond CCR Unit Boundary

Notes

- Coal Combustion Residual (CCR) Unit boundary is approximate.
- Aerial imagery provided by ArcGIS.

2,500 1,250 0 2,500 5,000 7,500 Feet

N

Site Map

Joppa Power Station
Joppa, Illinois

Geosyntec consultants

GLP8030 | May 2022

Figure 1

\\stlouismo-01\data\Company\Projects_post_2014\GLP8021_Vistra_Joppa Part 845 Field Efforts\01_Field Efforts\GIS\Site Map - Joppa.mxd 3/17/2021 10:34:31 AM

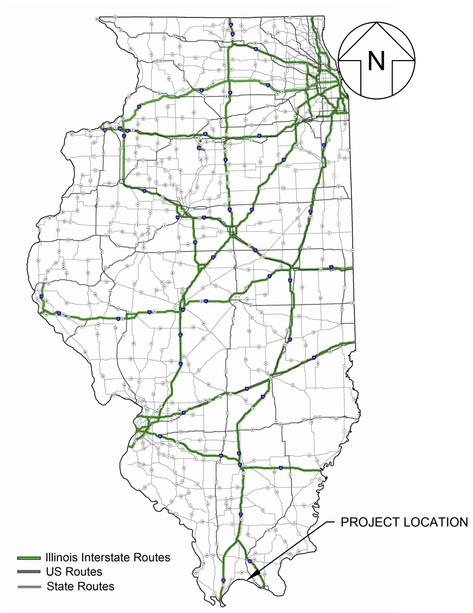
Geosyntec
consultants

ATTACHMENT C

Final Closure Plan Drawings and Material Specifications

July 2022

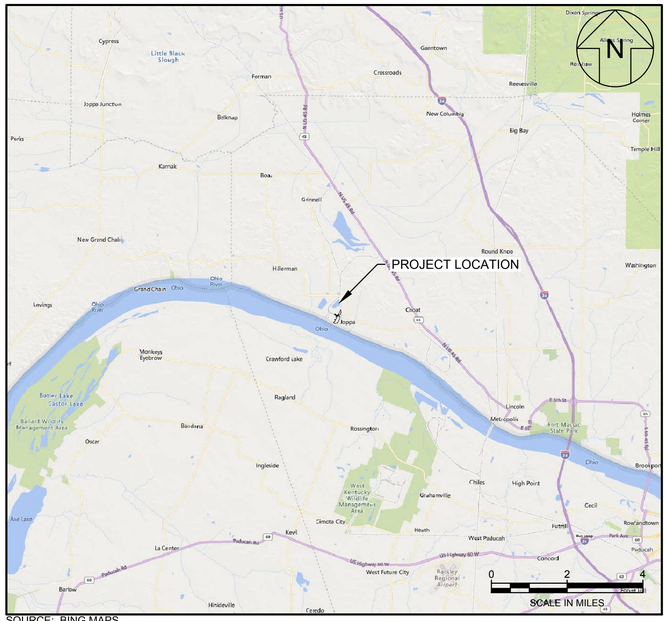
ELECTRIC ENERGY INCORPORATED
JOPPA POWER PLANT
JOPPA, ILLINOIS
EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS
PROJECT NO. GLP8025
JULY 2022



SOURCE: IDOT

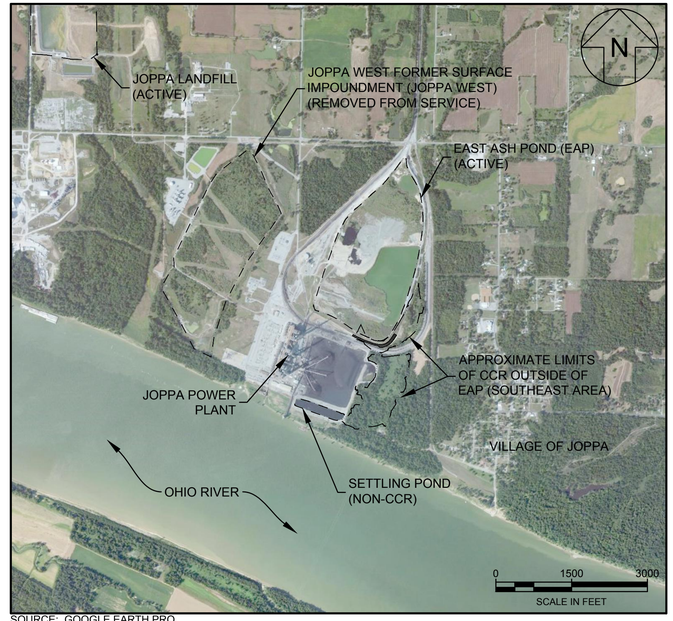
STATE MAP

NOT TO SCALE



SOURCE: BING MAPS

LOCATION MAP



SOURCE: GOOGLE EARTH PRO

SITE MAP

DETAIL NUMBER
4
C-400
DRAWING ON WHICH ABOVE DETAIL IS PRESENTED

DETAIL NUMBER
4
C-300
DETAIL TITLE
SCALE:
XREF:
DRAWING ON WHICH ABOVE DETAIL WAS FIRST REFERENCED

EXAMPLE: DETAIL NUMBER 4 PRESENTED ON DRAWING NO. C-400 WAS REFERENCED FOR THE FIRST TIME ON DRAWING NO. C-300.

ABOVE SYSTEM ALSO APPLIES TO SECTION IDENTIFICATIONS.

DETAIL IDENTIFICATION LEGEND

DRAWING LIST

SHEET NO.	SHEET TITLE
G-100	COVER SHEET AND LOCATION MAP
G-110	EXISTING CONDITIONS – OVERALL
G-120	EXISTING CONDITIONS – EAST ASH POND INSERT
G-130	EXISTING CONDITIONS – SOUTHEAST AREA INSERT
C-100	DEMOLITION, RELOCATION, AND ABANDONMENT
C-110	FINAL GRADING PLAN – OVERALL
C-120	FINAL GRADING PLAN – EAST ASH POND INSERT
C-130	FINAL GRADING PLAN – SOUTHEAST AREA INSERT
C-140	SECTIONS – 1 OF 2
C-150	SECTIONS – 2 OF 2
C-160	DETAILS AND MATERIAL SPECIFICATION – 1 OF 3
C-170	DETAILS AND MATERIAL SPECIFICATION – 2 OF 3
C-180	DETAILS AND MATERIAL SPECIFICATION – 3 OF 3
S-100	SOLAR DEVELOPMENT PLAN
S-110	SOLAR DEVELOPMENT DETAILS

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REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: COVER SHEET AND LOCATION MAP

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

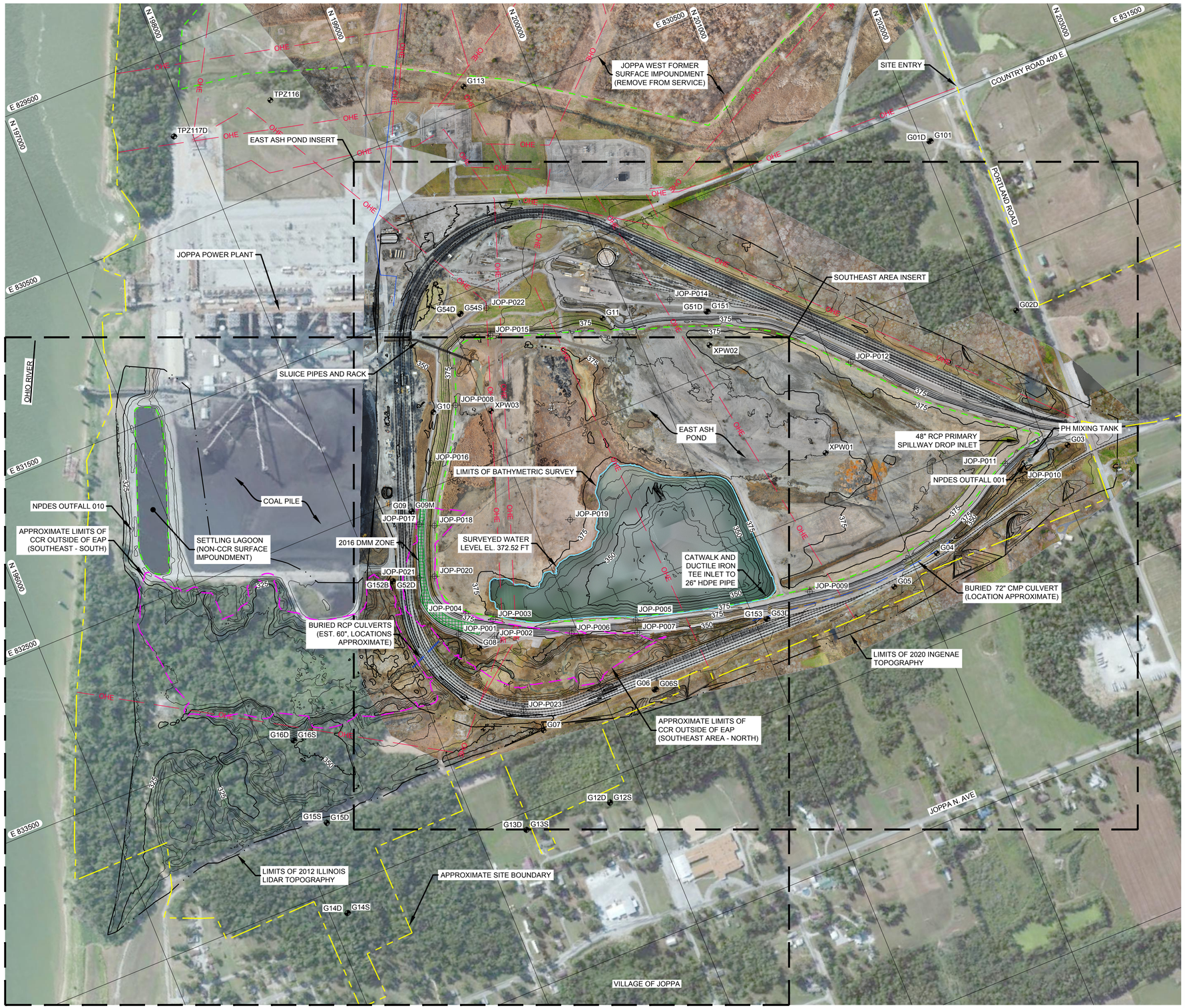
SITE: JOPPA POWER PLANT JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 G-100
REVIEWED BY:	JPS	DRAWING NO.:	G-100
APPROVED BY:	LPC		



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N

LEGEND

- 350 — EXISTING GROUND SURFACE ELEVATION (MAJOR) (5-FT INTERVAL)
- 2020 SURVEYED IMPOUNDMENT WATER LEVEL
- APPROXIMATE LIMITS OF CCR UNITS AND NON-CCR SURFACE IMPOUNDMENTS
- APPROXIMATE LIMITS OF CCR OUTSIDE OF EAP (SOUTHEAST AREA)
- APPROXIMATE SITE BOUNDARY
- BOUNDARY BETWEEN DECEMBER 2020 IMAGERY, BY INGENAE, LLC. AND 2020 GOOGLE EARTH AERIAL IMAGERY
- TOPOGRAPHIC SURVEY LIMITS
- OHE — OVERHEAD ELECTRICAL
- EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
- RAILROAD
- 2016 DEEP MIXING METHOD (DMM) ZONE
- EXISTING MONITORING WELL
- EXISTING PIEZOMETERS

NOTES:

1. COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLAN COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET).
2. EXISTING CONTOURS, AERIAL IMAGERY, AND WATER SURFACE ELEVATIONS FOR THE EAP AND IMMEDIATE SURROUNDING AREAS WERE TAKEN FROM "LUMINANT, ELECTRIC ENERGY, INC., JOPPA POWER STATION, DECEMBER 2020 TOPOGRAPHY", DATED MAY 20, 2021, BY INGENAE, LLC (2020 INGENAE SURVEY).
3. EXISTING CONTOURS FOR AREAS BEYOND THE LIMITS OF THE 2020 INGENAE SURVEY WERE TAKEN FROM LIDAR DATA PROVIDED BY THE ILLINOIS GEOSPATIAL CLEARINGHOUSE, ILLINOIS HEIGHT MODERNIZATION (ILHMP), ACCESSIBLE AT CLEARINGHOUSE.ISGS.ILLINOIS.EDU. THE IMAGERY WAS OBTAINED FOR MASSAC COUNTY AND WAS COLLECTED IN 2012.
4. EXISTING AERIAL IMAGERY FOR AREAS BEYOND THE LIMITS OF THE 2021 INGENAE SURVEY WERE OBTAINED FROM GOOGLE EARTH PRO IN 2022, AND THE IMAGERY WAS COLLECTED ON FEBRUARY 2, 2020.
5. APPROXIMATE SITE BOUNDARIES WERE TAKEN FROM THE MASSAC COUNTY, ILLINOIS ARCGIS HUB (HTTPS://GIS-MASSAC-COUNTY.HUB.ARCGIS.COM/) AND REPRESENT THE APPROXIMATE BOUDNARIES OF PARCELS OWNED BY ELECTRIC ENERGY, INC.
6. MONITORING WELL LOCATIONS WERE PROVIDED BY RAMBOLL (2022) AND PIEZOMETER LOCATIONS WERE PROVIDED BY AECOM (2016).
7. ALL OVERHEAD ELECTRIC LINE AND BURIED CULVERT LOCATIONS ARE APPROXIMATE AND SHOULD NOT BE CONSIDERED COMPREHENSIVE. ADDITIONAL SURVEYS SHOULD BE PERFORMED PRIOR TO CONSTRUCTION TO VERIFY THE LOCATIONS OF ALL OVERHEAD AND BURIED UTILITIES. UTILITY LOCATIONS ARE ONLY SHOWN WITHIN THE SITE BOUNDARIES.
8. LIMITS FOR THE EAP WERE TAKEN FROM "LUMINANT, JOPPA POWER PLANT, CCR FACILITY BOUNDARY EXHIBIT", DATED SEPTEMBER 7, 2021, BY INGENAE LLC (2021 INGENAE BOUNDARY SURVEY).
9. THE EXTENTS OF THE DEEP MIXING METHOD STABILITY IMPROVEMENT ZONE (DMM ZONE) WERE TAKEN FROM THE AECOM REPORT TITLED "HISTORY OF CONSTRUCTION, USEPA FINAL CCR RULE, 40 CFR § 257.73(C), JOPPA POWER STATION, JOPPA, ILLINOIS". THE EXTENTS SHOULD BE CONSIDERED APPROXIMATE AND MAY VARY.
10. THE DIAMETER OF THE RCP CULVERTS BENEATH THE RAILROAD TRACKS IS PRESUMED TO BE 60 INCHES BASED ON VISUAL OBSERVATIONS, BUT HAS NOT BEEN VERIFIED, AS OF THE DATE OF THESE DRAWINGS, DUE TO ACCESS DIFFICULTIES.
11. THE APPROXIMATE LIMITS OF CCR OUTSIDE OF THE EAP WERE TAKEN FROM "CCR INVESTIGATION AND DELINEATION REPORT, JOPPA POWER PLANT", DATED JULY 2022, BY GEOSYNTEC CONSULTANTS (CCR DELINEATION REPORT).

0 300 600
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: EXISTING CONDITIONS - OVERALL

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

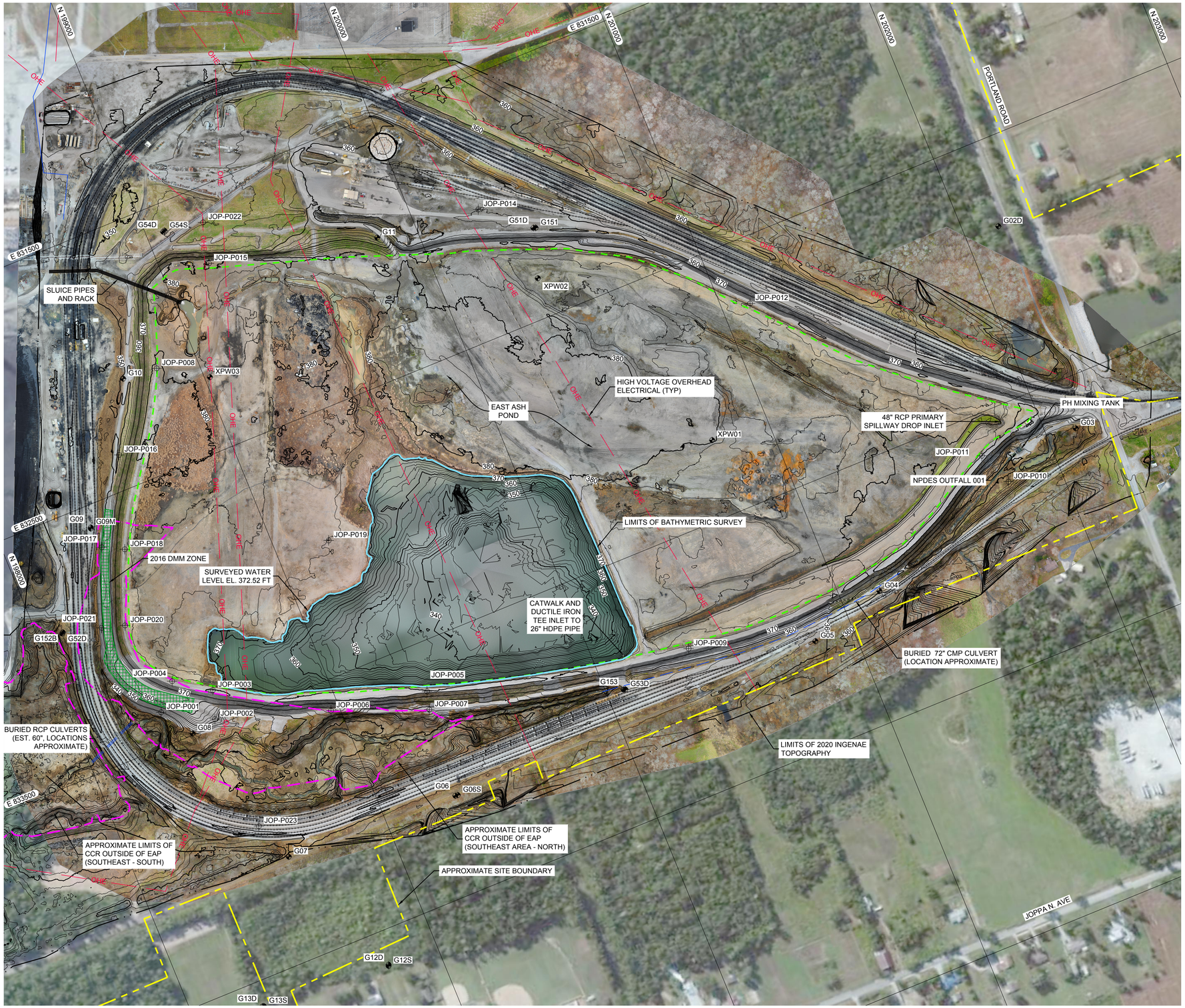
SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 G-110
REVIEWED BY:	JPS	DRAWING NO.:	G-110
APPROVED BY:	LPC		



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N

LEGEND

- 350 — EXISTING GROUND SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
- 2020 SURVEYED IMPOUNDMENT WATER LEVEL
- APPROXIMATE LIMITS OF CCR UNITS AND NON-CCR SURFACE IMPOUNDMENTS
- APPROXIMATE LIMITS OF CCR OUTSIDE OF EAP (SOUTHEAST AREA)
- APPROXIMATE SITE BOUNDARY
- BOUNDARY BETWEEN DECEMBER 2020 IMAGERY, BY INGENAE, LLC. AND 2020 GOOGLE EARTH AERIAL IMAGERY
- TOPOGRAPHIC SURVEY LIMITS
- OHE — OVERHEAD ELECTRICAL
- EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
- RAILROAD
- 2016 DEEP MIXING METHOD (DMM) ZONE
- EXISTING MONITORING WELL
- EXISTING PIEZOMETERS

NOTE:

1. SEE NOTES ON SHEET G-110 FOR INFORMATION ON COORDINATE SYSTEMS AND DATA SOURCES FOR EXISTING TOPOGRAPHY, AERIAL IMAGERY, SITE BOUNDARIES, MONITORING WELL LOCATIONS, UTILITIES, LIMITS OF CCR OUTSIDE OF THE EAP, AND OTHER FEATURES SHOWN ON THIS SHEET.

0 200 400
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: EXISTING CONDITIONS - EAST ASH POND INSERT

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

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SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 G-120
REVIEWED BY:	JPS	DRAWING NO.:	G-120
APPROVED BY:	LPC		

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N

LEGEND

- 350 — EXISTING GROUND SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
- 2020 SURVEYED IMPOUNDMENT WATER LEVEL
- APPROXIMATE LIMITS OF CCR UNITS AND NON-CCR SURFACE IMPOUNDMENTS
- APPROXIMATE LIMITS OF CCR OUTSIDE OF EAP (SOUTHEAST AREA)
- APPROXIMATE SITE BOUNDARY
- BOUNDARY BETWEEN DECEMBER 2020 IMAGERY, BY INGENAE, LLC. AND 2020 GOOGLE EARTH AERIAL IMAGERY
- TOPOGRAPHIC SURVEY LIMITS
- OHE — OVERHEAD ELECTRICAL
- EXISTING BURIED CULVERT (LOCATIONS APPROXIMATE)
- RAILROAD
- 2016 DEEP MIXING METHOD (DMM) ZONE
- EXISTING MONITORING WELL
- EXISTING PIEZOMETERS

NOTE:

1. SEE NOTES ON SHEET G-110 FOR INFORMATION ON COORDINATE SYSTEMS AND DATA SOURCES FOR EXISTING TOPOGRAPHY, AERIAL IMAGERY, SITE BOUNDARIES, MONITORING WELL LOCATIONS, UTILITIES, LIMITS OF CCR OUTSIDE OF THE EAP, AND OTHER FEATURES SHOWN ON THIS SHEET.

0 200 400
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: EXISTING CONDITIONS - SOUTHEAST AREA INSERT

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

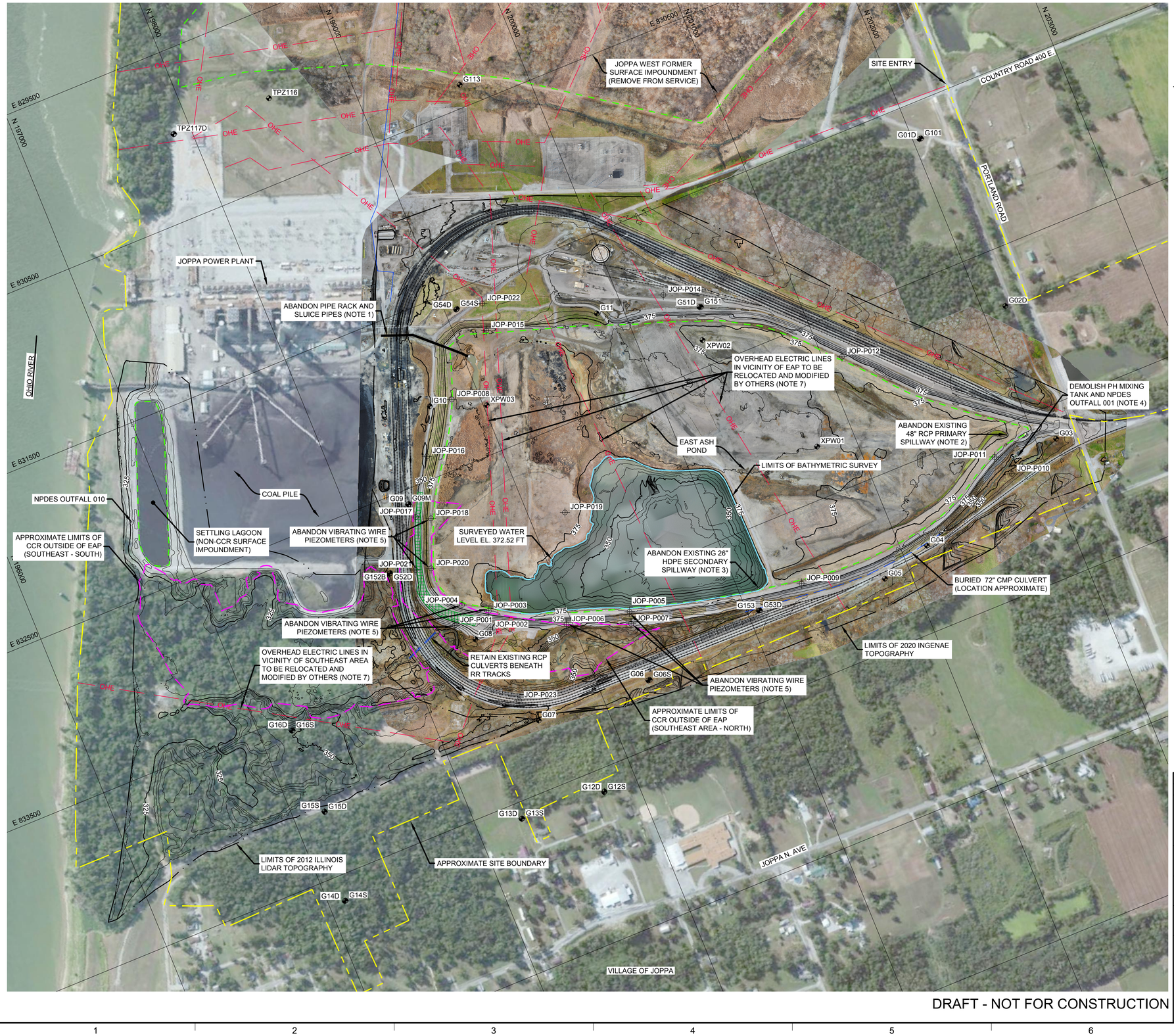
SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 G-130
REVIEWED BY:	JPS	DRAWING NO.:	G-130
APPROVED BY:	LPC		



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N

LEGEND

- 350 — EXISTING GROUND SURFACE ELEVATION (MAJOR) (5-FT INTERVAL)
- 2020 SURVEYED IMPOUNDMENT WATER LEVEL
- APPROXIMATE LIMITS OF CCR UNITS AND NON-CCR SURFACE IMPOUNDMENTS
- APPROXIMATE LIMITS OF CCR OUTSIDE OF EAP (SOUTHEAST AREA)
- APPROXIMATE SITE BOUNDARY
- BOUNDARY BETWEEN DECEMBER 2020 IMAGERY, BY INGENAE, LLC. AND 2020 GOOGLE EARTH AERIAL IMAGERY
- TOPOGRAPHIC SURVEY LIMITS
- OHE — OVERHEAD ELECTRICAL
- EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
- RAILROAD
- 2016 DEEP MIXING METHOD (DMM) ZONE
- EXISTING MONITORING WELL
- EXISTING PIEZOMETERS

NOTES:

1. EXISTING SLUICE PIPES, PIPE RACKS, AND APPURTENANT STRUCTURES ARE TO BE DEMOLISHED AND DISPOSED OF BENEATH THE FINAL COVER SYSTEM IN THE EAP. THE LIMITS OF ABANDONMENT SHALL BE ALL SLUICE PIPE STRUCTURES WITHIN THE EAP AND 125 FT BEYOND THE LIMITS OF THE EAP.
2. THE EXISTING 48" RCP PRIMARY SPILLWAY IS TO BE ABANDONED BY REMOVING THE WINGWALLS AND GRATE, DISPOSING OF THEM BENEATH THE FINAL COVER SYSTEM OF THE EAP, THOROUGHLY CLEANING THE INSIDE OF THE 48" RCP PIPE WITH PRESSURIZED WATER, CONSTRUCTING A BULKHEAD SEAL AT THE DOWNSTREAM END OF THE PIPE, AND THEN FILLING THE ANNULUS OF THE PIPE COMPLETELY WITH CEMENT-BENTONITE GROUT.
3. THE EXISTING 26" HDPE SECONDARY SPILLWAY IS TO BE ABANDONED BY DEMOLISHING THE CATWALK AND DUCTILE IRON TEE, DEMOLISHING ALL PORTIONS OF THE PIPE THAT ARE ABOVE EXISTING GRADES AT THE UPSTREAM AND DOWNSTREAM ENDS OF THE PIPE, AND DISPOSING OF THEM BENEATH THE FINAL COVER SYSTEM IN THE EAP. THE REMAINING PORTIONS ORE THE PIPE ARE THEN TO BE SEALED BY THOROUGHLY CLEANING THE INSIDE OF THE PIPE WITH PRESSURIZED WATER, CONSTRUCTING A BULKHEAD SEAL AT THE DOWNSTREAM END OF THE PIPE, AND THEN FILLING THE ANNULUS OF THE PIPE COMPLETELY WITH CEMENT-BENTONITE GROUT.
4. THE PH MIXING TANKS, STRUCTURES ASSOCIATED WITH NPDES OUTFALL 001, APPURTENANT STRUCTURES, AND FENCING ARE TO BE DEMOLISHED AND DISPOSED OF BENEATH THE FINAL COVER SYSTEM IN THE EAP.
5. VIBRATING-WIRE PIEZOMETERS JOP-P017, JOP-P018, JOP-0020, JOP-P021, JOP-P004, JOP-P003, JOP-P001, JOP-P002, JOP-P006, JOP-P005, AND JOP-P006 ARE TO BE ABANDONED BY CUTTING THE DATA CABLES OFF 1 FT BELOW FINAL GRADES.
6. ALL OTHER VIBRATING-WIRE PIEZOMETERS AND MONITORING WELLS ARE TO BE MAINTAINED AND ARE NOT TO DE DAMAGED DURING CONSTRUCTION.
7. OVERHEAD ELECTRIC LINES WITHIN THE EAP AND SOUTHEAST AREA WILL BE RELOCATED BY OTHERS, EITHER BY RE-ROUTING THE LINES OR MODIFYING THEM SUCH THAT EQUIPMENT CAN PASS BENEATH THEM DURING CLOSURE CONSTRUCTION WITH SUFFICIENT CLEARANCE.
8. SEE SHEET G-110 FOR NOTES REGARDING COORDINATE SYSTEMS AND SOURCES FOR EXISTING AERIAL IMAGERY, CONTOURS, SITE BOUNDARIES, MONITORING WELL LOCATIONS, OVERHEAD ELECTRIC LINES, LIMITS OF CCR OUTSIDE OF THE EAP, BURIED CULVERTS, AND LIMITS FOR THE EAP.

0 300 600
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: DEMOLITION, RELOCATION, AND ABANDONMENT

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

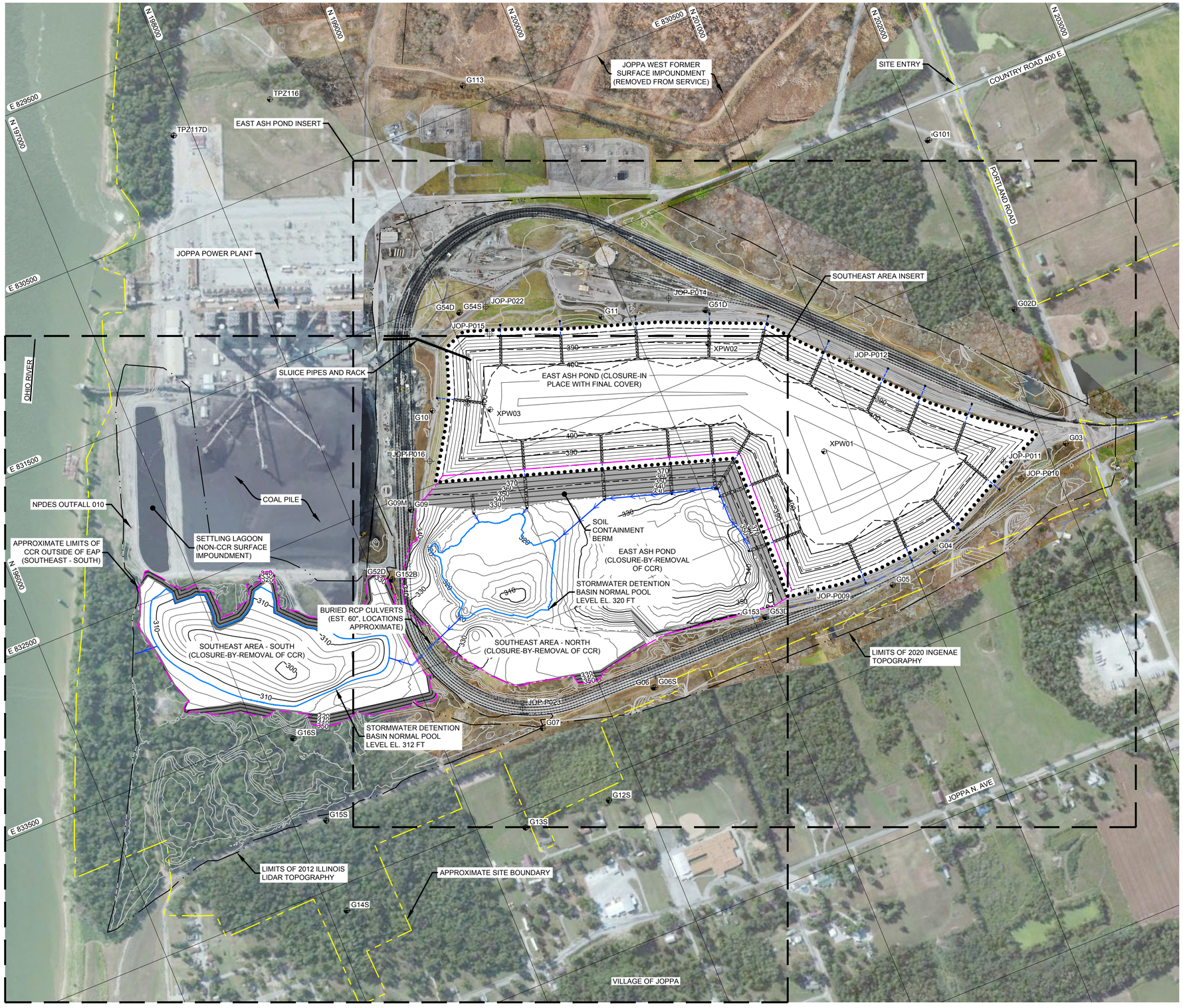
SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-100
REVIEWED BY:	JPS	DRAWING NO.:	C-100
APPROVED BY:	LPC		



N

LEGEND

- 350 — EXISTING GROUND SURFACE ELEVATION (MAJOR) (5-FT INTERVAL)
- 400 — PROPOSED SURFACE ELEVATION (MAJOR) (5-FT INTERVAL)
- LIMITS OF CCR REMOVAL
- APPROXIMATE SITE BOUNDARY
- TOPOGRAPHIC SURVEY LIMITS
- RAILROAD
- EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
- LIMITS OF FINAL COVER
- INTERCEPTOR BERM
- ROCK CHUTE
- CULVERT
- STORMWATER CHANNEL
- PROPOSED RIPRAP APRON
- EXISTING MONITORING WELL
- EXISTING PIEZOMETERS

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING THE COORDINATE SYSTEM AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS, AND THE LIMITS OF CCR OUTSIDE OF THE EAP.
2. EXISTING AND RELOCATED UTILITY ALIGNMENTS ARE NOT SHOWN ON THIS SHEET. SEE SHEET G-110 AND G-130 FOR UTILITY INFORMATION.

0 300 600
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: FINAL GRADING PLAN - OVERALL

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-110
REVIEWED BY:	JPS	DRAWING NO.:	C-110
APPROVED BY:	LPC		

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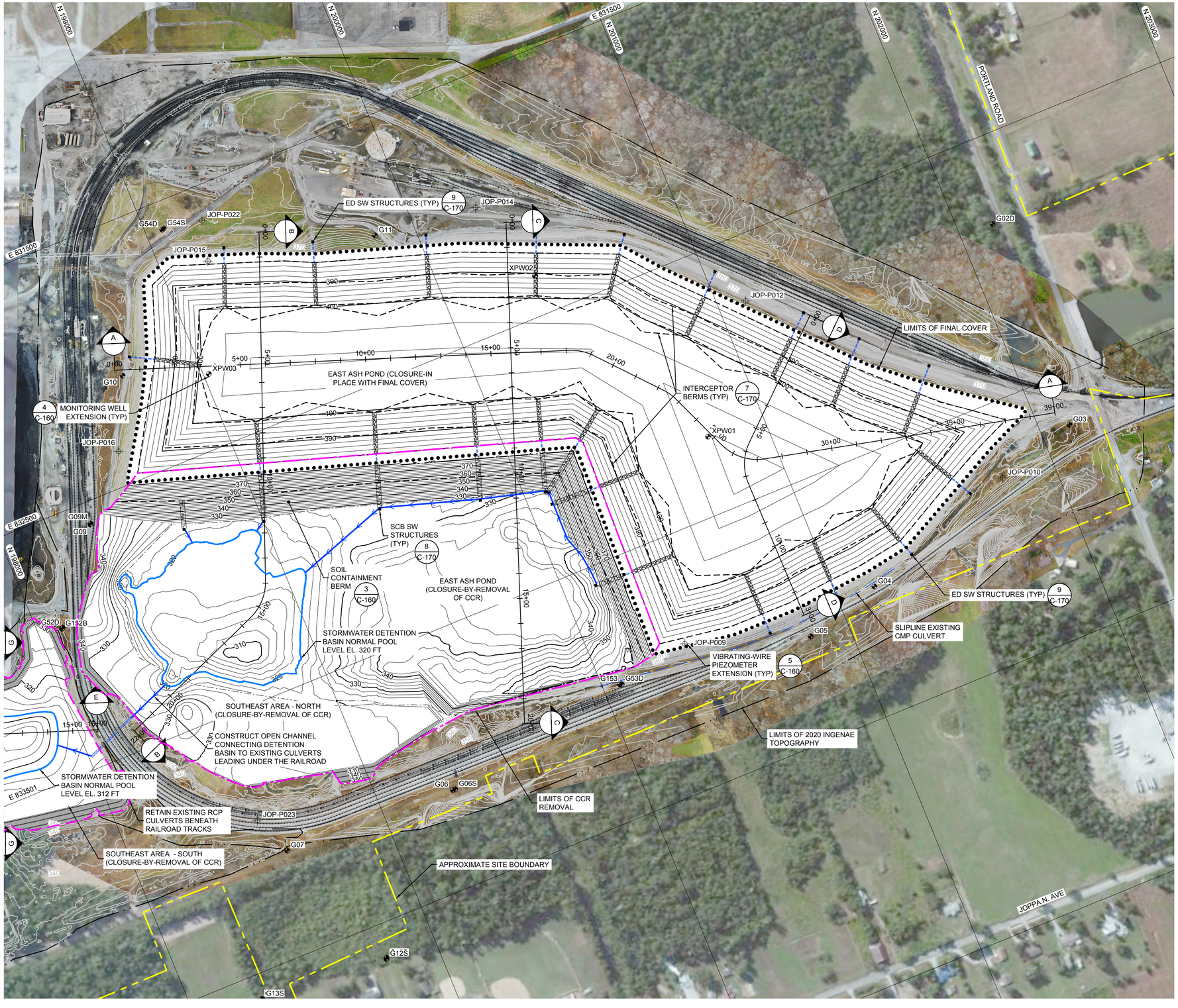

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LEGEND

- EXISTING GROUND SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
- PROPOSED SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
- LIMITS OF CCR REMOVAL
- APPROXIMATE SITE BOUNDARY
- TOPOGRAPHIC SURVEY LIMITS
- RAILROAD
- LIMITS OF FINAL COVER
- INTERCEPTOR BERM
- ROCK CHUTE
- EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
- STORMWATER CHANNEL
- RIPRAP APRON
- EXISTING MONITORING WELL
- EXISTING PIEZOMETERS
- EXISTING BURIED CULVERT (LOCATION APPROXIMATE)

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING THE COORDINATE SYSTEM, SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS, AND THE LIMITS OF CCR OUTSIDE OF THE EAP.
2. EXISTING AND RELOCATED UTILITY ALIGNMENTS ARE NOTE SHOWN ON THIS SHEET. SEE SHEET G-110 AND G-130 FOR UTILITY INFORMATION.
3. THE EXISTING PERIMETER DIKES ARE TO BE REMOVED WITHIN THE EAST ASH POND (CLOSURE-BY-REMOVAL OF CCR) AREA.
4. GRADES SHOWN WITHIN THE CLOSURE-BY-REMOVAL AREAS CORRESPOND TO 1 FT BELOW THE PRESUMED BOTTOM-OF-CCR GRADES, AS TAKEN FROM THE "CCR INVESTIGATION AND DELINEATION REPORT, JOPPA POWER PLANT, EAST ASH POND", DATED JULY 2022, BY GEOSYNTEC CONSULTANTS. ACTUAL GRADES MAY VARY BASED ON OBSERVATIONS PERFORMED DURING CCR EXCAVATION.
5. STORMWATER CHANNEL ALIGNMENTS AND DETENTION BASINS OUTSIDE OF THE FINAL COVER SYSTEM ARE APPROXIMATE AND WILL BE REFINED AT A LATER PHASE OF DESIGN.

0 200 400
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: FINAL GRADING PLAN - EAST ASH POND INSERT

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

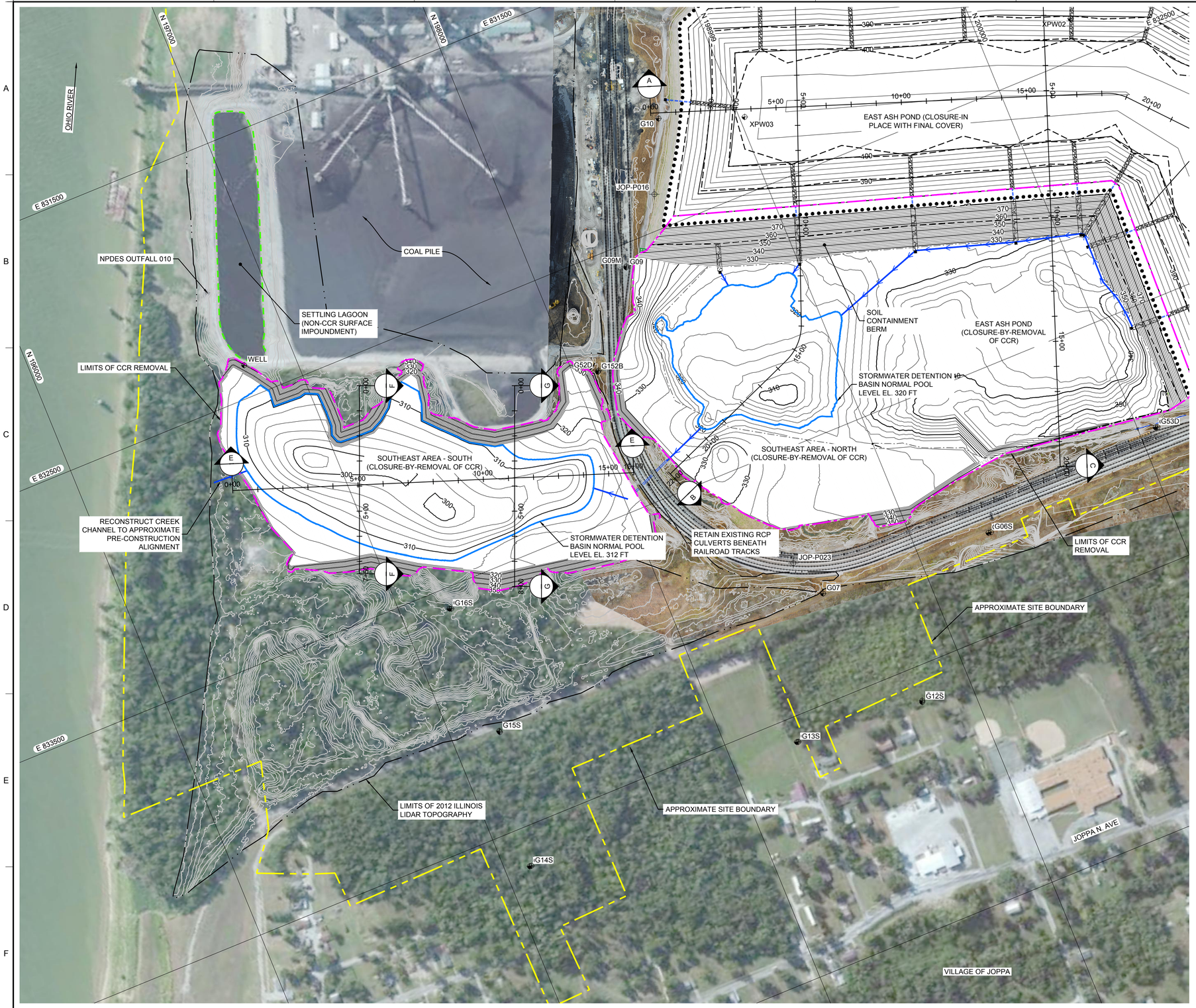
SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-120
REVIEWED BY:	JPS	DRAWING NO.:	C-120
APPROVED BY:	LPC		



DRAFT - NOT FOR CONSTRUCTION

LEGEND

350	EXISTING GROUND SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
400	PROPOSED SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
	LIMITS OF CCR REMOVAL
	APPROXIMATE SITE BOUNDARY
	TOPOGRAPHIC SURVEY LIMITS
	RAILROAD
	LIMITS OF FINAL COVER
	INTERCEPTOR BERM
	ROCK CHUTE
	CULVERT
	STORMWATER CHANNEL
	PROPOSED RIPRAP APRON
	EXISTING MONITORING WELL
	EXISTING PIEZOMETERS
	EXISTING BURIED CULVERT (LOCATIONS APPROXIMATE

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING THE COORDINATE SYSTEM, SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
2. EXISTING AND RELOCATED UTILITY ALIGNMENTS ARE NOT SHOWN ON THIS SHEET. SEE SHEET G-110 AND G-130 FOR UTILITY INFORMATION.
3. GRADES SHOWN WITHIN THE CLOSURE-BY-REMOVAL AREAS CORRESPOND TO 1 FT BELOW THE PRESUMED BOTTOM-OF-CCR GRADES. ACTUAL GRADES MAY VARY BASED ON OBSERVATIONS PERFORMED DURING CCR EXCAVATION.
4. STORMWATER CHANNEL ALIGNMENTS OUTSIDE OF THE FINAL COVER SYSTEM ARE APPROXIMATE AND WILL BE REFINED AT A LATER PHASE OF DESIGN.

0 200 400
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
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600 ROSELANE COURT, FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530
ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: FINAL GRADING PLAN - SOUTHEAST AREA INSERT

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

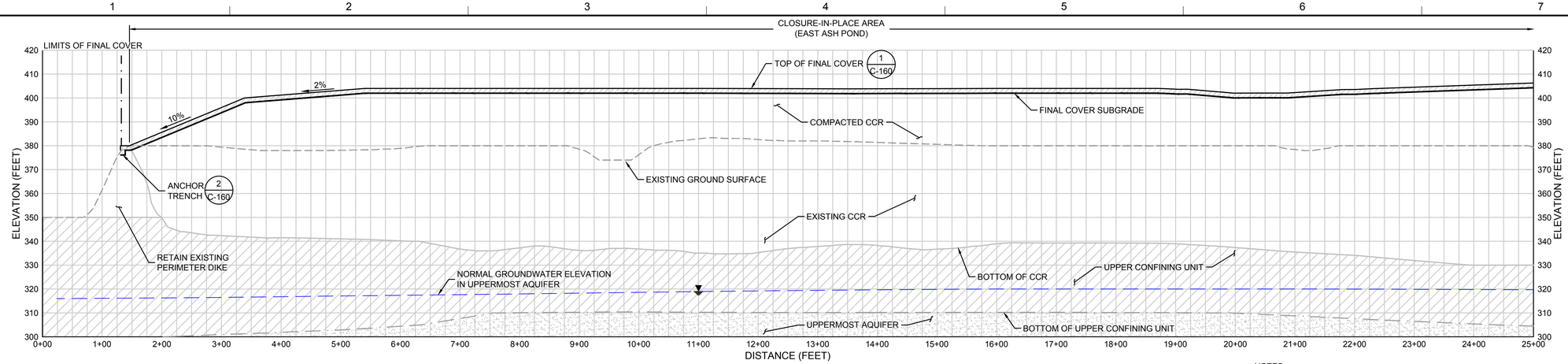
SITE: JOPPA POWER PLANT JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

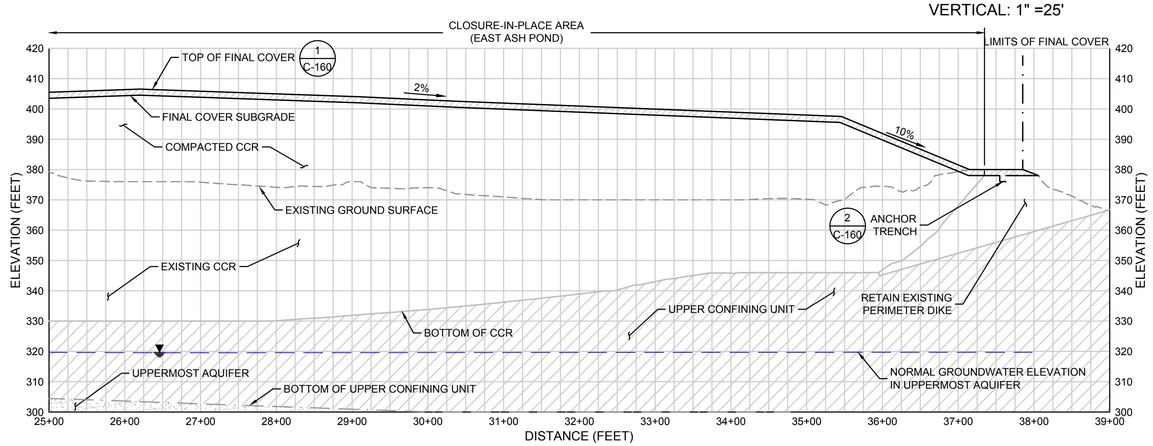
SIGNATURE

DATE

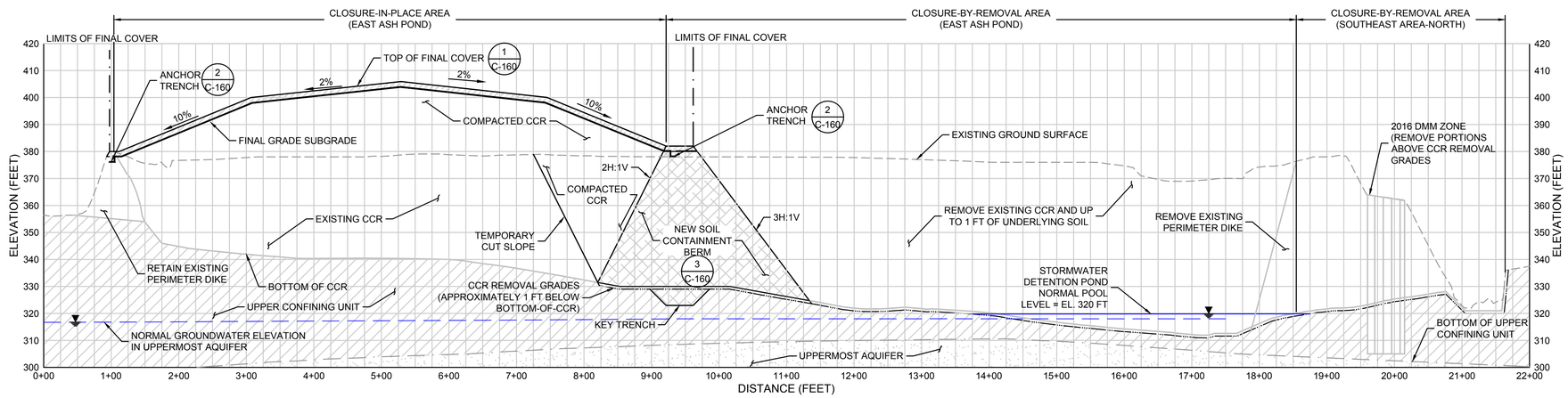
DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-130
REVIEWED BY:	JPS	DRAWING NO.:	C-130
APPROVED BY:	LPC		



A SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



A SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



B SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING COORDINATE SYSTEMS AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
2. THE BOTTOM AND LIMITS OF CCR INSIDE AND OUTSIDE OF THE EAP WAS TAKEN FROM THE "CCR INVESTIGATION AND DELINEATION REPORT, JOPPA POWER PLANT, EAST ASH POND", DATED JULY 2022, BY GEOSYNTEC CONSULTANTS.
3. THE INTERFACE BETWEEN THE UPPER CONFINING UNIT AND UPPERMOST AQUIFER AND THE NORMAL GROUNDWATER LEVEL WITHIN THE UPPERMOST AQUIFER WAS TAKEN FROM THE HYDROGEOLOGIC SITE CHARACTERIZATION REPORT, EAST ASH POND, JOPPA POWER PLANT, JOPPA ILLINOIS", RAMBOLL, OCTOBER 25, 2021. THE INTERFACE IS NOT SHOWN OUTSIDE OF THE HORIZONTAL LIMITS PROVIDED BY RAMBOLL.
4. THE NORMAL GROUNDWATER ELEVATION IN THE UPPERMOST AQUIFER WAS CALCULATED BY RAMBOLL USING DATA COLLECTED FROM 2015-2022. THIS NORMAL ELEVATION IS NOT EXPECTED TO CHANGE UNDER POST-CLOSURE CONDITIONS. THE GROUNDWATER ELEVATION IS NOT SHOWN OUTSIDE OF THE HORIZONTAL LIMITS PROVIDED BY RAMBOLL.
5. THE EXTENTS OF THE DEEP MIXING METHOD STABILITY IMPROVEMENT ZONE (DMM ZONE) WERE TAKEN FROM THE AECOM REPORT TITLED HISTORY OF CONSTRUCTION, USEPA FINAL CCR RULE, 40 CFR § 257.73(C), JOPPA POWER STATION, JOPPA, ILLINOIS". THE EXTENTS SHOULD BE CONSIDERED APPROXIMATE AND MAY VARY.
6. GRADES SHOWN WITHIN THE CLOSURE-BY-REMOVAL AREAS CORRESPOND TO 1 FT BELOW THE PRESUMED BOTTOM-OF-CCR GRADES. ACTUAL GRADES MAY VARY BASED ON OBSERVATIONS PERFORMED DURING CCR EXCAVATION.

LEGEND

- TOP OF FINAL COVER
- EXISTING GROUND SURFACE
- BOTTOM OF CCR
- GEOMEMBRANE
- STORMWATER POND WATER LEVEL
- PROTECTIVE COVER SOIL
- NEW SOIL CONTAINMENT BERM
- 2016 DMM ZONE
- UPPER CONFINING UNIT
- PERMOST AQUIFER

0 100 200
SCALE IN FEET

DRAFT - NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: SECTIONS - 1 OF 2

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

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SIGNATURE

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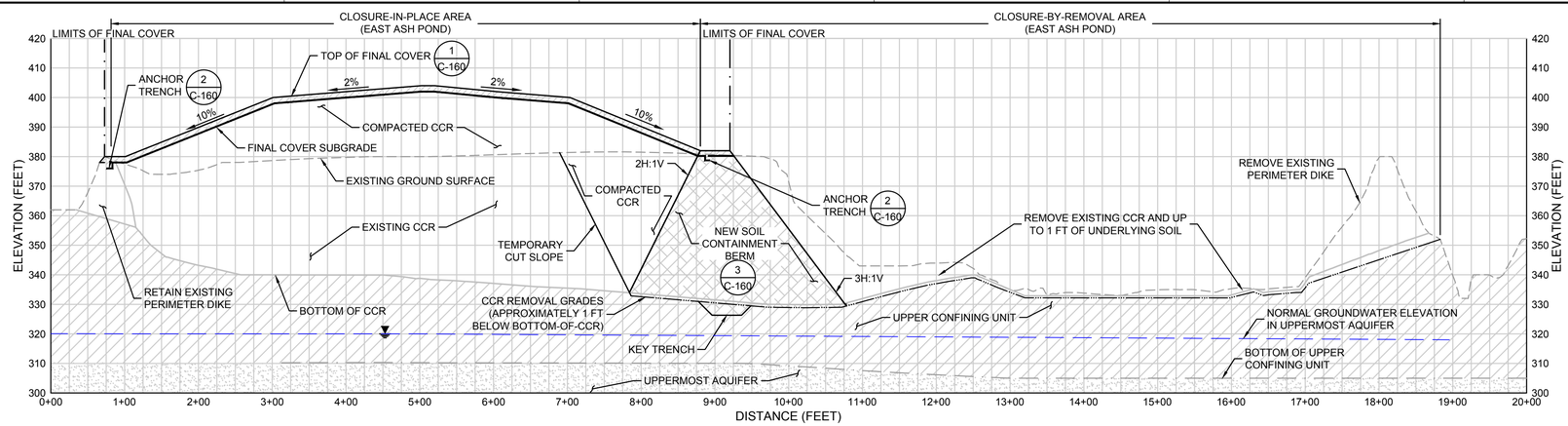
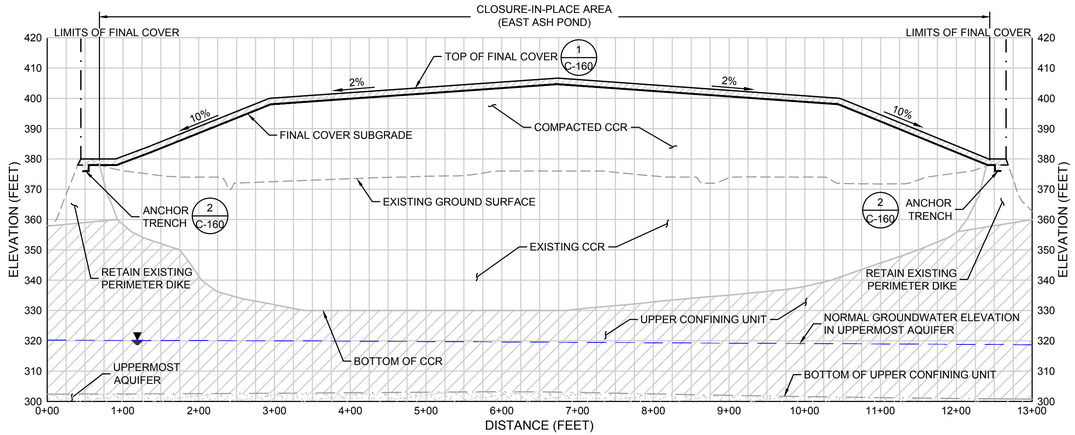
CHECKED BY:	TWW	FILE:	GLP8025 C-140
REVIEWED BY:	JPS	DRAWING NO.:	C-140
APPROVED BY:	LPC		



C SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



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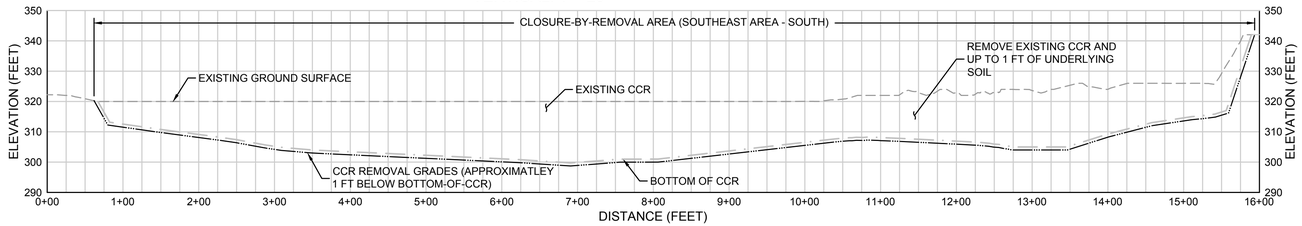
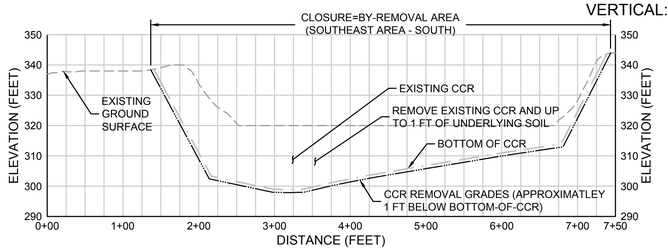
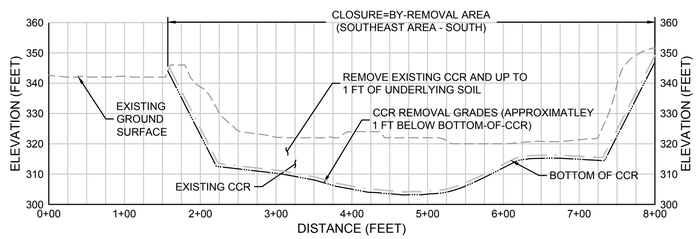
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



E SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



F SECTION E
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



G SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'

DRAFT - NOT FOR CONSTRUCTION

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING COORDINATE SYSTEM AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
2. THE BOTTOM AND LIMITS OF CCR INSIDE AND OUTSIDE OF THE EAP WAS TAKEN FROM THE "CCR INVESTIGATION AND DELINEATION REPORT, JOPPA POWER PLANT, EAST ASH POND", DATED JULY 2022, BY GEOSYNTEC CONSULTANTS.
3. THE INTERFACE BETWEEN THE UPPER CONFINING UNIT AND UPPERMOST AQUIFER AND THE NORMAL GROUNDWATER LEVEL WITHIN THE UPPERMOST AQUIFER WAS TAKEN FROM THE HYDROGEOLOGIC SITE CHARACTERIZATION REPORT, EAST ASH POND, JOPPA POWER PLANT, JOPPA ILLINOIS, RAMBOLL, OCTOBER 25, 2021. THE INTERFACE IS NOT SHOWN OUTSIDE OF THE HORIZONTAL LIMITS PROVIDED BY RAMBOLL.
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LEGEND

- TOP OF FINAL COVER
- EXISTING GROUND SURFACE
- BOTTOM OF CCR
- GEOMEMBRANE
- NORMAL GROUNDWATER ELEVATION IN UPPERMOST AQUIFER
- BOTTOM OF UPPER CONFINING UNIT
- PROTECTIVE COVER SOIL
- NEW SOIL CONTAINMENT BERM
- UPPER CONFINING UNIT
- PERMOST AQUIFER

0 100 200
SCALE IN FEET

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FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: SECTIONS - 2 OF 2

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

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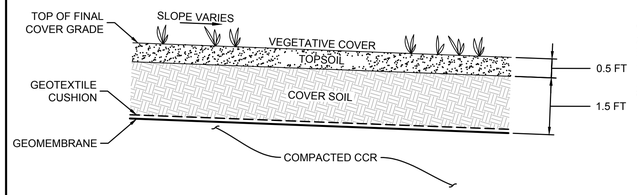
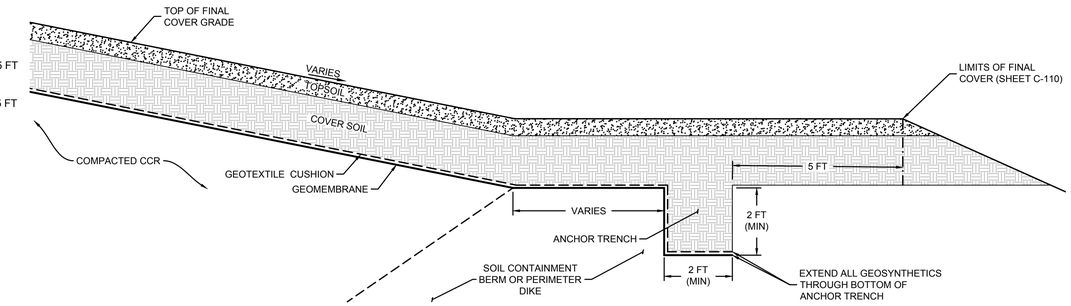
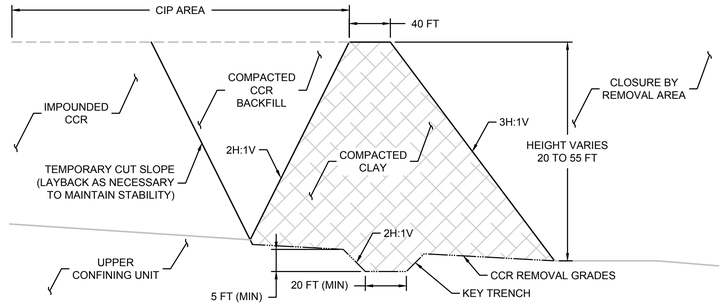
APPROVED BY:	LPC		



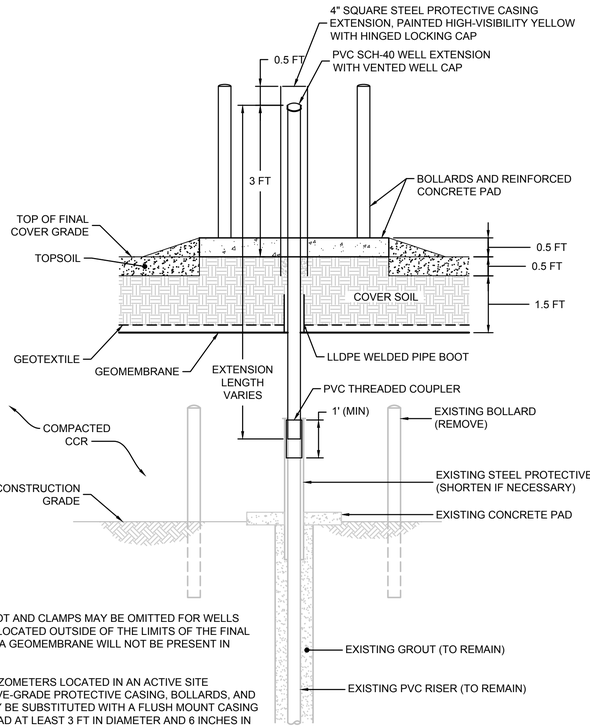
1 DETAIL
C-140,C-150 FINAL COVER
SCALE: N.T.S



2 DETAIL
C-140,C-150 ANCHOR TRENCH
SCALE: N.T.S



3 DETAIL
C-140,C-150 SOIL CONTAINMENT BERM AND KEY TRENCH
SCALE: N.T.S



NOTES:

1. THE LLDPE PIPE BOOT AND CLAMPS MAY BE OMITTED FOR WELLS AND PIEZOMETERS LOCATED OUTSIDE OF THE LIMITS OF THE FINAL COVER SYSTEM, AS A GEOMEMBRANE WILL NOT BE PRESENT IN THESE AREAS.
2. FOR WELLS AND PIEZOMETERS LOCATED IN AN ACTIVE SITE ROADWAY,THE ABOVE-GRADE PROTECTIVE CASING, BOLLARDS, AND CONCRETE PAD MAY BE SUBSTITUTED WITH A FLUSH MOUNT CASING AND A CONCRETE PAD AT LEAST 3 FT IN DIAMETER AND 6 INCHES IN THICKNESS. ALL OTHER DETAILS ARE TO REMAIN THE SAME.

4 DETAIL
C-120 STANDPIPE PIEZOMETER AND MONITORING WELL EXTENSION
SCALE: N.T.S

NOTES:

1. THE LLDPE PIPE BOOT AND CLAMPS MAY BE OMITTED FOR PIEZOMETERS LOCATED OUTSIDE OF THE LIMITS OF THE FINAL COVER SYSTEM, AS A GEOMEMBRANE WILL NOT BE PRESENT IN THESE AREAS.
2. FOR PIEZOMETERS LOCATED IN AN ACTIVE SITE ROADWAY,THE ABOVE-GRADE PROTECTIVE CASING, BOLLARDS, AND CONCRETE PAD MAY BE SUBSTITUTED WITH A FLUSH MOUNT CASING AND A CONCRETE PAD AT LEAST 3 FT IN DIAMETER AND 6 INCHES IN THICKNESS. ALL OTHER DETAILS ARE TO REMAIN THE SAME.

5 DETAIL
C-120 VIBRATING WIRE PIEZOMETER EXTENSION
SCALE: N.T.S

6 DETAIL
C-120 ACCESS ROAD
SCALE: N.T.S

MATERIAL SPECIFICATIONS

1. CRUSHED STONE
CRUSHED STONE IS TO CONSIST OF A SCREENED GRAVEL MATERIAL CONFORMING TO THE IDOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION SECTION 1004 REQUIREMENTS, GRADATION CA 6.

2. TOPSOIL
TOPSOIL IS TO CONSIST OF A NATURAL SOIL MATERIAL THAT IS RELATIVELY HOMOGENOUS, FREE OF DEBRIS, FOREIGN OBJECTS, AND LARGE ROCK FRAGMENTS. THE TOPSOIL IS TO:
-BE CLASSIFIED AS SC, CL, ML, OR OL (PER ASTM D2487), AND
-BE FERTILIZED, AS NECESSARY BASED ON AGRONOMIC TESTING, TO SUPPORT VEGETATION GROWTH AT THE SITE.

3. COVER SOIL
COVER SOIL IS TO CONSIST OF A NATURAL SOIL MATERIAL THAT IS RELATIVELY HOMOGENOUS, FREE OF DEBRIS, FOREIGN OBJECTS, AND LARGE ROCK FRAGMENTS. THE COVER SOIL IS TO:
-BE CLASSIFIED AS A CL, CH, CL-CH, CL-ML, SC, OR SM (PER ASTH D2487), AND
-HAVE A MAXIMUM PARTICLE SIZE OF 1.5 INCHES (PER ASTM D422 OR D6943).

4. COMPACTED CLAY
COMPACTED CLAY IS TO CONSIST OF A NATURAL SOIL THAT IS RELATIVELY HOMOGENOUS, FREE OF DEBRIS, FOREIGN OBJECTS AND LARGE ROCK FRAGMENTS. THE COMPACTED CLAY IS TO:
-BE CLASSIFIED AS A CL OR CH
-HAVE A PERMEABILITY OF NO HIGHER THAN $1x10^{6}$ CM PER SECOND (PER ASTM D5084)
-HAVE AN UNDRAINED SHEAR STRENGTH OF AT LEAST 2,500 PSF (PER ASTM D2850)
-PROVIDE A DRAINED SHEAR STRENGTH EQUIVALENT TO DRAINED FRICTION ANGLE OF AT LEAST 30 DEGREES AND AN EFFECTIVE COHESION OF 300 PSF (PER ASTM D4767)
-BE COMPACTED TO AT LEAST 95% OF THE STANDARD MOISTURE-DENSITY TEST (PER ASTM D698) AND AN APPROPRIATE MOISTURE CONTENT.

5. COMPACTED CCR
COMPACTED CCR IS TO CONSIST OF COAL COMBUSTION RESIDUALS, RESIDUAL COAL, AND NATIVE SUBGRADE MATERIALS EXCAVATED FROM WITHIN THE LIMITS OF THE EAP AND THE SOUTHEAST AREA. THE COMPACTED CCR IS TO:
-BE PLACED IN LOOSE LIFTS NOT TO EXCEED 2 FT IN THICKNESS.
-BE COMPACTED WITH AT LEAST 4 PASSES OF SMOOTH DRUM OR SHEEPSFOOT ROLLER, WITH COMPACTION VERIFIED VIA PROOF-ROLLING WITH A LOADED OFF-ROAD DUMP TRUCK UNTIL EXCESSIVE RUTTING DOES NOT OCCUR.

6. GEOTEXTILE (CUSHION AND SEPARATOR)
THE GEOTEXTILE IS TO CONSIST OF A NONWOVEN POLYPROPYLENE MATERIAL MANUFACTURED IN ACCORDANCE WITH THE LATEST VERSION OF GEOSYNTHETIC INSTITUTE GRI-GT12(A) STANDARD SPECIFICATION, AND WITH THE FOLLOWING REQUIREMENTS:
-MINIMUM MASS PER UNIT ARE OF 16 OZ/YD^{2} (PER ASTM D5261),
-MINIMUM GRAB STRENGTH OF 270 LB (PER ASTM D4632),
-MINIMUM TEAR STRENGTH OF 105 LB (PER ASTM D4533), AND
-MINIMUM PUNCTURE STRENGTH OF 725 LB (PER ASTM D6241).
GEOTEXTILE SEAMS ARE TO OVERLAPPED BY 1 FT DURING PLACEMENT AND EITHER MACHINE-SEWN OR THERMALLY BONDED TO ONE ANOTHER.

7. GEOMEMBRANE
THE GEOMEMBRANE IS TO CONSIST OF A LINEAR, LOW-DENSITY POLYETHYLENE (LLDPE) MATERIAL, TEXTURED ON BOTH SIDES, MANUFACTURED IN ACCORDANCE WITH THE LATEST VERSION OF GEOSYNTHETIC INSTITUTE GM17 STANDARD SPECIFICATION, AND WITH THE FOLLOWING REQUIREMENTS:
-MINIMUM NOMINAL THICKNESS OF 40 MIL (PER ASTM D5994),
-MINIMUM ASPERITY HEIGHT OF 16 MIL (PER ASTM D7466),
-MAXIMUM DENSITY OF 0.939 G/ML (PER ASTM D792, OR ASTM D1505),
-MINIMUM TENSILE STRENGTH AT BREAK OF 60 LB/IN (PER ASTM D6693),
-MINIMUM ELONGATION AT BREAK OF 250% (PER ASTM D6693), AND
-MINIMUM PUNCTURE RESISTANCE OF 44 LB (PER ASTM D3895).
GEOMEMBRANE SEAMS ARE TO BE FUSION-WELDED; REPAIRS AND PENETRATIONS FOR PIPE BOOTS ARE TO BE EXTRUSION WELDED.

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: DETAILS AND MATERIAL SPECIFICATION - 1 OF 3

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

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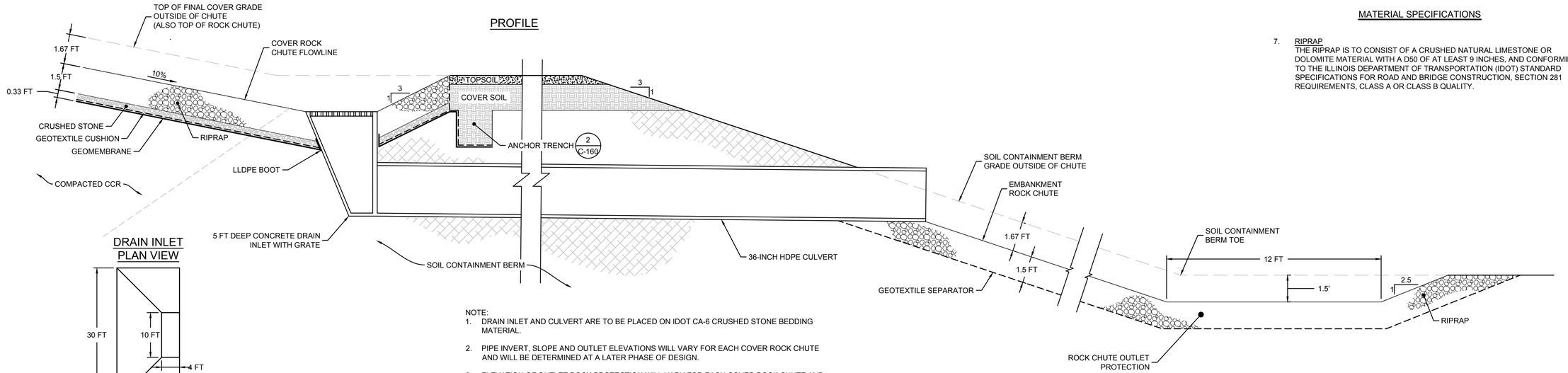
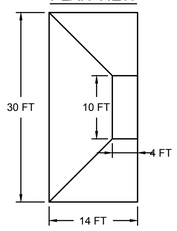
REVIEWED BY:	JPS	DRAWING NO.:	C-160
APPROVED BY:	LPC		

DRAFT - NOT FOR CONSTRUCTION

PROFILE



DRAIN INLET PLAN VIEW

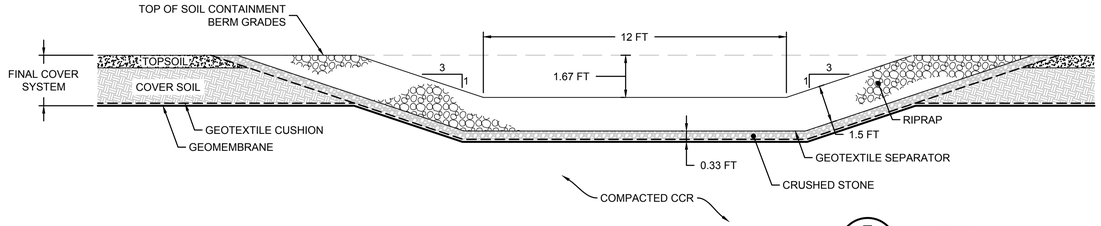


NOTE:
1. DRAIN INLET AND CULVERT ARE TO BE PLACED ON IDOT CA-6 CRUSHED STONE BEDDING MATERIAL.
2. PIPE INVERT, SLOPE AND OUTLET ELEVATIONS WILL VARY FOR EACH COVER ROCK CHUTE AND WILL BE DETERMINED AT A LATER PHASE OF DESIGN.
3. ELEVATION OF OUTLET ROCK PROTECTION WILL VARY FOR EACH COVER ROCK CHUTE AND WILL BE DETERMINED AT A LATER PHASE OF DESIGN.
4. THE LLDPE BOOT IS TO BE ATTACHED TO THE DRAIN INLET USING STAINLESS-STEEL SPREADER BARS, CONCRETE ANCHORS AND STAINLESS STEEL NUTS AND WASHERS. ALL ANCHOR PENETRATIONS THROUGH THE GEOMEMBRANE ARE TO BE SEALED WITH SILICONE.

MATERIAL SPECIFICATIONS

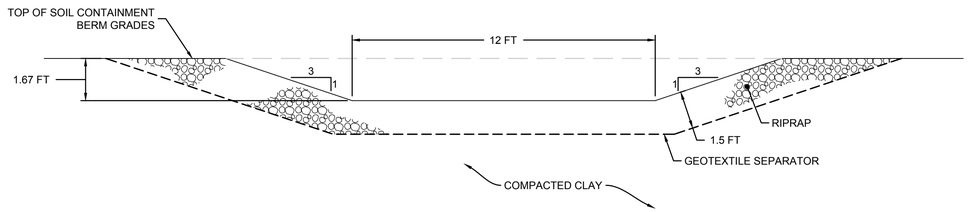
7. RIPRAP
THE RIPRAP IS TO CONSIST OF A CRUSHED NATURAL LIMESTONE OR DOLOMITE MATERIAL WITH A D50 OF AT LEAST 9 INCHES, AND CONFORMING TO THE ILLINOIS DEPARTMENT OF TRANSPORTATION (IDOT) STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, SECTION 281 REQUIREMENTS, CLASS A OR CLASS B QUALITY.

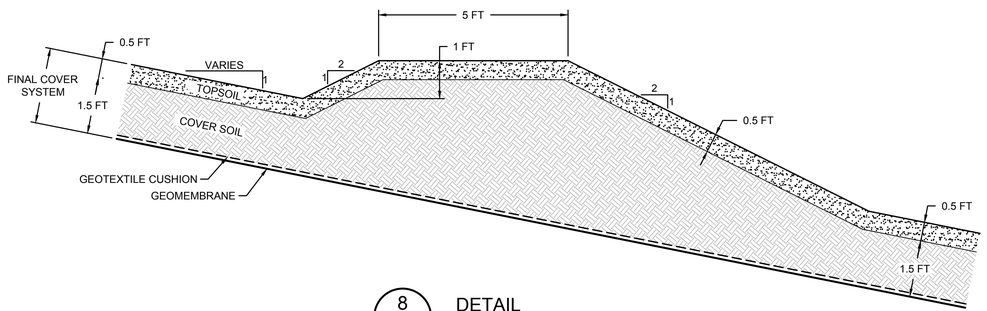
CROSS SECTION COVER ROCK CHUTE



7 C-170 DETAIL
SOIL CONTAINMENT BERM CULVERT AND CHUTES
SCALE: 1" = 2'

CROSS SECTION EMBANKMENT ROCK CHUTE





8 C-170 DETAIL
INTERCEPTOR BERM
SCALE: 1" = 2'

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600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
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ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: DETAILS AND MATERIAL SPECIFICATION - 2 OF 3

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS

SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

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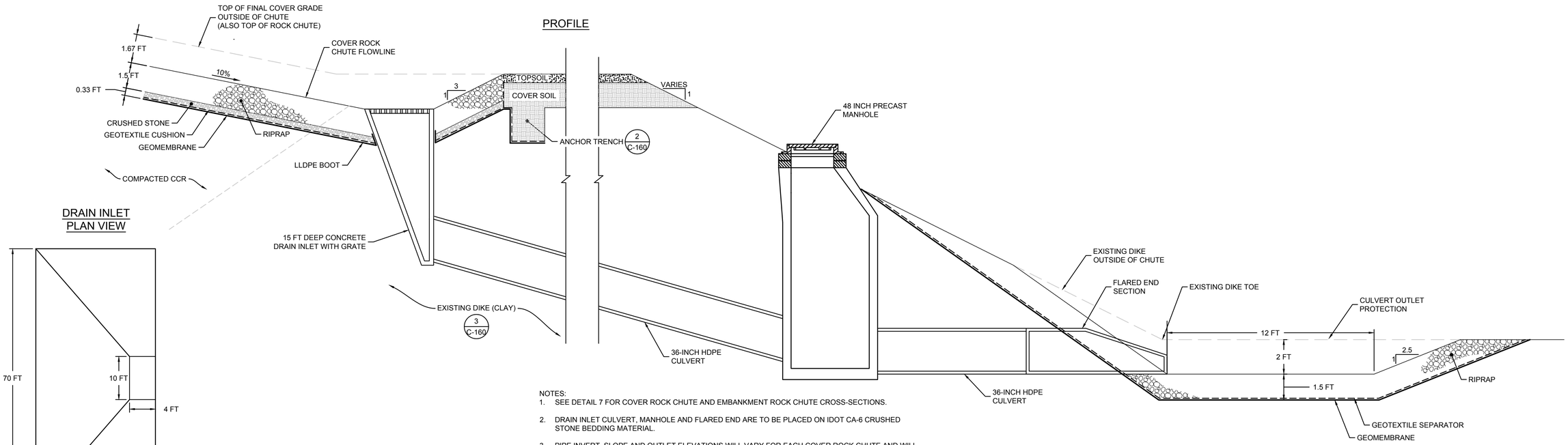

NOTES:

1. SEE DETAIL 7 FOR COVER ROCK CHUTE AND EMBANKMENT ROCK CHUTE CROSS-SECTIONS.
2. DRAIN INLET CULVERT, MANHOLE AND FLARED END ARE TO BE PLACED ON IDOT CA-6 CRUSHED STONE BEDDING MATERIAL.
3. PIPE INVERT, SLOPE AND OUTLET ELEVATIONS WILL VARY FOR EACH COVER ROCK CHUTE AND WILL BE DETERMINED AT A LATER PHASE OF DESIGN.
4. ELEVATION OF OUTLET ROCK PROTECTION WILL VARY FOR EACH COVER ROCK CHUTE AND WILL BE DETERMINED AT A LATER PHASE OF DESIGN.
5. THE LLDPE BOOT IS TO BE ATTACHED TO THE DRAIN INLET USING STAINLESS-STEEL SPREADER BARS, CONCRETE ANCHORS AND STAINLESS STEEL NUTS AND WASHERS. ALL ANCHOR PENETRATIONS THROUGH THE GEOMEMBRANE ARE TO BE SEALED WITH SILICONE.

9 / C-180 DETAIL

EXISTING DIKE (ED) STORMWATER (SW) STRUCTURES

SCALE: 1" = 3'

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2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: DETAILS AND MATERIAL SPECIFICATION - 3 OF 3

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

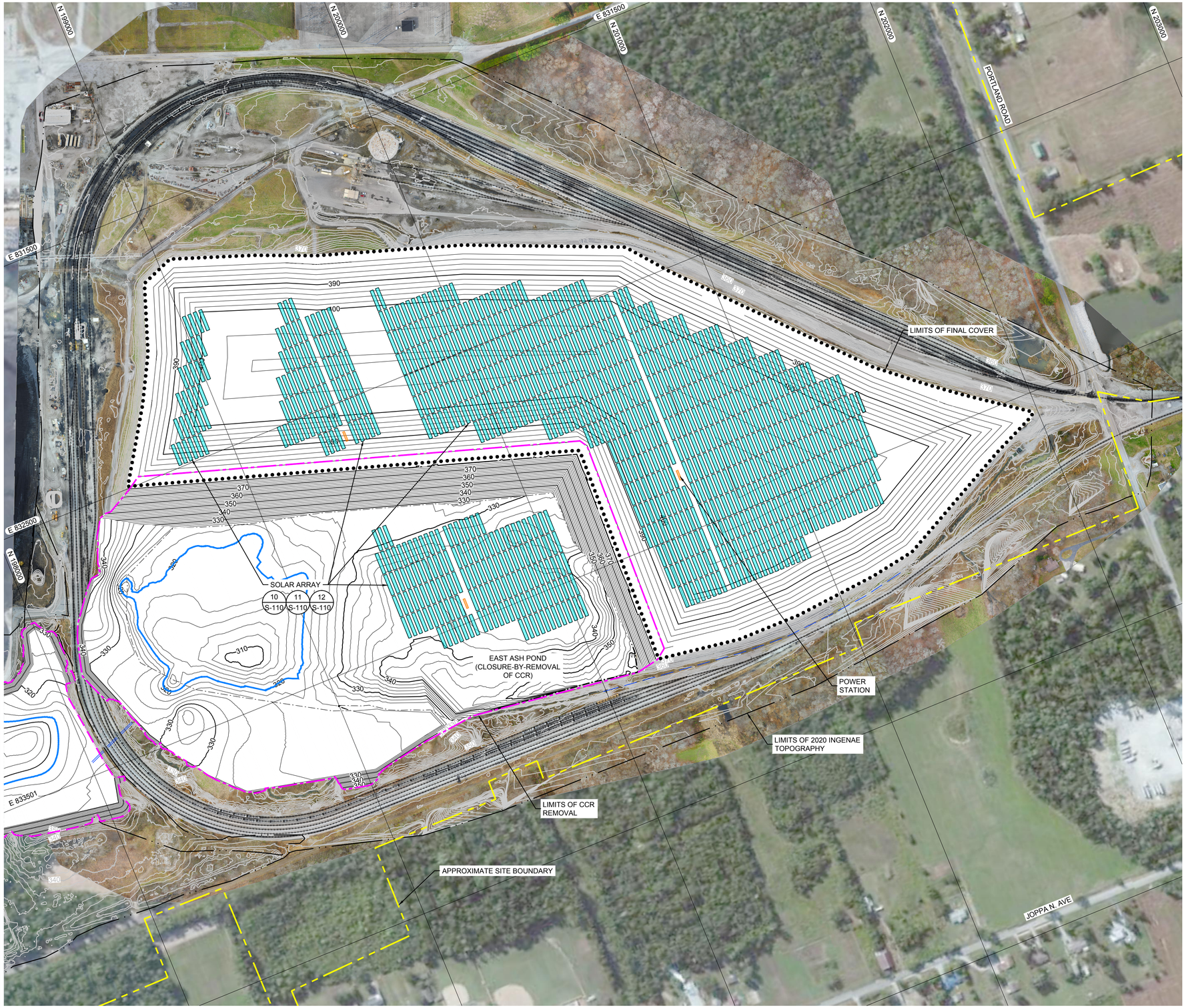
SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-180
REVIEWED BY:	JPS	DRAWING NO.:	C-180
APPROVED BY:	LPC		



DRAFT - NOT FOR CONSTRUCTION

N

LEGEND

- 350 — EXISTING GROUND SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
- 400 — PROPOSED SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
- LIMITS OF CCR REMOVAL
- APPROXIMATE SITE BOUNDARY
- TOPOGRAPHIC SURVEY LIMITS
- RAILROAD
- LIMITS OF FINAL COVER
- SOLAR PANEL
- POWER STATION

NOTES:

1. SEE SHEET C-120 FOR NOTES REGARDING THE COORDINATE SYSTEM AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS, UTILITY ALIGNMENTS, LIMITS OF CCR, CLOSURE BY REMOVAL GRADES, AND STORMWATER CHANNEL AND DETENTION BASIN ALIGNMENTS.
2. THE SOLAR LAYOUT AND OTHER INFORMATION WAS PROVIDED BY BURNS & McDONNELL IN JULY OF 2022. THE LAYOUT AND INFORMATION IS CONCEPTUAL IN NATURE AND IS FOR PLANNING PURPOSES ONLY.
3. THE DRAWING REPRESENTS A PROPOSED LAYOUT AND IS SUBJECT TO CHANGE BASED ON DETAILED DESIGN AND ACTUAL SITE CONDITIONS.

SOLAR INFORMATION		
POWER	RATED POWER (MWac)	13.9
	INSTALLED POWER (MWdc)	18.1
	DC:AC RATIO	1.3
	ESTIMATED ANNUAL ENERGY PRODUCTION (GWh)	25.3
EQUIPMENT ASSUMPTIONS	MODULE	FIRST SOLAR 480W
	INVERTER	SUNGROW 1100 kVA (Qty 12)
	RACKING	2V FIXED TILT
SITE INFO	ACREAGE (PANEL COVERAGE)	56 ACRES
	GROUND COVER RATIO	54%

0 200 400
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: SOLAR DEVELOPMENT PLAN

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

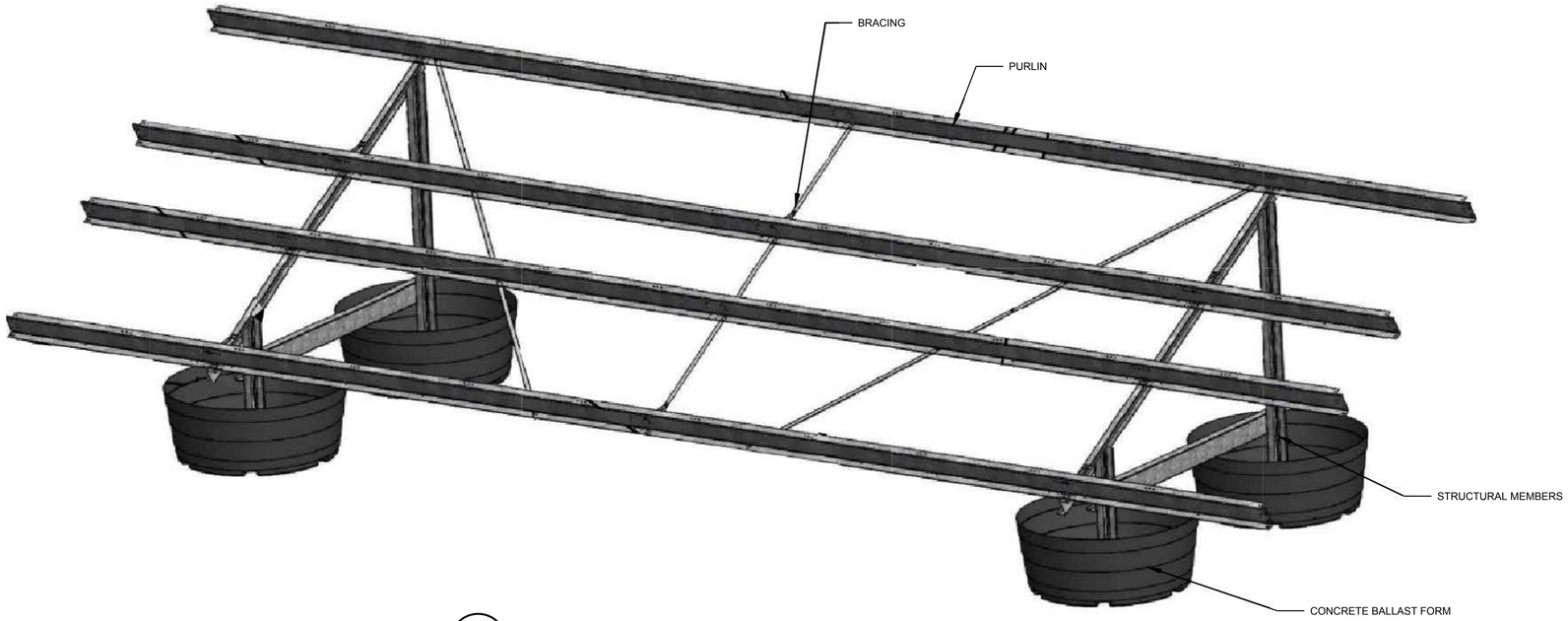
SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

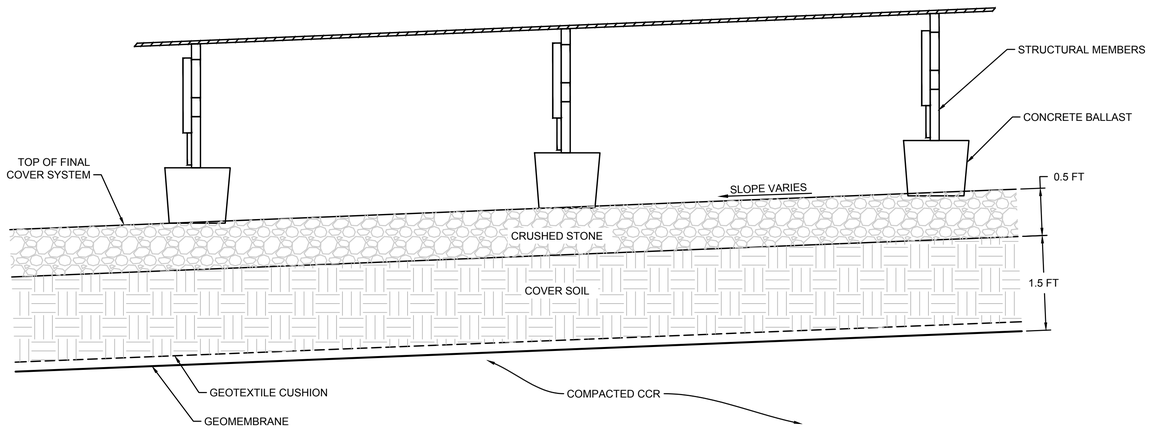
DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 S-100
REVIEWED BY:	JPS	DRAWING NO.:	S-100
APPROVED BY:	LPC		



10 S-110 DETAIL
TYPICAL FIXED TILT BALLAST RACKING
SCALE: NTS

12 S-110 DETAIL
TYPICAL SOLAR MODULE
SCALE: NTS



11 S-110 DETAIL
PROFILE VIEW OF BALLAST ON FINAL COVER SYSTEM
SCALE: NTS

NOTES:

1. THE SOLAR DETAILS WERE PROVIDED BY BURNS & McDONNELL IN JULY 2022. THE DETAILS ARE CONCEPTUAL IN NATURE AND ARE FOR PLANNING PURPOSES ONLY.
2. THE DETAILS REPRESENT PROPOSED CONDITIONS AND ARE SUBJECT TO CHANGE BASED ON DETAILED DESIGN AND ACTUAL SITE CONDITIONS.

DRAFT - NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: SOLAR DEVELOPMENT DETAILS

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

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SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 S-110
REVIEWED BY:	JPS	DRAWING NO.:	S-110
APPROVED BY:	LPC		

Geosyntec
consultants

ATTACHMENT D

CCR Investigation and Delineation Report

July 2022

Prepared for

Electric Energy, Inc.
2100 Portland Road
Joppa, Illinois 62953

CCR INVESTIGATION AND DELINEATION REPORT

JOPPA POWER PLANT
EAST ASH POND
(IEPA ID W1270100004-02)
Joppa, Illinois

Prepared by

Geosyntec consultants
engineers | scientists | innovators

600 Roselane Court
Farmington, MO 63640

Project Number GLP8025

Revision 0

July 25, 2022

TABLE OF CONTENTS

1. Introduction and Background 2
1.1. Report Contents 2

2. Existing Data Sources and Historical CCR Placement 3
2.1. Existing Data Sources 3
2.2. CCR Outside of the EAP Dike Limits 3

3. 2022 Geosyntec Subsurface Investigation 5
3.1. Hand Augers 5
3.2. DPT Borings 5
3.3. Summary of Subsurface Conditions 6

4. Development of Three-Dimensional Subsurface Models 7
4.1. Individual Surfaces 7
4.2. Bottom of Clay 9
4.3. Volume Estimates 9

5. Summary and Recommendations 11

6. References 12

FIGURES

Figure 1 Site Plan
Figure 2 Bottom of CCR Elevations within EAP
Figure 3 Top and Bottom of CCR Elevations within Southeast Area – North
Figure 4 Top and Bottom of CCR elevations within Southeast Area – South
Figure 5 Bottom of Clay

TABLES

Table 1 Existing Subsurface Investigation Data
Table 2 2022 Southeast Area Investigation Data

ATTACHMENTS

Attachment A Compiled Existing Data Sources
Attachment B 2022 Geosyntec Investigation and Soil Sample Photographs
Attachment C 2022 Geosyntec Boring Logs

1. INTRODUCTION AND BACKGROUND

Electric Energy, Inc. (EEI) is the owner of the coal-fired Joppa Power Plant (JPP), also referred to as Joppa Power Station, in Joppa, Illinois. The JPP is currently active, although EEI intends to cease the generation of electricity by September of 2022. EEI intends to complete closure of the East Ash Pond (EAP) at the JPP (IEPA ID No. W1270100004-02, EEI CCR Unit ID 401, and National Inventory of Dams Number IL50714). Closure of the EAP will be performed under the relevant Illinois Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845) [1] and the United States Environmental Protection Agency (USEPA) CCR Rule [2].

The evaluation of closure alternatives and closure design requires the delineation of the lateral and vertical extents of coal combustion residuals (CCRs) contained both within and outside of the limits of the EAP. The delineation is required to support groundwater modeling, the development of permit-level closure design drawings, supporting closure alternatives assessments that consider the total volume of CCR that must be either closed in-place or closed-by-removal, and performing geotechnical assessments. Additionally, the delineation of the interface between fine-grained clay and coarse-grained sand foundation soils beneath the EAP was required for performing geotechnical assessments.

This report summarizes the existing data sources, a subsurface investigation program completed by Geosyntec in 2022, and the procedures used to develop three-dimensional models of the bottom of CCR, top of CCR, and bottom of foundation clay (e.g., top of coarse-grained sand foundation soils) units within and outside of the limits of the EAP.

1.1. Report Contents

The following information is contained within this report:

- **Section 1** includes the introduction and background.
- **Section 2** includes a summary of existing data sources utilized by Geosyntec and areas where CCR is known to be present within and outside the limits of the EAP.
- **Section 3** includes a summary of subsurface investigations completed by Geosyntec in 2022 to support CCR delineation.
- **Section 4** includes an overview of the development of three-dimensional subsurface models for use in design and estimates of CCR volumes.
- **Section 5** includes a summary of this CCR delineation and recommendations for further phases of work.

2. EXISTING DATA SOURCES AND HISTORICAL CCR PLACEMENT

2.1. Existing Data Sources

Multiple existing data sources, including topographic data and subsurface explorations, were utilized as part of the CCR delineation. These data sources included:

- Topographic Ground Surface Data
    - Light detection and ranging (LIDAR) topographical and bathymetric survey data of the EAP and immediate surrounding areas collected in December 2020 by IngenAE, LLC (IngenAE) [3], representing existing topographical conditions.
    - LIDAR topographical data of the area outside of the EAP collected in 2012 by the State of Illinois [4], representing existing topographical conditions beyond the limits of the IngenAE survey.
    - United States Geological Survey (USGS) topographic maps dated 1932 [5], representing topographical conditions prior to construction of the EAP.
    - Design drawings for the EAP perimeter dike, dated 1973 and 1982, showing topographical conditions prior to construction of the EAP in some areas and conditions prior to construction of dike raises in other areas ([6], [7], [8]).
    - The topographic ground surface data is provided in **Attachment A**.
- Subsurface Explorations
    - Geotechnical borings and cone penetration tests (CPTs) performed in and around the EAP in 2015 and 2016 by AECOM [9].
    - Geotechnical borings and monitoring well installations performed in and around the EAP by Geosyntec in 2021 [10].
    - The existing subsurface explorations are summarized in **Table 1**, shown in plan on **Figure 1**, and provided in **Attachment A**.

2.2. CCR Outside of the EAP Dike Limits

CCR is known to be located both within and outside the limits of the existing EAP perimeter dikes. The CCR located outside of the EAP perimeter dikes is herein referred to as the “Southeast Area”, and is subdivided into the following sub-areas:

- The Southeast Area – North is approximately 21 acres in size and is located between the southeastern corner of the EAP perimeter dikes and the railroad loop embankment.

- The Southeast Area – South is approximately 11 areas in size and is located south of the Southeast Area – North, between the railroad loop embankment and the Ohio River.

The limits of the Southeast Area – North and Southeast Area – South are shown in plan on **Figure 1**.

3. 2022 GEOSYNTEC SUBSURFACE INVESTIGATION

While subsurface investigation data was available within the footprint of the existing EAP, limited subsurface investigation data was available for the Southeast Area – North and no subsurface investigation data was available for the Southeast Area – South. To support the delineation of the horizontal and vertical extents of CCR within these areas, Geosyntec completed a subsurface investigation program using hand augers and direct push technology (DPT) borings in March and April of 2022, as described in this section.

Hand auger and DPT information is summarized in **Table 2**; the locations of the investigations are shown on **Figure 1**; photographs collected during the investigation program, including photographs of soil samples, are provided in **Attachment B**. The subsurface investigation logs are provided in **Attachment C**.

3.1. Hand Augers

A total of 13 hand augers were completed by Geosyntec in March and April 2022 (HA-01 through HA-13). The hand augers were advanced using a 3-inch diameter auger to depths ranging from 2.5 to 7.5 ft below grade. The hand augers were generally advanced to below the bottom of observed CCR materials, or until either refusal or borehole collapse occurred. Material obtained from each hand auger was observed and photographed by Geosyntec to develop a log of subsurface conditions at each hand auger location. Hand auger locations backfilled with soil cuttings and their locations were surveyed by IngenAE.

3.2. DPT Borings

A total of 11 DPT borings were completed by Geosyntec in April 2022 (GEO-01 and GEO-06 through GEO-15[1]). The DPT borings were advanced using either a track-mounted or skid-steer mounted direct-push drilling rig subcontracted to Roberts Environmental Drilling, Inc., with a borehole diameter of 2.25 inches and a soil sample diameter of 1.5 inches. The DPTs were advanced to depth ranging from 17.0 to 23.9 ft below grade, until refusal occurred on dense or stiff subsurface materials that the DPT was unable to penetrate. Soil obtained from each DPT was observed and photographed by Geosyntec to develop a log of subsurface conditions at each boring location. DPT locations were backfilled with bentonite chips and their locations were surveyed by IngenAE.

[1] DPT borings GEO-02 through GEO-05 were initially proposed and staked in the field but were unable to be accessed due to steep slopes and equipment access considerations. Therefore, DPTs were not advanced at these locations.

3.3. Summary of Subsurface Conditions

CCR and/or coal fines were encountered in hand augers HA-02, HA-03, and HA-04, but were not encountered in HA-01. CCR and/or coal fines were encountered in GEO-01 and GEO-09 through GEO-15), but not in GEO-06 through GEO-08.

Where the CCR and coal fines were encountered (which are herein jointly referred to as "CCR"), they were typically mixed and/or interbedded with soil and alluvial sediments into a single stratum. The CCR was generally observed to overly fine-grained native foundation soils, although CCR was encountered directly overlying alluvial sand in GEO-14. Photographs showing the interbedded and layered nature of the CCR and soil sediments are provided in **Attachment B**.

4. DEVELOPMENT OF THREE-DIMENSIONAL SUBSURFACE MODELS

Three-dimensional models of the bottom of CCR, top of CCR, and bottom of foundation clay were developed and volumes of CCR were estimated utilizing AutoCAD Civil 3D computer aided design (CAD) [11] and geographic information system (GIS) software. The three-dimensional models were generated utilizing available topographical and subsurface data obtained from others and collected by Geosyntec in 2021 and 2022. Where GIS was utilized, three-dimensional models were developed and interpolated from available data using a combination of the kriging method within Earth Volumetric Studio (EVS) [12] and the topo to raster method within ArcMap GIS software [13].

Three laterally-separate bottom of CCR surfaces were developed, including the Bottom of CCR within the EAP, the Bottom of CCR in the Southeast Area – North, Bottom of CCR in the Southeast Area – South. Additionally, a Top of CCR surface was developed in the Southeast Area – North, to delineate where the perimeter dike raise [6] was constructed over existing CCR. A Bottom of Clay surface was developed with lateral extents that were similar to all three of the Bottom of CCR surfaces.

4.1. Individual Surfaces

Four separate three-dimensional model surfaces, each representing the bottom of CCR that was indicated from the source data, were developed utilizing available topographic, bathymetric, and subsurface investigation data. Each of the surfaces included three separate sub-surfaces, with adjacent but not overlapping lateral extents, including the Bottom of CCR within the EAP, Bottom of CCR in the Southeast Area – North, and Bottom of CCR in the Southeast Area – South. Two Bottom of Clay surfaces were developed, including one surface for the EAP and the Southeast Area – North, and one surface for the Southeast Area – South. Procedures used to develop each of the four surfaces are described below.

- Existing Conditions Surface
    - The 2020 IngenAE LIDAR and bathymetric survey [3] was used to represent existing topographical conditions, including the ground surface beneath impounded water within the EAP.
    - The 2012 State of Illinois LIDAR survey [4] was used to represent existing topographical conditions in the Southeast Area – South, beyond the limits of the IngenAE survey.
        - It should be noted that this LIDAR survey was collected in an area of dense vegetation and may have been collected during a high-water event on the Ohio River, therefore the actual existing ground surface elevations may vary from this survey.

- Pre-Construction Surface
    - The 1932 USGS topographical map [5] was digitized and used to represent approximate conditions prior to construction of the EAP, and ground surface elevations and the presumed top-of-clay prior to the deposition of CCR into the EAP and the Southeast Area.
- Intermediate EAP Operations Surface
    - Design drawings for the construction of the EAP embankment and dike raises from 1973 [7] and 1982 [8] were digitized and were used to represent conditions during operation of the EAP.
        - These drawings showed pre-construction ground surfaces in some areas, but not all, of the EAP, and ground surface during intermediate operation of the EAP in other areas. Therefore, they represent the presumed top-of-clay prior to the deposition of CCR into these areas.
- Subsurface Investigation Surface
    - Composite surfaces were developed using observed bottom-of-CCR data, and, for the southeast Area – North, top-of-CCR data from subsurface investigations, including the sources listed below.
        - A total of 53 geotechnical borings and CPTs performed in and around the EAP in 2015 and 2016 by AECOM [9].
        - A total of three geotechnical borings and monitoring well installations performed in and around the EAP in 2021 by Geosyntec [10].
        - The 24 hand augers and DPTs advanced by Geosyntec in 2022, as described in **Section 3**.
- Each of the four surfaces were compared, and, where the surface intersected, the lowest elevation surface was conservatively assumed to represent the bottom of CCR.
- Where the CCR was adjacent to the earthen EAP dikes, the interior slopes of the interface between the dikes and CCR was assumed to be 1.5H:1V (horizontal to vertical) based on design drawings [7].
- Within the Southeast Area, the lateral limits of the CCR were developed based on the observed boring data (e.g., where CCR was no longer located in borings), and based on an

examination of the existing conditions topography (e.g., CCR was not assumed to be present beyond the horizontal limits of the valley floor outside of the creek channel).

- Additionally, CCR was not assumed to be present beneath the rail loop, as CCR was not observed beneath the rail loop in limited subsurface investigations completed along the edges of the rail loop fill by AECOM in 2015 [9].

The resulting composite bottom-of-CCR and top-of-CCR surfaces were then constructed and are provided in **Figures 2**, **3**, and **4**.

4.2. Bottom of Clay

A composite Bottom-of-Clay surface was developed using bottom-of-clay observed from subsurface investigation data, using the same data sources as utilized for the bottom-of-CCR described in **Section 4.1**.

The bottom-of-clay was defined by Geosyntec by reviewing each boring or CPT log and identifying where the clay transitioned to a material which was sandier in nature and expected to behave in a drained manner during geotechnical loading conditions. It should be noted that Geosyntec's bottom-of-clay surface is similar, but not the same, as the top of the uppermost aquifer evaluated by others. This is because Geosyntec's surface is based on a geotechnical assessment of the foundation soils, considering shear strength, rather than a hydrogeological assessment, which would be based on permeability.

The resulting surface is provided in **Figure 5**. Similar to the CCR surfaces, Geosyntec did not extend the surface beneath the rail loop, due to relatively limited subsurface investigation data indicating the bottom of clay in that area.

4.3. Volume Estimates

The surfaces described in **Section 4.1** were used to estimate the volume of CCR present within the EAP, in the Southeast Area – North, and in the Southeast Area – South. Each volume estimate was performed using CAD. Estimated volumes are summarized is described below.

- The volume of CCR within the EAP was estimated to be 5.8 million cubic yards, by comparing the existing conditions topographic and bathymetric survey [3] and the bottom of CCR surface.

- The volume of CCR in the Southeast Area – North was estimated to be 80,000 cubic yards, by comparing the existing conditions topographic survey [3], the bottom of CCR surface, and the top of CCR surface.

- The volume of CCR in the Southeast Area – South was estimated to be 450,000 cubic yards, by comparing the existing conditions topographic survey [4] and the bottom of CCR surface.

5. SUMMARY AND RECOMMENDATIONS

Geosyntec developed three-dimensional models to delineate the vertical and horizontal extents of CCR within the EAP, the Southeast Area – North, and the Southeast Area – South using available:

- Existing subsurface investigation data;
- Subsurface investigation data collected by Geosyntec in 2022; and
- Available recent and historical topographical and bathymetric survey data.

These three-dimensional model surfaces were used to estimate volumes of CCR present within the EAP (5.8 million cubic yards), in the Southeast Area – North (80,000 cubic yards), and in the Southeast Area – South (450,000 cubic yards).

These three-dimensional models should be considered approximate and were based on the best available data. However, subsurface investigation data is not currently available to verify the surfaces within significant areas of the EAP, and the scope of the subsurface investigation for the Southeast Area – North and Southeast Area – South was limited due to site access concerns. Additionally, the existing ground surface elevations within the Southeast Area – South may vary from the 2012 State of Illinois LIDAR survey of the area. Therefore, the actual bottom of CCR, top of CCR, bottom of clay, and volumes of CCR may vary from these surfaces and estimates. If a refined estimate of the bottom of CCR and/or bottom of clay is required, additional subsurface investigation data should be collected and the surfaces presented in this report should be updated, as and if appropriate.

6. REFERENCES

[1] Illinois Environmental Protection Agency, "35 Ill. Adm. Code Part 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments," Springfield, IL, 2021.

[2] United Stated Environmental Protection Agency, "40 CFR Parts 257 and 261, Hazardous and Solid Waste Management System, Disposal of Coal Combustion Residuals from Electric Utilities, Final Rule, 2015," 2015.

[3] IngenAE, LLC, Electric Engergy, Inc., Joppa Power Station, December 2020 Topography, 2021.

[4] Illinois Geospatial Data Clearinghouse, "Massac, 2012," 2012. [Online]. Available: Massac, 2012 | clearinghouse.isgs.illinois.edu.. [Accessed 2022].

[5] United States Geologic Survey (USGS), L.A. Center Kentucky-Illinois Quandrangle, 1932.

[6] AECOM, "History of Construciton, USEPA Final CCR Rule, 40 CFR § 257.73(c), Joppa Power Station, Joppa, Illinois," October 2016.

[7] Wapora, Inc., Electric Energy, Inc. East Ash Pond Plan, Sections and Details, 1973.

[8] Electric Energy, Inc., Joppa, IL, East Ash Pond, 4229-8211, 1982.

[9] AECOM, CCR Certification Report: Initial Structural Stability Assessment, Initial Factor of Safetey Assessment, and Initial Inflow Design Flood Control System Plan for East CCR Pond at Joppa Power Station, 2016.

[10] Geosyntec Consultants, Illinois Administrative Code Part 845 Data Gap Analysis - Site: Joppa East Pond-CCR Unit 401, 2021.

[11] Autodesk, *AutoCAD Civil3D,* San Rafael, CA, 2022.

[12] C Tech Development Corporation, *Earth Volumetric Studio, Version 2021.4.3,* Las Vegas, 2021.

[13] ESRI, *ArcMap, Version 10.8.1,* Redlands, California, 2020.

FIGURES

N

Legend

- Geosyntec Boring Locations
- AECOM Boring Locations
- Limits of EAP
- Limits of Southeast Area - North
- Litmits of Southeast Area - South
- Rail Loop

NOTES:
1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.
2.THE EXTENTS OF CCR PRESENTED IN THESE DRAWINGS SHOULD BE CONSIDERED APPROXIMATE, DUE TO LIMITED INVESTIGATION DATA TO CONFIRM THE EXTENTS OF CCR.

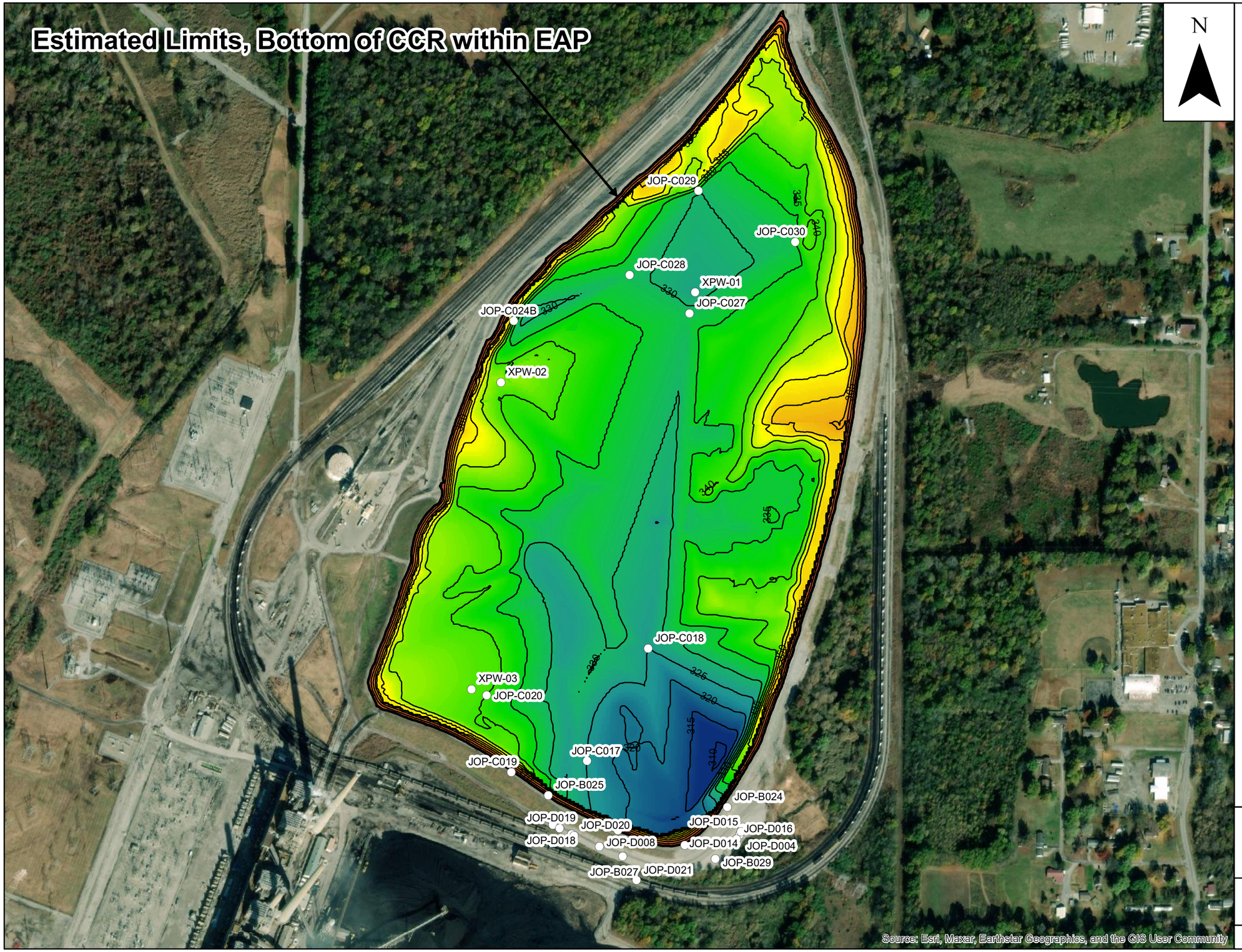
0 810 1,620
Feet

Site Plan
East Ash Pond
Joppa Power Plant
Joppa, Illinois

Geosyntec consultants

Figure **1**

GLP8025 | 6/1/2022



Legend

High : 377.2 (ft)

Low : 308.8 (ft)

Bottom of CCR Encountered in Subsurface Investigation

NOTES:
1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.
2.THE BOTTOM-OF-CCR SURFACE PRESENTED IN THIS FIGURE IS BASED ON LIMITED SUBSURFACE INVESTIGATION DATA, MULTIPLE HISTORICAL TOPOGRAPHIC SURVEYS AND OTHER TYPES OF INFORMATION, AND SHOULD BE CONSIDERED APPROXIMATE. ACTUAL BOTTOM-OF-CCR ELEVATIONS MAY VARY FROM WHAT IS PRESENTED IN THIS FIGURE.

0 425 850 Feet

Bottom of CCR Elevations within EAP, Joppa Power Plant Joppa, Illinois

Geosyntec consultants

Figure **2**

GLP8025 | 6/1/2022

Top of CCR Elevation
Southeast Area - North

HA-05
HA-04
JOP-C018
JOP-C017
JOP-B025
JOP-D017
JOP-D019
JOP-D018
JOP-B017
JOP-D020
JOP-B026
JOP-D008
JOP-B027
JOP-B030
JOP-D015
JOP-B001
JOP-D014
JOP-D016
JOP-D004
JOP-B029
JOP-D009
JOP-B021
JOP-B028
JOP-D021
JOP-B024
GEO-01
HA-03
322
323
324
325
326
327
328
329
330
331
336
338
317
316
318
320
321

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Bottom of CCR Elevation
Southeast Area - North

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

N

Legend

- Top of CCR Encountered in Subsurface Investigation
- Bottom of CCR Encountered in Subsurface Investigation

Top of CCR

Value

High : 345.6 (ft)

Low : 314.6 (ft)

Bottom of CCR

High : 338.3 (ft)

Low : 313.0 (ft)

NOTES:
1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.
2.THE BOTTOM-OF-CCR AND TOP-OF-CCR SURFACES PRESENTED IN THIS FIGURE ARE BASED ON LIMITED SUBSURFACE INVESTIGATION DATA, MULTIPLE HISTORICAL TOPOGRAPHIC SURVEYS, AND OTHER TYPES OF INFORMATION, AND SHOULD BOTH BE CONSIDERED APPROXIMATE. ACTUAL BOTTOM-OF-CCR AND TOP-OF-CCR ELEVATIONS MAY VARY FROM WHAT IS PRESENTED IN THIS FIGURE.

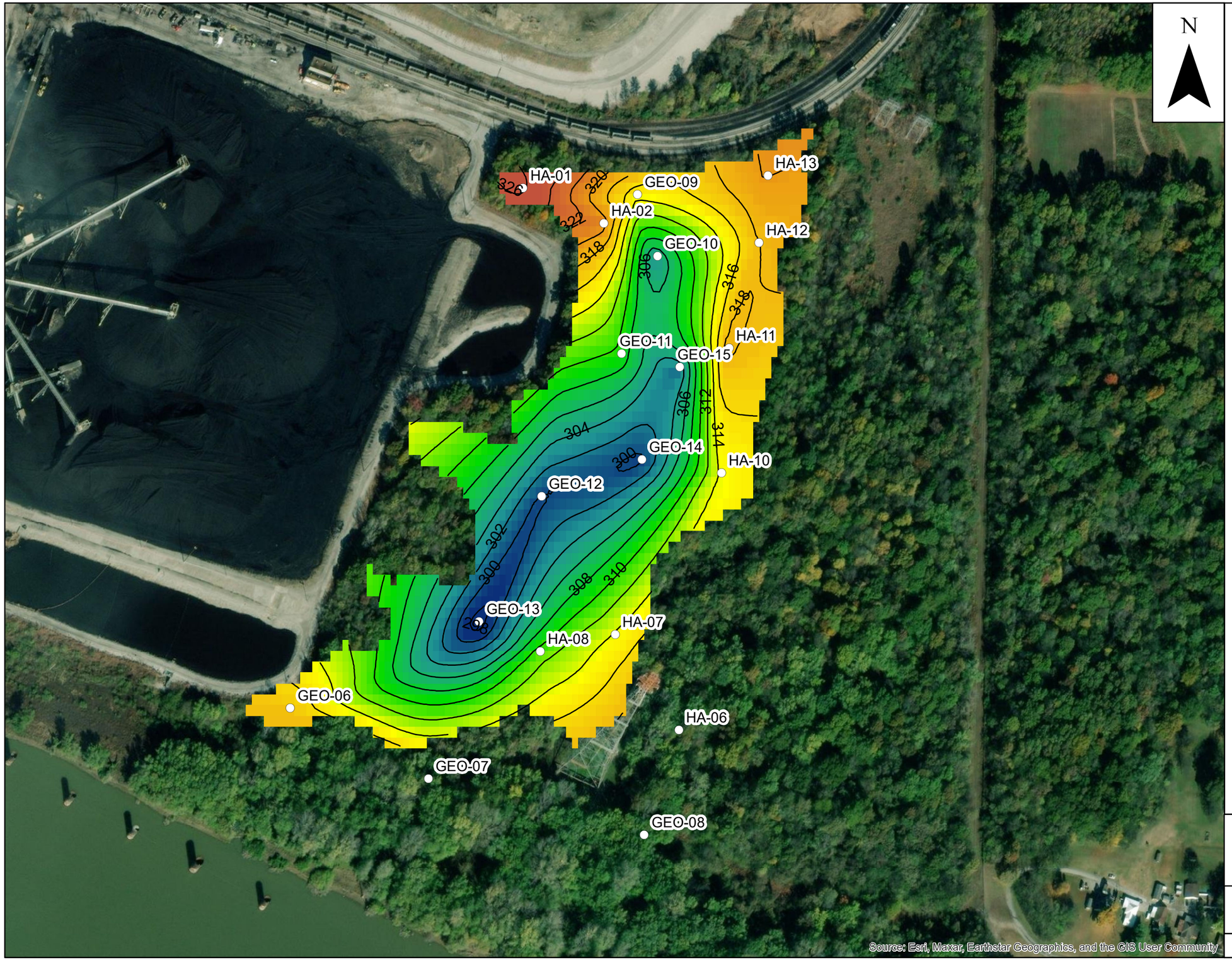
0 225 450
Feet

Top and Bottom of CCR Elevations within Southeast Area - North
East Ash Pond, Joppa Power Plant, Joppa, Illinois

Geosyntec consultants

GLP8025 | 6/1/2022

Figure **3**



Legend

Bottom of CCR Encountered in Subsurface Investigation

Bottom of CCR

High : 326.4 (ft)

Low : 296.7 (ft)

NOTES:
1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.
2.THE BOTTOM-OF-CCR AND TOP-OF-CCR SURFACES PRESENTED IN THIS FIGURE ARE BASED ON LIMITED SUBSURFACE INVESTIGATION DATA, MULTIPLE HISTORICAL TOPOGRAPHIC SURVEYS AND OTHER TYPES OF INFORMATION, AND SHOULD BE CONSIDERED APPROXIMATE. ACTUAL BOTTOM-OF-CCR AND TOP-OF-CCR ELEVATIONS MAY VARY FROM WHAT ARE PRESENTED IN THIS FIGURE.

0 225 450

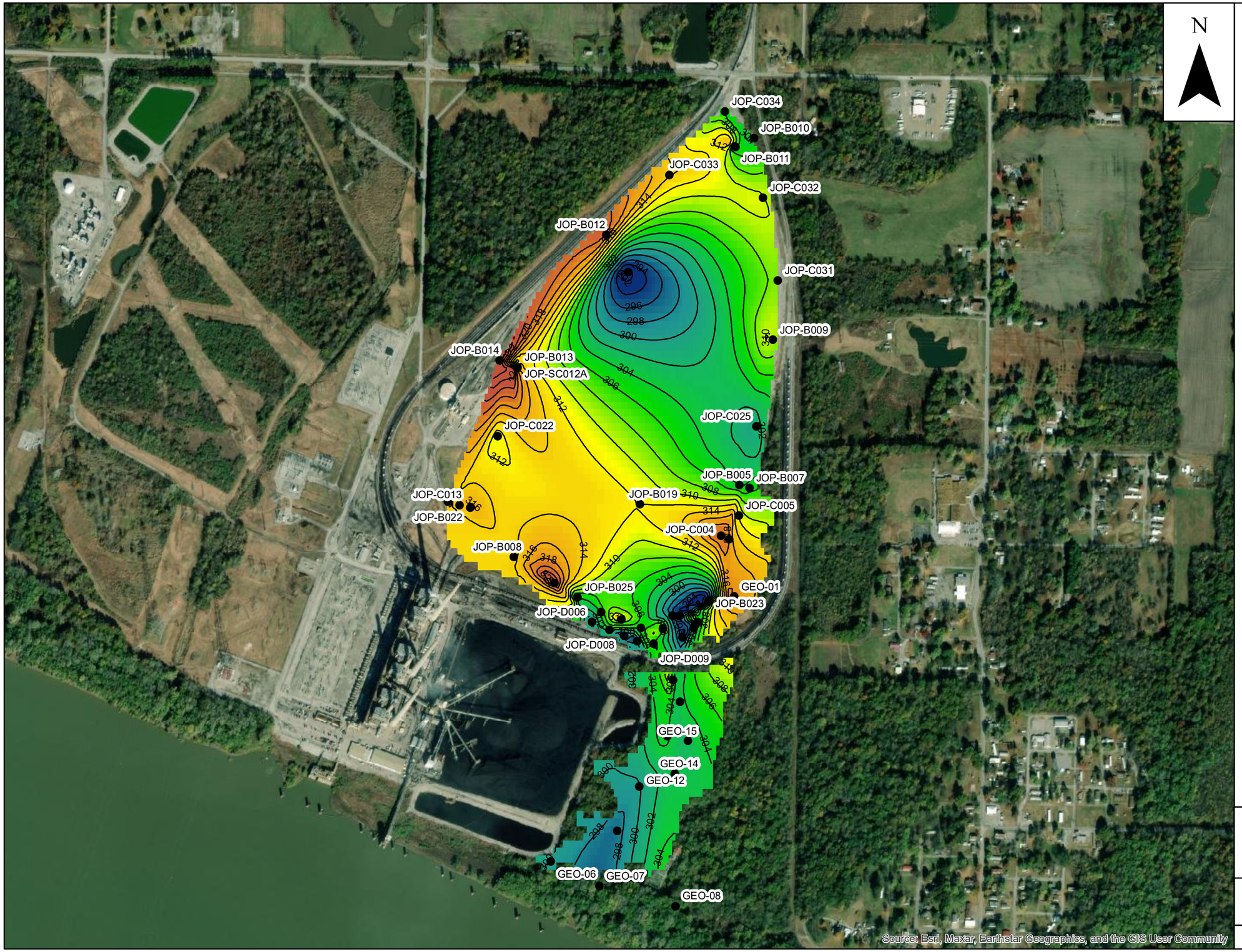
Feet

Bottom of CCR Elevations within Southeast Area - South East Ash Pond, Joppa Power Plant Joppa, Illinois

Geosyntec consultants

Figure 4

GLP8025 | 6/1/2022



Legend

High : 328.7 (ft)

Low : 290.8 (ft)

Bottom of Clay Encoutered in Subsurface Investigation

NOTES:
1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.
2.THE BOTTOM-OF-CLAY SURFACE PRESENTED IN THIS FIGURE IS BASED ON LIMITED SUBSURFACE INVESTIGATION DATA AND SHOULD BE CONSIDERED APPROXIMATE. ACTUAL BOTTOM-OF-CLAY ELEVATIONS MAY VARY FROM WHAT IS PRESENTED IN THIS FIGURE.

0 680 1,360 Feet

Bottom of Clay Elevations
East Ash Pond
Joppa Power Plant
Joppa, Illinois

Geosyntec consultants

Figure **5**

GLP8025 | 6/1/2022

Geosyntec
consultants

TABLES

July 2022

Table 1: Existing Investigation Data

Exploration ID	Northing (ft NAD83)	Easting (ft NAD83)	Ground Surface Elevation (ft NAVD88)	Estimated Layer Elevations (ft NAVD88)		
				Bottom of CCR	Top of CCR in SE Dike	Bottom of Clay
2015 AECOM Investigation						
JOP-B001	198,339.4	833,368.3	333.6	315.6	327.6	290.1
JOP-B002	198,526.7	833,473.7	341.5	NE	NA	285.6
JOP-B004	198,426.3	833,270.9	379.0	310.0	314.5	290.5
JOP-B005	199,345.5	833,690.4	379.9	NE	NA	303.9
JOP-B006	198,964.5	833,617.0	357.1	NE	NA	320.1
JOP-B007	199,326.6	833,760.8	347.6	NE	NA	303.6
JOP-B008	198,838.5	832,101.2	380.4	NE	NA	312.4
JOP-B009	200,368.5	833,926.1	378.8	NE	NA	310.3
JOP-B010	201,791.2	833,794.1	350.0	NE	NA	303.5
JOP-B011	201,732.5	833,659.5	380.0	NE	NA	316.5
JOP-B012	201,111.0	832,753.5	379.6	NE	NA	321.6
JOP-B013	200,176.2	832,128.5	379.3	NE	NA	307.3
JOP-B014	200,225.8	832,001.4	361.8	NE	NA	329.8
JOP-B015	199,187.8	831,795.1	380.3	NE	NA	316.8
JOP-B017	198,369.4	832,674.8	347.2	339.2	342.2	NE
JOP-B018	198,450.7	832,716.5	378.6	NE	NA	303.1
JOP-B019	199,211.3	832,989.8	376.1	325.1	NA	312.1
JOP-B020	198,337.4	832,996.0	378.1	NE	NA	305.1
JOP-B021	198,247.4	832,969.4	344.0	330.5	338.0	296.0
JOP-B022	199,227.6	831,636.1	353.4	NE	NA	314.1
JOP-B023	198,526.7	833,473.7	341.5	300.5	NA	292.5
JOP-C004	198,989.8	833,562.6	380.6	NE	NA	320.8
JOP-C005	199,130.6	833,688.6	344.0	NE	NA	316.5
JOP-C013	199,204.9	831,720.2	354.0	NE	NA	314.0
JOP-C017	198,703.0	832,722.1	377.6	334.1	NA	NE
JOP-C018	199,199.8	832,990.7	376.2	325.2	NA	0.0
JOP-C019	198,655.5	832,387.7	380.0	380.0	NA	326.3
JOP-C020	198,992.1	832,279.5	378.8	345.3	NA	NE
JOP-C021	198,847.0	832,092.2	380.0	380.0	NA	0.0
JOP-C022	199,692.4	831,988.8	379.5	379.5	NA	310.7
JOP-C024	200,642.3	832,399.8	373.8	327.8	NA	NE
JOP-C024A	200,642.3	832,399.8	373.8	373.8	NA	NE
JOP-C024B	200,642.3	832,399.8	373.8	373.8	NA	NE
JOP-C025	199,758.8	833,810.6	380.3	380.3	NA	300.3
JOP-C027	200,675.5	833,173.1	380.5	331.5	NA	0.0
JOP-C028	200,844.1	832,909.1	373.4	331.4	NA	290.4
JOP-C029	201,214.5	833,211.5	373.0	330.0	NA	NE
JOP-C030	200,989.8	833,638.7	371.7	332.2	NA	NE
JOP-C031	200,786.5	833,960.8	378.7	NE	NA	308.2
JOP-C032	201,370.3	833,857.1	381.2	NE	NA	310.7
JOP-C033	201,531.9	833,197.9	379.4	NE	NA	314.9
JOP-C034	201,978.0	833,588.0	380.3	NE	NA	305.8
JOP-B027	198,284.6	832,878.2	343.5	330.5	337.0	297.5
JOP-B028	198,333.0	833,152.3	378.0	NE	NA	310.0
JOP-B030	198,426.6	833,218.3	381.0	312.0	NA	298.0
JOP-D006	198,380.9	832,653.7	346.4	NE	NA	298.9
JOP-D008	198,327.8	832,775.7	345.9	337.9	345.4	303.9
JOP-D009	198,230.3	833,085.6	341.6	322.8	NA	307.1
JOP-D012	198,422.2	833,411.4	337.5	336.5	337.0	NE
JOP-D013	198,400.8	833,404.0	335.9	332.9	335.4	NE
JOP-D014	198,411.3	833,407.5	336.0	332.7	333.7	NE
JOP-D015	198,391.0	833,399.3	335.3	315.8	332.3	NE
JOP-D016	198,359.4	833,380.5	333.4	NE	327.4	311.4
2021 Geosyntec Investigation						
XPW-01	200,767.2	833,197.3	380.7	326.7	NA	NE
XPW-02	200,371.3	832,342.6	373.2	345.4	NA	NE
XPW-03	199,020.7	832,213.2	378.6	341.6	NA	NE

NA = Not applicable
NE = Not encountered

Table 2 – SE Investigation Data

Exploration ID	Northing (ft NAD83)	Easting (ft NAD83)	Ground Surface Elevation (ft NAVD88)	Total Depth (ft NAVD88)	Estimated Layer Elevations (ft NAVD88)	
					Bottom of CCR	Bottom of Clay
GEO-01	198,560.1	833,653.8	328.9	19.9	323.4	318.4
GEO-06	196,693.9	832,361.5	319.2	22.5	317.7	300.2
GEO-07	196,518.8	832,703.9	319.1	23.9	NE	295.6
GEO-08	196,378.4	833,240.6	321.4	19.9	NE	306.9
GEO-09	197,970.7	833,223.6	323.0	17.0	314.5	309.5
GEO-10	197,817.7	833,273.4	321.6	19.4	303.6	302.6
GEO-11	197,575.3	833,184.1	320.0	19.1	309.5	305.0
GEO-12	197,220.8	832,985.3	318.0	19.5	299.5	NE
GEO-13	196,909.6	832,830.1	314.5	18.0	296.5	NE
GEO-14	197,312.2	833,234.8	319.1	19.9	299.2	303.1
GEO-15	197,541.7	833,329.0	321.1	19.8	301.3	302.1
HA-01	197,986.0	832,939.4	330.9	4.3	326.4	NE
HA-02	197,899.2	833,140.2	326.3	6.0	321.3	NE
HA-03	198,550.8	833,663.0	327.1	5.0	323.6	NE
HA-04	199,050.8	833,715.1	328.0	7.0	321.5	NE
HA-05	199,281.8	833,847.8	329.9	2.5	NE	NE
HA-06	196,640.7	833,326.7	322.2	7.0	NE	NE
HA-07	196,877.1	833,168.5	315.8	2.2	314.3	NE
HA-08	196,834.6	832,982.8	314.5	4.0	311.2	NE
HA-09	196,906.5	832,831.8	324.6	3.0	NE	NE
HA-10	197,278.7	833,432.3	319.1	6.5	314.1	NE
HA-11	197,589.6	833,451.3	321.2	7.5	318.7	NE
HA-12	197,849.9	833,526.1	322.5	4.8	317.7	NE
HA-13	198,018.0	833,548.3	323.1	4.0	320.1	NE

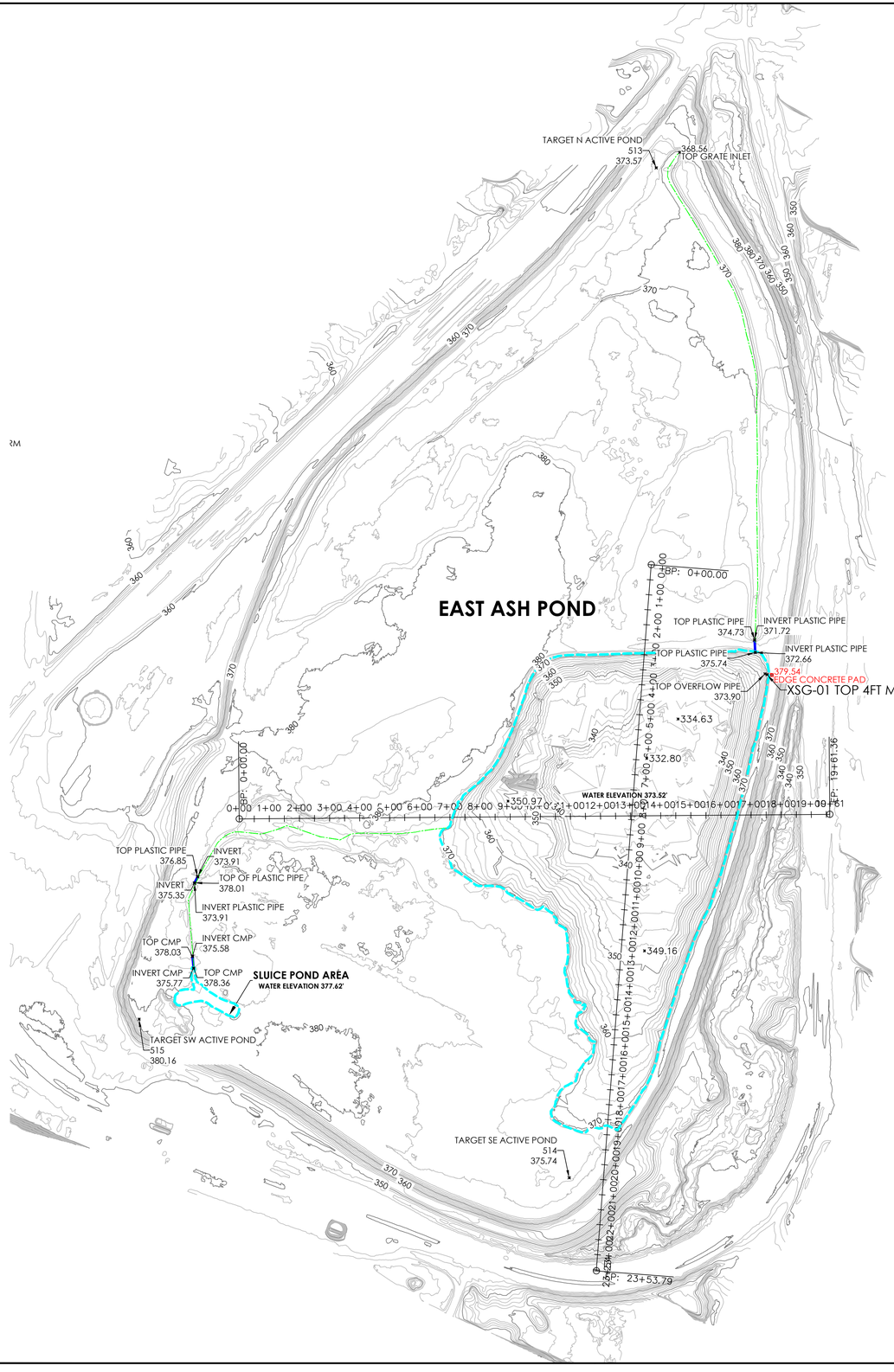
NE = Not encountered

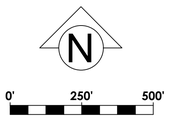
Attachment A

Compiled Data Sources

Attachment A.1

2020 IngenAE Topographic and Bathymetric Survey





LEGEND

- EXISTING CONTOUR (2' INTERVAL)
- EXISTING CONTOUR (10' INTERVAL)
- LIMITS OF BATHYMETRIC SURVEY
- PIPING
- DRAINAGE SWALE
- CONCRETE
- MANHOLE

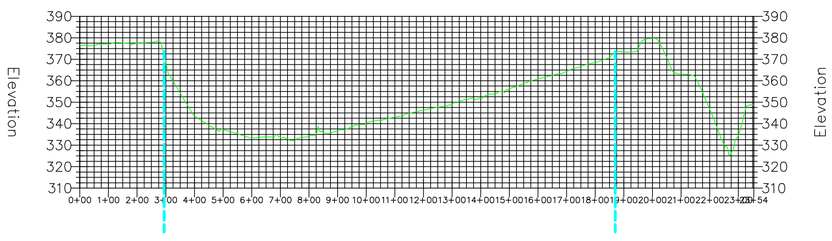
NOTES:

1. THIS EXHIBIT REPRESENTS A TOPOGRAPHIC FIELD SURVEY AND IS NOT INTENDED TO BE A BOUNDARY SURVEY.
2. TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/8/2020 & 12/9/2020.
3. NO UNDERGROUND OR OVERHEAD UTILITIES WERE LOCATED DURING THIS SURVEY.

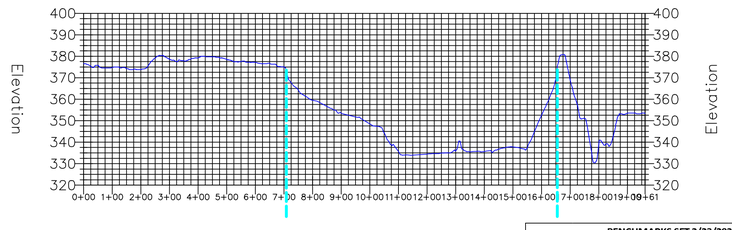
Aerial Target Point Table

Point #	Northing	Easting	Elevation	Description
503	205054.12	826315.63	385.29	7002 IPIN TARGET NW
505	204043.40	826300.71	362.47	7001 IPIN TARGET WEST SIDE
506	203554.60	827437.98	364.92	TARGET SE AT LANDFILL
507	201597.03	829627.78	366.07	TARGET BY SEWER PONDS
508	200907.92	831134.32	362.36	TARGET ON BERM
509	198555.06	829233.33	344.04	TARGET SW OLD POND
513	201797.05	833491.00	373.57	TARGET N ACTIVE POND
514	198440.74	833202.06	375.74	TARGET SE ACTIVE POND
515	198967.84	831773.64	380.16	TARGET SW ACTIVE POND

CROSS SECTION A–A PROFILE



CROSS SECTION B–B PROFILE



BENCHMARKS SET 2/23/2021 BY INGENAE

POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
1013	200113.0	833859.3	375.78	XSG-01 TOP 4FT MARK ON GAUGE

IngenAE
502 Earth City Plaza, Suite 120
Earth City, MO 63045
www.ingenae.com

Submissions / Revisions: Date:

1		
2		
3		
4		
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9		
10		
11		
12		
13		

Luminant

Project Name & Location:

JOPPA
POWER STATION

2100 PORTLAND ROAD
JOPPA, IL 62953

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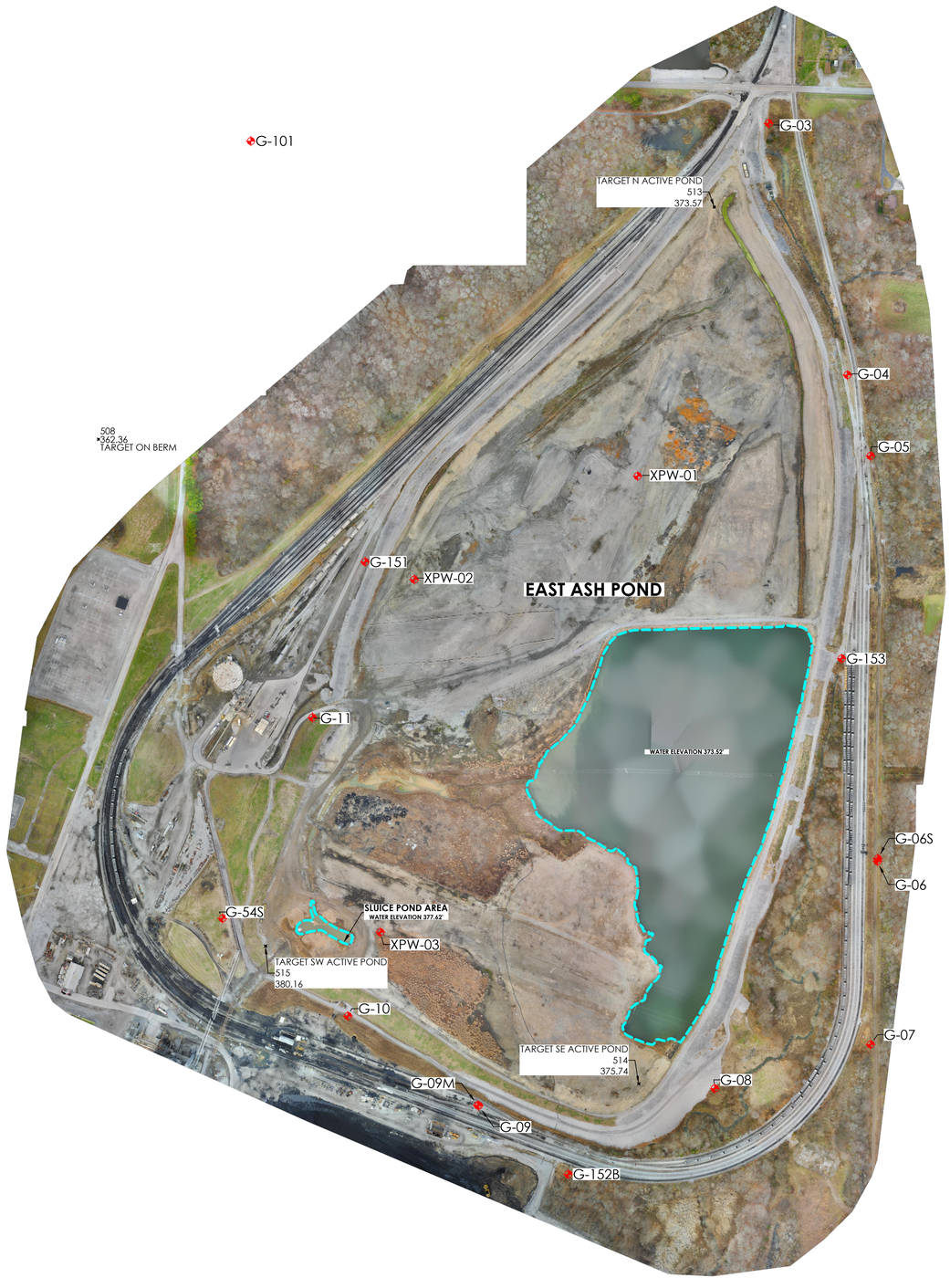
Drawing Name:

EXISTING TOPOGRAPHY EAST ASH POND

Date: 5/20/2021	Project No.
Type: SITE	Drawing No. 6
Drawn By: CB	
Approved By: BH	
Scale: AS NOTED	



N

0' 250' 500'

LEGEND

LIMITS OF BATHYMETRIC SURVEY

WELLS

NOTES:

1. EXISTING AERIAL SHOWN ARE FROM AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/18/2020.
2. THE WELL LOCATIONS AND ELEVATIONS, BORING LOCATIONS AND BENCHMARK DATA WAS RETRIEVED IN SUBSEQUENT SURVEYS DONE BY INGENAE DATED FEBRUARY 23, 2021 & March 22, 2021.

Aerial Target Point Table

Point #	Northing	Easting	Elevation	Description
503	205054.12	826315.63	385.29	7002 IPIN TARGET NW
505	204043.40	826300.71	362.47	7001 IPIN TARGET WEST SIDE
506	203554.60	827437.98	364.92	TARGET SE AT LANDFILL
507	201597.03	829627.78	366.07	TARGET BY SEWER PONDS
508	200907.92	831134.32	362.36	TARGET ON BERM
509	198555.06	829233.33	344.04	TARGET SW OLD POND
513	201797.05	833491.00	373.57	TARGET N ACTIVE POND
514	198440.74	833202.06	375.74	TARGET SE ACTIVE POND
515	198967.84	831773.64	380.16	TARGET SW ACTIVE POND

WELL LOCATION POINT TABLE

POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
1061	202117.8	833699.1	354.84	G-03 GROUND
1062	202117.8	833699.1	355.49	G-03 TOP CONCRETE
1063	202117.8	833699.1	358.56	G-03 TOP METAL CASING
1064	202117.8	833699.1	357.87	G-03 TOP PVC WELL
1041	201154.3	834001.0	356.15	G-04 GROUND
1042	201154.3	834001.0	356.72	G-04 TOP CONCRETE
1043	201154.3	834001.0	359.53	G-04 TOP METAL CASING
1044	201154.3	834001.0	359.07	G-04 TOP PVC WELL
1045	200844.2	834088.7	358.45	G-05 GROUND
1046	200844.2	834088.7	358.92	G-05 TOP CONCRETE
1047	200844.2	834088.7	361.68	G-05 TOP METAL CASING
1048	200844.2	834088.7	361.21	G-05 TOP PVC WELL
1060	199292.6	834115.5	352.60	G-06 GROUND
1059	199292.6	834115.5	353.27	G-06 TOP CONCRETE
1058	199292.6	834115.5	355.65	G-06 TOP METAL CASING
1057	199292.6	834115.5	355.24	G-06 TOP PVC WELL
1053	199302.8	834116.6	352.47	G-06S GROUND
1054	199302.8	834116.6	353.17	G-06S TOP CONCRETE
1055	199302.8	834116.6	355.92	G-06S TOP METAL CASING
1056	199302.8	834116.6	355.35	G-06S TOP PVC WELL
1049	198590.8	834089.4	350.34	G-07 GROUND
1050	198590.8	834089.4	350.86	G-07 TOP CONCRETE
1051	198590.8	834089.4	353.86	G-07 TOP METAL CASING
1052	198590.8	834089.4	353.53	G-07 TOP PVC WELL
1034	198423.0	833492.8	341.72	G-08 GROUND
1035	198423.0	833492.8	341.98	G-08 TOP CONCRETE
1036	198423.0	833492.8	344.22	G-08 TOP METAL CASING
1037	198423.0	833492.8	343.54	G-08 TOP PVC WELL
1026	198356.9	832589.5	348.69	G-09 GROUND
1027	198356.9	832589.5	349.24	G-09 TOP CONCRETE
1028	198356.9	832589.5	351.99	G-09 TOP METAL CASING
1029	198356.9	832589.5	351.70	G-09 TOP PVC WELL
1033	198358.8	832585.2	348.60	G-09M GROUND
1032	198358.8	832585.2	349.21	G-09M TOP CONCRETE
1031	198358.8	832585.2	351.88	G-09M TOP METAL CASING
1030	198358.8	832585.2	351.53	G-09M TOP PVC WELL
1022	198700.5	832089.0	350.75	G-10 GROUND
1023	198700.5	832089.0	351.11	G-10 TOP CONCRETE
1024	198700.5	832089.0	353.83	G-10 TOP METAL CASING
1025	198700.5	832089.0	353.49	G-10 TOP PVC WELL
1030	202049.5	831717.0	361.03	G-101 GROUND
1031	202049.5	831717.0	363.72	G-101 TOP METAL CASING
1032	202049.5	831717.0	363.47	G-101 TOP PVC COUPLING WELL
1014	199843.0	831952.8	363.38	G-11 GROUND
1015	199843.0	831952.8	363.78	G-11 TOP CONCRETE
1016	199843.0	831952.8	366.88	G-11 TOP METAL CASING
1017	199843.0	831952.8	366.55	G-11 TOP TOP PVC WELL
1024	200806.9	829139.4	356.52	G-111 GROUND
1025	200806.9	829139.4	359.13	G-111 TOP METAL CASING
1026	200806.9	829139.4	358.97	G-111 TOP PVC WELL
1027	198552.2	829088.3	323.46	G-112C GROUND
1028	198552.2	829088.3	326.31	G-112C TOP METAL CASING
1029	198552.2	829088.3	325.89	G-112C TOP PVC WELL
1020	199599.9	830365.7	350.59	G-113 GROUND
1021	199599.9	830365.7	352.95	G-113 TOP METAL CASING
1022	199599.9	830365.7	352.91	G-113 TOP PVC COUPLING WELL
1033	200438.6	832154.5	360.79	G-151 GROUND
1034	200438.6	832154.5	363.55	G-151 TOP METAL CASING
1035	200438.6	832154.5	363.38	G-151 TOP PVC COUPLING WELL
1039	198094.5	832931.7	345.84	G-152B GROUND
1040	198094.5	832931.7	347.99	G-152B TOP METAL CASING
1041	198094.5	832931.7	347.56	G-152B TOP PVC COUPLING WELL
1036	200068.3	833978.7	351.56	G-153 GROUND
1037	200068.3	833978.7	354.32	G-153 TOP METAL CASING
1038	200068.3	833978.7	354.11	G-153 TOP PVC COUPLING WELL
1018	199073.9	831608.8	353.58	G-54S GROUND
1019	199073.9	831608.8	353.75	G-54S TOP CONCRETE
1020	199073.9	831608.8	356.93	G-54S TOP METAL CASING
1021	199073.9	831608.8	356.57	G-54S TOP PVC WELL
1001	199376.8	828684.5	346.96	TPZ-114 GROUND
1002	199376.8	828684.5	350.58	TPZ-114 TOP METAL CASING
1003	199376.8	828684.5	349.95	TPZ-114 TOP PVC WELL
1015	198505.9	830005.0	343.26	TPZ-116 GROUND
1016	198505.9	830005.0	346.02	TPZ-116 TOP METAL CASING
1017	198505.9	830005.0	345.77	TPZ-116 TOP PVC WELL
1008	197896.0	829988.7	347.48	TPZ-117 GROUND
1009	197896.0	829988.7	350.09	TPZ-117 TOP METAL CASING
1010	197896.0	829988.7	349.55	TPZ-117 TOP PVC WELL
1011	197891.5	829987.2	347.26	TPZ-117D GROUND
1012	197891.5	829987.2	349.84	TPZ-117D TOP METAL CASING
1013	197891.5	829987.2	349.27	TPZ-117D TOP PVC WELL
1001	200767.2	833197.3	380.75	XPW-01 GROUND
1002	200767.2	833197.3	381.22	XPW-01 TOP CONCRETE
1003	200767.2	833197.3	383.82	XPW-01 TOP METAL CASING
1004	200767.2	833197.3	383.36	XPW-01 TOP PVC WELL
1005	200371.3	832342.6	373.23	XPW-02 GROUND
1006	200371.3	832342.6	373.77	XPW-02 TOP CONCRETE
1007	200371.3	832342.6	376.53	XPW-02 TOP METAL CASING
1008	200371.3	832342.6	376.05	XPW-02 TOP PVC WELL
1009	199020.7	832213.2	378.65	XPW-03 GROUND
1010	199020.7	832213.2	379.18	XPW-03 TOP CONCRETE
1011	199020.7	832213.2	382.04	XPW-03 TOP METAL CASING
1012	199020.7	832213.2	381.52	XPW-03 TOP PVC WELL
1004	200570.4	830167.2	361.43	XTPW-01 GROUND
1005	200570.4	830167.2	364.08	XTPW-01 TOP METAL CASING
1006	200570.4	830167.2	363.52	XTPW-01 TOP PVC WELL

IngenAE
502 Earth City Plaza, Suite 120
Earth City, MO 63045
www.ingenae.com

Submissions / Revisions: Date:

1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		

Luminant

Project Name & Location:

JOPPA
POWER STATION

2100 PORTLAND ROAD
JOPPA, IL 62953

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www.ingenae.com

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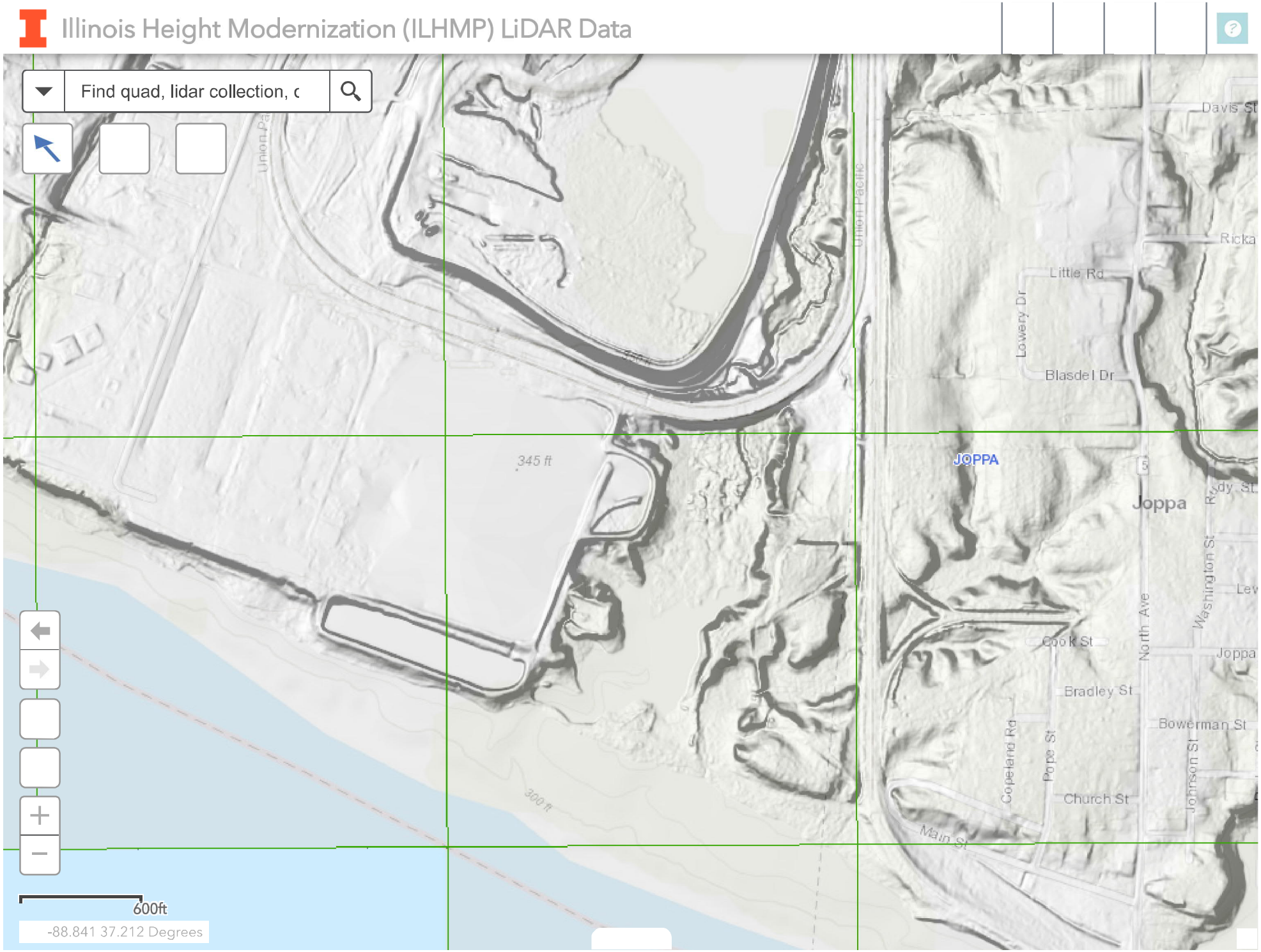
Drawing Name:

AERIAL PHOTOGRAPHY
EAST ASH POND

Date: 5/20/2021	Project No.
Type: SITE	Drawing No. 7
Drawn By: CB	
Approved By: BH	
Scale: AS NOTED	

Attachment A.2

2012 State of Illinois LIDAR Topography


Illinois Height Modernization (ILHMP) LiDAR Data
Find quad, lidar collection, c
Union Pacific
Davis St
Ricka
Little Rd
Lowery Dr
Blasdel Dr
345 ft
JOPPA
Joppa
Cook St
North Ave
Washington St
Joppa
Bradley St
Bowerman St
Copeland Rd
Pope St
Church St
Johnson St
Main St
300 ft
600ft
-88.841 37.212 Degrees

Attachment A.3

1932 USGS Topographical Map

U. S. Geol. Survey.

"UNIVERSITY OF WISCONSIN"
Department of Geography

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

STATE OF KENTUCKY
KENTUCKY GEOLOGICAL SURVEY
WILLARD ROUSE JILLSON
DIRECTOR AND STATE GEOLOGIST

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
M.F. WALSH, DIRECTOR
GEOLOGICAL SURVEY DIVISION, M.M. LEIGHTON, CHIEF, URBANA, ILLINOIS

KENTUCKY-ILLINOIS
LA CENTER QUADRANGLE

(Dongola) (Vienna) (Brownfield) (Cairo) (Padwoah)

GRAND CHAIN 1½ MI.

HARRISBURG 12 MI.
VIENNA 12 MI.

METROPOLIS 1 MI.
PADUCAH 11 MI.

CAIRO 12 MI.
BARLOW 3 MI.

WICKLIFFE 6 MI.

PADUCAH 8 MI.
NASHVILLE 180 MI.
LOUISVILLE 295 MI.

89°00' 37°15' 55' 50' 88°45' 37°15' 37°00'

R. 2 E. R. 3 E. R. 4 E.

T. 14 S. T. 15 S. T. 16 S.

15 Miles

1580000 YARDS

1005000 YARDS

Topography by J.E. Blackburn, R.A. Kiger, W.J. Lloyd, J.A. Duck, and Frank Lamer
Culture and drainage in Illinois in part compiled from aerial photographs taken by Air Corps, U.S. Army
Control by U.S. Geological Survey and Corps of Engineers, U.S. Army
Surveyed in 1926 and 1928

APPROXIMATE MEAN DECLINATION, 1928

Scale 1/62500

1 0 1 2 3 4 Miles
5000 0 5000 10000 15000 20000 Feet
1 0 1 2 3 4 5 Kilometers

Contour interval 20 feet
Datum is mean sea level

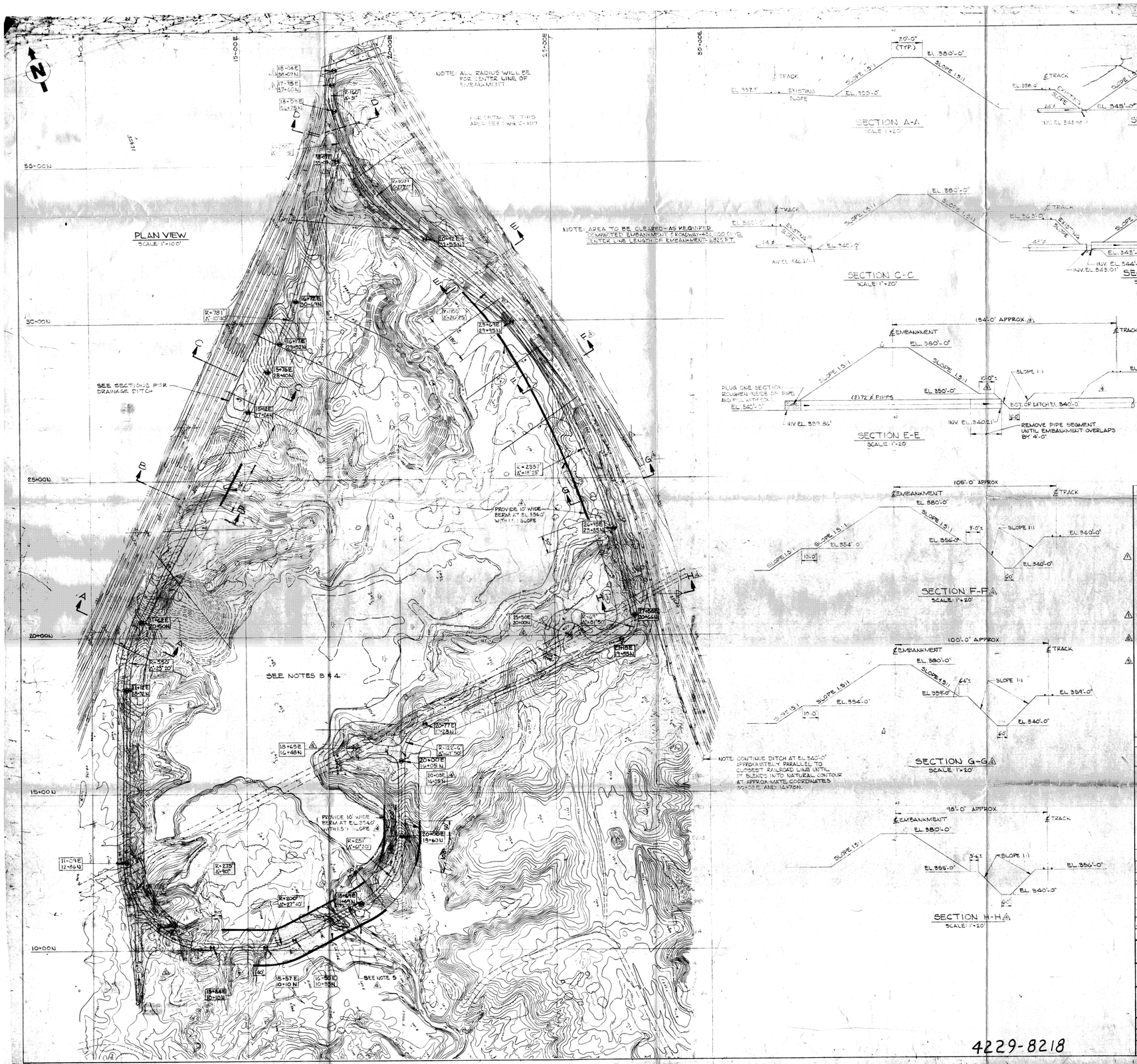
Polyconic projection. North American datum
5000 yard grid based upon U.S. zone system, C

HARD IMPERVIOUSLY SURFACED ROADS
OTHER MAIN TRAVELED ROADS
1931

LA. CENTER, KY.-ILL.
Edition of 1932

Attachment A.4

EAP and Dike Raise Design Drawings, 1973 and 1982



NOTES

1. RAILROAD SLOPES ARE NOT TO BE DISTURBED.
2. STONE RIPRAP TO BE PLACED IN THE VICINITY OF ALL PIPE TO A DEPTH OF 6" AND 3'-0" ON BOTH SIDES OF PIPE. THE RIPRAP SHALL BE PLACED IN THE DITCH AND ON THE OPPOSITE SLOPE IN THE VICINITY OF THE PIPE. THE RIPRAP SHALL BE PLACED TO A HEIGHT PARALLEL TO TOP OF PIPE ON BOTH SLOPES.
3. THE BORROW AREA SHALL BE THAT AREA INSIDE THE EMBANKMENT. THE EMBANKMENT SECTIONS BEING BUILT SHALL BE SERVED BY A BORROW AREA PROVIDING THE SHORTEST HAUL. THE CUT FROM THE DRAINAGE DITCH SHALL BE USED IN THE EMBANKMENT EXCEPT FOR THAT PORTION WHICH REQUIRES AN UNECONOMICAL HAULING DISTANCE.
4. ALL SLOPES INSIDE OF EMBANKMENT BELOW THE EXISTING GRADE SHALL BE MAINTAINED AT 1.5:1.
5. UNDERCUT AND REMOVE AS REQUIRED SAND AND GRAVEL OR OTHER UNSATISFACTORY MATERIAL BEFORE PLACING COMPACTED FILL MATERIAL.
6. THE SIDE SLOPE OF EXISTING EMBANKMENT SHALL BE KEYED BY CUTTING NOTCHES IN THE EXISTING SLOPE AT LEAST 4' WIDE AND 4' DEEP AND SPACED ON THE SLOPE 15' TO 20' APART.

REFERENCE DWGS.

EAST ASH POND SULFURIC ACID STORAGE TANKS AND pH CONTROL SYSTEM	C-107

4229-8218

ENG FILE COPY
DO NOT REMOVE

NO.	DATE	BY	REVISIONS	CHKD	ENGR	PROJ ENGR	APPR
5	9/11/73	JFF	ADDED NOTE 6				
4	9/5/73	JFF	ADDED SECTIONS & REVISED AS NOTED				
3	8/21/73	JFF	ISSUED FOR CONSTRUCTION				
2	7/27/73	JFF	REVISED SOUTHWEST EMBANKMENT				
1	7/17/73	JFF	REVISED EMBANKMENT COORDINATES & ADDED NOTES 3 & 4.				
0	6/29/73	JFF	ISSUED FOR APPROVAL				

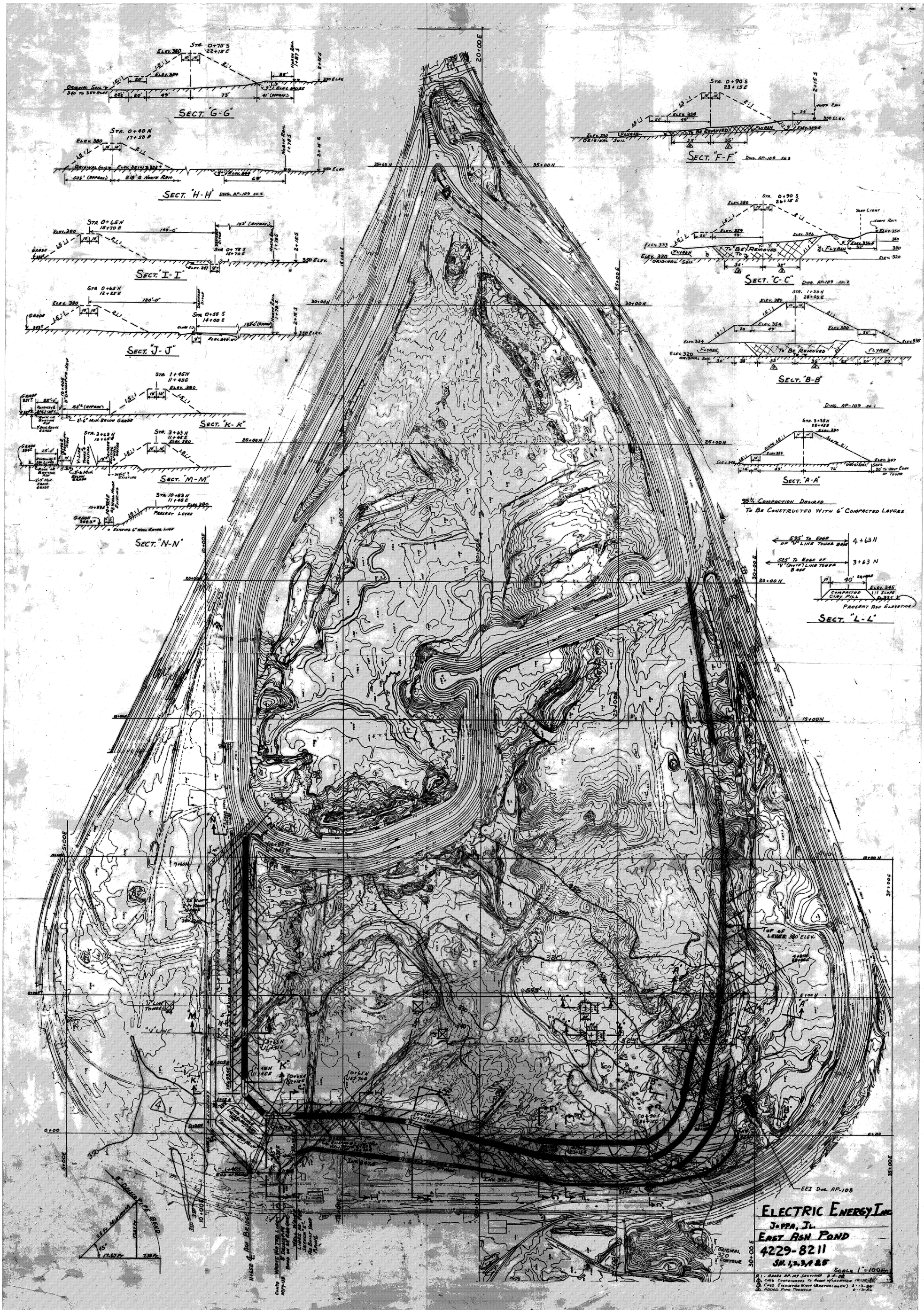
WAPORA INC.
WASHINGTON, D.C. 20015

ELECTRIC ENERGY INC.

EAST ASH POND
PLAN, SECTIONS AND DETAILS

SCALE: AS NOTED	DATE: 6/22/73	DR. BY: J. FORD
JOB NO.	DRAWING NO.	REV.
I-28-A	C-106	3

4229-8218


SECT. "G-G"
SECT. "H-H" DWG. AP-109 SH. 4
SECT. "I-I"
SECT. "J-J"
SECT. "K-K"
SECT. "M-M"
SECT. "N-N"
SECT. "F-F" DWG. AP-109 SH. 3
SECT. "C-C" DWG. AP-109 SH. 2
SECT. "B-B"
DWG. AP-109 SH. 1
SECT. "A-A"
95% COMPACTION DESIRED
TO BE CONSTRUCTED WITH 6" COMPACTED LAYERS
SECT. "L-L"
PRESENT ASH ELEVATION
EEI DWG. AP-108
ELECTRIC ENERGY INC.
JOPPA, IL.
EAST ASH POND
4229-8211
SH. 1, 2, 3, 4 & 5
SCALE 1"=100FT.
R1 - ADDED AP-109 SECTIONS 8-7-86
CMBD COORDINATES TO REFLECT RELOCATION 10-10-86
CMBD EXCAVATING WIDTH (ABERTHOLDREW) 8-12-86
ADDED FINE TRACTILE 6-12-87

Attachment A.5

AECOM Geotechnical Borings and CPT Logs, 2015 and 2016

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B001

Date(s) Drilled	08/10/2015 1:00 PM to 08/10/2015 3:00 PM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	333.6 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198339.4 E 833368.3 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0						333.6 / 0.0 [EMBANKMENT] SILT (ML), loose, gray, chips of coal								*Start 8/10/15 at 1:00 PM*
		S-1	1 4 3		89		331.6 / 2.0 Lean CLAY with Sand (CL), brown/orange staining								
330		ST-1	P					18.5	131.4	34	17				
	5							19.4	127.8						*P200 = 80.4*
								21.1	123.6					2.1	
							327.6 / 6.0								
		S-2	1 0 0		100		[ASH] SILT (ML), dark gray, very loose, moist to saturated	30.5							*P200 = 85.2*
325		ST-2	P												*Shelby pushed 20"*
	10														
320															
		S-3	0 0 1		100										
	15														
							315.6 / 18.0								
315		S-4	1 0 0		78		[FOUNDATION] Lean CLAY with Sand (CL), tan/brown, very soft	23.4		27	9				*P200 = 84.6*
	20														
							light gray, stiff, with varying sand								
310		S-5	2 4 9		100										
	25														
305		ST-3	P												*Shelby pushed 9", showed dent*
	30														

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:30 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B001

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
305	30													
300	35	S-6	6 7 5	100			21.3							*P200 = 81.8*
295	40	S-7	3 4 6	100										
290	45	ST-4	P			290.1 / 43.5 Clayey SAND (SC) 288.9 / 44.8 Poorly Graded SAND (SP), gray and tan, subangular	14.6 13.6 14.5	123.5 131.5	29	17				*P200 = 38.5* *Shelby pushed 14"*
285	50	S-8		100		283.6 / 50.0 End of Boring at 50 ft	16.5							*P200 = 2.8* *End 8/10/15 at 3:00 PM*
280	55													
275	60													
270	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:30 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B002

Date(s) Drilled	08/18/2015 10:00 AM to 08/18/2015 2:00 PM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	65.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	350.1 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198371.3 E 833329.2 (ft NAD83)	Groundwater Level(s)	13.8 ft on 8/18/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	0					350.1 / 0.0								
		S-A	2 2 4	33		[FOUNDATION] Lean CLAY with Sand (CL), light gray, firm, moist, low to medium plasticity, pockets of orange with varying sand, and organic matter odor to 3'								*Start 8/18/15 at 10:00 AM*
		ST-1	P	92		light gray								
345	5	S-B	1 2 4	100										
		ST-2	P	100			24.1 23.5 24.3 23.7 22.7	117.2 123.0 125.9	34	17			1.2	
340	10													
		S-1	2 2 3	78		▽	25.6							*~14 inches of water on outside of split spoon* *P200 = 91.0*
335	15													
		S-2	2 3 4	89										
330	20													
		S-3	3 4 5	89		with trace fine black sand	20.1		28	15				
325	25													
		S-4	4 5 7	78		stiff								
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:36 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B002

Elevation (feet)	Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
320	30													
		S-5	5 7 6	78										
315	35													
		ST-3	P	100			26.6 22.2 21.2 21.4	130.2 127.9	35	18				*P200 = 92.1*
310	40													
		S-6	4 6 8	100			20.8							*P200 = 93.9* *Auger flight brought water to surface*
305	45													
		S-7	4 6 8	89										
300	50													
		S-8	4 5 6	78			22.4		35	19				
295	55													
		S-9	5 6 9	78										
290	60													
		S-10	5 4 12	100		285.6 / 64.5 285.1 / 65.0 Sandy SILT (ML), gray, medium stiff	17.9							*P200 = 56.7*
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:36 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B002

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
285														*End 8/18/15 at 2:00 PM*
						End of Boring at 65 ft								
280	70													
275	75													
270	80													
265	85													
260	90													
255	95													
	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:36 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Date(s) Drilled	08/10/2015 12:00 AM to 08/11/2015 12:00 AM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	120.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198426.3 E 833270.9 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					379.0 / 0.0 [CREST WEARING SURFACE]								*Start 8/10/15*
						378.0 / 1.0 Gray to dark gray, crusher STONE, angular								
						[EMBANKMENT] Lean CLAY with Sand (CL), orange brown to brown, stiff, moist with little sand								
375	5	ST-1	P	75										
370	10	S-2	2 4 5	83			16.0							
365	15	S-3	2 4 5	61										
360	20	ST-4	P	83			17.2 15.8 14.7 15.7 16.6	132.2 133.3	36	22				*LV Su=5.2 ksf* *P200 = 83.8*
355	25	S-5	1 4 6	78			16.2		37	23				*P200 = 81.0*
350	30	S-6	6 4 8	94		consistency varies	16.3		34	20				

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:54 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
345		ST-7	P	100										
	35													
340		S-8	3 6 8	100			16.8							*P200 = 82.5*
	40													
335		S-9	2 4 5	100		with some sand	17.3		33	20				*P200 = 77.3*
	45													
														P200 = 83.8
330		ST-10	P	100			16.0 15.7 15.9 16.2	127.9 134.8 133.4	34	18			3.6	*End 8/10/15 at 5:00 PM* *Start 8/11/15 at 7:30 AM with Mud Rotary*
	50													
						325.5 / 53.5								
325		S-11	2 6 8	92		Sandy Lean CLAY (CL), stiff, and trace dark gray fine sand or ash	17.0		31	18				*P200 = 69.3*
	55													
						321.0 / 58.0								
						Lean CLAY with Sand (CL), orange brown, medium stiff, moist	19.9	134.6	37	23				*P200 = 81.5*
320		ST-12	P	100				106.0						
	60						57.9 29.0	119.5						
315		S-13	2 3 4				25.7		24	5				*P200 = 76.9*
	65					314.5 / 64.5 [ASH]								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:54 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
		ST-14	P	83		Silty CLAY with Sand (CL-ML), black, wet	25.2 22.7	123.3 123.7	25	6				*P200=80.4*
						312.0 / 67.0								
		S-15	10 8 12	100		Sandy SILT (ML), black, medium dense, wet	20.0							*P200 = 61.5*
310						310.0 / 69.0	28.2 21.3							
	70	ST-16	P	100		[FOUNDATION] Lean CLAY (CL), brown gray to gray brown, stiff, moist; occasional poorly-graded sand pockets; varying levels of sand	19.9 19.2	131.1	32	16				*P200 = 93.1*
305	75													*Drillers drilled through sample* *Drillers made mistake, no samples. Some soil recovered to confirm layer uniformity* *Drilled split spoon from 75' to 80'*
300	80													
		S-17	2 4 7	100										
295	85													
						290.5 / 88.5								
290	90	S-18	9 18 27	6		Silty SAND (SM), brown to brown orange, dense, medium to coarse sand, gravel in split spoon catcher with trace gravel								*Rattling and grinding of rig*
285	95	S-19	7 7 9	89		medium dense, brown gray to gray brown, wet, trace coarse sand	19.8		21	2				*P200 = 19.4*
						284.0 / 95.0								
280	100	S-20	16 29 27	61		Poorly Graded SAND (SP), brown to gray brown, very dense, wet, medium to coarse sand								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:54 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275	105	S-21	17 29 29	33		more coarse sand and gravel								*Grinding, rattling, shaking of drill rig*
270	110	S-22	28 50/5"	73		with 6" layer of brown to orange brown, fine to medium sand								
265	115	S-23	15 23 30	67										
260	120	S-24	22 25 23	56		Elevation (feet) 259.0 Depth (feet) 120.0 End of Boring at 120 ft								*End 8/11/15 at 4:45 PM*
255	125													
250	130													
245	135													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:54 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Date(s) Drilled	08/09/2015 12:00 AM to 08/09/2015 5:30 PM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	100.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379.9 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199345.5 E 833690.4 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					379.9 / 0.0 [CREST WEARING SURFACE]								*Start 8/9/15*
						378.9 / 1.0 Gray to dark gray, crushed rock, stone								
						[EMBANKMENT] Lean CLAY (CL), brown to orange brown, stiff, moist to dry, with trace sand								
		S-1	2 4 5	22										
375	5													
		ST-2	P	75			16.4 17.7	130.5 121.0 127.5					2.8	*Pushed 16"-18" /24" from stratum found by CPT* *P200 = 96.1*
370	10					dark gray brown to dark brown with trace coal (approximately 0.5" diameter)								
		S-3	3 5 7	83			17.3							
365	15					brown to brown orange								
		ST-4	P	83			19.6 19.9 20.1	 125.9 129.1	 37	 16				*Pushed Shelby 20"* *P200 = 95.3*
360	20													
		S-5	3 4 5	28		with trace coal (approximately 0.25" diameter)								
355	25													
		S-6	2 4 5	6										
350	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:04 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Elevation (feet)	Depth (feet)	Sample Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
		ST-7	P	94			15.8 21.4 20.0 18.7	124.0 128.6 129.6	38	19			2.4	*Pushed Shelby 18"* *P200 = 97.5*
345	35					344.9 / 35.0 [FOUNDATION] Lean CLAY (CL), brown to orange brown and gray, stiff, with varying sand								
		S-8	3 5 6	100			23.4		36	19				*P200 = 90.6*
		S-9	2 4 7	100			22.3		37	20				
340	40					with sand								
		ST-10	P	100			22.2 22.1 20.8	129.1						*LV Su=4.1 ksf*
335	45						20.9 20.6	129.4	39	25				*P200 = 81.2*
		S-11	2 4 6	100			19.3							*P200 = 90.4*
330	50													*Switch to mud rotary @ 50', cased through augers*
		S-12	2 4 6	100			23.3		35	20				
325	55													
		S-13	2 4 4	100										
320	60					gray to gray brown								
		S-14	3 5 6	100			19.7		33	20				*P200 = 89.0*
315	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:04 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						with sand								
310	70	S-15	3 7 9	100			16.4		31	19				*P200 = 77.9*
						306.9 / 73.0 Sandy CLAY (CL), gray, medium stiff, wet								
305	75	S-16	3 4 4	100			17.2		21	12				*P200 = 57.5*
						303.9 / 76.0 [FOUNDATION] Silty SAND (SM), gray, dense, wet								
300	80	S-17	12 22 20	100			15.3		19	1				*P200 = 23.9*
295	85	S-18	11 8 14	100										
		S-19	12 9 17	100		290.9 / 89.0 [FOUNDATION] Poorly graded SAND (SP), gray to gray brown, dense, wet								
290	90													
285	95	S-20	16 21 22	56										
						283.9 / 96.0 [FOUNDATION] Poorly graded SAND with Gravel (SP), brown to orange brown, very dense, wet								*Grinding noted. Rig rattling and shaking*
280	100	S-21	21 24 30	78		279.9 / 100.0								*End 8/9/15 at 5:30*

End of Boring at 100 ft

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:04 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275	105													*PM*
270	110													
265	115													
260	120													
255	125													
250	130													
245	135													

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Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B006

Date(s) Drilled	08/18/2015 4:15 PM to 08/19/2015 10:15 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	40.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	357.1 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198964.5 E 833617 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					357.1 / 0.0								
355		S-1	2 4 5	44		[FILL] Silty SAND (SM), dark gray, loose, moist, little to no plasticity								*Start 8/18/15 at 4:15 PM*
	5					352.2 / 4.9								*Pushed Shelby 24", no recovery.*
350		S-2	3 5 6	67		[FOUNDATION] Lean CLAY (CL), burnt orange/brown, stiff, moist	25.2							*P200 = 98.3*
		ST-1	P	100			26.1 26.2 26.5	114.1	33	10				
345	10													*End 8/18/15 at 5:30 PM* *Start 8/19/15 at 7:30 AM*
		S-3	2 7 5	78										
340	15													
		S-4	2 5 8	78			18.9		39	24				
335	20													
		S-5	3 4 5	67										
330	25													
		ST-2	P	100			19.4 18.7 18.0	118.1	39	26				*P200 = 85.7*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B006

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30						17.4							
325														
		S-6	3 3 5	67			18.0							*P200 = 83.9*
	35													
320						320.1 / 37.0 Silty SAND (SM), beige, medium dense, moist								
		S-7	9 12 15	44			14.7							*P200 = 24.8*
	40					317.1 / 40.0 End of Boring at 40 ft								*End 8/19/15 at 10:15 AM*
315														
	45													
310														
	50													
305														
	55													
300														
	60													
295														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B007

Date(s) Drilled	08/11/2015 10:35 AM to 08/11/2015 1:45 PM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	347.6 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199326.6 E 833760.8 (ft NAD83)	Groundwater Level(s)	44.2 ft on 8/11/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					347.6 / 0.0								
						[FILL]								*Start 8/11/15 at 10:35 AM*
						346.6 / 1.0 Silty SAND with Gravel (SM)								
		S-1	2 3 4	83		[FOUNDATION] Lean CLAY (CL), gray with orange staining, stiff, moist, bits of root (wet)								
345														
		ST-1	P	100										*Pushed Shelby 20"*
	5													
		S-2	2 4 6	72			20.0		40	24				
340														
		ST-2	P	100			21.4 20.2 19.7 19.9 18.6 20.6	131.0 128.0 127.9 117.0	36	20				*Pushed Shelby 20"* *P200 = 93.1*
	10													
335														
		S-3	2 5 6	83		with sand	18.3		36	22				*P200 = 84.9*
	15													
330														
		S-4	2 5 7	83										
	20													
325														
		S-5	2 4 7	83			18.5		38	24				*P200 = 73.5*
	25													
320														
		ST-3	P	100		less sand	18.0 16.8	128.2 129.8	37	22				*LV Su=6.7 ksf* *Pushed Shelby 20"*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B007

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30						18.3 18.7							*P200 = 91.0*
315						gray, with sand								
		S-6	4 6 7	100			17.6		37	25				*P200 = 84.1*
	35													
310														
		S-7	0 2 4	100										
	40													
305														
		S-8	8 8 16	56		303.6 / 44.0 [FOUNDATION] Silty SAND (SM), gray, medium dense, wet, band of rust at 6" of split spoon	15.6		18	2				*P200 = 23.8* *Water observed on outside of split spoon*
	45													
300														
		S-9		100		no rust								*Attempted Shelby tube, recovered sample with split spoon* *End 8/11/15 at 1:45 PM*
	50					297.6 / 50.0 End of Boring at 50 ft								
295														
	55													
290														
	60													
285														
	65													

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Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Date(s) Drilled	08/19/2015 2:50 PM to 08/20/2015 10:45 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	80.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	380.4 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198838.5 E 832101.2 (ft NAD83)	Groundwater Level(s)	38 ft on 8/19/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
380	0					380.4 / 0.0								
						[CREST WEARING SURFACE]								*Start 8/19/15 at 2:50 PM*
						379.4 / 1.0 Crushed stone, gray to dark gray								
						[FILL] Lean CLAY (CL), very soft, burnt orange, moist								
		S-1	1 0 0	100			24.3							
375	5					372.9 / 7.5								
						[EMBANKMENT] Lean CLAY (CL), firm, brown/orange, moist								
		ST-1	P	100			17.5							
							16.4	139.3						
370	10						20.0							
		S-2	3 5 4	33										
365	15													
		S-3	1 3 8	44			19.6		37	19				
360	20													
		S-4	5 8 13	39			17.1		39	20				*P200 = 96.9*
355	25						18.4	127.2						
		ST-2	P	100			17.6	129.5	41	23			2.7	
							18.8							*P200 = 91.2*
		S-5	5 7 13	44			17.3		41	23				*P200 = 93.5 Sand looks to be coal sand < 8%*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:25 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	30													
		S-6	2 2 3	100			25.8		34	14				
345	35					345.4 / 35.0 [FOUNDATION] Lean CLAY (CL), firm, gray with orange/brown pockets								
		ST-3	P	100			21.4 21.1 21.8 21.3 21.6 20.6	127.5 128.4 127.3 125.3					6.7	*Pushed Shelby 24", shows signs of water on top, also on outside of sample rod* *P200 = 95.8*
340	40	S-7	4 5 6	100		stiff								
		ST-4	P	100			23.1 22.4 22.2 22.0 22.3	96.8	42	26				*LV Su=2.6 ksf*
335	45													
		S-8	7 10 9	67		very stiff	17.6		35	20				*P200 = 91.0*
330	50													
		S-9	5 7 9	89		stiff								
325	55													*End 8/19/15* *Start 8/20/15 at 7:30 AM*
		S-10	4 5 8	100										
320	60													
		ST-5	P	100			16.3 16.0 17.6	135.9 130.1						*LV Su=2.4 ksf*
	65													

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Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
315							19.6							*P200 = 92.6*
							19.3							*P200 = 93.5*
						312.4 / 68.0								
						[FOUNDATION] Silty SAND (SM), gray/beige, medium dense, low plasticity								
		S-11	11 17 12	44			18.3							*P200 = 89.7*
310	70													
		S-12	8 11 18	50										
305	75													
						303.4 / 77.0								
						Silty, clayey, SAND (SC-SM), gray/beige, low plasticity								
							17.3							
		ST-6	P				16.3	135.6						*Pushed Shelby 20"*
							16.8		21	6				*LV Su=2.9 ksf*
							15.1							*P200 = 36.2*
300	80					300.4 / 80.0	14.2							*End 8/20/15 at 10:45 AM*
						End of Boring at 80 ft								
295	85													
290	90													
285	95													
	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:25 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B009

Date(s) Drilled	08/07/2015 12:00 AM to 08/08/2015 12:00 AM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	80.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	378.8 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 200368.5 E 833926.1 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					378.8 / 0.0 [CREST WEARING SURFACE]								*Start 8/7/15*
						377.8 / 1.0 Stone or crushed rock, gray to dark gray								
						[EMBANKMENT] Sandy Lean CLAY (CL), orange brown, stiff, moist to dry								
375		S-1	2 5 6	78			14.8							*P200 = 69.6*
	5													*End 8/7/15 at 5:20 PM* *Start 8/8/15 at 7:25 AM*
370		S-2	2 3 5	67										
	10													
						365.8 / 13.0								
365		ST-3	P	100		Lean CLAY with Sand (CL), orange brown, stiff, moist	14.8 16.9 15.2 15.5	134.2 140.3 134.9	34	20				*P200 = 76.5*
	15													
360		S-4	2 5 7	72			15.4		35	21				*P200 = 91.1*
	20													
355		S-5	2 6 9	28		some gravel								*Rock in sampler that was crushed*
	25					353.3 / 25.5								
						[FOUNDATION] Lean CLAY (CL), orange brown, stiff, moist								
350		ST-6	P	100										
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B009

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
		S-7	3 5 7	100		with sand	20.8		39	22				*P200 = 81.3*
345														
		S-8	5 7 9	100										
	35													
340		S-9	1 4 5	100			20.3		34	20				*P200 = 87.7*
	40													
335		S-10	3 7 7	100										
	45													
		ST-11	P	100			19.5 19.8 18.2 18.4 20.1	126.3 128.6 127.9	37	22			3.7	*P200 = 87.0* *Switched to mud rotary*
330	50													
325		S-12	4 5 7	100			21.3		38	25				*P200 = 94.5*
	55					322.8 / 56.0								
						Sandy Lean CLAY (CL), gray brown to brown gray, stiff, wet to moist								
320		S-13	5 6 8	100										
	60													
		ST-14	P	100			18.5 18.4 18.9	129.5 128.3					3.8	
315	65													

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Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B009

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
							17.9 17.8	130.6	27	17				*P200 = 69.1*
310	70	S-15	2 3 6	100		310.3 / 68.5 Clayey SAND (SC), gray brown to brown gray, loose	18.7		29	18				*P200 = 46.7*
305	75	S-16	2 3 22	100		304.3 / 74.5 Silty SAND (SM), gray and brownish orange to orange, dense								
300	80	S-17	11 14 21	78		298.8 / 80.0 End of Boring at 80 ft	20.7		NP	NP				*P200 = 23.7* *End 8/8/2015 at 2:30 PM*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:33 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B010

Date(s) Drilled	08/06/2015 12:00 AM to 08/06/2015 12:00 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	350 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 201791.2 E 833794.1 (ft NAD83)	Groundwater Level(s)	42 ft on 8/6/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	0					350.0 / 0.0								
		ST-1	P			[FOUNDATION] Lean CLAY (CL), yellow, stiff, medium plasticity, with pockets of beige sand	20.7	122.5						*Start 8/6/15*
							20.2	122.5	37	22				*P200 = 88.6*
							19.8	119.2						
							18.1	122.5						
						346.5 / 3.5	18.0	122.6						
		S-1	2 5 5	89		Lean CLAY with Sand (CL), stiff, medium plasticity	18.5	124.8	38	23				*P200 = 82.6*
345	5													
		S-2	4 5 7	44										
		ST-2	P											*Pushed Shelby 10"*
340	10													*Driller notes harder to drill*
						336.5 / 13.5								
		S-3	3 7 12	50		Lean CLAY (CL), yellow, very stiff, pockets of sand more apparent less sand	15.2							*P200 = 87.6*
335	15													
						with sand								
		S-4	1 6 5	89			17.1		33	19				*P200 = 76.9*
330	20													
		S-5	3 4 5	100										
325	25													
						321.5 / 28.5								
		S-6	1 3 9	100		Sandy Lean CLAY (CL), stiff	17.6		26	16				*P200 = 52.9*
320	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:40 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B010

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
320	30													
		ST-3	P				15.8 16.1 15.1 15.8 16.7	120.3 132.4 130.5 132.9	27	16				*P200 = 53.5*
315	35													
		S-7	1 2 5	100										
310	40													
		S-8	3 6 8	100		Layer of silty sand, 6" thick								
305	45					303.5 / 46.5								
						[FOUNDATION] Poorly Graded SAND with Silt (SP-SM), beige								
		S-9		100			27.6		NP	NP				*Pushed Shelby 18", no recovery. Split spoon recovered sample.* *P200 = 9.9* *End 8/6/15*
300	50					300.0 / 50.0 End of Boring at 50 ft								
295	55													
290	60													
285	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:40 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B011

Date(s) Drilled	08/06/2015 12:00 AM to 08/07/2015 12:00 AM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	80.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	380 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 201732.5 E 833659.5 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
380	0						380.0 / 0.0								
							379.2 / 0.8 [CREST WEARING SURFACE] Crushed rock surface, gray to dark gray								*Start 8/6/15*
							[EMBANKMENT] Lean CLAY with Sand (CL), brown to orange brown, soft, dry to moist								
		S	S-1	1 1 2	67										
375	5														
		ST	ST-2	P	75		372.0 / 8.0 Lean CLAY with Sand (CL), gray brown to dark brown, moist, contains organic matter								
370	10														
							367.0 / 13.0 Lean CLAY with Sand (CL), orange brown to brown, stiff, moist to dry, contains pockets of gray sand								
		S	S-3	1 4 8	56			16.0		34	18				*P200 = 83.6*
365	15														
		S	S-4	5 7 4	22		with gravel, dry								*Rough drilling*
360	20														
							357.0 / 23.0 Lean CLAY (CL), gray brown, firm, moist								
		ST	ST-5	P	100			17.8 17.8 18.2 18.0	126.1 126.5 129.4	33	15			2.8	*P200 = 92.7* *End 8/6/15* *Start 8/7/15*
355	25														
		S	S-6	2 4 4	44		with sand	18.5							*P200 = 84.1*
350	30						350.0 / 30.0								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:45 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B011

Elevation (feet)	Depth (feet)	SAMPLES Type Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	30					[FOUNDATION] Lean CLAY (CL) gray brown to brown and orange brown,, firm, varying gray sand content								
		S-7	2 4 7	61			22.6		36	15				*P200 = 97.7*
345	35													
		S-8	2 6 6	61		with sand	19.9							*P200 = 83.6*
340	40													
		ST-9	P	100		less sand	17.1 18.0 18.8 18.7 18.3	128.6 128.9	36	22				*P200 = 87.6*
335	45													
		S-10	1 5 7	100		with sand	17.5		35	21				*P200 = 79.6*
330	50													
		S-11	3 4 5	33		326.5 / 53.5 Sandy Lean CLAY (CL), brown to orange brown, stiff	22.6		34	23				*P200 = 54.9*
325	55													
		S-12	7 7 8	100										
320	60													
		S-13	2 4 4	100		316.5 / 63.5 Clayey SAND (SC), brown to brown orange, loose, with dark orange clayey sand pockets, moist								
315	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:45 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B011

Elevation (feet)	Depth (feet)	SAMPLES Type Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
							20.2							
		ST-14	P	100			17.4	125.3						*LV Su=2.2 ksf*
310	70						16.8							
							16.6	130.2	34	23				*P200 = 45.3*
							16.4							
		S-15	3 5 8	100										
305	75													
						303.8 — 76.2 Poorly Graded SAND with Silt (SP-SM), gray to brown gray, very dense, wet								
		S-16	22 28 30											
300	80					300.0 — 80.0 End of Boring at 80 ft								*End 8/7/15*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:45 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B012

Date(s) Drilled	08/04/2015 12:00 AM to 08/06/2015 12:00 AM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	80.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379.6 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 201111 E 832753.5 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						379.6 / 0.0								
	0					379.1 / 0.5 [CREST WEARING SURFACE] Crushed rock or stone, gray to dark gray								*Start 8/4/15*
						[EMBANKMENT] Lean CLAY with Sand (CL), brown to orange brown, very stiff, moist								
375	5	ST-1	P	89										
		S-2	4 11 11	31										*Poor recovery, same material*
370	10													
365	15	ST-3	P				16.7 17.9 16.6 17.7 17.4	130.8 131.6 131.9	37	24				*LV Su=3.1 ksf* *P200 = 72.8*
		S-4	3 6 8	78		occasional pockets of poorly-graded sand	16.2		35	19				*P200 = 78.7*
360	20													
		S-5	4 5 7	39			15.3							*P200 = 78.6*
355	25													
						351.1 / 28.5								
		S-6	5 8 13	78		Lean CLAY (CL), brown to orange brown, very stiff, moist	17.0		38	20				*P200 = 91.7*
350	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:53 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B012

Elevation (feet)	Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30					349.1 / 30.5 [FOUNDATION] Lean CLAY (CL), gray brown to brown gray, firm, moist, organics/roots present								*Poor recovery. Tip was soft.*
		S-7	2 4 2	11										
		ST-8	P	100			27.3 28.7 28.8 29.4	121.0 120.8	40	21			0.5	
345	35					345.6 / 34.0 Lean CLAY (CL), gray brown to brown, stiff, moist, becomes brown with frequent gray to light gray sand lenses	29.1							*P200 = 98.2*
		S-9	8 8 6	100			26.1		33	12				*P200 = 95.9*
		ST-10	P	100										
340	40													*Switch to mud rotary @ 40' bgs*
		S-11	4 4 4	100		light brown gray to brown gray with orange and brown throughout	21.0		44	30				*P200 = 91.7*
335	45					331.1 / 48.5 Sandy Lean CLAY (CL), gray brown to gray, stiff, moist								*P200 = 69.3*
		S-12	5 5 6	100			21.7							
330	50													*Casing pushed to 50'*
		ST-13	P	100			18.6 16.8 17.0 17.0 17.4 17.4	132.3 135.8 132.0	27	15				*LV Su=3.5 ksf* *P200 = 63.9* *End 8/4/15 at 5:00 PM* *Start 8/5/15*
325	55													
		S-14	8 11 24	100		321.6 / 58.0 Clayey SAND (SC), brown to orange brown, dense, gravel present	17.3		33	22				*End 8/5/15 due to storm* *Start 8/6/15* *P200 = 36.7*
320	60													
						316.6 / 63.0 Lean CLAY with Sand (CL), brown orange to brown and gray, stiff, moist								
		S-15	3 4 5	100										
315	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:53 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B012

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
		ST-16	P	100		with some gravel	21.2 20.2 18.2 20.0	126.5 126.8	33	20				*P200 = 62.7*
310	70	S-17	2 3 6	100										
305	75	S-18	2 3 3	100		303.6 / 76.0 Poorly Graded SAND (SP), brown to gray brown, dense, moist								
300	80	S-19	2 16 24	78		299.6 / 80.0 End of Boring at 80 ft								*End 8/6/2015 at 11:00 AM* *End 8/6/15*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:53 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Date(s) Drilled	08/21/2015 12:30 PM to 08/22/2015 10:45 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	80.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379.3 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 200176.2 E 832128.5 (ft NAD83)	Groundwater Level(s)	73 ft on 8/21/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					379.3 / 0.0 [CREST WEARING SURFACE]								*Start 8/21/15 at 12:30 PM*
						378.3 / 1.0 Crushed rock or stone, gray to dark gray								
						[EMBANKMENT] Sandy Lean CLAY with sand (CL), brown to orange brown, stiff, moist								
375		S-1	3 6 7	33										
	5													
370		S-2	3 5 10	39			14.7							*P200 = 67.8*
	10													
365		ST-1	P	100			15.9 16.1 15.8 15.4	147.4						
	15													
						with light gray stones/gravel								
360		S-3	50/2"	0		360.3 / 19.0 [EMBANKMENT] Lean CLAY (CL), very stiff, brown to orange-brown, moist								*Lots of chatter on augers Could not auger with center punch HSA. Only pulled 4 1/4 plugs of light, gray stones*
	20					357.3 / 22.0 [FOUNDATION] Lean CLAY (CL), stiff, gray, moist								
355		S-4	1 3 6	72			23.1							*P200 = 95.8*
	25													
350		ST-2	P	100			21.6 21.1 21.9 19.9	114.4	33	13				
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:01 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
345		S-5	2 5 5	78			20.8		38	21				
	35													
340		S-6	4 5 7	89		gray with orange streaking								
	40						18.9							
		ST-3	P	100			20.5 20.7 19.9	125.1	35	19				
335		S-7	3 4 5	100			19.8							*P200 = 85.4*
	45													
330		S-8	2 4 5	100										
	50													
325		S-9	12 25 42	78		with sand and gravel	12.7		27	16				
	55													
320		S-10	2 2 5	100			19.5		37	24				
	60					316.8 / 62.5								
						Sandy Lean CLAY (CL), gray with orange/rust streaks, stiff, moist								
315		S-11	5 5 6	100										
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:01 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310	70	S-12	3 5 8	100			17.1							*P200 = 50.9*
						307.3 / 72.0 Silty SAND (SM), tan with streaks of orange, dense, saturated ▽								
305	75	S-13	9 17 18	67			16.3							*Split spoon saturated with water* *P200 = 27.9*
300	80	S-14	9 27	100		300.3 / 79.0 Poorly-graded SAND with Gravel (SP) 299.3 / 80.0 End of Boring at 80 ft								*End 8/22/15 at 10:45 AM*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:01 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B014

Date(s) Drilled	08/07/2015 12:00 AM to 08/07/2015 12:00 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	361.8 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 200225.8 E 832001.4 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0						Elevation (feet) 361.8 / Depth (feet) 0.0								
360		S	S-1	6 5 3	11		[FILL] Clayey SAND with Gravel (SP), brown to dark gray, loose								*Start 8/7/15*
							358.8 / 3.0								
		ST	ST-1	P	80		[FOUNDATION] Lean CLAY (CL), burnt orange/yellow, stiff, sand is vertical vein and beige in color								*Pushed Shelby 20"*
	5														
355		S	S-2	2 4 5	78			23.4		31	9				*P200 = 96.8*
		ST	ST-2	P	100			23.3	123.9						*Pushed Shelby 20"*
								20.8							
	10							20.7							*LV Su=2.1 ksf*
								20.8	126.8	33	13				*P200 = 91.8*
350								21.5							
		S	S-3	2 5 5	67										
	15														
345															
		S	S-4	2 4 5	89			20.1		47	33				*P200 = 88.8*
	20														
340							339.8 / 22.0								
							Lean CLAY with Sand (CL), burnt orange/yellow, stiff, moist								
		S	S-5	3 5 7	78										
	25														
335															
		S	S-6	2 4 5	100		mostly beige	20.8		39	24				*P200 = 85.0*
	30														

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B014

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
330	30					329.8 / 32.0 Clayey SAND (SC), gray with orange mottling, stiff, moist, noticeable flakes of rust, in various states of decomposition	14.9	126.7	26	15				
		ST-3	P	100			13.8 14.1	130.4						*Pushed Shelby 20", crumpled at tip. Inverted for wax plug.*
	35						14.9 17.4 16.1	130.2					4.3	*P200 = 45.2*
325		S-7	4 4 4	100										
	40					318.8 / 43.0 Sandy Lean CLAY (CL), gray with orange mottling, moist, with flakes of rust	17.2 18.8	132.6						*Pushed Shelby 20" LV Su=3.4 ksf*
		ST-4	P	100			17.6 17.9 16.7	132.5	33	21				*P200 = 63.7*
315	45													
		S-8	5 6 7	100			16.2		26	15				*P200 = 54.6*
	50					311.8 / 50.0 End of Boring at 50 ft								*End 8/7/15*
310														
	55													
305														
	60													
300														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Date(s) Drilled	08/20/2015 1:15 PM to 08/20/2015 12:00 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	HSA/Mud rotary	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	80.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	380.3 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199187.8 E 831795.1 (ft NAD83)	Groundwater Level(s)	43 ft on 8/20/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
380	0					380.3 / 0.0 [FILL] Poorly Grades SAND with Silt (SP-SM)								*Start 8/20/15 at 1:15 PM*
		S-1	3 7 7	33										
375	5					373.3 / 7.0 [EMBANKMENT] Lean CLAY (CL), orange brown to brown, stiff, moist, contains some silt and sand								
		S-2	2 4 7	67			19.4		41	25				
370	10													
		S-3	3 7 7	33										
365	15													
		ST-1	P				17.4 16.5 16.5 16.8 18.7	132.2 128.9 128.4	38	21				*LV Su=4.1 ksf*
360	20					burnt orange/gray								
		S-4	4 8 11	50		very stiff	16.7							*P200 = 94.1*
355	25													
		S-5	4 8 9	33		351.8 / 28.5 [FOUNDATION] Lean CLAY (CL), burnt orange/gray, very stiff, moist								
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Elevation (feet)	Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	30					reddish brown								
		S-6	1 4 6	89		stiff	8.5		33	13				
345	35													
						firm, gray with orange vertical streaking								
		S-7	2 3 4	89			20.8							
340	40													
		ST-2	P	100			23.8 23.7 23.3 23.0	125.0 122.7						
		S-8	2 2 2	100		wet	22.7							
335	45													
		ST-3	P				21.4 21.1 20.1 20.6 19.5	126.3 128.0	31	16				*LV Su=1.6 ksf*
		S-9	2 2 4	100										
330	50													
		S-10	3 5 6	100										
325	55													
		S-11	4 6 6	100										
320	60													
		S-12	3 6 7	100		316.8 / 63.5 Silty SAND (SM), beige, medium dense, saturated	17.2							*P200 = 48.4*
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
315						314.8 / 65.5 [FOUNDATION] Sandy Lean CLAY (CL), gray with burnt orange vertical streaking, stiff								
							22.4							
		ST-4		100			19.9	124.9						
							21.4	124.7						*P200 = 91.0*
310	70						21.5							
						Lean CLAY with Sand (CL), gray, stiff, with orange mottling and vertical streaking								
		S-13	5 5 4	100			18.6		26	11				*P200 = 62.8*
305	75													
		S-14	3 3 5	100			24.3		35	19				
300	80					300.3 / 80.0 End of Boring at 80 ft								*End 8/7/15*
295	85													
290	90													
285	95													
	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B017

Sheet 1 of 2

Date(s) Drilled	08/10/2015 8:00 AM to 08/10/2015 10:30 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	40.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	347.2 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198369.4 E 832674.8 (ft NAD83)	Groundwater Level(s)	38 ft on 8/10/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					347.2 / 0.0 [FILL] Lean CLAY (CL), brown gray, very stiff, moist								*Start 8/10/15 at 8:00 AM*
345		S-1	1 2 16	56		with fine sand								
		ST-1	P	80										*Pushed Shelby 20"*
	5					342.2 / 5.0 [ASH] SILT with Sand (ML), dark gray, very loose, moist, with chips of coal								
340		S-2	1 1 1	67			30.8		NP	NP				*Appears to be fly ash. Chips of coal in tip of split spoon P200 = 83.1*
						339.2 / 8.0 [FOUNDATION] Sandy Lean CLAY (CL), yellow brown, very soft, moist	22.5	123.0	33	16				
		ST-2	P	90			17.1	129.6						*Pushed Shelby 20" P200 = 67.1*
	10													
335														
		S-3	WOR	89			23.7		38	20				*P200 = 94.7*
	15					reduced sand content								
330						329.2 / 18.0 Sandy Lean CLAY (CL), brown, firm, moist								
		S-4	4 6 8	100										
	20													
325														
						reduced sand content	17.9							*Pushed Shelby 20"*
		ST-3	P	80			21.4	128.5						
	25						20.3 21.3	127.2	34	20				*P200 = 93.3*
320														
		S-5	2 2 6	100			19.5		35	23				*P200 = 60.4*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:26 PM

AECOM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B017

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
315	30					gray, specks of rust, streaks of orange								
		ST-4	P				15.2 15.0 17.4 21.2	136.4 128.1	35	21				*Pushed Shelby 20"* *P200 = 82.4*
310	35					▽								*Water returned to surface*
		S-6	2 4 5	100										
	40					307.2 / 40.0 End of Boring at 40 ft								*End 8/10/15 at 10:30 AM*
305	45													
300														
	50													
295														
	55													
290														
	60													
285														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:26 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Date(s) Drilled	08/20/2015 12:00 AM to 08/21/2015 12:00 AM	Logged By	SWB	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD HSA/4.25" OD Mud rotary	Drill Bit Size/Type	Tricone bit, bent claw	Borehole Depth	80.0 ft
Drill Rig Type	CME 850 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	378.6 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198450.7 E 832716.5 (ft NAD83)	Groundwater Level(s)	43 ft on 8/21/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					378.6 / 0.0 [CREST WEARING SURFACE]								*Start 8/20/15*
						377.6 / 1.0 Crushed stone, sand, silt, gray to dark gray								
						[EMBANKMENT] Lean CLAY (CL), brown/gray with gray mottling, stiff								
375		ST-1	P				14.6 15.1	145.5						
	5													
370			3 4 6											*No recovery*
	10	S-1	3 5 6	78			14.0		38	25				
365														*No recovery*
	15	S-2	2 5 8	72										
360		ST-2	P	71			15.4 14.7 15.0	130.8						*P200 = 90.6*
	20													
355		S-3	4 7 9	89										
	25													*End 8/20/15* *Start 8/21/15*
350		S-4	3 5 7	94			15.2		37	24				
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
345		ST-3	P	100			13.5 13.5 17.7 15.6	132.1 133.9	38	24			4.5	
	35													
340		S-5	2 8 8	89		with sand, very stiff	14.2							*P200 = 75.3*
	40													
335		S-6	3 9 14	89		with 2" seam of sand and gravel	17.3		35	21				
	45													
330		ST-4	P	75			17.5 16.8 16.6	135.8	35	20				
	50					328.6 / 50.0 [FOUNDATION] Lean CLAY (CL), gray, firm, moist, with some sand								*Switch to mud rotary*
325		S-7	2 3 3	89			25.7		44	25				
	55													
320		ST-5	P	100			44.4 19.6 17.8 16.8	141.3						*P200 = 88.6* *Pushed Shelby 18"*
	60													
315		S-8	1 2 4	100		less sand								
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310	70	S-9	2 3 2	100										
305	75	S-10	1 2 2	100			21.5							*P200 = 89.7*
						303.1 / 75.5 [FOUNDATION] Silty SAND (SM), gray/orange, medium dense, fine to medium sand								
300	80	S-11	13 9 9	89		298.6 / 80.0 End of Boring at 80 ft	19.5		NP	NP				*End 8/21/15*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Date(s) Drilled	08/08/2015 10:44 AM to 08/09/2015 9:10 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	HSA/Mud rotary	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	100.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	376.1 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199211.3 E 832989.8 (ft NAD83)	Groundwater Level(s)	6 ft on 8/8/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					376.1 / 0.0 [ASH] Sandy SILT to SILT (ML), gray to dark gray, very loose, wet, non-plastic								*Start 8/8/15 at 10:44 AM*
375		S-1	1 0 1	100			48.2		NP	NP				*P200 = 51.4*
	5					▽								*Observed water*
370									NP	NP				*P200 = 94.5*
		ST-1	P	10			106.0	87.7						*Pushed Shelby 20"*
	10													
365														
		S-2	0 1 1	100			102.0		NP	NP				
	15													
360														
		S-3	WOR	100										
	20													
355														
		S-4	WOR	100										*Switch to mud rotary*
	25													
350														
		S-5	WOR	100			43.4							*P200 = 97.6*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:39 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
345	30													
		S-6												*Pushed Shelby 20". Sample fell out of tube, recovered with split spoon*
340	35													
		S-7	WOR	100			36.8		NP	NP				*P200 = 70.8*
335	40						41.8	109.6						
		ST-2	P	50			46.0	102.9	NP	NP				*P200 = 83.5*
330	45						54.5	106.8						*Pushed Shelby 20"*
		S-8	WR	100										
325	50					325.1 / 51.0 [FOUNDATION] Sandy Lean CLAY (CL), yellow, stiff, wet								
		S-9	10 5 4	100			18.9							*Driller reports drilling getting harder P200 = 64.2*
320	55	S-10												*Pushed Shelby 20". Sample fell out of tube at surface. Bagged and labeled.*
		S-11	2 3 4	33			17.7		24	13				*P200 = 61.1*
315	60	ST-3	P	75		vibrant orange, moist/saturated, medium sand								*Pushed Shelby 20"*
		S-12	10 15 20			312.1 / 64.0 Silty SAND (SM), gray, dense, wet								
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:40 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310														
		S-13	15 19 17	28										
	70													
305						304.1 / 72.0								
						Silty CLAY with Sand (CL-ML), gray, stiff, low to medium plasticity, fine sand, vertical orange stripping								
		S-14	1 6 6	100			20.9		22	6				*P200 = 71.5*
	75													
300						299.1 / 77.0								
						Poorly-Graded SAND with Clay (SP-SC), yellow, very dense, medium to coarse sand, angular								
		S-15	17 28 21	56										*Shelby tube will not advance. Retrieve sample with split spoon. Drilling mud possibly not allocating sample to enter split spoon. Check valve working correctly.*
	80													
295														
		S-16	14 26 30	28			13.3		33	16				*End 8/8/15 at 5:20 PM* *P200 = 7.6*
	85													*Start 8/9/15 at 7:20 AM* *15ft of hole collapsed over again. Redrill.*
290														
		S-17	24 24 23	33										
	90													
285														
		S-18	11 10 11	33										
	95													
280						278.1 / 98.0								
						Poorly-Graded SAND with Gravel (SP), burnt yellow/orange, dense, angular								
		S-19	13 19 18	33										*End 8/9/15 at 9:10 AM*
	100					276.1 / 100.0								

End of Boring at 100 ft

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Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:40 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Date(s) Drilled	08/19/2015 12:00 AM to 08/20/2015 12:00 AM	Logged By	SWB	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD HSA/4.25" OD Mud rotary	Drill Bit Size/Type	Tricone bit, bent claw	Borehole Depth	100.0 ft
Drill Rig Type	CME 850 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	378.1 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198337.4 E 832996 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					378.1 / 0.0 [CREST WEARING SURFACE]								*Start 8/19/15*
						377.1 / 1.0 Crushed stone with Gravel and Sand, gray to dark gray								
						[EMBANKMENT] Lean CLAY (CL), brown/gray, moist, stiff								
375		ST-1	P	50			16.5 15.3 15.8	134.3 129.9	35	19			4.8	*LV Su=6.8 ksf*
	5													
370		S-1	3 4 6	72										
	10													
365		S-2	2 3 4	72			16.2		36	21				
	15													
360		ST-2	P	79		with gray mottles	15.7 13.7 15.3	129.5 130.3						*P200 = 97.8*
	20													
355		S-3	2 5 8	94										
	25													
350		S-4	3 4 12	89			14.3							*P200 = 95.6*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:47 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
345		ST-3	P	100			15.2 18.0 14.6 16.7	138.7	34	21				
	35													
340		S-5	6 8 13	100										
	40													
335		S-6	3 8 11	100			14.0		34	21				
	45													
330		ST-4	P	100			15.5 15.9 12.6 13.3	131.9 134.0	31	17				*Switch to mud rotary at 50'*
	50													
325		S-7	4 9 7	100		with occasional layers of clayey sand	20.2							*P200 = 93.1*
	55													
320		S-8	2 4 5	100			20.7		38	25				
	60													
315		S-9	4 5 7	100		gray to dark gray 313.6 64.5 [FOUNDATION]	20.9		36	23				*Bottom 4" appears to be ash*
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:47 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						Lean CLAY with Sand (CL), brownish gray to gray, stiff, moist								
310		ST-5	P	100			25.9 18.8 17.5	128.9 128.6						
	70	S-10	2 3 6	100			18.2 22.8		41	29				*P200 = 82.9*
305						305.1 / 73.0								
		S-11	15 21 12	67		Clayey SAND with Gravel (SC), gray, dense								
						303.7 / 74.5								
	75					Poorly-Graded SAND with Gravel (SP), dense, brown/gray, moist								
300		S-12	12 15 21	72		gray, fine to medium	21.4							*P200 = 7.7*
	80													
295						more gravel								
		S-13	13 21 33	67		orange								
	85													
290														
		S-14	6 18 17	61										
	90													
285														
		S-15	12 32 50	56										
	95													
280														*Sand and gravel keeps collapsing in the boring. Can't advance below 100'*
	100					278.1 / 100.0								

End of Boring at 100 ft

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:48 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275	105													*End 8/20/15*
270	110													
265	115													
260	120													
255	125													
250	130													
245	135													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:48 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B021

Date(s) Drilled	08/17/2015 2:45 PM to 08/18/2015 9:30 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	344 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198247.4 E 832969.4 (ft NAD83)	Groundwater Level(s)	7 ft on 8/17/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					344.0 / 0.0 [FILL] Lean CLAY with Sand (CL), gray, soft, moist								*Start 8/17/15 at 2:45 PM*
		S-1	1 2 1	100			19.5							
340		ST-1	P	100			16.6 15.0	129.6 126.8 131.5	39	26				*LV Su=2.3 ksf*
	5					338.0 / 6.0								
		S-2	1 1 1	67		[ASH] SILT (ML), gray, soft to medium stiff, wet, low plasticity ▽ 6" layer of clay at 6'	23.7		42	26				
335		S-3		0			49.8		NP	NP				*Pushed Shelby 24". No recovery in Shelby Tube, Split Spoon used to recover sample. Outside of Split Spoon shows water*
	10													
						330.5 / 13.5								
330		ST-2	P	100		[FOUNDATION] Sandy Lean CLAY (CL), light gray with patches of orange, very cohesive, low to medium plasticity	44.8 25.1 24.7 23.1	106.9 118.4 124.3 125.4						*Piston sampler, pushed 24" P200 = 99.0*
	15													
325		S-4	2 4 4	100										
	20													
320		S-5	0 1 5	89			21.0							*P200 = 90.7*
	25													
315		S-6	2 1 3	100										
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:58 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B021

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
310		ST-3	P	100			16.3 14.7 15.0 17.6 18.9	135.0 127.6	22	9				*Piston sampler, pushed 24"* *P200 = 62.2* *LV Su=3.0 ksf*
	35													
305		S-7	4 7 8	100										
	40													*End 8/17/15 5:30 PM* *Start 8/18/15 8:00 AM*
300		S-8	5 6 7	100			18.0		25	9				
	45													
						296.0 / 48.0								
295		S-9	1 2 4	44		Poorly-Graded SAND with Silt (SP-SM), beige, loose, wet	17.7		NP	NP				*P200 = 8.2*
	50					294.0 / 50.0 End of Boring at 50 ft								*End 8/18/15 at 9:30 AM*
290														
	55													
285														
	60													
280														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:58 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B022

Sheet 1 of 2

Date(s) Drilled	08/07/2015 4:00 PM to 08/08/2015 8:45 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	40.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	353.4 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199227.6 E 831636.1 (ft NAD83)	Groundwater Level(s)	21.5 ft on 8/8/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					353.4 / 0.0								
						[FILL] Poorly-Graded SAND with Silt (SP-SM)								*Start 8/7/15 at 4:00 PM*
						351.9 / 1.5								
		S-1	2 3 5	39		[FOUNDATION] Lean CLAY (CL), burnt orange/brown, firm, moist, medium plasticity								
350		ST-1	P	100										*Pushed Shelby 20"*
	5													
		S-2	2 3 4	89		yellow brown, higher plasticity	23.9							*P200 = 96.7*
							22.4	127.1						
345		ST-2	P				20.8	128.3					2.3	*P200 = 93.7*
							21.5	132.2	35	17				
	10						21.3	128.2						
							21.7							
							21.4							
340		S-3	2 4 4	100										*12" of split spoon wet on recovery*
	15													
335		S-4	2 3 3	78			20.6		35	20				*Split spoon dry on recovery*
	20													*End 8/7/15*
						▽								*Start 8/8/15 at 7:30 AM*
														Augers pulling significant water up
330		ST-3	P	100			19.7	127.3						*Pushed Shelby 20"*
							19.3	129.1					1.8	
	25						18.9	130.6	38	24				*P200 = 92.4*
							19.5							
325		S-5	4 7 9	83		with sand	15.9							*P200 = 80.1*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:03 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B022

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
320	30													
	35	S-6	2 3 5	100		beige, with more fine sand								
315	40	ST-4	P			314.1 / 39.3 Silty SAND (SM), beige, bottom of ST. 313.4 / 40.0 End of Boring at 40 ft	14.9 18.0	131.8 123.2	23	9			2.2	*P200 = 71.0* *Pushed Shelby 15"* *End 8/8/15 at 8:45 AM*
310	45													
305	50													
300	55													
295	60													
290	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:03 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023

Date(s) Drilled	08/04/2015 8:25 AM to 08/06/2015 10:15 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	HSA/Mud rotary	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	100.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	341.5 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198526.7 E 833473.7 (ft NAD83)	Groundwater Level(s)	13 ft on 8/4/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						Elevation (feet) 341.5 / Depth (feet) 0.0								
340	0					[ASH] Mixed layers of SILT to SILT with Sand (ML) and Sandy SILT, gray to dark gray, very loose, low plasticity to non-plastic, wet								*Start 8/4/15 at 8:25 AM*
		S-1	1 2 1	11										
335	5													
		S-2	2 0 1	11										
330	10					▽								
		S-3					26.6		NP	NP				*Pushed Shelby 20", no recovery. Sample recovered with split spoon. P200 = 94.5*
325	15													
		S-4	1 0 1	100										
320	20													
		S-5	WOR	67			31.3							*P200 = 57.4*
315	25													
		S-6	WOR	0										
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310	30													
	35	S-7	WOR	11										*16"/18" drilling mud*
305														
	40	S-8	WOR	11			37.6		NP	NP				*P200 = 97.3* *16"/18" driling mud*
300						300.5 / 41.0 Mixed Lean CLAY (CL) and Silt (ML), gray, moist								
		ST-1	P	100			57.5 27.1	104.2 109.9 123.2	32	10				*Pushed Shelby 5"* *P200 = 93.0*
	45													
295							20.5							
		ST-2	P	93		292.5 / 49.0 [FOUNDATION] Clayey SAND (SC), yellow-orange loose	20.9 19.9 13.6 18.1	129.6 137.9 132.1	35	21			2.2	*Pushed Shelby 21"* *P200 = 74.0*
290	50													
	55	S-9	3 4 4	100		some coarse sand, rounded to subrounded	17.4		22	12				*P200 = 49.7*
285														
	60	S-10	4 3 4	100										
280														
	65	S-11	4 4 4	100		with moist to wet, pockets of poorly-graded sand	19.9							*P200 = 49.7*

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275						273.0 / 68.5								
		S-12	5 4 5	100		[FOUNDATION] Clayey SAND (SC), yellow orange, stiff, moist	19.5		28	17				*P200 = 52.4*
270	70													
		S-13	2 2 4	100		mostly clay	24.5							*P200 = 93.1*
265	75					264.5 / 77.0								
		S-14	8 8 9	100		Clayey SAND (SC), yellow-orange, medium dense, moist	16.7							*P200 = 37.5*
260	80					258.5 / 83.0								
		S-15	8 50/5"	0		Poorly Graded SAND with Silt (SP-SM) to Poorly-Graded SAND (SP), yellow orange, very dense, with gravel								*Driller reports gravel in cuttings return at 83'*
255	85													
		S-16	22 22 12	33										
250	90					with less silt								
		S-17	11 13 20	11										*16"/18" drilling mud*
245	95													
		S-18	20 40 50/5"	88		241.5 / 100.0								*End 8/9/15 at 10:15 AM*
	100					End of Boring at 100 ft								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028

Date(s) Drilled	03/20/2016 12:00 AM to 03/20/2016 12:00 AM	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	87.0 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0					0.0 [CREST WEARING SURFACE] Crushed STONE with Sand (GP), gray, dense, moist — 1.0 [EMBANKMENT] Lean CLAY (CL), brown, stiff, moist, some Silt and trace Fine Sand								
5													
10													
15													
20													
25													
30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:49 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30													
35													
40													
45													
50					gray, very stiff, moist								
55	S-1	n/a n/a n/a n/a	66		brown and gray					n/a 2.5 2.5 3			
	S-2	woh/12" 7 8	66							n/a n/a 1 1			
60	S-3	3 5 5 7	100							1.5 1.5 1.5 1.5			
					62.0 / 62.5 [FOUNDATION]								
	S-4	1 4 5 6	100		Lean CLAY (CL-OL), dark gray, stiff, moist Silty Clay with trace decomposed organics (CL-ML), gray, loose, saturated					1 1 1.25 1.5			
65													

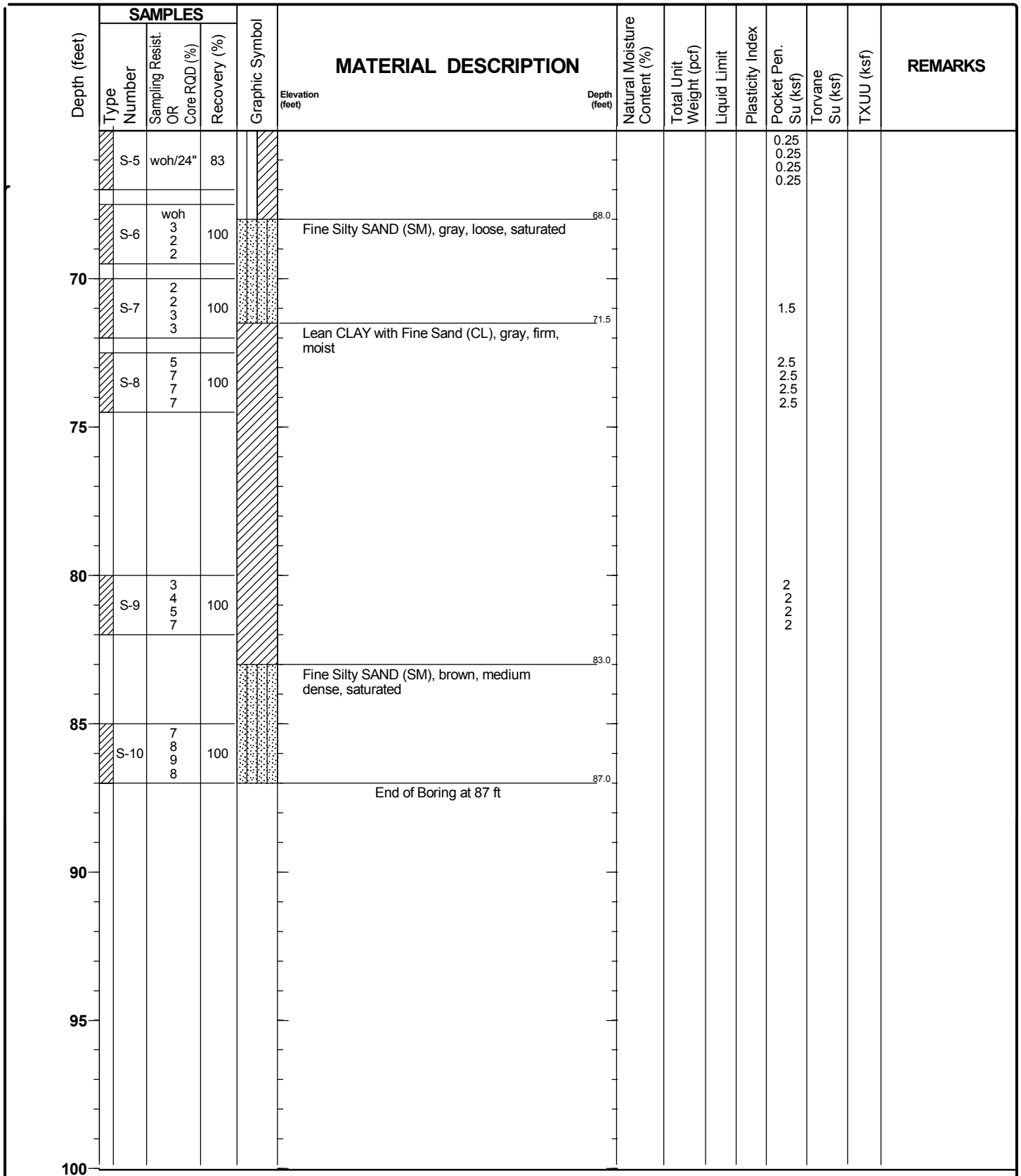
Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:49 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028



Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:49 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B030

Date(s) Drilled	03/18/2016 12:00 AM to 03/18/2016 12:00 AM	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	87.0 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	Near Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0						[TEMPORARY ACCESS RAMP] Crushed STONE (GP), gray, medium dense, moist	0.0								
							3.0								
						[BOTTOM ASH] Poorly Graded SAND (SP), medium dense, moist									
5							5.0								
						[ASH] SILT with some Clay (ML), gray, loose, moist									
10						very loose and saturated									
15															
20		S-1	WOR/24"	100											
		S-2	WOH/12" WOH 1	54			23.5					<0.25 0.25			
25		S-3	4 6 5 8	63		[EMBANKMENT] Lean CLAY with Silt (CL), brown, soft, wet firm, moist stiff						2.5 2.5 3			
		S-4	3 5 8 11	71								2 2.5 2.75			
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:01 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B030

Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-5	4 5 5 8	66							2 2.5 2.5			
	S-6	4 9 11 12	79		very stiff					4 4.5 >4.5			
35	S-7	8 9 12 11	66							4 4.5 >4.5			
	S-8	5 9 12 15	88							4 4.5 >4.5			
40	S-9	7 8 10 9	100		some fine sand					2.5 4 4 4.5			
	S-10	4 5 5 5	100		soft, saturated, layers of clay with fine sand					1.5 2 2 2.5			
45	S-11	1 3 5 5	100							1.5 1.5 2 2			
	S-12	WOH/18" 3	100							0.25 0.25 0.25 1			
50	S-13	2 2 3 4	83		51.0 [ASH] SILT (ML), dark gray, loose, saturated					1 1			
	S-14	1 WOH/18"	50		very soft								
55	S-15	1/18" 1	58										
	S-16	WOH/12" 1 2	75										
60	S-17	WOR/24"	0										
	S-18	1 1 WOH/12"	0										
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:02 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B030

Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet) / Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	S-19	3 3 4 3	83		[ASH] SILT (ML), dark gray, loose, saturated								
	S-20	WOR/12" 4 1	66		69.0					1			
70					[FOUNDATION] Lean CLAY (CL), light gray, soft, moist								
	S-21	3 5 6 8	100		stiff					3.5 3.5 3.5 3.5			
75	S-22	3 5 8 8	100							2 2 2.5 2.5			
80	S-23	4 5 8 8	92							3.5 3.5 3.5 4			
					83.0								
85	S-24	5 4 6 7	83		Fine Silty SAND (SM), brown, medium dense, moist								
					87.0								
					End of Boring at 87 ft								
90													
95													
100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:02 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D006

Date(s) Drilled	03/17/2016 10:45 AM to 03/18/2016 10:30 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	50.7 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/17/16 at 10:45 AM*
	S	S-1		100		Sandy SILT (ML), brown, firm, low plasticity, moist									
						Silty SAND and fine Gravel (SM), grey, loose	3.5								
5						Fine GRAVEL with Silt and Fine Sand (GM), loose, moist to wet	4.5								
	S	S-2		75		Organic CLAY (OL), brown and dark grey, traces of wood and coal, firm, medium plasticity, moist	6.0								
						[FOUNDATION] Silty Lean CLAY (CL), gray and orange to brown, traces of coal, firm to stiff, trace iron stain, medium plasticity, moist	8.0								
10	S	S-3		100											
						6" organic lean clay, dark grey to grey, becomes stiff									
	S	S-4		100											
15															
	S	S-5		100											
20															
	S	S-6		100											
25															
	S	S-7		100		6" silty clay, low to medium plasticity, moist grey with iron staining									
	S	S-8		100		soft									
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:12 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D006

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-8		100		3" seam of fine to medium sand light gray with iron staining, stiff, low to medium plasticity								
					stiff, medium plasticity, moist								
	S-9		100										
35					Lean CLAY with Fine Sand (CL), gray and orange-brown, firm to stiff, medium plasticity, moist								*End 3/17/16 Start 3/18/16 at 7:30 AM*
	S-10		63										
40					becomes very soft to firm, low to medium plasticity								
	S-11		100										
45					soft to firm								
	S-12		100										
					47.5								
					Fine SAND (SP), light gray with orange-brown spotting, dense								
50					50.7								
					End of Boring at 50.7 ft								*Refusal at 50.7ft. End 3/18/16 at 10:30 AM*
55													
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:12 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D008

Sheet 1 of 2

Date(s) Drilled	03/18/2016 12:00 AM to 03/19/2016 10:45 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	54.7 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/18/16*
		S-1		63		[ASH] SILT with Sand (ML), soft, non-plastic									
						wet, 6" organic clay and ash, coal									
5		S-2		94		with organics, coal, black and gray, medium plasticity									
							8.0								
		S-3		100		[FOUNDATION] Lean CLAY (CL), gray and orange-ish brown, medium plasticity									
10															
		S-4		100		more silt, low to medium plasticity, gray with iron staining									
15						medium plasticity									
		S-5		100											
20						very stiff									
		S-6		92											
25		S-7		100		frim to very stiff, low to medium plasticity wet									
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D008

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30					very stiff								
	S-8		100		6" pocket of grayish brown dense fine to medium grained sand								*End 3/18/16 at 5:55 PM*
35													*Start 3/19/16 at 7:20 AM*
	S-9		83		soft zones								
40													
	S-10		100		42.0								
					Fine Silty SAND (SM), gray, dense								
45													
	S-11		0		very loose								*Driller noted very soft layer*
	S-12		80										
50													
	S-13		100		dense, pockets of very stiff clayey silt, medium dense								*Refusal at 50.5ft.*
					brown and gray								
					54.7								
55					End of Boring at 54.7 ft								*End 3/19/16 at 10:45 AM*
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D009

Date(s) Drilled	03/20/2016 1:00 PM to 03/20/2016 12:00 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	31.1 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/20/16 at 1:00 PM*
	S	1		63		SILT with Ash (ML), gray, firm, no plasticity, moist									
							4.0								
5	S	2		75		Lean CLAY (CL), orange-brown, firm, medium plasticity, with 6" of fine to medium sand									
10	S	3		75											
							11.8								
	S	4		75		[ASH] SILT (ML), dark grey, soft, wet, no plasticity									
15	S	5		100											
							18.8								
20	S	6		40		[FOUNDATION] Lean CLAY (CL), trace ash, fine sand layers, stiff, medium plasticity, greenish-gray, moist									
25	S	7		63		low plasticity									
	S	8		100											
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:24 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D009

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-8		100		low to medium plasticity, gray to gray and orange-brown								
					very stiff								
	S-9		71		34.5								
35					Fine to Medium SAND (SP), brown, very dense, moist								*First Refusal at 35.1ft. Second Refusal at 35.4ft. End 3/20/16*
					35.4 End of Boring at 31.1 ft								
40													
45													
50													
55													
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:24 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D012

Sheet 1 of 1

Date(s) Drilled	03/15/2016 3:00 PM to 03/15/2016 3:30 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	8.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	SAMPLES Number	Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0								0.0								*Start 3/15/16 at 3:00 PM*
						[FILL] Base Course GRAVEL (GP)		0.5								
						[ASH] SILT with Sand (ML), gray, non-plastic		1.0								
	S	S-1		88		[FILL] Lean CLAY (CL), moist, orange-brown, trace fine sand, stiff										
5	S	S-2		85												
								8.0								
						End of Boring at 8 ft										*End 3/15/16 at 3:30 PM*
10																
15																
20																
25																
30																

AECOM

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:34 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D013

Sheet 1 of 1

Date(s) Drilled	03/16/2016 9:20 AM to 03/16/2016 9:50 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	12.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	SAMPLES Number	Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0						0.0								
						[FILL] Base Course GRAVEL and Sand (GP) — 0.5								*Start 3/16/16 at 9:20 AM*
		S-1		65		Sandy SILT (ML), brown, firm to stiff, low plasticity; ASH with clay, non-plastic to medium plasticity, gray, moist — 3.0								
5						Silty Lean CLAY (CL-ML), brown, firm, medium plasticity, moist								
		S-2		65										
						8.0								
						[FOUNDATION] Lean CLAY with Sand (CL), orange-brown to gray, stiff, medium plasticity								
10		S-3		58										
						12.0								
						End of Boring at 12 ft								*End 3/16/16 at 9:50 AM*
15														
20														
25														
30														

AECOM

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:37 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D014

Sheet 1 of 1

Date(s) Drilled	03/16/2016 10:05 AM to 03/16/2016 10:50 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	8.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	SAMPLES Number	Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0								0.0								
						[FILL] Base Course GRAVEL (GP)		0.5								*Start 3/16/16 10:05 AM*
	S	S-1		73		Sandy SILT (ML), brown, firm, low plasticity, moist		2.3								
						[ASH] SILT with Sand (ML), gray, soft, moist, no to low plasticity		3.3								
						Lean CLAY with Sand (CL), gray, firm, medium plasticity, moist		4.0								
5	S	S-2		79		[FOUNDATION] Lean CLAY (CL), gray to orange brown, stiff, medium plasticity, moist										
								8.0								
						End of Boring at 8 ft										*Enf 3/16/16 at 10:50 AM*
10																
15																
20																
25																
30																

AECOM

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:39 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D015

Sheet 1 of 1

Date(s) Drilled	03/16/2016 10:45 AM to 03/16/2016 3:00 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	24.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0								0.0								
						[FILL] Base Course GRAVEL (GP)		0.5								*Start 3/16/16 at 10:45 AM*
		S-1		75		Sandy SILT (ML), brown, firm, low plasticity										
								3.0								
						[ASH] SILT with Sand (ML), stiff, no to low plasticity, moist		4.0								
5		S-2		58		[FILL] Lean CLAY (CL), firm, medium plasticity, moist										
		S-3		83				10.0								
10						[ASH] SILT with Sand (ML), gray, soft, no plasticity, wet, 2" layer of medium sand										
		S-4		100												
15		S-5		100												
								19.5								
20		S-6		100		Lean CLAY with Ash (CL) gray, soft, medium plastiticy, wet										
								24.0								
						End of Boring at 24 ft										*End 3/16/16 at 3:00 PM*
25																
30																

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:42 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D016

Sheet 1 of 1

Date(s) Drilled	03/16/2016 3:05 PM to 03/16/2016 4:00 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	24.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/16/16 at 3:05 PM*
	S	S-1		73		[FILL] Lean CLAY (CL), brown, stiff, medium plasticity, moist to wet, trace fine sand									
						firm									
5	S	S-2		79			6.0								
						[ASH] SILT with Sand (ML), gray, soft, wet, traces of fine sand									
10	S	S-3		83											
	S	S-4		83											
15	S	S-5		100											
							19.0								
						Lean CLAY with Ash (CL), gray, soft, medium plasticity, wet									
20	S	S-6		100			22.0								
						Fine SAND with ash (SM), gray, loose, wet									
							24.0								
						End of Boring at 24 ft									*End 3/16/16 at 4:00 PM*
25															
30															

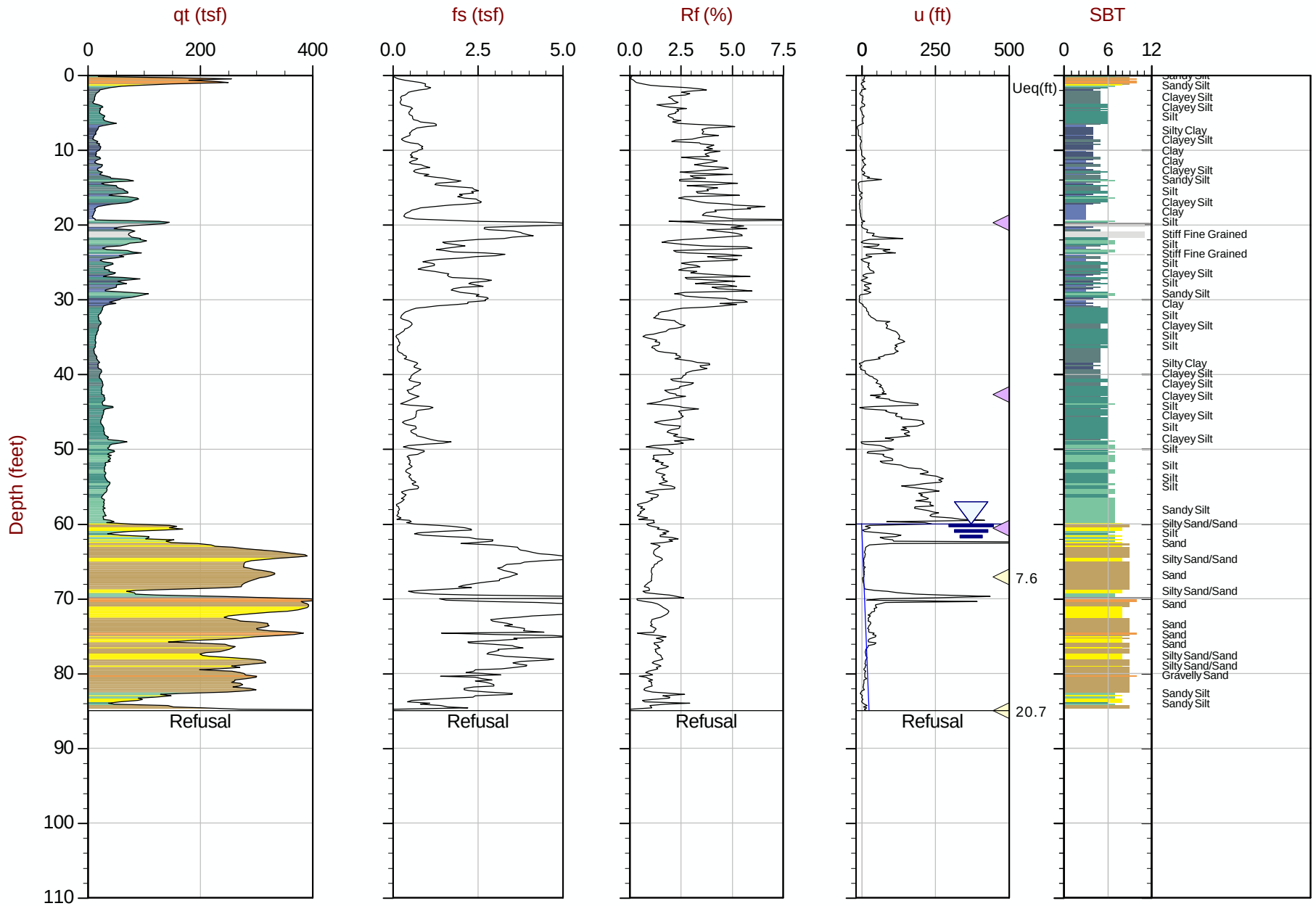
Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:45 PM

CONETEC

AECOM

Job No: 15-54071
Date: 08:07:15 07:41
Site: Dynegy Joppa IL

Sounding: JOP-C004
Cone: 349:T1500F15U500



Max Depth: 25.900 m / 84.97 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C004.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21260 Long: -88.85030

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

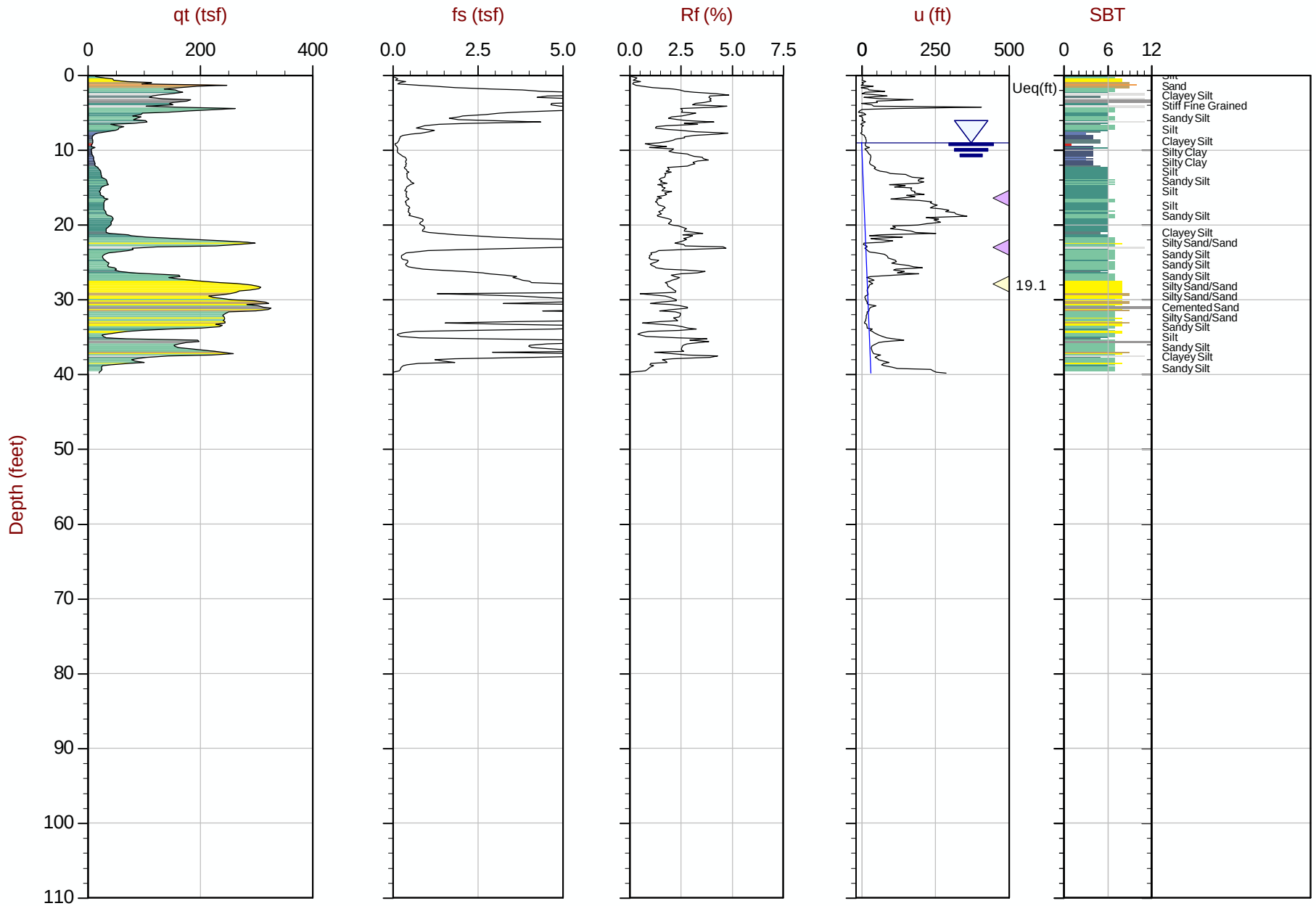
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:20:15 10:29
Site: Dynegy Joppa IL

Sounding: JOP-C005
Cone: 392:T1500F15U500



Max Depth: 12.150 m / 39.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C005.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21240 Long: -88.85047

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

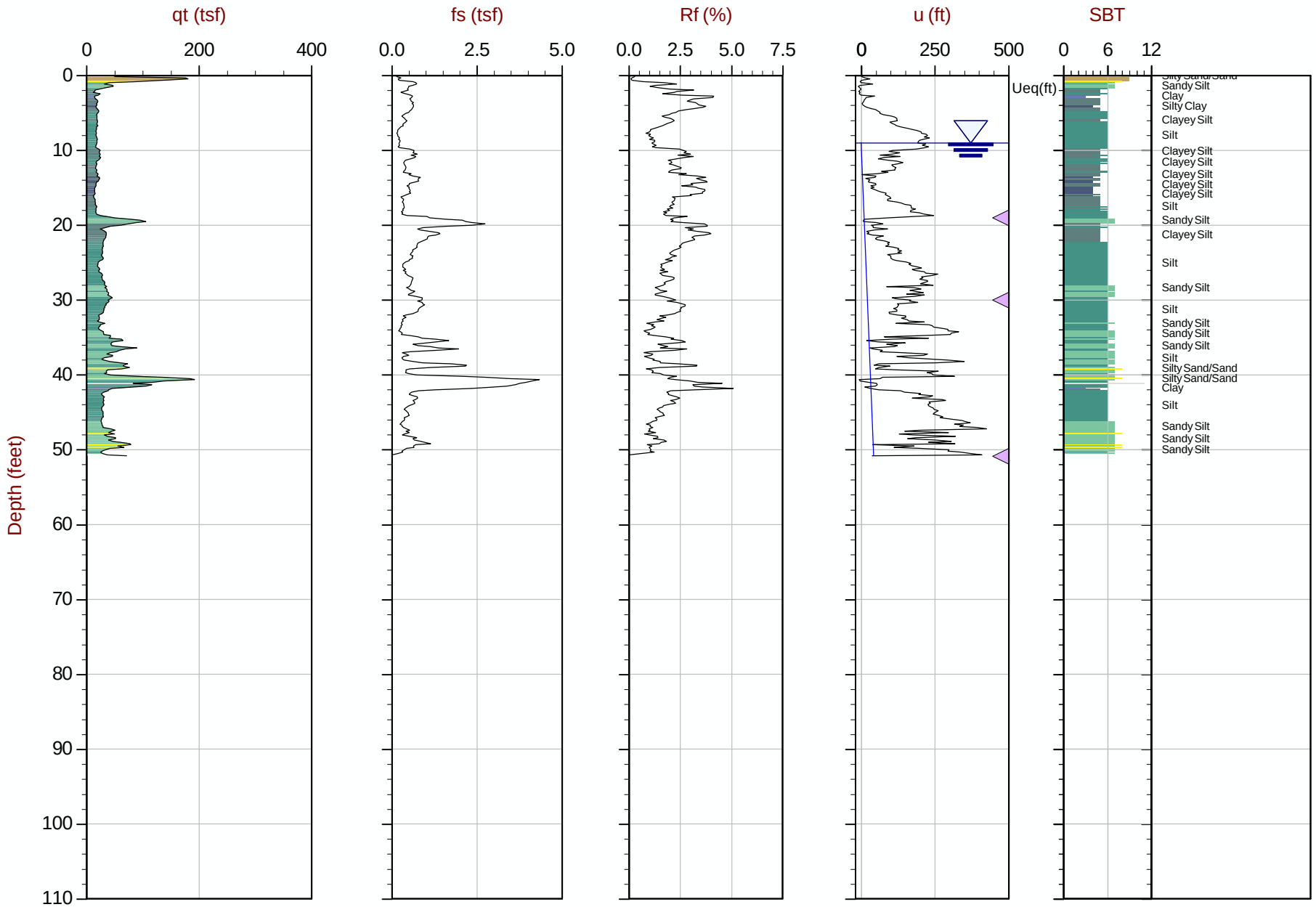
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:09:15 14:16
Site: Dynegy Joppa IL

Sounding: JOP-C013
Cone: 349:T1500F15U500



Max Depth: 15.500 m / 50.85 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C013.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21265 Long: -88.85710

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

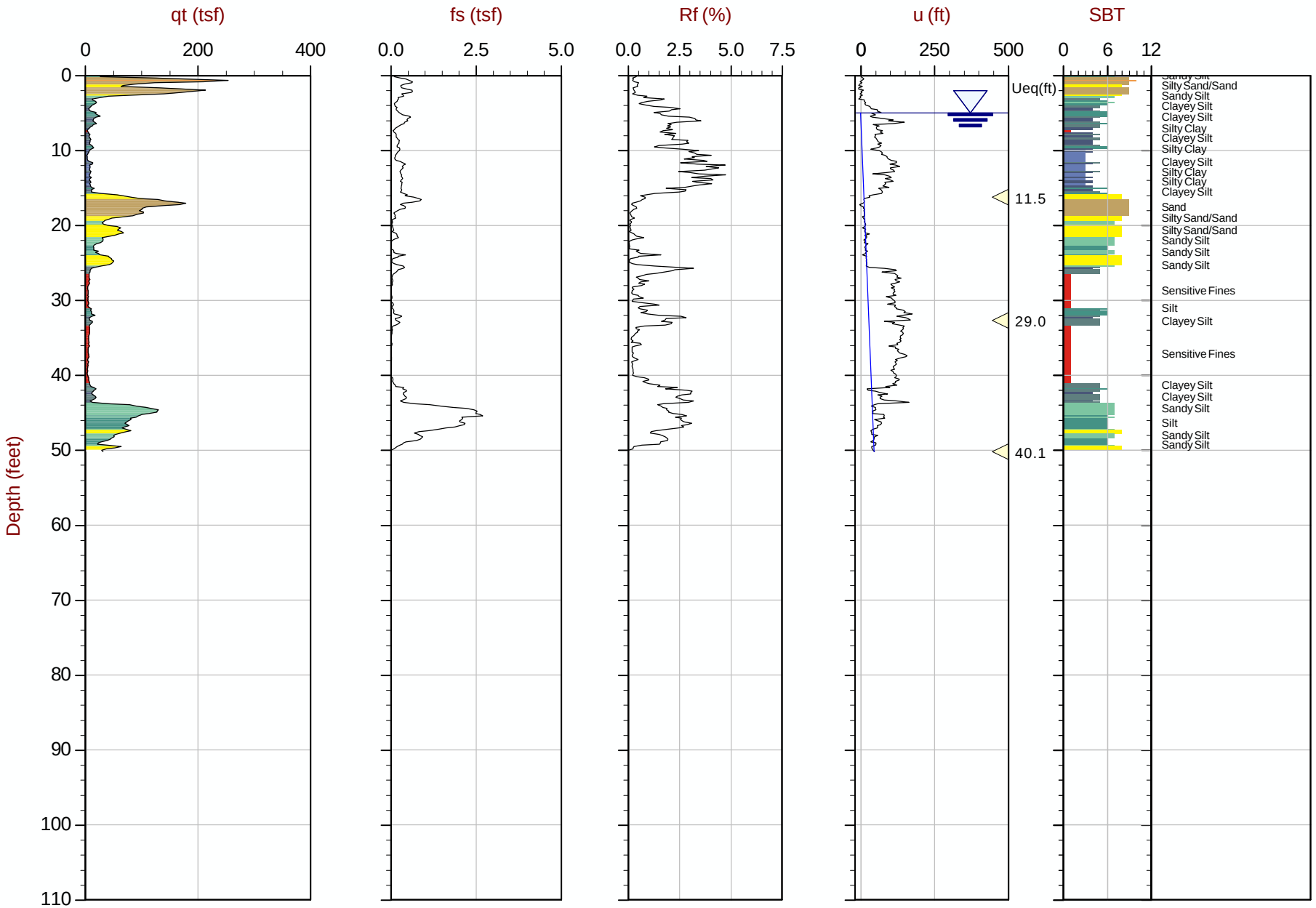
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:20:15 10:19
Site: Dynegy Joppa IL

Sounding: JOP-C017
Cone: 349:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C017.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21128 Long: -88.85363

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

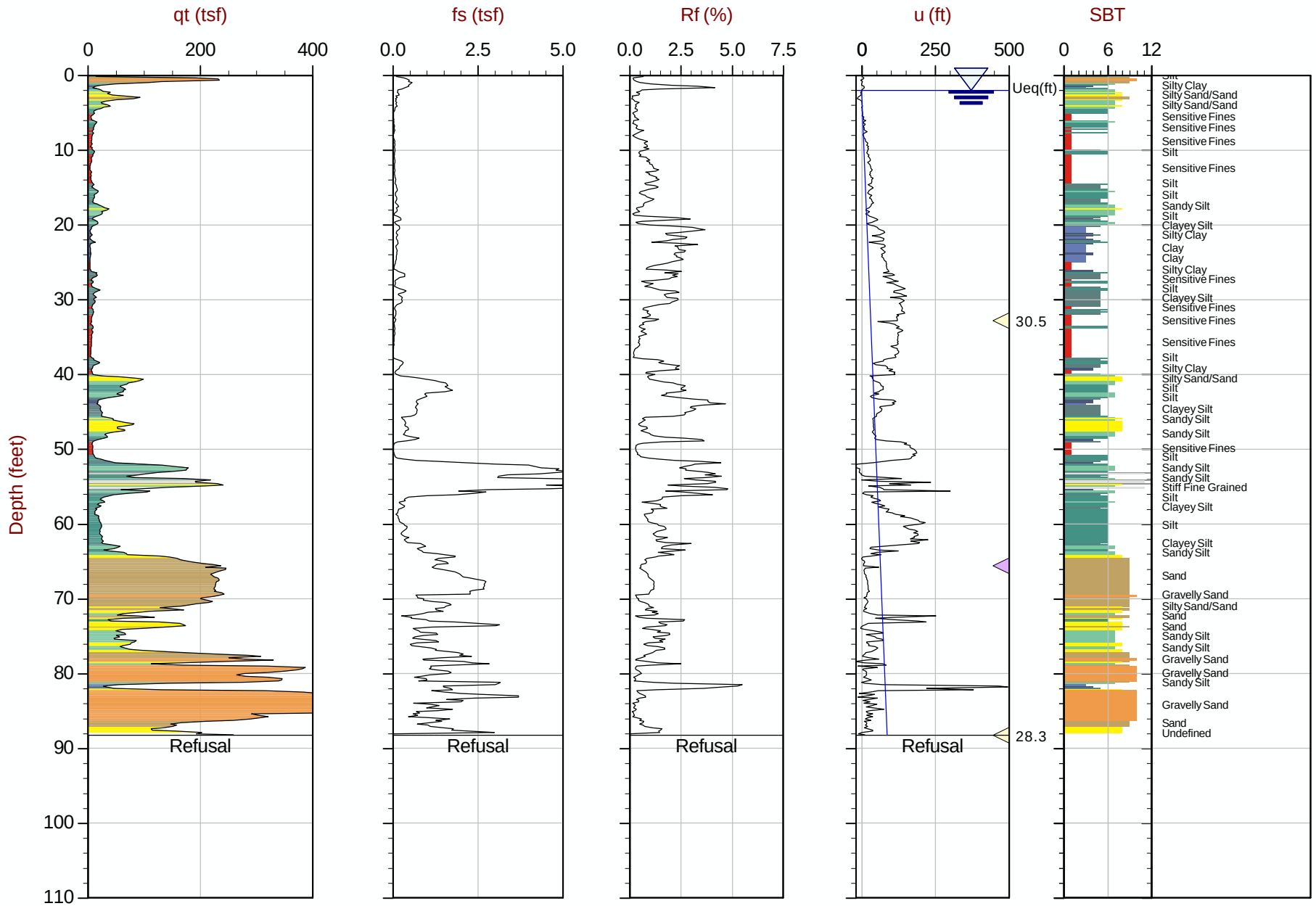
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:20:15 07:39
Site: Dynegy Joppa IL

Sounding: JOP-C018
Cone: 349:T1500F15U500



Max Depth: 26.900 m / 88.25 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C018.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21265 Long: -88.85275

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

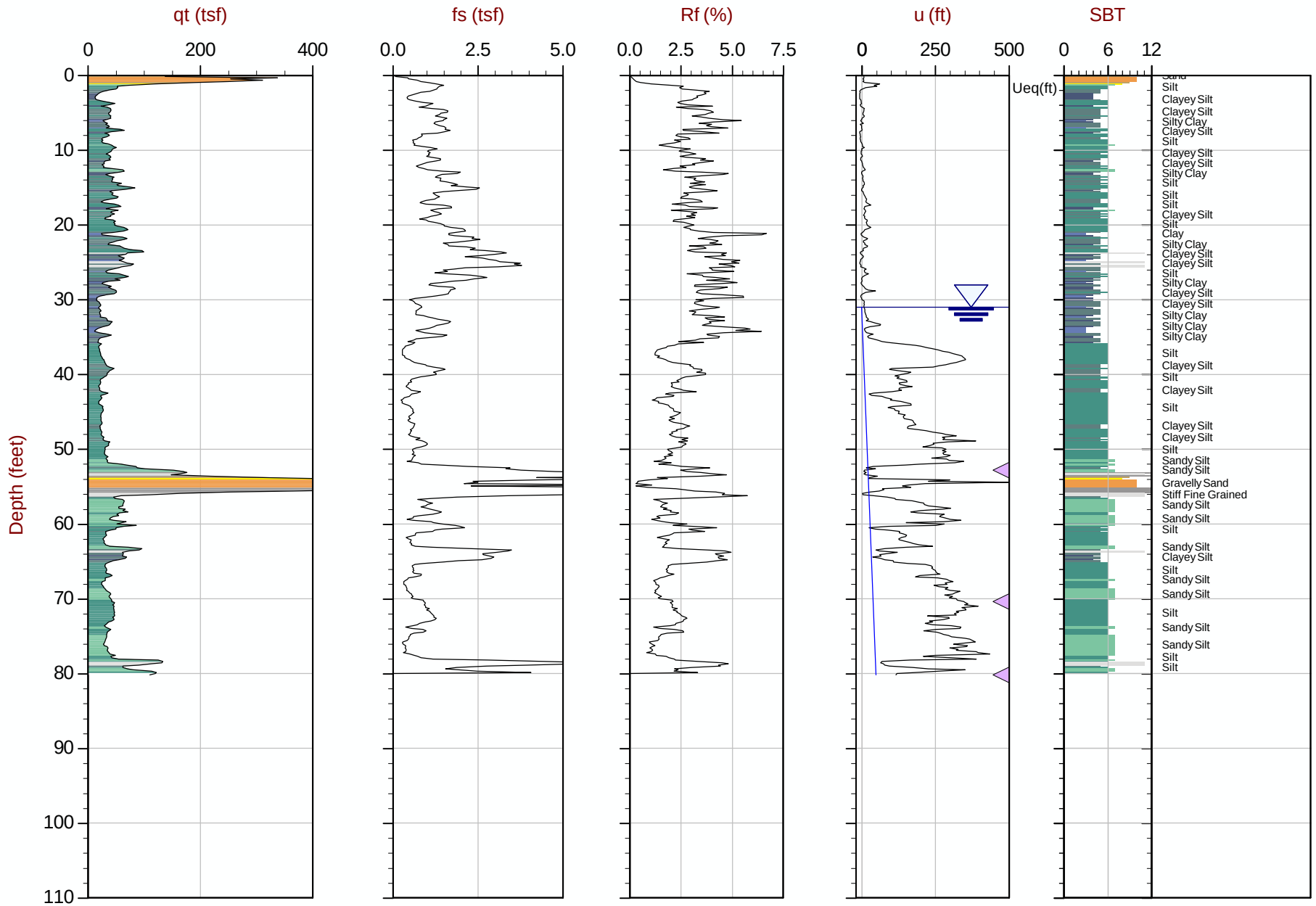
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:08:15 13:15
Site: Dynegy Joppa IL

Sounding: JOP-C019
Cone: 349:T1500F15U500



Max Depth: 24.450 m / 80.22 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C019.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21110 Long: -88.85490

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

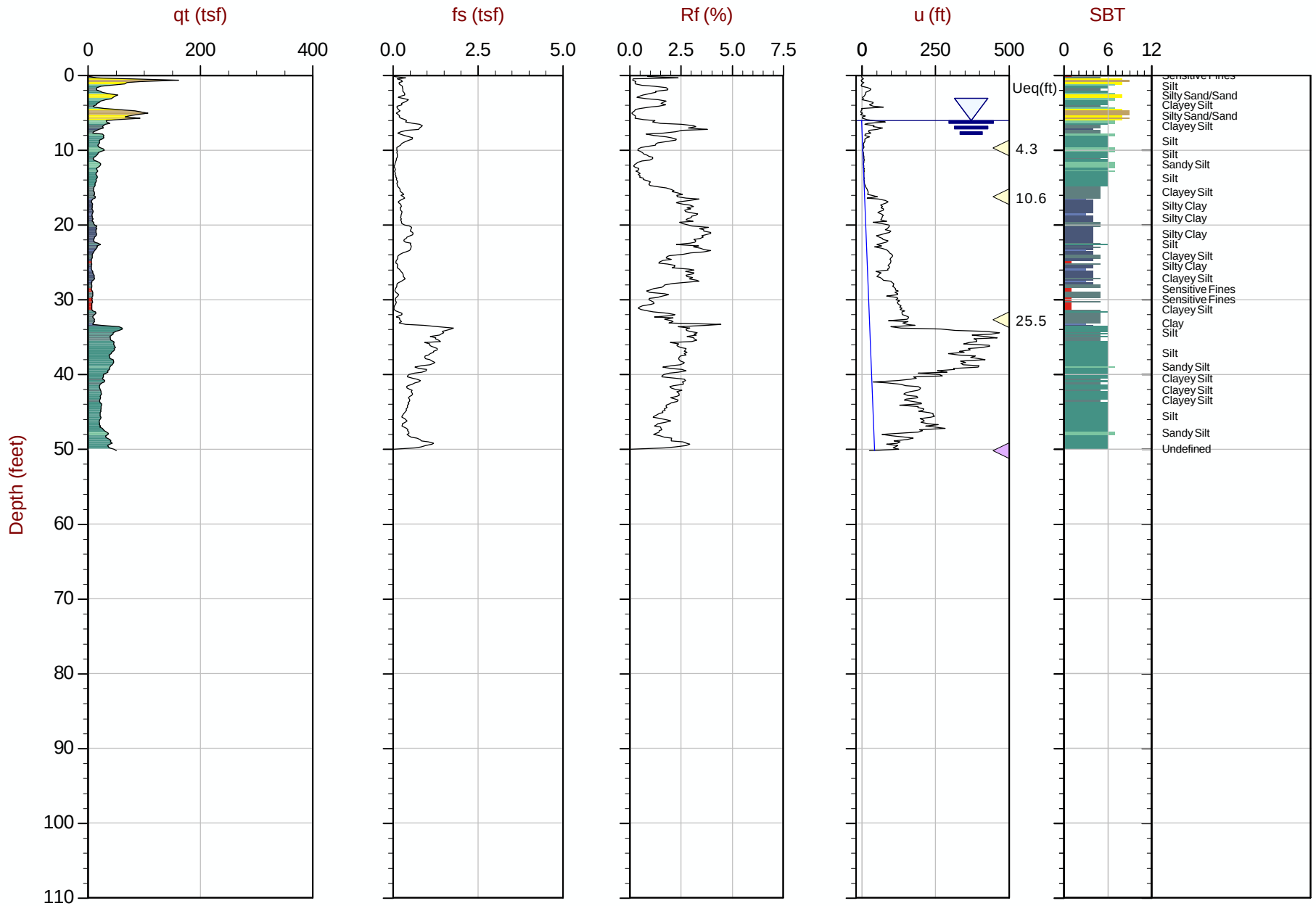
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 14:21
Site: Dynegy Joppa IL

Sounding: JOP-C020
Cone: 349:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C020.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21205 Long: -88.85517

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

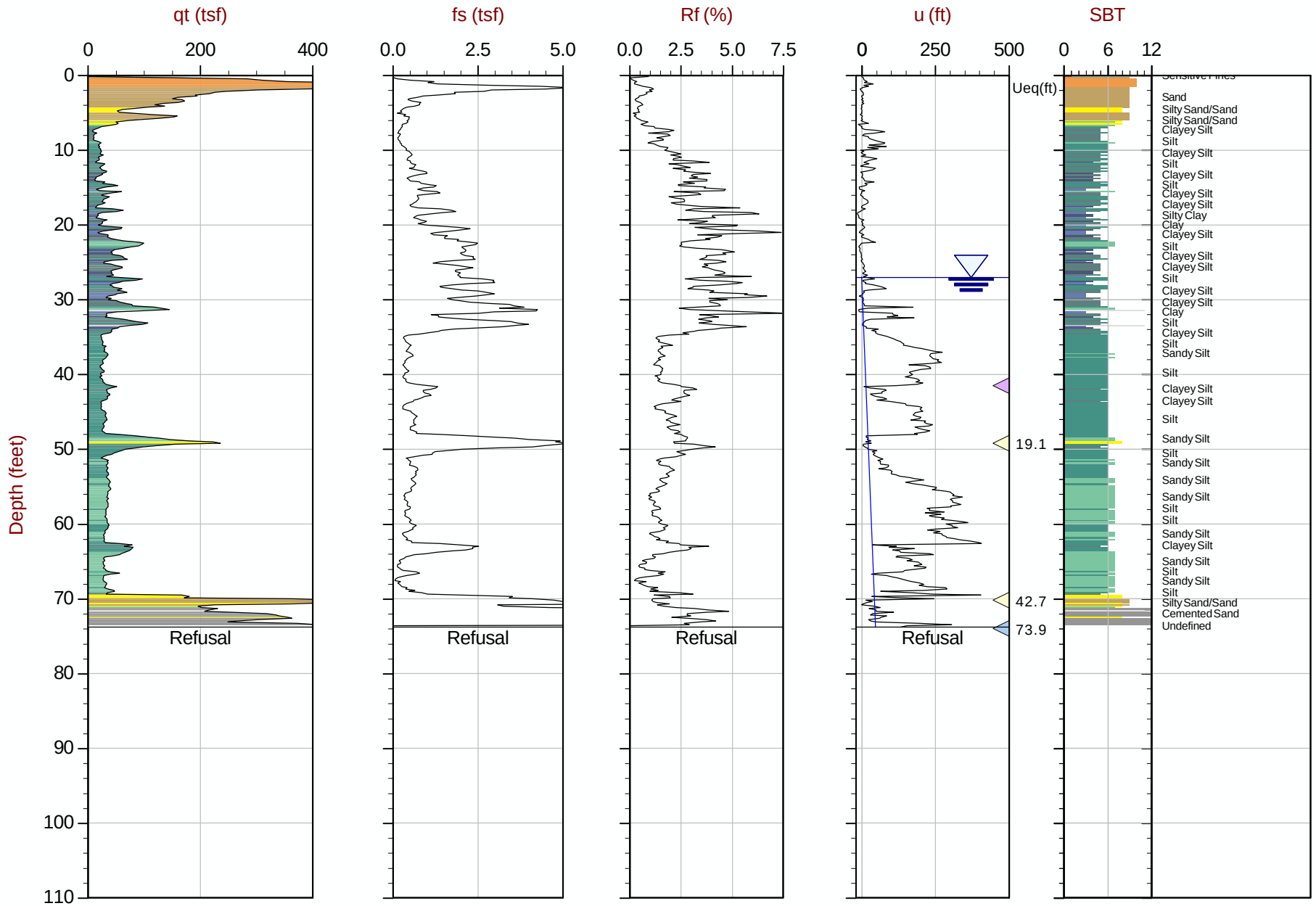
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:09:15 09:29
Site: Dynegy Joppa IL

Sounding: JOP-C021
Cone: 349:T1500F15U500



Max Depth: 22.500 m / 73.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C021.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21165 Long: -88.85580

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

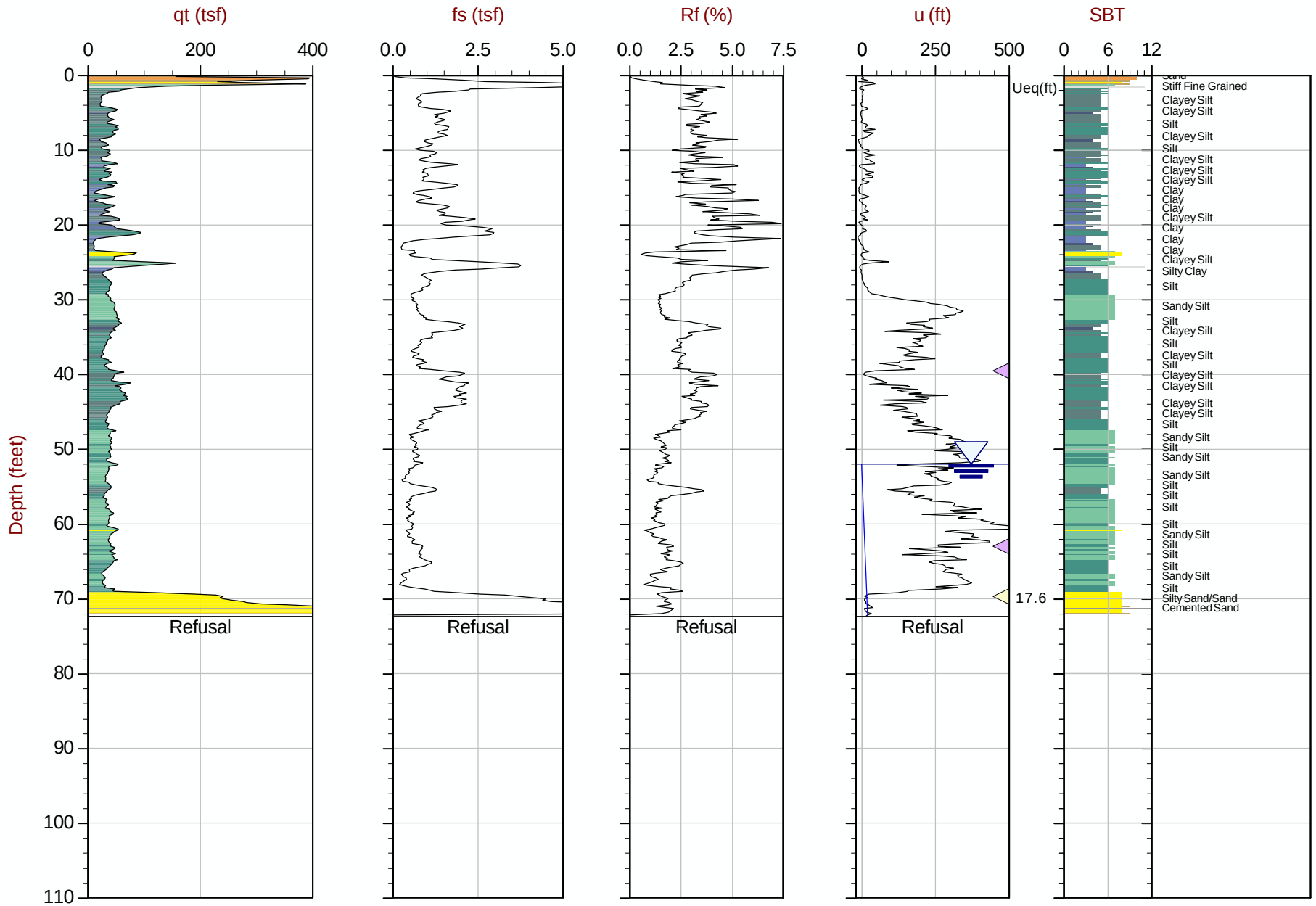
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:09:15 11:56
Site: Dynegy Joppa IL

Sounding: JOP-C022
Cone: 349:T1500F15U500



Max Depth: 22.050 m / 72.34 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C022.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21403 Long: -88.85622

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

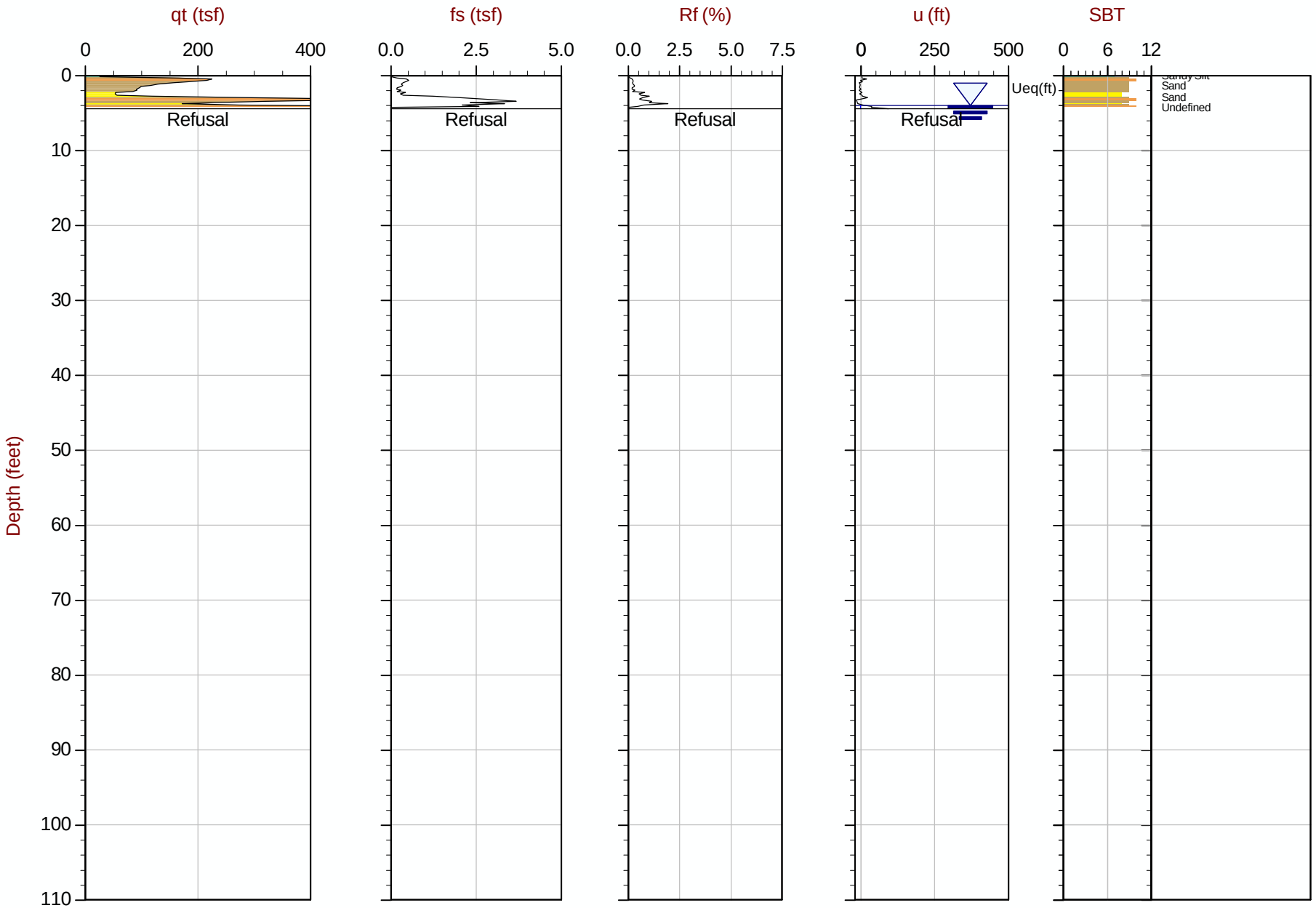
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 07:54
Site: Dynegy Joppa IL

Sounding: JOP-C024
Cone: 184:T1500F15U500



Max Depth: 1.350 m / 4.43 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C024.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21665 Long: -88.85482

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

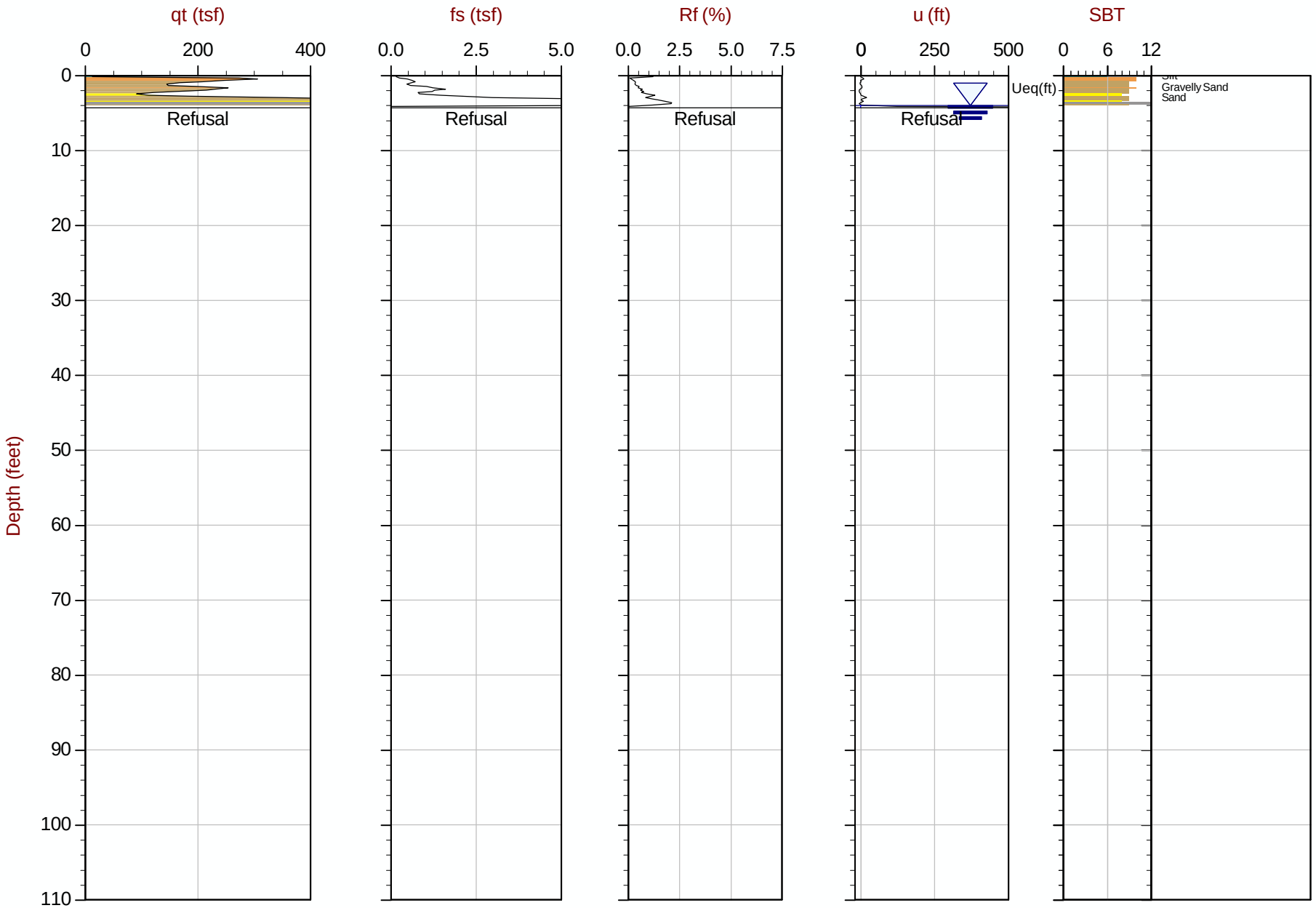
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 08:27
Site: Dynegy Joppa IL

Sounding: JOP-C024A
Cone: 349:T1500F15U500



Max Depth: 1.300 m / 4.27 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C024A.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21665 Long: -88.85482

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

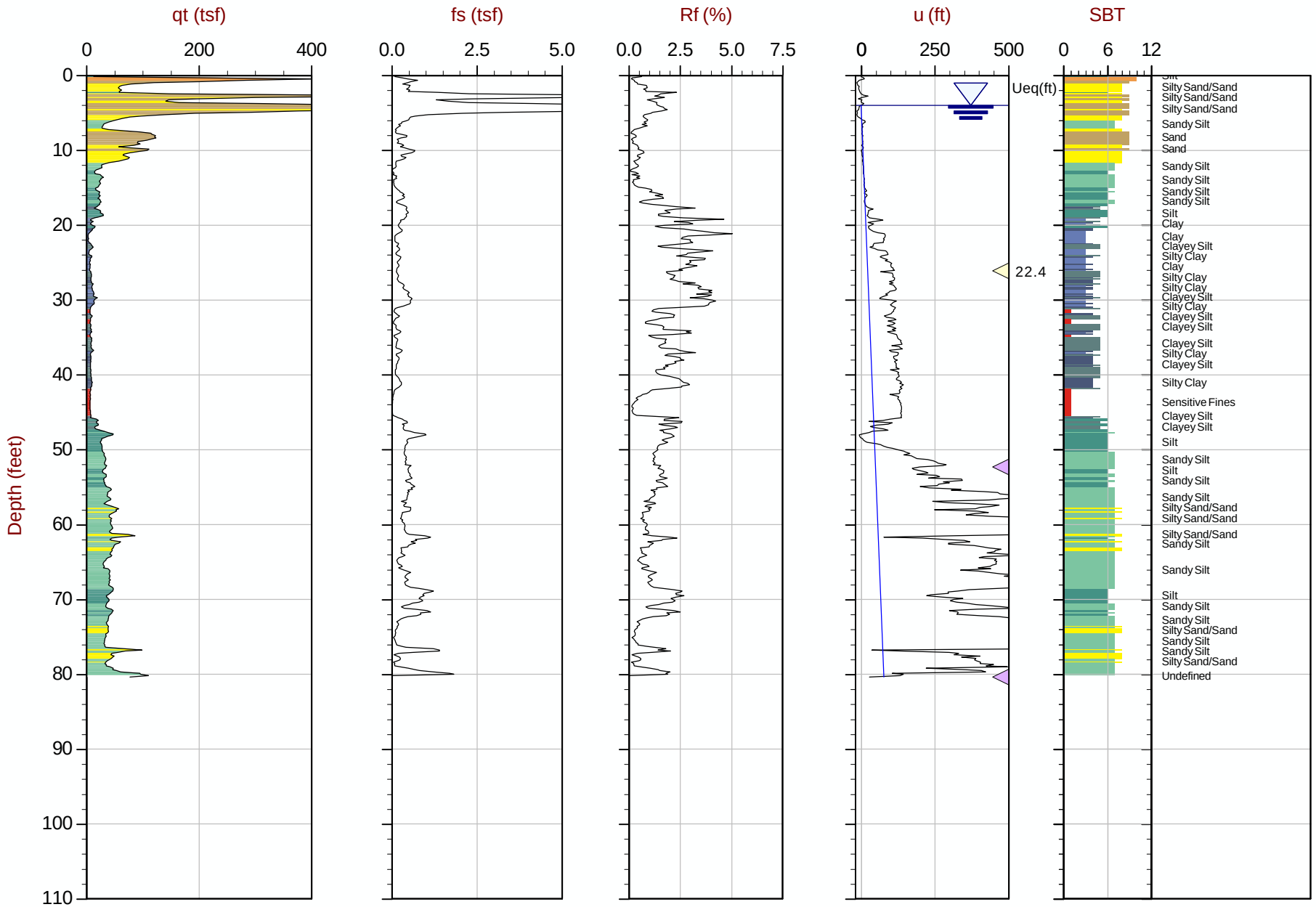
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 11:08
Site: Dynegy Joppa IL

Sounding: JOP-C024B
Cone: 349:T1500F15U500



Max Depth: 24.500 m / 80.38 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C024B.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21658 Long: -88.85478

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

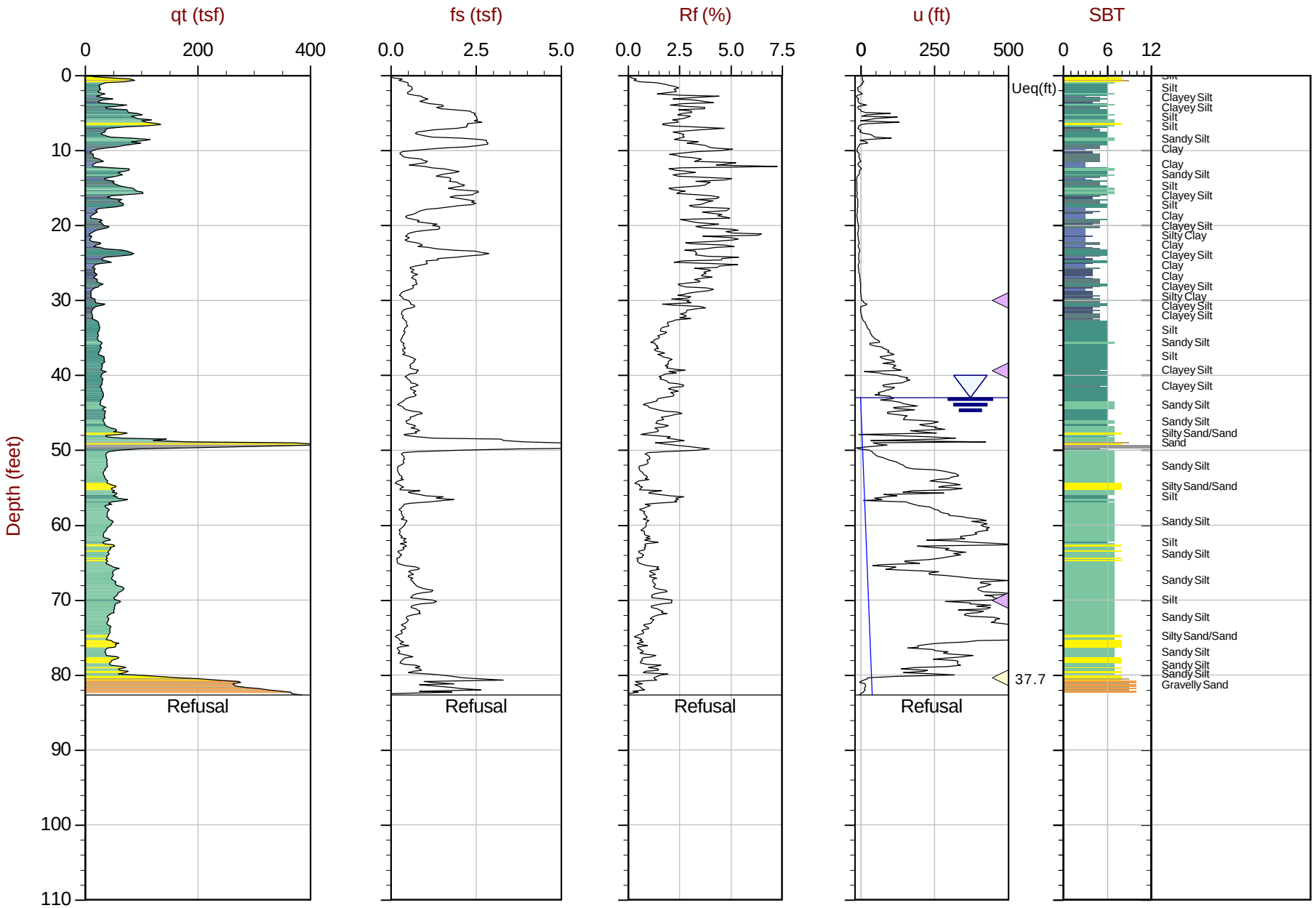
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:06:15 09:22
Site: Dynegy Joppa IL

Sounding: JOP-C025
Cone: 349:T1500F15U500



Max Depth: 25.200 m / 82.68 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C025.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21422 Long: -88.84995

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

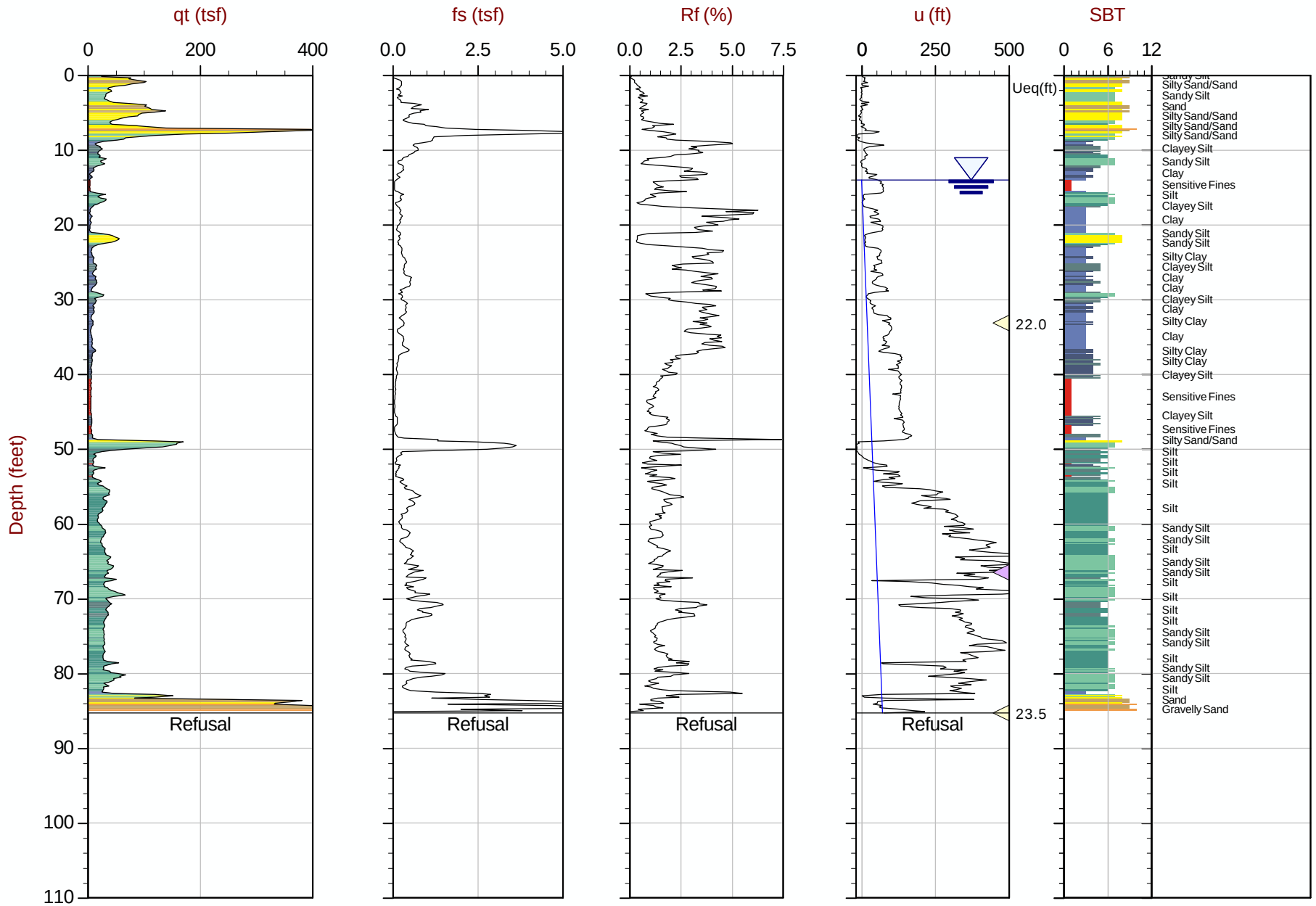
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:13:15 07:28
Site: Dynegy Joppa IL

Sounding: JOP-C027
Cone: 184:T1500F15U500



Max Depth: 26.000 m / 85.30 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C027.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21673 Long: -88.85213

△ Dissipation with estimated Ueq value
△ Dissipation, equilibrium not achieved

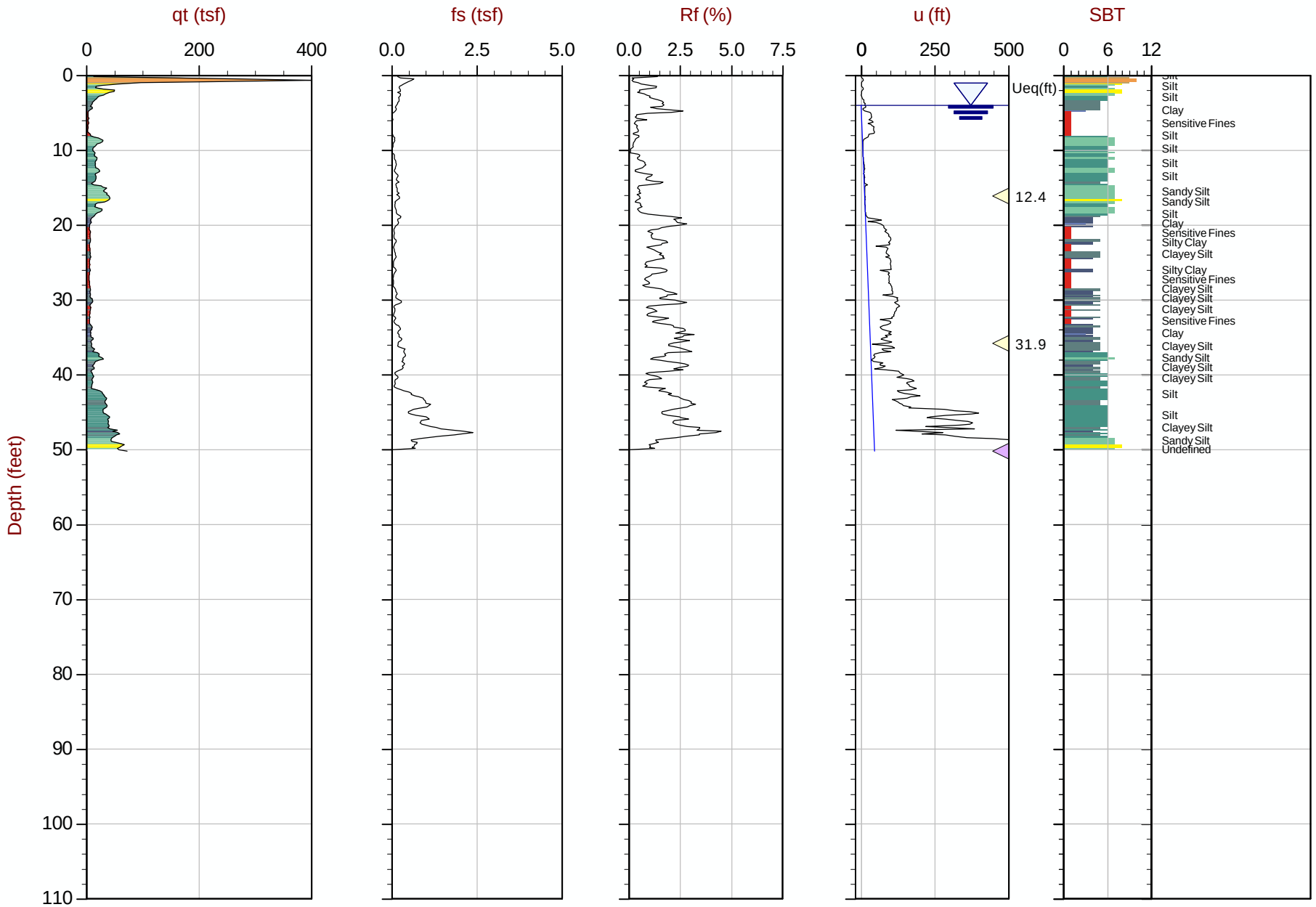
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 08:59
Site: Dynegy Joppa IL

Sounding: JOP-C028
Cone: 349:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C028.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21715 Long: -88.85305

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

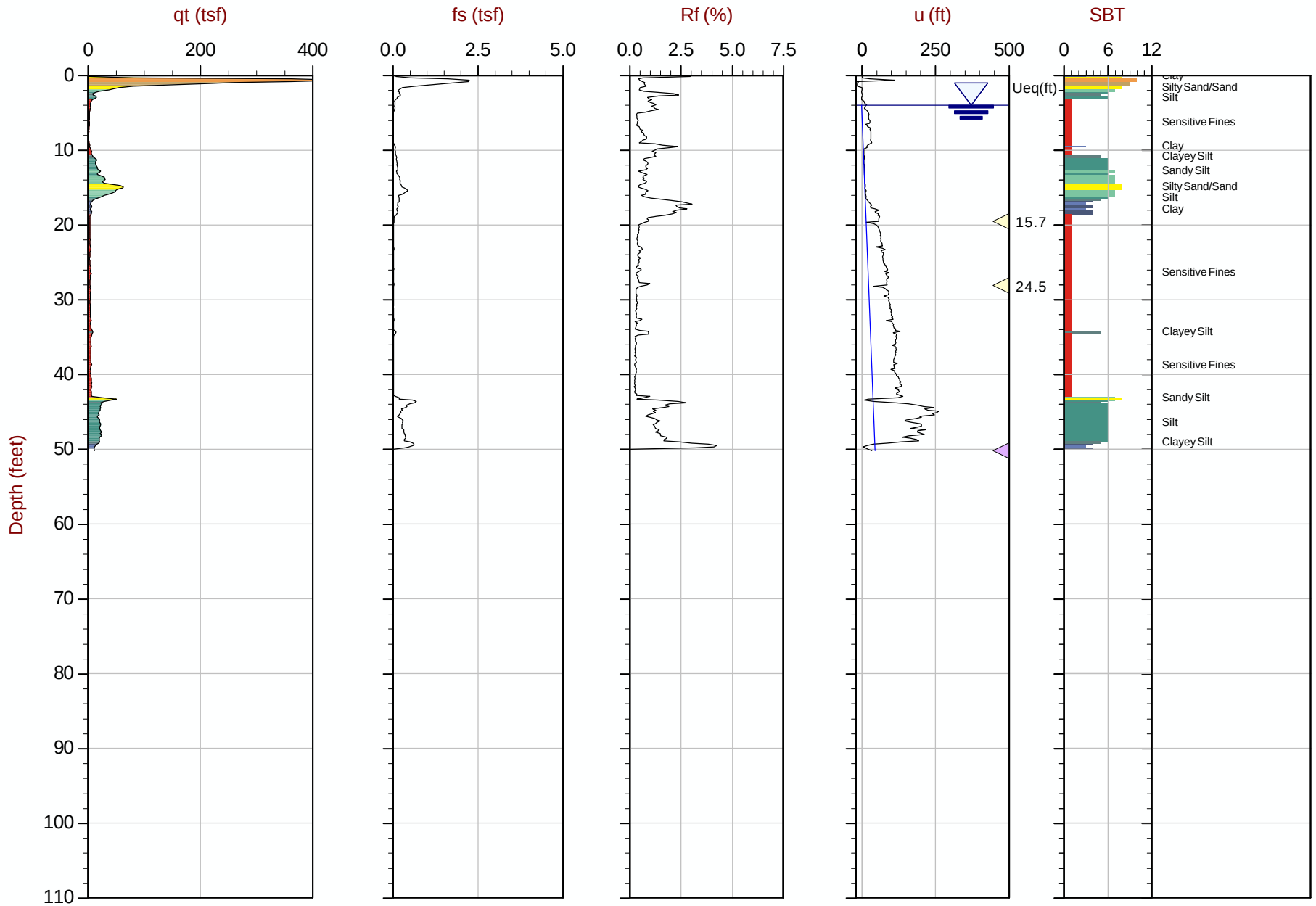
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 13:54
Site: Dynegy Joppa IL

Sounding: JOP-C029
Cone: 184:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C029.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21818 Long: -88.85203

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

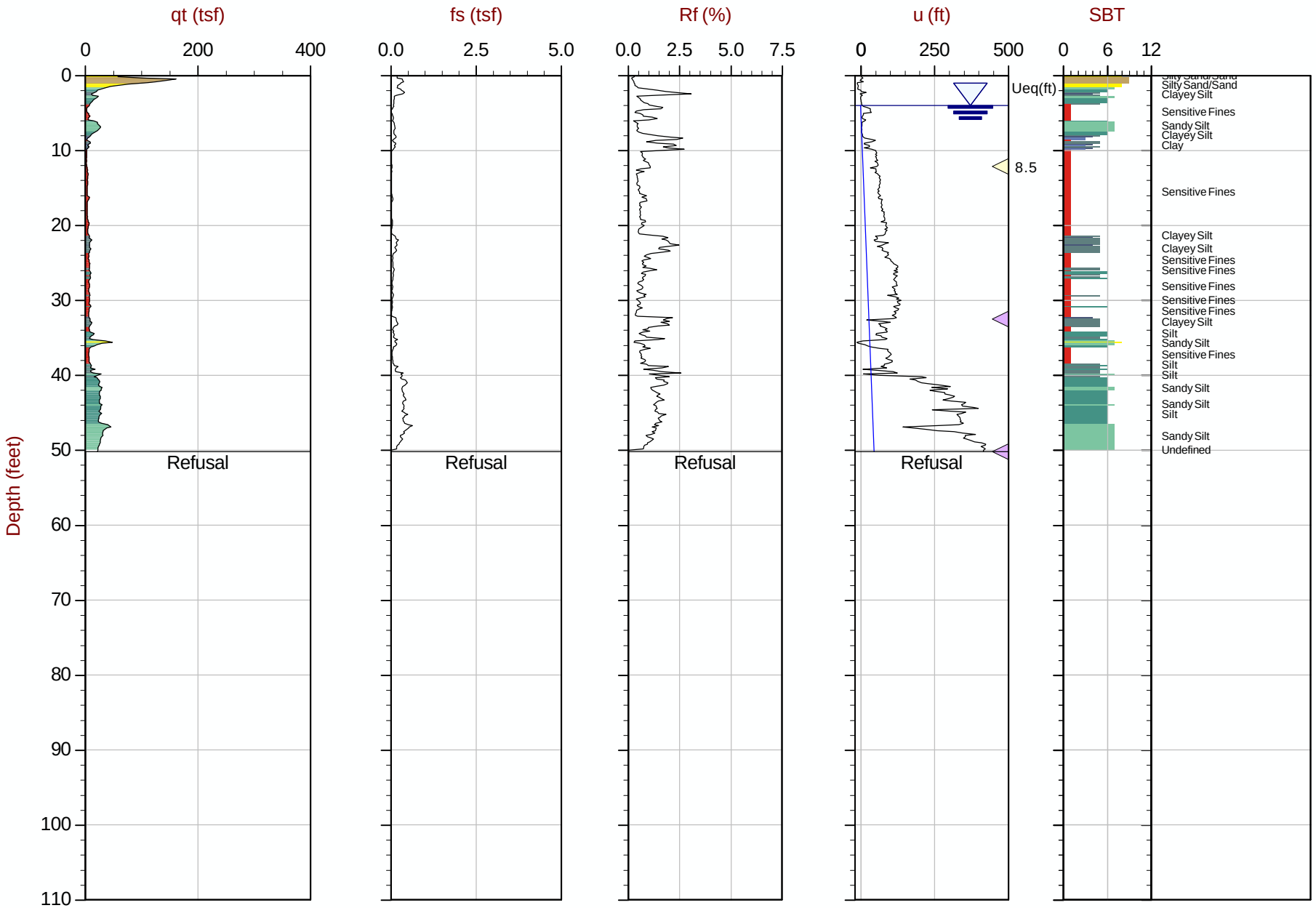
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 12:21
Site: Dynegy Joppa IL

Sounding: JOP-C030
Cone: 184:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C030.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21757 Long: -88.85053

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

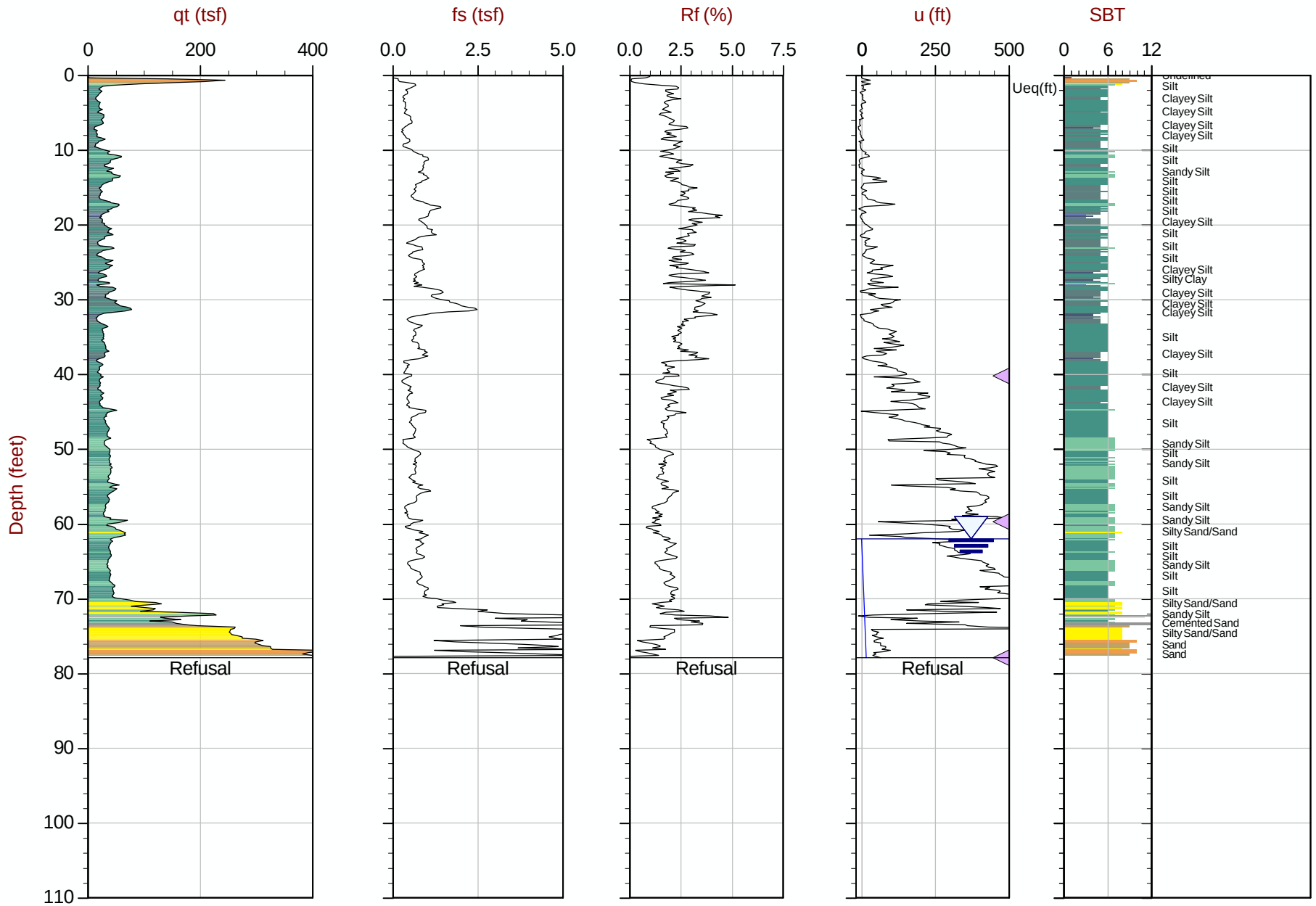
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:11:15 13:50
Site: Dynegy Joppa IL

Sounding: JOP-C031
Cone: 184:T1500F15U500



Max Depth: 23.750 m / 77.92 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C031A.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21702 Long: -88.84940

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

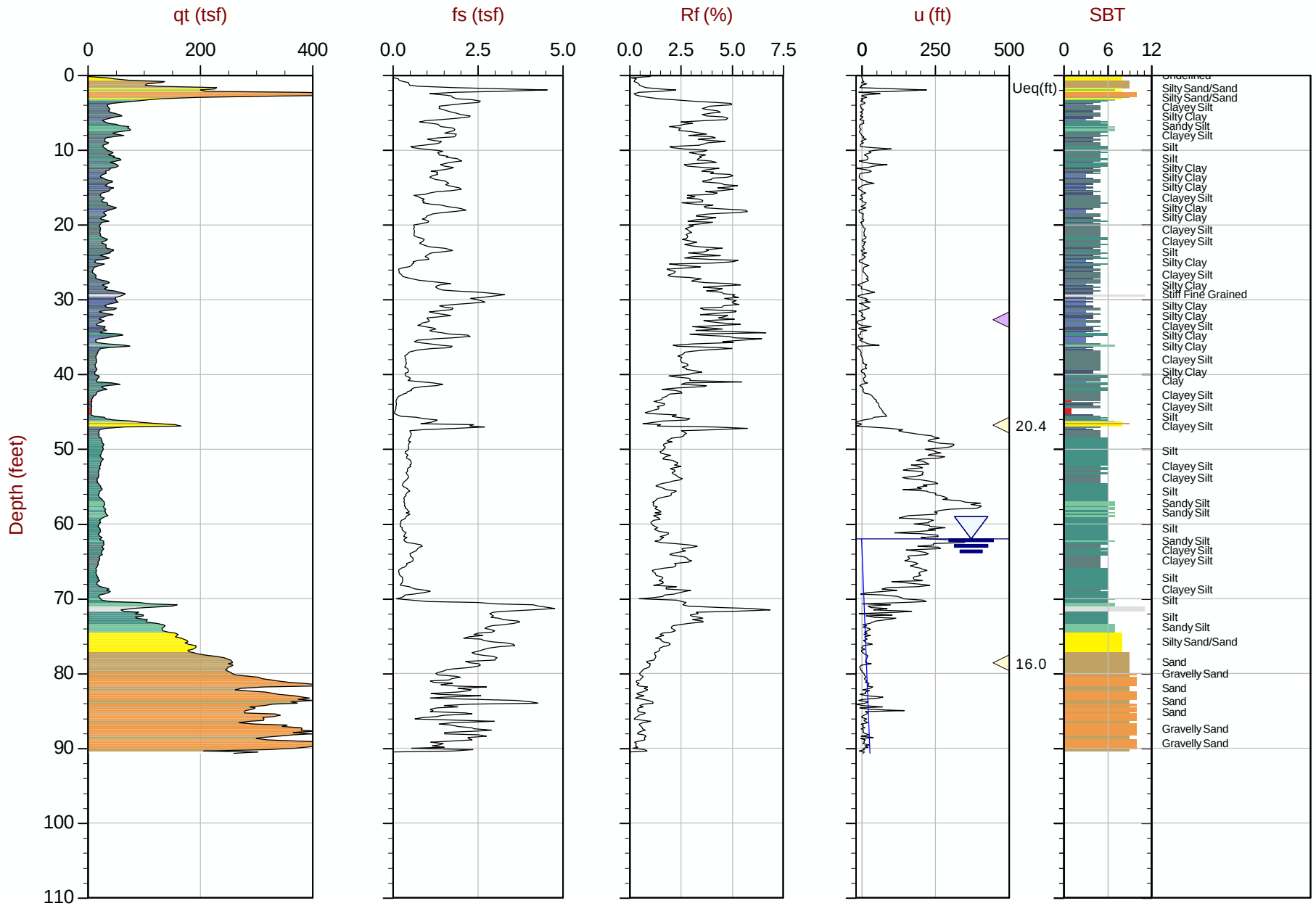
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:11:15 10:44
Site: Dynegy Joppa IL

Sounding: JOP-C032
Cone: 184:T1500F15U500



Max Depth: 27.650 m / 90.71 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C032.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21863 Long: -88.84977

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

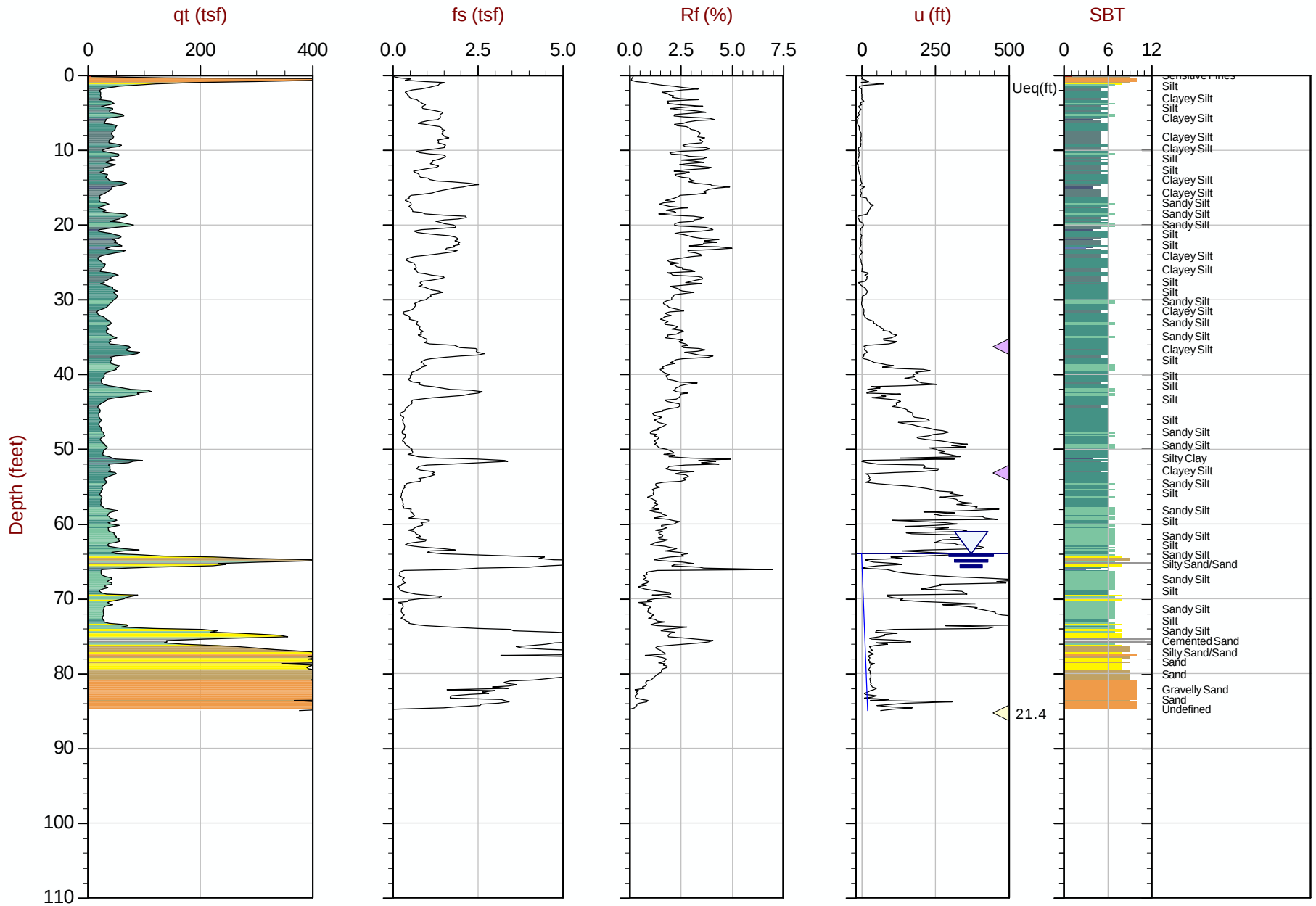
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:10:15 11:14
Site: Dynegy Joppa IL

Sounding: JOP-C033
Cone: 184:T1500F15U500



Max Depth: 25.900 m / 84.97 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C033.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21907 Long: -88.85207

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

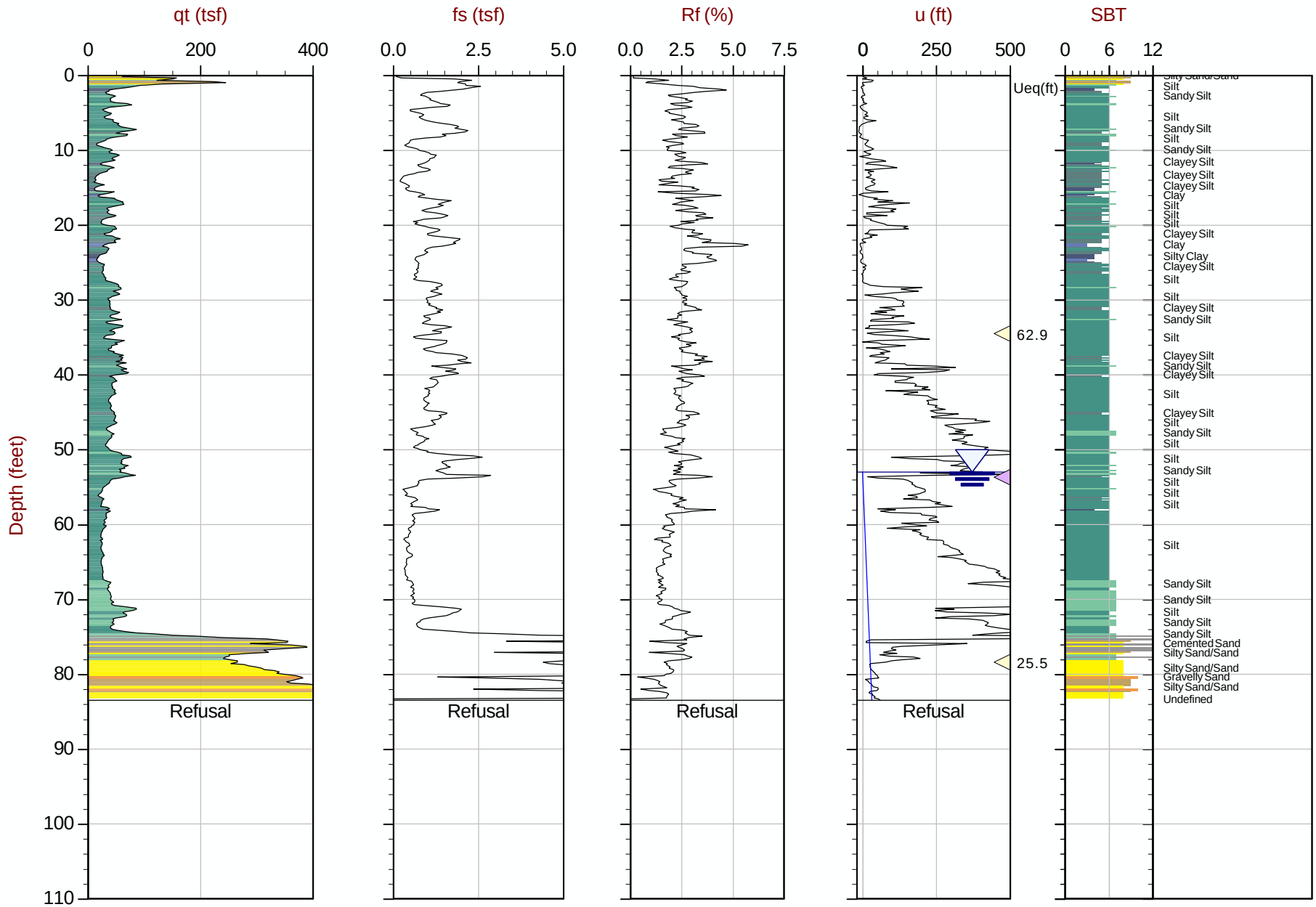
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:10:15 14:05
Site: Dynegy Joppa IL

Sounding: JOP-C034
Cone: 184:T1500F15U500



Max Depth: 25.450 m / 83.50 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C034.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.22028 Long: -88.85073

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Attachment A.6

Geosyntec Geotechnical Borings and Monitoring Well Logs, 2021

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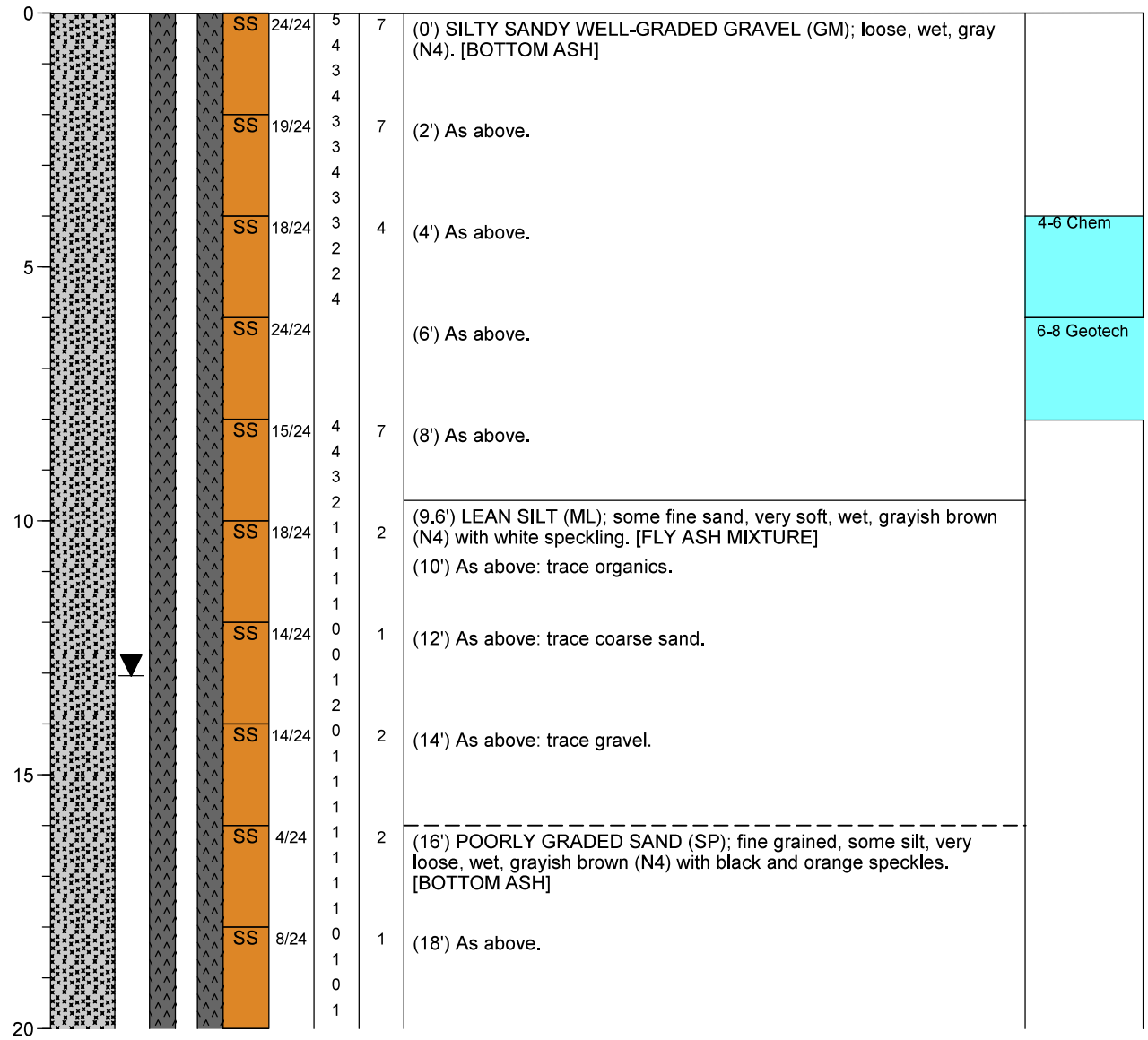
engineers | scientists | innovators

Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW01
Page: 1 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
0	SS	24/24	5 4 3 4	7	(0') SILTY SANDY WELL-GRADED GRAVEL (GM); loose, wet, gray (N4). [BOTTOM ASH]	
	SS	19/24	3 3 4 3	7	(2') As above.	
5	SS	18/24	3 2 2 4	4	(4') As above.	4-6 Chem
	SS	24/24			(6') As above.	6-8 Geotech
	SS	15/24	4 4 3 2	7	(8') As above.	
10	SS	18/24	1 1 1 1	2	(9.6') LEAN SILT (ML); some fine sand, very soft, wet, grayish brown (N4) with white speckling. [FLY ASH MIXTURE] (10') As above: trace organics.	
	SS	14/24	0 0 1 2	1	(12') As above: trace coarse sand.	
15	SS	14/24	0 1 1 1	2	(14') As above: trace gravel.	
	SS	4/24	1 1 1 1	2	(16') POORLY GRADED SAND (SP); fine grained, some silt, very loose, wet, grayish brown (N4) with black and orange speckles. [BOTTOM ASH]	
20	SS	8/24	0 1 0 1	1	(18') As above.	

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe. XPW01-(06-08)-20210120: 34.2% moisture content, 85.6 pcf dry unit weight, 2.711 specific gravity, 2.1×10^{-5} cm/s vertical hydraulic conductivity, 26.3% gravel, 45.4% sand, 58.3% fines.

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW01
Page: 2 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	10/24	0 0 0	0	(20') As above.		
						1		(21.3') LEAN SILT (ML); very soft, wet, grayish brown (N4) with white and orange speckling. [FLY ASH MIXTURE]		
				SS	1/24	0 0 0 0 0	0	(22') As above: little fine sand, trace coal.		
				SS	24/24	0 0 0 0 0	0	(24') LEAN SILT (ML); very soft, wet, grayish brown (N4). [FLY ASH]		
25				SS	24/24	0 0 0 0 0	0	(26') As above.		
				SS	26/24	0 0 0 0 0	0	(28') As above.		
30				SS	26/24	0 0 0 0 0	0	(30') As above.		
				SS	26/24	0 0 0 0 0	0	(32') As above.		
				SS	26/24	0 0 0 0 0	0	(34') As above.		
35				SS	24/24	0 0 0 0 0	0	(36') As above.		
				SS	25/24	0 0 0 0 0	0	(38') As above.		
40										

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.

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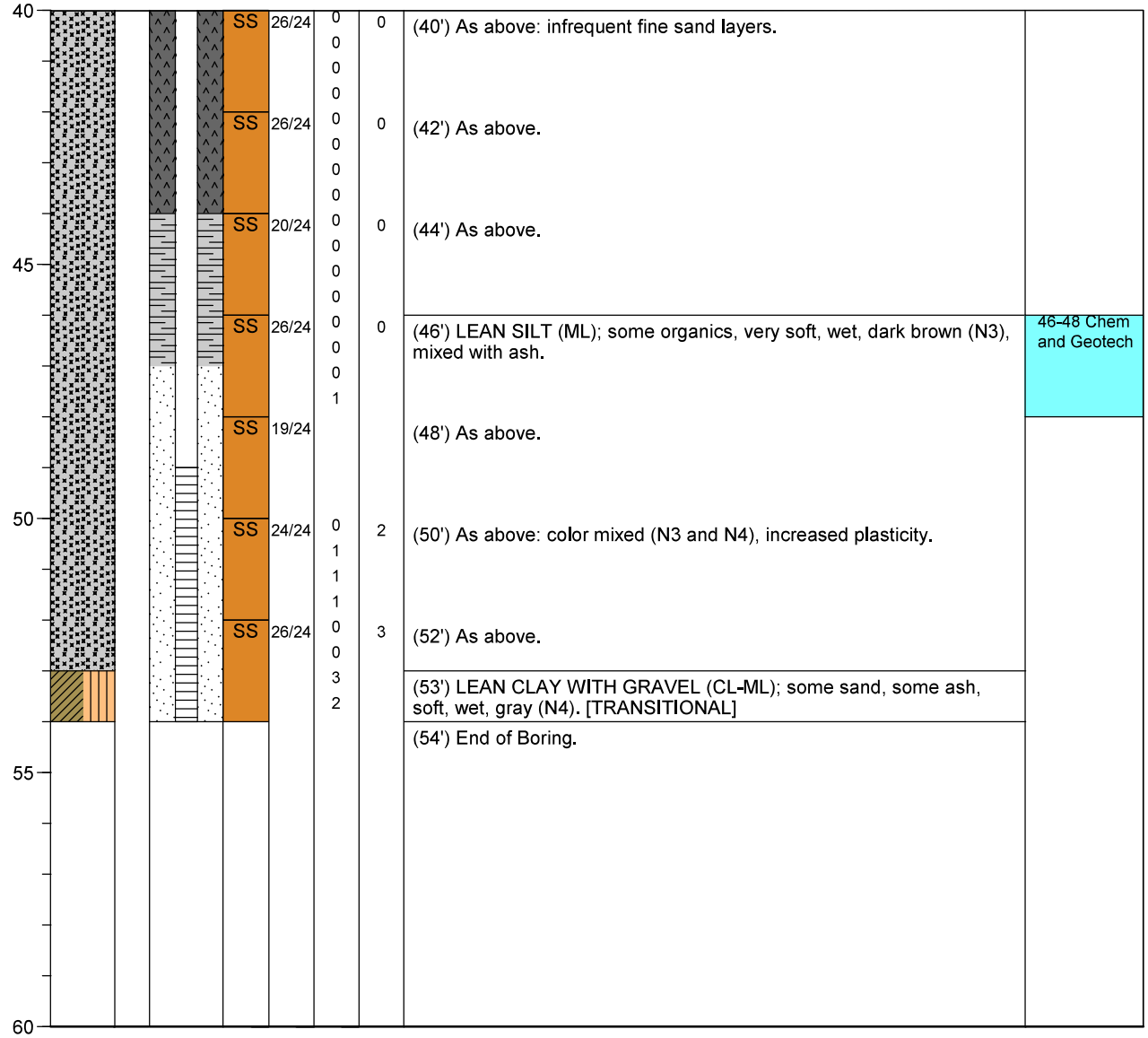
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW01
Page: 3 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
40	SS	26/24	0 0 0 0	0	(40') As above: infrequent fine sand layers.		
	SS	26/24	0 0 0 0	0	(42') As above.		
45	SS	20/24	0 0 0 0	0	(44') As above.		
	SS	26/24	0 0 0 1	0	(46') LEAN SILT (ML); some organics, very soft, wet, dark brown (N3), mixed with ash.	46-48 Chem and Geotech	
	SS	19/24			(48') As above.		
50	SS	24/24	0 1 1 1	2	(50') As above: color mixed (N3 and N4), increased plasticity.		
	SS	26/24	0 0 3 2	3	(52') As above.		
					(53') LEAN CLAY WITH GRAVEL (CL-ML); some sand, some ash, soft, wet, gray (N4). [TRANSITIONAL]		
55					(54') End of Boring.		
60							

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.
XPW01-(46-48)-20210120: 31.7% moisture content, 87.7 pcf dry unit weight, 2.675 specific gravity, 2.8×10^{-7} cm/s vertical hydraulic conductivity, 25 LL, 20 PL, 5 PI, 0.0% gravel, 18.7% sand, 81.3% fines.

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW02
Page: 1 of 2

Drilling Start Date:	01/20/2021	Boring Depth (ft):	30	Well Depth (ft):	30
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	376.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	373.23	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21575, -88.85504	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	24/24	4 17 44 22	61	(0') SANDY WELL-GRADED GRAVEL WITH SILT (GW); very dense, moist, gray (N4).		
				SS	22/24	3 9 6 7	15	(2') GRAVELLY LEAN SILT WITH SAND (ML); very soft, moist, gray (N4).		
5				SS	26/24	17 17 10 7	27	(4') As above: becomes wet.	4-6 Chem	
				SS	18/24	2 5 3 2	8	(6.2') SILTY SANDY GRAVEL (GM); loose, wet, gray (N4).		
				SS	14/24	2 1 1 1	2	(8.1') LEAN SILT WITH SAND (ML); some gravel, very soft, wet, gray (N4 to brown (10YR 3/1).		
10				SS	12/24	12 13 7 5	20	(10') As above: becomes very stiff, sandy, gravelly.		
				SS	10/24	2 5 3 2	8	(12') GRAVELLY WELL-GRADED SAND WITH SILT (ML); loose, wet, brown (10YR 3/1).		
				SS	10/24	1 2 2 2	4	(14') As above: with gravel, white speckles.		
15				SS	16/24	3 2 2 2	4	(16') As above: silty, trace coal.		
				SS	8/24	1 2 2 3	4	(18') As above: gravelly layer.		
20										

NOTES: Augers were washed out using water & tremie pipe.
Ash mixed with logged materials throughout boring

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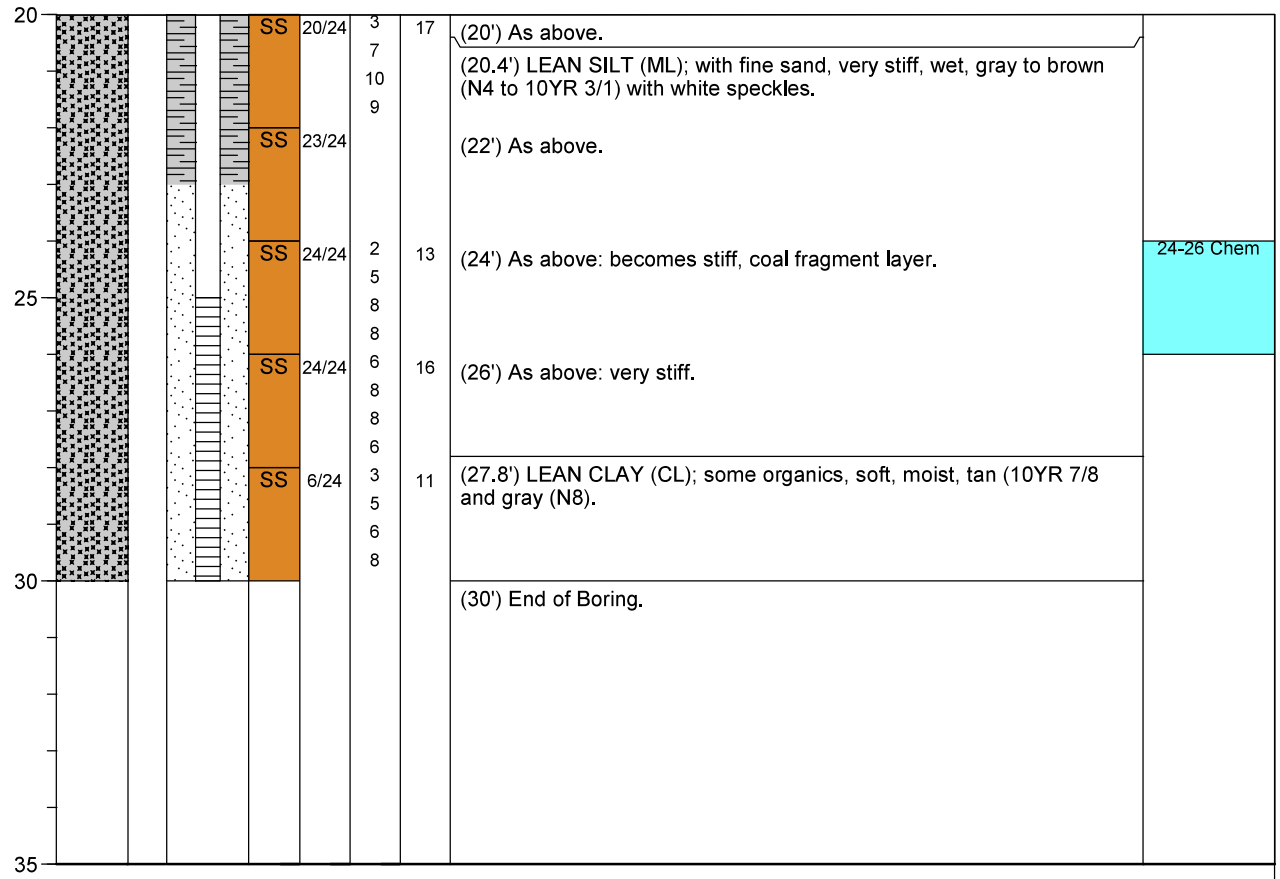
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW02
Page: 2 of 2

Drilling Start Date:	01/20/2021	Boring Depth (ft):	30	Well Depth (ft):	30
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	376.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	373.23	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21575, -88.85504	Filter Pack:	Sand



DEPTH (ft)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
20	(20') As above.		
	(20.4') LEAN SILT (ML); with fine sand, very stiff, wet, gray to brown (N4 to 10YR 3/1) with white speckles.		
	(22') As above.		
25	(24') As above: becomes stiff, coal fragment layer.	24-26 Chem	
	(26') As above: very stiff.		
	(27.8') LEAN CLAY (CL); some organics, soft, moist, tan (10YR 7/8 and gray (N8).		
30	(30') End of Boring.		
35			

NOTES: Augers were washed out using water & tremie pipe. Ash mixed with logged materials throughout boring
XPW02-(22-24)-20210120: 47.6% moisture content, 74.0 pcf dry unit weight, 2.567 specific gravity, 9.3% gravel, 74.1% sand, 16.6% fines.

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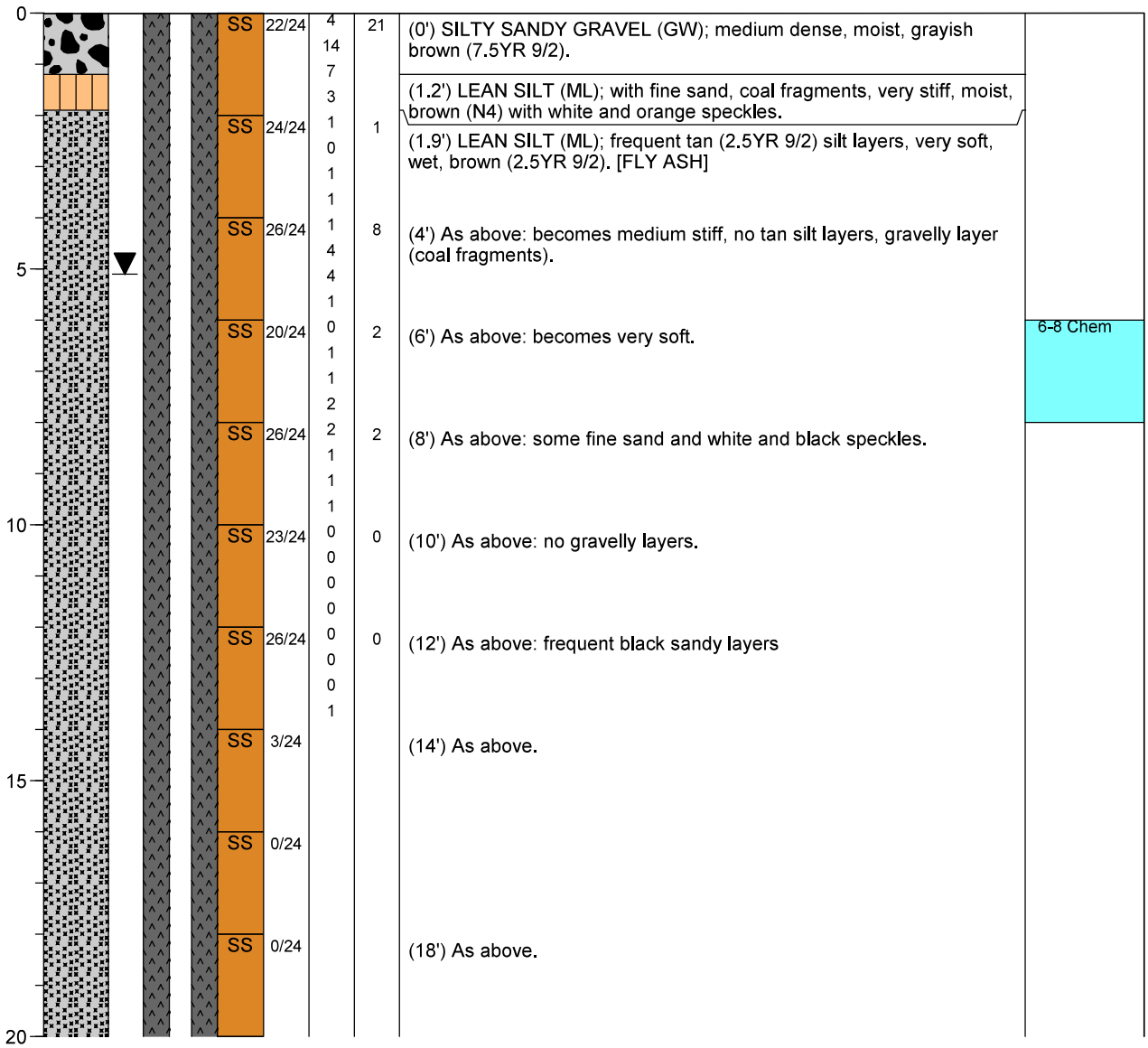
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW03
Page: 1 of 2

Drilling Start Date:	01/21/2021	Boring Depth (ft):	30	Well Depth (ft):	37
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	382.04	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	378.65	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21197, -88.85555	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
0	SS	22/24	4, 14, 7	21	(0') SILTY SANDY GRAVEL (GW); medium dense, moist, grayish brown (7.5YR 9/2).		
					(1.2') LEAN SILT (ML); with fine sand, coal fragments, very stiff, moist, brown (N4) with white and orange speckles.		
	SS	24/24	3, 1, 0	1	(1.9') LEAN SILT (ML); frequent tan (2.5YR 9/2) silt layers, very soft, wet, brown (2.5YR 9/2). [FLY ASH]		
5	SS	26/24	1, 1, 1	8	(4') As above: becomes medium stiff, no tan silt layers, gravelly layer (coal fragments).		
	SS	20/24	4, 4, 1	2	(6') As above: becomes very soft.	6-8 Chem	
	SS	26/24	0, 1, 1	2	(8') As above: some fine sand and white and black speckles.		
10	SS	23/24	2, 2, 1	0	(10') As above: no gravelly layers.		
	SS	26/24	1, 1, 1	0	(12') As above: frequent black sandy layers		
	SS	3/24	0, 0, 0		(14') As above.		
15	SS	0/24	0, 0, 0				
	SS	0/24	0, 0, 1		(18') As above.		
20							

NOTES:

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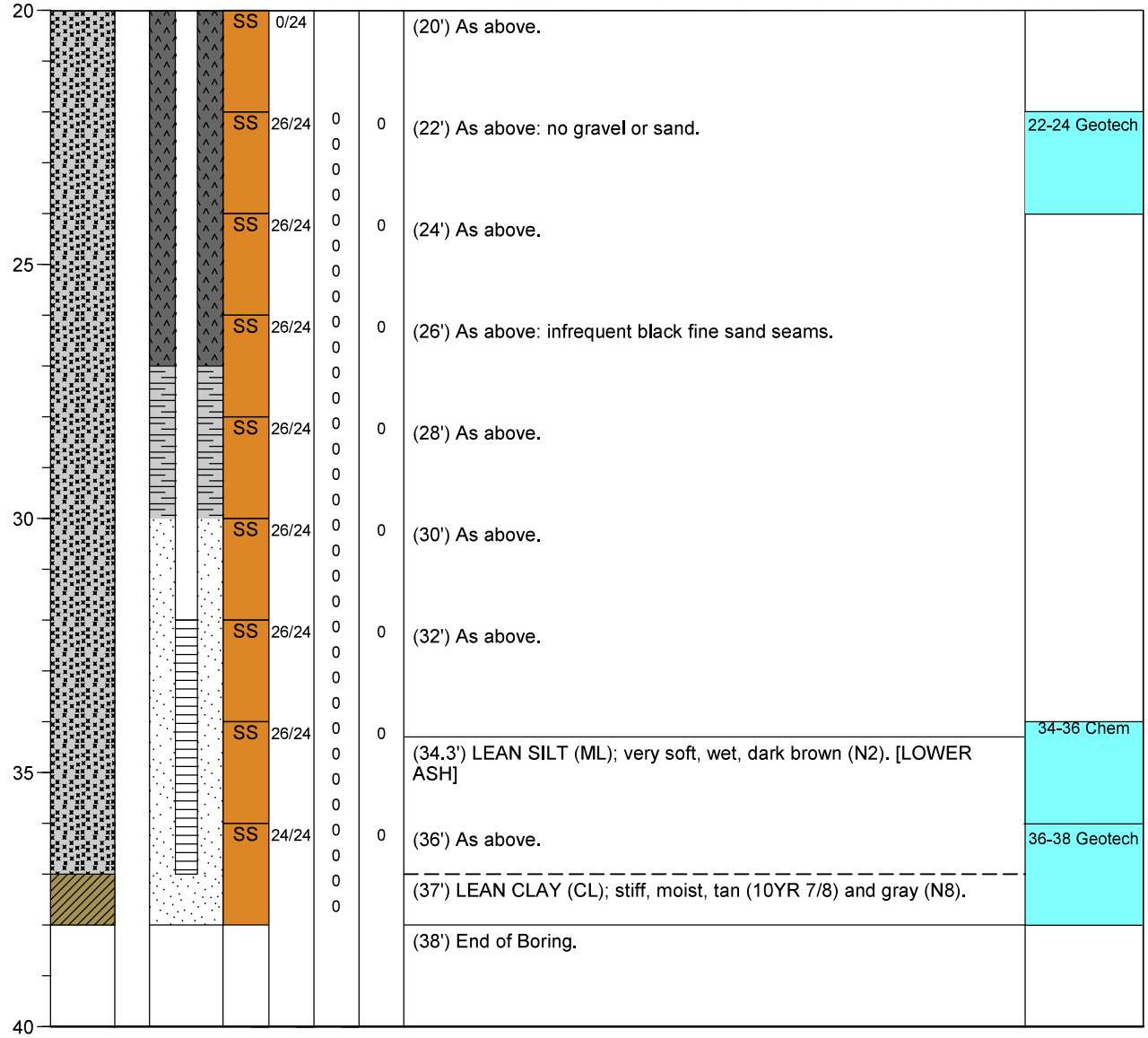
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW03
Page: 2 of 2

Drilling Start Date:	01/21/2021	Boring Depth (ft):	30	Well Depth (ft):	37
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	382.04	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	378.65	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21197, -88.85555	Filter Pack:	Sand



NOTES: XPW03-(22-24)-20210121: 45.4% moisture content, 2.410 specific gravity, 0.0% gravel, 4.2% sand, 95.8% fines.
XPW03-(36-38)-20210121: 46.5% moisture content, 65.7 pcf dry unit weight, 1.999 specific gravity, 1.8×10^{-7} cm/s vertical hydraulic conductivity, 46 LL, 31 PL, 15 PI, 0.0% gravel,9.4% sand, 90.6% fines.

Attachment B

2022 Geosyntec Investigation and Soil Sample Photographs

GEOSYNTEC CONSULTANTS
Photographic Record

Geosyntec consultants

Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 1 **Date: 3/2/2022** **Direction: South** **Comments: Edge of high water from Ohio River within the Southeast Area**	
Photograph ID: 2 **Date: 3/2/2022** **Direction: Northwest** **Comments: Edge of high water form Ohio River within the Southeast Area**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 3 **Date: 3/2/2022** **Direction: South** **High water within the creek channel inside of the rail loop.**	
Photograph ID: 4 **Date: 3/2/2022** **Direction: Northwest** **Comments: Coal fines visible at ground surface within the Southeast Area.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 5 **Date: 3/2/2022** **Direction: East** **Comments: Coal fines observed at the ground surface within the Southeast Area.**	

Photograph ID: 6 **Date: 3/2/2022** **Direction: East** **Comments: Coal fines observed at the ground surface within the Southeast Area.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 7 **Date: 3/2/2022** **Direction: NA** **Coal fines mixed with native soils below the ground surface in a shovel full of material.**	

Photograph ID: 8 **Date: 3/2/2022** **Direction: NA** **Comments: Coal fines mixed with native soils, as obtained from HA-01.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 9 **Date: 3/2/2022** **Direction: N/A** **Comments: Coal fines mixed with native soils, as obtained from HA-02**	

Photograph ID: 10 **Date: 3/2/2022** **Direction: N/A** **Comments: Mixed CCR and native soil, as obtained from HA-02**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 11 **Date: 3/2/2022** **Direction: NA** **Comments: Native alluvial soils encountered in HA-02**	

Photograph ID: 12 **Date: 3/2/2022** **Direction: NA** **Comments: Clay fill observed at the ground surface in HA-03**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 13 **Date: 3/2/2022** **Direction: NA** **CCR obtained from HA-03**	

Photograph ID: 14 **Date: 3/2/2022** **Direction: NA** **Comments: Native alluvial clay beneath CCR from HA-03**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 15 **Date: 3/2/2022** **Direction: NA** **Comments: Clay fill at the ground surface, from HA-04**	

Photograph ID: 16 **Date: 3/2/2022** **Direction: NA** **Comments: Mixture of CCR and clay beneath the ground surface, rom HA-04**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 17 **Date: 3/2/2022** **Direction: NA** **Comments: CCR beneath the ground surface in HA-04**	

Photograph ID: 18 **Date: 4/25/2022** **Direction: S** **Comments: Typical cut bank of creek within the Southeast Area – South, showing layered CCR and alluvial soils/river sediments.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 19 **Date: 4/25/2022** **Direction: S** **Comments: Cut bank along creek channel in central portion of Southeast Area, showing layered soil and CCR units.**	

Photograph ID: 20 **Date: 4/25/2022** **Direction: N/A** **Comments: CCR from HA-07**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 21 **Date: 4/27/2022** **Direction: N/A** **Comments: GEO-01, 0-4 ft**	

Photograph ID: 22 **Date: 4/27/2022** **Direction: N/A** **Comments: GEO-01, 4-8 feet. Clay which is largely representative of core from 4-16 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 23 **Date: 4/27/2022** **Direction: N/A** **Comments: GEO-01, 16-19.9 feet**	
Photograph ID: 24 **Date: 4/26/2022** **Direction: NA** **Comments: GEO-06 0-4 feet. NOTE: whiteboard in frame states 0-5 feet, but actual run is from 0-4.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 25 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-06, 8-12 feet.**	

Photograph ID: 26 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-06, 16-20 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

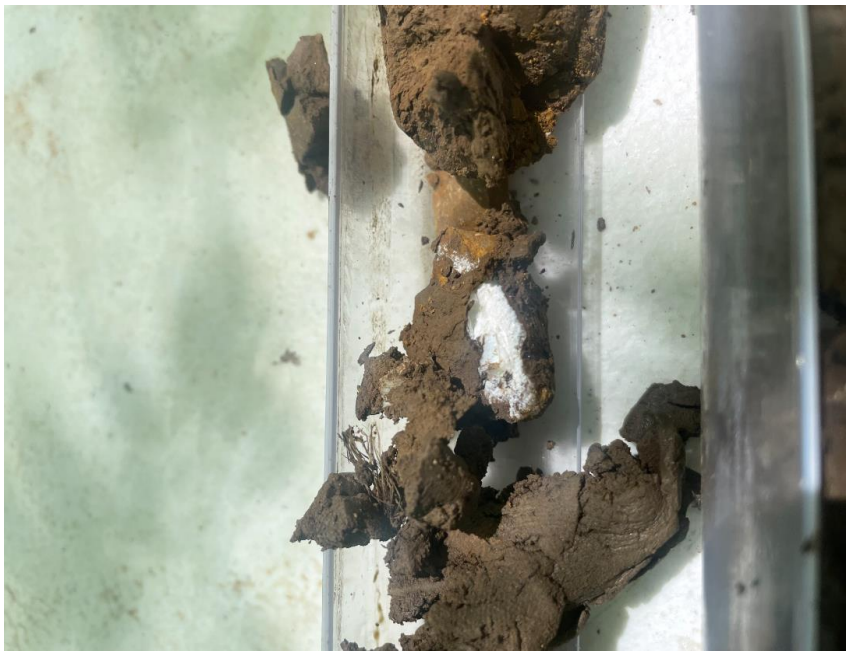
Photograph ID: 27 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-06, 20-22.5 feet**	
Photograph ID: 28 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-07, 0-4 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 29 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-07, 8-12 feet.**	
Photograph ID: 30 **Date: 4/26/2022** **Direction: N/A** **Comments: Comments: GEO-07, 20-23.5 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 31 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-08, 0-4 feet.**	

Photograph ID: 32 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-08, 0-4 feet continued. White, unidentified material in core.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 33 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-08, 8-12 feet.**	

Photograph ID: 34 **Date: 4/26/2022** **Direction: N/A** **Comments: GEO-08, 16-19 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 35 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-09, 0-4 feet.**	
Photograph ID: 36 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-09, 4-8 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 37 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-09, 8-12 feet.**	

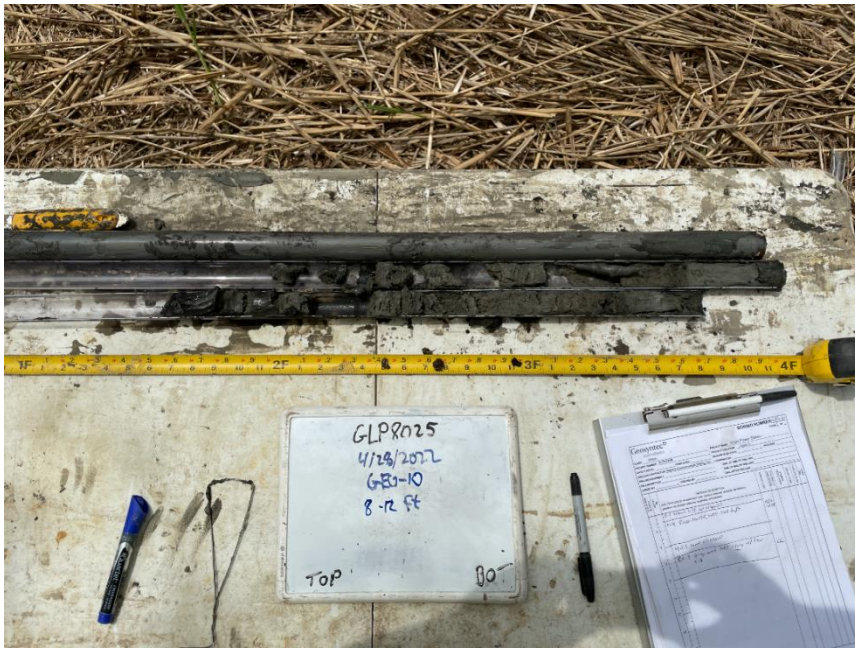
Photograph ID: 38 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-09, 12-18 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 39 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-10, 0-4 feet.**	

Photograph ID: 40 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-10, 4-8 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 41 **Date: 4/28/2022** **Direction: N** **Comments: GEO-10, 8-12 feet.**	
Photograph ID: 42 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-10, 12-16 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 43 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-10, 16-19.9 feet.**	

Photograph ID: 44 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-11, 0-4 feet.** **Note: poor recovery.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 45 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-11, 4-8 feet.**	

Photograph ID: 46 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-11, 12-16 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 47 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-12, 0-4 feet.**	
Photograph ID: 48 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-12, 4-8 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 49 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-12, 12-16 feet.**	

Photograph ID: 50 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-12, 16-19 feet grey clay.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 51 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-13, 0-4 feet. NOTE: The core is mislabeled as GEO-14 in the image.**	

Photograph ID: 52 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-13, 8-12 feet. Note: The core is mislabeled as GEO-14 in the image.**	

GEOSYNTEC CONSULTANTS
Photographic Record

Geosyntec consultants

Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 53

Date: 4/28/2022

Direction: N/A

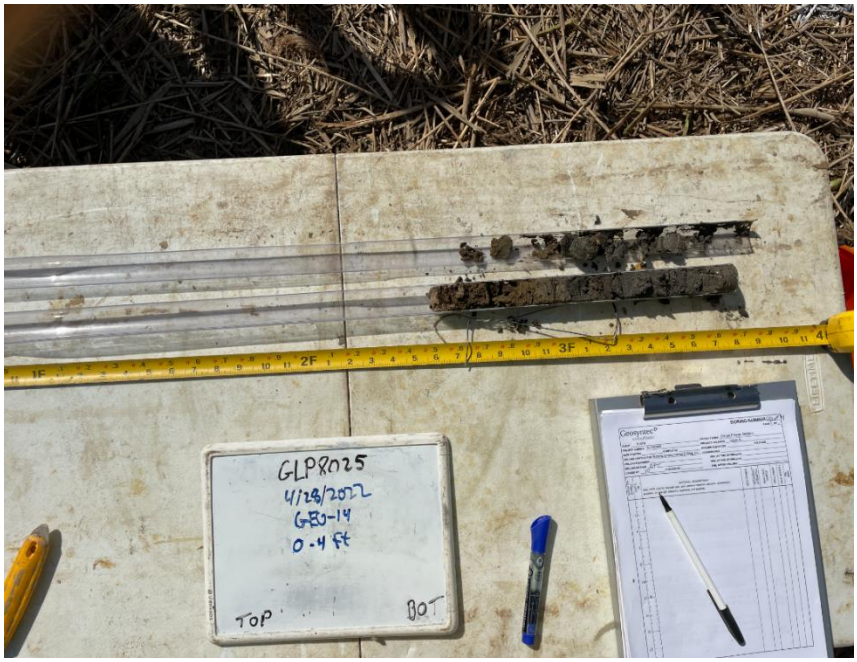
Comments: GEO-13, 12-16 feet. Note: The core is mislabeled as GEO-14 in the image.

Photograph ID: 54

Date: 4/28/2022

Direction: N/A

Comments: GEO-14, 0-4 feet.



GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 55 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-14, 4-8 feet.**	
Photograph ID: 56 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-14, 8-12 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 57 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-14, 16-19.9 feet.**	

Photograph ID: 58 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-14, deep CCR.**	

GEOSYNTEC CONSULTANTS
Photographic Record

Geosyntec consultants

Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 59	
Date: 4/28/2022	
Direction: N/A	
Comments: GEO-15, 0-4 feet.	

Photograph ID: 60	
Date: 4/28/2022	
Direction: N/A	
Comments: GEO-15, 4-8 feet.	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 61 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-15, 8-12 feet.**	
Photograph ID: 62 **Date: 4/28/2022** **Direction: N/A** **Comments: GEO-15, 12-16 feet.**	

GEOSYNTEC CONSULTANTS Photographic Record	Geosyntec consultants
Client: Electric Energy, Inc.	**Project Number: GLP8025**
Site Name: Joppa East Ash Pond	**Site Location: Joppa, IL**

Photograph ID: 63	
Date: 5/2/2022	
Direction: N/A	
Comments: GEO-15, 16-20 feet.	

Attachment C

2022 Geosyntec Boring Logs

Boring GEO-01

Drilling Start Date:	4/27/2022	**Boring Depth (ft):**	19.9 ft	
Drilling End Date:	4/27/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 6620	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	328.9	
Logged By:	D. Tallman	**Northing, Easting (ft):**	198560.1	833653.8

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Grey/brown, moist, fine-medium **SAND** [FILL]	SP	
2	GEO-01-01	Wet, fine, grey **SAND** with some silt [CCR].	SP	
4	GEO-01-02	Wet, soft, grey/brown silty lean **CLAY** with some dark grey mottling. [ALLUVIUM]	CL-ML	
6		Moist, stiff, grey/brown, low plasticity silty **CLAY**. [ALLUVIUM]	CL-ML	
8				
10				
12	GEO-01-03	Moist, fine, grey/brown **SAND** with some dark grey mottling. [ALLUVIUM]	SW	
14				
16	GEO-01-04			
18		With trace gravel.		
20				Refusal at 19.9 feet. Boring terminated, and backfilled with Bentonite chips.

Boring GEO-06

Drilling Start Date:	4/26/2022	**Boring Depth (ft):**	22.5 feet	
Drilling End Date:	4/26/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 6620	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	319.2	
Logged By:	D. Tallman	**Northing, Easting (ft):**	196693.9	832361.5

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Moist, red/brown lean **CLAY** with some silt and trace large gravel. [ALLUVIUM]	CL	
	GEO-06-01	Black, coarse, sand-sized **COAL**. [COAL FINES]		
2		Moist, red/grey **SILT** with some low-plasticity lean clay. [ALLUVIUM]	ML	
4				
		Sift, red/brown to grey, silty lean **CLAY.** [ALLUVIUM]	CL	
6		Becomes grey.		
8				
10				
12				
14				
16				
		6-inch layer of **SILT**	ML	
18			CL	
		12-inch fine-medium **SAND** with some gravel.	SW	
20	GEO-06-02			
		Fine to medium, grey **SAND** with some silt. [ALLUVIUM]	SP	
22	GEO-06-03			
				Refusal at 22.5 feet. Boring terminated and backfilled with Bentonite chips.
24				

Boring GEO-07

Drilling Start Date:	4/26/2022	**Boring Depth (ft):**	23.9 feet	
Drilling End Date:	4/26/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 6620	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	319.1	
Logged By:	D. Tallman	**Northing, Easting (ft):**	196518.8	832703.9

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Brown clayey **SILT** with some organics. [ALLUVIUM]	ML	
2		Brown, stiff, silty lean **CLAY.** [ALLUVIUM]	CL	
4	GEO-07-01	With trace organics.		
6				
8				
10				
12				
14				
16		Brown/grey, clayey **SILT** with lenses of clay. [ALLUVIUM]	ML	
18	GEO-07-02			
20				
22				Refusal at 23.9 feet. Boring terminated and backfilled with Bentonite chips.
24	GEO-07-03	Fine-medium **SAND.** [ALLUVIUM]	SP	

Boring GEO-08

Drilling Start Date:	4/26/2022	**Boring Depth (ft):**	19.9 feet	
Drilling End Date:	4/26/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 6620	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	321.4	
Logged By:	D. Tallman	**Northing, Easting (ft):**	196378.4	833240.6

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Fine to medium, moist **SAND.** [ALLUVIUM]	SW	
		Dark brown, stiff, moist, lean **CLAY** with gravel. [ALLUVIUM]	CL	
2				
4		Becomes red/brown.		
6	GEO-08-01			
8				
10		Brown, clayey **SILT** with dark brown mottling. [ALLUVIUM]	ML	
	GEO-08-02			
12		With grey to brown mottling.		
14				
		Grey/brown, fine **SAND.** [ALLUVIUM]	SP	
16		Becomes silty.		
18	GEO-08-03			
	GEO-08-04	Grey, medium **SAND** with some medium gravel. [ALLUVIUM]	SP	
20				Refusal at 19.9 feet. Boring terminated and backfilled with Bentonite chips.
22				
24				

Boring GEO-09

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	19.9 ft	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 540 Geo Cat	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	323.0	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197970.7	833223.6

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Interbedded wet, brown **SILT** and coarse **coal dust.** [COAL FINES]	ML	Poor recovery.
2	GEO-09-01			
4				
6				
8				
		Soft, moist, grey **CLAY** with silt. [ALLUVIUM]	CL	
10	GEO-09-02			
12				
		Fine-medium, moist, grey, silty **SAND.** [ALLUVIUM]	SW	
14	GEO-09-03			
16	GEO-09-04			
				Refusal at 17 feet. Boring terminated and backfilled with Bentonite chips.
18				
20				

Boring GEO-10

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	19.9 ft	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 540 Geo Cat	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	321.6	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197817.7	833273.4

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Brown, dry **SILT** with some organics. [TOPSOIL]	ML	
		Fine-coarse, wet **COAL DUST.** [COAL FINES]		
2	GEO-10-01			
4				
6		Grey, wet, soft lean **CLAY** with few silt. [ALLUVIUM]	CL	
8		Becomes silty clay with trace gravel and dark grey mottling.		
	GEO-10-02			
10				
12		Wet, dark grey **SILT.** [ALLUVIUM]	ML	
14		Becomes wet, fine, dark grey **SAND.** [ALLUVIUM]	SP	
	GEO-10-03			
16		Soft, grey **CLAY**. [ALLUVIUM]	CL	
	GEO-10-04	Medium, brown **SAND** with small-medium gravel. [ALLUVIUM]	SP	
18		Stiff, grey **CLAY.** [ALLUVIUM]	CL	
	GEO-10-05	Fine, grey **SAND**. [ALLUVIUM]	SP	Refusal at 19.4 feet. Boring terminated and backfilled with Bentonite chips.
20				

Boring GEO-11

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	19.5 feet	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 540 Geo Cat	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	320.0	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197575.3	833184.1

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Coarse **COAL DUST** with some organics. [CCR AND COAL FINES]		Poor recovery.
2	GEO-11-01			
4				
		Soft, moist, plastic grey lean **CLAY.** [ALLUVIUM]	CL	
6				
8				
		Fine, brown/dark grey **CCR**. [CCR]	ML	
10	GEO-11-02			
		Stiff, moist, grey **CLAY** with brown mottling. [ALLUVIUM]	CL	
	GEO-11-03			
12		Grey/brown, soft, sandy **CLAY.** [ALLUVIUM]	CL	
14				
		Brown/red, fine clayey **SAND.** [ALLUVIUM]	SC	
16	GEO-11-04	Grey, medium stiff, sandy **CLAY**. [ALLUVIUM]	CL	
18	GEO-11-05			
20				Refusal at 19.1 feet. Boring terminated and backfilled with Bentonite chips.

Boring GEO-12

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	19.5 feet	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 540 Geo Cat	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	318.0	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197220.8	832985.3

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Moist, brown, silty **CLAY** with some organics. [TOPSOIL]	CL	
		Coarse, black **COAL DUST.** [COAL FINES]		
2	GEO-12-01			
		Dark grey/red, moist, lean **CLAY** with dark grey mottling. [ALLUVIUM]	CL	
4		Becomes brown with some silt.		
6				
		Moist, soft, medium plasticity grey **CLAY** with grey silt and trace organics. [CCR]	CL	
8				
	GEO-12-02			
10				
	GEO-12-03	Fine, grey, silty **SAND** with dark mottling. [ALLUVIUM]	SM	
12		Soft-medium, moist, light brown/grey, **CLAY** with some silt and some organics. [ALLUVIUM]	CL	
	GEO-12-04			
14				
16	GEO-12-05	Soft-medium, wet, light brown/grey with dark mottling, **CLAY** with some silt and some organics. [CCR]	CL	
18				
				Refusal at 19.5 feet. Boring terminated and backfilled with Bentonite chips.
20				

Boring GEO-13

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	19.5 feet	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 540 Geo Cat	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	314.5	
Logged By:	D. Tallman	**Northing, Easting (ft):**	196909.6	832830.1

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Brown, moist, lean **CLAY** with silt. [TOPSOIL]	CL	
		Dark grey, medium plasticity, moist silty **CLAY**. [CCR]	CL	
2	GEO-13-01			
		Brown, stiff, medium plasticity **CLAY** with some silt, trace organics [ALLUVIUM]	CL	
4				
6	GEO-13-02			
8				
10				
		Soft, moist, medium plasticity grey silty **CLAY.** [CCR]	CL	
12				
14	GEO-14-03			
16				
	GEO-14-04			
18				Refusal at 18.0 feet. Boring terminated and backfilled with Bentonite chips.
20				

Boring GEO-14

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	19.5 feet	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 540 Geo Cat	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	319.1	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197312.2	833234.8

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Brown, dry **SILT** with some organics. [TOPSOIL]	ML	
		Wet, dark grey **SILT** with fine sand. [CCR]	ML	
2	GEO-14-01			
4				
		Light brown, moist, medium plasticity **CLAY** with trace silt. [ALLUVIUM]	CL	
6				
		Wet, dark grey, soft, **CLAY** with some silt and dark grey streaks/mottling. [CCR]	CL	
8	GEO-14-02			
10				
12				
14	GEO-14-03			
16		Fine-medium, wet, mottled dark grey **SAND**. [ALLUVIUM]	SW	
18	GEO-14-04			Refusal at 19.9 feet. Boring terminated and backfilled with Bentonite chips.
20				

Boring GEO-15

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	19.5 feet	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	2.25 inches	
Drilling Company:	Roberts Environmental Drilling, Inc.	**Sampling Method(s):**	Grab	
Drilling Method:	Direct Push Technology (DPT)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Geoprobe 540 Geo Cat	**GW After Drilling (ft bgs):**	NM	
Driller Name:	C. Harter, T. White	**Ground Surface Elev. (ft):**	321.1	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197541.7	833329.0

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Dark grey, wet, **SILT** with fine sand. [CCR]	ML	
2	GEO-15-01			
4				
6				
		Dark grey, wet, mottled, soft **CLAY** with some silt. [ALLUVIUM]	CL	
8				
	GEO-15-02			
10				
12		Grey, wet, mottled **SILT** with some clay. [ALLUVIUM]	ML	
14				
	GEO-15-03			
16				
18				
		Grey/brown, wet, fine **SAND**. [ALLUVIUM]		Refusal at 19.8 feet. Boring terminated and backfilled with Bentonite chips.
20	GEO-15-04			

Boring HA-01

Drilling Start Date:	3/2/2022	**Boring Depth (ft):**	4 ft	
Drilling End Date:	3/2/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	-	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	-	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	-	
Driller Name:	-	**Ground Surface Elev. (ft):**	330.9	
Logged By:	Pourya Kargar	**Northing, Easting (ft):**	197986.0	832939.4

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Black, wet, silty fine **SAND.** [COAL FINES]	SM	
1		Becomes brown coarse sand and clay.		
2		Becomes predominantly natural clayey well-graded **SAND** with organics.	SW	
3		With trace gravel.		
4		With coarser gravel.		
5				Boring Terminated-Hole Collapse.
6				
7				
8				
9				
10				

Boring HA-02

Drilling Start Date:	3/2/2022	**Boring Depth (ft):**	6 ft	
Drilling End Date:	3/2/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	-	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	-	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	-	
Driller Name:	-	**Ground Surface Elev. (ft):**	326.3	
Logged By:	Pourya Kargar	**Northing, Easting (ft):**	197899.2	833140.2

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Black, wet, soft silty **CLAY**- clayey **SILT.** [COAL FINES]	CL-ML	
1				
2				
3		With pockets of loose gray silt. [CCR]		
		Loose, wet, grey/brown/black, **SILT**, with some sand and coal chunks, clay trace [COAL FINES]	ML	
4				
5		Grey, wet, black smears, soft **CLAY.** [ALLUVIUM]	CL	
6				Boring Terminated.
7				
8				
9				
10				

Boring HA-03

Drilling Start Date:	3/2/2022	**Boring Depth (ft):**	5 ft	
Drilling End Date:	3/2/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	-	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	-	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	-	
Driller Name:	-	**Ground Surface Elev. (ft):**	327.1	
Logged By:	Pourya Kargar	**Northing, Easting (ft):**	198550.8	833663.0

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Moist, tan, wet, grey & brown mix, silty **CLAY.** [FILL]	CL-ML	
1				
		Loose, wet, gey, **SILT.** [CCR]	ML	
2				
		Soft,Wet, Brown & grey, **CLAY** with grey silt. [CCR]	CL	
3				
		Soft, wet, brown & tan, fat **CLAY.** [ALLUVIUM]	CH	
4		With mottling.		
5				Boring Terminated.
6				
7				
8				
9				
10				

Boring HA-04

Drilling Start Date:	3/2/2022	**Boring Depth (ft):**	7 ft	
Drilling End Date:	3/2/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	-	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	-	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	-	
Driller Name:	-	**Ground Surface Elev. (ft):**	328.0	
Logged By:	Pourya Kargar	**Northing, Easting (ft):**	199050.8	833715.1

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Moist, tan, lean **CLAY.** [FILL]	CL	
1		Becomes wet.		
2				
3		Loose, wet, grey, **CLAY** with grey silt. [CCR]	CL	
4				
5				No recovery
6		Loose, wet, grey **SILT.** [CCR]	ML	
		Wet, tan & grey, fine silty **SAND.** [ALLUVIUM]	SM	
7				Boring Terminated.
8				
9				
10				

Boring HA-05

Drilling Start Date:	3/2/2022	**Boring Depth (ft):**	2.5 ft	
Drilling End Date:	3/2/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	-	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	-	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	-	
Driller Name:	-	**Ground Surface Elev. (ft):**	329.9	
Logged By:	Pourya Kargar	**Northing, Easting (ft):**	199281.8	833847.8

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Moist, tan, lean **CLAY.** [FILL]	CL	
1				
2				
3				Boring Terminated-Gravel Refusal.
4				
5				
6				
7				
8				
9				
10				

Boring HA-06

Drilling Start Date:	4/25/2022	**Boring Depth (ft):**	7 feet.	
Drilling End Date:	4/25/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	-	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	NM	
Driller Name:	-	**Ground Surface Elev. (ft):**	322.2	
Logged By:	D. Tallman	**Northing, Easting (ft):**	196640.7	833326.7

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Dark grey/brown, wet, lean **CLAY** with organics. [ALLUVIUM]	CL	
1				
2		becomes grey.		
3		Brown, lean **CLAY** with some silt and trace organics. [ALLUVIUM]	CL	
4				
5				
6		with trace medium sand.		
7				Boring terminated at 7 ft. Cave-in. Backfilled with removed material.
8				
9				
10				

Boring HA-07

Drilling Start Date:	4/25/2022	**Boring Depth (ft):**	2.2 feet	
Drilling End Date:	4/25/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	-	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	NM	
Driller Name:	-	**Ground Surface Elev. (ft):**	315.8	
Logged By:	D. Tallman	**Northing, Easting (ft):**	196877.1	833168.5

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Moist, dark grey, **SILT** with some brown clay. [CCR]	ML	
1		Brown, moist, lean **CLAY** with interbedded grey silt. [CCR]	CL	
		Brown/red, lean, dry **CLAY**. [ALLUVIUM]	CL	
2				Refusal at 2.2 ft. Boring terminated. Backfilled with
3				
4				
5				
6				
7				
8				
9				
10				

Boring HA-08

Drilling Start Date:	4/25/2022	**Boring Depth (ft):**	4.0 feet.	
Drilling End Date:	4/25/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	-	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	NM	
Driller Name:	-	**Ground Surface Elev. (ft):**	314.5	
Logged By:	D. Tallman	**Northing, Easting (ft):**	196834.6	832982.8

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Grey/brown, moist, **SILT** with some low-plasticity clay. [ALLUVIUM]	ML	
		Low-plasticity, red/brown moist **CLAY.** [ALLUVIUM]	CL	
1				
		Grey, moist, **SILT.** [CCR]	ML	
2				
3				
		Red/brown, moist, silty, lean **CLAY**. [ALLUVIUM]	CL	
4				Refusal at 4 ft. Boring terminated. Backfilled with removed material.
5				
6				
7				
8				
9				
10				

Boring HA-09

Drilling Start Date:	4/26/2022	**Boring Depth (ft):**	3 feet.	
Drilling End Date:	4/26/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	Grab	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	NM	
Driller Name:	-	**Ground Surface Elev. (ft):**	324.6	
Logged By:	D. Tallman	**Northing, Easting (ft):**	196906.5	832831.8

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Brown/red, moist, clayey **SILT.** [ALLUVIUM]	ML	
1				
2	HA-09-01	Lense of dark grey, **COAL** at 2.0-2.1. [COAL FINES]		
		Brown/red, moist, clayey **SILT**. [ALLUVIUM]	CL-ML	
3				Refusal at 3 ft. Roots. Boring Terminated. Backfilled with removed material.
4				
5				
6				
7				
8				
9				
10				

Boring HA-10

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	6.5 feet	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	Grab	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	NM	
Driller Name:	-	**Ground Surface Elev. (ft):**	319.1	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197278.7	833432.3

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0	HA-10-01	Brown, moist **SILT** with interbedded dark grey silt. [CCR]	ML	
1	HA-10-02	Moist dark grey, **SILT**. [CCR]	ML	
5	HA-10-03	Moist, red/brown, stiff, lean **CLAY** with some organics [ALLUVIUM]	CL	
6		Becomes grey/brown.		
7				Refusal at 6.5 ft. Cave-in. Boring terminated. Backfilled with removed material.

Boring HA-11

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	7.5 feet.	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	Grab	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	NM	
Driller Name:	-	**Ground Surface Elev. (ft):**	321.2	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197589.6	833451.3

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Brown, moist **SILT** with some organics. [ALLUVIUM]	ML	
1				
2	HA-11-01	Moist, brown **SILT** with interbedded grey silt. [CCR]	ML	
3	HA-11-02	Stiff, brown/red, moist, lean **CLAY** with silt. [ALLUVIUM]	CL	
4				
5	HA-11-03	Wet, grey **SILT.** [CCR]	ML	
6				
7	HA-11-04	Stiff, moist, red, lean **CLAY** with silt. [ALLUVIUM]	CL	
8				Cave-in at 7.5 ft. Boring terminated. Backfilled with
9				
10				

Boring HA-12

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	4.75 feet	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	Grab	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	NM	
Driller Name:	-	**Ground Surface Elev. (ft):**	322.5	
Logged By:	D. Tallman	**Northing, Easting (ft):**	197849.9	833526.1

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Brown, moist, **SILT** with clay and interbedded grey silt. [CCR]	ML	
1	HA-12-01			
		Grey, moist **SILT**. [CCR]	ML	Low recovery between 1.5 and 3 ft.
2	HA-12-02			
3				
4				
5				Cave-in at 4.75 ft. Boring terminated. Backfilled with removed material.
6				
7				
8				
9				
10				

Boring HA-13

Drilling Start Date:	4/28/2022	**Boring Depth (ft):**	4.0 feet.	
Drilling End Date:	4/28/2022	**Boring Diameter (in.)**	3 inches	
Drilling Company:	-	**Sampling Method(s):**	Grab	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	NM	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	NM	
Driller Name:	-	**Ground Surface Elev. (ft):**	323.1	
Logged By:	D. Tallman	**Northing, Easting (ft):**	198018.0	833548.3

Note: Coordinates recorded in 1983 NAD Illinois State Plane East. Elevation data recorded in NAVD88.

DEPTH (ft)	SAMPLE TYPE/NUMBER	MATERIAL DESCRIPTION	FIELD USCS	REMARKS
0		Brown, moist **SILT** with interbedded grey silt. [CCR]	ML	
1				
		Moist, grey **SILT**. [CCR]	ML	
2	HA-13-01			
3		Grades to wet, brown/red, soft, silty lean **CLAY.** [ALLUVIUM]	CL	
4				Refusal at 4.0 ft. Boring terminated. Backfilled with
5				
6				
7				
8				
9				
10				

Geosyntec
consultants

ATTACHMENT E

Alternative Final Protective Layer Equivalency Demonstration

July 2022

Geosyntec consultants

134 N. La Salle Street, Suite 300
Chicago, Illinois 60602
PH 312.658.0500
FAX 312.658.0576
www.geosyntec.com

Technical Memorandum

Date:	July 25, 2022
To:	Victor Modeer, P.E., DGE, Vistra on behalf of Electric Energy Incorporated
Copies to:	Phil Morris, Rhys Fuller, Vistra on behalf of Electric Energy Incorporated
From:	John Seymour, P.E., Geosyntec Consultants (Geosyntec) Lucas Carr, P.E., Geosyntec
Subject:	Proposed Alternative Final Protective Layer Equivalency Demonstration East Ash Pond, Joppa Power Plant Joppa, Illinois Geosyntec Project: GLP8025

PROPOSAL

An alternative final protective layer is proposed by Electric Energy Incorporated (EEI) for the East Ash Pond (EAP) surface impoundment that will be closed-in-place at the Joppa Power Plant (JPP). The closure will be in accordance with Illinois Administrative Code (IAC) Part 845 Rule [1] (Part 845). Overall, the proposal will meet the requirements of Section 845.750 c) 2).

This Technical Memorandum presents a demonstration that a 2-foot-thick alternative final protective layer consisting of an 18-inch-thick soil layer and a 6-inch layer of topsoil provide equivalent or superior performance to the default protective layer set forth in Section 845.750 c) 2). The alternative final protective layer works in combination with an underlying low permeability (geomembrane) layer in place of the default three-foot thick, low permeability compacted earth layer required by Section 845.750 c) 1) A). In addition, a cushion layer consisting of a geotextile is placed on top of the geomembrane prior to installation of the final protective layer. The combination of the above materials comprises the final "alternative final cover system".

A discussion of how the closure, including the proposed alternative final cover system discussed herein, meets the performance standards is contained in the Closure Plan, which includes the Closure Alternatives Assessment required by Section 845.710.

REQUIREMENTS OF SECTION 845

Section 845.750 provides requirements for both the final protective layer and underlying low permeability layer. They work in tandem to provide protection of groundwater and surface exposure conditions. A principal intention of the low permeability layer is to reduce the infiltration of liquid through the final cover system and into the CCR waste mass during post-closure conditions, in accordance with Section 845.720 (a), which states in part:

> *The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will*:
>
> *1) Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate or contaminated run-off to the ground or surface waters or to the atmosphere;*

Specific default requirements for the final cover system are included in Section 845.750(c), which requires the final cover system to have either: 1) a three-foot thick soil low permeability compacted earth layer overlain by a three-foot-thick final protective layer (final protective layer), or 2) a geomembrane low permeability layer with a three-foot-thick final protective layer.

The specific Section 845.750 (c) (2) design requirements for the final protective layer are as follows (emphasis added):

> *Standards for the Final Protective Layer: The final protective layer must meet the following requirements, **unless the owner or operator demonstrates that another final protective layer construction technique or material provides equivalent or superior performance to the requirements of this subsection (c)(2)** and is approved by the Agency.*

Therefore, Section 845.750 (c) (2) specifically allows the use of an alternate final protective layer as long as it provides an equivalent or superior performance to the default standards set forth in Section 845.750(c)(2), which are as follows:

A) Cover the entire low permeability layer;

B) Be at least three feet thick, be sufficient to protect the low permeability layer from freezing, and minimize root penetration of the low permeability layer;

C) Consist of soil material capable of supporting vegetation;

D) Be placed as soon as possible after placement of the low permeability layer; and

E) Be covered with vegetation to minimize wind and water erosion.

The alternate design is only requesting an alternate to Section 845.740(c)(2)(B) related to the thickness of the of the final protective layer.

PROPOSED FINAL COVER SYSTEM SUMMARY

The proposed final cover systems will include:

- A low permeability layer consisting of a linear low-density polyethylene (LLDPE) geomembrane that is at least 40-mil in thickness, placed on a smooth CCR subgrade;
- A geotextile cushion; and
- A final protective layer consisting of 18 inches of protective cover soil with a 6-inch layer of topsoil capable of supporting vegetation.

The final protective layer will meet all Section 845.750(c)(2) criteria, will not need any supplemental engineering measures, and will be designed by a qualified professional engineer licensed in Illinois.

The concepts of the alternative cover system are illustrated on **Figure 1**.

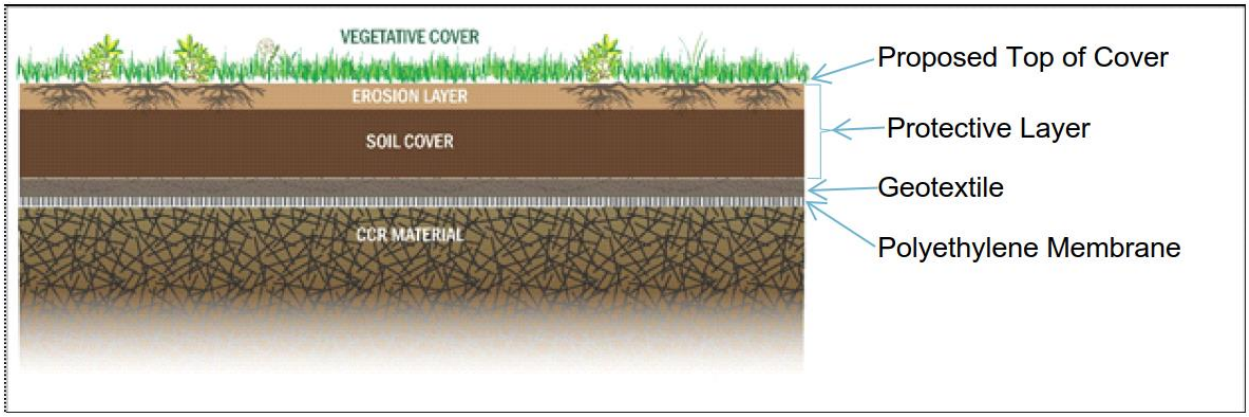


Figure 1: Proposed Alternative Final Cover System

The JPP Site is slated for re-development as a utility-scale solar facility if closure-in-place (CIP) is approved. A solar facility atop the cover system is currently being designed. Components of the vegetative cover may change as details of the solar facility are finalized. This will be discussed further under "Additional Considerations."

DEMONSTRATION

The proposed alternate final protective layer will address the five requirements of Section 845.750 (c)(2)(A) to (E), as described in this section.

Section 845.750(c)(2)(A) Cover the entire low permeability layer

The final protective layer will horizontally cover the entire low-permeability layer, as indicated in the drawings in Attachment B of the Closure Plan [2].

Therefore, the use of the two-foot-thick final protective layer will meet the minimum requirements of Section 845 750(c)(2)(A) because it will completely cover the low-permeability layer.

Section 845.750(c)(2)(B) Be sufficient to protect the low permeability layer from freezing, and minimize root penetration of the low permeability layer

The existing Part 845, which has the same requirements as Part 814 (closure rule for landfills), requires a three-foot-thick final protective layer to protect the underlying low permeability layer from freeze-thaw effects and root penetration. However, when a geomembrane is used as the low permeability layer it does not need these protections since it is not subject to the same impacts (i.e., causing an increase in hydraulic conductivity) as a compacted earth layer as discussed in more detail below.

A geomembrane low permeability layer will be used for the JPP EAP. Geomembranes have the following characteristics:

- Geomembranes do not have pores that can contain water and are therefore not susceptible to freeze-thaw damage that may reduce their performance as a low permeability layer and/or lead to degradation of the geomembrane.
    - In fact, geomembrane panel strength and stiffness both increase with decreasing temperatures ([3], [4]). In 1996, the United States Bureau of Reclamation [5] (USBR) performed testing of both geomembrane panels and seams subjected to up to 500 freeze-thaw cycles, in both constrained and unconstrained conditions, with temperature cycles as severe as +30º C to -20º C.

  - The testing showed no changes in the strength of the geomembrane panels or seams. The USBR concluded that *"…there is simply "no change" in tensile behavior of geomembrane sheets or their seams after freeze-thaw cycling"*.
  - In 2013, the Geosynthetic Institute, upon reviewing the results of the USBR and other studies, concluded that *"the essential question often raised in this regard, i.e., "will freeze-thaw conditions affect geomembrane sheets or their seam behavior," is answered with a resounding "NO""* [6].

- Geomembranes are not susceptible to grass plant root penetration because the geomembranes do not provide organic nutrients to plant roots and do not have pores or other areas where roots can enter the geomembrane.
  - Consequently, geomembranes are not a hospitable material that would either encourage root penetration or allow root penetration. Additionally, the geomembrane will be covered with a or geocomposite drainage layer with a geotextile filter on top, which will provide an additional barrier to root penetration.

U.S. EPA research [7] states that *"…a typical minimum thickness of the cover soil is 0.45 to 0.6 m…" (18 to 24 inches) thick "… for cover systems with hydraulic barriers"* (low permeability layer). This is particularly appropriate when using a geomembrane low permeability which is not susceptible to any impact from freezing. U.S. EPA research also states that cover thickness design for root penetration into the low permeability layer is only a concern for compacted clay layers or geosynthetic clay barriers. This is when using an appropriate design of cover vegetation.

Therefore, the use of the two-foot-thick final protective layer will provide equivalent or superior performance to the requirements of Section 845.750 (c) (2) (B) when coupled with a geotextile cushion and a geomembrane low permeability layer, as geomembranes are not susceptible to freeze-thaw damage or root penetration as compared to a low permeability compacted earth layer.

Section 845.750(c)(2)(C) Consist of soil material capable of supporting vegetation.

The uppermost six inches of the final protective layer will consist of topsoil that is capable of supporting vegetation, which is the same requirement as the default (three-foot thick) final protective layer. This is also consistent with the Federal CCR Rule, which requires a six-inch-thick "erosion" (topsoil) layer. Research [7] and Geosyntec's experience indicate topsoil layers are designed to have shallow-rooted grasses and most shallow-rooted grasses do not typically penetrate more than six inches into the subsurface. Shallow-rooted grasses will be specified based on recommendations from specialists at nurseries in the location of JPP and Illinois Department of Transportation guidelines. The topsoil layer will be fertilized and/or amended, as necessary, on

a site-specific basis based on agronomical soil testing, to provide a growing medium for the vegetation that provides the required levels of nutrients and water storage during drought conditions.

Grass species will also be selected on a site-specific basis to minimize long-term vegetation maintenance, based on the climatic conditions at each site and the soil types. Vegetation will be established by applying seed and mulch and watering to establish the vegetation. Temporary erosion control measures will also be used during vegetation establishment to protect the topsoil layer from erosion. These measures may include erosion control blankets (ECBs), silt fences, hydroseeding, and/or other methods. The Post-Closure Care Plan includes the commitment to maintain the vegetation of the surface for the closed JPP EAP in the Construction Permit within the Construction Permit Application, Attachment J.

The 18-inches of the protective layer below the topsoil will consist of a soil type suitable for retaining moisture to provide additional support for vegetation during times of drought, and to support any grass species with roots that exceed six inches. Such soil types may include sandy clay loam, silty loam, silts, silty clays, lean clays, sandy clays, and/or sandy silts.

Therefore, the use of the two-foot-thick protective layer will meet the requirements of Section 845.750(c)(2)(C), as the final protective layer will utilize soil capable of supporting vegetation.

Section 845.750(c)(2)(D) Be placed as soon as possible after placement of the low permeability layer

The JPP EAP Closure Plan (Section 4.7.2 [2]) states that the geotextile and cover soil "…will be placed as soon as practical after the geomembrane has been deployed and both quality assurance and quality control testing has been performed on the geomembrane seams."

The use of a two-foot-thick protective layer will allow the final protective layer to be placed on top of the low permeability layer and vegetation to be established on top of the final protective layer sooner than if a three-foot thick final protective layer is used. This is due to the 33% reduction in earthwork volumes associated with the thinner 2-ft-thick final protective layer.

Therefore, the use of the two-foot-thick final protective layer will exceed the minimum requirements of Section 845.750(c)(2)(D), by allowing the protective layer to be installed sooner than when using a three-foot-thick protective layer.

Section 845.750(c)(2)(E) Be covered with vegetation to minimize wind and water erosion.

Vegetation will be established to cover the final protective layer immediately after the protective layer is installed, as noted in the discussion regarding Section 4.7.2 [2]. Additionally, the following design and engineering features, construction techniques, and maintenance procedures will be used

to reduce the potential for wind and water erosion under both long-term conditions and during vegetation establishment.

- Design and Engineering Features
    - Final cover system slopes will be installed at relatively gentle grades (e.g., typically 2%, with 10% slopes used near the perimeter of the final cover system). The use of gentle grades will reduce water runoff velocities and therefore reduce the potential for water erosion of the final cover soils.
    - A stormwater management system consisting of channels, diversion berms, culverts, and/or letdown structures is included in the Construction Permit Application and will be designed to collect stormwater in a controlled manner and route it off the final cover system which will minimize infiltration into the CCR waste mass. The stormwater management system will minimize the overland flow distance between stormwater channels. Channels will be lined with an appropriate material, based on estimated stormwater velocities, to limit water erosion.
- Construction Techniques
    - The final protective layer is typically the most susceptible to wind and water erosion in the period between the placement of the protective layer and the establishment of vegetation. To reduce the potential for both wind and water erosion during this time, the following approaches will be utilized:
        - Temporary erosion and sediment controls (ESCs) will be installed to reduce the potential for erosion, such as erosion control blankets (ECBs), silt socks (e.g., straw wattles), silt fences, and other methods. These ESCs will be regularly inspected and maintained until vegetation is established.
        - The entire surface of the final protective layer will be stabilized during seeding and until vegetation is established. Coverings may consist of straw mulch, hydroseeding binder, ECBs, or engineering growing media.
        - The final protective layer will be regularly inspected and maintained during vegetation establishment. Any areas that become eroded by wind and water will be repaired until vegetation is established to a suitable level over the surface of the final cover.
- Maintenance Procedures
    - During the post-closure care period, vegetation established on the final protective

cover layer will be regularly maintained using a written and IEPA-approved maintenance program. The program will consist of regular mowing and inspections. Any bare areas or areas of erosion will be repaired by seeding and stabilizing the area, and observing the area until vegetation becomes re-established.

- The final cover slopes will be relatively gentle (2% with limited areas of steeper slopes); these slopes experience less erosion in general, especially less than typical landfill covers sloped at predominately 25 to 33%. Typically, after three to five years, it is Geosyntec's experience that the cover vegetation becomes fully stabilized and experiences less erosion.

In conclusion, the use of the two-foot-thick final protective layer will exceed the minimum requirements of Section 845 750 c) 2) E), using a robust program to support the establishment of protective vegetation, prevent and address any erosion that may occur during vegetation establishment, and monitor and maintain the vegetation during post-closure conditions.

ADDITIONAL CONSIDERATIONS

Infiltration Analysis

The use of the proposed two-foot-thick final protective layer, when coupled with a geomembrane low permeability layer, will also meet the criteria contained within Section 845.750 (a) (1). Section 845.750 (a) (1) provides the following requirement:

> *Section 845.750(a)(1) Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;*

Section 845.750(a)(1) is an important overall measure of the effectiveness of the final cover system because it requires control of post-closure infiltration of liquids through the final cover and into the waste and releases of CCR.

An infiltration analysis was performed to by Ramboll, within the JPP EAP Construction Permit Application [2], to estimate post-closure liquid infiltration rates through both the default and the proposed alternate final cover systems at the JPP EAP. The infiltration analysis used the Hydrologic Evaluation of Landfill Performance (HELP) software promulgated by the USEPA [8]. The HELP model estimates the infiltration rates from the top of the cover, through the final protective layer and through the low permeability layer (either a geomembrane or the three-foot thick compacted earth layer). The results are included in **Appendix A**. The resulting estimated infiltration rates are provided in **Table 1**.

Table 1 – JPP EAP Final Cover Systems for Infiltration Analysis

Description	Low Permeability Layer[1]	Final Protective Layer	Infiltration Rate[2]
Proposed Alternative Final Cover System	40-mil Linear Low-Density Polyethylene (LLDPE) Geomembrane	2 ft of cover material, including, from bottom to top, a 10 oz nonwoven geotextile, 1.5 ft of clay and 0.5 ft of sandy clay loam topsoil	0.016 in/yr
Default Cover with Geomembrane Barrier	40-mil LLDPE Geomembrane	3 ft of cover material, including, from bottom to top, a 10 oz nonwoven geotextile, 2.5 ft of clay soil and 0.5 ft of sandy clay loam topsoil	0.031 in/yr
Default Cover with Compacted Earth Layer	3-ft thick compacted earth layer (1×10-7 cm/sec)	3 ft of cover material, including, from bottom to top, 2.5 ft of clay soil and 0.5 ft of sandy clay loam topsoil	2.05 in/yr

The JPP EAP analysis indicated that the performance of the proposed alternative final cover system with a geomembrane and a two-foot-thick final protective cover exceeds the performance offered by the default final cover system utilizing a geomembrane with the default three-foot-thick protective layer and cushion layer, with the infiltration rate reduced by a factor of 1.9.

Furthermore, the proposed alternate final cover system performance exceeds the performance of a final cover system using a three-foot-thick compacted earthen low permeability layer and a three-foot-thick final protective layer (a total cover thickness of six feet) by reducing infiltration by a factor of 128.

Post-Closure Construction of Solar Panel Electrical Generating System

The JPP Site is slated for re-development as a utility-scale solar facility if closure in place (CIP) is approved. A solar facility atop the cover system is currently being designed. Components of the vegetative cover may change as details of the solar facility are finalized. The system will be designed, installed, and operated such that the closure performance standards will be maintained at an equivalent level as proposed in the JPP EAP Closure Plan.

For example, the panels are expected to be supported by concrete slab ballast foundations that will replace portions of the erosion (topsoil) layer and not cause excessive settlement of the cover and

[1] All HELP run versions used a pinhole density of 1 hole per acre, installation defects of 1 hole/acre, and construction quality as "good".
[2] Infiltration is out the bottom of the low permeability layer.

will reduce the amount of infiltration. The ballast foundations will not penetrate the geomembrane low-permeability layer to reduce the potential for defects that could otherwise increase infiltration. The space around the panel foundations will be replaced with an alternative to shallow rooted vegetation and will include stormwater runoff and erosion materials that will meet the erosion control standards of Section 845.750 and may also include forbs (herbaceous flowering plants).

Environmental and Societal Benefits

The use of the proposed two-foot-thick final protective layer will provide the following additional environmental and societal benefits, relative to the default three-foot-thick final protective layer:

- The final cover system earthwork quantities will be reduced by 33%. This will result in a corresponding 33% reduction in the amount of onsite soil fill that needs to be excavated, hauled to the construction location, and placed. This provides multiple benefits, such as:
    - Reduced disruption to onsite areas caused by the excavation of fill materials and corresponding disturbance to the natural environment.
    - Reduced haul truck traffic on site access roadways, thereby reducing air pollution and carbon emissions.
    - Reduced earthwork effort during installation of the final cover system, thereby reducing air pollution and carbon emissions.
- Construction of the alternate final cover system can be completed faster than the default final cover, providing multiple benefits, such as:
    - Initiation of the reduction of infiltration at a sooner date than with the default final cover system.
    - Ceasing construction-related impacts to offsite residents (e.g., air pollution, carbon emissions) at a sooner date than otherwise possible.
- The installation of a solar panel electrical generating system will provide green energy to the community and reduce the maintenance associated with the shallow rooted vegetation.

SUMMARY

The proposed alternate final protective layer will:

- Provide equivalent or superior performance to the requirements of Section 845.750 (c)(2).
- Have a geotextile cushion layer, which is not required by Section 845.750, over the geomembrane that adds physical protection for the geomembrane.
- Have a lower infiltration rate than the infiltration through the default soil final cover system.
- Meet or exceed the same criteria for long term performance and all other requirements of Section 845.750(c)(2).
- Provide other benefits by reducing the amount of final cover earthwork by 33% for the JPP EAP.
- A solar panel electrical generating system will provide green energy to the community and reduce the maintenance of the cover.

REFERENCES

[1] Illinois Environmental Protection Agency, "35 Ill. Adm. Code Part 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments," Springfield, IL, 2021.

[2] Geosyntec Consultants, "CCR Surface Impoundment Final Closure Plan, Joppa Power Plant, East Ash Pond," Farmington, MO, 2022.

[3] A. L. Rollin, J. Lafleur, M. Marcotte, O. Dascal and Z. Akber, "Selection Criteria for the Use of Geomembranes in Dams and Dykes in Northern Climate," in *Proceedings of the International Conference on Geomembranes*, Denver, Colorado, 1945.

[4] D. E. Thorton and P. Blackall, "Report EPA-3-76-13: Field Evaluation of Plastic Film Liners for Petroleum Storage Areas in the Mackenzie Delta," Canadian Environmental Protection Service, 1976.

[5] A. I. Comer and Y. G. Hsuan, "Report R-96-03: Freeze-Thaw Cycling and Cold Temperature Effects on Geomembrane Sheets and Seams," U.S. Bureau of Reclamation, 1996.

[6] Y. G. Hsuan, R. M. Koerner and A. I. Comer, "GSI White Paper #28: Cold Temperature and Freeze-Thaw Cycling Behavior of Geomembranes and their Seams," Geosynthetic Institute, Folsom, Pennsylvania, 2013.

[7] United States Environmental Protection Agency, "(Draft) Technical Guidance For RCRA/CERCLA Final Covers," Office of Solid Waste and Emergency Response, Washington D.C., 2004.

[8] T. Tolaymat and M. Krause, "Hydrologic Evaluation of Landfill Performance: HELP 4.0 User Manual," United States Environmental Protection Agency, Washington, DC, 2020.

APPENDIX A: HELP MODEL OUTPUT

A-1: JPP EAP- 2-FT FINAL PROTECTIVE COVER SOIL

A-2: JPP EAP-3-FT FINAL PROTECTIVE COVER SOIL

A-3: JPP EAP-3-FT COMPACTED EARTH LAYER, 3-FT FINAL PROTECTIVE COVER SOIL

APPENDIX A-1

JPP EAP- 2-FT FINAL PROTECTIVE COVER SOIL

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Joppa EAP CIP Cons **Simulated On:** 6/24/2022 16:36

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SCL - Sandy Clay Loam
Material Texture Number 10

Thickness	=	6	inches
Porosity	=	0.398	vol/vol
Field Capacity	=	0.244	vol/vol
Wilting Point	=	0.136	vol/vol
Initial Soil Water Content	=	0.398	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
C - Clay (Low Density)
Material Texture Number 15

Thickness	=	18	inches
Porosity	=	0.475	vol/vol
Field Capacity	=	0.378	vol/vol
Wilting Point	=	0.265	vol/vol
Initial Soil Water Content	=	0.475	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-05	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
10 oz Nonwoven Geotextile
Material Texture Number 123

Thickness	=	0.11	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.85	vol/vol
Effective Sat. Hyd. Conductivity	=	3.00E-01	cm/sec
Slope	=	4.67	%
Drainage Length	=	600	ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness	=	0.04	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	1	Holes/Acre
FML Installation Defects	=	1	Holes/Acre
FML Placement Quality	=	3	Good

Layer 5

Type 1 - Vertical Percolation Layer (Waste)
CCR Material
Material Texture Number 83

Thickness	=	312	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1871	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-06	cm/sec

Layer 6

Type 1 - Vertical Percolation Layer
Clay
Material Texture Number 43

Thickness	=	252	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.371	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	85.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	74	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.088	inches
Upper Limit of Evaporative Storage	=	8.088	inches
Lower Limit of Evaporative Storage	=	3.996	inches
Initial Snow Water	=	0	inches

Initial Water in Layer Materials	=	162.884	inches
Total Initial Water	=	162.884	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	37.21	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	95	days
End of Growing Season (Julian Date)	=	297	days
Average Wind Speed	=	7	mph
Average 1st Quarter Relative Humidity	=	71	%
Average 2nd Quarter Relative Humidity	=	70	%
Average 3rd Quarter Relative Humidity	=	76	%
Average 4th Quarter Relative Humidity	=	75	%

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Cons
Simulated on: 6/24/2022 16:37

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	10.613	[5.037]	2,850,768.6	22.03
Evapotranspiration	33.583	[3.577]	9,021,032.4	69.71
Subprofile1				
Lateral drainage collected from Layer 3	3.9684	[0.5199]	1,066,001.8	8.24
Percolation/leakage through Layer 4	0.016120	[0.003456]	4,330.0	0.03
Average Head on Top of Layer 4	9.5123	[2.0558]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.004411	[0.000998]	1,185.0	0.01
Water storage				
Change in water storage	0.0038	[1.6278]	1,009.3	0.01

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Joppa EAP CIP Cons
Simulated on: 6/24/2022 16:38

	Peak Values for Years 1 - 30*		
	(inches)		(cubic feet)
Precipitation	3.90		1,047,367.0
Runoff	3.327		893,753.5
Subprofile1			
Drainage collected from Layer 3	0.0162		4,364.8
Percolation/leakage through Layer 4	0.000111		29.9
Average head on Layer 4	24.1098		---
Maximum head on Layer 4	38.5407		---
Location of maximum head in Layer 3	119.39	(feet from drain)	
Subprofile2			
Percolation/leakage through Layer 6	0.000049		13.0
Other Parameters			
Snow water	3.0749		825,966.9
Maximum vegetation soil water	0.4493	(vol/vol)	
Minimum vegetation soil water	0.2220	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Joppa EAP CIP Cons
Simulated on: 6/24/2022 16:38
Simulation period: 30 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	2.1495	0.3582
2	8.5499	0.4750
3	0.0935	0.8500
4	0.0000	0.0000
5	58.7119	0.1882
6	93.4920	0.3710
Snow water	0.0000	---

APPENDIX A-2

JPP EAP- 3-FT FINAL PROTECTIVE COVER SOIL

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Joppa EAP CIP Default Cover **Simulated On:** 6/24/2022 16:46

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SCL - Sandy Clay Loam
Material Texture Number 10

Thickness	=	6	inches
Porosity	=	0.398	vol/vol
Field Capacity	=	0.244	vol/vol
Wilting Point	=	0.136	vol/vol
Initial Soil Water Content	=	0.398	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
C - Clay (Low Density)
Material Texture Number 15

Thickness	=	30	inches
Porosity	=	0.475	vol/vol
Field Capacity	=	0.378	vol/vol
Wilting Point	=	0.265	vol/vol
Initial Soil Water Content	=	0.475	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-05	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
10 oz Nonwoven Geotextile
Material Texture Number 123

Thickness	=	0.11	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.85	vol/vol
Effective Sat. Hyd. Conductivity	=	3.00E-01	cm/sec
Slope	=	4.67	%
Drainage Length	=	600	ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness	=	0.04	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	1	Holes/Acre
FML Installation Defects	=	1	Holes/Acre
FML Placement Quality	=	3	Good

Layer 5

Type 1 - Vertical Percolation Layer (Waste)
CCR Material
Material Texture Number 83

Thickness	=	312	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1871	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-06	cm/sec

Layer 6

Type 1 - Vertical Percolation Layer
Clay
Material Texture Number 43

Thickness	=	252	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.371	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	85.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	74	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.088	inches
Upper Limit of Evaporative Storage	=	8.088	inches
Lower Limit of Evaporative Storage	=	3.996	inches
Initial Snow Water	=	0	inches

Initial Water in Layer Materials	=	168.594	inches
Total Initial Water	=	168.594	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	37.21	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	95	days
End of Growing Season (Julian Date)	=	297	days
Average Wind Speed	=	7	mph
Average 1st Quarter Relative Humidity	=	71	%
Average 2nd Quarter Relative Humidity	=	70	%
Average 3rd Quarter Relative Humidity	=	76	%
Average 4th Quarter Relative Humidity	=	75	%

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Default Cover
Simulated on: 6/24/2022 16:47

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	9.606	[5.013]	2,580,252.8	19.94
Evapotranspiration	33.574	[3.579]	9,018,602.4	69.70
Subprofile1				
Lateral drainage collected from Layer 3	4.9822	[0.4157]	1,338,319.0	10.34
Percolation/leakage through Layer 4	0.030562	[0.005081]	8,209.6	0.06
Average Head on Top of Layer 4	17.9539	[2.9669]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.003474	[0.001644]	933.3	0.01
Water storage				
Change in water storage	0.0070	[2.1225]	1,889.5	0.01

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Joppa EAP CIP Default Cover
Simulated on: 6/24/2022 16:47

	Peak Values for Years 1 - 30*		
	(inches)		(cubic feet)
Precipitation	3.90		1,047,367.0
Runoff	3.327		893,723.2
Subprofile1			
Drainage collected from Layer 3	0.0163		4,388.9
Percolation/leakage through Layer 4	0.000170		45.7
Average head on Layer 4	36.1098		---
Maximum head on Layer 4	54.4695		---
Location of maximum head in Layer 3	146.48	(feet from drain)	
Subprofile2			
Percolation/leakage through Layer 6	0.000049		13.0
Other Parameters			
Snow water	3.0749		825,966.9
Maximum vegetation soil water	0.4493	(vol/vol)	
Minimum vegetation soil water	0.2220	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Joppa EAP CIP Default Cover
Simulated on: 6/24/2022 16:47
Simulation period: 30 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	1.7864	0.2977
2	14.2499	0.4750
3	0.0935	0.8500
4	0.0000	0.0000
5	59.1834	0.1897
6	93.4920	0.3710
Snow water	0.0000	---

APPENDIX A-3

JPP EAP-3-FT COMPACTED EARTH LAYER, 3-FT FINAL PROTECTIVE COVER SOIL

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Joppa EAP CIP Default Earth **Simulated On:** 6/24/2022 16:51

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SCL - Sandy Clay Loam
Material Texture Number 10

Thickness	=	6	inches
Porosity	=	0.398	vol/vol
Field Capacity	=	0.244	vol/vol
Wilting Point	=	0.136	vol/vol
Initial Soil Water Content	=	0.398	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
C - Clay (Low Density)
Material Texture Number 15

Thickness	=	30	inches
Porosity	=	0.475	vol/vol
Field Capacity	=	0.378	vol/vol
Wilting Point	=	0.265	vol/vol
Initial Soil Water Content	=	0.475	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-05	cm/sec

Layer 3

Type 3 - Barrier Soil Liner
Liner Soil (High)
Material Texture Number 16

Thickness	=	36	inches
Porosity	=	0.427	vol/vol
Field Capacity	=	0.418	vol/vol
Wilting Point	=	0.367	vol/vol
Initial Soil Water Content	=	0.427	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-07	cm/sec

Layer 4

Type 1 - Vertical Percolation Layer (Waste)
CCR Material

Material Texture Number 83

Thickness	=	312	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1933	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-06	cm/sec

Layer 5

Type 1 - Vertical Percolation Layer

Clay

Material Texture Number 43

Thickness	=	252	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.371	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	85.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	74	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.088	inches
Upper Limit of Evaporative Storage	=	8.088	inches
Lower Limit of Evaporative Storage	=	3.996	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	185.811	inches
Total Initial Water	=	185.811	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	37.21	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	95	days
End of Growing Season (Julian Date)	=	297	days

Average Wind Speed	=	7 mph
Average 1st Quarter Relative Humidity	=	71 %
Average 2nd Quarter Relative Humidity	=	70 %
Average 3rd Quarter Relative Humidity	=	76 %
Average 4th Quarter Relative Humidity	=	75 %

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Default Earth
Simulated on: 6/24/2022 16:52

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	12.078	[5.327]	3,244,351.3	25.07
Evapotranspiration	34.049	[3.576]	9,146,287.4	70.68
Subprofile1				
Percolation/leakage through Layer 3	2.050194	[0.070975]	550,723.0	4.26
Average Head on Top of Layer 3	23.4090	[2.0491]	---	---
Subprofile2				
Percolation/leakage through Layer 5	0.000793	[0.002101]	213.0	0.00
Water storage				
Change in water storage	2.0443	[1.766]	549,145.3	4.24

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Joppa EAP CIP Default Earth
Simulated on: 6/24/2022 16:52

	Peak Values for Years 1 - 30*		
	(inches)		(cubic feet)
Precipitation	3.90		1,047,367.0
Runoff	3.334		895,677.2
Subprofile1			
Percolation/leakage through Layer 3	0.006803		1,827.4
Average head on Layer 3	35.9998		
Subprofile2			
Percolation/leakage through Layer 5	0.000049		13.2
Other Parameters			
Snow water	3.0749		825,966.9
Maximum vegetation soil water	0.4493	(vol/vol)	
Minimum vegetation soil water	0.2220	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Joppa EAP CIP Default Earth
Simulated on: 6/24/2022 16:52
Simulation period: 30 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	2.2356	0.3726
2	14.2499	0.4750
3	15.3720	0.4270
4	121.7913	0.3904
5	93.4920	0.3710
Snow water	0.0000	---

Geosyntec
consultants

ATTACHMENT F

Hydrologic and Hydraulic Design of Stormwater Management System

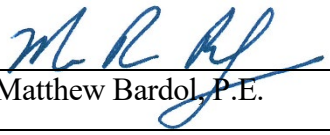
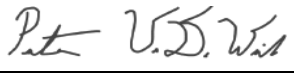
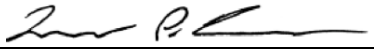
July 2022

Geosyntec consultants

COMPUTATION COVER SHEET

Client:	Electric Energy, Inc. (EEI)	Project:	**Joppa East Ash Pond (EAP) Closure Plan**	Project/ Proposal No.:	**GLP8025**
				Task No.	**02**

Title of Computations: **Cover System Hydrologic and Hydraulic Analysis Report**

Computations by:	Signature		28-06-2022
	Printed Name	Priya Iyengar	Date
	Title	Project Engineer	
Assumptions and Procedures Checked by: (senior reviewer)	Signature		28-06-2022
	Printed Name	Matthew Bardol, P.E.	Date
	Title	Senior Principal	
Computations Checked by:	Signature		28-06-2022
	Printed Name	Patrick VanDeWiele, P.E.	Date
	Title	Project Engineer	
Computations backchecked by: (originator)	Signature		28-06-2022
	Printed Name	Priya Iyengar	Date
	Title	Professional	
Approved by: (pm or designate)	Signature		28-06-2022
	Printed Name	Lucas Carr, P.E.	Date
	Title	Senior Engineer	

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

Written by:	PI	Date:	28 06 2022 DD MM YY	Reviewed by:	PV	Date:	28 06 2022 DD MM YY
Client:	EEI	Project:	Joppa EAP Closure Plan	Project No.:	GLP8025	Task No.:	02

TABLE OF CONTENTS

1. INTRODUCTION 1

2. DESIGN APPROACH 1

3. ASSUMPTIONS AND ANALYSIS 1

3.1 PROJECT SITE CONDITION 2
3.1.1 Pre-Closure Topographic Survey 2
3.1.2 Proposed Post-Closure Design 2
3.2 HYDROLOGY 2
3.2.1 Drainage Areas 2
3.2.2 Rainfall Depth and Distribution 3
3.2.3 Rainfall Runoff - Curve Number 3
3.2.4 Time of Concentration 4
3.3 HYDRAULICS 5
3.3.1 Interceptor Berms 5
3.3.2 Rock Chutes 5
3.3.3 Culverts 6

4. RESULTS AND FINDINGS 6

4.1 INTERCEPTOR BERM DESIGN 6
4.2 ROCK CHUTE DESIGN 7
4.3 CULVERT DESIGN 7

5. REFERENCES 9

6. APPENDICES 10

6.1 APPENDIX A – DRAINAGE MAPS 10
6.2 APPENDIX B – NOAA ATLAS 14, VOLUME 2, VERSION 3 10
6.3 APPENDIX C – INTERCEPTOR BERM HYDRAULIC ANALYSIS 10
6.4 APPENDIX D – ROCK CHUTE ANALYSIS 10
6.5 APPENDIX E – CULVERT CROSSING ANALYSIS 10

Written by:	PI	Date:	28 06 2022 DD MM YY	Reviewed by:	PV	Date:	28 06 2022 DD MM YY
Client:	EEI	Project:	Joppa EAP Closure Plan	Project No.:	GLP8025	Task No.:	02

LIST OF TABLES

TABLE 1: KEY PARAMETERS FOR INTERCEPTOR BERMS 6
TABLE 2: KEY PARAMETERS FOR ROCK CHUTES 7

Written by:	PI	Date:	28 06 2022 DD MM YY	Reviewed by:	PV	Date:	28 06 2022 DD MM YY
Client:	EEI	Project:	Joppa EAP Closure Plan	Project No.:	GLP8025	Task No.:	02

1. Introduction

This report documents the conceptual-level hydrologic and hydraulic analysis to support the permit-level design of stormwater features for the Joppa East Ash Pond Closure Plan. The project site is approximately 75 acres located in Joppa, Illinois.

The following sections describe the design approach, methodology, assumptions, results, and findings. Stormwater features analyzed include interceptor berms, rock chutes, culverts and riprap aprons.

2. Design Approach

In accordance with the CCR Rule (USEPA, 2015) and the Illinois Part 845 Rule (IEPA, 2021) the stormwater features are designed to adequately manage a 100-year, 24-hour Soil Conservation Service (SCS) Type II storm event.

The following summarizes tools and methodology used in the hydrologic and hydraulic analysis:

- HEC-HMS 4.9 (USACE, 2021) is a hydrologic modelling system that was used to analyze and estimate peak runoff from delineated drainage areas and sub-catchments.
- A Manning's flow calculator tool (NEH, 2010) was used to analyze hydraulic performance of interceptor berms.
- The National Resource Conservation Service (NRCS) rock chute design tool (Robinson et al., 1998) was utilized for sizing rock chute grade stabilization structures.
- The Federal Highway Administration (FHWA) HY-8 7.7 Culvert Analysis Program (FHWA, 2021) was used to analyze culvert design elements.
- The National Resource Conservation Service (NRCS) Riser-barrel hydraulics calculator tool for rectangular drop-structures was utilized to design the culvert inlet depression component.

3. Assumptions and Analysis

The following sections present a summary of the performed analyses, along with an overview of the information relied upon and the associated assumptions.

3.1 Project Site Condition

3.1.1 Pre-Closure Topographic Survey

Site topographic surveys of existing (pre-closure) conditions were performed by IngenAE, LLC in December 2020 (IngenAE, May 2021).

3.1.2 Proposed Post-Closure Design

Proposed post-closure design will be permit-level design drawings, dated July 2022.

3.2 Hydrology

A hydrologic analysis was performed for the project site to assess and quantify the peak flow from site under a range of design storm events. The results of the hydrologic analysis were used as part of the hydraulic analysis to design the various stormwater features.

3.2.1 Drainage Areas

The final cover system is approximately 64 acres. An existing embankment with varying side slopes wraps around the perimeter of the final cover system. The total project area includes the final cover system and the existing perimeter embankment.

The final cover system was delineated into 21 drainage areas ranging from 1.20 acres to a maximum of 4.35 acres. The drainage map and associated drainage parameters are presented in Table 1 and Figure 1 of **Appendix A**.

The largest drainage area on the final cover system was determined to be Drainage Area No. 14 and was utilized as the *critical cover drainage area*. This *critical cover drainage area* of 4.35 acres is the largest and serves as the basis for design of all stormwater features within the cover system.

The largest perimeter embankment section (Embankment Drainage Area No. 6) was identified as the *critical embankment drainage area*. Area No. 6 is approximately 1.83 acres. The drainage map and associated drainage parameters for the embankment section are presented in Table 2 and Figure 2 of **Appendix A**.

The design of stormwater features that traverse the existing perimeter embankment section was based on cumulative flows from the *critical cover drainage area* (Area No. 14) and *critical embankment drainage area* (Area No. 6).

3.2.2 Rainfall Depth and Distribution

The National Oceanic Atmospheric Administration (NOAA) Atlas 14 provides precipitation frequency information for the U.S. states and territories. NOAA precipitation frequency estimates serve as standard practice for designing, building, and operating infrastructure to withstand the forces of heavy precipitation and floods.

Rainfall depths used in this analysis were based on NOAA Atlas 14 (NOAA, 2006) Point Precipitation Frequency Estimates, as shown in **Appendix B**.

The rainfall distribution used in this analysis was SCS Type-II distribution, which is considered a conservative temporal distribution for a 24-hour duration storm event due to its peak rainfall intensity. The SCS distribution results in a greater peak flow as compared to other acceptable standardized distributions, such as Huff 3rd Quartile, as published in the Illinois State Water Survey (ISWS) Circular 173 (ISWS, 1990).

The Type II SCS 100-year, 24-hour event of 7.43 inches was used as the *design rainfall event* to size the proposed stormwater features.

3.2.3 Rainfall Runoff - Curve Number

To estimate stormwater runoff from the *design rainfall event*, the SCS curve number method was applied. A curve number (CN) is a numerical representation of the runoff potential of a watershed that is based on soil type, plant cover, imperviousness, interception, and surface storage (USDA, 1986).

The final cover system will include, from bottom to top, a geomembrane, geotextile, 1.5 feet of cover soil, 0.5 feet of topsoil, and a vegetative cover. For this analysis, based on assumed soil conditions, a single CN was determined from TR-55 manual (USDA, 1986) to represent the final cover system as follows:

- Post-closure Areas (CN=78)
  - Cover Type – Meadow
  - Hydrologic Condition – Fair

- Hydrologic Soil Group – D

3.2.4 Time of Concentration

The Time of Concentration (T_c) value represents the total time for stormwater runoff to travel from the hydraulically most distant point of a drainage area to a point of interest. Factors affecting T_c include surface roughness, channel shape, flow patterns, and slope. Varying slopes across the project site are presented in Figure 3 of **Appendix A**.

For this analysis, the method outlined in the TR-55 manual (USDA, 1986) was followed, which is consistent with NRCS, 1997.

The T_c value for a given drainage area, or sub-catchment, is the sum of the individual various travel time (T_t) values of the above flow types. The equations for calculating the T_t are presented below.

Sheet Flow: $$T_t = \frac{0.007\ (nL)^{0.8}}{(P2)^{0.5} s^{0.4}}$$

Shallow Concentrated Flow: $$T_t = \frac{L}{3600V}$$

where: T_t = travel time (hours);

L = length of flow (feet);

P_2 = rainfall from a 2-year, 24-hour storm (inches); and

s = Bed or surface slope in the flow direction (feet/feet)

Manning's roughness coefficient "n" (dimensionless) for sheet flow, for ten different surfaces ranging from smooth-concrete surface to woods-dense underbrush is provided in Table 15-1 of the SCS NEH Part 630. A sheet flow Manning's n of 0.15 was selected for "Short Grass Prairie". Velocity "V" (feet/second) was calculated from Table 15-3 of the SCS NEH Part 630.

The Tc method uses Lag Time value equal to 60% of the T_c value (0.6* T_c) which was utilized in the HEC-HMS model.

3.3 Hydraulics

The results of the hydrologic analysis were used as part of the hydraulic analysis to design the various stormwater features, that include interceptor berms, rock chutes, culverts, inlet and outlet controls, and energy dissipation devices. HEC-HMS model generated peak discharges from *critical drainage areas,* and their corresponding sub-catchment, were utilized in this analysis.

3.3.1 Interceptor Berms

Interceptor berms with triangular cross-section will be used to intercept sheet and shallow concentrated flows from the final cover system and portions of the existing perimeter embankment area. *Critical drainage areas* described in **Section 3.2.1** were further delineated into sub-catchments as part of the design process to determine the location, length, height, and longitudinal slope of the interceptor berms.

According to Manning's n for Channels (Chow, 1959), a Manning's roughness coefficient of 0.030 was used for excavated earthen channels with short grass and few weeds. Hydraulic analyses using the Manning's flow calculator tool (NEH, 2010) were performed to determine maximum intercept berm height required to adequately convey flow from sub-catchments to the corresponding rock chute, without overtopping.

3.3.2 Rock Chutes

Rock chutes with trapezoidal cross-section will be used to collect flow from interceptor berms and adequately convey the peak discharges down steep slopes on the final cover system and the existing perimeter embankment. Each Cover Rock Chute will discharge into an inlet depression that feeds into a culvert. Embankment Rock Chutes were designed to convey cumulative flow from both the contributing cover drainage area culvert discharge and interceptor berms on the embankment slope.

The rock chute trapezoidal cross-section design consists of 3H:1V side slopes. Rock chutes were analyzed on longitudinal slopes no greater than 3H:1V. Hydraulic analyses using the NRCS rock chute design tool (Robinson et al., 1998) were performed to determine minimum chute depth to contain the *design storm event* and riprap lining (minimum D_{50} and layer thickness) to withstand erosive forces from the design storm event.

3.3.3 Culverts

Culverts will be located at the end of each cover rock chute (21 in total). The culverts are designed to adequately convey the *design storm event* discharge from the cover rock chute through the existing perimeter embankment.

A HDPE circular pipe was analyzed as the horizontal culvert outlet pipe through the perimeter embankment. Hydraulic analyses were performed to determine the size of culvert's horizontal outlet pipe using HY-8. Culvert material was assumed to be smooth HDPE with a Manning's n of 0.012.

Flow transition between a rock chute and a downstream culvert was analyzed by adding an inlet depression, a vertical drop of the inlet control section below the rock chute flowline. At the culvert outlet, a combination of manhole structure and riprap apron was analyzed for energy dissipation and grade control.

4. Results and Findings

4.1 Interceptor Berm Design

Key parameters such as peak flow, maximum velocity and maximum flow depth were evaluated on varying slopes as presented in **Table 1** below. Sub-catchment tributary to the interceptor berm and a schematic representation of the respective interceptor berm are presented in **Appendix C**.

Table 1: Key Parameters for Interceptor Berms

Surface Description	Peak Flow (cubic feet/second)	Max Velocity (feet/second)	Max Flow Depth (feet)
2% Cover Slope	8.5	1.78	0.43
10% Cover Slope	3.4	2.02	0.53
33% Embankment Slope	3.6	2.48	0.76

Around the cover system's 2% and 10% slopes, 3 sets of interceptor berms will be tributary to a cover rock chute, and on the 33% embankment slope, one set will be

tributary to a rock chute. Since the maximum flow depth was 0.76 feet, the **berm height** to adequately convey flow from sub-catchments to the rock chute was determined to be set at **1-foot**, across all slopes, for consistency. Figure 4 of **Appendix A** presents locations of all interceptor berms.

4.2 Rock Chute Design

Key parameters such as peak flow, slope, channel bottom width, and riprap lining D_{50} are presented in **Table 2** below. The inlet and outlet invert elevations, bottom and top widths, flow depths and riprap layer thicknesses are presented in **Appendix D.**

Table 2: Key Parameters for Rock Chutes

Surface Description	Peak Flow (cubic feet/second)	Channel Bottom Width (feet)	Riprap Lining D_{50} (inches)
On 10% Cover Slope	27.6	10.0	6.0
On 33% Embankment Slope	38.1	12.0	9.0

A total of 21 rock chutes with a bottom width of 10 feet and a riprap lining D50 of 6 inches will adequately convey *design storm event* on the 10% cover slope. A total of 8 rock chutes with a bottom width of 12 feet and a riprap lining D50 of 9 inches will adequately convey cumulative flows from both cover and *embankment critical drainage areas* on the 33% embankment slope.

For consistency across the site, all 29 rock chutes will have a **channel bottom width** of **12 feet** with a **riprap lining D50** of **9 inches**. Figure 4 of **Appendix A** presents locations of all rock chutes.

4.3 Culvert Design

Key parameters such as culvert discharge, headwater and tailwater elevations, flow velocities, and profile view are presented in **Appendix E**. The hydraulic analyses of culvert crossings were based on a peak flow of 27.6 cubic feet per second on varying slopes.

It was determined that a **36-inch diameter** circular **HDPE culvert outlet pipe** would adequately convey peak flows from upstream cover rock chutes. Of the total 21 culvert crossings, 7 will be used to convey flows down the embankment rock chutes and the remaining 14 will be used to convey flows to a manhole structure. A minimum **48-inch** diameter **manhole structure** was determined to adequately provide grade control.

A **riprap apron** (FHWA, 2006) will be used at the culvert system discharge point within the perimeter channel, for energy dissipation. The key design elements of the riprap apron are riprap size, length, width and depth of apron.

Based on the culvert diameter, peak flow of 27.6 cubic feet per second and a tailwater depth of 0.4 feet, $\mathbf{D_{50}}$ was determined to be **6 inches**. From Table 10.1 of HEC-14, a Class 2 riprap, **12 feet long** and **2 feet deep** was determined to be adequate for the riprap apron design within the perimeter channel.

Figure 4 of **Appendix A** presents locations of all culverts, manhole structures and riprap aprons.

5. References

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6. Appendices

6.1 Appendix A – Drainage Maps

6.2 Appendix B – NOAA Atlas 14, Volume 2, Version 3

6.3 Appendix C – Interceptor Berm Hydraulic Analysis

6.4 Appendix D – Rock Chute Analysis

6.5 Appendix E – Culvert Crossing Analysis

APPENDIX A

Drainage Maps

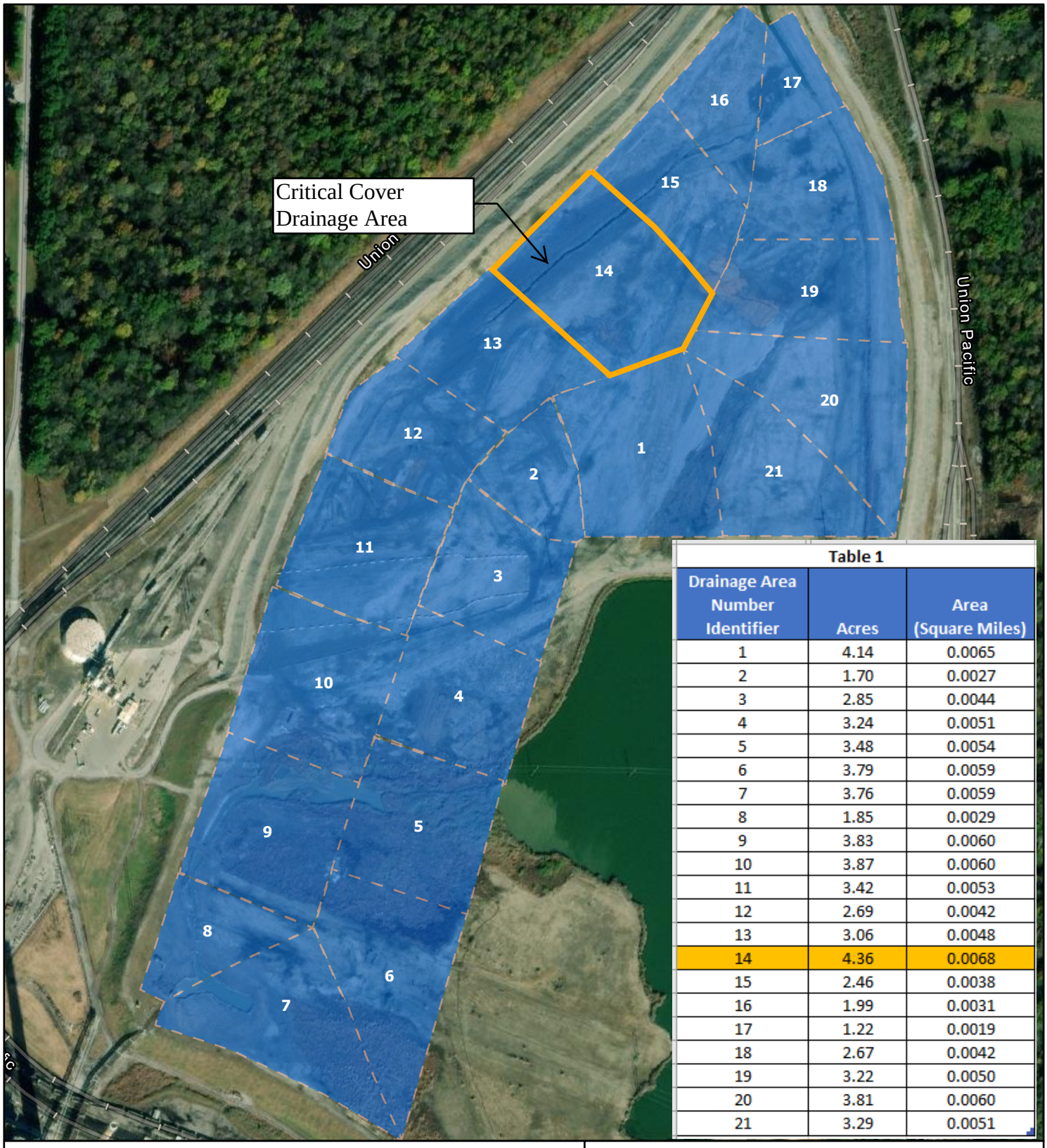

Table 1

Drainage Area Number Identifier	Acres	Area (Square Miles)
1	4.14	0.0065
2	1.70	0.0027
3	2.85	0.0044
4	3.24	0.0051
5	3.48	0.0054
6	3.79	0.0059
7	3.76	0.0059
8	1.85	0.0029
9	3.83	0.0060
10	3.87	0.0060
11	3.42	0.0053
12	2.69	0.0042
13	3.06	0.0048
14	4.36	0.0068
15	2.46	0.0038
16	1.99	0.0031
17	1.22	0.0019
18	2.67	0.0042
19	3.22	0.0050
20	3.81	0.0060
21	3.29	0.0051

Legend

Cover Drainage Areas

N

0 360 Feet

FINAL COVER SYSTEM DRAINAGE AREAS

(Joppa, Illinois)

Geosyntec consultants

(Joppa EAP Closure) | June 2022

Figure 1

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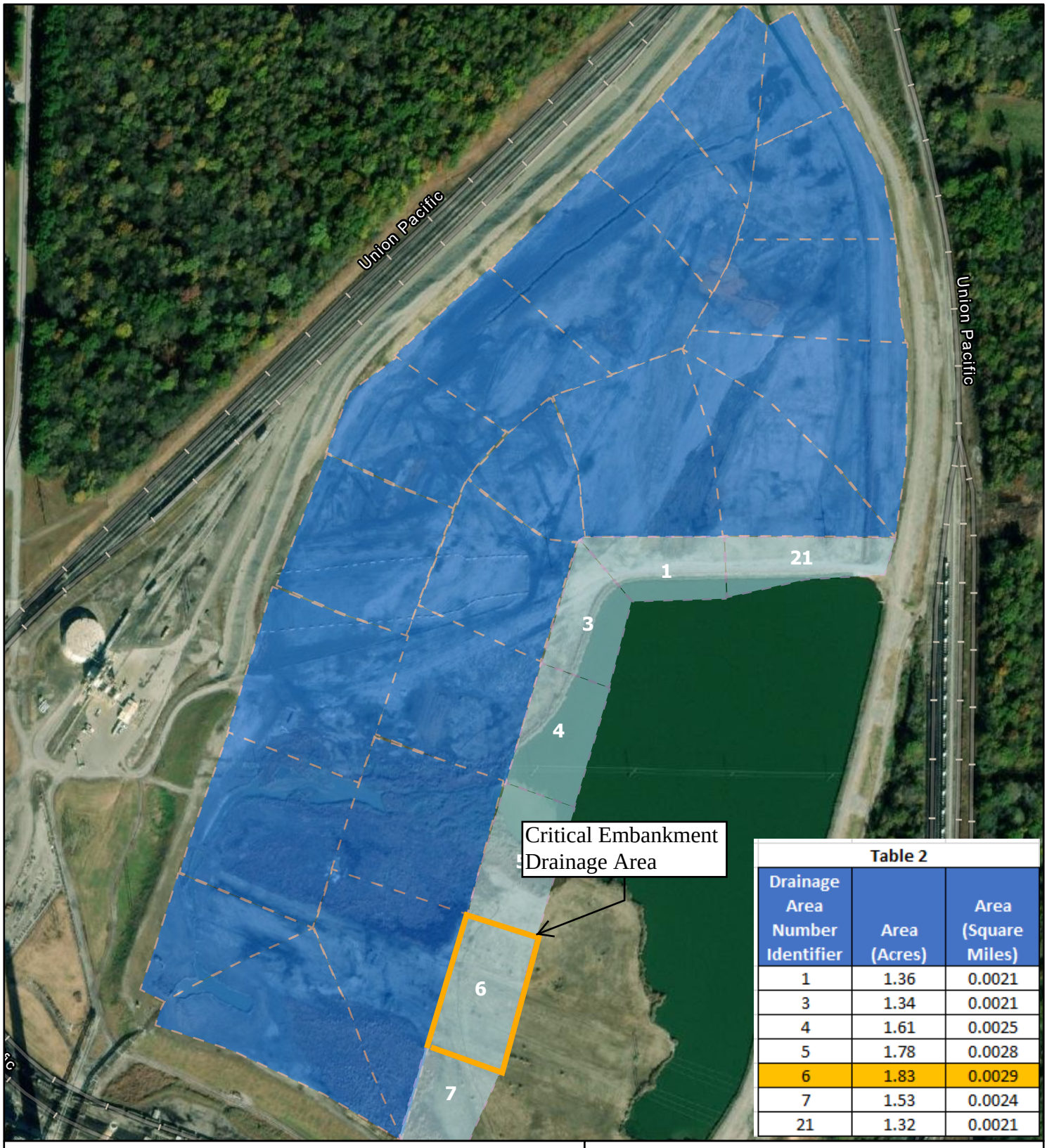

Table 2

Drainage Area Number Identifier	Area (Acres)	Area (Square Miles)
1	1.36	0.0021
3	1.34	0.0021
4	1.61	0.0025
5	1.78	0.0028
6	1.83	0.0029
7	1.53	0.0024
21	1.32	0.0021

Legend

Embk Drainage Areas

Cover Drainage Area

N

0 360 Feet

DRAINAGE AREAS

(Joppa, Illinois)

Geosyntec consultants

(Joppa EAP Closure) | June 2022

Figure 2

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Legend

- Embk Drainage Areas
- Cover Drainage Areas
- Top of Final Cover-30%Grading

N

0 360 Feet

Site Slopes

(Joppa, Illinois)

Geosyntec consultants

(Joppa EAP Closure) | June 2022

Figure 3

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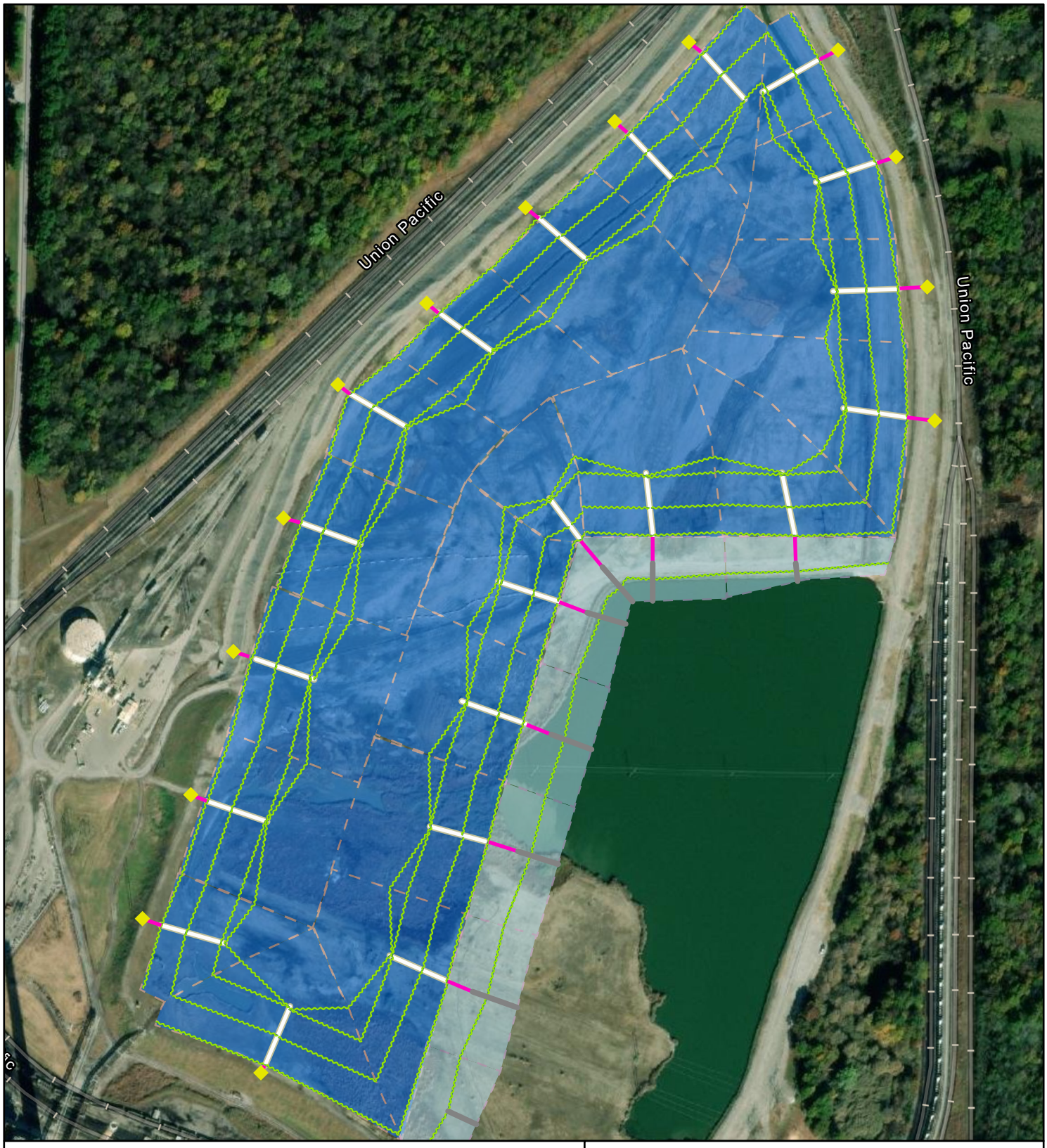

Legend

- Manhole and Riprap Apron
- Embk Rock Chute
- Culvert Crossing
- Interceptor Berm
- Cover Rock Chute
- Embk Drainage Areas
- Cover Drainage Areas

N

0 360 Feet

Stormwater Features

(Joppa, Illinois)

Geosyntec consultants

(Joppa EAP Closure) | June 2022

Figure 4

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APPENDIX B

NOAA Atlas 14, Volume 2, Version 3

NOAA Atlas 14, Volume 2, Version 3
Location name: Metropolis, Illinois, USA*
Latitude: 37.1518°, Longitude: -88.7312°
Elevation: 361.15 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.419** (0.387-0.457)	**0.495** (0.456-0.539)	**0.575** (0.529-0.626)	**0.640** (0.588-0.694)	**0.720** (0.659-0.781)	**0.779** (0.711-0.843)	**0.836** (0.761-0.905)	**0.897** (0.812-0.970)	**0.973** (0.876-1.05)	**1.03** (0.922-1.12)
10-min	**0.655** (0.604-0.713)	**0.776** (0.716-0.845)	**0.900** (0.828-0.978)	**0.993** (0.914-1.08)	**1.11** (1.01-1.20)	**1.19** (1.09-1.29)	**1.27** (1.16-1.38)	**1.35** (1.22-1.46)	**1.45** (1.31-1.57)	**1.52** (1.36-1.65)
15-min	**0.805** (0.742-0.876)	**0.953** (0.879-1.04)	**1.11** (1.02-1.21)	**1.23** (1.13-1.33)	**1.38** (1.26-1.49)	**1.48** (1.35-1.60)	**1.59** (1.44-1.72)	**1.68** (1.53-1.82)	**1.81** (1.63-1.96)	**1.90** (1.70-2.06)
30-min	**1.07** (0.989-1.17)	**1.28** (1.18-1.40)	**1.53** (1.41-1.67)	**1.72** (1.58-1.87)	**1.96** (1.79-2.12)	**2.14** (1.95-2.32)	**2.31** (2.10-2.50)	**2.49** (2.25-2.69)	**2.72** (2.45-2.94)	**2.89** (2.59-3.13)
60-min	**1.32** (1.21-1.43)	**1.58** (1.46-1.72)	**1.93** (1.78-2.10)	**2.20** (2.02-2.39)	**2.55** (2.34-2.77)	**2.83** (2.59-3.07)	**3.11** (2.83-3.36)	**3.40** (3.08-3.68)	**3.79** (3.41-4.10)	**4.09** (3.66-4.43)
2-hr	**1.57** (1.44-1.71)	**1.89** (1.73-2.06)	**2.32** (2.12-2.53)	**2.66** (2.42-2.89)	**3.11** (2.83-3.38)	**3.47** (3.14-3.77)	**3.84** (3.46-4.17)	**4.22** (3.79-4.59)	**4.74** (4.22-5.16)	**5.15** (4.56-5.62)
3-hr	**1.71** (1.56-1.88)	**2.06** (1.88-2.26)	**2.53** (2.31-2.77)	**2.90** (2.64-3.17)	**3.41** (3.10-3.73)	**3.82** (3.46-4.17)	**4.24** (3.82-4.63)	**4.69** (4.19-5.11)	**5.31** (4.71-5.78)	**5.80** (5.10-6.32)
6-hr	**2.11** (1.93-2.33)	**2.54** (2.32-2.80)	**3.12** (2.84-3.43)	**3.58** (3.26-3.93)	**4.22** (3.82-4.62)	**4.73** (4.27-5.18)	**5.27** (4.73-5.77)	**5.84** (5.21-6.39)	**6.64** (5.86-7.26)	**7.27** (6.37-7.96)
12-hr	**2.55** (2.33-2.80)	**3.07** (2.80-3.37)	**3.77** (3.44-4.13)	**4.33** (3.94-4.75)	**5.10** (4.62-5.58)	**5.72** (5.16-6.26)	**6.37** (5.71-6.96)	**7.05** (6.28-7.71)	**8.00** (7.06-8.78)	**8.77** (7.67-9.63)
24-hr	**3.08** (2.87-3.30)	**3.70** (3.46-3.97)	**4.55** (4.24-4.88)	**5.20** (4.83-5.57)	**6.06** (5.63-6.49)	**6.74** (6.24-7.21)	**7.43** (6.86-7.95)	**8.13** (7.47-8.70)	**9.09** (8.31-9.74)	**9.83** (8.95-10.5)
2-day	**3.65** (3.40-3.91)	**4.38** (4.08-4.70)	**5.37** (5.00-5.75)	**6.12** (5.69-6.55)	**7.10** (6.59-7.61)	**7.87** (7.29-8.43)	**8.64** (7.99-9.25)	**9.42** (8.68-10.1)	**10.5** (9.60-11.2)	**11.3** (10.3-12.1)
3-day	**3.86** (3.60-4.14)	**4.64** (4.32-4.97)	**5.67** (5.28-6.07)	**6.44** (5.99-6.90)	**7.47** (6.93-8.00)	**8.26** (7.66-8.85)	**9.06** (8.37-9.70)	**9.86** (9.08-10.6)	**10.9** (10.0-11.7)	**11.8** (10.7-12.6)
4-day	**4.07** (3.79-4.36)	**4.89** (4.56-5.24)	**5.96** (5.55-6.38)	**6.77** (6.30-7.25)	**7.83** (7.27-8.39)	**8.65** (8.02-9.27)	**9.48** (8.75-10.2)	**10.3** (9.49-11.0)	**11.4** (10.5-12.2)	**12.2** (11.2-13.2)
7-day	**4.73** (4.40-5.08)	**5.67** (5.28-6.09)	**6.93** (6.44-7.44)	**7.90** (7.33-8.48)	**9.18** (8.50-9.86)	**10.2** (9.41-10.9)	**11.2** (10.3-12.0)	**12.2** (11.2-13.1)	**13.6** (12.4-14.7)	**14.7** (13.3-15.8)
10-day	**5.28** (4.93-5.66)	**6.32** (5.89-6.78)	**7.66** (7.14-8.22)	**8.68** (8.09-9.31)	**10.0** (9.32-10.8)	**11.1** (10.3-11.9)	**12.1** (11.2-13.0)	**13.2** (12.1-14.1)	**14.5** (13.3-15.6)	**15.6** (14.3-16.8)
20-day	**7.18** (6.74-7.65)	**8.54** (8.02-9.10)	**10.2** (9.53-10.8)	**11.4** (10.7-12.1)	**12.9** (12.1-13.8)	**14.1** (13.2-15.0)	**15.3** (14.2-16.2)	**16.4** (15.3-17.5)	**17.9** (16.5-19.0)	**19.0** (17.5-20.2)
30-day	**8.76** (8.27-9.31)	**10.4** (9.81-11.0)	**12.2** (11.6-13.0)	**13.6** (12.8-14.5)	**15.4** (14.5-16.3)	**16.7** (15.7-17.7)	**18.0** (16.9-19.1)	**19.2** (18.0-20.5)	**20.9** (19.4-22.2)	**22.1** (20.5-23.6)
45-day	**11.0** (10.3-11.6)	**13.0** (12.2-13.8)	**15.2** (14.3-16.1)	**16.8** (15.8-17.8)	**18.8** (17.6-19.9)	**20.3** (19.0-21.5)	**21.7** (20.3-23.1)	**23.1** (21.5-24.6)	**24.9** (23.1-26.5)	**26.2** (24.3-27.9)
60-day	**13.0** (12.3-13.7)	**15.3** (14.5-16.2)	**17.8** (16.9-18.8)	**19.6** (18.5-20.7)	**21.9** (20.7-23.1)	**23.5** (22.2-24.8)	**25.1** (23.7-26.5)	**26.6** (25.0-28.2)	**28.6** (26.8-30.3)	**30.0** (28.0-31.8)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

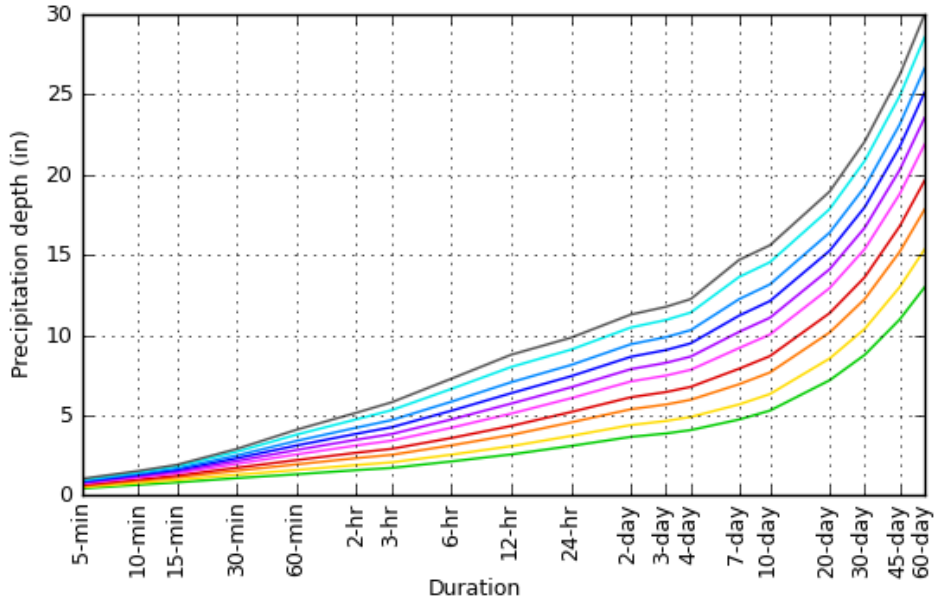
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

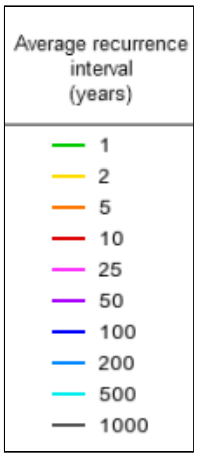
Please refer to NOAA Atlas 14 document for more information.

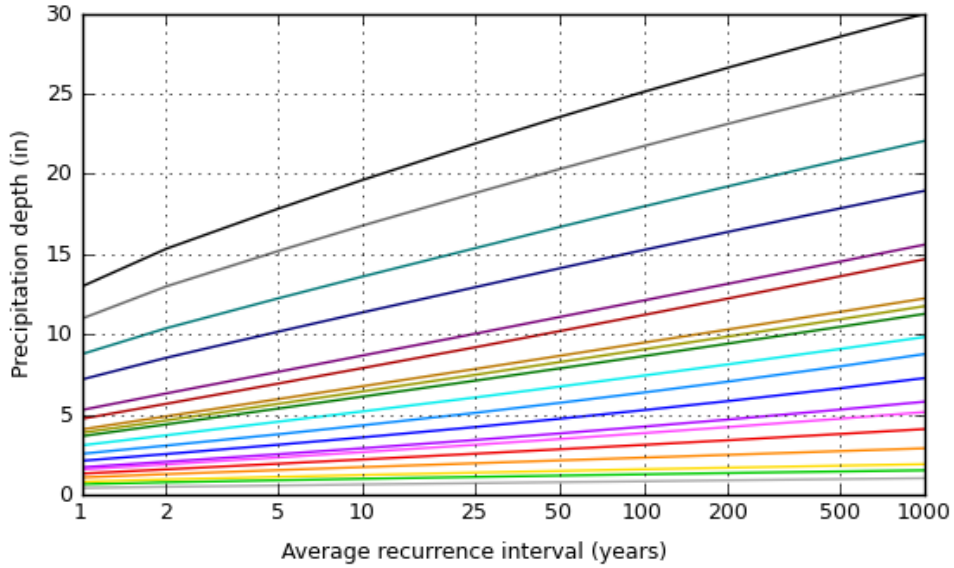
Back to Top

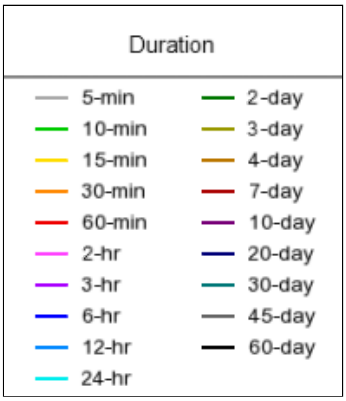
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 37.1518°, Longitude: -88.7312°









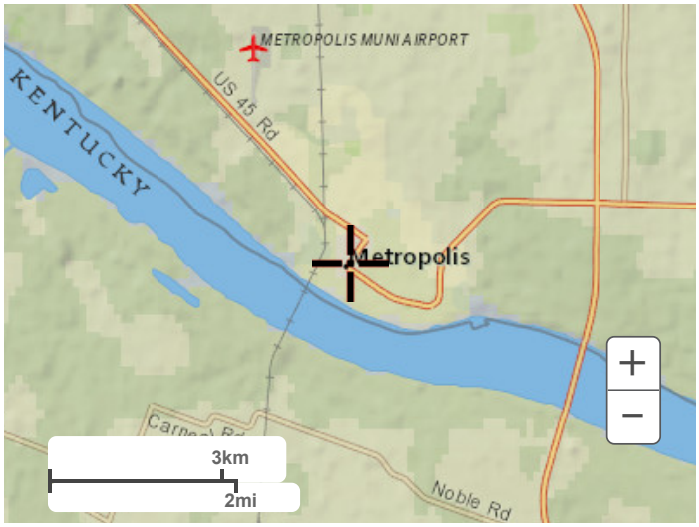
NOAA Atlas 14, Volume 2, Version 3

Created (GMT): Tue Mar 22 21:06:47 2022

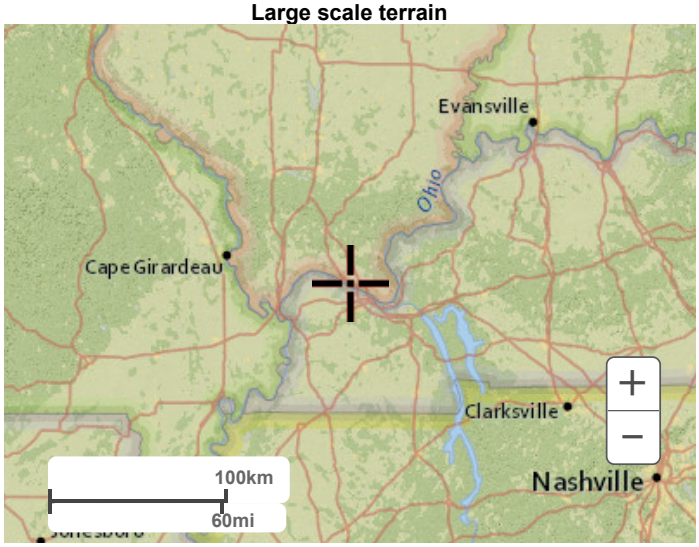
Back to Top

Maps & aerials

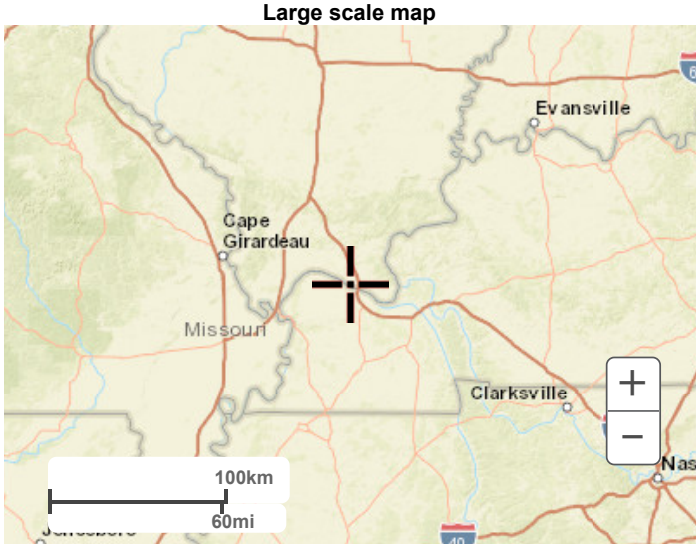
Small scale terrain



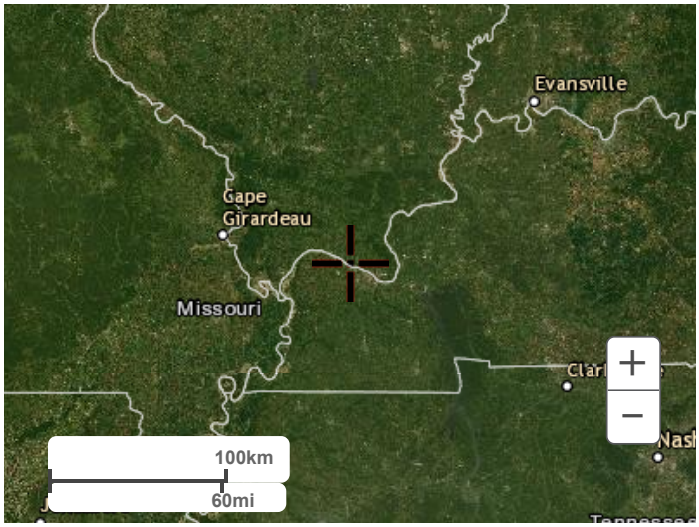
Large scale terrain



Large scale map



Large scale aerial



Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX C

Interceptor Berm Hydraulic Analysis

Geosyntec consultants
engineers | scientists | innovators

9300 W 110th Street
Overland Park, KS
TELEPHONE (913) 224-1056

JOB: Joppa EAP Closure Plan
SHEET NO. ____ OF ____
CALCULATED BY: PI DATE: 4/24/2022
CHECKED BY ____ DATE ____
SCALE ____
DESCRIPTION: Interceptor Berm Design (on 2% Slope)
100-year, 24 hr. SCS Type II

Drainage Area=	1.29	acres	0.0020156 square miles
Total Peak Discharge Qmax	8.5	cfs	

V-Ditch Design Parameters

Bottom Width, B =	0.00	ft	
Left Side Slope, Z1 =	50.00	horizontal :1 vertical	Cover Slope
Right Side Slope, Z2 =	2.00	horizontal :1 vertical	Berm Side Slope
Manning's Roughness Coeff., n =	0.030		
Longitudinal Channel Slope, So =	0.0100	ft/ft	

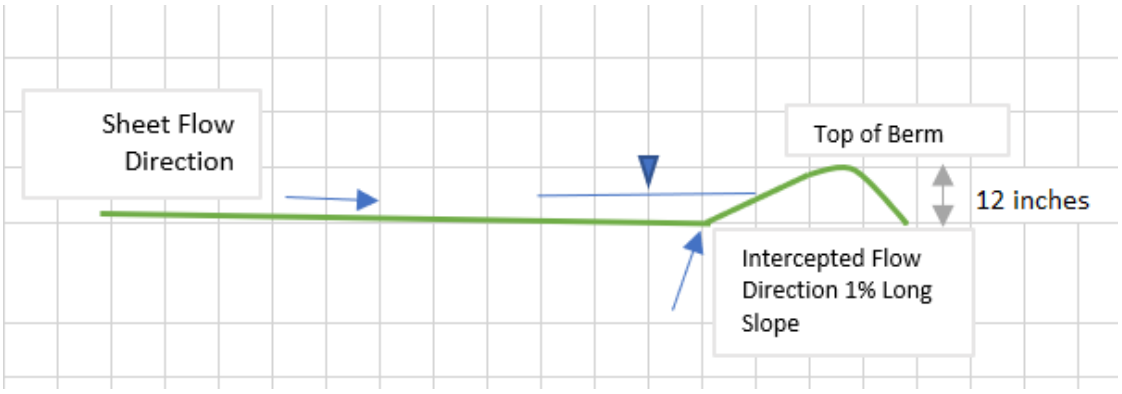
Depth of Flow	Top Width	Area of Flow	Wetted Perimeter	Hydraulic Radius	Channel Slope	Average Velocity	Discharge (Flow Rate)	Avg. Tractive Stress	Comments
Y	T	A	P	R=A/P		V	Q=AV	to	
ft	ft	ft2	ft	ft	ft/ft	ft/s	ft3/s	lb./ft2	
0.01	0.52	0.00	0.52	0.00	0.010	0.14	0.00	0.00	
0.05	2.64	0.07	2.66	0.03	0.010	0.43	0.03	0.02	
0.09	4.77	0.22	4.79	0.05	0.010	0.63	0.14	0.03	
0.13	6.89	0.46	6.92	0.07	0.010	0.81	0.37	0.04	
0.17	9.01	0.78	9.06	0.09	0.010	0.97	0.76	0.05	
0.21	11.14	1.19	11.19	0.11	0.010	1.12	1.33	0.07	
0.26	13.26	1.69	13.32	0.13	0.010	1.25	2.12	0.08	
0.30	15.38	2.28	15.46	0.15	0.010	1.38	3.15	0.09	
0.34	17.51	2.95	17.59	0.17	0.010	1.51	4.45	0.10	
0.38	19.63	3.71	19.72	0.19	0.010	1.63	6.03	0.12	
0.42	21.75	4.55	21.86	0.21	0.010	1.74	7.93	0.13	
0.46	23.88	5.48	23.99	0.23	0.010	1.86	10.17	0.14	
0.50	26.00	6.50	26.12	0.25	0.010	1.96	12.77	0.16	
0.43	**22.36**	**4.81**	**22.47**	**0.21**	**0.01**	**1.78**	**8.5**	**0.13**	**Design Q (Q100)**

Q

P

Channel Flow

Velocity (ft/s)	1.78
Flow Length (ft)	200
Tc or Tt (hr)	0.03



Geosyntec consultants

engineers | scientists | innovators

9300 W 110th Street
Overland Park, KS
TELEPHONE (913) 224-1056

JOB	Joppa EAP Closure Plan
SHEET NO.	OF
CALCULATED BY	PI
DATE	4/24/2022
CHECKED BY	
DATE	
SCALE	
DESCRIPTION	Interceptor Berm Design (on 10% Slope)
	100-year, 24 hr. SCS Type II

Drainage Area	0.43000	acres	0.000672 square miles
Total Peak Discharge Qmax	3.40	cfs	

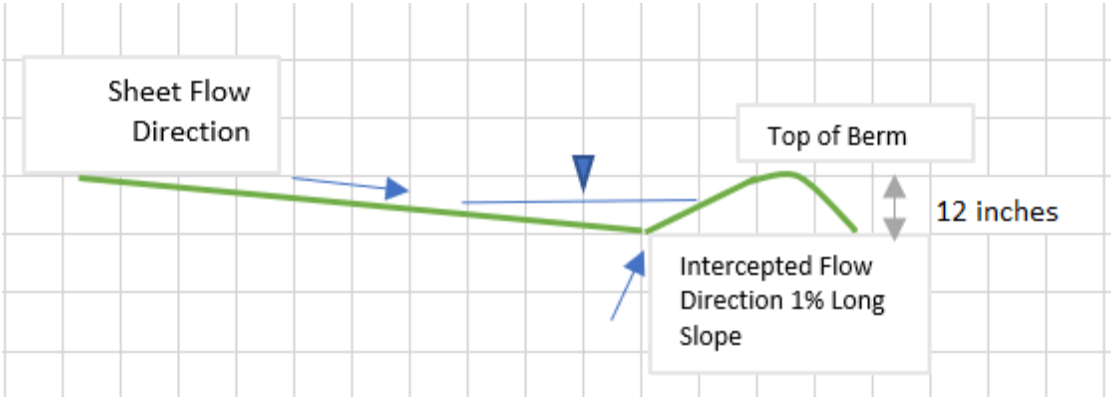
V-Ditch Design Parameters

Bottom Width, b =	0.00	ft	
Left Side Slope, Z1 =	10.00	horizontal :1 vertical	Cover Slope
Right Side Slope, Z2 =	2.00	horizontal :1 vertical	Berm Side Slope
Manning's Roughness Coeff., n =	0.030		
Longitudinal Channel Slope, So =	0.0100	ft/ft	

Depth of Flow	Top Width	Area of Flow	Wetted Perimeter	Hydraulic Radius	Channel Slope	Average Velocity	Discharge (Flow Rate)	Avg. Tractive Stress	Comments
Y	T	A	P	R=A/P		V	Q=AV	to	
ft	ft	ft2	ft	ft	ft/ft	ft/s	ft3/s	lb./ft2	
0.01	0.12	0.00	0.12	0.00	0.010	0.14	0.00	0.00	
0.09	1.11	0.05	1.14	0.05	0.010	0.63	0.03	0.03	
0.18	2.10	0.18	2.15	0.09	0.010	0.96	0.18	0.05	
0.26	3.09	0.40	3.16	0.13	0.010	1.25	0.50	0.08	
0.34	4.08	0.69	4.18	0.17	0.010	1.50	1.04	0.10	
0.42	5.07	1.07	5.19	0.21	0.010	1.73	1.86	0.13	
0.51	6.06	1.53	6.20	0.25	0.010	1.95	2.99	0.15	
0.59	7.05	2.07	7.22	0.29	0.010	2.16	4.47	0.18	
0.67	8.04	2.69	8.23	0.33	0.010	2.36	6.35	0.20	
0.75	9.03	3.40	9.25	0.37	0.010	2.55	8.65	0.23	
0.84	10.02	4.18	10.26	0.41	0.010	2.73	11.42	0.25	
0.92	11.01	5.05	11.27	0.45	0.010	2.91	14.69	0.28	
1.00	12.00	6.00	12.29	0.49	0.010	3.08	18.48	0.30	
0.53	**6.36**	**1.69**	**6.51**	**0.26**	**0.01**	**2.02**	**3.40**	**0.16**	**Design Q (Q100)**

Channel Flow

Velocity (ft/s)	2.02
Flow Length (ft)	200
Tc or Tt (hr)	0.03



Geosyntec consultants
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9300 W 110th Street
Overland Park, KS
TELEPHONE (913) 224-1056

JOB Joppa EAP Closure Plan
SHEET NO. OF
CALCULATED BY PI DATE 4/24/2022
CHECKED BY DATE
SCALE
DESCRIPTION Interceptor Berm Design (on 33% Slope)
100-year, 24 hr. SCS Type II

Drainage Area	0.47000	acres	0.000734 square miles
Total Peak Discharge Qmax	3.60	cfs	

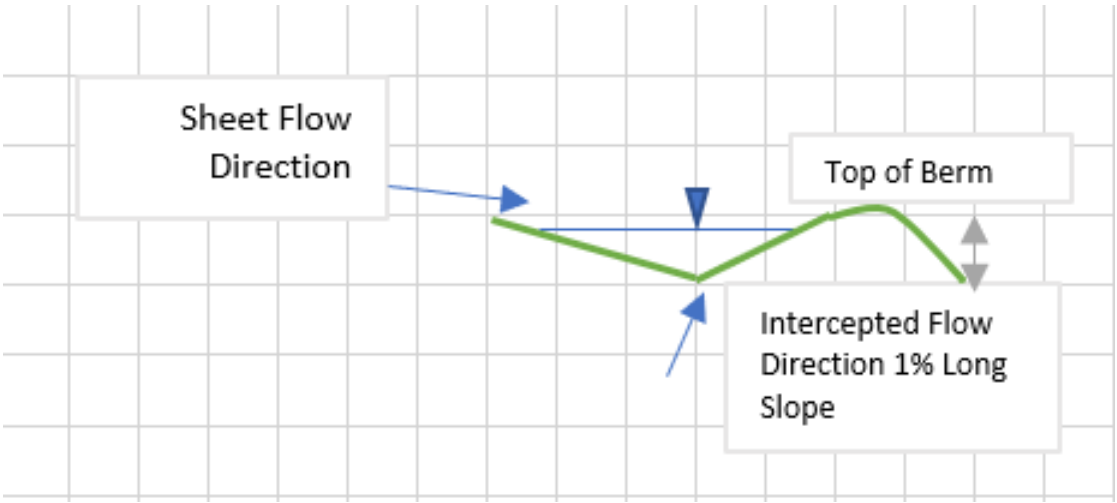
V-Ditch Design Parameters

Bottom Width, b =	0.00	ft	
Left Side Slope, Z1 =	3.00	horizontal :1 vertical	Cover Slope
Right Side Slope, Z2 =	2.00	horizontal :1 vertical	Berm Side Slope
Manning's Roughness Coeff., n =	0.030		
Longitudinal Channel Slope, So =	0.0100	ft/ft	

Depth of Flow	Top Width	Area of Flow	Wetted Perimeter	Hydraulic Radius	Channel Slope	Average Velocity	Discharge (Flow Rate)	Avg. Tractive Stress	Comments
Y	T	A	P	R=A/P		V	Q=AV	to	
ft	ft	ft2	ft	ft	ft/ft	ft/s	ft3/s	lb./ft2	
0.01	0.05	0.00	0.05	0.00	0.010	0.14	0.00	0.00	
0.09	0.46	0.02	0.50	0.04	0.010	0.61	0.01	0.03	
0.18	0.88	0.08	0.94	0.08	0.010	0.93	0.07	0.05	
0.26	1.29	0.17	1.39	0.12	0.010	1.20	0.20	0.07	
0.34	1.70	0.29	1.84	0.16	0.010	1.45	0.42	0.10	
0.42	2.11	0.45	2.28	0.20	0.010	1.67	0.75	0.12	
0.51	2.53	0.64	2.73	0.23	0.010	1.88	1.20	0.15	
0.59	2.94	0.86	3.17	0.27	0.010	2.08	1.80	0.17	
0.67	3.35	1.12	3.62	0.31	0.010	2.28	2.55	0.19	
0.75	3.76	1.42	4.06	0.35	0.010	2.46	3.48	0.22	
0.84	4.18	1.74	4.51	0.39	0.010	2.64	4.59	0.24	
0.92	4.59	2.10	4.95	0.42	0.010	2.81	5.91	0.27	
1.00	5.00	2.50	5.40	0.46	0.010	2.97	7.43	0.29	
0.76	**3.81**	**1.45**	**4.11**	**0.35**	**0.01**	**2.48**	**3.60**	**0.22**	**Design Q (Q100)**

Channel Flow

Velocity (ft/s)	2.48
Flow Length (ft)	200
Tc or Tt (hr)	0.02



APPENDIX D

Rock Chute Analysis

Rock Chute Design - Cut/Paste Plan

(Version WI-Nov. 2017, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

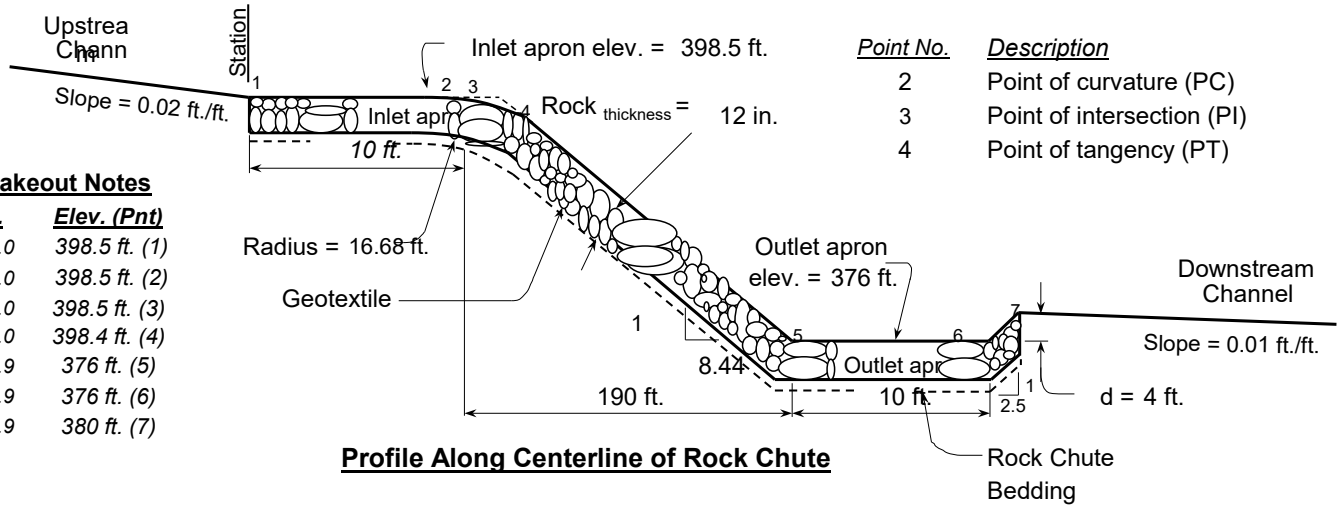
Project: Joppa EAP Impoundment
Designer: Priya Iyengar
Date: 4/22/2022

County: 0.00
Checked by:
Date:

Design Values		Rock Gradation Envelope		Quantities [a]	
D_{50} dia. =	6.0 in.	% Passing	Diameter, in. (weight, lbs.)	Rock =	154 yd^3
$Rock_{chute}$ thickness =	12.0in	D_{100}--------	9 - 12 (52 - 122)	Geotextile (WCS-13)[b] =	542 yd^2
Inlet apron length =	10 ft.	D_{85}--------	8 - 11 (34 - 89)	Bedding =	0 yd^3
Outlet apron length =	10 ft.	D_{50}--------	6 - 9 (15 - 52)	Excavation =	0 yd^3
Radius =	17 ft	D_{10}--------	5 - 8 (8 - 34)	Earthfill =	0 yd^3
Will bedding be used?	No	*Coefficient of Uniformity, $(D_{60})/(D_{10}) < 1.7$*		Seeding =	0.0acre

Notes: [a] *Rock, bedding, and geotextile quantities are determined from x-section below (neglect radius).*

[b] *Geotextile Class I (Non-woven) shall be overlapped and anchored (18-in. minimum along sides and 24-in. minimum on the ends) --- quantity not included.*

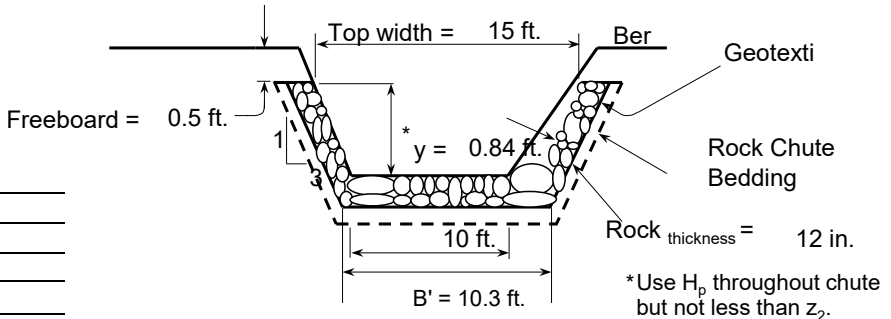


Point No.	Description
2	Point of curvature (PC)
3	Point of intersection (PI)
4	Point of tangency (PT)

Stakeout Notes

Sta.	Elev. (Pnt)
0+00.0	398.5 ft. (1)
0+09.0	398.5 ft. (2)
0+10.0	398.5 ft. (3)
0+11.0	398.4 ft. (4)
1+99.9	376 ft. (5)
2+09.9	376 ft. (6)
2+19.9	380 ft. (7)

Profile Along Centerline of Rock Chute



Rock Chute Cross Section

Notes:
Rock gradation envelope can be met with
DOT Light riprap Gradation

Profile, Cross Sections, and Quantities

NRCS
Natural Resources Conservation Service
United States Department of Agriculture

Joppa EAP Impoundment

County

	Date	
Designe	Priya Iyengar	
Drawn		
Checked		
Approved		

File Name
Drawing Name
Sheet __ of __

Rock Chute Design - Cut/Paste Plan

(Version WI-Nov. 2017, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Joppa EAP Impoundment
Designer: Priya Iyengar
Date: 4/22/2022

County: 0.00
Checked by:
Date:

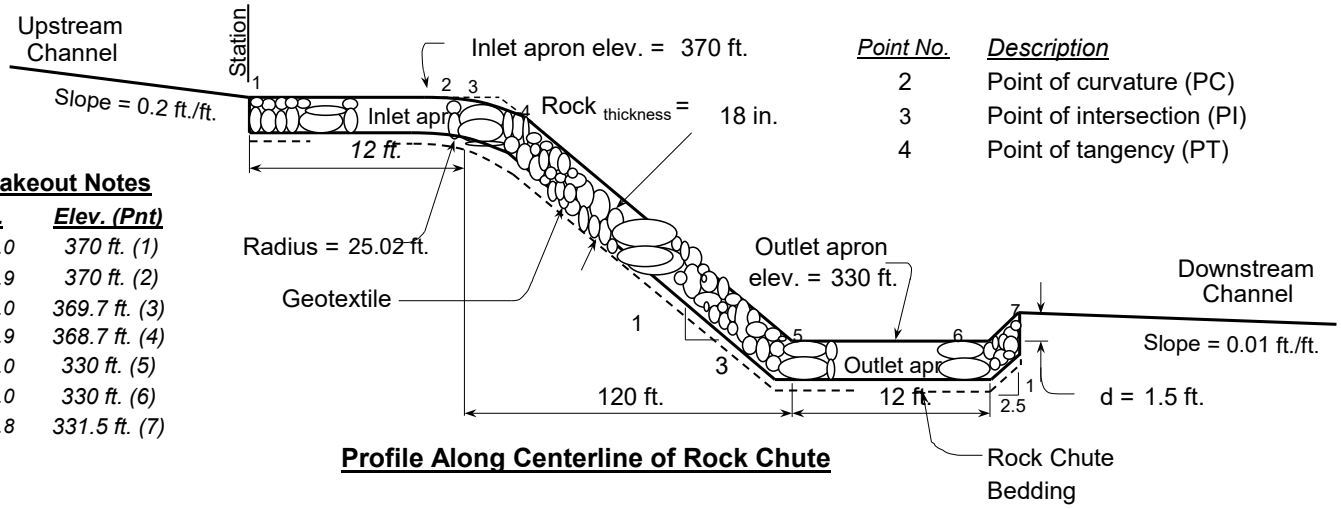
Design Values	
D_{50} dia. =	9.0 in.
$Rock_{chute}$ thickness =	18.0in
Inlet apron length =	12 ft.
Outlet apron length =	12 ft.
Radius =	25 ft
Will bedding be used?	No

Rock Gradation Envelope	
% Passing	*Diameter, in. (weight, lbs.)*
D_{100}--------	14 - 18 (174 - 413)
D_{85}--------	12 - 16 (113 - 301)
D_{50}--------	9 - 14 (52 - 174)
D_{10}--------	7 - 12 (26 - 113)
Coefficient of Uniformity, $(D_{60})/(D_{10}) < 1.7$	

Quantities [a]	
Rock =	203 yd^3
Geotextile (WCS-13)[b] =	491 yd^2
Bedding =	0 yd^3
Excavation =	0 yd^3
Earthfill =	0 yd^3
Seeding =	0.0acre

Notes: [a] *Rock, bedding, and geotextile quantities are determined from x-section below (neglect radius).*

[b] *Geotextile Class I (Non-woven) shall be overlapped and anchored (18-in. minimum along sides and 24-in. minimum on the ends) --- quantity not included.*

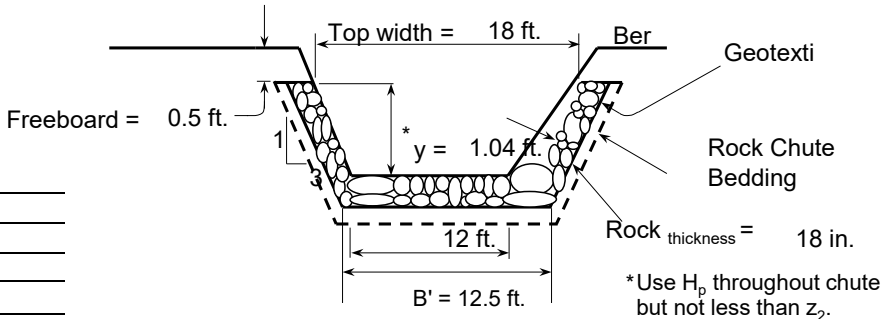


Profile Along Centerline of Rock Chute

Point No.	Description
2	Point of curvature (PC)
3	Point of intersection (PI)
4	Point of tangency (PT)

Stakeout Notes

Sta.	Elev. (Pnt)
0+00.0	370 ft. (1)
0+07.9	370 ft. (2)
0+12.0	369.7 ft. (3)
0+15.9	368.7 ft. (4)
1+32.0	330 ft. (5)
1+44.0	330 ft. (6)
1+47.8	331.5 ft. (7)



Rock Chute Cross Section

Notes:
Rock gradation envelope can be met with
DOT Light riprap Gradation

Profile, Cross Sections, and Quantities

NRCS
Natural Resources Conservation Service
United States Department of Agriculture

Joppa EAP Impoundment

County

	Date
Designe	Priya Iyengar
Drawn	
Checked	
Approved	

File Name
Drawing Name
Sheet __ of __

APPENDIX E

Culvert Crossing Analysis

Culvert Crossing Hydraulic Analysis Using HY-8

Table 1: Culvert Summary Table

Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
13.40	377.25	6.25	0.28	0.83	1.16	0.86	0.13	8.06	8.16
17.14	377.31	6.31	0.51	0.95	1.32	0.98	0.15	8.55	8.98
20.89	377.35	6.35	0.74	1.05	1.47	1.09	0.17	8.97	9.67
24.63	377.40	6.40	0.98	1.15	1.60	1.20	0.19	9.33	10.29
27.60	377.43	6.43	1.18	1.22	1.70	1.29	0.20	9.54	10.75
32.12	377.49	6.49	1.48	1.33	1.84	1.40	0.22	9.92	11.38
35.86	377.53	6.53	1.75	1.42	1.95	1.49	0.24	10.20	11.86
39.61	377.56	6.56	2.03	1.50	2.05	1.59	0.25	10.42	12.31
43.35	377.60	6.60	2.32	1.58	2.14	1.68	0.27	10.65	12.73
47.10	377.64	6.64	2.62	1.67	2.24	1.77	0.28	10.87	13.13
50.84	377.67	6.67	3.28	1.75	2.32	1.85	0.29	11.08	13.50

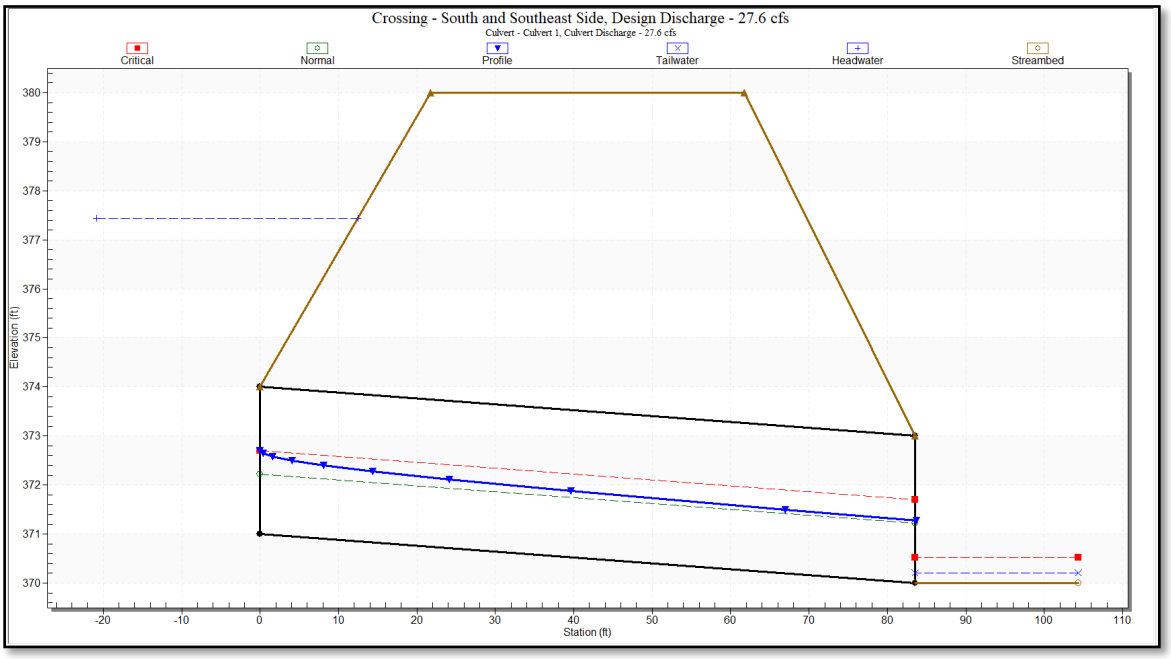


Figure 1: Culvert Crossing Profile on the Southeast Side (7 culverts)

Discharges from 7 culverts represented in Figure 1 will be conveyed to embankment rock chutes and into the perimeter channel.

Project:_____ Designed By: _____ Checked By:_____

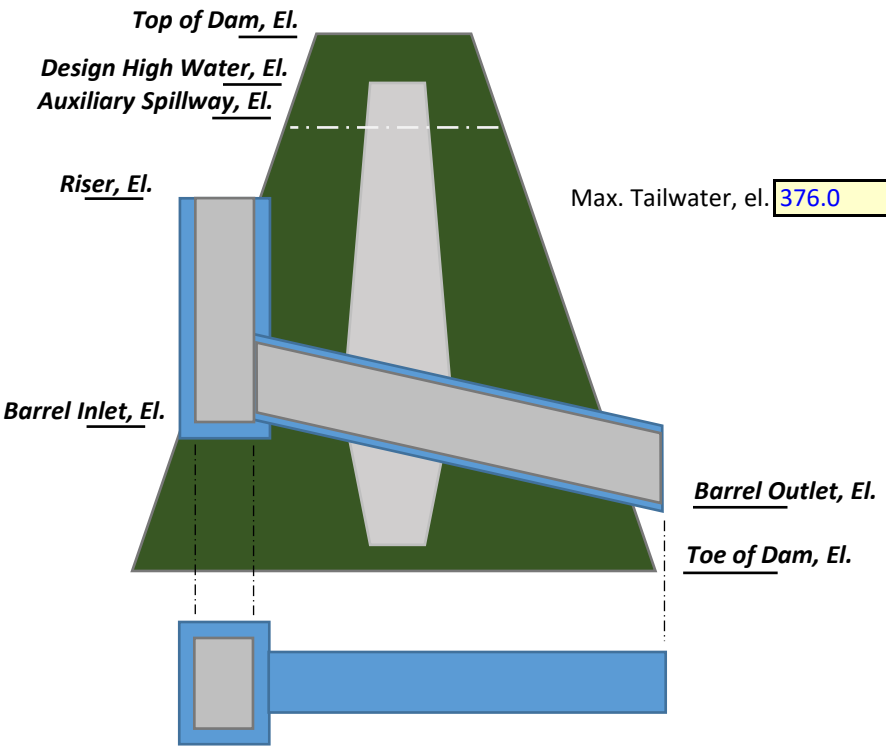
Date:_____ Date: _____ Date:_____

INPUT

Riser Length, ft (inside)	10.0
Riser Width, ft (inside)	4.0
Barrel Diameter, in	36.0
Manning's *n* -value	0.0250
Skew angle, degrees	90.0
Upstream SS, #:1	3.0
Downstream SS, #:1	3.0
Top Width, ft	40.0
Extra Pipe, ft	0.0

Elevation

Top of Dam, el.	380.0
Design High Water, el.	379.5
Auxiliary Spillway, el.	380.0
Riser Inlet, el.	376.0
Barrel Inlet, invert, el.	371.0
Barrel Outlet, invert, el.	370.0
Toe of Dam, el.	369.5
Pipe length, ft.	83.5



Max. Tailwater, el. 376.0

EQUATIONS

Elevation (ft)	Weir Flow (cfs)	High Orifice (cfs)	Low Orifice (cfs)	Pipe Flow (cfs)	Design Flow (cfs)
376.0	0.00	0.00	63.67	0.00	**0.00**
376.1	2.74	60.91	64.58	8.72	**2.74**
376.2	7.76	86.13	65.47	12.33	**7.76**
376.3	14.26	105.49	66.35	15.10	**14.26**
376.4	21.96	121.81	67.21	17.44	**17.44**
376.5	30.69	136.19	68.07	19.49	**19.49**
376.6	40.34	149.19	68.92	21.36	**21.36**
376.7	50.84	161.14	69.75	23.07	**23.07**
376.8	62.11	172.27	70.58	24.66	**24.66**
376.9	74.11	182.72	71.39	26.15	**26.15**
377.0	86.80	192.60	72.20	27.57	**27.57**
377.1	100.14	202.00	73.00	28.91	**28.91**
377.2	114.10	210.98	73.79	30.20	**30.20**
377.3	128.66	219.60	74.57	31.43	**31.43**
377.4	143.78	227.89	75.34	32.62	**32.62**
377.5	159.46	235.88	76.10	33.77	**33.77**
377.6	175.67	243.62	76.86	34.87	**34.87**
377.7	192.39	251.12	77.61	35.95	**35.95**
377.8	209.62	258.40	78.35	36.99	**36.99**
377.9	227.33	265.48	79.09	38.00	**38.00**
378.0	245.51	272.38	79.82	38.99	**38.99**
378.1	264.15	279.10	80.54	39.95	**39.95**
378.2	283.24	285.67	81.26	40.89	**40.89**
378.3	302.77	292.09	81.97	41.81	**41.81**
378.4	322.73	298.37	82.67	42.71	**42.71**
378.5	343.11	304.53	83.37	43.59	**43.59**
378.6	363.90	310.56	84.06	44.45	**44.45**
378.7	385.09	316.47	84.75	45.30	**45.30**
378.8	406.68	322.28	85.43	46.13	**46.13**

378.9	428.66	327.98	86.10	46.95	**46.95**
379.0	451.03	333.59	86.77	47.75	**47.75**
379.1	473.76	339.11	87.44	48.54	**48.54**
379.2	496.87	344.53	88.10	49.32	**49.32**
379.3	520.34	349.87	88.75	50.08	**50.08**
379.4	544.17	355.14	89.40	50.84	**50.84**

Table 2: Culvert Summary Table

Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
5.00	361.80	0.80	-20.28	0.25	0.70	0.25	0.07	18.19	5.57
9.58	362.12	1.12	-19.96	0.33	0.98	0.34	0.11	21.55	7.17
14.16	362.38	1.38	-19.67	0.40	1.20	0.42	0.14	23.34	8.34
18.74	362.65	1.65	-19.39	0.47	1.39	0.47	0.16	26.87	9.28
23.32	362.94	1.94	-19.10	0.52	1.56	0.55	0.18	26.37	10.09
27.60	363.19	2.19	-18.81	0.56	1.70	0.60	0.20	27.73	10.75
32.48	363.48	2.48	-18.47	0.61	1.85	0.65	0.22	28.98	11.43
37.06	363.75	2.75	-18.14	0.65	1.98	0.70	0.24	29.82	12.00
41.64	364.04	3.04	-17.79	0.69	2.10	0.74	0.26	30.45	12.54
46.22	364.35	3.35	-17.41	0.73	2.21	0.79	0.28	31.01	13.04
50.80	364.69	3.69	-16.68	0.76	2.32	0.83	0.29	31.64	13.50

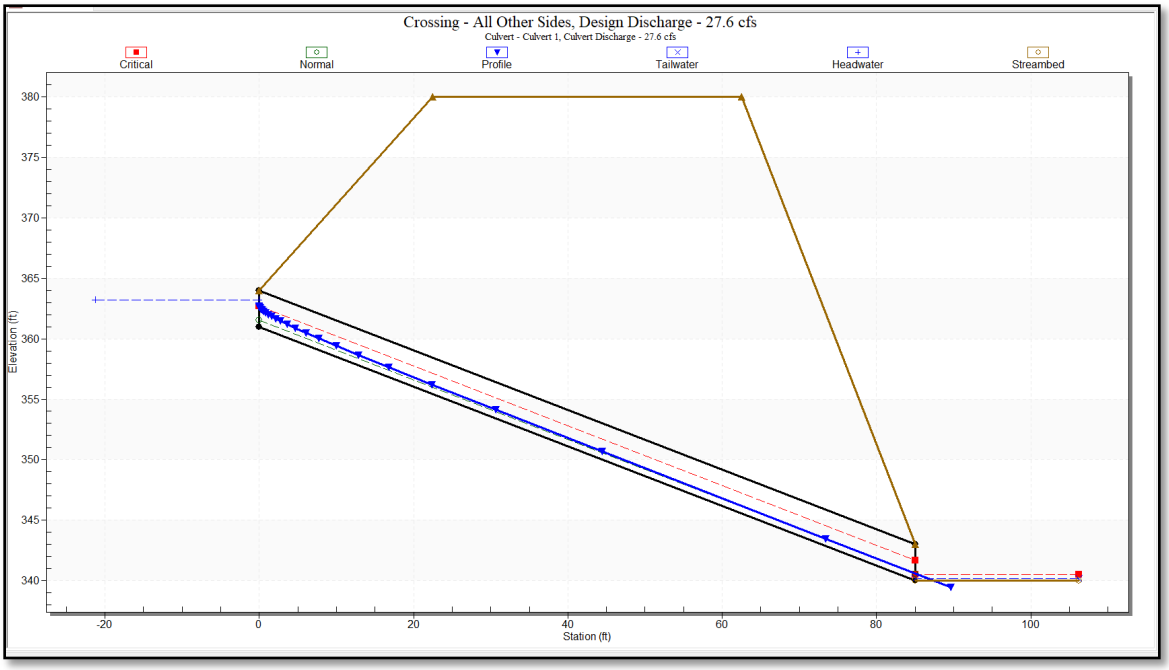


Figure 2: Culvert Crossing Profile on All Other Sides (14 culverts)

Discharges from 14 culverts represented in Figure 2 will be conveyed to a 48-inch manhole structure which will then discharge to a riprap apron through an outlet pipe or a flared end section.

Project:_____ Designed By: _____ Checked By:_____

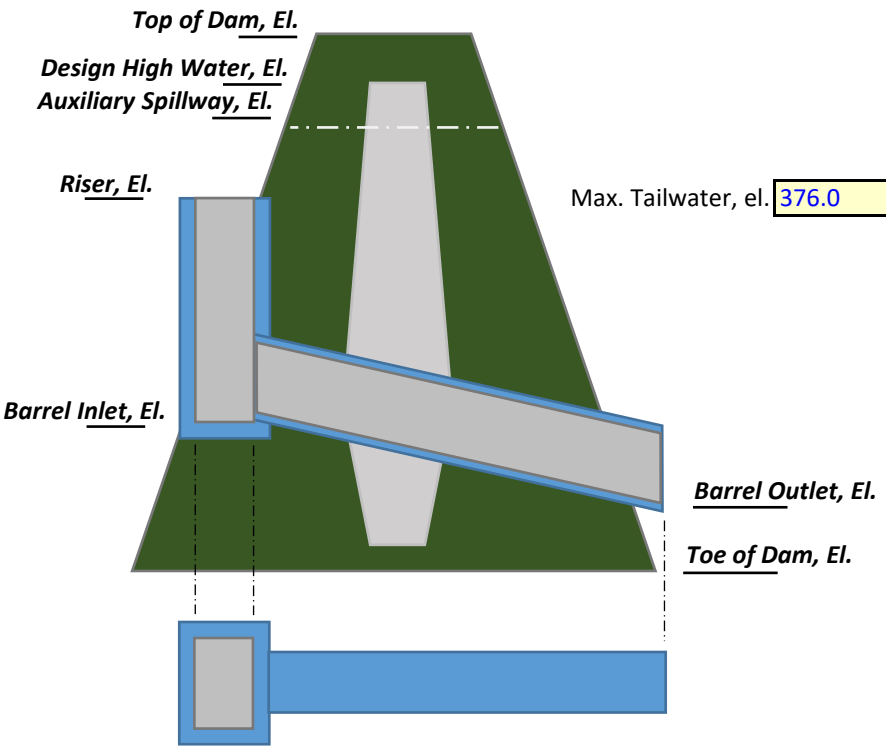
Date:_____ Date: _____ Date:_____

INPUT

Riser Length, ft (inside)	10.0
Riser Width, ft (inside)	4.0
Barrel Diameter, in	36.0
Manning's *n* -value	0.0250
Skew angle, degrees	90.0
Upstream SS, #:1	3.0
Downstream SS, #:1	3.0
Top Width, ft	40.0
Extra Pipe, ft	0.0

Elevation

Top of Dam, el.	380.0
Design High Water, el.	379.5
Auxiliary Spillway, el.	380.0
Riser Inlet, el.	376.0
Barrel Inlet, invert, el.	361.0
Barrel Outlet, invert, el.	330.0
Toe of Dam, el.	369.5
Pipe length, ft.	89.1



Max. Tailwater, el. 376.0

EQUATIONS

Elevation (ft)	Weir Flow (cfs)	High Orifice (cfs)	Low Orifice (cfs)	Pipe Flow (cfs)	Design Flow (cfs)
376.0	0.00	0.00	125.05	0.00	**0.00**
376.1	2.74	60.91	125.52	8.57	**2.74**
376.2	7.76	86.13	125.98	12.12	**7.76**
376.3	14.26	105.49	126.43	14.84	**14.26**
376.4	21.96	121.81	126.89	17.14	**17.14**
376.5	30.69	136.19	127.35	19.16	**19.16**
376.6	40.34	149.19	127.80	20.99	**20.99**
376.7	50.84	161.14	128.25	22.67	**22.67**
376.8	62.11	172.27	128.70	24.24	**24.24**
376.9	74.11	182.72	129.15	25.71	**25.71**
377.0	86.80	192.60	129.60	27.10	**27.10**
377.1	100.14	202.00	130.05	28.42	**28.42**
377.2	114.10	210.98	130.49	29.68	**29.68**
377.3	128.66	219.60	130.94	30.90	**30.90**
377.4	143.78	227.89	131.38	32.06	**32.06**
377.5	159.46	235.88	131.82	33.19	**33.19**
377.6	175.67	243.62	132.26	34.28	**34.28**
377.7	192.39	251.12	132.69	35.33	**35.33**
377.8	209.62	258.40	133.13	36.35	**36.35**
377.9	227.33	265.48	133.56	37.35	**37.35**
378.0	245.51	272.38	134.00	38.32	**38.32**
378.1	264.15	279.10	134.43	39.27	**39.27**
378.2	283.24	285.67	134.86	40.19	**40.19**
378.3	302.77	292.09	135.29	41.09	**41.09**
378.4	322.73	298.37	135.71	41.98	**41.98**
378.5	343.11	304.53	136.14	42.84	**42.84**
378.6	363.90	310.56	136.57	43.69	**43.69**
378.7	385.09	316.47	136.99	44.53	**44.53**
378.8	406.68	322.28	137.41	45.34	**45.34**

378.9	428.66	327.98	137.83	46.14	**46.14**
379.0	451.03	333.59	138.25	46.93	**46.93**
379.1	473.76	339.11	138.67	47.71	**47.71**
379.2	496.87	344.53	139.09	48.47	**48.47**
379.3	520.34	349.87	139.50	49.22	**49.22**
379.4	544.17	355.14	139.92	49.96	**49.96**

Geosyntec
consultants

ATTACHMENT G

Geotechnical Design of Slopes and Final Cover System

July 2022

Geosyntec consultants

COMPUTATION COVER SHEET

Client: **Dynegy** Project: **Joppa EAP Closure Plan** Project No.: **GLP8025**
Task No.: **02/03**

Title of Computations: **Geotechnical Calculations for Closure Design**

Computations by:	Signature		06-21-2022
	Printed Name	Pourya Kargar	Date
	Title	Senior Staff Professional	
Assumptions and Procedures Checked by: (peer reviewer)	Signature		06-21-2022
	Printed Name	Lucas P. Carr, P.E.	Date
	Title	Senior Engineer	
Computations Checked by:	Signature		5-25-2022
	Printed Name	Thierno Kane, Ph. D	Date
	Title	Engineer	
Computations backchecked by: (originator)	Signature		06-21-2022
	Printed Name	Pourya Kargar	Date
	Title	Senior Staff Professional	
Approved by: (pm or designate)	Signature		06-21-2022
	Printed Name	John P. Seymour, P.E.	Date
	Title	Senior Principal	

Approval notes: Closure Plan Submittal

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

TABLE OF CONTENTS

1. Purpose 4
2. Summary of Subsurface Investigations 4
2015 AECOM Investigation 4
2021 Geosyntec Investigation 6
3. Summary of Subsurface Conditions 8
Embankment Fill 8
CCR 8
Foundation Clay 8
Foundations Sand 8
Soft Clay/Miscellaneous Fill 9
4. Design Geotechnical Strength and Unit Weight Parameters 9
Drained Shear Strength 10
Undrained Shear Strength 12
Unit Weight 16
5. Consolidation characterization 19
6. Groundwater Conditions 20
7. Settlement Analysis for Post-closure Condition 22
8. Seismic Assessments 25
Site Seismic Hazard Assessment 25
Liquefaction Triggering Analysis 26
Pseudostatic Seismic Analysis 27
9. Liquefaction and Cyclic Softening Assessment 27
Data for Evaluation 27
Liquefaction of Cohesive and Fine-Grained Soils 28
Liquefaction Assessment of Cohesionless Soils 29
Cyclic Softening Triggering Assessment for Cohesive Soils 31
Residual Shear Strength for CCR 31
10. Global Slope Stability 33
Selected Cross-sections 34
Results 35
11. Veneer Cover Stability 36
12. Conclusions 39
13. References 40

LIST OF ATTACHMENTS

Attachment A – 2016 AECOM Geotechnical Report
Attachment B – Excerpts from 2021 Geosyntec Investigation
Attachment C – Summary of 2022 Geosyntec Subsurface Characterization
Attachment D – 3-D Settlement Analysis
Attachment E – AECOM Seismic Hazard Assessment
Attachment F – Liquefaction and Cyclic Softening Assessment
Attachment G – Global Slope Stability Analysis Output
Attachment H – Interface Friction Testing Data
Attachment I – Veneer Stability Analysis Outputs

1. PURPOSE

This calculation package presents geotechnical calculations in support of the development of the closure design for the East Ash Pond (EAP) at the Joppa Power Plant (JPP) in Joppa, Illinois. The analyses provided in this calculation package (Package) includes:

(i) A summary of past geotechnical investigations completed at and around the EAP;

(ii) A summary of subsurface conditions, selected geotechnical design parameters, and seismic inputs developed by Geosyntec;

(iii) Settlement analyses for post-closure conditions;

(iv) Liquefaction screening analyses for the CCR and subsurface soils;

(v) Global slope stability analyses considering post-closure conditions for static and seismic conditions; and

(vi) Cover system veneer stability analyses.

2. SUMMARY OF SUBSURFACE INVESTIGATIONS

2015 AECOM Investigation

A subsurface investigation program was performed by AECOM at the EAP and in August of 2015 [1] to evaluate the design and operation of the surface impoundment against the regulatory standards set in 40 CFR §257.73 [2]. The field program consisted of conventional hollow stem auger (HSA) borings, Standard Penetration Testing (SPT), Shelby tube sampling, Cone Penetration testing with porewater pressure testing (CPTu), and piezometer installation. Laboratory testing was conducted on the materials obtained through various sampling techniques to assist in characterization of the subsurface conditions. The investigation also included a discussion of the results from a sampling and testing program performed by Geotechnology Inc. in 2010. CPTu and boring locations by this investigation are shown on **Figure 1**.

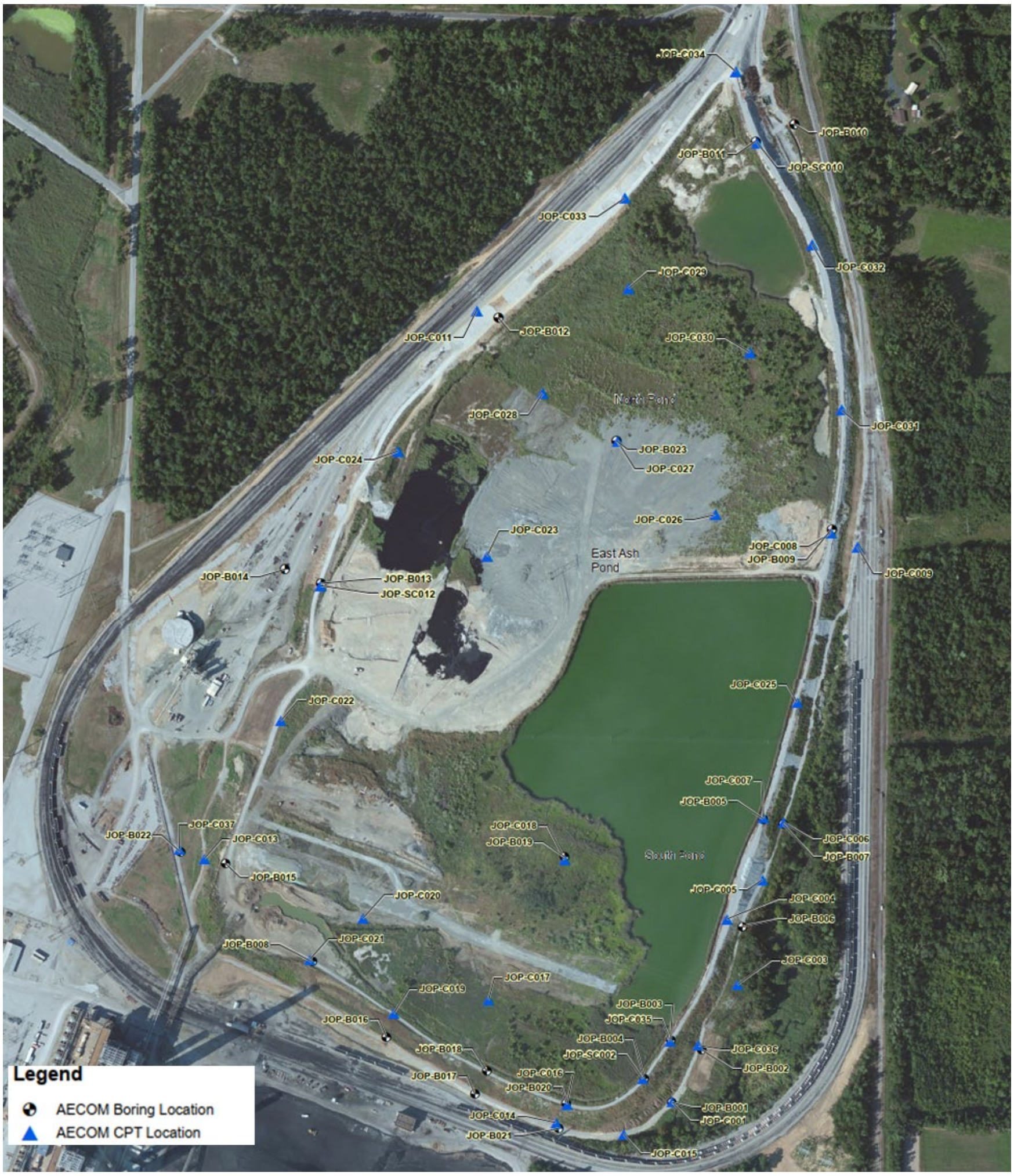


Figure 1 – 2015 AECOM Subsurface Investigation Locations (C-prefix denotes a CPT, B-prefix denotes a boring)

[1]

AECOM's geotechnical report is provided in **Attachment A**.

2021 Geosyntec Investigation

A supplemental investigation of the CCR contained within the East Ash Pond was completed by Geosyntec in 2021 [3] to resolve data gaps and meet the requirements of the Draft Illinois Administrative Code Part 845 regulations for the Joppa EAP. The investigation program included advancing three hollow-stem auger borings within the interior of the EAP and 10 well borings outside the EAP, as shown in **Figure 2**.

The hollow-stem auger borings were advanced approximately 17 to 20 ft below grade and the sonic borings were advanced between 64 and 98 ft below grade. Laboratory testing was performed on disturbed and undisturbed samples of CCR collected from the hollow-stem auger borings, and summarized below:

Index Tests:

- Moisture content (ASTM D2216): 13 tests
- Atterberg limits (ASTM D4318): 9 tests
- Grain size analyses (ASTM D422): 13 tests
- Dry unit weight (ASTM D7263): 11 tests
- Specific Gravity (ASTM D854): 13 tests

Hydraulic Tests:

- Flexible Wall Hydraulic Conductivity (ASTM D5084): 7 tests

Each of the borings were converted into monitoring wells after completion. Excerpts from Geosyntec's report, including boring location information, boring logs, and laboratory testing data, are provided in **Attachment B**.

Figure 2 – 2021 Geosyntec Subsurface Investigation Locations[1]

[1]The 2021 Geosyntec investigation also included monitoring wells installed around the perimeter of the EAP. These monitoring wells did not include in-situ geotechnical tests or laboratory tests and were not used for contouring the groundwater flow. Therefore, these monitoring wells are not further discussed in this report.

3. SUMMARY OF SUBSURFACE CONDITIONS

AECOM [1] and Geosyntec [3] identified the following subsurface materials within, beneath, and around the EAP:

(i) Embankment Fill ("Embankment Clay" in the AECOM report);
(ii) Foundation Clay;
(iii) Foundation Sand;
(iv) Soft Clay/Miscellaneous Fill;
(v) CCR ("Ash" or "Bottom Ash" and "Fly Ash" in the AECOM Report).

Each material is discussed below.

Embankment Fill

Embankment Fill consists of the materials used to construct the perimeter embankments of the EAP. The dike soils were characterized as stiff lean clay and sandy clay, based on CPT logs, SPT N-values, and laboratory testing data [1].

CCR

CCR consists of ash materials that were sluiced into the EAP for disposal. The CCR materials included well-graded sand to silt with trace slag and coal fragments, generally consisting of fly ash, bottom ash, and fly ash/bottom ash mixtures. Bottom ash was typically saturated and loose to very loose and fly ash was soft to very soft [1].

Foundation Clay

Foundation Clay consists of lean clay (CL) and sandy clay (SC) in the native deposits that form the upper portion of site foundation materials. Most soil samples obtained from the field investigation suggest that the soil is generally stiff [1].

Foundations Sand

The lower portion of the site foundation materials consist of dense silty sand (SM) and poorly graded sand (SP) with varying amount of gravel content. Samples obtained from the field investigation suggest the Foundation Sand may be described as dense to very dense [1].

Soft Clay/Miscellaneous Fill

Soft clay/Miscellaneous Fill soil layer existing in the southeast of EAP, reported by AECOM [1], was not considered in the analyses reported in this package due to the removal of the dike and CCR materials in this area as a part of the closure plan.

4. DESIGN GEOTECHNICAL STRENGTH AND UNIT WEIGHT PARAMETERS

Design geotechnical strength and unit weight parameters for each subsurface soil material were initially selected by AECOM using available laboratory data, in-situ measurements, published correlations, and engineering judgment. Geosyntec reviewed AECOM's shear strength parameters and generally agreed with the parameters for Foundation Sand. Geosyntec utilized AECOM's geotechnical laboratory testing data [1] to re-characterize the shear strength parameters for the Embankment Fill, Foundation Clay, and CCR. Each of AECOM's shear strength tests were reviewed and re-characterized, using the process listed below.

- Consolidated-undrained triaxial compression testing with pore pressure measurements (CIU) (ASTM D4767 [4]).
    - A total of 45 tests were performed on samples of Embankment Fill, CCR, and Foundation Clay.
    - Failure criteria for individual CIU specimens was defined as the peak shear strength limited to 10% axial strain, to consider the effects of strain incompatibilities, based on Geosyntec's experience.
    - The drained and undrained shear strengths were calculated using CIU test results by computation of shear stress on the failure plane at failure, τ_{ff}, for each individual specimen.
    - All CIU tests were considered for the development of drained shear strength parameters, while only tests consolidated in the laboratory to stresses no more 20% higher than the in-situ effective stresses were considered for undrained shear strength computations. This was performed to avoid potentially over-estimating undrained strength parameters that could be caused by consolidation significantly above in-situ stresses.
- Direct shear (DS) tests (ASTM D3080 [5]).
    - A total of six tests were performed on samples of Foundation Clay.
    - Failure criteria for individual CIU specimens was defined as peak shear strength limited to 10% shear strain, to consider the effects of strain incompatibilities.

  - All the DS test results provided by AECOM [1] were used in developing drained shear strength parameters with respect to the failure criterion mentioned above.
- Direct simple shear (DSS) tests (ASTM D6528 [6]).
  - A total of seven tests were performed on samples of Foundation Clay and CCR.
  - Failure criteria for individual CIU specimens was defined as peak strength limited to 10% shear strain, to consider the effects of strain incompatibilities.
  - All the DSS test results provided by AECOM [1] were used in developing undrained shear strength parameters with respect to the failure criterion mentioned above and similar to CIU tests, the tests conducted at consolidation stresses 20% higher than the in-situ effective stresses were excluded from the shear strength data pool for calculation of undrained strength parameters.
- Triaxial unconsolidated undrained (UU) tests (ASTM D2850 [7]).
  - A total of 22 tests were performed on samples of Embankment Fill, CCR, and Foundation Clay.
  - Failure criteria for individual UU specimens was defined as peak strength limited to 10% axial strain, to consider the effects of strain incompatibilities.
  - All the conducted UU test results provided by AECOM [1] were used in developing undrained shear strength parameters in this calculation package with respect to the failure criterion mentioned above.
- Laboratory vane (LV) tests (ASTM D4648 [8]).
  - A total of 18 tests were performed on samples of Embankment Fill, and Foundation Clay.
  - Peak shear strength from the LV tests provided by AECOM [1] were directly utilized in developing undrained shear strength parameters in this calculation package.

Further details and summary of calculations conducted regarding the above-mentioned are provided in **Attachment C.**

Drained Shear Strength

Drained strengths were established by plotting effective stresses normal to the failure plane at failure, σ'_n, versus shear stress on the failure plane at failure, τ_f, for Embankment Fill, Foundation Clay, and CCR materials, utilizing both CIU and DS test data. The effective design effective friction angle, ϕ', and effective cohesion, c', for each material

was assigned such that one-third of the plotted points fell below and two-thirds fell on or above the failure envelope. These plots are provided in **Figures 4** through **6** for Embankment Fill, Foundation Clay, and CCR, respectively.

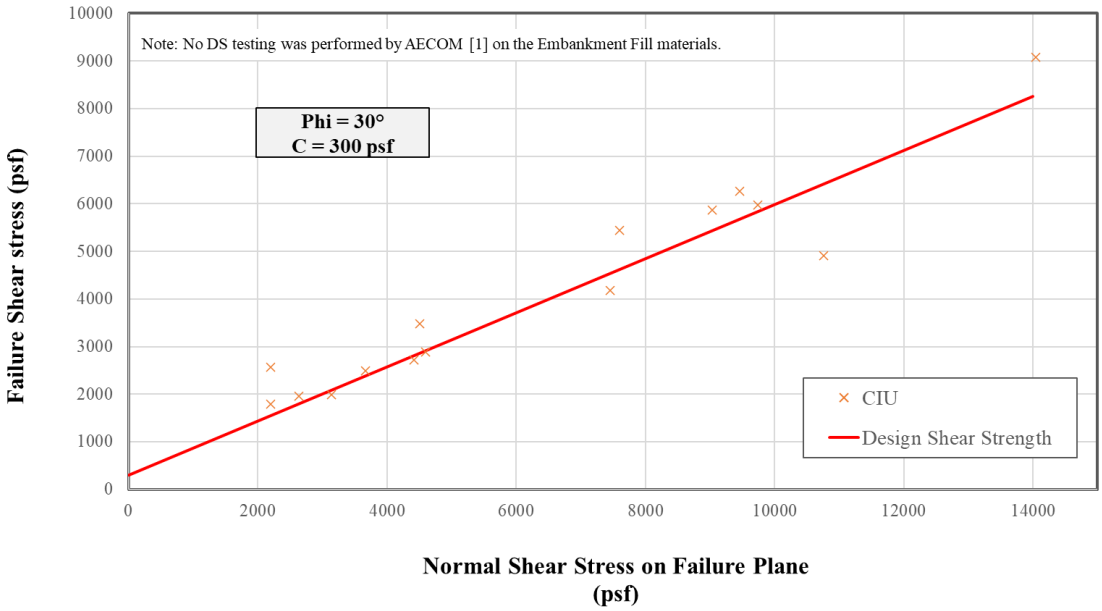


Figure 4. Drained Strength Data and Design Envelope for Embankment Fill

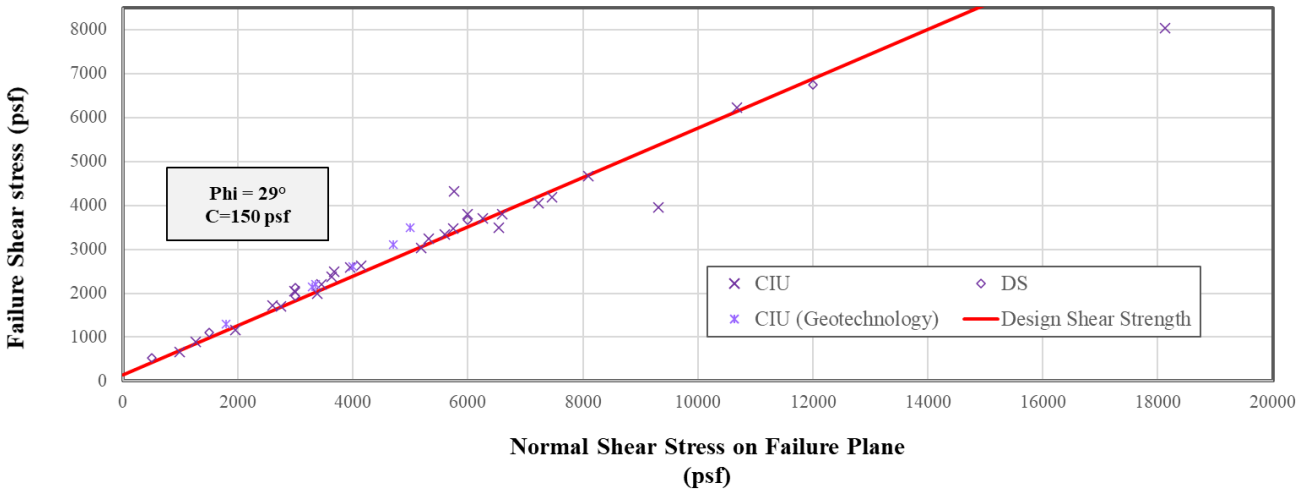


Figure 5. Drained Strength Data and Design Envelope for Foundation Clay

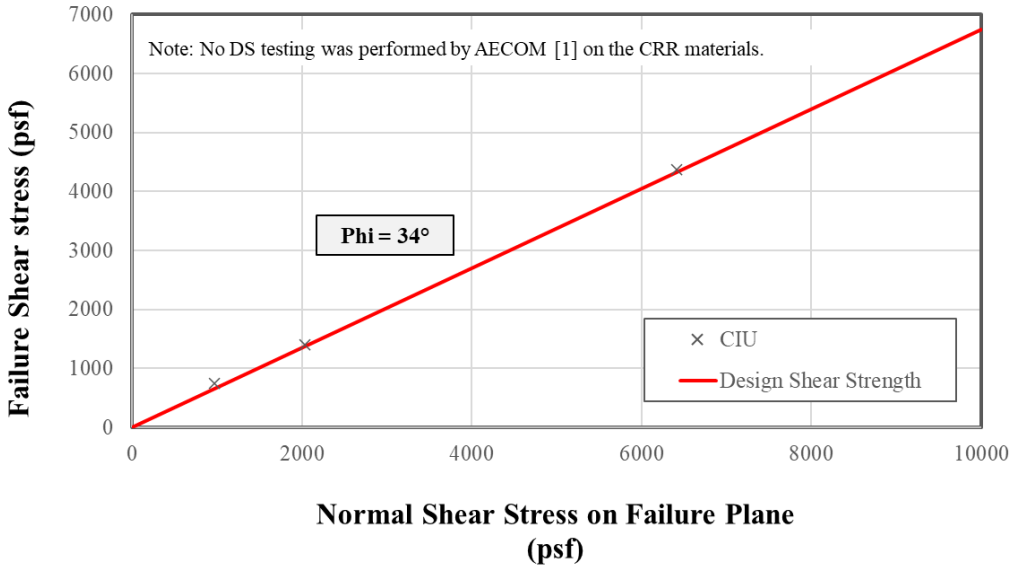


Figure 6. Drained Strength Data and Design Envelope for CCR

Undrained Shear Strength

Design undrained strength parameters were developed for Embankment Fill and Foundation Clay by plotting undrained shear strength, S_u, versus the elevation from which the samples were collected, and selecting a design strength profile line that corresponds

to the approximate lower-third of the plotted points (i.e., one-third of the shear strength data is below the design strength profile lines). For the Embankment Fill material, a constant undrained shear strength value vs. elevation was assigned because the data did not indicate significant variations in undrained shear strength with depth.

For the Foundation Clay, a variable undrained shear strength envelope was utilized, where a constant undrained shear strength value was assigned above El. 340 ft, and an undrained shear strength increasing with depth was assigned below El. 340 ft, based on observed trends in the data. These plots are provided in **Figures 7** and **8**.

Results of shear strength tests, shown in **Figure 9**, indicate that the CCR undrained shear strength versus confining effective stress, results in a shear strength envelope similar to the drained shear strength (**Figure 6**). Due to this observation in conjunction with expecting an instant dissipation of porewater pressure in CCR after fill placement, drained parameters were employed for CCR materials in all the analysis cases for this calculation package.

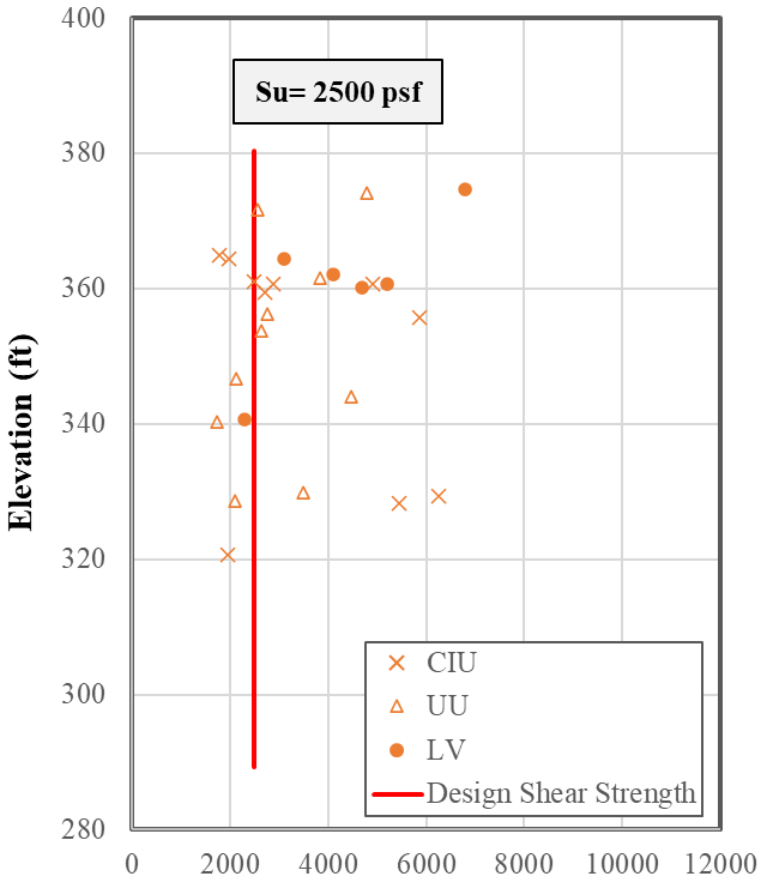


Figure 7. Undrained Strength Data and Design Envelope for Embankment Fill

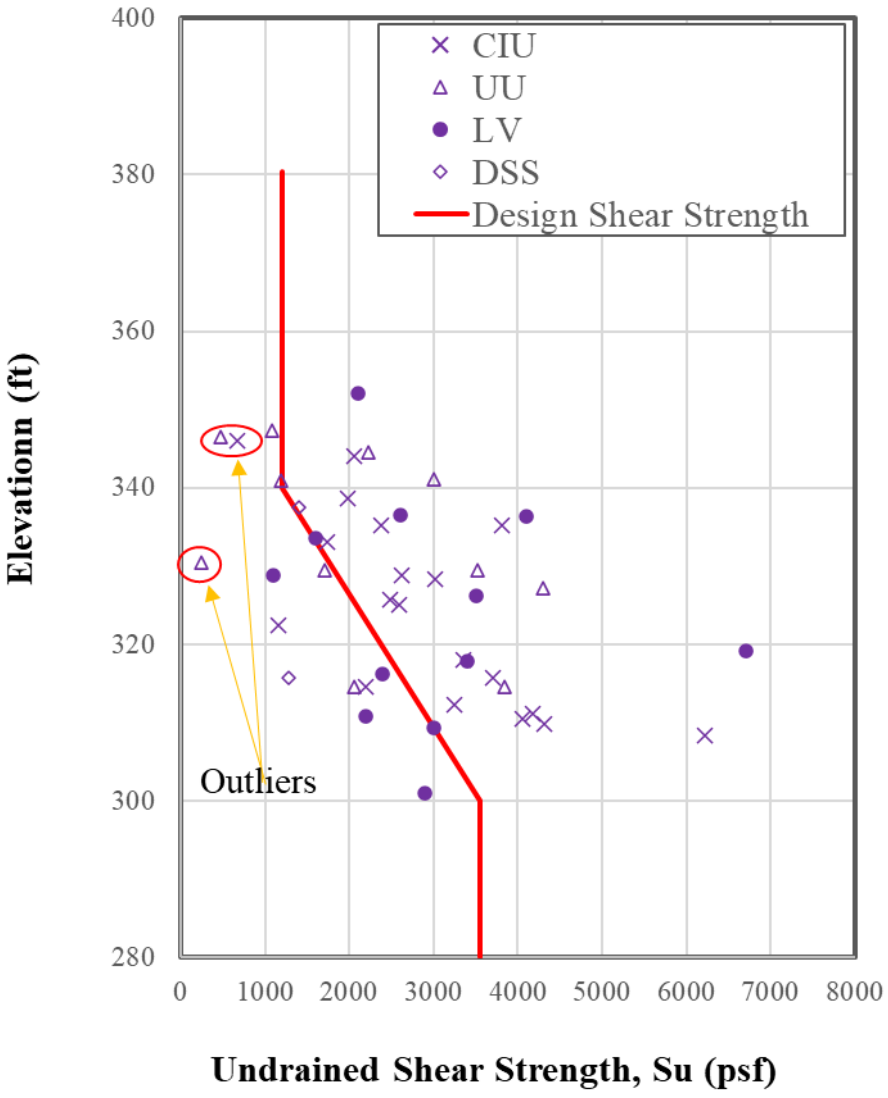


Figure 8. Undrained Strength Data and Design Envelope for Foundation Clay
(Note: S_u is capped at 3,550 psf below El. 300 ft)

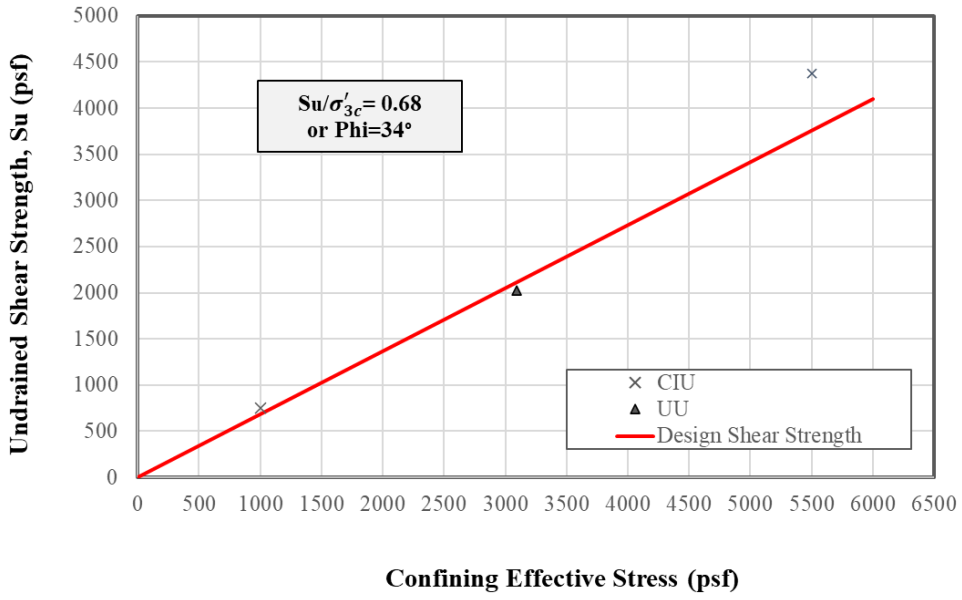


Figure 9. Undrained Strength Data and Envelope for CCR

Design geotechnical materials for the final covers were also selected based on Geosyntec's experience.

Unit Weight

A total of 169 total unit weight measurements from the AECOM [1] report was utilized to develop design total unit weights, γ_t, for the Embankment Fill, Foundation Clay, and CCR materials, and plotted against sample elevation. The geometric mean of the measured unit weights was used as the design total unit weight for the materials as shown in **Figure 10** through **12.**

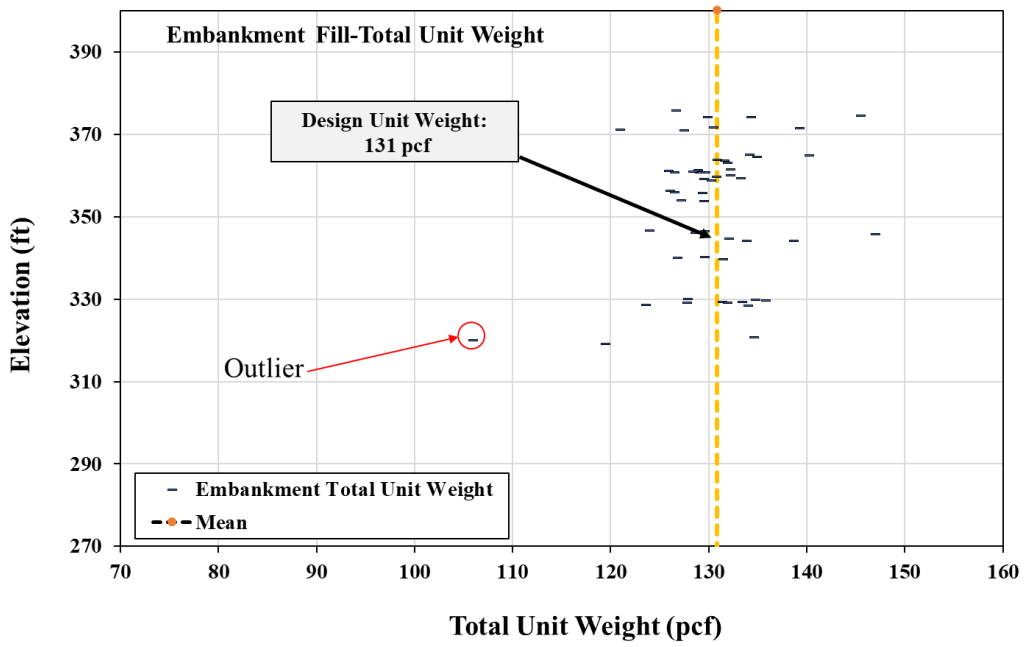


Figure 10. Embankment Fill Design Total Unit Weight

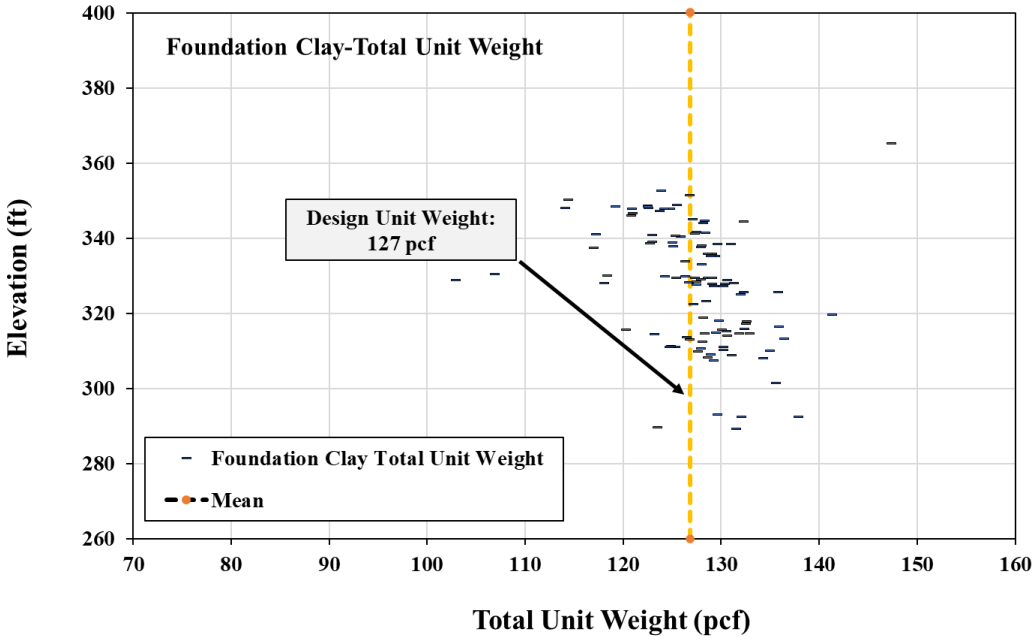


Figure 11. Foundation Clay Design Total Unit Weight

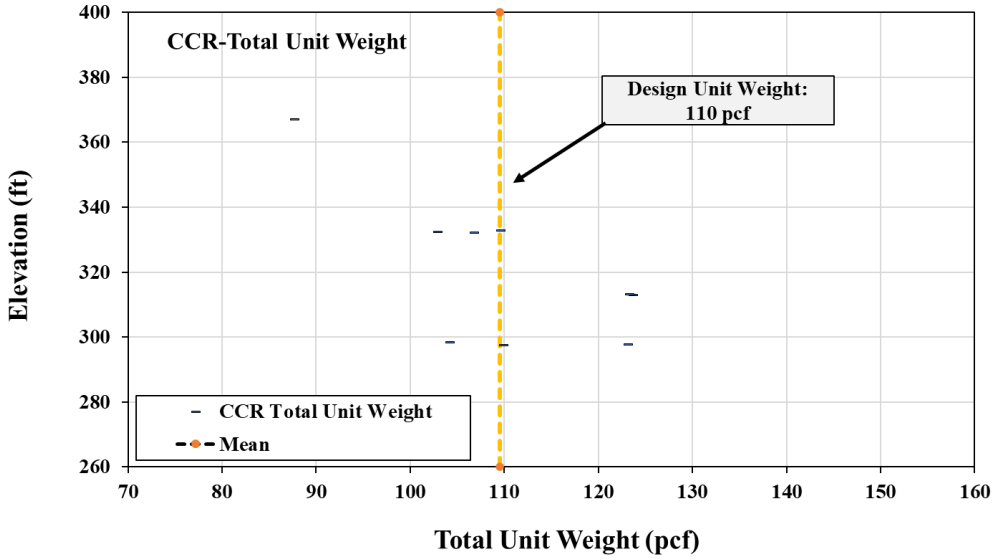


Figure 12. CCR Design Total Unit Weight

Design geotechnical parameters used for the analyses of this calculation package are summarized in **Table 1**.

Table 1. Design Geotechnical Parameters

Material	Total Unit Weight (γ_t, pcf)	Drained Shear Strength		Undrained Shear Strength	
		Friction Angle (ϕ', deg)	Cohesion (c', psf)	Peak	Post-EQ[4]
Embankment Fill[5]	131	30	300	2,500 psf	2,500 psf
Foundation Clay	127	29	150	Bi-linear envelope: Elevation >= 340 ft: 1200 psf Elevation < 340 ft: 1200psf + 58.75 psf/ft <= 3550 psf	80% of Peak
Foundation Sand[1]	130	0	35	Assumed drained under each evaluated loading condition	Drained
CCR[2]	110	34	0		$S_r/\sigma'_{vo} = 0.07$
Final Cover System[3]	110	27	0		Drained

[1]Foundation Sand strength parameters are based on the values estimated by AECOM [1].
[2]CCR properties are conservatively assumed to remain the same for both existing and compacted CCR. Note that the CCR unit weight is relatively high based on Geosyntec's experience, and therefore is expected to be applicable for CCR.
[3]Final cover system strength parameters are developed according to Geosyntec's experience.
[4]Assumptions and calculations for developing post-earthquake undrained shear strength parameters are described in Section 9 of this package.
[5]Embankment fill includes new soil containment berm.

5. CONSOLIDATION CHARACTERIZATION

The results of one-dimensional consolidation tests reported by AECOM [1] were used to estimate the compressibility parameters of Foundation Clay. The compressibility of the CCR and underlying Foundation Sand were not assessed because the post-construction settlement of the Foundation Clay was considered the primary layer that might affect the final cover system grades. In Geosyntec's experience, settlement in the CCR and the underlying Foundation Sand will occur nearly immediately when fill is being placed, while the Foundation Clay is expected to settle with time (i.e., experience consolidation).

The compression ratio ($C_{c\varepsilon}$), recompression ratio ($C_{r\varepsilon}$), and the coefficient of consolidation (c_v) for the Foundation Clay were estimated from each laboratory consolidation test. **Table 2** summarizes the laboratory results and average design parameters selected for the consolidation parameters of Foundation Clay.

Table 2. Summary of Consolidation Testing and Design Parameters of Foundation Clay

Summary of Consolidation Testing Data Results											
Boring ID	Sample Depth (ft)	Sample Elevation (ft)	Soil Unit	Initial Void Ratio (eo)	Re-Compression Index, C_r	Virgin Compression Index, C_c	Re-compression Ratio, $C_{r\varepsilon}$	Virgin Compression Ratio, $C_{c\varepsilon}$	Maximum Past-Pressure, P'_p (psf)	Coefficient of Consolidation , c_v (ft^2/min)	OCR
JOP-B007 - ST-2C	10.05	337.6	Foundation	0.52	0.006	0.125	0.004	0.082	23000	0.00027	17.86
JOP-B008 - ST-3C	39.8	340.6	Foundation	0.604	0.013	0.154	0.008	0.096	21800	0.00063	4.29
JOP-B010 - ST-1C	1.4	348.6	Foundation	0.606	0.014	0.136	0.009	0.085	11400	0.00038	64.19
JOP-B010 - ST-3C	34.8	315.2	Foundation	0.482	0.009	0.117	0.006	0.079	16200	0.00038	3.67
JOP-B014 - ST-3A	33.5	328.3	Foundation	0.498	0.001	0.129	0.001	0.086	11200	0.00072	4.75
JOP-B016 - ST-1B	4.25	347.9	Foundation	0.772	0.004	0.230	0.002	0.130	11800	0.00076	21.25
JOP-B017 - ST-2A	8.25	339	Foundation	0.585	0.010	0.138	0.006	0.087	3400	0.00011	3.35
JOP-B021 - ST-2B	14.1	329.9	Foundation	0.715	0.043	0.175	0.025	0.102	9200	0.00003	7.42
JOP-B022 - ST-2A	8.3	345.1	Foundation	0.59	0.003	0.111	0.002	0.070	20200	0.00088	19.1
		Mean		0.597	0.011	0.146	0.007	0.091	14244	0.00046	16.21
		Geometric Mean		**0.590**	**0.007**	**0.143**	**0.005**	**0.089**	**12552**	**0.00032**	**9.84**

Additionally, using the calculated over-consolidation ratio (OCR) shown in **Table 2**, an OCR profile was developed as shown **Figure 13**.

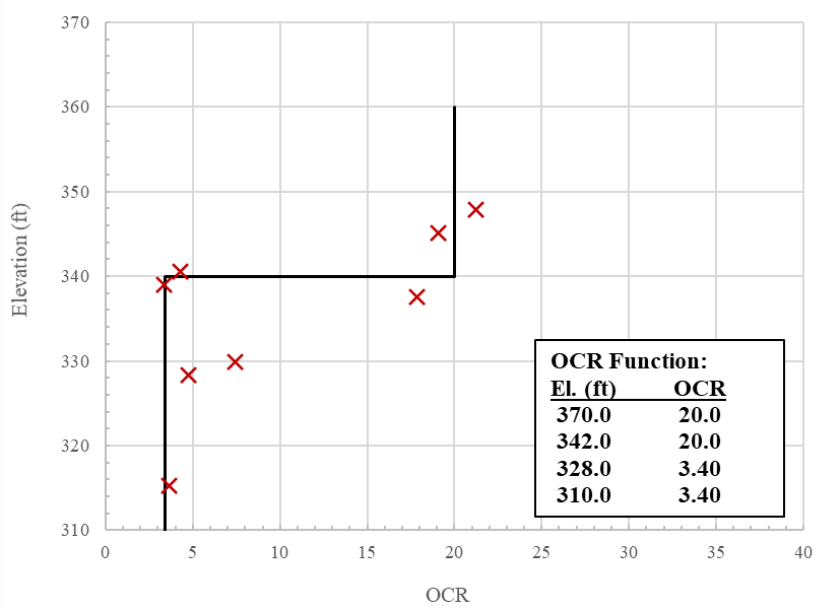


Figure 13. Over-Consolidation Ratio (OCR) Profile for Foundation Clay

6. GROUNDWATER CONDITIONS

Available groundwater elevations for piezometers XPW01, XPWO2, and XPW03, located within the EAP, and piezometers JOP-P014 through JOP-P023, located within and around the EAP, were used for delineation of phreatic conditions. Measurements were provided by EEI for dates ranging from July of 2015 through June of 2021. The data were plotted, as shown in **Figure 18**.

The data indicates that groundwater levels in the CCR retained within the EAP typically vary between El. 355 ft and El. 374.5 ft. To encompass the most critical scenario, the highest groundwater water levels recorded by the relevant piezometers during the monitoring period were chosen for slope stability analyses.

The water level within the embankment was then assumed to linearly decrease to the embankment toe, and then follow the ground surface beyond the embankment toe.

Actual water levels within the EAP are expected to decrease during closure due to dewatering activities and anticipated reduction in infiltration caused by installation of the final cover system. Therefore, the selected groundwater conditions are conservative.

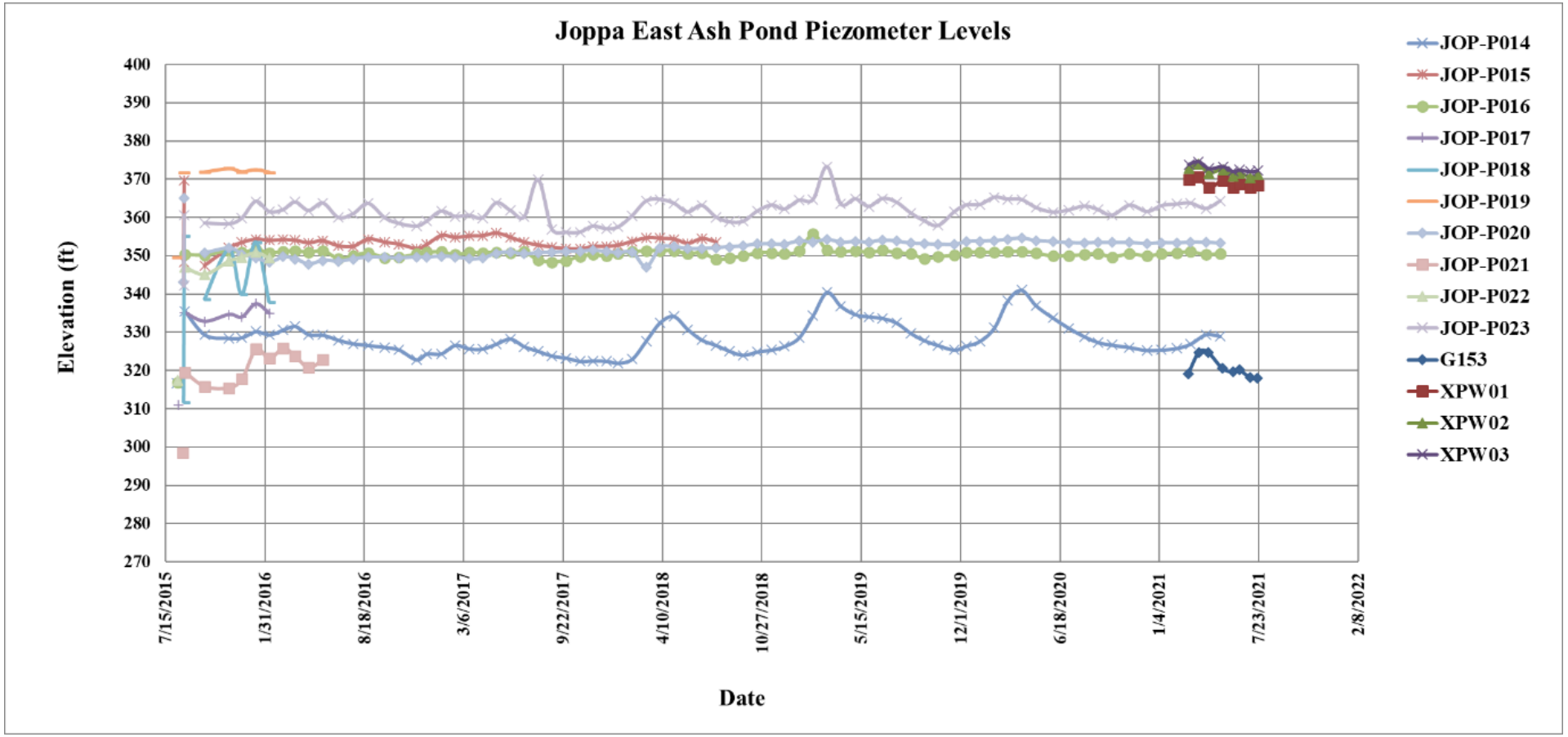


Figure 18. EAP Piezometer Data

7. SETTLEMENT ANALYSIS FOR POST-CLOSURE CONDITION

A three-dimensional (3-D) consolidation analysis using Settle3D [9] was conducted to evaluate the magnitude of post-closure settlement of the existing fine-grained Foundation Clay in EAP and its impact on the stormwater drainage system of the closed pond.

The post-closure surface of EAP was divided into Region A for the Southern zone and Region B for the Northern zone. To model the unlevel surface of the pond surface with a 3D geometry, a grid with 35 and 56 points, respectively, was defined for Region A and Region B. **Figure 14** and **Figure 15** show, respectively, the geometries and built grids of Region A and Region B in Settle3.

The primary consolidation of the Foundation Clay layer was considered the primary of the post-closure settlement of EAP considering the other materials at the site (CCR and Foundation Sand) are expected to settle nearly immediately as fill is placed to reach closure grades. The groundwater table was assumed to be at the top of the existing CCR at the site for consolidation analysis. The soil deposits below the Foundation Clay were considered to be incompressible and permeable, thereby allowing the drainage from the Foundation Clay into the Foundation Sand. The input consolidation parameters of Foundation Clay are summarized by **Table 2.** Two different loadings were applied on the surface of existing CCR including the weight of compacted CCR and the loading that represents the increase in effective stress due to dewatering of existing CCR. The CCR was assumed to be completely dewatered (e.g., the groundwater table in the CCR reduced from the surface of the CCR to the bottom of the CCR). For the sake of analysis simplification, these loadings were applied in the form of uniform vertical surcharges all over the final surface of EAP after closure, including the edges.

Attachment D summarizes all the input parameters and corresponding values for the 3-D settlement analyses presented in this package.

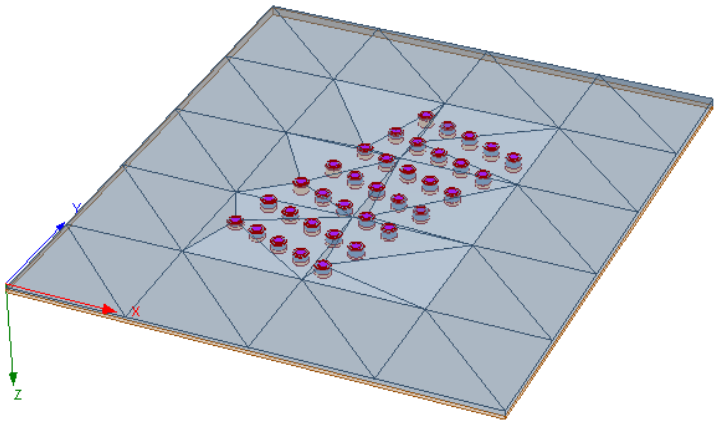


Figure 14 – Region A Settle3 Model Surface Geometry

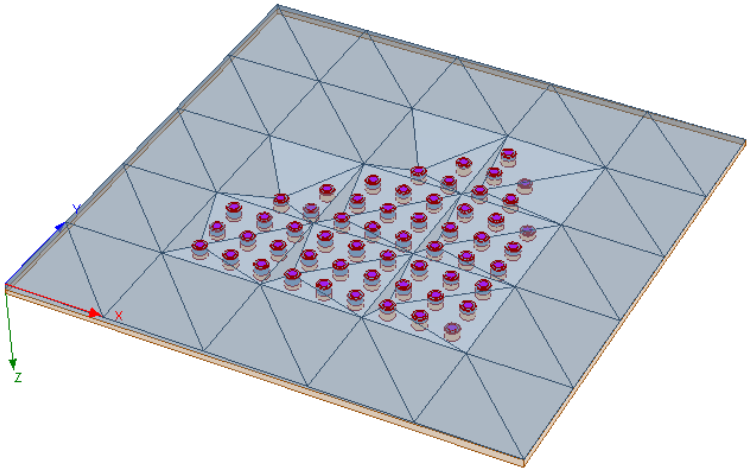


Figure 15 – Region B Settle3 Model Surface Geometry

Figure 16 and Figure 17 present the calculated settlements as heatmaps. The figures indicate that the maximum estimated settlement for the post-closure condition of EAP is approximately 2.9 inches and 3.5 inches for Region A and Region B, respectively. This level of settlement is not expected to cause issues related to post-closure stormwater drainage or other issues that may negatively affect the final cover system.

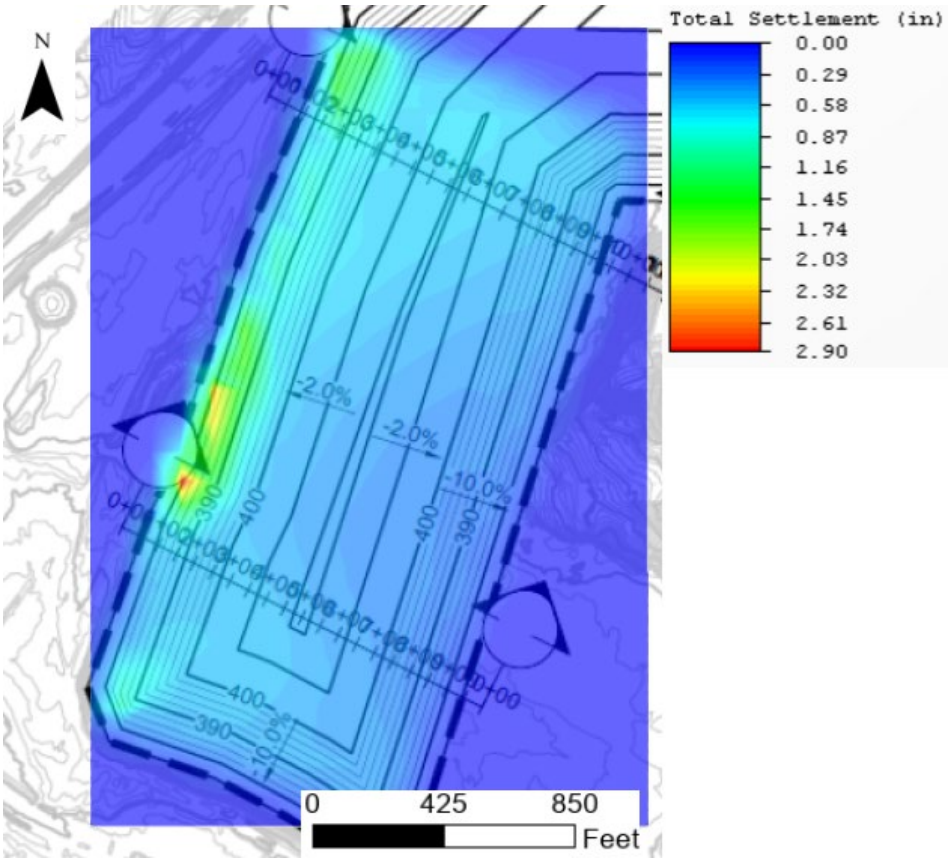


Figure 16 – Region A Calculated Surface Settlement Isopach Map

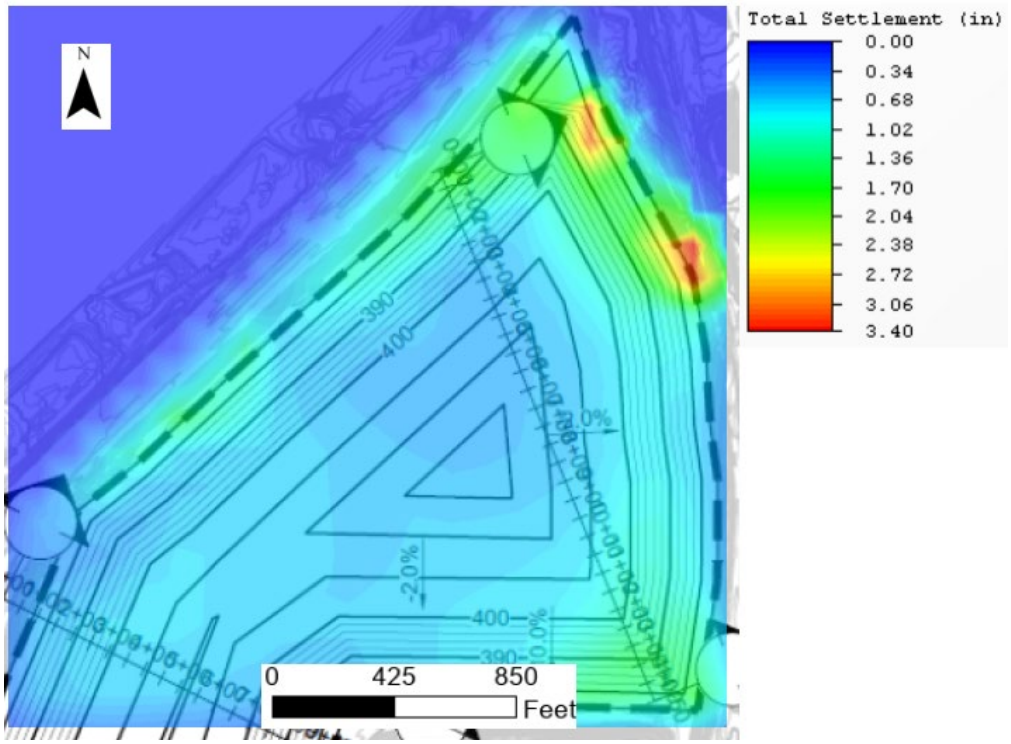


Figure 17 – Region B Calculated Surface Settlement Isopach Map

8. SEISMIC ASSESSMENTS

Site Seismic Hazard Assessment

AECOM evaluated seismic hazards at the site by performing a site-specific probabilistic seismic hazard assessment (PSHA) and one-dimensional dynamic response analysis [10] for the 2% probability of exceedance in 50-years earthquake event (e.g., 2,475-year return period) which is provided in **Attachment E**. AECOM also developed a unified hazard spectrum (UHS) for both the top-of-rock (based on the results of the PSHA) and top-of-ground (based on the results of the 1D dynamic response analysis using the PSHA as an input) for the site. The UHS for the top-of-rock and top-of-soil are shown in **Figure 19**.

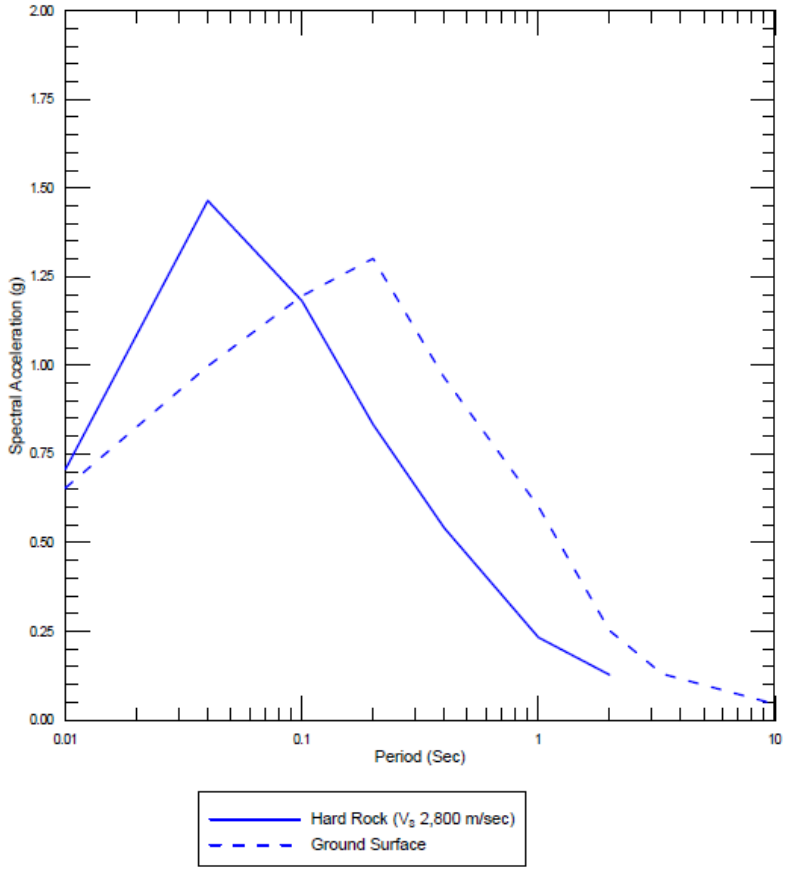


Figure 19. Horizontal Mean UHS on Hard Rock and Ground Surface, AECOM [10]

Liquefaction Triggering Analysis

AECOM's field exploration [1] generally did not encounter cohesionless soils in the embankment or foundation of the EAP, with the exception of encountered CCR and the deep dense to very dense Foundation Sand .AECOM interpreted that the Foundation Sand at the site were dilative and non-liquefiable based on their location deep below the overlying highly over-consolidated clays, and CPT tip resistance data.

Consequently, AECOM [1] found a formal liquefaction triggering analysis unnecessary for EAP, as the embankment and foundation soils at the site are not susceptible to liquefaction based on their composition and observed index properties. However, AECOM [1] suggested a post-liquefaction (residual) undrained shear strength for the CCR materials equal to 0.07 based on Idriss and Boulanger (2008) [11] which was also utilized by Geosyntec for the post-earthquake slope stability analyses.

Geosyntec also performed a supplemental liquefaction triggering analysis for EAP for post-closure conditions in this package to independently evaluate AECOM's conclusions.

Pseudostatic Seismic Analysis

Geosyntec selected the pseudostatic seismic coefficient for slope stability analysis using the Bray and Macedo [12] method, assuming a maximum tolerable deformation of 18 inches, and a 50% probability of exceedance. Individual pseudostatic seismic coefficients were estimated for each cross-section, described in **Section 10** of this package, including 0.108 g for cross-sections A and B, 0.124 g for cross-section C, and 0.110 g for cross-section D. Additional details regarding the calculation of pseudostatic coefficients are included in **Attachments E and G**.

9. LIQUEFACTION AND CYCLIC SOFTENING ASSESSMENT

Liquefaction and cyclic softening assessments were performed to evaluate the potential for seismically-induced strength losses in the impounded CCR, embankment, and foundation soils using the procedures developed by Idriss and Boulanger in 2008 [11], Boulanger and Idriss in 2014 [13], and Bray and Sancio in 2006 [14].

Data for Evaluation

The liquefaction assessment considered in-situ testing, laboratory tests, and instrumentation data from co-located geotechnical borings, CPTs, and piezometers advanced and installed within the EAP perimeter dikes and interior in 2015 by AECOM [1], as listed in **Table 3**. Co-located exploration locations were utilized as they provided a direct comparison between laboratory and in-situ testing data.

Table 3 – Summary of Liquefaction Assessment Data

CPT	Co-Located Boring	Co-Located Piezo.	Piezometer Depth (ft)	Piezometer Tip Material	CPT Ground Surface Elevation (ft)	CPT Upper GWT Depth at Advancement (ft)	CPT Upper GWT Depth at Earthquake (ft)
JOP-C008	JOP-B009	JOP-P009	50	Foundation Clay	379.41	19	21.4
JOP-SC010	JOP-B011	JOP-P011	49	Foundation Clay	380.2	9	17.8
JOP-SC012A	JOP-B013	None	N/A	N/A	379.3	23	23
JOP-C018	JOP-B019	JOP-P019	25	CCR	376.2	2	2
JOP-C021	JOP-B008	JOP-P008	35	Foundation Clay	380	27	4.1
JOP-C027	JOP-B023	JOP-P023	30	CCR	380.5	14	6.5

Liquefaction of Cohesive and Fine-Grained Soils

The liquefaction potential for cohesive and fine-grained soils, including Embankment Fill, Foundation Clay, and CCR, were evaluated using a screening-level assessment following Bray and Sancio [14], which evaluates the liquefaction susceptibility of fine-grained soil based on the plasticity index, water content, and liquid limit. Depending on the relationship between the plasticity index and ratio of water content to liquid limit, is the soil may be classified as "not susceptible", "moderately susceptible", or "susceptible" to liquefaction.

Laboratory Atterberg limits and water content tests performed on samples collected from co-located geotechnical borings listed in **Table 3** were used to assess the liquefaction susceptibility of the Foundation Clay. This included a total of 9 Embankment Fill samples, 21 samples of Foundation Clay, and 7 samples of CCR. It should be noted that the laboratory test results indicated the CCR to be non-plastic (i.e., plasticity index equal zero), and as such, the ratio of water content to liquid limit was capped at 1.4.

The results of the assessment are presented graphically in **Figure 20**. In summary:

- None of the nine data points for the Embankment Fill screened were susceptible for liquefaction. Therefore, it is concluded that the Embankment fill not susceptible to liquefaction.
- Only 1 of the 21 Foundation Clay data points appeared to be susceptible to liquefaction, and 1 was moderately susceptible to liquefaction. Therefore, it is concluded that the majority of the Foundation Clay is not susceptible to liquefaction, although small pockets of the material may be susceptible to liquefaction, they are unlikely to comprise a widespread and/or continuous zone.
- All of seven CCR samples CCR were susceptible to liquefaction, and therefore, it is concluded that the CCR may be susceptible to liquefaction. However, the Bray and Sancio approach was developed for natural soil units as opposed to man-made CCR. Additional study may be performed at a later phase of design to determine if the CCR is actually as susceptible to liquefaction in nature, as suggested by the Bray and Sancio approach.

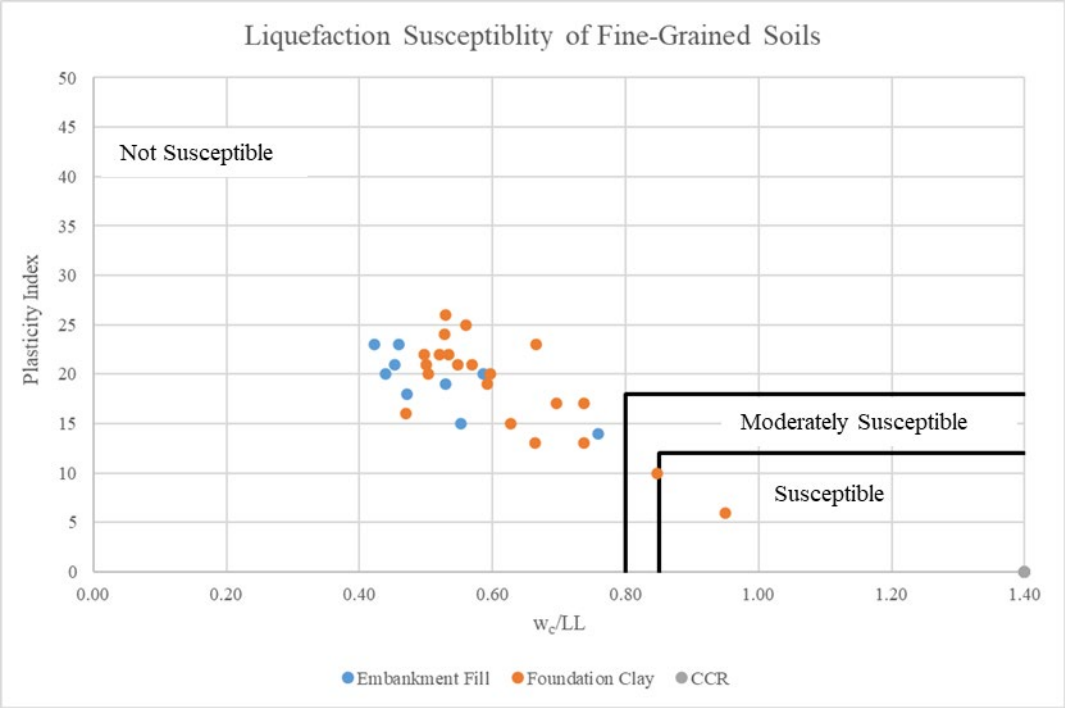


Figure 20 – Liquefaction Assessment of Fine-Grained Soils

Liquefaction Assessment of Cohesionless Soils

The liquefaction potential of cohesionless soils and coarse-grained, including the Foundation Sand and CCR, were evaluated using the CPT-based liquefaction triggering methods developed by Idriss and Boulanger in 2008 [11] and Boulanger and Idriss in 2014 [13] as implemented in a calculation spreadsheet.

The liquefaction assessment calculated a liquefaction triggering factor of safety for each CPT data point, expressed as the ratio of the soil's estimated cyclic resistance ratio (CRR) to the cyclic stress ratio (CSR) induced by the earthquake. A factor of safety of 1.1 was selected as the minimum allowable factor of safety above which liquefaction was not expected to occur (e.g., calculated factor of safety below 1.1 suggests that the soil unit is expected to liquefy).

Input data for the liquefaction assessment included the following:

- Tabulated tip resistance and side friction vs. depth were obtained from Excel data files for each CPT provided by ConeTec [1].
- Fines content data were obtained from available laboratory testing data from the co-located geotechnical borings.
- Seismic accelerations were taken from the probabilistic seismic hazard assessment (PSHA) performed by AECOM [10] for the 2% probability of exceedance in 50 years (e.g., 2,475-year return period) seismic event. This

included a peak ground acceleration of 0.66 g and a modal moment magnitude of 7.6.

- Two separate groundwater tables were assumed, based on a review of the CPT and piezometer data.
    - This included an upper groundwater table, which was applied to the Embankment Fill and CCR, and a lower groundwater table, which was applied to the Foundation Sand.
    - Groundwater tables for analysis were assigned separately for the time of CPT advancement, based on pore pressure measurements conducted during testing, and at the time of the earthquake, based on upper ranges from available piezometric data for the Site
    - Groundwater tables at the time of CPT advancement were obtained by reviewing the u_2 pore pressure readings and pore pressure dissipation test data from the CPT and selecting the highest of the two interpreted readings.
    - Groundwater tables at the time of the earthquake were obtained by reviewing available vibrating-wire piezometer data collected from 2015-2021 and selecting an approximate upper-third groundwater table elevation. If this was higher than the groundwater table at the time of advancement, it was utilized for the analysis. If it was not higher, the groundwater table at the time of advancement was also utilized for the groundwater table at the time of the earthquake.

The liquefaction assessment results are provided in **Attachment F**. In general, the assessment indicated the following:

- CCR is expected to be susceptible to liquefaction, where saturated, as most calculated factor of safety values were less than 0.5. Therefore, post-liquefaction residual shear strengths should be utilized for saturated CCR within post-earthquake slope stability analyses. However, the CPT liquefaction assessments were developed for natural soils, as opposed to man-made CCR. Additional study may be performed at a later phase of design to determine if the CCR is actually as susceptible to liquefaction as the CPT-based screening-level approach.
- The Foundation Sand is not expected to be susceptible to widespread liquefaction, as most liquefaction factor of safety values were 2 or higher. Therefore, peak drained shear strengths should be utilized for the Foundation Sand for post-earthquake slope stability analyses.
    - A review of the CPT and boring log data did indicate the presence of silty and clayey seams within the Foundation Sand. These seams are also indicated within the CPT liquefaction assessment as thin zones with a low liquefaction triggering factor of safety. As these materials are fine-grained, they may not be susceptible to liquefaction.

- However, it can be concluded that if liquefaction were to occur in these zones, they would comprise thin pockets rather than a laterally or vertically continuous layer.

Cyclic Softening Triggering Assessment for Cohesive Soils

The potential for cyclic softening of cohesive soils, including the Embankment Fill and Foundation Clay, were evaluated following the screening-level approach presented in Idriss and Boulanger (2008) [11]. The approach calculates a factor of safety against cyclic softening by estimating the CSR of the clay soil using the peak undrained shear strength and comparing it to the CRR induced by the earthquake. The same factor of safety of 1.1 for the liquefaction triggering factor of safety was used for cyclic softening. The peak undrained shear strength for both soil units was obtained from the design undrained shear strength profiles provided in **Section 4**, and the assessment was performed within the same spreadsheets as the liquefaction triggering assessment.

The cyclic softening assessment results are provided in **Attachment F**. In general, the assessment indicated the following:

- The Embankment Fill is not expected to be susceptible to cyclic softening, as all calculated factors of safety were above 1.1, with most above 2.0. Therefore, peak undrained shear strengths should be utilized for the Embankment Fill within post-earthquake slope stability analyses.
- The Foundation Clay is expected to be susceptible to cyclic softening, with calculated factors of safety typically on the order of 0.5 to 1.0. Therefore, a reduced undrained shear strength should be utilized for the Foundation clay within post-earthquake slope stability analyses. A 20% reduction from peak undrained shear strength is typically appropriate for this type of material, based on Geosyntec's experience. However, the cyclic-softening assessment is screening-level in nature. Most soils at the site have a high over-consolidation ratio (OCR), of 5 or higher, and may be strain-hardening in nature. Therefore, the screening-level assessment is expected to be conservative.

Residual Shear Strength for CCR

The residual shear strength ratio (S_r/σ'_{vo}) for the CCR was estimated using the relationship based on corrected CPT tip resistance ($q_{c1}N_{cs}$) presented in Figure 90 in Idriss and Boulanger (2008) [11]. The approximate lower-third tip resistance was estimated as 65, using both CPTs advanced through the CCR (JOP-C018 and JOP-C027), shown in **Figure 21.**

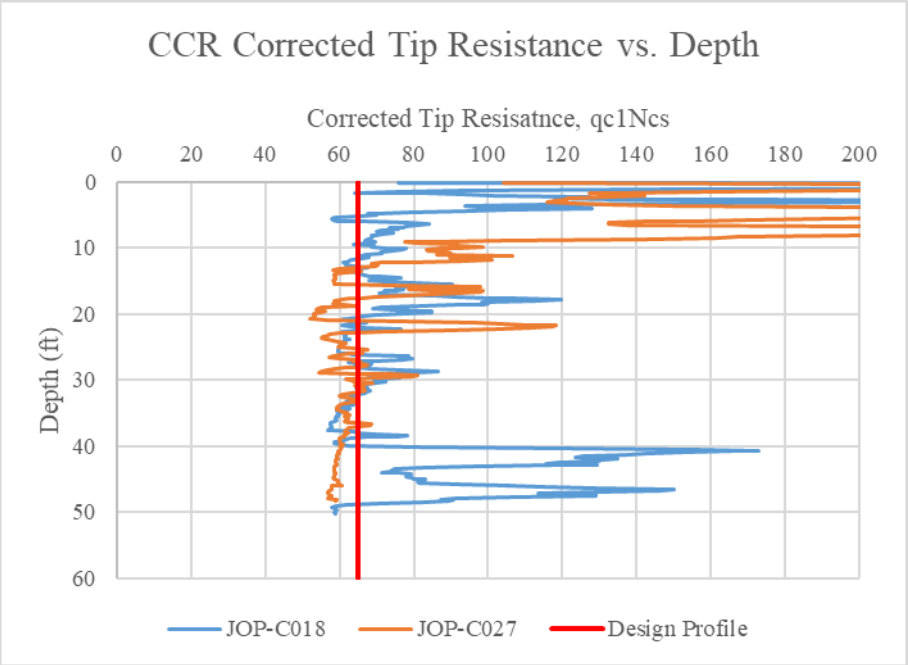


Figure 21 – Corrected CPT Tip Resistance for CCR

Using the correlation in Figure 90 of Idriss and Boulanger (Figure 22), this results in an approximate residual shear strength ratio of 0.07.

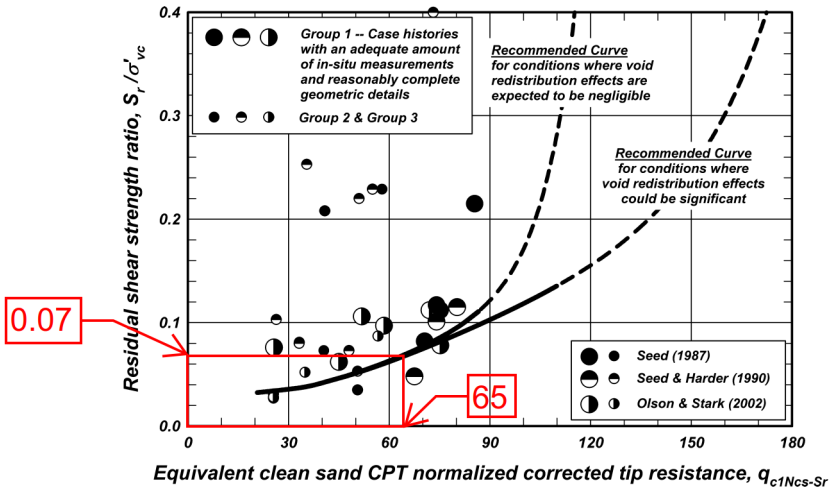


Figure 22 – Residual Shear Strength Ratio of CCR (Annotated from Idriss & Boulanger, 2008)

10. GLOBAL SLOPE STABILITY

Global slope stability analyses for the post-closure EAP were performed using limit-equilibrium SLOPE/W, a two-dimensional (2D) slope stability software developed by GeoStudio [15], to calculate the factor of safety (FoS) of the perimeter dikes of the EAP against global instability. Four critical cross-sections were selected to be analyzed by the Spencer's limit equilibrium method [16]. Evaluated circular slip surface defined using the entry-exit method, with each critical slip surface being optimized into a non-circular slip surface. Factors of safety were calculated for the following loading conditions:

End-of-Construction Static Conditions: This loading condition corresponds to the stability of the post-closure EAP dikes immediately after completion of closure construction. Peak undrained shear strength parameters are used for all cohesive soils, as construction induced excess pore pressures are assumed to not have dissipated. Peak drained shear strengths are used for all free-draining soils because pore pressures are assumed to dissipate concurrently with loading. The minimum acceptable FoS for this loading condition is 1.30, per the USEPA CCR Rule [2] and the Illinois Part 845 Rule [17].

Long-Term Static Conditions: This loading condition corresponds to the stability of the post-closure EAP dikes under long-term, normal operating conditions with conservatively estimated static groundwater levels that are similar to currently levels (e.g., no post-closure groundwater drawdown is assumed). Drained shear strength, representing effective stress conditions, are used for all materials, as this condition corresponds to static conditions without application of loads inducing pore-pressure. The minimum acceptable FoS for this loading condition is 1.50, per the USEPA CCR Rule [2] and the Illinois Part 845 Rule [17].

Pseudostatic Seismic Conditions: This loading condition corresponds to the stability of the EAP dikes under short-term seismic shaking conditions. This loading condition assumed peak drained shear strengths in all free-draining materials (CCR and Foundation Sand) and peak undrained shear strengths in the embankment fill. The seismic loads are modeled as an outward-acting horizontal force, as discussed above. The minimum acceptable FoS for this loading condition is 1.00, per the USEPA CCR Rule [2] and the Illinois Part 845 Rule [17].

Post-Earthquake Conditions: This loading condition corresponds to the stability of the EAP dikes and final cover surface immediately following a seismic event. This loading condition assumed peak drained strengths in all non-liquified free-draining materials (unsaturated CCR and Foundation Sand), residual liquefied shear strengths in saturated CCR and cyclic-softened Foundation Clay based on the results of the liquefaction and cyclic softening triggering analyses, and peak

undrained strengths in the embankment fill, with saturated CCR conservatively assumed to be present below current groundwater conditions (e.g., no post-closure groundwater drawdown is assumed). It should be noted that this loading condition is not expressly required by the USEPA CCR Rule [2] and the Illinois Part 845 Rule [17], as liquefaction-susceptible materials are not present within the dikes or foundations of the EAP. However, this condition was checked to evaluate the mass stability of the EAP dikes and final cover system, as a conservative evaluation of the consequence for potential liquefaction within the retained CCR. A minimum acceptable FoS of 1.20 was assumed. This is equal to the USEPA CCR Rule [2] and the Illinois Part 845 Rule [17] loading condition where liquefaction-susceptible materials are present within the dike of a CCR surface impoundment.

It should be noted that flood loading conditions (e.g., maximum storage pool [2], [17]) are not evaluated because closure of the EAP will prevent water retention in the EAP. Therefore, this loading condition will not be applicable under post-closure conditions.

All slope stability analyses include proposed post-closure grades within the EAP, and the estimated long-term groundwater levels as discussed earlier in the report.

Subsurface material interfaces at each cross-section were developed using the "Bottom of CCR" and "Bottom of Clay" three-dimensional surfaces developed by EVS software using available boring data, as developed by Geosyntec for the EAP and provided within the "CCR Investigation and Delineation Report" prepared for the East Ash Pond [18].

Selected Cross-sections

Four cross-sections (A, B, C, and D) were selected based on critical surface geometry and subsurface conditions (**Figure 23**). The specific items considered for selecting each of the cross-sections are listed below.

Cross-Section A:

This section includes the tallest height of the proposed new soil containment berm, at approximately 61 ft. The dike slope is 3H:1V and retains a 24 ft high consolidated CCR. The Foundation Clay at this section is approximately 27 ft thick.

Cross-Section B:

This section includes the second-tallest height of the proposed new soil containment berm of approximately 48 ft. The dike slope is 3H:1V, and will retain a 26 ft height of consolidated CCR. The Foundation Clay at this location has the maximum thickness along the proposed new soil containment berm, reaching a thickness of 36 ft.

Cross-Section C:

This section includes the tallest height of the existing perimeter dike of approximately 29 ft. The dike slope is approximately 2H:1V, and will retain 26 ft high consolidated CCR. This section captures the thickest Foundation Clay along the existing perimeter dike, with a thickness of 43 ft.

Cross-section D:

This section includes the tallest height of the existing perimeter dike, along the west side of the EAP, of approximately 21 ft. The dike slope is equal to approximately 2H:1V and at present retains a 24 ft high consolidated CCR.

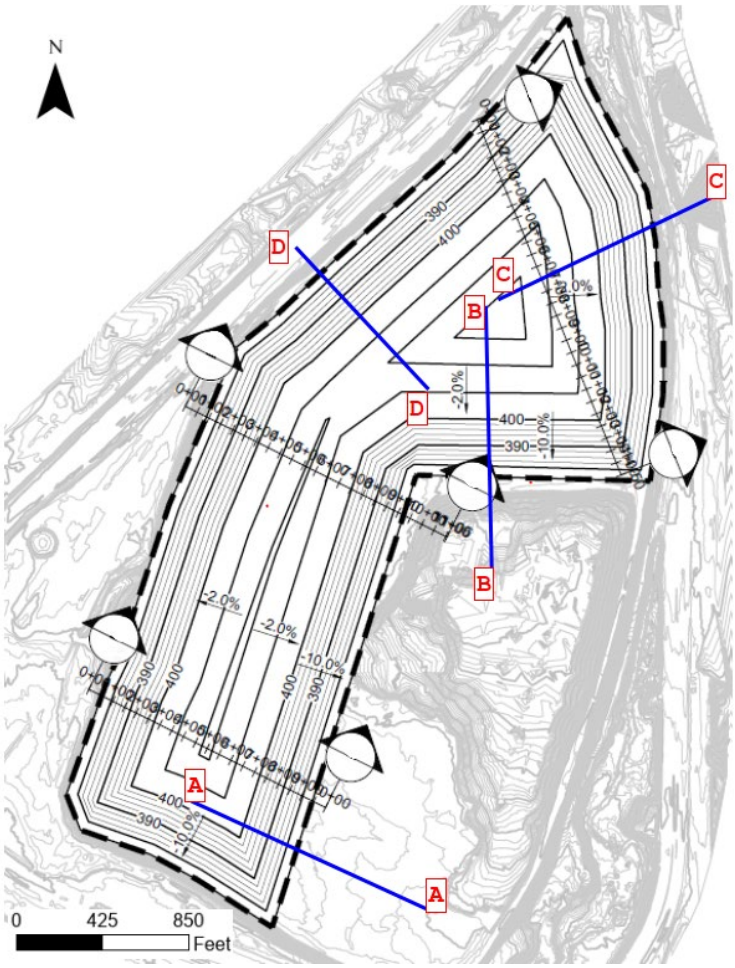


Figure 23. Post-closure Condition Cross-section Locations for Slope Stability Analysis

Results

The results of each of the design scenarios is presented in **Table 4**. Each calculated factor of safety exceeds minimum acceptable values. Graphical output from the slope stability analyses is provided in **Attachment G** for each of the design scenarios and Sections.

Table 4. Results of Stability Analyses

Loading Condition	Required Minimum Factor of Safety	Results				Pass/ Fail
		A	B	C	D	
End-of-Construction	1.30	2.18	2.57	2.54	2.98	PASS
Long-Term Static	1.50	1.66	1.80	2.03	2.00	PASS
Pseudostatic Seismic	1.00	1.55	1.54	1.31	1.61	PASS
Post-Earthquake	1.20	1.48	1.70	1.59	1.58	PASS

11. VENEER COVER STABILITY

Veneer stability refers to the shallow, translational stability of the cover system and each material interface within the cover system. The cover system will include, from bottom to top, a CCR subgrade, a low permeability geomembrane layer, a geotextile cushion, 1.5 ft of final protective layer, and 0.5 ft of topsoil capable of sustaining vegetation. Veneer stability calculations were performed to evaluate the factor of safety against sliding between each of the material interfaces within the final cover system.

Veneer stability for static loading conditions was evaluated following published methodology [19]. Two final cover system slopes were evaluated at the site and represent critical veneer stability sections, based on the maximum height of 2.0% slope (Slope A) and maximum height of 10% slope (Slope B). The evaluated slopes are listed in **Table 5** and shown in plan in **Figure 24**.

Table 5 – Slopes Evaluated for Veneer Stability

Slope	Grade	Height (ft)	Length (ft)	Crest Elevation (ft)
Slope A	2% (50H:1V)	7.6	380	407
Slope B	10% (10H:1V)	20	200	400

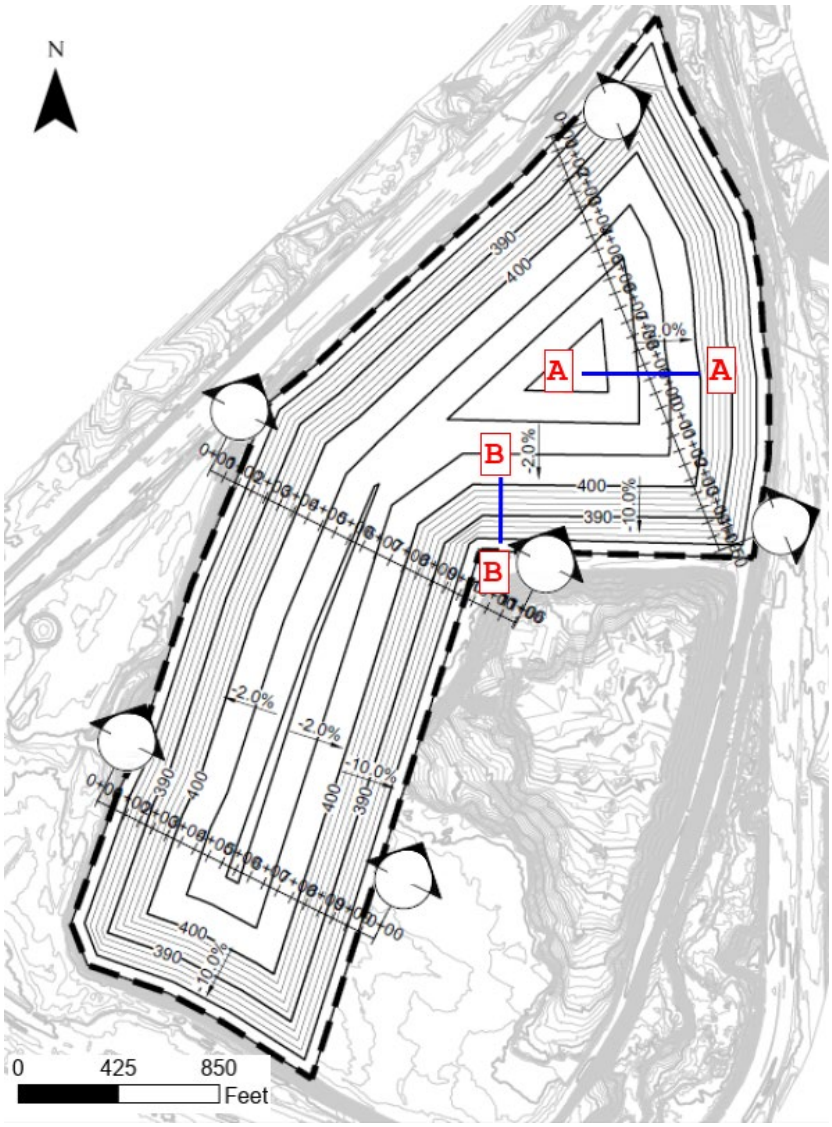


Figure 24 – Veneer Stability Slope Locations

Interface friction angles and adhesion values were taken from results of site-specific laboratory interface friction testing data (ASTM D5321) performed by Geosyntec's laboratory testing subcontractors for the closure of the Old West Ash Pond (OWAP) at the Hennepin Power Plant in Hennepin, Illinois. The layered veneer materials tested by Geosyntec included clay cover soil in contact with a 16-ounce nonwoven geotextile, the 16-ounce nonwoven geotextile in contact with a 40-mil textured liner low density polyethylene (LLDPE) geomembrane, and the 40-mil textured LLDPE geomembrane in contact with the CCR subgrade soils and granular soil [20]. Similar materials will be used for the final cover system at the JOP EAP; therefore, it is appropriate to use this data to assess the veneer stability. Actual testing using site-specific materials will be performed

as part of final design and/or construction. The available interface friction data is summarized in **Table 6** and laboratory testing sheets are provided in **Attachment H**.

Table 6 – Interface Friction Data

Material (Top to Bottom)	Peak		Large Displacement	
	Friction Angle (degrees)	Interface Adhesion (psf)	Friction Angle (degrees)	Interface Adhesion (psf)
Clay Cover Soil	27.8	81	17.1	0
Skaps Nonwoven Geotextile GE116				
Skaps 40 mil LLDPE Textured Geomembrane				
CCR				
Design Parameters for EAP	**27.8**	**81**	**17.1**	**0**

Analyses were performed for the lower interfaces, including a single analysis considering sliding along the subgrade against geomembrane liner, geomembrane liner against geotextile, and geotextile against cover soil, as the effective stresses would be the same for all three interfaces. Each analyzed loading condition is described below:

Normal Static Conditions: This analysis considers the stability of the cover system under normal, static, steady-state operating conditions. The cover system soil is assumed to be unsaturated, and 0.25 inches of water is present within the geotextile, which corresponds to a full thickness of water within a geotextile. The minimum acceptable FoS for this condition is 1.5, as recommended by Koerner and Soong [21]. Peak interface shear strength data was used for this condition.

Saturated Conditions: This analysis considers the stability of the cover system under static, saturated operating conditions that could potentially occur after a rainfall event that results in the entire cover system becoming fully saturated with two feet of water present (full cover soil thickness). Because this is a temporary condition and is expected to only occur after a significant rainfall event, a minimum acceptable FoS for this condition of 1.2 was selected for design. No regulatory guidance is available in Part 845 or the CCR Rule for this loading condition. Peak interface shear strength data was used for this condition.

Seismic Conditions: Veneer stability for seismic conditions was calculated following Matasovic (1991) [22], for the same slope orientations as the static veneer analyses. Saturated conditions were not considered for the seismic analyses as the likelihood of a significant rainfall event occurring at the same time as a seismic event is low. A pseudostatic seismic coefficient of 0.43 g was selected

for analysis, which is 65% of the site-class amplified peak ground acceleration of 0.66 g, as recommended by Matasovic [22]. The minimum acceptable factor of safety for this condition is 1.0, also as recommended by Matasovic. Peak interface shear strength data was used for this condition.

Post-Earthquake Conditions: This analysis considers the stability of the final cover condition under conditions immediately after a seismic event, when seismic shaking has stopped. Saturated conditions were not considered for the seismic analyses as the likelihood of a significant rainfall event occurring at the same time as a seismic event is low. The minimum factor of safety for this condition was assumed to be 1.2, which corresponds to the USEPA CCR Rule [2] and Illinois Part 845 [17] regulatory guidance for global dike stability. The residual, large-displacement friction angle was used for this condition, to account for reduced post-peak shear strengths that may be induced by seismic shaking.

Resulting veneer stability factors of safety are provided in **Table 7.** Each calculated factor of safety exceeds the minimum acceptable values. Calculation output data is provided in **Attachment I**.

Table 7 – Veneer Stability Analysis Results

Loading Condition	Required Minimum Factor of Safety	Results		Pass/ Fail
		Slope A	Slope B	
Normal	1.5	38.4	7.3	PASS
Saturated	1.2	23.6	4.5	PASS
Seismic	1.0	1.6	1.3	PASS
Post-Earthquake	1.2	18.7	3.3	PASS

12. CONCLUSIONS

The calculations presented in this report demonstrate that the proposed closure plan for the East Ash Pond at the Joppa Power Plant provides sufficient geotechnical dike stability, exceeding minimum acceptable factors of safety for end-of-construction, long-term static, seismic, and post-earthquake loading conditions. Additionally, the cover system veneer stability exceeds the minimum acceptable factors of safety for static, saturated, seismic, and post-earthquake conditions. This calculation package will be updated at a later date to include liquefaction triggering and settlement analyses.

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Geosyntec
consultants

ATTACHMENT A

2016 AECOM Geotechnical Report

AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110-1337
www.aecom.com

314.429.0100 tel
314.429.0462 fax

October 2016

Mr. Matt Ballance, PE
Senior Project Engineer
Dynegy Inc.
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

RE: Geotechnical Report
Joppa Power Station
East Ash Pond

Dear Mr. Ballance:

AECOM is pleased to provide this Geotechnical Report for the Electric Energy, Inc. (EEI) East Ash Pond Coal Combustion Residuals (CCR) unit at the Joppa Power Station located in Joppa, Illinois. This Geotechnical Report has been prepared to document the analyses we performed to check the geotechnical stability requirements including Factors of Safety required by 40 CFR § 257.73.

AECOM looks forward to providing continued support to Electric Energy, Inc. (EEI) and working together on this important program. Please do not hesitate to call Vic Modeer at 314-429-0100 (office) if you have any questions or comments on this Geotechnical Report.

Sincerely,

AECOM

Victor A. Modeer, PE, D.GE
Senior Project Manager
victor.modeer@aecom.com

Ron Hager
Program Manager
ronald.hager@aecom.com

cc: Mark Rokoff, PE – AECOM

Attachments:
A. Figures
B. Boring Logs
C. Piezometer Calibration Sheets
D. CPT Data Report
E. Laboratory Test Data
F. Material Characterization Calculations
G. Slope Stability Analysis
H. Probabilistic Seismic Hazard Analysis Report

1. INTRODUCTION

1.1. ***Purpose of this Report***

This report presents the results of the geotechnical analysis prepared by AECOM for the Electric Energy, Inc. (EEI)[1] Coal Combustion Residuals (CCR) unit East Ash Pond (EAP) at the Joppa Power Station located in Joppa, Illinois (See **Attachment A**, **Figure A-1** for location map). The Joppa East Ash Pond is comprised of the north sub-basin and south sub-basin. The purpose of the geotechnical investigation and analyses performed is to evaluate the design, performance, and condition of each of the impoundments and associated structures using the data collected from surface and subsurface investigations, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents provided to AECOM by EEI. This information was then used to evaluate the design and operation of the surface impoundment against the regulatory standards set in 40 CFR §257.73 and current engineering practice.

The geotechnical field evaluation was conducted between August 10, 2015 and August 22, 2015. The field program consisted of conventional hollow stem auger (HSA) borings, Standard Penetration Testing (SPT), Cone Penetration testing (CPTu), and piezometer installation. Laboratory testing was conducted on the materials obtained through various sampling techniques to assist in characterization of the subsurface conditions, especially with respect to defining material parameters for use in stability analyses.

During the 2015 geotechnical exploration, a zone of fly ash that existed before the construction of the East Ash Pond dike was identified under the southeast embankment of the Joppa East Ash Pond. Therefore, a supplementary geotechnical investigation was conducted from March 15, 2016 to March 23, 2016. The supplementary geotechnical investigation provided more detail of the lithology and ash zones within the embankment. The field program consisted of SPT, thin walled tube samples, direct push testing, and hand augers.

Stability analyses were performed by AECOM, in accordance with the Environmental Protection Agency (EPA) regulation 40 CFR §257.73(d) and (e).

A summary of the geotechnical field program, laboratory testing program and stability evaluations are presented herein. Detailed interpretation, calculations, and presentation of analysis results are provided in the Attachments to this report.

1.2. ***Description of Impoundments***

The East Ash Pond (EAP) is an approximate 111-acre active CCR Unit located north-northeast of the plant. Currently, the EAP is used to store and dispose bottom ash and fly ash, and clarify water prior to discharge. The EAP is an enclosed embankment with dikes, which has a total perimeter length of approximately 8,950 feet. The embankment fill materials generally consist of clay and sandy clay, with isolated soft clay layers. The north sub-basin (along with all outlet structures, piping, and other impoundment features) was built in 1973. The south sub-basin (along with all outlet structures, piping, and other impoundment features) was built between 1977 and 1985, with a

[1] Although the Joppa Power Station and East Ash Pond are owned by EEI, Dynegy Administrative Services Company (*Dynegy*) contracted AECOM to develop this Geotechnical Report on behalf of EEI. Therefore, "Dynegy" is referenced in materials attached to this geotechnical report.

new outlet structure installed in 1992. Between July 2016 and September 2016, Hayward Baker Inc. performed ground improvement along the southeastern portion of the south sub-basin using the Deep Mixing Method (DMM) by the wet soil cement mixed method from STA 83+00 to 1+50. See **Attachment A Figure A-9**.

The north sub-basin has mostly been filled and is still used to hold dry CCR materials. The south sub-basin operates with one pond holding approximately 430 acre-feet, and other smaller ponds. The exterior slopes are graded at a slope of approximately 1.5H:1V and predominately covered in armor rock. The interior slopes are unlined, graded at a slope of approximately 1.5H:1V, and covered in armor rock, ash or embankment fill. The site location and vicinity are shown in **Figure A-1** of **Attachment A**.

2. SUMMARY OF FIELD INVESTIGATIONS

A subsurface exploration was performed at the EAP from August 10, 2015 to August 22, 2015. The subsurface exploration included seven soil borings, six vibrating wire piezometers and sixteen CPTs in the north sub-basin; and sixteen soil borings, sixteen vibrating wire piezometers and twenty-one CPTs in the south sub-basin. Selected CPT soundings included pore pressure dissipation testing and seismic shear wave measurements. A supplementary geotechnical investigation was completed from March 15, 2016 to March 23, 2016 to identify more detail of the lithology and ash zones within the embankment. The supplementary investigation included seven borings and thirteen direct push testing in the southeast corner of the EAP. The locations of the various explorations are shown on **Figures A-2**, **A-5** and **A-6** in **Attachment A**.

The 2015 borings were drilled by AECOM's subcontractor Geotechnology, Inc. of St. Louis, Missouri and the 2016 geotechnical explorations by Stantec, Inc. of St. Louis, MO, under the full-time supervision of AECOM geotechnical personnel. AECOM personnel also visually classified and logged the soil formations encountered during the investigation in general accordance with ASTM D 2487. Geotechnology, Inc. used a CME-75 truck-mounted and a CME 850 track-mounted drill rigs, in conjunction with 4-3/4 and 4-1/4 inch inner diameter hollow stem augers and tricone bit method to drill the borings. Stantec used a CME-85 truck-mounted drill rig in conjunction with 3-7/8 inch inner diameter hollow stem augers method to drill the borings and a Geo Probe 5400 with 2-1/8 inch inner diameter for the direct push testing. The geotechnical explorations were advanced through the underlying soil strata to depths ranging from 8 to 120 feet below existing ground surface (ft. bgs), depending on the location of each boring. It was estimated that bedrock is in excess of 120 feet below the ground surface, based on AECOM's experience in the area; therefore, borings were terminated in the overlying soil overburden and were not extended to rock. Representative soil samples were collected from each of the borings for classification and/or testing. The soil samples were obtained by SPT with a split-spoon sampler, in accordance with ASTM D 1586. Undisturbed samples of fly ash and/or fine-grained soils were obtained using 3-inch outside diameter steel (Shelby) tubes, either conventionally pushed in accordance with ASTM D 1587 or by utilizing a piston sampler in accordance with ASTM D 6519 (in ash and very soft soils). Pocket Penetrometer and torvane tests were performed on fine-grained soils to correlate the unconfined compression and shear strength of the soil. Where encountered, the presence of phreatic water was noted within the soil samples collected from the borings and water levels in the open boreholes were measured prior to backfilling. The boring logs were also used for comparison and visual confirmation of the CPT data. A complete set of boring logs, including soil descriptions, types of sampling, and selected laboratory test results, is provided in **Attachment B**.

The CPT soundings were performed by AECOM's subcontractor ConeTec, Inc., again with full-time oversight by AECOM personnel. CPT sounding depths varied approximately from 4 to 104 feet bgs

and were performed in accordance with ASTM D 5778. All CPT soundings were advanced to the planned depth or to refusal, whichever occurred first. In-situ measurements such as tip resistance, sleeve resistance, and dynamic pore pressure were continuously recorded as the cone was advanced into the ground. Seismic shear wave measurements (SCPTu) were typically taken at 1 to 2 meter (3.3 to 6.6 feet) intervals and pore pressure dissipation tests (PPD) were generally taken at 5 to 20 feet intervals once the tip advanced below the phreatic water level. Graphical CPT logs and the results of the SCPTu and PPD tests performed by ConeTec are included in **Attachment D**. **Table 1** presents the geotechnical explorations.

Table 1: Geotechnical Explorations

ID	Northing (ft)	Easting (ft)	Surface Elevation (ft)	Depth (ft)	Piezometer ID	Depth (ft)
JOP-B001	198339.4	833368.3	333.6	50.0	JOP-P001	49.0
JOP-B002	198526.7	833473.7	341.5	65.0	JOP-P002	50.0
JOP-B003	198562.4	833364.5	379.8	110.0	JOP-P003	80.0
JOP-B004	198426.3	833270.9	379.0	120.0	JOP-P004	60.0
JOP-B005	199345.5	833690.4	379.9	100.0	JOP-P005	50.0
JOP-B006	198964.5	833617	357.1	40.0	JOP-P006	38.0
JOP-B007	199326.6	833760.8	347.6	50.0	JOP-P007	48.0
JOP-B008	198838.5	832101.2	380.4	80.0	JOP-P008	35.0
JOP-B009	200368.5	833926.1	378.8	80.0	JOP-P009	50.0
JOP-B010	201791.2	833794.1	350.0	50.0	JOP-P010	45.0
JOP-B011	201732.5	833659.5	380.0	80.0	JOP-P011	49.0
JOP-B012	201111.0	832753.5	379.6	80.0	JOP-P012	50.0
JOP-B013	200176.2	832128.5	379.3	80.0	-	-
JOP-B014	200225.8	832001.4	361.8	50.0	JOP-P014	45.0
JOP-B015	199187.8	831795.1	380.3	80.0	JOP-P015	30.0
JOP-B016	198570.8	832362.0	352.1	40.0	JOP-P016	35.0
JOP-B017	198369.4	832674.8	347.2	40.0	JOP-P017	38.0
JOP-B018	198450.7	832716.5	378.6	80.0	JOP-P018	65.0
JOP-B019	199211.3	832989.8	376.1	100.0	JOP-P019	25.0
JOP-B020	198337.4	832996.0	378.1	100.0	JOP-P020	35.0
JOP-B021	198247.4	832969.4	344.0	50.0	JOP-P021	48.0
JOP-B022	199227.6	831636.1	353.4	40.0	JOP-P022	35.0
JOP-B023	198526.7	833473.7	341.5	100.0	JOP-P023	30.0
JOP-B023B	200678.4	833168.4	380.4	25.0		
JOP-C001	198341.1	833369.3	333.7	50.0	-	-
JOP-C003	198758.0	833600.0	349.0	40.0	-	-
JOP-C004	198989.8	833562.6	380.6	85.0	-	-
JOP-C005	199130.6	833688.6	344.0	39.9	-	-
JOP-C006	199332.8	833762.9	347.4	59.9	-	-
JOP-C007	199349.0	833691.9	380.1	97.8	-	-
JOP-C008	200353.2	833923.2	379.1	81.2	-	-
JOP-C009	200305.9	834016.3	355.5	50.0	-	-
JOP-C011	201137.3	832677.1	358.0	53.0	-	-

ID	Northing (ft)	Easting (ft)	Surface Elevation (ft)	Depth (ft)	Piezometer ID	Depth (ft)
JOP-C013	199204.9	831720.2	354.0	50.9	-	-
JOP-C014	198268.5	832960.5	346.1	40.0	-	-
JOP-C015	198227.9	833197.9	339.6	40.0	-	-
JOP-C016	198333.7	832998.5	378.3	85.5	-	-
JOP-C017	198703.0	832722.1	377.6	50.2	-	-
JOP-C018	199199.8	832990.7	376.2	88.3	-	-
JOP-C019	198655.5	832387.7	380.0	80.2	-	-
JOP-C020	198992.1	832279.5	378.8	50.2	-	-
JOP-C021	198847.0	832092.2	380.0	73.8	-	-
JOP-C022	199692.4	831988.8	379.5	72.3	-	-
JOP-C023	200272.2	832713.0	380.6	50.2	-	-
JOP-C024	200642.3	832399.8	373.8	4.4	-	-
JOP-C024A	200642.3	832399.8	373.8	4.3	-	-
JOP-C024B	200642.3	832399.8	373.8	80.4	-	-
JOP-C025	199758.8	833810.6	380.3	82.7	-	-
JOP-C026	200417.8	833516.3	373.4	50.0	-	-
JOP-C027	200675.5	833173.1	380.5	85.3	-	-
JOP-C028	200844.1	832909.1	373.4	50.2	-	-
JOP-C029	201214.5	833211.5	373.0	50.2	-	-
JOP-C030	200989.8	833638.7	371.7	50.2	-	-
JOP-C031	200786.5	833960.8	378.7	77.9	-	-
JOP-C032	201370.3	833857.1	381.2	90.7	-	-
JOP-C033	201531.9	833197.9	379.4	85.0	-	-
JOP-C034	201978.0	833588.0	380.3	83.5	-	-
JOP-C035	198555.7	833362.8	380.0	98.4	-	-
JOP-C036	198542.0	833461.7	342.6	50.0	-	-
JOP-C036	198542.0	833461.7	342.6	50.0	-	-
JOP-C037	199239.6	831631.9	353.4	40.0	-	-
JOP-C037	199239.6	831631.9	353.4	40.0	-	-
JOP-SC002	198422.9	833265.8	378.9	104.8	-	-
JOP-SC010	201728.0	833663.5	380.2	83.8	-	-
JOP-SC012	200168.8	832127.0	379.3	16.4	-	-
JOP-SC012A	200168.8	832127.0	379.3	55.0	-	-
JOP-B024	198500.2	833339.0	378.0	97.0	-	-
JOP-B025	198554.0	832550.9	378.0	89.5	-	-
JOP-B026	198397.6	832858.2	377.6	82.0	-	-
JOP-B027	198284.6	832878.2	343.5	54.5	-	-
JOP-B028	198333.0	833152.3	378.0	87.0	-	-
JOP-B029	198272.9	833287.4	333.9	47.0	-	-
JOP-B030	198426.6	833218.3	381.0	87.0	-	-
JOP-D004	198380.4	833394.3	334.0	24.0	-	-

ID	Northing (ft)	Easting (ft)	Surface Elevation (ft)	Depth (ft)	Piezometer ID	Depth (ft)
JOP-D006	198380.9	832653.7	346.4	50.7	-	-
JOP-D007	198261.0	832611.1	348.0	16.0	-	-
JOP-D008	198327.8	832775.7	345.9	54.7	-	-
JOP-D009	198230.3	833085.6	341.6	31.1	-	-
JOP-D010	198130.4	833180.0	348.0	31.2	-	-
JOP-D012	198422.2	833411.4	337.5	8.0	-	-
JOP-D013	198400.8	833404.0	335.9	12.0	-	-
JOP-D014	198411.3	833407.5	336.0	8.0	-	-
JOP-D015	198391.0	833399.3	335.3	24.0	-	-
JOP-D016	198359.395	833380.459	333.4	24.0	-	-
JOP-D020	198375.0	832665.0	346.5	16.0	-	-
JOP-D021	198178.0	832939.4	348.0	31.1	-	-

Note: Easting and Northing datum is NAD83. Surface elevation datum is NAVD88 (Weaver Consultants Group, Dec 2015).

3. SUMMARY OF SITE-SPECIFIC SUBSURFACE CONDITIONS

In general, the exploration encountered the following subsurface profile materials across the East Ash Pond (from highest to lowest elevation): Bottom Ash and Fly Ash, Embankment Clay Fill, an infrequently encountered thin soft clay layer, a zone of fly ash that existed before the construction of the East Ash Pond dike encountered at the southeast section of the impoundment, and Pleistocene foundation clay and foundation sand native layers. These strata are briefly described below. A more detailed presentation of the field data obtained in each stratum is given in **Attachment F**.

3.1. *Site Stratigraphy*

Impounded CCR Materials: The impounded materials in the East Ash Pond are generally considered, respectively, fine to medium sand (SP) and non-plastic silt (ML). Both bottom and fly ash types of ash were encountered within the ash pond, and fly ash was encountered beneath the southeast corner of the south sub-basin embankment. Samples were generally moist or saturated and field investigations showed that ash deposits were soft to very soft with the following index soil characteristics: SPT N-values (uncorrected) ranged from 0 to 3 blows per foot (bpf), in-situ moisture content from 25 to 50%, plasticity index of 6 or less (most were non-plastic), generally 60 to 80% or more of fine particles, and total unit weight of 106 pcf.

Embankment Clay Fill Materials: The embankment fill materials at the East Ash Pond generally consist of over-consolidated, silty clay (CL) and sandy clay (SC). Some isolated soft clay (dark brown in color) layers were encountered. Samples obtained from the field investigation showed samples to be generally stiff with the following index soil characteristics: SPT N-values (uncorrected) ranged from 8 to 12 blows per foot (bpf), with natural moisture contents from 16 to 18%, liquid limits of 34 to 38, plasticity indices of 18 to 24, generally 70% or more of fine particles, and total unit weight of 131 pcf.

Foundation Clay Layer - Native Materials: The foundation clay layer native materials at the East Ash Pond generally consist of lean clay (CL) and sandy clay (SC). Some samples exhibited dilative behavior while limited samples exhibited contractive behavior. The soils were highly interbedded; however, the contractive clay was generally identified in deeper stratum and was less prevalent in

surficial and shallow clays. At several boring and CPT sounding locations, very thin, soft to very soft dark brown to brown clay with some organics were encountered immediately below the embankment. These areas were generally isolated and were generally located in areas of historic drainage channels. Most soil samples obtained from the field investigation showed samples to be generally stiff with the following index soil characteristics: SPT N-values (uncorrected) ranged from 6 to 15 blows per foot (bpf) depending on sand content, with natural moisture content from 16 to 20%, liquid limit of 23 to 40, plasticity index of 16 to 25 with low of 9, generally 50% or more of fine particles, and total unit weight of 128 pcf.

Foundation Sand Layer, Native Materials: The foundation sand native materials at the East Ash Pond generally consist of dense silty sand (SM) and poorly graded sand (SP) with varying gravel content. Some isolated zones of soft silt to medium stiff silty sand or poorly graded sand were encountered beneath the foundation clay and immediately above the dense sand and gravel layers, and very limited zones of loose sand were encountered. These zones were generally only a couple feet thick, and are not expected to form a laterally or vertically continuous zone. The medium dense zones are generally located along the south and southeastern edges of the East Ash Pond. Foundations sands, including the less dense SM and SP zones are in the Cretaceous Period, McNairy Formation based on the Illinois State Geologic Survey. This Cretaceous-Period formation is not expected to be susceptible to liquefaction.

The transition into the dense to very dense silty sand to poorly graded sand with gravel from the foundation clay is much more rapid around the large majority of the East Ash Pond. Undisturbed samples were not obtained during the field investigation for this stratum; however, index testing was performed on disturbed samples. Samples obtained from the field investigation showed samples to be dense to very dense with the following index soil characteristics: SPT N-values (uncorrected) ranged from 25 to 50 blows per foot (bpf), plasticity index of 5 or less with most of the samples being non-plastic, and generally 25% or less of fine particles.

Soft Clay Material: The Soft Clay (miscellaneous fill) was encountered during the field exploration outside of the embankment toe as a low blow count soft clay. Shear strength for this material was assigned based on engineering judgment, and corresponds to normally-consolidated clay. A 20% strength reduction was applied for post-earthquake shear strengths.

3.2. ***Phreatic Conditions***

The presence of phreatic water was noted in samples collected during drilling activities. Phreatic levels in the open boreholes were also measured prior to backfilling the borings. In addition to noting where phreatic water was encountered during sampling, twenty-two vibrating wire piezometers were installed in offset boring locations to monitor phreatic levels. Refer to **Figure 4** in **Attachment A** for the piezometer locations. **Table 2** provides extended phreatic monitoring data for all six of the installed piezometers:

Table 2: Piezometer Measured Levels

Piezometer Number	Total Depth (ft)	Water Surface Elevation (ft NAVD88)					
		10/2/2015	10/23/2015	11/20/2015	12/16/2015	1/13/2016	2/9/2016
JOP-P001[1]	49.0	305.2	304.5	-	-	319.9	315.2
JOP-P002	50.0	332.7	332.6	335.0	335.1	337.7	335.9
JOP-P003	80.0	344.3	343.8	345.1	344.2	345.5	344.2
JOP-P004	60.0	345.6	345.3	345.6	346.1	347.9	346.9
JOP-P005	50.0	362.7	362.4	362.2	362.8	363.8	363.1
JOP-P006	38.0	327.3	324.2	329.6	326.5	329.8	325.0
JOP-P007	48.0	312.8	312.0	311.7	313.4	321.8	319.3
JOP-P008	35.0	357.3	357.4	357.9	358.0	359.2	358.5
JOP-P009	50.0	359.3	358.9	360.3	360.3	361.4	360.6
JOP-P010[2]	45.0	330.0	329.8	-	330.4	331.8	331.7
JOP-P011	50.0	333.9	334.3	334.5	334.7	335.7	335.5
JOP-P012	50.0	340.9	340.6	341.6	343.0	345.5	344.7
JOP-P014	45.0	323.3	328.6	328.5	328.6	330.2	329.4
JOP-P015	30.0	347.4	347.5	352.0	353.4	354.3	354.0
JOP-P016	35.0	350.2	349.5	351.4	350.8	351.7	350.8
JOP-P017	38.0	332.8	331.9	334.6	334.0	337.4	335.0
JOP-P018	65.0	338.7	332.3	351.7	339.9	353.6	337.9
JOP-P019	25.0	371.9	371.9	372.8	371.9	372.5	371.8
JOP-P020	35.0	350.7	348.7	352.0	350.4	349.4	348.3
JOP-P021	48.0	315.8	315.3	315.4	317.9	325.6	323.1
JOP-P022	35.0	345.1	344.0	348.7	349.7	350.9	349.5
JOP-P023	30.0	358.6	357.4	358.3	359.9	364.2	361.5

[1] Piezometer not accessible in November and December 2015.
[2] Piezometer not accessible in November 2015.

Based on the results of the exploration findings and the monitoring of the piezometers, the phreatic levels conditions across the site appear to be continuous. The south sub-basin has a pool elevation of about 373.2 feet based on the 2015 survey by Weaver Consultants and also reflected in piezometer JOP-P019. The EAP phreatic level at the crest varies from elevation 335 to 363 feet, with an average of 349 feet. The lower phreatic level was found at the toe of the embankment, with an average of 331 feet. Piezometer calibration sheets are located in **Attachment C**. Piezometer locations are presented in **Attachment A, Figures A-4** and **A-8**.

4. SUMMARY OF LABORATORY TESTING

Soil samples collected from the 2015 and 2016 subsurface explorations were sealed at the site and were then transported to an AECOM office, where a geotechnical engineer reviewed the samples and selected samples for laboratory testing. The selected SPT soil samples and undisturbed samples (Shelby and piston tube samples) were then sent to AECOM's laboratory testing subcontractor TerraSense, LLC of Totowa, New Jersey. The sections below summarize the number of tests performed and results of the soil testing. No laboratory testing was performed on the soil samples collected during the 2016 subsurface exploration.

4.1. *Summary of Laboratory Testing Scope*

Laboratory testing was performed to confirm visual soil classifications and to establish the index and engineering properties of the soils. **Table 3** summarizes the laboratory testing program for the EAP and includes the type and total number of tests performed. Complete results of the laboratory tests are presented in **Attachment E** and pertinent test data are also incorporated onto the boring logs.

Table 3: Summary of Laboratory Testing Program

Test	ASTM Method	Number of Tests				
		Total	Ash	Embankment Fill	Foundation Clay	Foundation Sand
Moisture Content	D2216	220	25	68	106	21
Atterberg Limits	D4318	153	20	43	81	9
Grain Size Analysis	D422	164	20	37	87	20
Specific Gravity	D854	8	0	3	5	0
Unit Weight	D2937	1	1	0	0	0
Consolidation	D2435	9	1	1	7	0
Unconsolidated Undrained (UU)	D2850	25	5	11	9	0
Consolidated Undrained (CIU)	D4767	45	2	19	22	2
Direct Shear (DS)	D3080	4	2	0	2	0
Direct Simple Shear (DSS)	D6528	7	1	0	5	1
Cyclic Direct Simple Shear (CDSS)	GTX S1085	2	2	0	0	0
Permeability	D5084	11	2	3	6	0
Lab Vane	D4648	32	0	9	21	2

4.2. *Summary of Laboratory Testing Results*

The test results for each of the four subsurface strata identified in the exploration were analyzed and used to determine the material parameters and shear strength characterization. Details and graphical displays of the shear strength characterization for the stratigraphic materials are included in the Material Characterization Calculation Package in **Appendix F**.

5. SLOPE STABILITY ANALYSES

Slope stability analyses were performed for varying loading conditions at selected cross-sections. Cross-sections utilized for the analyses were selected at locations featuring critical surface geometry and/or subsurface stratigraphy. Surface topography, subsurface stratigraphy and soil parameters were established from the results of the site geotechnical exploration and pertinent historic data.

5.1. *Cross-Sections for Analysis*

Six representative cross sections were utilized to evaluate the perimeter embankment stability at the EAP. Two cross sections (B-B and C-C) are located in the east embankment of the EAP, one

section (G-G) is located in the west embankment of the EAP, and three cross sections (H-H, K-K, and A-A) are located in the southeast corner of the EAP where the soil improvement (DMM zone) was performed.

The locations and extents of the cross sections are shown on **Figure A-3** and **A-5** in **Attachment A**. The cross sections were selected based on stratigraphy and geometry, and are located in the east side of the EAP.

The embankment at cross sections B-B (STA 10+00) and C-C (near STA 19+80) has a height between 25.3 and 34.8 feet (crest to base) and a width of approximately 20 feet. Section B-B was selected due to the presence of the 430 acre-feet pond at El 373.2 feet and because of the height of the embankment of 34.8 feet. Adjacent cross section, C-C, was selected because CCR material is stored to the near full limits of the pond (near El. 377.6 feet). The cross section, G-G, was selected because CCR material is stored to the near full limits of the pond at this location (near El. 377 feet).

Cross section H-H (STA 84+40) is located in the western extent of the DMM zone. Geotechnical explorations drilled at the crest of the embankment near the cross section identified ash underneath the embankment. Soft clay and ash zones were also identified at the toe of the embankment, where the DMM was performed. The soil improvement zone in this area extends to 33.6 feet bgs, with an average depth of 28.5 feet bgs.

Cross section K-K (STA 87+50) is located near the southeast corner of the embankment. Geotechnical explorations at the embankment identified a potential zone of poor compaction at lowest point in the bottom of the embankment. This zone appeared to be very limited in size and scope. The design and constructed soil improvement zone in this area extends modifies the aforementioned poorly compacted soils as well as potential ash from El 310.0 feet to 305.0 feet.

Cross section A-A (STA 90+50) represents the critical cross section for the DMM zone, due to being located at the area of maximum embankment height, and the close proximity of the stream at the toe of the embankment, as well as the thickness of ash underlying the embankment. The soil improvement zone in this area extends to El 300.0 feet, with an average elevation of El. 305.0 feet bgs.

To apply the subsurface profile at each of the cross section locations, topographic information was used in conjunction with a combination of historic geotechnical information and AECOM's 2015 geotechnical explorations. A summary of the borings referenced at each cross section location is provided in **Table 9**.

Table 9: Summary of Geotechnical Explorations at Cross Sectional Locations

Cross Section	Geotechnical Explorations Used
B-B	JOP-B005/P005, JOP-C007 JOP-B007/P007, JOP-C006
C-C	JOP-B009/P009, JOP-C008 JOP-C009
H-H	JOP-B025, JOP-B026, JOP-B018 JOP-B017, JOP-D006, JOP-D020 JOP-D007
K-K	JOP-B020, JOP-C016 JOP-B021, JOP-C014 JOP-D021
A-A	JOP-B004, JOP-SC002 JOP-B001, JOP-C001
G-G	JOP-B015, JOP-C013, JOP-B022, JOP-C037

5.2. ***Stability Analysis Conditions Considered***

Consistent with the criteria provided in the USEPA CCR Rule § 257.73(e), the stability of the EAP embankment was evaluated for four load cases:

Static, Steady-State, Normal Pool Condition: This case models the conditions under static, long-term conditions, under the normal storage water level within the impoundment (El. 373.2 feet), as listed in AECOM's hydrologic and hydraulic report (AECOM, 2016). (For conservatism, the higher pool elevation from the south sub-basin was used for both the north and south sub-basins.) Drained (effective stress) shear strength parameters were used for all materials, and phreatic conditions were estimated based on available piezometer and CPT dissipation test data. ***Target Factor of Safety = 1.50***

Static, Maximum Surcharge Pool Condition: This case models the conditions under short-term surcharge pool conditions (El. 377.6 feet), as listed in AECOM's hydrologic and hydraulic report (AECOM, 2016). (For conservatism, the higher pool elevation from the south sub-basin was used for both the north and south sub-basins.) Undrained (total stress) shear strength parameters were used for analysis, as the increase in pool level is relatively small and unlikely to result in the development to undrained conditions in the embankment or foundation soils. The phreatic surface was modeled equivalent to the steady state case, since the pond system is internally lined and the liner is hydraulically isolating the pool from the embankments. ***Target Factor of Safety = 1.40***

Seismic Slope Stability Analysis: These analyses incorporate a horizontal seismic coefficient k_h selected to be representative of expected loading during the design earthquake event (i.e., a "pseudostatic" analysis). The analyses utilized peak undrained strength parameters in soils that are not consider to be rapidly draining materials, and peak drained strengths in soils considered to freely drain. The phreatic surface and pore water pressures corresponding to the Steady State Maximum Storage Pool case from the static analyses were utilized. ***Target Factor of Safety = 1.00.***

Post-Liquefaction Condition: These analyses were performed at each stability cross section where liquefaction triggering analysis indicates potential liquefaction of granular, non-plastic materials or cyclic softening of fine-grained soils. The purpose of the post-liquefaction stability analysis is to assess stability conditions immediately following a seismic event. No horizontal seismic coefficient is included in these analyses, but selection of strength parameters for the

analyses takes into account the potential for softening/ weakening of the soils as a result of pore pressures generated in sand-like materials, or cyclic softening in clay-like materials due to the earthquake shaking. ***Target Factor of Safety = 1.20.***

Post Liquefaction Condition was analyzed for the DMM zone (cross sections H-H, K-K, and A-A) to evaluate the effects of liquefied ash in the EAP. Sluiced CCRs retained by the dikes and beneath the embankment at cross-section K-K were assumed to liquefy for this analysis. No soils susceptible to liquefaction were identified at cross sections B-B and C-C so a post-earthquake (i.e. liquefaction) slope stability analysis is not required per §257.73(e), and was therefore not performed. The likely liquefiable condition of the ash prior to modification was not the limiting factor requiring modification; the seismic stability required the significant modification through DMM.

5.3. ***Material Properties***

Material properties for slope stability analyses were developed using both laboratory testing data (index and strength testing) and strength correlations from CPT and SPT data. The material properties and characterization utilized for the stability analyses are described in detail in **Attachment F**. The final parameters selected for slope stability analyses are presented in Section 5.4.

5.4. ***Methodology of Analyses***

Limit equilibrium stability analyses were performed using the computer software program SLOPE/W v.7.23 from GeoSlope International. Factors of safety were calculated using Spencer's method and using circular search routines (based on the entry and exit search method) to determine the critical failure surface for each analysis section and load case. Critical surfaces with respect to the embankment safety were considered to be those which intersected the embankment crest and could result in a release of ash materials. Pore pressures were assigned as hydrostatic pressure under the piezometric line.

The following sections briefly summarize the analysis and soil parameters used for the static and seismic conditions. Detailed presentations of the analyses are provided in **Attachment G** for slope stability. Development of ground motions for the earthquake loading condition is discussed in **Attachment H**.

5.4.1. *Static Analysis Conditions*

Static stability was evaluated for steady-state conditions using a normal pool elevation of 373.2 feet and a maximum flood surcharge pool elevation of 377.6 feet, which is conservative for the north sub-basin. Material and shear strength parameters were based on the results of the subsurface exploration, laboratory test results, and a detailed review of Plant historic documentation. **Table 10** and **Table 10A** summarize the parameters used in the static stability analysis:

Table 10: Summary of Material Parameters used in Static Stability Analysis

Material Description	Unit Weight	Drained Strength	
		Cohesion	Friction Angle[1]
	(pcf)	(psf)	(deg)
Embankment Clay [Fill]	131	Non-linear strength envelope. See Table 10.A.	
Foundation Clay	128	0	α > 5°: 33 deg -5° ≤ α ≤ 5°: 29 deg α < -5°: 33 deg
Foundation Sand	130	0	35
Ash	106	0	α > 5°: 33 deg -5° ≤ α ≤ 5°: 29 deg α < -5°: 33 deg
Soft Clay [Miscellaneous Fill]	125	0	24

1. Where applicable, α represents the failure plane angle measured from horizontal.

Table 10A: Embankment Clay [Fill] Non-linear Drained Strength Failure Envelope

Normal Effective Stress on Failure Plane (σ'_{ff}), psf	Shear Strength (τ_{ff}), psf
0	0
585.2	561
1308.6	1050.4
1497.4	1124.6
2000	1400.4
10000	7002.1

5.4.2. *Earthquake Analysis Conditions*

The site-specific seismic hazard was assessed with a probabilistic seismic hazard analysis (PSHA), performed to identify the earthquake loads at the site.

5.4.2.1. Probabilistic Seismic Hazard Analysis

A site-specific PSHA was completed to develop 2,500-year earthquake ground motions for use in liquefaction and dynamic response analyses for the plant. The PSHA results were used to compute a 2,500-yr return period Uniform Hazard Spectrum (UHS) for top of rock (shear wave velocity = 9,200 ft/s) and at the soil-rock interface. Parameters were developed including magnitude, distance, style of faulting, response spectra, and Arias Intensity for the current study. Seismically capable faults in the project region were considered. Near field and directivity effects were also considered. Because the top of hard rock at the Joppa site is about 200+ feet deep, based on available geologic data as described in the PSHA (**Attachment H**), a site response analysis was performed to account for the effect of the overlying firm rock (shear wave velocities over 9,000 ft/s) and generate a UHS for the top of the firm rock at this site.

Three sets of time histories were developed for the UHS at the top of firm rock. The time histories represent the site-specific ground motions associated with the controlling near-field or far-field earthquake event, and consider the magnitude, distance, and Arias Intensity. The site-specific

acceleration time histories for top of soft rock were developed for use in two-dimensional dynamic response analysis of the soil column that overlies the firm rock, and to estimate site-specific seismic loads for liquefaction triggering and seismic (pseudo-static) stability analysis.

The calculated site-specific peak ground acceleration (PGA) for a 2,500-year event was 0.18g for top of firm rock. The majority of the PGA hazard at the site comes from events associated with the New Madrid Seismic Zone, with modal moment magnitudes ranging from 7.5 to 8.0. Details of the PSHA are included in **Attachment H**.

5.4.2.2. Seismic Coefficient

Seismic coefficients were calculated for use in the pseudostatic slope stability analysis based on the simplified procedure developed by Makdisi and Seed (1978). The largest crest acceleration resulting from the dynamic response analysis was 0.81g. Application of the Makdisi and Seed methodology using this acceleration and the full-height critical slip surfaces that were identified in the analysis, a seismic coefficient of 0.275g was used in the pseudo-static analysis.

5.4.2.3. Liquefaction Triggering Analysis

Liquefaction is used to describe the contraction of coarse-grained (i.e. cohesionless) sand and gravel soils under cyclic loading imposed by earthquake shaking. The result is a reduction in the effective confining stress within the soil and an associated loss of strength (Idriss and Boulanger 2008). Liquefaction only occurs in saturated soils. Liquefaction susceptibility also largely depends on compositional characteristics such as particle size, shape, and gradation.

With the exception of encountered ash, and deep over-consolidated sands, AECOM's field exploration generally did not encounter cohesionless soils in the embankment or foundation of the EAP, and with the exception of these materials, only cohesive soils were encountered by AECOM. Based on the location of the deep sands below the overlying highly over-consolidated clays, and the CPT tip resistance of these materials, they were judged to be dilative and non-liquefiable. Additionally, these sands are of Cretaceous Period which also lowers the potential for liquefaction. This means that the soils encountered in AECOM's field exploration are not susceptible to liquefaction. Consequently, a formal liquefaction analysis was determined to be unnecessary as the embankment and foundation soils at the site are not susceptible to liquefaction based on their composition and observed index properties.

Fly ash placed before the construction of the embankment dikes, over the natural soils and underlying the southeast corner of the EAP embankment dike will liquefy under earthquake induced loading prior to the soil improvement. Soil improvement (DMM) performed from July to September 2016 was constructed primarily to meet seismic stability criteria in the USEPA CCR Rule § 257.73(e), but will also comply with the criteria provided in the USEPA CCR Rule § 257.73(d)(1)(i).

5.4.2.4. Strength Parameter Selection

Based on the subsurface exploration and laboratory tests, **Table 11** listed below summarizes the material parameters used in the seismic stability analysis:

Table 11: Summary of Material Parameters used in Seismic Stability Analysis

Material Description	Unit Weight	Peak Undrained Strength	Post-Earthquake Strength
		S_u	S_u[1]
	(pcf)	(psf)	(psf)
Embankment Clay [Fill]	131	σ'_{fc} < 0.5 ksf: S_u = 600 psf σ'_{fc} ≥ 0.5 ksf: S_u/σ'_{fc} = 0.65 and c_o = 274 psf	Peak undrained strength. Cyclic softening is not expected due to stiff nature of soil.
Foundation Clay	128	S_u/σ'_{fc} = 0.41 c_o = 700 psf	
Foundation Sand	128	Drained Strength Use (See Table 10)	Drained Strength Use (See Table 10)
Ash	106	S_u/σ'_{fc} = 0.44	S_u/σ'_{vc} = 0.07[2]
Soft Clay (Miscellaneous Fill)[3]	125	S_u/σ'_{fc} = 0.25, min Su = 500 psf	S_u/σ'_{fc} = 0.18, min Su = 400 psf
Working Pad[4]	125	1,500 psf	Peak Undrained
Crushed Stone[5]	135	Drained Strength Use (See Table 10)	Peak Drained
Spoil Material (soil and cement)	125	7200 psf	Peak Undrained

1. Where applicable, post-earthquake analyses used drained strengths, 80% of the static undrained strengths, post-earthquake (liquefied) strengths.
2. Where applicable, post-earthquake (liquefied) strengths were calculated using the methodology proposed in Idriss and Boulanger (2008).
3. Soft clay (miscellaneous fill) I was encountered during the field exploration as low-blow count soft clay. Shear strength for this material was assigned based on engineering judgment, and corresponds to a normally-consolidated clay. A 20% strength reduction was applied for post-earthquake shear strengths.

For additional information pertaining to the material properties used in the seismic and post-liquefaction stability analysis, see **Attachment F**.

6. RESULTS

6.1. ***Results of Static Analyses***

The results of the limit equilibrium slope stability analyses for the static load cases are summarized in **Table 12** below. The SLOPE/W output figures showing the analyzed circular and block slip surfaces and details of the analyses are included in **Attachment G**.

Table 12: Summary of Minimum Static Slope Stability Factors

Load Case	Program Criteria	B-B	C-C	H-H	K-K	A-A	G-G
Steady State (Normal Pool)	FS ≥ 1.50	1.87	1.77	1.72	1.59	1.83	1.68
Surcharge Pool (Flood Pool)	FS ≥ 1.40	1.78	1.71	1.70	1.57	1.83	1.68

6.2. *Results of Earthquake Analyses*

6.2.1. *Seismic Stability Analysis*

The results of the seismic slope stability analyses are summarized in **Table 13**, below. The Slope/W output figures showing the analyzed circular slip surfaces and details of the analyses are included in **Attachment G**.

Table 13: Summary of Minimum Seismic Slope Stability Factors

Load Case	Program Criteria	B-B	C-C	H-H	K-K	A-A	G-G
Seismic (Pseudostatic)	FS ≥ 1.00	1.14	1.26	1.04	1.01	1.05	1.16
Post-Liquefaction	FS ≥ 1.20	-	-	1.39	1.57	1.63	-

7. CONCLUSIONS

The calculated factors of safety from the limit equilibrium static and seismic slope stability analysis satisfy the USEPA CCR Rule § 257.73(e) requirements for all the critical analysis sections that comprise the embankment perimeter of the East Ash Pond at the Joppa Power Station owned by Electric Energy, Inc.

8. LIMITATIONS

Ground survey and other plant-specific background information and other data have been furnished to AECOM by third parties, which AECOM has used in preparing this report. AECOM has relied on this information as furnished. Our recommendations are based on available information from previous and current investigations. These recommendations may be updated as future investigations are performed.

Borings have been spaced as closely as economically feasible, but variations in soil properties between borings, that may become evident at a later date, are possible. The recommendations made in this report are based on the assumption that the subsurface soil, rock, and phreatic water conditions do not deviate appreciably from those disclosed in the site-specific exploratory borings. If any variations or undesirable conditions are encountered in any future exploration, we should be notified so that additional recommendations can be made, if necessary.

The conclusions presented in this report are intended only for the purpose, site location, and project indicated. The recommendations presented in this report should not be used for other projects or purposes. Conclusions or recommendations made from these data by others are their responsibility. The conclusions and recommendations are based on AECOM's understanding of current plant operations, maintenance, stormwater handling, and ash handling procedures at the station, as provided by EEI. Changes in any of these operations or procedures may invalidate the findings in this report until AECOM has had the opportunity to review the changes, and revise the report if necessary.

This geotechnical investigation was performed in accordance with the standard of care commonly used as state-of-practice in our profession. Specifically, our services have been performed in accordance with accepted principles and practices of the geological and geotechnical engineering profession. The conclusions presented in this report are professional opinions based on the

indicated project criteria and data available at the time this report was prepared. Our services were provided in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation is intended.

9. REFERENCES

AECOM (2016). "Hydrologic and Hydraulic Report, Joppa Power Station, East Ash Pond"

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Idriss, I. M., and Boulanger, R. W. (2008). "Soil Liquefaction During Earthquakes". Earthquake Engineering Research Institute, Oakland, California, USA.

Idriss, I.M. and Boulanger, R.W. (2014). "CPT and SPT Based Liquefaction Triggering Procedures", Center of Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, California.

Makdisi, F.I. and Seed, B. H., August, (1977). "A Simplified Procedure for Estimating Earthquake-Induced Deformations in Dams and Embankments", Earthquake Engineering Research Center Report No. UCB/EERC-77/19, University of California, Berkeley, CA.

Seed, H.B., and Idriss, I.M., (1970). "Soil Moduli and Damping Factors for Dynamic Response Analysis", Earthquake Engineering Research Center, College of Engineering, University of California, Berkley, California.

Silva, W.J. and Lee, K. (1987). "WES RASCAL Code for Synthesizing Earthquake Ground Motions: State-of-the-Art for Assessing Earthquake Hazards in the United States, Report 24": U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper S-73-1, 120 p.

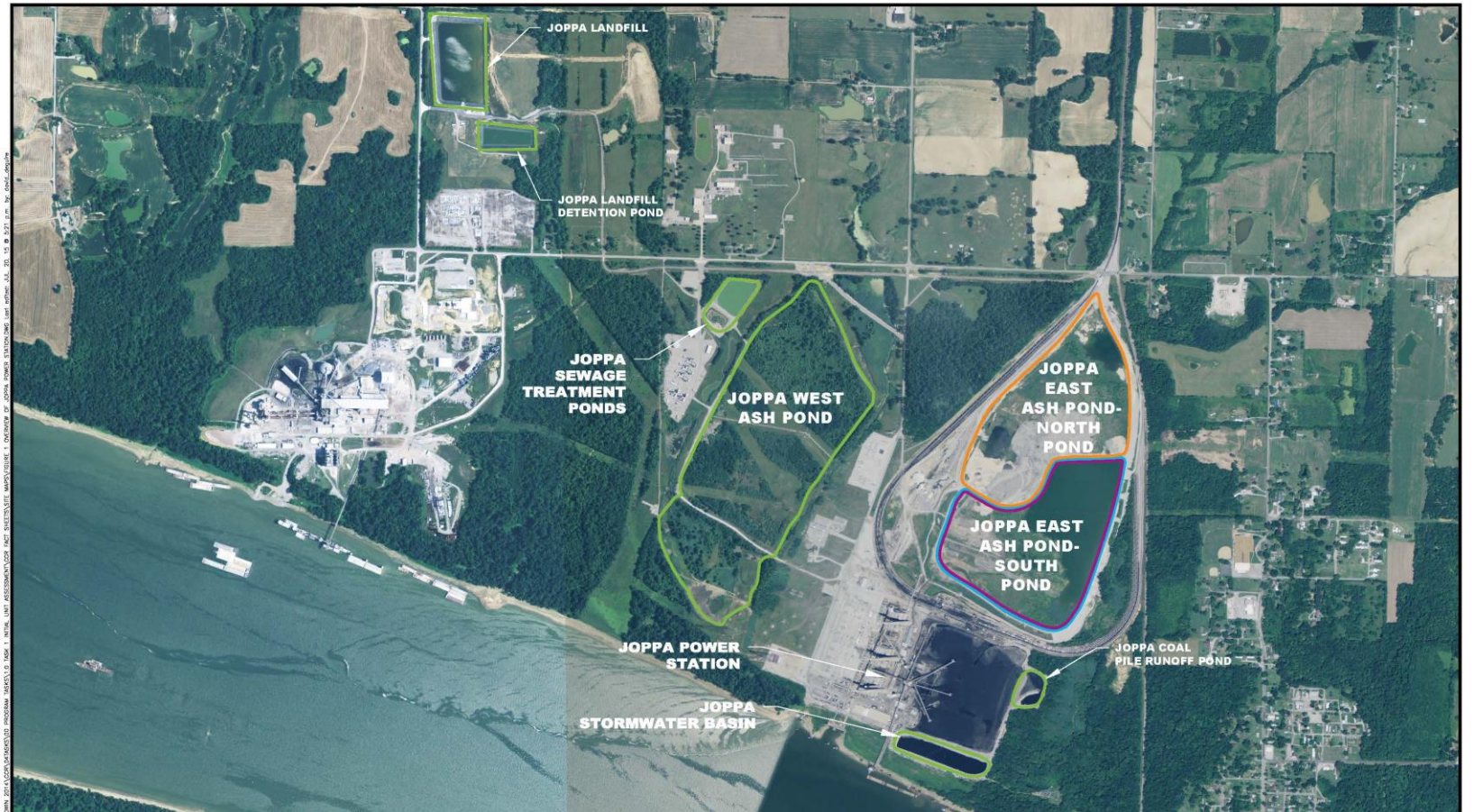
Vucetic, M. and Dobry, R. (1991). "Effect of Soil Plasticity on Cyclic Response". Journal of Geotechnical Engineering (ASCE). Vol. 117, No. 1, pp. 89-117.

Youd et al. (2001). "Liquefaction Resistance of Soils: Summary from the 1996 NCEER and 1998 NCERR/NSF Workshops on Evaluation of Liquefaction Resistance of Soils", ASCE Journal of Geotechnical and Geoenvironmental Engineering, Vol. 127, No. 10, pp. 817-833.

Weaver Consultants Group, "Joppa 2015 Aerial Topography", December 2015

ATTACHMENT A

FIGURES



SOURCE:
MAP PROVIDED BY GOOGLE EARTH PRO 2015

NOT TO SCALE

DYNEGY, INC		PROJECT NO. 60428794
AECOM		
DRN. BY: djd July 2015 DSGN. BY: eg CHKD. BY: eg	Overview of Joppa Power Station	FIG. NO. A - 1

PRIVILEGED & CONFIDENTIAL - ATTORNEY CLIENT PRIVILEGED

Q:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - North.mxd

Legend

- AECOM Boring Location
- AECOM CPT Location

N
W E
S

250 0 250 500 Feet

DYNEGY

Figure A - 2
Exploration Locations - North Pond
Joppa Power Station
Massac County, Illinois

AECOM

Q:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - North wXS.mxd

Legend

- Cross Sections
- AECOM Boring Location
- AECOM CPT Location

N W E S

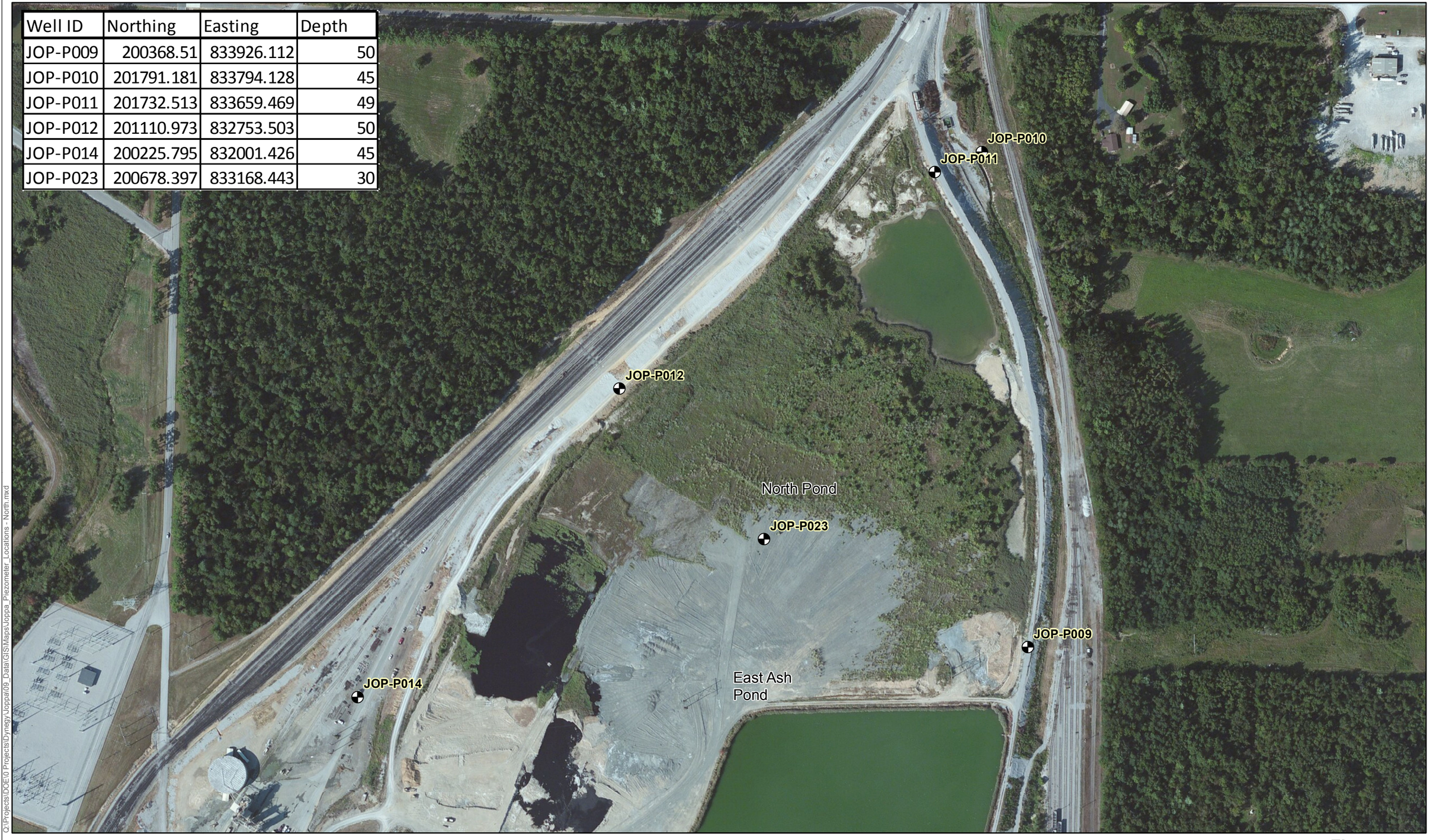
250 0 250 500 Feet

DYNEGY

Figure A - 3
Cross Section Locations - North Pond
Joppa Power Station
Massac County, Illinois

AECOM

Well ID	Northing	Easting	Depth
JOP-P009	200368.51	833926.112	50
JOP-P010	201791.181	833794.128	45
JOP-P011	201732.513	833659.469	49
JOP-P012	201110.973	832753.503	50
JOP-P014	200225.795	832001.426	45
JOP-P023	200678.397	833168.443	30



O:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Piezometer_Locations - North.mxd

Legend

- AECOM Vibrating-Wire Piezometer Location

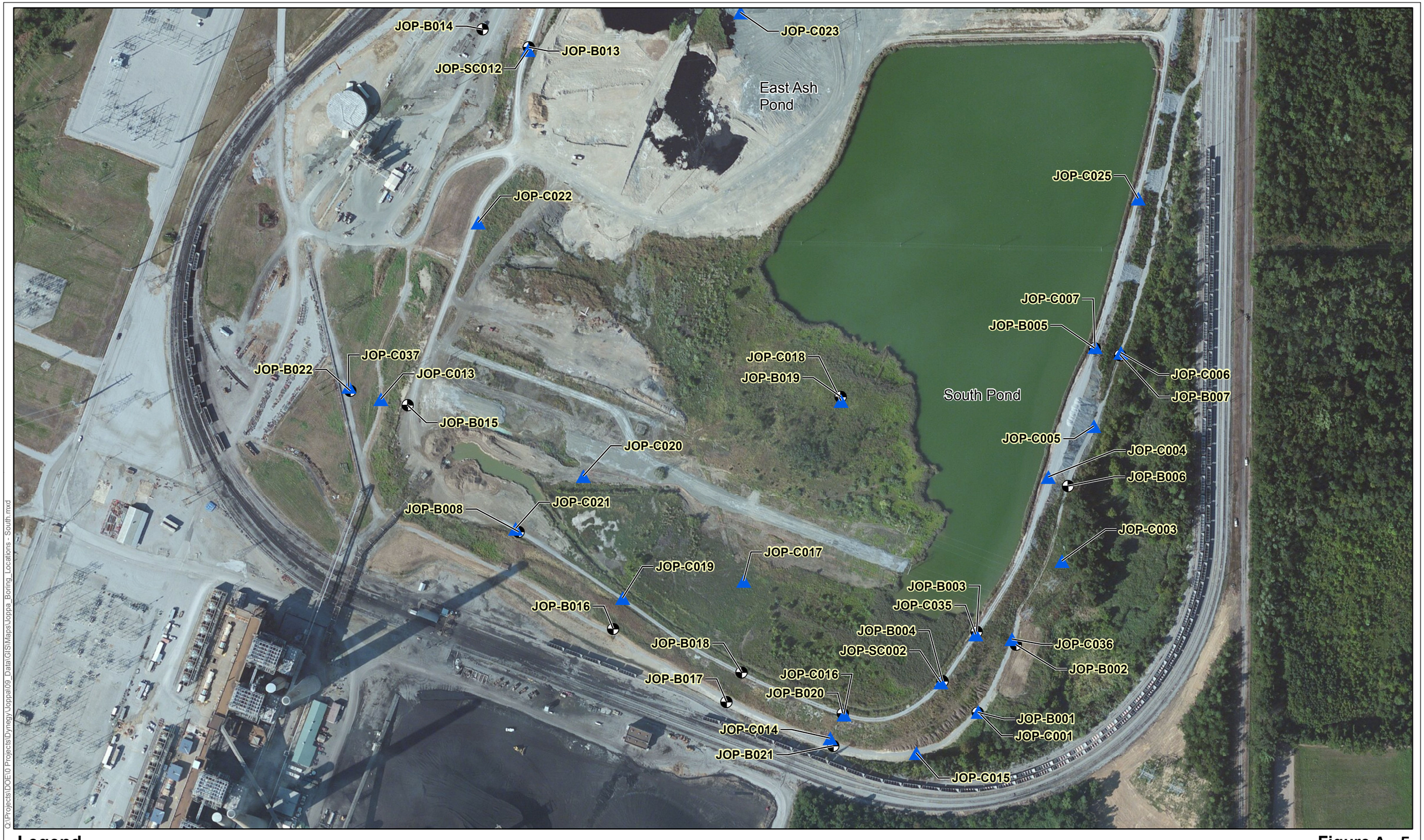
N
W E
S

250 0 250 500 Feet

DYNEGY

Figure A - 4
Piezometer Locations - North Pond
Joppa Power Station
Massac County, Illinois

AECOM



Q:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - South.mxd

Legend

- AECOM Boring Location
- AECOM CPT Location

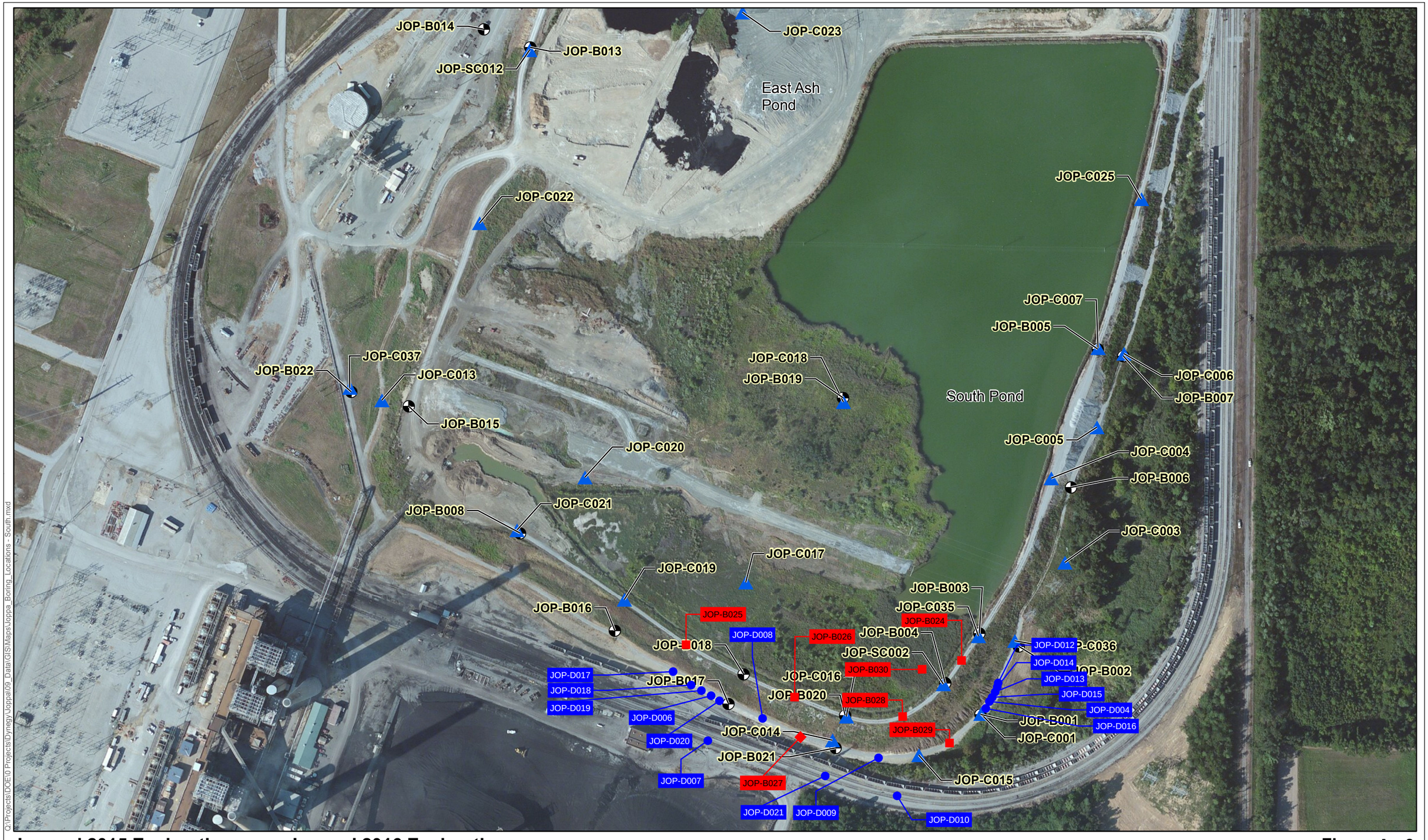
N
W E
S

250 0 250 500 Feet

DYNEGY

Figure A - 5
Exploration Locations - South Pond
Joppa Power Station
Massac County, Illinois

AECOM



Q:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - South.mxd

Legend 2015 Explorations

- AECOM Boring Location
- AECOM CPT Location

Legend 2016 Explorations

- Mud hole for liquefaction
- Direct Push hole

N W E S

250 0 250 500 Feet

Figure A - 6
2016 Exploration Locations - South Pond
Joppa Power Station
Massac County, Illinois

DYNEGY

AECOM

JOP-B014
JOP-B013
JOP-SC012
JOP-C023
East Ash Pond
JOP-C025
JOP-C022
JOP-C007
JOP-B005
B
B'
JOP-C006
JOP-B007
JOP-C018
JOP-B019
South Pond
JOP-B022
JOP-C037
JOP-C013
G
G'
JOP-B015
JOP-C005
JOP-C004
JOP-B006
JOP-C020
JOP-C021
JOP-B008
JOP-C003
JOP-C017
JOP-C019
JOP-B016
JOP-B003
JOP-C035
I
I'
JOP-B004
JOP-SC002
JOP-C036
JOP-B002
JOP-B018
JOP-B017
H
H'
JOP-C016
JOP-B020
A
A'
JOP-B001
JOP-C001
JOP-C014
J
J'
JOP-B021
JOP-C015

Q:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - South wXS.mxd

Legend

- Cross Sections
- AECOM Boring Location
- AECOM CPT Location

N
W E
S

250 0 250 500 Feet

DYNEGY

AECOM

Figure A - 7
Cross Section Locations - South Pond
Joppa Power Station
Massac County, Illinois

Well ID	Northing	Easting	Depth
JOP-P001	198339.356	833368.329	49
JOP-P002	198526.687	833473.656	50
JOP-P003	198562.396	833364.52	80
JOP-P004	198426.288	833270.929	60
JOP-P005	199345.517	833690.417	50
JOP-P006	198964.527	833617.004	38
JOP-P007	199326.609	833760.769	48
JOP-P008	198838.543	832101.152	35
JOP-P015	199187.756	831795.058	30
JOP-P016	198570.826	832362.032	35
JOP-P017	198369.43	832674.819	38
JOP-P018	198450.745	832716.494	65
JOP-P019	199211.282	832989.788	25
JOP-P020	198337.355	832995.972	35
JOP-P021	198247.407	832969.41	48
JOP-P022	199227.577	831636.112	35

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Legend

- AECOM Vibrating-Wire Piezometer Location

N W E S

250 0 250 500 Feet

DYNEGY

Figure A - 8
Piezometer Locations - South Pond
Joppa Power Station
Massac County, Illinois

AECOM

CARUSO, MICHAEL 5/18/2016 10:58 AM

EAST ASH POND

ACCESS ROAD

BERM ALIGNMENT

EXISTING GRAVEL ROAD

SOIL MIXING ZONE

CONSTRUCTION DISTURBANCE AREA

JOP-P017

JOP-P018

JOP-P020

JOP-P021

JOP-P003

JOP-P002

JOP-P004

JOP-P001

PC: 81+79.44

PT: 85+89.03

PC: 87+19.01

PC: 3+41.80

EP: 90+64.72

EXISTING ROCK EROSION PROTECTION

SILT FENCE (TYP)
SEE DETAIL ON SHEET SWPPP-103

EXISTING DRAINAGE CHANNEL

CULVERT INLET PROTECTION
SEE DETAIL ON SHEET SWPPP-103

DITCH CHECKS (TYP)
SILT SOCK
SEE DETAIL ON SHEET SWPPP-103

EXISTING CULVERT
(ESTIMATED LOCATION)

LEGEND:

- SF — PROPOSED SILT FENCE LOCATION
- SOIL MIXING AREA
- CONSTRUCTION DISTURBANCE AREA
- DITCH CHECK
- CULVERT INLET PROTECTION
- PIEZOMETER LOCATION

NOTE:

SILT FENCE SHALL BE INSTALLED AROUND ALL BORROW, STOCKPILE, AND SPOIL AREAS.

N

0 50 100 150
SCALE IN FEET

AECOM
1001 Highlands Plaza
Drive West, Suite 300
St. Louis, MO 63110-1337
314-429-0100 (phone)
314-429-0462 (fax)

ELECTRIC ENERGY, INC.
2100 PORTLAND ROAD
JOPPA, IL 62953

WORK PAD AND SITE RESTORATION
EAST ASH POND

ISSUED FOR BIDDING

ISSUED FOR BIDDING — DATE BY

ISSUED FOR CONSTRUCTION — DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
1	PRE-BID COMMENTS	5/5/2016
2	SURVEY CONTROL	5/18/2016

AECOM PROJECT NO:	60440155
DRAWN BY:	MJC
DESIGNED BY:	MJC
CHECKED BY:	LPC
DATE CREATED:	3/15/2016
PLOT DATE:	5/18/2016
SCALE:	1" = 40'
ACAD VER:	2014

SHEET TITLE

SWPPP SITE PLAN

FIGURE A-9

AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\Joppa Remediation\CAD Files from SLC\SWPP Files\Joppa-Sheet 2.dwg

ATTACHMENT B

BORING LOGS

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B001

Date(s) Drilled	08/10/2015 1:00 PM to 08/10/2015 3:00 PM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	333.6 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198339.4 E 833368.3 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0						333.6 / 0.0 [EMBANKMENT] SILT (ML), loose, gray, chips of coal								*Start 8/10/15 at 1:00 PM*
		S-1	1 4 3		89		331.6 / 2.0 Lean CLAY with Sand (CL), brown/orange staining								
330		ST-1	P					18.5	131.4	34	17				
	5							19.4	127.8						*P200 = 80.4*
								21.1	123.6					2.1	
							327.6 / 6.0								
		S-2	1 0 0		100		[ASH] SILT (ML), dark gray, very loose, moist to saturated	30.5							*P200 = 85.2*
325		ST-2	P												*Shelby pushed 20"*
	10														
320															
		S-3	0 0 1		100										
	15														
							315.6 / 18.0								
315		S-4	1 0 0		78		[FOUNDATION] Lean CLAY with Sand (CL), tan/brown, very soft	23.4		27	9				*P200 = 84.6*
	20														
							light gray, stiff, with varying sand								
310		S-5	2 4 9		100										
	25														
305		ST-3	P												*Shelby pushed 9", showed dent*
	30														

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:30 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B001

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
305	30													
300	35	S-6	6 7 5	100			21.3							*P200 = 81.8*
295	40	S-7	3 4 6	100										
290	45	ST-4	P			290.1 / 43.5 Clayey SAND (SC) 288.9 / 44.8 Poorly Graded SAND (SP), gray and tan, subangular	14.6 13.6 14.5	123.5 131.5	29	17				*P200 = 38.5* *Shelby pushed 14"*
285	50	S-8		100		283.6 / 50.0 End of Boring at 50 ft	16.5							*P200 = 2.8* *End 8/10/15 at 3:00 PM*
280	55													
275	60													
270	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:30 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B002

Date(s) Drilled	08/18/2015 10:00 AM to 08/18/2015 2:00 PM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	65.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	350.1 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198371.3 E 833329.2 (ft NAD83)	Groundwater Level(s)	13.8 ft on 8/18/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	0					350.1 / 0.0								
		S-A	2 2 4	33		[FOUNDATION] Lean CLAY with Sand (CL), light gray, firm, moist, low to medium plasticity, pockets of orange with varying sand, and organic matter odor to 3'								*Start 8/18/15 at 10:00 AM*
		ST-1	P	92		light gray								
345	5	S-B	1 2 4	100										
		ST-2	P	100			24.1 23.5 24.3 23.7 22.7	117.2 123.0 125.9	34	17			1.2	
340	10													
		S-1	2 2 3	78		▽	25.6							*~14 inches of water on outside of split spoon* *P200 = 91.0*
335	15													
		S-2	2 3 4	89										
330	20													
		S-3	3 4 5	89		with trace fine black sand	20.1		28	15				
325	25													
		S-4	4 5 7	78		stiff								
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:36 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B002

Elevation (feet)	Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
320	30													
		S-5	5 7 6	78										
315	35													
		ST-3	P	100			26.6 22.2 21.2 21.4	130.2 127.9	35	18				*P200 = 92.1*
310	40													
		S-6	4 6 8	100			20.8							*P200 = 93.9* *Auger flight brought water to surface*
305	45													
		S-7	4 6 8	89										
300	50													
		S-8	4 5 6	78			22.4		35	19				
295	55													
		S-9	5 6 9	78										
290	60													
		S-10	5 4 12	100		285.6 / 64.5 285.1 / 65.0 Sandy SILT (ML), gray, medium stiff	17.9							*P200 = 56.7*
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:36 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B002

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
285														*End 8/18/15 at 2:00 PM*
						End of Boring at 65 ft								
280	70													
275	75													
270	80													
265	85													
260	90													
255	95													
	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:36 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B003

Date(s) Drilled	08/17/2015 12:00 AM to 08/18/2015 12:00 AM	Logged By	SWB	Checked By	Vonmarie Martinez
Drilling Method	HSA/Mud rotary	Drill Bit Size/Type	Tricone bit, bent claw	Borehole Depth	110.0 ft
Drill Rig Type	CME 850 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379.8 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198562.4 E 833364.5 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					379.8 / 0.0 [CREST WEARING SURFACE]								*Start 8/17/15*
						378.8 / 1.0 Crushed stone, sand and gravel								
						[EMBANKMENT] Lean CLAY with Sand (CL), brown/gray, stiff, dry to moist, varying sand content								
							15.9							
		ST-1	P	75			15.6	126.7	41	24				*P200 = 82.0*
375	5						17.2							
		S-1	3 4 6	56										
370	10													
		S-2	3 5 8	56			13.4		40	24				
365	15					with little sand, trace gravel								
		ST-2	P	100			18.4	129.7						
							16.2	126.5						*P200 = 85.7*
360	20						16.1							*LV Su=4.7 ksf*
							14.7							
		S-3	4 6 8	33										
355	25													
		S-4	3 3 6	67			17.4							*P200 = 87.6*
350	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:44 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B003

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
		ST-3	P	83			12.7 24.7 18.0 16.2	147.0	38	19				*P200 = 96.2*
345	35					with gray mottling, trace sand and gravel								
		S-5	4 5 10	78			17.4							
340	40													
		S-6	2 2 3	11		335.8 / 44.0 [FOUNDATION] Lean CLAY (CL), brown/gray with gray mottling, stiff, trace sand and gravel								*Piece of wood blocked opening of split spoon*
335	45													
		S-7	4 5 8	100			20.6							*Pushed Shelby 24", no recovery. Recovered with split spoon.*
330	50						23.1	102.9	34	17				*P200 = 95.2*
		ST-4	P	67										*End 8/17/15. Start 8/18/15 with mud rotary.*
		S-8	3 3 2	100										
325	55													
		S-9	2 2 2	100			28.2		41	25				
320	60													
		S-10	3 5 6	100		stiff								
315	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:44 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B003

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						Elevation (feet) / Depth (feet)								
310	70	S-11	3 5 7	100			23.2							*P200 = 91.8*
305	75	S-12	4 3 9			gray								
300	80	S-13	6 9 8			very stiff								
295	85	S-14	4 5 6			stiff	21.7		37	21				
290	90	S-15	9 11 12			very stiff	20.6							*P200 = 96.5*
285	95	S-16	5 6 9											
280	100	S-17	6 6 11											

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:44 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B003

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275	105	S-18					21.0		36	21				
270	110	S-19	6 6 6			269.8 / 110.0 End of Boring at 110 ft	20.2							*P200 = 96.8* *End 8/18/15*
265	115													
260	120													
255	125													
250	130													
245	135													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:44 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Date(s) Drilled	08/10/2015 12:00 AM to 08/11/2015 12:00 AM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	120.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198426.3 E 833270.9 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					379.0 / 0.0 [CREST WEARING SURFACE]								*Start 8/10/15*
						378.0 / 1.0 Gray to dark gray, crusher STONE, angular								
						[EMBANKMENT] Lean CLAY with Sand (CL), orange brown to brown, stiff, moist with little sand								
375	5	ST-1	P	75										
370	10	S-2	2 4 5	83			16.0							
365	15	S-3	2 4 5	61										
360	20	ST-4	P	83			17.2 15.8 14.7 15.7 16.6	132.2 133.3	36	22				*LV Su=5.2 ksf* *P200 = 83.8*
355	25	S-5	1 4 6	78			16.2		37	23				*P200 = 81.0*
350	30	S-6	6 4 8	94		consistency varies	16.3		34	20				

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:54 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
345		ST-7	P	100										
	35													
340		S-8	3 6 8	100			16.8							*P200 = 82.5*
	40													
335		S-9	2 4 5	100		with some sand	17.3		33	20				*P200 = 77.3*
	45													
														P200 = 83.8
330		ST-10	P	100			16.0 15.7 15.9 16.2	127.9 134.8 133.4	34	18			3.6	*End 8/10/15 at 5:00 PM* *Start 8/11/15 at 7:30 AM with Mud Rotary*
	50													
						325.5 / 53.5								
325		S-11	2 6 8	92		Sandy Lean CLAY (CL), stiff, and trace dark gray fine sand or ash	17.0		31	18				*P200 = 69.3*
	55													
						321.0 / 58.0								
						Lean CLAY with Sand (CL), orange brown, medium stiff, moist	19.9	134.6	37	23				*P200 = 81.5*
320		ST-12	P	100				106.0						
	60						57.9 29.0	119.5						
315		S-13	2 3 4				25.7		24	5				*P200 = 76.9*
	65					314.5 / 64.5 [ASH]								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:54 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
		ST-14	P	83		Silty CLAY with Sand (CL-ML), black, wet	25.2 22.7	123.3 123.7	25	6				*P200=80.4*
						312.0 / 67.0								
		S-15	10 8 12	100		Sandy SILT (ML), black, medium dense, wet	20.0							*P200 = 61.5*
310						310.0 / 69.0	28.2 21.3							
	70	ST-16	P	100		[FOUNDATION] Lean CLAY (CL), brown gray to gray brown, stiff, moist; occasional poorly-graded sand pockets; varying levels of sand	19.9 19.2	131.1	32	16				*P200 = 93.1*
305	75													*Drillers drilled through sample* *Drillers made mistake, no samples. Some soil recovered to confirm layer uniformity* *Drilled split spoon from 75' to 80'*
300	80													
		S-17	2 4 7	100										
295	85													
						290.5 / 88.5								
290	90	S-18	9 18 27	6		Silty SAND (SM), brown to brown orange, dense, medium to coarse sand, gravel in split spoon catcher with trace gravel								*Rattling and grinding of rig*
285	95	S-19	7 7 9	89		medium dense, brown gray to gray brown, wet, trace coarse sand	19.8		21	2				*P200 = 19.4*
						284.0 / 95.0								
280	100	S-20	16 29 27	61		Poorly Graded SAND (SP), brown to gray brown, very dense, wet, medium to coarse sand								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:54 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275	105	S-21	17 29 29	33		more coarse sand and gravel								*Grinding, rattling, shaking of drill rig*
270	110	S-22	28 50/5"	73		with 6" layer of brown to orange brown, fine to medium sand								
265	115	S-23	15 23 30	67										
260	120	S-24	22 25 23	56		Elevation (feet) 259.0 Depth (feet) 120.0 End of Boring at 120 ft								*End 8/11/15 at 4:45 PM*
255	125													
250	130													
245	135													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:25:54 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Date(s) Drilled	08/09/2015 12:00 AM to 08/09/2015 5:30 PM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	100.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379.9 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199345.5 E 833690.4 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					379.9 / 0.0 [CREST WEARING SURFACE]								*Start 8/9/15*
						378.9 / 1.0 Gray to dark gray, crushed rock, stone								
						[EMBANKMENT] Lean CLAY (CL), brown to orange brown, stiff, moist to dry, with trace sand								
		S-1	2 4 5	22										
375	5													
		ST-2	P	75			16.4 17.7	130.5 121.0 127.5					2.8	*Pushed 16"-18" /24" from stratum found by CPT* *P200 = 96.1*
370	10					dark gray brown to dark brown with trace coal (approximately 0.5" diameter)								
		S-3	3 5 7	83			17.3							
365	15					brown to brown orange								
		ST-4	P	83			19.6 19.9 20.1	 125.9 129.1	 37	 16				*Pushed Shelby 20"* *P200 = 95.3*
360	20													
		S-5	3 4 5	28		with trace coal (approximately 0.25" diameter)								
355	25													
		S-6	2 4 5	6										
350	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:04 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Elevation (feet)	Depth (feet)	Sample Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
		ST-7	P	94			15.8 21.4 20.0 18.7	124.0 128.6 129.6	38	19			2.4	*Pushed Shelby 18"* *P200 = 97.5*
345	35					344.9 / 35.0 [FOUNDATION] Lean CLAY (CL), brown to orange brown and gray, stiff, with varying sand								
		S-8	3 5 6	100			23.4		36	19				*P200 = 90.6*
		S-9	2 4 7	100			22.3		37	20				
340	40					with sand								
		ST-10	P	100			22.2 22.1 20.8	129.1						*LV Su=4.1 ksf*
335	45						20.9 20.6	129.4	39	25				*P200 = 81.2*
		S-11	2 4 6	100			19.3							*P200 = 90.4*
330	50													*Switch to mud rotary @ 50', cased through augers*
		S-12	2 4 6	100			23.3		35	20				
325	55													
		S-13	2 4 4	100										
320	60					gray to gray brown								
		S-14	3 5 6	100			19.7		33	20				*P200 = 89.0*
315	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:04 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						with sand								
310	70	S-15	3 7 9	100			16.4		31	19				*P200 = 77.9*
						306.9 / 73.0 Sandy CLAY (CL), gray, medium stiff, wet								
305	75	S-16	3 4 4	100			17.2		21	12				*P200 = 57.5*
						303.9 / 76.0 [FOUNDATION] Silty SAND (SM), gray, dense, wet								
300	80	S-17	12 22 20	100			15.3		19	1				*P200 = 23.9*
295	85	S-18	11 8 14	100										
		S-19	12 9 17	100		290.9 / 89.0 [FOUNDATION] Poorly graded SAND (SP), gray to gray brown, dense, wet								
290	90													
285	95	S-20	16 21 22	56										
						283.9 / 96.0 [FOUNDATION] Poorly graded SAND with Gravel (SP), brown to orange brown, very dense, wet								*Grinding noted. Rig rattling and shaking*
280	100	S-21	21 24 30	78		279.9 / 100.0								*End 8/9/15 at 5:30*

End of Boring at 100 ft

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:04 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275	105													*PM*
270	110													
265	115													
260	120													
255	125													
250	130													
245	135													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:04 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B006

Date(s) Drilled	08/18/2015 4:15 PM to 08/19/2015 10:15 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	40.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	357.1 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198964.5 E 833617 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					357.1 / 0.0								
355		S-1	2 4 5	44		[FILL] Silty SAND (SM), dark gray, loose, moist, little to no plasticity								*Start 8/18/15 at 4:15 PM*
	5					352.2 / 4.9								*Pushed Shelby 24", no recovery.*
350		S-2	3 5 6	67		[FOUNDATION] Lean CLAY (CL), burnt orange/brown, stiff, moist	25.2							*P200 = 98.3*
		ST-1	P	100			26.1 26.2 26.5	114.1	33	10				
345	10													*End 8/18/15 at 5:30 PM* *Start 8/19/15 at 7:30 AM*
		S-3	2 7 5	78										
340	15													
		S-4	2 5 8	78			18.9		39	24				
335	20													
		S-5	3 4 5	67										
330	25													
		ST-2	P	100			19.4 18.7 18.0	118.1	39	26				*P200 = 85.7*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B006

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30						17.4							
325														
		S-6	3 3 5	67			18.0							*P200 = 83.9*
	35													
320						320.1 / 37.0 Silty SAND (SM), beige, medium dense, moist								
		S-7	9 12 15	44			14.7							*P200 = 24.8*
	40					317.1 / 40.0 End of Boring at 40 ft								*End 8/19/15 at 10:15 AM*
315														
	45													
310														
	50													
305														
	55													
300														
	60													
295														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B007

Date(s) Drilled	08/11/2015 10:35 AM to 08/11/2015 1:45 PM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	347.6 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199326.6 E 833760.8 (ft NAD83)	Groundwater Level(s)	44.2 ft on 8/11/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					347.6 / 0.0								
						[FILL]								*Start 8/11/15 at 10:35 AM*
						346.6 / 1.0 Silty SAND with Gravel (SM)								
		S-1	2 3 4	83		[FOUNDATION] Lean CLAY (CL), gray with orange staining, stiff, moist, bits of root (wet)								
345														
		ST-1	P	100										*Pushed Shelby 20"*
	5													
		S-2	2 4 6	72			20.0		40	24				
340														
		ST-2	P	100			21.4 20.2 19.7 19.9 18.6 20.6	131.0 128.0 127.9 117.0	36	20				*Pushed Shelby 20"* *P200 = 93.1*
	10													
335														
		S-3	2 5 6	83		with sand	18.3		36	22				*P200 = 84.9*
	15													
330														
		S-4	2 5 7	83										
	20													
325														
		S-5	2 4 7	83			18.5		38	24				*P200 = 73.5*
	25													
320														
		ST-3	P	100		less sand	18.0 16.8	128.2 129.8	37	22				*LV Su=6.7 ksf* *Pushed Shelby 20"*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B007

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30						18.3 18.7							*P200 = 91.0*
315						gray, with sand								
		S-6	4 6 7	100			17.6		37	25				*P200 = 84.1*
	35													
310														
		S-7	0 2 4	100										
	40													
305														
		S-8	8 8 16	56		303.6 / 44.0 [FOUNDATION] Silty SAND (SM), gray, medium dense, wet, band of rust at 6" of split spoon	15.6		18	2				*P200 = 23.8* *Water observed on outside of split spoon*
	45													
300														
		S-9		100		no rust								*Attempted Shelby tube, recovered sample with split spoon* *End 8/11/15 at 1:45 PM*
	50					297.6 / 50.0 End of Boring at 50 ft								
295														
	55													
290														
	60													
285														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Date(s) Drilled	08/19/2015 2:50 PM to 08/20/2015 10:45 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	80.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	380.4 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198838.5 E 832101.2 (ft NAD83)	Groundwater Level(s)	38 ft on 8/19/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
380	0					380.4 / 0.0								
						[CREST WEARING SURFACE]								*Start 8/19/15 at 2:50 PM*
						379.4 / 1.0 Crushed stone, gray to dark gray								
						[FILL] Lean CLAY (CL), very soft, burnt orange, moist								
		S-1	1 0 0	100			24.3							
375	5					372.9 / 7.5								
						[EMBANKMENT] Lean CLAY (CL), firm, brown/orange, moist								
		ST-1	P	100			17.5							
							16.4	139.3						
370	10						20.0							
		S-2	3 5 4	33										
365	15													
		S-3	1 3 8	44			19.6		37	19				
360	20													
		S-4	5 8 13	39			17.1		39	20				*P200 = 96.9*
355	25						18.4	127.2						
		ST-2	P	100			17.6	129.5	41	23			2.7	
							18.8							*P200 = 91.2*
		S-5	5 7 13	44			17.3		41	23				*P200 = 93.5 Sand looks to be coal sand < 8%*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:25 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	30													
		S-6	2 2 3	100			25.8		34	14				
345	35					345.4 / 35.0 [FOUNDATION] Lean CLAY (CL), firm, gray with orange/brown pockets								
		ST-3	P	100			21.4 21.1 21.8 21.3 21.6 20.6	127.5 128.4 127.3 125.3					6.7	*Pushed Shelby 24", shows signs of water on top, also on outside of sample rod* *P200 = 95.8*
340	40	S-7	4 5 6	100		stiff								
		ST-4	P	100			23.1 22.4 22.2 22.0 22.3	96.8	42	26				*LV Su=2.6 ksf*
335	45													
		S-8	7 10 9	67		very stiff	17.6		35	20				*P200 = 91.0*
330	50													
		S-9	5 7 9	89		stiff								
325	55													*End 8/19/15* *Start 8/20/15 at 7:30 AM*
		S-10	4 5 8	100										
320	60													
		ST-5	P	100			16.3 16.0 17.6	135.9 130.1						*LV Su=2.4 ksf*
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:25 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
315							19.6							*P200 = 92.6*
							19.3							*P200 = 93.5*
						312.4 / 68.0								
						[FOUNDATION] Silty SAND (SM), gray/beige, medium dense, low plasticity								
		S-11	11 17 12	44			18.3							*P200 = 89.7*
310	70													
		S-12	8 11 18	50										
305	75													
						303.4 / 77.0								
						Silty, clayey, SAND (SC-SM), gray/beige, low plasticity								
							17.3							
		ST-6	P				16.3	135.6						*Pushed Shelby 20"*
							16.8		21	6				*LV Su=2.9 ksf*
							15.1							*P200 = 36.2*
300	80					300.4 / 80.0	14.2							*End 8/20/15 at 10:45 AM*
						End of Boring at 80 ft								
295	85													
290	90													
285	95													
	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:25 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B009

Date(s) Drilled	08/07/2015 12:00 AM to 08/08/2015 12:00 AM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	80.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	378.8 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 200368.5 E 833926.1 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					378.8 / 0.0 [CREST WEARING SURFACE]								*Start 8/7/15*
						377.8 / 1.0 Stone or crushed rock, gray to dark gray								
						[EMBANKMENT] Sandy Lean CLAY (CL), orange brown, stiff, moist to dry								
375		S-1	2 5 6	78			14.8							*P200 = 69.6*
	5													*End 8/7/15 at 5:20 PM* *Start 8/8/15 at 7:25 AM*
370		S-2	2 3 5	67										
	10													
						365.8 / 13.0								
365		ST-3	P	100		Lean CLAY with Sand (CL), orange brown, stiff, moist	14.8 16.9 15.2 15.5	134.2 140.3 134.9	34	20				*P200 = 76.5*
	15													
360		S-4	2 5 7	72			15.4		35	21				*P200 = 91.1*
	20													
355		S-5	2 6 9	28		some gravel								*Rock in sampler that was crushed*
	25					353.3 / 25.5								
						[FOUNDATION] Lean CLAY (CL), orange brown, stiff, moist								
350		ST-6	P	100										
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B009

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
		S-7	3 5 7	100		with sand	20.8		39	22				*P200 = 81.3*
345														
		S-8	5 7 9	100										
	35													
340		S-9	1 4 5	100			20.3		34	20				*P200 = 87.7*
	40													
335		S-10	3 7 7	100										
	45													
		ST-11	P	100			19.5 19.8 18.2 18.4 20.1	126.3 128.6 127.9	37	22			3.7	*P200 = 87.0* *Switched to mud rotary*
330	50													
325		S-12	4 5 7	100			21.3		38	25				*P200 = 94.5*
	55					322.8 / 56.0								
						Sandy Lean CLAY (CL), gray brown to brown gray, stiff, wet to moist								
320		S-13	5 6 8	100										
	60													
		ST-14	P	100			18.5 18.4 18.9	129.5 128.3					3.8	
315	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B009

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
							17.9 17.8	130.6	27	17				*P200 = 69.1*
310	70	S-15	2 3 6	100		310.3 / 68.5 Clayey SAND (SC), gray brown to brown gray, loose	18.7		29	18				*P200 = 46.7*
305	75	S-16	2 3 22	100		304.3 / 74.5 Silty SAND (SM), gray and brownish orange to orange, dense								
300	80	S-17	11 14 21	78		298.8 / 80.0 End of Boring at 80 ft	20.7		NP	NP				*P200 = 23.7* *End 8/8/2015 at 2:30 PM*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:33 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B010

Date(s) Drilled	08/06/2015 12:00 AM to 08/06/2015 12:00 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	350 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 201791.2 E 833794.1 (ft NAD83)	Groundwater Level(s)	42 ft on 8/6/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	0					350.0 / 0.0								
		ST-1	P			[FOUNDATION] Lean CLAY (CL), yellow, stiff, medium plasticity, with pockets of beige sand	20.7	122.5						*Start 8/6/15*
							20.2	122.5	37	22				*P200 = 88.6*
							19.8	119.2						
							18.1	122.5						
						346.5 / 3.5	18.0	122.6						
		S-1	2 5 5	89		Lean CLAY with Sand (CL), stiff, medium plasticity	18.5	124.8	38	23				*P200 = 82.6*
345	5													
		S-2	4 5 7	44										
		ST-2	P											*Pushed Shelby 10"*
340	10													*Driller notes harder to drill*
						336.5 / 13.5								
		S-3	3 7 12	50		Lean CLAY (CL), yellow, very stiff, pockets of sand more apparent less sand	15.2							*P200 = 87.6*
335	15													
						with sand								
		S-4	1 6 5	89			17.1		33	19				*P200 = 76.9*
330	20													
		S-5	3 4 5	100										
325	25													
						321.5 / 28.5								
		S-6	1 3 9	100		Sandy Lean CLAY (CL), stiff	17.6		26	16				*P200 = 52.9*
320	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:40 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B010

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
320	30													
		ST-3	P				15.8 16.1 15.1 15.8 16.7	120.3 132.4 130.5 132.9	27	16				*P200 = 53.5*
315	35													
		S-7	1 2 5	100										
310	40													
		S-8	3 6 8	100		Layer of silty sand, 6" thick								
305	45					303.5 / 46.5								
						[FOUNDATION] Poorly Graded SAND with Silt (SP-SM), beige								
		S-9		100			27.6		NP	NP				*Pushed Shelby 18", no recovery. Split spoon recovered sample.* *P200 = 9.9* *End 8/6/15*
300	50					300.0 / 50.0 End of Boring at 50 ft								
295	55													
290	60													
285	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:40 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B011

Date(s) Drilled	08/06/2015 12:00 AM to 08/07/2015 12:00 AM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	80.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	380 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 201732.5 E 833659.5 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
380	0						380.0 / 0.0								
							379.2 / 0.8 [CREST WEARING SURFACE] Crushed rock surface, gray to dark gray								*Start 8/6/15*
							[EMBANKMENT] Lean CLAY with Sand (CL), brown to orange brown, soft, dry to moist								
		S	S-1	1 1 2	67										
375	5														
		ST	ST-2	P	75		372.0 / 8.0 Lean CLAY with Sand (CL), gray brown to dark brown, moist, contains organic matter								
370	10														
							367.0 / 13.0 Lean CLAY with Sand (CL), orange brown to brown, stiff, moist to dry, contains pockets of gray sand								
		S	S-3	1 4 8	56			16.0		34	18				*P200 = 83.6*
365	15														
		S	S-4	5 7 4	22		with gravel, dry								*Rough drilling*
360	20														
							357.0 / 23.0 Lean CLAY (CL), gray brown, firm, moist								
		ST	ST-5	P	100			17.8 17.8 18.2 18.0	126.1 126.5 129.4	33	15			2.8	*P200 = 92.7* *End 8/6/15* *Start 8/7/15*
355	25														
		S	S-6	2 4 4	44		with sand	18.5							*P200 = 84.1*
350	30						350.0 / 30.0								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:45 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B011

Elevation (feet)	Depth (feet)	SAMPLES Type Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	30					[FOUNDATION] Lean CLAY (CL) gray brown to brown and orange brown,, firm, varying gray sand content								
		S-7	2 4 7	61			22.6		36	15				*P200 = 97.7*
345	35													
		S-8	2 6 6	61		with sand	19.9							*P200 = 83.6*
340	40													
		ST-9	P	100		less sand	17.1 18.0 18.8 18.7 18.3	128.6 128.9	36	22				*P200 = 87.6*
335	45													
		S-10	1 5 7	100		with sand	17.5		35	21				*P200 = 79.6*
330	50													
		S-11	3 4 5	33		326.5 / 53.5 Sandy Lean CLAY (CL), brown to orange brown, stiff	22.6		34	23				*P200 = 54.9*
325	55													
		S-12	7 7 8	100										
320	60													
		S-13	2 4 4	100		316.5 / 63.5 Clayey SAND (SC), brown to brown orange, loose, with dark orange clayey sand pockets, moist								
315	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:45 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B011

Elevation (feet)	Depth (feet)	SAMPLES Type Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
							20.2							
		ST-14	P	100			17.4	125.3						*LV Su=2.2 ksf*
310	70						16.8							
							16.6	130.2	34	23				*P200 = 45.3*
							16.4							
		S-15	3 5 8	100										
305	75													
						303.8 — 76.2 Poorly Graded SAND with Silt (SP-SM), gray to brown gray, very dense, wet								
		S-16	22 28 30											
300	80					300.0 — 80.0 End of Boring at 80 ft								*End 8/7/15*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:45 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B012

Date(s) Drilled	08/04/2015 12:00 AM to 08/06/2015 12:00 AM	Logged By	BNF	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD 6" ID HSA, 4.25" ID steel-cased mud rotary	Drill Bit Size/Type	Tricone bit, bear claw	Borehole Depth	80.0 ft
Drill Rig Type	CME 850 track-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379.6 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 201111 E 832753.5 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						379.6 / 0.0								
	0					379.1 / 0.5 [CREST WEARING SURFACE] Crushed rock or stone, gray to dark gray								*Start 8/4/15*
						[EMBANKMENT] Lean CLAY with Sand (CL), brown to orange brown, very stiff, moist								
375	5	ST-1	P	89										
		S-2	4 11 11	31										*Poor recovery, same material*
370	10													
365	15	ST-3	P				16.7 17.9 16.6 17.7 17.4	130.8 131.6 131.9	37	24				*LV Su=3.1 ksf* *P200 = 72.8*
		S-4	3 6 8	78		occasional pockets of poorly-graded sand	16.2		35	19				*P200 = 78.7*
360	20													
		S-5	4 5 7	39			15.3							*P200 = 78.6*
355	25													
						351.1 / 28.5								
		S-6	5 8 13	78		Lean CLAY (CL), brown to orange brown, very stiff, moist	17.0		38	20				*P200 = 91.7*
350	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:53 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B012

Elevation (feet)	Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30					349.1 / 30.5 [FOUNDATION] Lean CLAY (CL), gray brown to brown gray, firm, moist, organics/roots present								*Poor recovery. Tip was soft.*
		S-7	2 4 2	11										
		ST-8	P	100			27.3 28.7 28.8 29.4	121.0 120.8	40	21			0.5	
345	35					345.6 / 34.0 Lean CLAY (CL), gray brown to brown, stiff, moist, becomes brown with frequent gray to light gray sand lenses	29.1							*P200 = 98.2*
		S-9	8 8 6	100			26.1		33	12				*P200 = 95.9*
		ST-10	P	100										
340	40													*Switch to mud rotary @ 40' bgs*
		S-11	4 4 4	100		light brown gray to brown gray with orange and brown throughout	21.0		44	30				*P200 = 91.7*
335	45					331.1 / 48.5 Sandy Lean CLAY (CL), gray brown to gray, stiff, moist								*P200 = 69.3*
		S-12	5 5 6	100			21.7							
330	50													*Casing pushed to 50'*
		ST-13	P	100			18.6 16.8 17.0 17.0 17.4 17.4	132.3 135.8 132.0	27	15				*LV Su=3.5 ksf* *P200 = 63.9* *End 8/4/15 at 5:00 PM* *Start 8/5/15*
325	55													
		S-14	8 11 24	100		321.6 / 58.0 Clayey SAND (SC), brown to orange brown, dense, gravel present	17.3		33	22				*End 8/5/15 due to storm* *Start 8/6/15* *P200 = 36.7*
320	60													
						316.6 / 63.0 Lean CLAY with Sand (CL), brown orange to brown and gray, stiff, moist								
		S-15	3 4 5	100										
315	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:53 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B012

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
		ST-16	P	100		with some gravel	21.2 20.2 18.2 20.0	126.5 126.8	33	20				*P200 = 62.7*
310	70	S-17	2 3 6	100										
305	75	S-18	2 3 3	100		303.6 / 76.0 Poorly Graded SAND (SP), brown to gray brown, dense, moist								
300	80	S-19	2 16 24	78		299.6 / 80.0 End of Boring at 80 ft								*End 8/6/2015 at 11:00 AM* *End 8/6/15*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:26:53 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Date(s) Drilled	08/21/2015 12:30 PM to 08/22/2015 10:45 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	80.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	379.3 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 200176.2 E 832128.5 (ft NAD83)	Groundwater Level(s)	73 ft on 8/21/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					379.3 / 0.0 [CREST WEARING SURFACE]								*Start 8/21/15 at 12:30 PM*
						378.3 / 1.0 Crushed rock or stone, gray to dark gray								
						[EMBANKMENT] Sandy Lean CLAY with sand (CL), brown to orange brown, stiff, moist								
375		S-1	3 6 7	33										
	5													
370		S-2	3 5 10	39			14.7							*P200 = 67.8*
	10													
365		ST-1	P	100			15.9 16.1 15.8 15.4	147.4						
	15													
						with light gray stones/gravel								
360		S-3	50/2"	0		360.3 / 19.0 [EMBANKMENT] Lean CLAY (CL), very stiff, brown to orange-brown, moist								*Lots of chatter on augers Could not auger with center punch HSA. Only pulled 4 1/4 plugs of light, gray stones*
	20					357.3 / 22.0 [FOUNDATION] Lean CLAY (CL), stiff, gray, moist								
355		S-4	1 3 6	72			23.1							*P200 = 95.8*
	25													
350		ST-2	P	100			21.6 21.1 21.9 19.9	114.4	33	13				
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:01 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
345		S-5	2 5 5	78			20.8		38	21				
	35													
340		S-6	4 5 7	89		gray with orange streaking								
	40						18.9							
		ST-3	P	100			20.5 20.7 19.9	125.1	35	19				
335		S-7	3 4 5	100			19.8							*P200 = 85.4*
	45													
330		S-8	2 4 5	100										
	50													
325		S-9	12 25 42	78		with sand and gravel	12.7		27	16				
	55													
320		S-10	2 2 5	100			19.5		37	24				
	60					316.8 / 62.5								
						Sandy Lean CLAY (CL), gray with orange/rust streaks, stiff, moist								
315		S-11	5 5 6	100										
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:01 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310	70	S-12	3 5 8	100			17.1							*P200 = 50.9*
						307.3 / 72.0 Silty SAND (SM), tan with streaks of orange, dense, saturated ▽								
305	75	S-13	9 17 18	67			16.3							*Split spoon saturated with water* *P200 = 27.9*
300	80	S-14	9 27	100		300.3 / 79.0 Poorly-graded SAND with Gravel (SP) 299.3 / 80.0 End of Boring at 80 ft								*End 8/22/15 at 10:45 AM*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:01 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B014

Date(s) Drilled	08/07/2015 12:00 AM to 08/07/2015 12:00 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	361.8 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 200225.8 E 832001.4 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0						Elevation (feet) 361.8 / Depth (feet) 0.0								
360		S	S-1	6 5 3	11		[FILL] Clayey SAND with Gravel (SP), brown to dark gray, loose								*Start 8/7/15*
							358.8 / 3.0								
		ST	ST-1	P	80		[FOUNDATION] Lean CLAY (CL), burnt orange/yellow, stiff, sand is vertical vein and beige in color								*Pushed Shelby 20"*
	5														
355		S	S-2	2 4 5	78			23.4		31	9				*P200 = 96.8*
		ST	ST-2	P	100			23.3	123.9						*Pushed Shelby 20"*
								20.8							
	10							20.7							*LV Su=2.1 ksf*
								20.8	126.8	33	13				*P200 = 91.8*
350								21.5							
		S	S-3	2 5 5	67										
	15														
345															
		S	S-4	2 4 5	89			20.1		47	33				*P200 = 88.8*
	20														
340							339.8 / 22.0								
							Lean CLAY with Sand (CL), burnt orange/yellow, stiff, moist								
		S	S-5	3 5 7	78										
	25														
335															
		S	S-6	2 4 5	100		mostly beige	20.8		39	24				*P200 = 85.0*
	30														

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B014

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
330	30					329.8 / 32.0 Clayey SAND (SC), gray with orange mottling, stiff, moist, noticeable flakes of rust, in various states of decomposition	14.9	126.7	26	15				
		ST-3	P	100			13.8 14.1	130.4						*Pushed Shelby 20", crumpled at tip. Inverted for wax plug.*
	35						14.9 17.4 16.1	130.2					4.3	*P200 = 45.2*
325		S-7	4 4 4	100										
	40					318.8 / 43.0 Sandy Lean CLAY (CL), gray with orange mottling, moist, with flakes of rust	17.2 18.8	132.6						*Pushed Shelby 20" LV Su=3.4 ksf*
		ST-4	P	100			17.6 17.9 16.7	132.5	33	21				*P200 = 63.7*
315	45													
		S-8	5 6 7	100			16.2		26	15				*P200 = 54.6*
	50					311.8 / 50.0 End of Boring at 50 ft								*End 8/7/15*
310														
	55													
305														
	60													
300														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Date(s) Drilled	08/20/2015 1:15 PM to 08/20/2015 12:00 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	HSA/Mud rotary	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	80.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	380.3 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199187.8 E 831795.1 (ft NAD83)	Groundwater Level(s)	43 ft on 8/20/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
380	0					380.3 / 0.0 [FILL] Poorly Grades SAND with Silt (SP-SM)								*Start 8/20/15 at 1:15 PM*
		S-1	3 7 7	33										
375	5					373.3 / 7.0 [EMBANKMENT] Lean CLAY (CL), orange brown to brown, stiff, moist, contains some silt and sand								
		S-2	2 4 7	67			19.4		41	25				
370	10													
		S-3	3 7 7	33										
365	15													
		ST-1	P				17.4 16.5 16.5 16.8 18.7	132.2 128.9 128.4	38	21				*LV Su=4.1 ksf*
360	20					burnt orange/gray								
		S-4	4 8 11	50		very stiff	16.7							*P200 = 94.1*
355	25													
		S-5	4 8 9	33		351.8 / 28.5 [FOUNDATION] Lean CLAY (CL), burnt orange/gray, very stiff, moist								
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Elevation (feet)	Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	30					reddish brown								
		S-6	1 4 6	89		stiff	8.5		33	13				
345	35													
						firm, gray with orange vertical streaking								
		S-7	2 3 4	89			20.8							
340	40													
		ST-2	P	100			23.8 23.7 23.3 23.0	125.0 122.7						
		S-8	2 2 2	100		wet	22.7							
335	45													
		ST-3	P				21.4 21.1 20.1 20.6 19.5	126.3 128.0	31	16				*LV Su=1.6 ksf*
		S-9	2 2 4	100										
330	50													
		S-10	3 5 6	100										
325	55													
		S-11	4 6 6	100										
320	60													
		S-12	3 6 7	100		316.8 / 63.5 Silty SAND (SM), beige, medium dense, saturated	17.2							*P200 = 48.4*
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
315						314.8 / 65.5 [FOUNDATION] Sandy Lean CLAY (CL), gray with burnt orange vertical streaking, stiff								
							22.4							
		ST-4		100			19.9	124.9						
							21.4	124.7						*P200 = 91.0*
310	70						21.5							
						Lean CLAY with Sand (CL), gray, stiff, with orange mottling and vertical streaking								
		S-13	5 5 4	100			18.6		26	11				*P200 = 62.8*
305	75													
		S-14	3 3 5	100			24.3		35	19				
300	80					300.3 / 80.0 End of Boring at 80 ft								*End 8/7/15*
295	85													
290	90													
285	95													
	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:14 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B016

Date(s) Drilled	08/09/2015 12:10 PM to 08/09/2015 3:45 PM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	40.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	352.1 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198570.8 E 832362 (ft NAD83)	Groundwater Level(s)	6.17 ft on 8/9/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					352.1 / 0.0 [FILL]								*Start 8/9/15 at 12:10 PM*
						351.1 / 1.0 Crushed stone and gravel with silt and sand								
350		S-1	3 4 6	33		Lean CLAY (CL), blue green, stiff, moist, some organic material								
						348.1 / 4.0								
		ST-1	P	80		[FOUNDATION] Lean CLAY (CL), blue green, stiff, moist	25.2	120.9	33	12				*Pushed Shelby 20"*
	5						25.8	124.2					1.1	
							25.8	123.7						*P200 = 98.3*
							26.6							
345		S-2	2 3 5	44		with burnt orange	21.1		30	10				*Water observed on split spoon ~10" up from bottom* *P200 = 96.3*
		ST-2	P	80										*Pushed Shelby 20"*
	10													
340														
		S-3	1 6 6	50		wet								
	15													
335														
		S-4	3 6 7	50			21.1		30	14				*P200 = 90.0*
	20													
330														
		ST-3	P			gray	23.0							
							19.7	127.5	35	20				*LV Su=1.1 ksf*
							19.5	131.3						*P200 = 98.8*
	25						19.2	129.1						*Pushed Shelby 20"*
							19.1	127.5						
							17.6	129.2						
325							18.2							
		S-5	1 5 5	67			21.3		40	26				*P200 = 97.0*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:21 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B016

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
320	30													
							21.0							
							20.1							
		ST-4	P				18.0	134.3	27	10				*Pushed Shelby 20"*
	35						18.1	129.2						*P200 = 88.1*
315														
		S-6	2 3 3	100										
	40					312.1 / 40.0 End of Boring at 40 ft									*End 8/9/15 at 3:45 PM*
310														
	45													
305														
	50													
300														
	55													
295														
	60													
290														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:21 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B017

Sheet 1 of 2

Date(s) Drilled	08/10/2015 8:00 AM to 08/10/2015 10:30 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	40.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	347.2 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198369.4 E 832674.8 (ft NAD83)	Groundwater Level(s)	38 ft on 8/10/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					347.2 / 0.0 [FILL] Lean CLAY (CL), brown gray, very stiff, moist								*Start 8/10/15 at 8:00 AM*
345		S-1	1 2 16	56		with fine sand								
		ST-1	P	80										*Pushed Shelby 20"*
	5					342.2 / 5.0 [ASH] SILT with Sand (ML), dark gray, very loose, moist, with chips of coal								
340		S-2	1 1 1	67			30.8		NP	NP				*Appears to be fly ash. Chips of coal in tip of split spoon P200 = 83.1*
						339.2 / 8.0 [FOUNDATION] Sandy Lean CLAY (CL), yellow brown, very soft, moist	22.5	123.0	33	16				
		ST-2	P	90			17.1	129.6						*Pushed Shelby 20" P200 = 67.1*
	10													
335														
		S-3	WOR	89			23.7		38	20				*P200 = 94.7*
	15					reduced sand content								
330						329.2 / 18.0 Sandy Lean CLAY (CL), brown, firm, moist								
		S-4	4 6 8	100										
	20													
325														
						reduced sand content	17.9							*Pushed Shelby 20"*
		ST-3	P	80			21.4	128.5						
	25						20.3 21.3	127.2	34	20				*P200 = 93.3*
320														
		S-5	2 2 6	100			19.5		35	23				*P200 = 60.4*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:26 PM

AECOM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B017

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
315	30					gray, specks of rust, streaks of orange								
		ST-4	P				15.2 15.0 17.4 21.2	136.4 128.1	35	21				*Pushed Shelby 20"* *P200 = 82.4*
310	35					▽								*Water returned to surface*
		S-6	2 4 5	100										
	40					307.2 / 40.0 End of Boring at 40 ft								*End 8/10/15 at 10:30 AM*
305	45													
300														
	50													
295														
	55													
290														
	60													
285														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:26 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Date(s) Drilled	08/20/2015 12:00 AM to 08/21/2015 12:00 AM	Logged By	SWB	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD HSA/4.25" OD Mud rotary	Drill Bit Size/Type	Tricone bit, bent claw	Borehole Depth	80.0 ft
Drill Rig Type	CME 850 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	378.6 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198450.7 E 832716.5 (ft NAD83)	Groundwater Level(s)	43 ft on 8/21/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					378.6 / 0.0 [CREST WEARING SURFACE]								*Start 8/20/15*
						377.6 / 1.0 Crushed stone, sand, silt, gray to dark gray								
						[EMBANKMENT] Lean CLAY (CL), brown/gray with gray mottling, stiff								
375		ST-1	P				14.6 15.1	145.5						
	5													
370			3 4 6											*No recovery*
	10	S-1	3 5 6	78			14.0		38	25				
365														*No recovery*
	15	S-2	2 5 8	72										
360		ST-2	P	71			15.4 14.7 15.0	130.8						*P200 = 90.6*
	20													
355		S-3	4 7 9	89										
	25													*End 8/20/15* *Start 8/21/15*
350		S-4	3 5 7	94			15.2		37	24				
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
345		ST-3	P	100			13.5 13.5 17.7 15.6	132.1 133.9	38	24			4.5	
	35													
340		S-5	2 8 8	89		with sand, very stiff	14.2							*P200 = 75.3*
	40													
335		S-6	3 9 14	89		with 2" seam of sand and gravel	17.3		35	21				
	45													
330		ST-4	P	75			17.5 16.8 16.6	135.8	35	20				
	50					328.6 / 50.0 [FOUNDATION] Lean CLAY (CL), gray, firm, moist, with some sand								*Switch to mud rotary*
325		S-7	2 3 3	89			25.7		44	25				
	55													
320		ST-5	P	100			44.4 19.6 17.8 16.8	141.3						*P200 = 88.6* *Pushed Shelby 18"*
	60													
315		S-8	1 2 4	100		less sand								
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310	70	S-9	2 3 2	100										
305	75	S-10	1 2 2	100			21.5							*P200 = 89.7*
						303.1 / 75.5 [FOUNDATION] Silty SAND (SM), gray/orange, medium dense, fine to medium sand								
300	80	S-11	13 9 9	89		298.6 / 80.0 End of Boring at 80 ft	19.5		NP	NP				*End 8/21/15*
295	85													
290	90													
285	95													
280	100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:32 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Date(s) Drilled	08/08/2015 10:44 AM to 08/09/2015 9:10 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	HSA/Mud rotary	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	100.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	376.1 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199211.3 E 832989.8 (ft NAD83)	Groundwater Level(s)	6 ft on 8/8/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					376.1 / 0.0 [ASH] Sandy SILT to SILT (ML), gray to dark gray, very loose, wet, non-plastic								*Start 8/8/15 at 10:44 AM*
375		S-1	1 0 1	100			48.2		NP	NP				*P200 = 51.4*
	5					▽								*Observed water*
370									NP	NP				*P200 = 94.5*
		ST-1	P	10			106.0	87.7						*Pushed Shelby 20"*
	10													
365														
		S-2	0 1 1	100			102.0		NP	NP				
	15													
360														
		S-3	WOR	100										
	20													
355														
		S-4	WOR	100										*Switch to mud rotary*
	25													
350														
		S-5	WOR	100			43.4							*P200 = 97.6*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:39 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
345	30													
		S-6												*Pushed Shelby 20". Sample fell out of tube, recovered with split spoon*
340	35													
		S-7	WOR	100			36.8		NP	NP				*P200 = 70.8*
335	40						41.8	109.6						
		ST-2	P	50			46.0	102.9	NP	NP				*P200 = 83.5*
330	45						54.5	106.8						*Pushed Shelby 20"*
		S-8	WR	100										
325	50					325.1 / 51.0 [FOUNDATION] Sandy Lean CLAY (CL), yellow, stiff, wet								
		S-9	10 5 4	100			18.9							*Driller reports drilling getting harder P200 = 64.2*
320	55	S-10												*Pushed Shelby 20". Sample fell out of tube at surface. Bagged and labeled.*
		S-11	2 3 4	33			17.7		24	13				*P200 = 61.1*
315	60	ST-3	P	75		vibrant orange, moist/saturated, medium sand								*Pushed Shelby 20"*
		S-12	10 15 20			312.1 / 64.0 Silty SAND (SM), gray, dense, wet								
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:40 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310														
		S-13	15 19 17	28										
	70													
305						304.1 / 72.0								
						Silty CLAY with Sand (CL-ML), gray, stiff, low to medium plasticity, fine sand, vertical orange stripping								
		S-14	1 6 6	100			20.9		22	6				*P200 = 71.5*
	75													
300						299.1 / 77.0								
						Poorly-Graded SAND with Clay (SP-SC), yellow, very dense, medium to coarse sand, angular								
		S-15	17 28 21	56										*Shelby tube will not advance. Retrieve sample with split spoon. Drilling mud possibly not allocating sample to enter split spoon. Check valve working correctly.*
	80													
295														
		S-16	14 26 30	28			13.3		33	16				*End 8/8/15 at 5:20 PM* *P200 = 7.6*
	85													*Start 8/9/15 at 7:20 AM* *15ft of hole collapsed over again. Redrill.*
290														
		S-17	24 24 23	33										
	90													
285														
		S-18	11 10 11	33										
	95													
280						278.1 / 98.0								
						Poorly-Graded SAND with Gravel (SP), burnt yellow/orange, dense, angular								
		S-19	13 19 18	33										*End 8/9/15 at 9:10 AM*
	100					276.1 / 100.0								

End of Boring at 100 ft

AECOM

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:40 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Date(s) Drilled	08/19/2015 12:00 AM to 08/20/2015 12:00 AM	Logged By	SWB	Checked By	Vonmarie Martinez
Drilling Method	10.25" OD HSA/4.25" OD Mud rotary	Drill Bit Size/Type	Tricone bit, bent claw	Borehole Depth	100.0 ft
Drill Rig Type	CME 850 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	378.1 ft NAVD88
Borehole Backfill	Grout with piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198337.4 E 832996 (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					378.1 / 0.0 [CREST WEARING SURFACE]								*Start 8/19/15*
						377.1 / 1.0 Crushed stone with Gravel and Sand, gray to dark gray								
						[EMBANKMENT] Lean CLAY (CL), brown/gray, moist, stiff								
375		ST-1	P	50			16.5 15.3 15.8	134.3 129.9	35	19			4.8	*LV Su=6.8 ksf*
	5													
370		S-1	3 4 6	72										
	10													
365		S-2	2 3 4	72			16.2		36	21				
	15													
360		ST-2	P	79		with gray mottles	15.7 13.7 15.3	129.5 130.3						*P200 = 97.8*
	20													
355		S-3	2 5 8	94										
	25													
350		S-4	3 4 12	89			14.3							*P200 = 95.6*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:47 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
345		ST-3	P	100			15.2 18.0 14.6 16.7	138.7	34	21				
	35													
340		S-5	6 8 13	100										
	40													
335		S-6	3 8 11	100			14.0		34	21				
	45													
330		ST-4	P	100			15.5 15.9 12.6 13.3	131.9 134.0	31	17				*Switch to mud rotary at 50'*
	50													
325		S-7	4 9 7	100		with occasional layers of clayey sand	20.2							*P200 = 93.1*
	55													
320		S-8	2 4 5	100			20.7		38	25				
	60													
315		S-9	4 5 7	100		gray to dark gray 313.6 64.5 [FOUNDATION]	20.9		36	23				*Bottom 4" appears to be ash*
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:47 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						Lean CLAY with Sand (CL), brownish gray to gray, stiff, moist								
310		ST-5	P	100			25.9 18.8 17.5	128.9 128.6						
	70	S-10	2 3 6	100			18.2 22.8		41	29				*P200 = 82.9*
305						305.1 / 73.0								
		S-11	15 21 12	67		Clayey SAND with Gravel (SC), gray, dense								
						303.7 / 74.5								
	75					Poorly-Graded SAND with Gravel (SP), dense, brown/gray, moist								
300		S-12	12 15 21	72		gray, fine to medium	21.4							*P200 = 7.7*
	80													
295						more gravel								
		S-13	13 21 33	67		orange								
	85													
290														
		S-14	6 18 17	61										
	90													
285														
		S-15	12 32 50	56										
	95													
280														*Sand and gravel keeps collapsing in the boring. Can't advance below 100'*
	100					278.1 / 100.0								

End of Boring at 100 ft

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:48 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275	105													*End 8/20/15*
270	110													
265	115													
260	120													
255	125													
250	130													
245	135													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:48 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B021

Date(s) Drilled	08/17/2015 2:45 PM to 08/18/2015 9:30 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	50.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	344 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198247.4 E 832969.4 (ft NAD83)	Groundwater Level(s)	7 ft on 8/17/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					344.0 / 0.0 [FILL] Lean CLAY with Sand (CL), gray, soft, moist								*Start 8/17/15 at 2:45 PM*
		S-1	1 2 1	100			19.5							
340		ST-1	P	100			16.6 15.0	129.6 126.8 131.5	39	26				*LV Su=2.3 ksf*
	5					338.0 / 6.0								
		S-2	1 1 1	67		[ASH] SILT (ML), gray, soft to medium stiff, wet, low plasticity ▽ 6" layer of clay at 6'	23.7		42	26				
335		S-3		0			49.8		NP	NP				*Pushed Shelby 24". No recovery in Shelby Tube, Split Spoon used to recover sample. Outside of Split Spoon shows water*
	10													
						330.5 / 13.5								
330		ST-2	P	100		[FOUNDATION] Sandy Lean CLAY (CL), light gray with patches of orange, very cohesive, low to medium plasticity	44.8 25.1 24.7 23.1	106.9 118.4 124.3 125.4						*Piston sampler, pushed 24" P200 = 99.0*
	15													
325		S-4	2 4 4	100										
	20													
320		S-5	0 1 5	89			21.0							*P200 = 90.7*
	25													
315		S-6	2 1 3	100										
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:58 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B021

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30													
310		ST-3	P	100			16.3 14.7 15.0 17.6 18.9	135.0 127.6	22	9				*Piston sampler, pushed 24"* *P200 = 62.2* *LV Su=3.0 ksf*
	35													
305		S-7	4 7 8	100										
	40													*End 8/17/15 5:30 PM* *Start 8/18/15 8:00 AM*
300		S-8	5 6 7	100			18.0		25	9				
	45													
						296.0 / 48.0								
295		S-9	1 2 4	44		Poorly-Graded SAND with Silt (SP-SM), beige, loose, wet	17.7		NP	NP				*P200 = 8.2*
	50					294.0 / 50.0 End of Boring at 50 ft								*End 8/18/15 at 9:30 AM*
290														
	55													
285														
	60													
280														
	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:27:58 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B022

Sheet 1 of 2

Date(s) Drilled	08/07/2015 4:00 PM to 08/08/2015 8:45 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	40.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	353.4 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 199227.6 E 831636.1 (ft NAD83)	Groundwater Level(s)	21.5 ft on 8/8/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					353.4 / 0.0								
						[FILL] Poorly-Graded SAND with Silt (SP-SM)								*Start 8/7/15 at 4:00 PM*
						351.9 / 1.5								
		S-1	2 3 5	39		[FOUNDATION] Lean CLAY (CL), burnt orange/brown, firm, moist, medium plasticity								
350		ST-1	P	100										*Pushed Shelby 20"*
	5													
		S-2	2 3 4	89		yellow brown, higher plasticity	23.9							*P200 = 96.7*
							22.4	127.1						
345		ST-2	P				20.8	128.3					2.3	*P200 = 93.7*
							21.5	132.2	35	17				
	10						21.3	128.2						
							21.7							
							21.4							
340		S-3	2 4 4	100										*12" of split spoon wet on recovery*
	15													
335		S-4	2 3 3	78			20.6		35	20				*Split spoon dry on recovery*
	20													*End 8/7/15*
						▽								*Start 8/8/15 at 7:30 AM*
														Augers pulling significant water up
330		ST-3	P	100			19.7	127.3						*Pushed Shelby 20"*
							19.3	129.1					1.8	
	25						18.9	130.6	38	24				*P200 = 92.4*
							19.5							
325		S-5	4 7 9	83		with sand	15.9							*P200 = 80.1*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:03 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B022

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
320	30													
	35	S-6	2 3 5	100		beige, with more fine sand								
315	40	ST-4	P			314.1 / 39.3 Silty SAND (SM), beige, bottom of ST. 313.4 / 40.0 End of Boring at 40 ft	14.9 18.0	131.8 123.2	23	9			2.2	*P200 = 71.0* *Pushed Shelby 15"* *End 8/8/15 at 8:45 AM*
310	45													
305	50													
300	55													
295	60													
290	65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:03 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023

Date(s) Drilled	08/04/2015 8:25 AM to 08/06/2015 10:15 AM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	HSA/Mud rotary	Drill Bit Size/Type	4 3/4 in HSA	Borehole Depth	100.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	341.5 ft NAVD88
Borehole Backfill	Bentonite/Grout & piezometer	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	N 198526.7 E 833473.7 (ft NAD83)	Groundwater Level(s)	13 ft on 8/4/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						Elevation (feet) 341.5 / Depth (feet) 0.0								
340	0					[ASH] Mixed layers of SILT to SILT with Sand (ML) and Sandy SILT, gray to dark gray, very loose, low plasticity to non-plastic, wet								*Start 8/4/15 at 8:25 AM*
		S-1	1 2 1	11										
335	5													
		S-2	2 0 1	11										
330	10					▽								
		S-3					26.6		NP	NP				*Pushed Shelby 20", no recovery. Sample recovered with split spoon. P200 = 94.5*
325	15													
		S-4	1 0 1	100										
320	20													
		S-5	WOR	67			31.3							*P200 = 57.4*
315	25													
		S-6	WOR	0										
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
310	30													
	35	S-7	WOR	11										*16"/18" drilling mud*
305														
	40	S-8	WOR	11			37.6		NP	NP				*P200 = 97.3* *16"/18" driling mud*
300						300.5 / 41.0 Mixed Lean CLAY (CL) and Silt (ML), gray, moist								
		ST-1	P	100			57.5 27.1	104.2 109.9 123.2	32	10				*Pushed Shelby 5"* *P200 = 93.0*
	45													
295							20.5							
		ST-2	P	93		292.5 / 49.0 [FOUNDATION] Clayey SAND (SC), yellow-orange loose	20.9 19.9 13.6 18.1	129.6 137.9 132.1	35	21			2.2	*Pushed Shelby 21"* *P200 = 74.0*
290	50													
	55	S-9	3 4 4	100		some coarse sand, rounded to subrounded	17.4		22	12				*P200 = 49.7*
285														
	60	S-10	4 3 4	100										
280														
	65	S-11	4 4 4	100		with moist to wet, pockets of poorly-graded sand	19.9							*P200 = 49.7*

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
275						273.0 / 68.5								
		S-12	5 4 5	100		[FOUNDATION] Clayey SAND (SC), yellow orange, stiff, moist	19.5		28	17				*P200 = 52.4*
270	70													
		S-13	2 2 4	100		mostly clay	24.5							*P200 = 93.1*
265	75					264.5 / 77.0								
		S-14	8 8 9	100		Clayey SAND (SC), yellow-orange, medium dense, moist	16.7							*P200 = 37.5*
260	80					258.5 / 83.0								
		S-15	8 50/5"	0		Poorly Graded SAND with Silt (SP-SM) to Poorly-Graded SAND (SP), yellow orange, very dense, with gravel								*Driller reports gravel in cuttings return at 83'*
255	85													
		S-16	22 22 12	33										
250	90					with less silt								
		S-17	11 13 20	11										*16"/18" drilling mud*
245	95													
		S-18	20 40 50/5"	88		241.5 / 100.0								*End 8/9/15 at 10:15 AM*
	100					End of Boring at 100 ft								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:08 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023B

Sheet 1 of 1

Date(s) Drilled	08/19/2015 11:30 AM to 08/19/2015 1:30 PM	Logged By	Gabriel Cuestas	Checked By	Vonmarie Martinez
Drilling Method	HSA	Drill Bit Size/Type	4 1/4 in HSA	Borehole Depth	25.0 ft
Drill Rig Type	CME 75 truck-mounted	Drilling Contractor	Geotechnology, Inc.	Surface Elevation	380.4 ft NAVD88
Borehole Backfill	Cuttings	Sampling Method(s)	SPT, Shelby Tube	Hammer Data	N/A
Boring Location	N 200678.4 E 833168.4 (ft NAD83)	Groundwater Level(s)	22.5 ft on 8/19/2015		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						Elevation (feet) 380.4 / Depth (feet) 0.0								
380	0					[ASH] Dark gray SILT, moist								*Start 8/19/15 at 11:30 AM*
		ST-1		83										
375	5													
		ST-2		38										
370	10													
		ST-3		92		Saturated								
365	15													
		ST-4		88										
360	20													
		ST-5		100										
355	25					355.4 / 25.0 End of Boring at 25 ft								*End 8/19/15 at 1:30 PM*
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:16 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B024

Date(s) Drilled	03/19/2016 12:00 AM to 03/19/2016 12:00 AM	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	97.0 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0					0.0 [CREST WEARING SURFACE] Crushed STONE with Sand (GP), gray, dense, moist								*Start 3/19/16*
					1.5 [EMBANKMENT] Lean CLAY with Silt (CL), orange-brown to brown, stiff, moist, trace Fine Sand								
5													
10													
15													
20													
25													
30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B024

Depth (feet)	SAMPLES Type Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30													
35													
40													
					42.0								
					Lean CLAY with Sand (CL), brown, stiff, moist								
45					very stiff								
50	S-1	n/a	100							3 3.5 3.5 3.5			
					stiff								
	S-2	7 7 6 8	100							2 2.25 2.5 2.5			
55	S-3	4 8 8 8	100		brownish gray and wet					1.5 1.5 1.5 2			
					57.0								
					[FOUNDATION]								
	S-4	WOH/12" 4 7	100		Lean CLAY with Sand, gray, stiff, moist to saturated 12-inch layer of soft, saturated					0.25 0.25 1 1			
60	S-5	4 5 10 12	100							2.5 2.5 3 3			
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B024

Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet) / Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	S-6	5 7 11 11	100							2 2 2.5 2.5			
70	S-7	6 10 12 18	100		more sand, with vertical partings, blocky					n/a			
75	S-8	6 10 12 15	100							4 4 4 4			
					with silt zones								
80	S-9	6 8 9 9	100							3 3 3 3			
85	S-10	7 8 9 8	100							3 3 3 3			
90	S-11	4 11 21 22	100		more sand and silt					3 3 3 3			
95	S-12	5 7 8 9	100		97.0 End of Boring at 97 ft					2.5 2.5 2.5 2.5			*End 3/19/16*
100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B025

Date(s) Drilled	03/22/2016 12:00 AM to 03/22/2016 12:00 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	89.5 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
		Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0					0.0 [FILL] Base Course GRAVEL (GP) 1.0 [EMBANKMENT] Lean CLAY with Sand (CL), brown to orange-brown, moist								*Start 3/22/16*
5													
10													
15													
20													
25													
30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:26 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B025

Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet) / Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30													
					35.0								
35	S-1	8 9 13 12	83		Lean CLAY with Fine to Medium Sand (CL), orangish brown and brown and varved gray, very stiff, moist, seams of fine to medium Sand								
	S-2	9 10 10 13	79										
40	S-3	5 8 12 14	100										
	S-4	5 11 16 27	100										
45	S-5	10 17 20 18	83		traces of ash								
	S-6	6 7 13 12	100										
50	S-7	WOH/18" 1	100		soft to firm, orangish brown								
	S-8	WOH/12" 3 3	100		53.5 [FOUNDATION] Lean CLAY (CL), dark brown, soft, moist, medium plasticity, some ash								
55	S-9	WOH/12" 4 5	100		gray clay with ash								
	S-10	5 7 12 19	100		seam of ash, very stiff								
60	S-11	13 12 9 9	83		brown								
	S-12	5 4 2 2	100										
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:26 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B025

Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet) / Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	S-13	4 6 8 8	88		gray with patches of orange brown, stiff								
70	S-14	15 13 8 8	100		Sandy CLAY (CL), gray, medium dense								
	S-15	WOH/12" 6 8	100		74.0								
					Fine SAND (SP), gray, medium dense, moist								
75	S-16	6 5 3 3	100		gray with patches of brown								*S-16: Based on blow counts, it is classified as loose. But the sample can hardly be penetrated*
	S-17	3 5 6 6	100										
80	S-18	6 14 8 9	100		brown and gray								
	S-19	15 20 20 25	100		dense								
85	S-20	7 21 27 23	42		with trace gravel								
	S-21	10 20 18 19	67		89.5								*End 3/22/16*
90					End of Boring at 89.5 ft								
95													
100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:26 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B026

Date(s) Drilled	03/21/2016 12:00 AM to 03/21/2016 12:00 AM	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	82.0 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	61 ft on 3/21/2026		

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0					0.0 [FILL] Base Course GRAVEL (GP) 1.0 [EMBANKMENT] Lean CLAY with Sand (CL), brown, some Silt, stiff, moist								*Start 3/21/16*
5													
10													
15													
20													
25													
30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:34 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B026

Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet) / Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30													
35													
40	S-1	10 13 16 27	100							4.5 4.5 4.5 4.5			
	S-2	8 9 9 14	100							3 3 3 4.5			
45	S-3	7 10 11 14	100							4 4 4 4.5			
	S-4	8 8 8 9	100							3 3 3 3			
50	S-5	5 5 7 13	100							2.5 2.5 3 3			
	S-6	8 12 13 17	100							4 4 4 4.5			
55	S-7	5 7 10 10	100							3 3.5 3.5 3.5			
	S-8	5 7 6 7	100		4-inch layer of stiff, moist, gray Flyash becomes firm					1 1.5 1.75 1.75			
60	S-9	1 3 11 15	100		▽ 61.0 [ASH] FLYASH (ML), gray, stiff, saturated 62.0					1 1.5			
	S-10	18 9 8 22	83		[FOUNDATION] Lean CLAY with Sand (CL), stiff, moist 64.5								
65					Fine SAND (SP), brown, trace silt, loose.								

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:34 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B026

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	S-11	2 4 5 8	83		saturated Lean CLAY with Silt (CL), brown, stiff, moist (65.5)					n/a 3 3 3.5			
70	S-12	5 4 4 6	100		becomes with vertical partings and blocky					n/a			
75													
					Fine SAND (SP), gray, dense, saturated (79.0)								
80	S-13	12 16 25 25	100		End of Boring at 82 ft (82.0)								*End 3/21/16*
85													
90													
95													
100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:34 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B027

Date(s) Drilled	03/23/2016 8:35 AM to 03/23/2016 3:00 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	54.5 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	Elevation (feet)	Depth (feet)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0									
								[FILL] Base Course GRAVEL (GP)								*Start 3/23/16 at 8:35 AM*
							1.0	[FILL] Silty SAND (SM), brown, medium dense, moist								
	S	1	3 7 9 6	100			3.5	Lean CLAY with Sand (CL), dark gray, very stiff, medium plasticity, moist, trace ash								*Switched to mud rotary after collection first sample*
5	S	2	2 3 7 9	67				becomes orangish-brown, to gray, with fine sand, low to medium plasticity, stiff								
							6.5	[ASH] FLYASH with Clay, no to low plasticity								
	S	3	3 5 10 11	71				FLYASH with no clay								
10	S	4	4 4 3 WOH	67				becomes wet								
	S	5	WOH 1 2 4	75			13.0	[RAILROAD EMBANKMENT] Lean CLAY with Ash (CL), greenish grey to dark grey, soft, low plasticity, moist to wet								
15	S	6	5 7 5 5	75												
	S	7	WOH 2 2 3	79				Traces of wood								
20	S	8	WOH WOH WOH WOH	100												
	ST	1	<100 PSI	100									>4.5			*Shelby tube 22-24,Driller noted soft layer and hit stiff layer right at bottom.*
							24.5									
25	S	9	6 7 10 14	100				[FOUNDATION] Lean CLAY (CL), greenish grey, very stiff, medium plasticity, moist, iron stain with sand								
	S	10	5 7 8 12	100												
30																

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:41 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B027

Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet) / Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-11	4 10 8 12	100		fine sand								
	S-12												
35					35.0								
	S-13	5 5 5 11	88		gray mottled with brown, low plasticity, moist								
	S-14	2 4 4 6	100		seams of brown sand								
40	S-15	3 4 6 8	83										
45	S-16	4 5 10 15	67		46.0 Fine SAND with trace Clay (SP), gray mottled with orange, medium dense								
	S-17	8 17 16 20	67		dense, brown to gray								
50	S-18	7 15 16 19	67		trace gravel								
	S-19	8 16 17 26			54.5 End of Boring at 54.5 ft								
55													
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:41 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B027

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
70													
75													
80													
85													
90													
95													*End 3/23/16 at 3:00 PM*
100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:41 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028

Date(s) Drilled	03/20/2016 12:00 AM to 03/20/2016 12:00 AM	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	87.0 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0					0.0 [CREST WEARING SURFACE] Crushed STONE with Sand (GP), gray, dense, moist — 1.0 [EMBANKMENT] Lean CLAY (CL), brown, stiff, moist, some Silt and trace Fine Sand								
5													
10													
15													
20													
25													
30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:49 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30													
35													
40													
45													
50					gray, very stiff, moist								
55	S-1	n/a n/a n/a n/a	66		brown and gray					n/a 2.5 2.5 3			
	S-2	woh/12" 7 8	66							n/a n/a 1 1			
60	S-3	3 5 5 7	100							1.5 1.5 1.5 1.5			
					62.0 / 62.5 [FOUNDATION]								
	S-4	1 4 5 6	100		Lean CLAY (CL-OL), dark gray, stiff, moist Silty Clay with trace decomposed organics (CL-ML), gray, loose, saturated					1 1 1.25 1.5			
65													

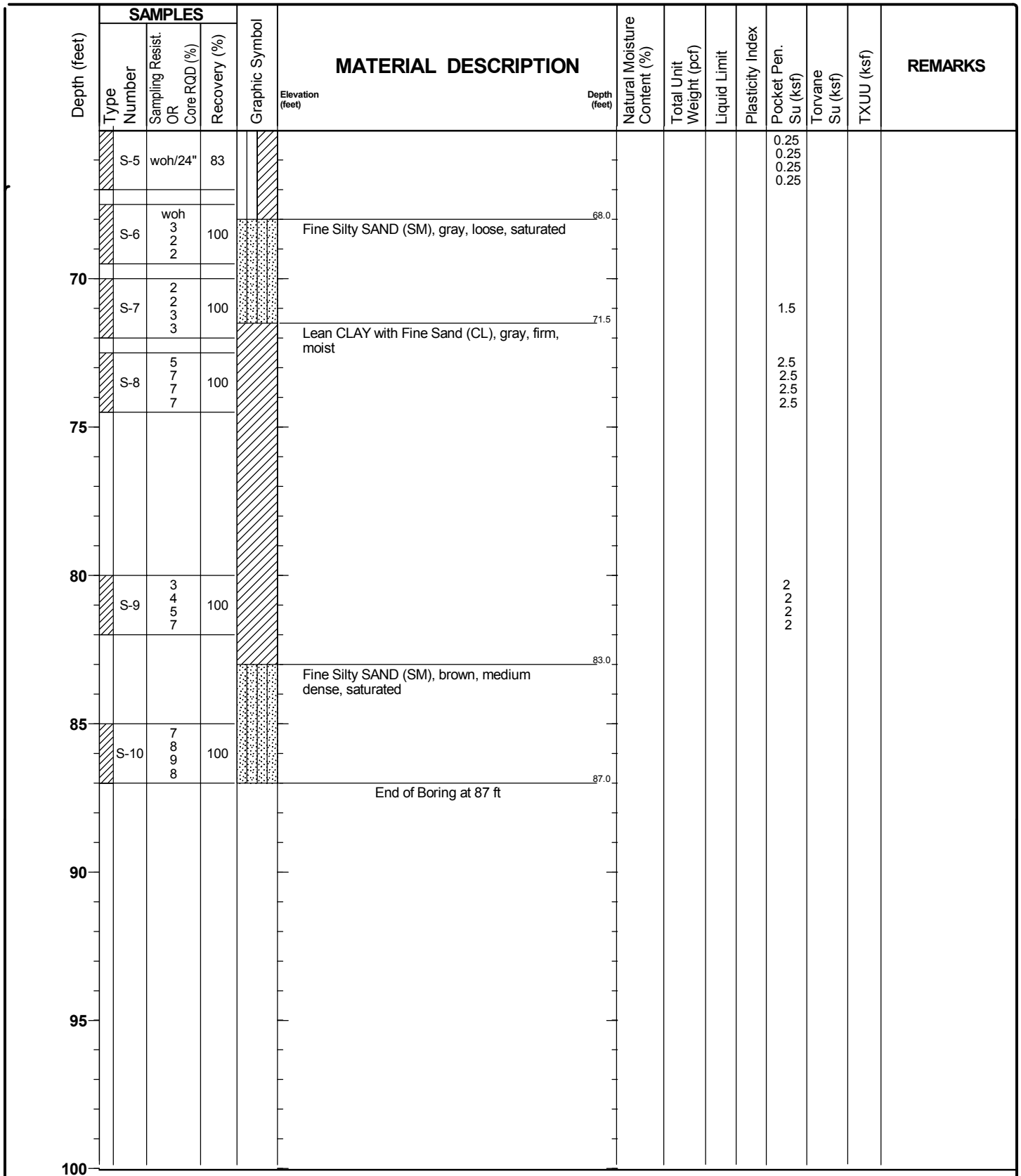
Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:49 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028



Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:49 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B029

Date(s) Drilled	03/16/2016 12:00 AM to 03/17/2016 12:00 AM	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	47.0 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	Elevation (feet)	Depth (feet)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0									
							1.0	[CREST WEARING SURFACE] Crushed STONE (Pavement) (GP), gray, medium dense, moist								
							2.0	[FILL] SAND with Silt (SP), brown, trace clay, medium dense, moist								
	S	1	3 4 4 4	75				Lean CLAY with Silt to some Silt (CL), brown, stiff, moist					1.5 2 2.5			
5							6.5									
								[ASH] SILT with some Clay (ML), gray, soft, moist								
	S	2	2 4 5 7	92									2 1.5 1.75			
10	S	3	1 2 1 1	100				very loose, saturated								
	S	4	WOH/24"	100												
15	S	5	WOH/24"	83												
	S	6	WOH/18" 2	100			19.0									
								[FOUNDATION] Lean CLAY with Silt (CL), gray, decomposed organics, soft, moist								
20	S	7	2 2 2 2	100									0.75			
								very soft								
	S	8	WOH/12" 3 6	100				with Silt and Silt zones, stiff, without organics					<0.25 <0.25 1.5 2			
25	S	9	3 4 6 7	100									1.5 2 2.5 2.5			
30																

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:56 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B029

Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet) / Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-10	4 5 6 9	100							2.5			
35	S-11	3 3 5 7	100							2 2.75 2.5			
					36.5 Fine SAND with trace course to medium Sand (SP), brown, medium dense, wet								
40	S-12	3 7 9 11	92		trace gravel								
					dense								
45	S-13	15 19 22 18	83		very dense								
					47.0 End of Boring at 47 ft								
50													
55													
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:28:56 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B030

Date(s) Drilled	03/18/2016 12:00 AM to 03/18/2016 12:00 AM	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Mud rotary	Drill Bit Size/Type	3 7/8 in	Borehole Depth	87.0 ft
Drill Rig Type	CME 85 truck-mounted	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Cement/Bentonite Grout	Sampling Method(s)	SPT	Hammer Data	Standard Auto 140 lbs, 30" drop
Boring Location	Near Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0						[TEMPORARY ACCESS RAMP] Crushed STONE (GP), gray, medium dense, moist	0.0								
							3.0								
						[BOTTOM ASH] Poorly Graded SAND (SP), medium dense, moist									
5							5.0								
						[ASH] SILT with some Clay (ML), gray, loose, moist									
10						very loose and saturated									
15															
20		S-1	WOR/24"	100											
		S-2	WOH/12" WOH 1	54			23.5					<0.25 0.25			
25		S-3	4 6 5 8	63		[EMBANKMENT] Lean CLAY with Silt (CL), brown, soft, wet firm, moist stiff						2.5 2.5 3			
		S-4	3 5 8 11	71								2 2.5 2.75			
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:01 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B030

Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-5	4 5 5 8	66							2 2.5 2.5			
	S-6	4 9 11 12	79		very stiff					4 4.5 >4.5			
35	S-7	8 9 12 11	66							4 4.5 >4.5			
	S-8	5 9 12 15	88							4 4.5 >4.5			
40	S-9	7 8 10 9	100		some fine sand					2.5 4 4 4.5			
	S-10	4 5 5 5	100		soft, saturated, layers of clay with fine sand					1.5 2 2 2.5			
45	S-11	1 3 5 5	100							1.5 1.5 2 2			
	S-12	WOH/18" 3	100							0.25 0.25 0.25 1			
50	S-13	2 2 3 4	83		51.0 [ASH] SILT (ML), dark gray, loose, saturated					1 1			
	S-14	1 WOH/18"	50		very soft								
55	S-15	1/18" 1	58										
	S-16	WOH/12" 1 2	75										
60	S-17	WOR/24"	0										
	S-18	1 1 WOH/12"	0										
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:02 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B030

Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet) / Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	S-19	3 3 4 3	83		[ASH] SILT (ML), dark gray, loose, saturated								
	S-20	WOR/12" 4 1	66		69.0					1			
70					[FOUNDATION] Lean CLAY (CL), light gray, soft, moist								
	S-21	3 5 6 8	100		stiff					3.5 3.5 3.5 3.5			
75	S-22	3 5 8 8	100							2 2 2.5 2.5			
80	S-23	4 5 8 8	92							3.5 3.5 3.5 4			
					83.0								
85	S-24	5 4 6 7	83		Fine Silty SAND (SM), brown, medium dense, moist								
					87.0								
					End of Boring at 87 ft								
90													
95													
100													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:02 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D004

Sheet 1 of 1

Date(s) Drilled	03/15/2016 3:50 PM to 03/15/2016 4:50 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	24.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/15/16 at 3:50 PM*
	S	S-1		83		[FILL] Sandy SILT (ML), light brown, stiff, moist, low plasticity, trace fine sand	3.5								
						Lean CLAY (CL), brown, stiff, moist, trace roots, woods, fine sand and ash	4.5								
5						[ASH] SILT (ML), gray, moist to wet, non-plastic									
	S	S-2		98											
	S	S-3		100		6" layer of Sand									
10															
	S	S-4		100											
15															
	S	S-5		100											
							19.0								
20						[FOUNDATION] Lean CLAY with Ash (CL), gray, soft, moist to wet, medium plasticity									
	S	S-6		100											
							23.0								
						Fine to Medium SAND (SP), gray, loose, moist	24.0								
						End of Boring at 24 ft									*End 3/15/16 at 4:50 PM*
25															
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:09 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D006

Date(s) Drilled	03/17/2016 10:45 AM to 03/18/2016 10:30 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	50.7 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/17/16 at 10:45 AM*
	S	S-1		100		Sandy SILT (ML), brown, firm, low plasticity, moist									
						Silty SAND and fine Gravel (SM), grey, loose	3.5								
5						Fine GRAVEL with Silt and Fine Sand (GM), loose, moist to wet	4.5								
	S	S-2		75		Organic CLAY (OL), brown and dark grey, traces of wood and coal, firm, medium plasticity, moist	6.0								
						[FOUNDATION] Silty Lean CLAY (CL), gray and orange to brown, traces of coal, firm to stiff, trace iron stain, medium plasticity, moist	8.0								
10	S	S-3		100											
						6" organic lean clay, dark grey to grey, becomes stiff									
	S	S-4		100											
15															
	S	S-5		100											
20															
	S	S-6		100											
25															
	S	S-7		100		6" silty clay, low to medium plasticity, moist grey with iron staining									
	S	S-8		100		soft									
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:12 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D006

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-8		100		3" seam of fine to medium sand light gray with iron staining, stiff, low to medium plasticity								
					stiff, medium plasticity, moist								
	S-9		100										
35					Lean CLAY with Fine Sand (CL), gray and orange-brown, firm to stiff, medium plasticity, moist								*End 3/17/16 Start 3/18/16 at 7:30 AM*
	S-10		63										
40					becomes very soft to firm, low to medium plasticity								
	S-11		100										
45					soft to firm								
	S-12		100										
					47.5								
					Fine SAND (SP), light gray with orange-brown spotting, dense								
50					50.7								
					End of Boring at 50.7 ft								*Refusal at 50.7ft. End 3/18/16 at 10:30 AM*
55													
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:12 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D007

Sheet 1 of 1

Date(s) Drilled	03/20/2016 11:00 AM to 03/20/2016 12:15 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	16.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	ft NAVD88
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Rail Road North of Stockpile	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								*Start 3/20/16 at 11:00 AM*
		S-1		94		[RAILROAD] Lean CLAY (CL), soft, moist, gray and orange-brown, medium plasticity									
						firm									
						soft									
5		S-2		85											
						stiff									
						wet and soft									
						firm									
10		S-3		63											
		S-4		100											
15							16.0								
						End of Boring at 16 ft									*End 3/20/16 at 12:15 PM*
20															
25															
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:17 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D008

Sheet 1 of 2

Date(s) Drilled	03/18/2016 12:00 AM to 03/19/2016 10:45 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	54.7 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond (ft NAD83)	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/18/16*
		S-1		63		[ASH] SILT with Sand (ML), soft, non-plastic									
						wet, 6" organic clay and ash, coal									
5		S-2		94		with organics, coal, black and gray, medium plasticity									
							8.0								
		S-3		100		[FOUNDATION] Lean CLAY (CL), gray and orange-ish brown, medium plasticity									
10															
		S-4		100		more silt, low to medium plasticity, gray with iron staining									
15						medium plasticity									
		S-5		100											
20						very stiff									
		S-6		92											
25		S-7		100		frim to very stiff, low to medium plasticity wet									
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D008

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30					very stiff								
	S-8		100		6" pocket of grayish brown dense fine to medium grained sand								*End 3/18/16 at 5:55 PM*
35													*Start 3/19/16 at 7:20 AM*
	S-9		83		soft zones								
40													
	S-10		100		42.0								
					Fine Silty SAND (SM), gray, dense								
45													
	S-11		0		very loose								*Driller noted very soft layer*
	S-12		80										
50													
	S-13		100		dense, pockets of very stiff clayey silt, medium dense								*Refusal at 50.5ft.*
					brown and gray								
					54.7								
55					End of Boring at 54.7 ft								*End 3/19/16 at 10:45 AM*
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:19 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D009

Date(s) Drilled	03/20/2016 1:00 PM to 03/20/2016 12:00 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	31.1 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/20/16 at 1:00 PM*
	S	1		63		SILT with Ash (ML), gray, firm, no plasticity, moist									
							4.0								
5	S	2		75		Lean CLAY (CL), orange-brown, firm, medium plasticity, with 6" of fine to medium sand									
10	S	3		75											
							11.8								
	S	4		75		[ASH] SILT (ML), dark grey, soft, wet, no plasticity									
15	S	5		100											
							18.8								
20	S	6		40		[FOUNDATION] Lean CLAY (CL), trace ash, fine sand layers, stiff, medium plasticity, greenish-gray, moist									
25	S	7		63		low plasticity									
	S	8		100											
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:24 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D009

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-8		100		low to medium plasticity, gray to gray and orange-brown								
					very stiff								
	S-9		71		34.5								
35					Fine to Medium SAND (SP), brown, very dense, moist								*First Refusal at 35.1ft. Second Refusal at 35.4ft. End 3/20/16*
					35.4 End of Boring at 31.1 ft								
40													
45													
50													
55													
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:24 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D010

Date(s) Drilled	03/19/2016 11:55 AM to 03/19/2016 3:00 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	31.2 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Rail Road, SE Corner of Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	1.0								*Start 3/19/16 at 11:55 AM*
	S	S-1		85		[RAILROAD EMBANKMENT] Lean CLAY with Ash (CL), gray, stiff, low plasticity, iron staining									
5	S	S-2		75		low to medium plasticity clayey silt firm, medium plasticity									*Driller noted soft layer*
	S	S-3		100		stiff									
10	S	S-4		100											
15	S	S-5		100		orange-brown, gray layers									
20						very stiff, gray and orange-brown									*Driller noted hand push*
25	S	S-6		94		18" layer, organic clay, dark brown, medium stiff, moist									
	S	S-7		88		very stiff, moist, gray and orange-brown, silty clay									
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:29 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D010

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-7		88		31.2 End of Boring at 31.2 ft								*Refusal at 31.2ft. End 3/19/16 at 3:00 PM*
35													
40													
45													
50													
55													
60													
65													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:29 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D012

Sheet 1 of 1

Date(s) Drilled	03/15/2016 3:00 PM to 03/15/2016 3:30 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	8.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	SAMPLES Number	Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0								0.0								*Start 3/15/16 at 3:00 PM*
						[FILL] Base Course GRAVEL (GP)		0.5								
						[ASH] SILT with Sand (ML), gray, non-plastic		1.0								
	S	S-1		88		[FILL] Lean CLAY (CL), moist, orange-brown, trace fine sand, stiff										
5	S	S-2		85												
								8.0								
						End of Boring at 8 ft										*End 3/15/16 at 3:30 PM*
10																
15																
20																
25																
30																

AECOM

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:34 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D013

Sheet 1 of 1

Date(s) Drilled	03/16/2016 9:20 AM to 03/16/2016 9:50 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	12.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	SAMPLES Number	Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0						0.0								
						[FILL] Base Course GRAVEL and Sand (GP) — 0.5								*Start 3/16/16 at 9:20 AM*
		S-1		65		Sandy SILT (ML), brown, firm to stiff, low plasticity; ASH with clay, non-plastic to medium plasticity, gray, moist — 3.0								
5						Silty Lean CLAY (CL-ML), brown, firm, medium plasticity, moist								
		S-2		65										
						8.0								
						[FOUNDATION] Lean CLAY with Sand (CL), orange-brown to gray, stiff, medium plasticity								
10		S-3		58										
						12.0								
						End of Boring at 12 ft								*End 3/16/16 at 9:50 AM*
15														
20														
25														
30														

AECOM

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:37 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D014

Sheet 1 of 1

Date(s) Drilled	03/16/2016 10:05 AM to 03/16/2016 10:50 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	8.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	SAMPLES Number	Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0								0.0								
						[FILL] Base Course GRAVEL (GP)		0.5								*Start 3/16/16 10:05 AM*
	S	S-1		73		Sandy SILT (ML), brown, firm, low plasticity, moist		2.3								
						[ASH] SILT with Sand (ML), gray, soft, moist, no to low plasticity		3.3								
						Lean CLAY with Sand (CL), gray, firm, medium plasticity, moist		4.0								
5	S	S-2		79		[FOUNDATION] Lean CLAY (CL), gray to orange brown, stiff, medium plasticity, moist										
								8.0								
						End of Boring at 8 ft										*Enf 3/16/16 at 10:50 AM*
10																
15																
20																
25																
30																

AECOM

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:39 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D015

Sheet 1 of 1

Date(s) Drilled	03/16/2016 10:45 AM to 03/16/2016 3:00 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	24.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0								0.0								
						[FILL] Base Course GRAVEL (GP)		0.5								*Start 3/16/16 at 10:45 AM*
		S-1		75		Sandy SILT (ML), brown, firm, low plasticity										
								3.0								
						[ASH] SILT with Sand (ML), stiff, no to low plasticity, moist		4.0								
5		S-2		58		[FILL] Lean CLAY (CL), firm, medium plasticity, moist										
		S-3		83				10.0								
10						[ASH] SILT with Sand (ML), gray, soft, no plasticity, wet, 2" layer of medium sand										
		S-4		100												
15		S-5		100												
								19.5								
20		S-6		100		Lean CLAY with Ash (CL) gray, soft, medium plastiticy, wet										
								24.0								
						End of Boring at 24 ft										*End 3/16/16 at 3:00 PM*
25																
30																

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:42 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D016

Sheet 1 of 1

Date(s) Drilled	03/16/2016 3:05 PM to 03/16/2016 4:00 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	24.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/16/16 at 3:05 PM*
	S	S-1		73		[FILL] Lean CLAY (CL), brown, stiff, medium plasticity, moist to wet, trace fine sand									
						firm									
5	S	S-2		79			6.0								
						[ASH] SILT with Sand (ML), gray, soft, wet, traces of fine sand									
10	S	S-3		83											
	S	S-4		83											
15	S	S-5		100											
							19.0								
						Lean CLAY with Ash (CL), gray, soft, medium plasticity, wet									
20	S	S-6		100			22.0								
						Fine SAND with ash (SM), gray, loose, wet									
							24.0								
						End of Boring at 24 ft									*End 3/16/16 at 4:00 PM*
25															
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:45 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D017

Sheet 1 of 1

Date(s) Drilled	03/16/2016 4:45 PM to 03/16/2016 5:15 PM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	12.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
		Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								*Start 3/16/16 at 4:45 PM*
		S-1		65		[FILL] Sandy SILT (ML), brown, soft to medium stiff, trace gravel	4.0								
5		S-2		54		[FILL] Lean CLAY (CL) with silt, brown, medium stiff, wet, trace wood, fine gravel	8.0								
10		S-3		100		[FOUNDATION] Lean CLAY (CL), brown, stiff	12.0								
						End of Boring at 12 ft									
15															
20															
25															*End 3/16/16 at 5:15 PM*
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:47 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D018

Sheet 1 of 1

Date(s) Drilled	03/17/2016 7:55 AM to 03/17/2016 8:55 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	16.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
		Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/17/16 at 7:55 AM*
	S	1		85		[FILL] Sandy SILT (ML), brown, medium stiff, moist, low plastic, trace clay	4.0								
5	S	2		52		[FOUNDATION] Lean CLAY (CL) with fine to medium sand, gray with iron stain, medium stiff to stiff, medium plasticity									
10	S	3		100											
	S	4		100											
15							16.0								
						End of Boring at 16 ft									*End 3/17/16 at 8:55 AM*
20															
25															
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:50 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D019

Sheet 1 of 1

Date(s) Drilled	03/17/2016 9:15 AM to 03/17/2016 10:15 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	16.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
		Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0								0.0								*Start 3/17/16 at 9:15 AM*
						[FILL] Silty SAND (SM) with gravel		1.5								
	S	1		100		[FILL] Sandy SILT (ML), brown, medium stiff, moist, low plasticity		4.0								
5						[FILL] Lean CLAY (CL), gray to dark gray, medium stiff, moist, medium plasticity, trace coal		5.0								
	S	2		75		[FILL] Sandy SILT (ML), brown, sotf to medium stiff, moist to wet, medium plasticity		9.0								
10	S	3		100		[FOUNDATION] Silty lean CLAY (CL), gray to orangish brown, medium stiff, moist, medium plasticity										
						stiff, with iron stains										
	S	4		100												
15								16.0								
						End of Boring at 16 ft										*End 3/17/16 at 10:15 AM*
20																
25																
30																

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:52 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D020

Sheet 1 of 1

Date(s) Drilled	03/18/2016 10:35 AM to 03/18/2016 11:45 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	16.0 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	Road, SE corner of South Pond	Groundwater Level(s)	Groundwater not encountered		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/18/16 at 10:35 AM*
	S	1		81		[ASH] SILT with Sand (ML), gray, firm, moist									
5	S	2		46											
	S	3		63			10.0								
10						[FOUNDATION] Lean CLAY with Ash (CL), gray and orange-brown, firm, medium plasticity, moist traces of ash									
	S	4		67											
15							16.0								
						End of Boring at 16 ft									*End 3/18/16 at 11:45 AM*
20															
25															
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:55 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D021

Date(s) Drilled	03/19/2016 3:45 PM to 03/20/2016 10:15 AM	Logged By	Betty Tesfu	Checked By	Vonmarie Martinez
Drilling Method	Direct Push	Drill Bit Size/Type	2 1/8 in	Borehole Depth	31.1 ft
Drill Rig Type	Geo Probe model 5400	Drilling Contractor	Stantec	Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)	Direct Push	Hammer Data	N/A
Boring Location	RR Embankment in SE Corner	Groundwater Level(s)	22.5 ft on 3/19/2016		

Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0							0.0								
						[FILL] Base Course GRAVEL (GP)	1.5								*Start 3/19/19 at 3:45 PM*
	S	S-1		75		[RAILROAD EMBANKMENT] Lean CLAY with Ash (CL), gray and orange-brown, stiff, no to low plasticity, moist									
5	S	S-2		100		Silty CLAY (CL-ML), orange-brown and gray, stiff, low to medium plasticity, moist gray	5.5								
	S	S-3		83		brown and gray, medium plasticity									*Driller noted soft layer*
10															*End 3/19/16 at 5:50 PM*
	S	S-4		63		trace silt, brown, very stiff									*Start 3/20/16 at 7:30 AM*
15							16.0								
	S	S-5		75		[FOUNDATION] Lean CLAY (CL), gray and green-gray, very stiff, medium to high plasticity, moist, traces of coal									
20	S	S-6		75		wet ▽									
25	S	S-7		79		ranges from brown to green-gray									
	S	S-8		62		orange-brown and gray, silty									
30															

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:58 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D021

Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION: Elevation (feet)	MATERIAL DESCRIPTION: Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
30	S-8		62			31.1								*Refusal at 31.1ft. End 3/20/16 at 10:15 AM*
					End of Boring at 31.1 ft									
35														
40														
45														
50														
55														
60														
65														

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:29:58 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D022

Sheet 1 of 1

Date(s) Drilled	03/22/2016	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Hand Auger	Drill Bit Size/Type		Borehole Depth	6.5 ft
Drill Rig Type		Drilling Contractor		Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)		Hammer Data	N/A
		Groundwater Level(s)	5.0 ft on 3/22/2016		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						Elevation (feet) / Depth (feet): NOT SURVEYED / 0.0								
	0	HA-1				[FILL] CLAY (CL), dark brown, soft, moist, with silt and decomposed organics								
		HA-2				brown, with sand								
	5	HA-3				brown and gray, medium stiff ▽ 5.0								
						[ASH] FLY ASH, gray, loose saturated — 6.5								
						End of Boring at 6.5 ft								
	10													
	15													
	20													
	25													
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:41:37 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D023

Sheet 1 of 1

Date(s) Drilled	03/22/2016	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Hand Auger	Drill Bit Size/Type		Borehole Depth	6.5 ft
Drill Rig Type		Drilling Contractor		Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)		Hammer Data	N/A
		Groundwater Level(s)	1 ft on 3/22/2016		

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					Elevation (feet) / Depth (feet): NOT SURVEYED 0.0								
		HA-1				[FILL] CLAY (CL), dark brown, soft, moist, with silt and decomposed organics — 0.5								
		HA-2				[FILL] SAND (SC), brown, loose, saturated, with clay and silt; 3" layer of medium dense, saturated crushed stone — 3.5								
	5	HA-3				[FILL] CLAY (CL), brown, soft, saturated, with silt and sand — 5.0								
						[ASH] FLY ASH, gray, loose, saturated — 6.5								
						End of Boring at 6.5 ft								
	10													
	15													
	20													
	25													
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:41:40 PM

AECOM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D024

Sheet 1 of 1

Date(s) Drilled	03/22/2016	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Hand Auger	Drill Bit Size/Type		Borehole Depth	6.5 ft
Drill Rig Type		Drilling Contractor		Surface Elevation	NOT SURVEYED
Borehole Backfill	Bentonite Pellets	Sampling Method(s)		Hammer Data	N/A
		Groundwater Level(s)	Groundwater not encountered		

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					Elevation (feet) / Depth (feet): NOT SURVEYED / 0.0								
						CLAY (CL), dark brown, soft, moist, with silt and decomposed organics								
						1.5								
						CLAY (CL), brown, medium stiff, with silt and some sand								
	5					gray, moist								
						6.5								
						End of Boring at 6.5 ft								
	10													
	15													
	20													
	25													
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:41:42 PM

AECOM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D025

Sheet 1 of 1

Date(s) Drilled	03/23/2016	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Hand Auger	Drill Bit Size/Type		Borehole Depth	4.0 ft
Drill Rig Type		Drilling Contractor		Surface Elevation	NOT SURVEYED
Borehole Backfill	Cuttings	Sampling Method(s)		Hammer Data	N/A
		Groundwater Level(s)	1.0 ft on 3/23/2016		

Elevation (feet)	Depth (feet)	SAMPLES: Type Number	SAMPLES: Sampling Resist. OR Core RQD (%)	SAMPLES: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					Elevation (feet) NOT SURVEYED / Depth (feet) 0.0								
						[FILL] CLAY (CL), dark brown, soft, moist, with silt and decomposed organics ▽								
						2.0								
						[ASH] FLY ASH, gray, very loose, saturated								
						4.0								
						End of Boring at 4 ft								
	5													
	10													
	15													
	20													
	25													
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:41:45 PM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D026

Sheet 1 of 1

Date(s) Drilled	03/23/2016	Logged By	Charles Siegel	Checked By	Vonmarie Martinez
Drilling Method	Hand Auger	Drill Bit Size/Type		Borehole Depth	4.0 ft
Drill Rig Type		Drilling Contractor		Surface Elevation	NOT SURVEYED
Borehole Backfill	Cuttings	Sampling Method(s)		Hammer Data	N/A
		Groundwater Level(s)	1.0 ft on 3/23/2016		

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
						Elevation (feet) / Depth (feet)								
	0					NOT SURVEYED 0.0								
						[FILL] CLAY (CL), dark brown, soft, moist, with silt and decomposed organics ▽								
		HA-1				brown, medium stiff, trace sand 2.0								
						[ASH] FLY ASH, gray, very loose, saturated								
		HA-2				4.0								
	5					End of Boring at 4 ft								
		HA-3												
	10													
	15													
	20													
	25													
	30													

Report: GEO_SOIL; File P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\JOPPA REMEDIATION\BORINGS\DYNEGY_2015UPDATED AND 2016.GPJ; 9/12/2016 3:41:47 PM

AECOM

ATTACHMENT C

PIEZOMETER CALIBRATION REPORTS

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520000

Temperature: 23.00 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.5 mbar

Cable Length: 120 feet

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8917	8917	8917	2.021	0.29	-0.046	-0.01
140.0	8100	8100	8100	139.6	-0.05	140.0	0.01
280.0	7276	7276	7276	278.4	-0.23	280.1	0.02
420.0	6446	6446	6446	418.2	-0.26	419.9	-0.01
560.0	5607	5607	5607	559.5	-0.08	560.0	-0.01
700.0	4760	4760	4760	702.1	0.31	700.1	0.01

(kPa) Linear Gage Factor (G): -0.1684 (kPa/ digit)

Polynomial Gage factors: A: -9.114E-07 B: -0.1560 C:

Thermal Factor (K): 0.05171 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02443 (psi/ digit)

Polynomial Gage Factors: A: -1.322E-07 B: -0.02262 C:

Thermal Factor (K): 0.007501 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8949 Temperature: 22.4 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520001

Calibration Instruction: VW Pressure Transducers

Cable Length: 100 feet

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Temperature: 23.00 °C

Barometric Pressure: 995.5 mbar

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8784	8785	8785	1.769	0.25	-0.054	-0.01
140.0	7965	7966	7966	139.8	-0.03	140.1	0.01
280.0	7141	7141	7141	278.7	-0.18	280.1	0.01
420.0	6311	6311	6311	418.6	-0.21	420.0	-0.01
560.0	5474	5474	5474	559.6	-0.06	559.9	-0.01
700.0	4629	4630	4630	701.9	0.28	700.1	0.02

(kPa) Linear Gage Factor (G): -0.1685 (kPa/ digit)

Polynomial Gage factors: A: -7.712E-07 B: -0.1582 C:

Thermal Factor (K): 0.04724 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02444 (psi/ digit)

Polynomial Gage Factors: A: -1.118E-07 B: -0.02294 C:

Thermal Factor (K): 0.006852 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8789 Temperature: 21.7 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St, Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520002

Temperature: 23.00 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.5 mbar

Cable Length: 100 feet

Technician: KSkyes

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8933	8934	8934	1.906	0.27	0.115	0.02
140.0	8102	8103	8103	139.6	-0.05	139.9	-0.01
280.0	7265	7265	7265	278.5	-0.22	279.8	-0.03
420.0	6418	6419	6419	418.8	-0.18	420.1	0.01
560.0	5566	5567	5567	560.0	0.00	560.3	0.04
700.0	4712	4712	4712	701.6	0.24	699.9	-0.02

(kPa) Linear Gage Factor (G): -0.1658 (kPa/ digit)

Polynomial Gage factors: A: -7.257E-07 B: -0.1559 C:

Thermal Factor (K): 0.0008946 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02404 (psi/ digit)

Polynomial Gage Factors: A: -1.053E-07 B: -0.02260 C:

Thermal Factor (K): 0.0001298 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8941 Temperature: 21.8 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St, Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520003

Calibration Instruction: VW Pressure Transducers

Cable Length: 100 feet

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Temperature: 23.00 °C

Barometric Pressure: 995.5 mbar

Technician: KS Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8978	8979	8979	1.884	0.27	0.093	0.01
140.0	8138	8139	8139	139.5	-0.07	139.9	-0.01
280.0	7291	7292	7292	278.3	-0.25	279.8	-0.03
420.0	6435	6434	6435	418.7	-0.19	420.2	0.03
560.0	5574	5574	5574	559.6	-0.06	560.1	0.01
700.0	4706	4707	4707	701.7	0.25	699.9	0.00

(kPa) Linear Gage Factor (G): -0.1638 (kPa/ digit)

Polynomial Gage factors: A: -7.646E-07 B: -0.1534 C:

Thermal Factor (K): -0.003234 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02376 (psi/ digit)

Polynomial Gage Factors: A: -1.109E-07 B: -0.02224 C:

Thermal Factor (K): -0.0004690 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8983 Temperature: 22.2 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1

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GEOKON 48 Spencer St, Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520004

Temperature: 23.00 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.5 mbar

Cable Length: 100 feet

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8798	8799	8799	1.827	0.26	0.148	0.02
140.0	8007	8007	8007	139.5	-0.07	139.8	-0.03
280.0	7208	7208	7208	278.6	-0.20	279.8	-0.03
420.0	6400	6401	6401	419.1	-0.14	420.3	0.04
560.0	5592	5592	5592	559.7	-0.04	560.0	0.00
700.0	4776	4777	4777	701.6	0.24	699.9	0.00

(kPa) Linear Gage Factor (G): -0.1740 (kPa/ digit)

Polynomial Gage factors: A: -7.554E-07 B: -0.1637 C:

Thermal Factor (K): 0.009045 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02524 (psi/ digit)

Polynomial Gage Factors: A: -1.096E-07 B: -0.02375 C:

Thermal Factor (K): 0.001312 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8801 Temperature: 22.1 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St, Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520005

Calibration Instruction: VW Pressure Transducers

Cable Length: 80 feet

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Temperature: 23.00 °C

Barometric Pressure: 995.5 mbar

Technician: KRogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8793	8792	8793	1.522	0.22	-0.034	0.00
140.0	8020	8021	8021	139.7	-0.04	140.0	0.01
280.0	7244	7244	7244	278.8	-0.17	280.0	0.00
420.0	6462	6462	6462	418.8	-0.18	420.0	0.00
560.0	5675	5676	5676	559.6	-0.06	559.9	-0.02
700.0	4882	4882	4882	701.6	0.24	700.1	0.02

(kPa) Linear Gage Factor (G): -0.1790 (kPa/ digit)

Polynomial Gage factors: A: -7.683E-07 B: -0.1685 C:

Thermal Factor (K): 0.0006379 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02597 (psi/ digit)

Polynomial Gage Factors: A: -1.114E-07 B: -0.02444 C:

Thermal Factor (K): 0.00009251 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8796 Temperature: 22.4 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520006

Calibration Instruction: VW Pressure Transducers

Cable Length: 80 feet

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Temperature: 23.00 °C

Barometric Pressure: 995.5 mbar

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8953	8953	8953	1.678	0.24	-0.054	-0.01
140.0	8130	8130	8130	139.8	-0.03	140.1	0.02
280.0	7303	7303	7303	278.5	-0.21	279.9	0.00
420.0	6469	6469	6469	418.4	-0.22	419.9	-0.02
560.0	5627	5627	5627	559.7	-0.05	560.1	0.01
700.0	4780	4781	4781	701.7	0.25	700.0	0.00

(kPa) Linear Gage Factor (G): -0.1678 **(kPa/ digit)**

Polynomial Gage factors: **A:** -7.612E-07 **B:** -0.1573 **C:**

Thermal Factor (K): -0.01561 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02433 **(psi/ digit)**

Polynomial Gage Factors: **A:** -1.104E-07 **B:** -0.02282 **C:**

Thermal Factor (K): -0.002265 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8958 **Temperature:** 21.8 °C **Barometer:** 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520007

Temperature: 23.00 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.5 mbar

Cable Length: 80 feet

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8896	8897	8897	0.602	0.09	0.006	0.00
140.0	8086	8087	8087	140.0	-0.01	140.0	0.00
280.0	7275	7275	7275	279.6	-0.06	280.0	0.00
420.0	6461	6461	6461	419.6	-0.05	420.0	0.00
560.0	5645	5645	5645	560.0	0.00	560.1	0.01
700.0	4828	4828	4828	700.6	0.09	700.0	0.00

(kPa) Linear Gage Factor (G): -0.1721 (kPa/ digit)

Polynomial Gage factors: A: -2.432E-07 B: -0.1687 C:

Thermal Factor (K): -0.01519 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02495 (psi/ digit)

Polynomial Gage Factors: A: -3.528E-08 B: -0.02447 C:

Thermal Factor (K): -0.002203 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8901 Temperature: 21.7 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520008

Temperature: 23.00 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.5 mbar

Cable Length: 80 feet

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8891	8891	8891	1.792	0.26	-0.021	0.00
140.0	8044	8045	8045	139.7	-0.05	140.1	0.01
280.0	7192	7193	7193	278.4	-0.22	280.0	0.00
420.0	6333	6333	6333	418.4	-0.23	420.0	-0.01
560.0	5466	5466	5466	559.6	-0.06	560.1	0.01
700.0	4593	4593	4593	701.8	0.26	700.0	0.00

(kPa) Linear Gage Factor (G): -0.1629 (kPa/ digit)

Polynomial Gage factors: A: -7.553E-07 B: -0.1527 C:

Thermal Factor (K): -0.01661 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02362 (psi/ digit)

Polynomial Gage Factors: A: -1.096E-07 B: -0.02215 C:

Thermal Factor (K): -0.002410 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures: **Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$***

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8901 Temperature: 21.6 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520660

Calibration Instruction: VW Pressure Transducers

Cable Length: 80 feet

Date of Calibration: July 24, 2015

This calibration has been verified/validated as of 07/31/2015

Temperature: 23.10 °C

Barometric Pressure: 991.3 mbar

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8623	8623	8623	2.010	0.29	-0.002	0.00
140.0	7801	7801	7801	139.7	-0.04	140.1	0.01
280.0	6973	6973	6973	278.4	-0.23	280.0	-0.01
420.0	6138	6138	6138	418.3	-0.24	419.9	-0.01
560.1	5293	5293	5293	559.8	-0.03	560.2	0.03
700.0	4444	4445	4445	702.0	0.28	700.0	-0.01

(kPa) Linear Gage Factor (G): -0.1675 (kPa/ digit)

Polynomial Gage factors: A: -8.548E-07 B: -0.1563 C:

Thermal Factor (K): 0.1089 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02430 (psi/ digit)

Polynomial Gage Factors: A: -1.24E-07 B: -0.02268 C:

Thermal Factor (K): 0.01580 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8625 Temperature: 21.4 °C Barometer: 988.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 24, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520661

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 991.3 mbar

Cable Length: 80 feet

Technician: K Ryan

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8795	8795	8795	1.671	0.24	0.079	0.01
140.0	7971	7971	7971	139.4	-0.09	139.8	-0.03
280.0	7137	7137	7137	278.8	-0.18	280.2	0.03
420.0	6300	6301	6301	418.5	-0.20	420.0	0.00
560.1	5457	5457	5457	559.5	-0.08	560.0	-0.01
700.0	4606	4607	4607	701.6	0.23	700.1	0.00

(kPa) Linear Gage Factor (G): -0.1671 **(kPa/ digit)**

Polynomial Gage factors: **A:** -7.211E-07 **B:** -0.1575 **C:**

Thermal Factor (K): 0.1221 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02424 **(psi/ digit)**

Polynomial Gage Factors: **A:** -1.046E-07 **B:** -0.02284 **C:**

Thermal Factor (K): 0.01771 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures: **Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$***

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8796 **Temperature:** 21.2 °C **Barometer:** 988.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520835

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 70 feet

Technician: K Ryan

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8896	8897	8897	1.813	0.26	0.071	0.01
140.0	8098	8098	8098	139.7	-0.04	140.0	-0.01
280.0	7294	7294	7294	278.6	-0.21	279.8	-0.03
420.0	6482	6482	6482	418.8	-0.17	420.1	0.02
560.0	5665	5665	5665	559.9	-0.02	560.2	0.02
700.0	4844	4844	4844	701.7	0.24	699.9	-0.01

(kPa) Linear Gage Factor (G): -0.1727 **(kPa/ digit)**

Polynomial Gage factors: **A:** -7.65E-07 **B:** -0.1622 **C:**

Thermal Factor (K): -0.02310 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02505 **(psi/ digit)**

Polynomial Gage Factors: **A:** -1.11E-07 **B:** -0.02352 **C:**

Thermal Factor (K): -0.003351 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures: **Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$***

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8903 **Temperature:** 21.1 °C **Barometer:** 988.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520836

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 70 feet

Technician: KS Ryan

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8857	8858	8858	1.430	0.20	0.114	0.02
140.0	8036	8036	8036	139.6	-0.05	139.8	-0.03
280.0	7207	7208	7208	279.0	-0.14	280.0	-0.01
420.0	6375	6375	6375	419.1	-0.13	420.0	0.01
560.0	5537	5538	5538	560.0	-0.01	560.2	0.02
700.0	4697	4698	4698	701.3	0.18	699.9	-0.01

(kPa) Linear Gage Factor (G): -0.1682 **(kPa/ digit)**

Polynomial Gage factors: **A:** -5.507E-07 **B:** -0.1608 **C:**

Thermal Factor (K): 0.09006 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02440 **(psi/ digit)**

Polynomial Gage Factors: **A:** -7.988E-08 **B:** -0.02332 **C:**

Thermal Factor (K): 0.01306 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8858 **Temperature:** 21.1 °C **Barometer:** 988.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520837

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 60 feet

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8791	8792	8792	1.972	0.28	0.018	0.00
140.0	7988	7988	7988	139.7	-0.04	140.1	0.01
280.0	7179	7180	7180	278.4	-0.24	279.8	-0.03
420.0	6362	6362	6362	418.5	-0.21	420.0	0.01
560.0	5538	5538	5538	559.8	-0.04	560.2	0.02
700.0	4709	4709	4709	701.9	0.27	700.0	-0.01

(kPa) Linear Gage Factor (G): -0.1715 (kPa/ digit)

Polynomial Gage factors: A: -8.632E-07 B: -0.1598 C:

Thermal Factor (K): 0.07087 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02487 (psi/ digit)

Polynomial Gage Factors: A: -1.252E-07 B: -0.02318 C:

Thermal Factor (K): 0.01028 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8795 Temperature: 20.9 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520838

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 50 feet

Technician: KS Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8893	8894	8894	1.747	0.25	0.025	0.00
140.0	8065	8066	8066	139.5	-0.07	139.9	-0.02
280.0	7229	7229	7229	278.8	-0.18	280.2	0.02
420.0	6389	6389	6389	418.6	-0.20	420.0	0.00
560.0	5542	5542	5542	559.5	-0.07	559.9	-0.02
700.0	4687	4687	4687	701.8	0.26	700.1	0.01

(kPa) Linear Gage Factor (G): -0.1664 **(kPa/ digit)**

Polynomial Gage factors: **A:** -7.369E-07 **B:** -0.1564 **C:**

Thermal Factor (K): 0.09089 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02414 **(psi/ digit)**

Polynomial Gage Factors: **A:** -1.069E-07 **B:** -0.02269 **C:**

Thermal Factor (K): 0.01318 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8900 **Temperature:** 20.9 °C **Barometer:** 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520839

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 50 feet

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8992	8992	8992	1.836	0.26	0.111	0.02
140.0	8168	8168	8168	139.4	-0.09	139.8	-0.03
280.0	7335	7335	7335	278.5	-0.22	280.0	0.00
420.0	6496	6496	6496	418.6	-0.20	420.1	0.02
560.0	5651	5651	5651	559.6	-0.06	560.1	0.01
700.0	4800	4800	4800	701.7	0.24	700.0	-0.01

(kPa) Linear Gage Factor (G): -0.1670 (kPa/ digit)

Polynomial Gage factors: A: -7.693E-07 B: -0.1563 C:

Thermal Factor (K): 0.09551 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02421 (psi/ digit)

Polynomial Gage Factors: A: -1.116E-07 B: -0.02268 C:

Thermal Factor (K): 0.01385 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8998 Temperature: 21.0 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St, Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520840

Calibration Instruction: VW Pressure Transducers

Cable Length: 50 feet

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Temperature: 22.90 °C

Barometric Pressure: 995.7 mbar

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8857	8858	8858	1.827	0.26	0.153	0.02
140.0	8066	8066	8066	139.6	-0.06	139.8	-0.03
280.0	7267	7267	7267	278.6	-0.20	279.8	-0.03
420.0	6460	6460	6460	419.0	-0.13	420.3	0.04
560.0	5651	5651	5651	559.8	-0.03	560.1	0.01
700.0	4836	4836	4836	701.6	0.23	699.9	-0.01

(kPa) Linear Gage Factor (G): -0.1740 (kPa/ digit)

Polynomial Gage factors: A: -7.489E-07 B: -0.1638 C:

Thermal Factor (K): 0.08551 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02524 (psi/ digit)

Polynomial Gage Factors: A: -1.086E-07 B: -0.02375 C:

Thermal Factor (K): 0.01240 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8861 Temperature: 21.1 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520842

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 50 feet

Technician: K Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8819	8820	8820	1.745	0.25	-0.015	0.00
140.0	7989	7989	7989	139.8	-0.03	140.0	0.00
280.0	7153	7153	7153	278.7	-0.18	280.0	0.00
420.0	6311	6311	6311	418.7	-0.18	420.0	0.00
560.0	5462	5463	5463	559.7	-0.05	560.0	-0.01
700.0	4607	4608	4608	701.8	0.26	700.1	0.00

(kPa) Linear Gage Factor (G): -0.1662 **(kPa/ digit)**

Polynomial Gage factors: **A:** -7.151E-07 **B:** -0.1566 **C:**

Thermal Factor (K): 0.03362 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02411 **(psi/ digit)**

Polynomial Gage Factors: **A:** -1.037E-07 **B:** -0.02271 **C:**

Thermal Factor (K): 0.004876 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8824 **Temperature:** 20.8 °C **Barometer:** 988 mbar

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520843

Calibration Instruction: VW Pressure Transducers

Cable Length: 50 feet

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Temperature: 22.90 °C

Barometric Pressure: 995.7 mbar

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8879	8880	8880	1.779	0.25	0.052	0.01
140.0	8066	8066	8066	139.6	-0.06	139.9	-0.02
280.0	7244	7244	7244	278.8	-0.17	280.1	0.02
420.0	6418	6419	6419	418.6	-0.19	420.0	0.00
560.0	5586	5586	5586	559.7	-0.05	560.0	-0.01
700.0	4747	4747	4747	701.8	0.25	700.1	0.00

(kPa) Linear Gage Factor (G): -0.1694 (kPa/ digit)

Polynomial Gage factors: A: -7.438E-07 B: -0.1593 C:

Thermal Factor (K): 0.07068 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02457 (psi/ digit)

Polynomial Gage Factors: A: -1.079E-07 B: -0.02310 C:

Thermal Factor (K): 0.01025 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8882 Temperature: 21.0 °C Barometer: 988 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St, Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520844

Calibration Instruction: VW Pressure Transducers

Cable Length: 40 feet

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Temperature: 22.90 °C

Barometric Pressure: 995.7 mbar

Technician: K Rogers

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8782	8781	8782	1.597	0.23	0.058	0.01
140.0	7960	7960	7960	139.7	-0.04	139.9	-0.01
280.0	7132	7133	7133	278.8	-0.17	279.9	-0.01
420.0	6299	6300	6300	418.8	-0.16	420.0	0.00
560.0	5460	5461	5461	559.9	-0.02	560.2	0.02
700.0	4618	4618	4618	701.5	0.21	700.0	-0.01

(kPa) Linear Gage Factor (G): -0.1681 (kPa/ digit)

Polynomial Gage factors: A: -6.469E-07 B: -0.1594 C:

Thermal Factor (K): -0.002025 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02438 (psi/ digit)

Polynomial Gage Factors: A: -9.383E-08 B: -0.02312 C:

Thermal Factor (K): -0.0002937 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8787 Temperature: 20.7 °C Barometer: 987.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520845

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 40 feet

Technician: KS Ryan

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8477	8477	8477	1.692	0.24	0.064	0.01
140.0	7663	7663	7663	139.4	-0.08	139.7	-0.04
280.0	6837	6838	6838	279.1	-0.12	280.4	0.06
420.0	6014	6014	6014	418.5	-0.21	419.8	-0.02
560.0	5180	5180	5180	559.7	-0.06	560.0	-0.01
700.0	4340	4341	4341	701.7	0.24	700.1	0.01

(kPa) Linear Gage Factor (G): -0.1692 **(kPa/ digit)**

Polynomial Gage factors: **A:** -7.063E-07 **B:** -0.1602 **C:**

Thermal Factor (K): 0.01215 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02455 **(psi/ digit)**

Polynomial Gage Factors: **A:** -1.024E-07 **B:** -0.02323 **C:**

Thermal Factor (K): 0.001762 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8478 **Temperature:** 21.1 °C **Barometer:** 987.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520846

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 40 feet

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8702	8701	8702	1.480	0.21	0.068	0.01
140.0	7908	7908	7908	139.7	-0.05	139.9	-0.01
280.0	7109	7109	7109	278.8	-0.17	279.9	-0.01
420.0	6305	6305	6305	418.9	-0.16	420.0	0.00
560.0	5495	5495	5495	559.9	-0.02	560.2	0.02
700.0	4683	4683	4683	701.4	0.19	699.9	-0.01

(kPa) Linear Gage Factor (G): -0.1742 (kPa/ digit)

Polynomial Gage factors: A: -6.499E-07 B: -0.1655 C:

Thermal Factor (K): 0.09466 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02526 (psi/ digit)

Polynomial Gage Factors: A: -9.426E-08 B: -0.02400 C:

Thermal Factor (K): 0.01373 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8705 Temperature: 21.6 °C Barometer: 987.9 mbar

The above instrument was found to be in tolerance in all operating ranges
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1524048

Calibration Instruction: VW Pressure Transducers

Cable Length: 100 feet

Date of Calibration: August 06, 2015

This calibration has been verified/validated as of 08/13/2015

Temperature: 23.70 °C

Barometric Pressure: 991.8 mbar

Technician:

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8743	8743	8743	1.058	0.15	0.009	0.00
140.0	7956	7956	7956	139.8	-0.02	140.0	0.00
280.0	7166	7166	7166	279.1	-0.12	279.9	-0.01
420.0	6372	6372	6372	419.2	-0.12	420.0	0.00
560.0	5574	5574	5574	559.9	-0.02	560.1	0.01
700.0	4773	4774	4774	701.0	0.14	700.0	-0.01

(kPa) Linear Gage Factor (G): -0.1763 (kPa/ digit)

Polynomial Gage factors: A: -4.903E-07 B: -0.1697 C:

Thermal Factor (K): -0.0002218 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.02558 (psi/ digit)

Polynomial Gage Factors: A: -7.111E-08 B: -0.02462 C:

Thermal Factor (K): -0.00003217 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8743 Temperature: 23.3 °C Barometer: 993.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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ATTACHMENT D

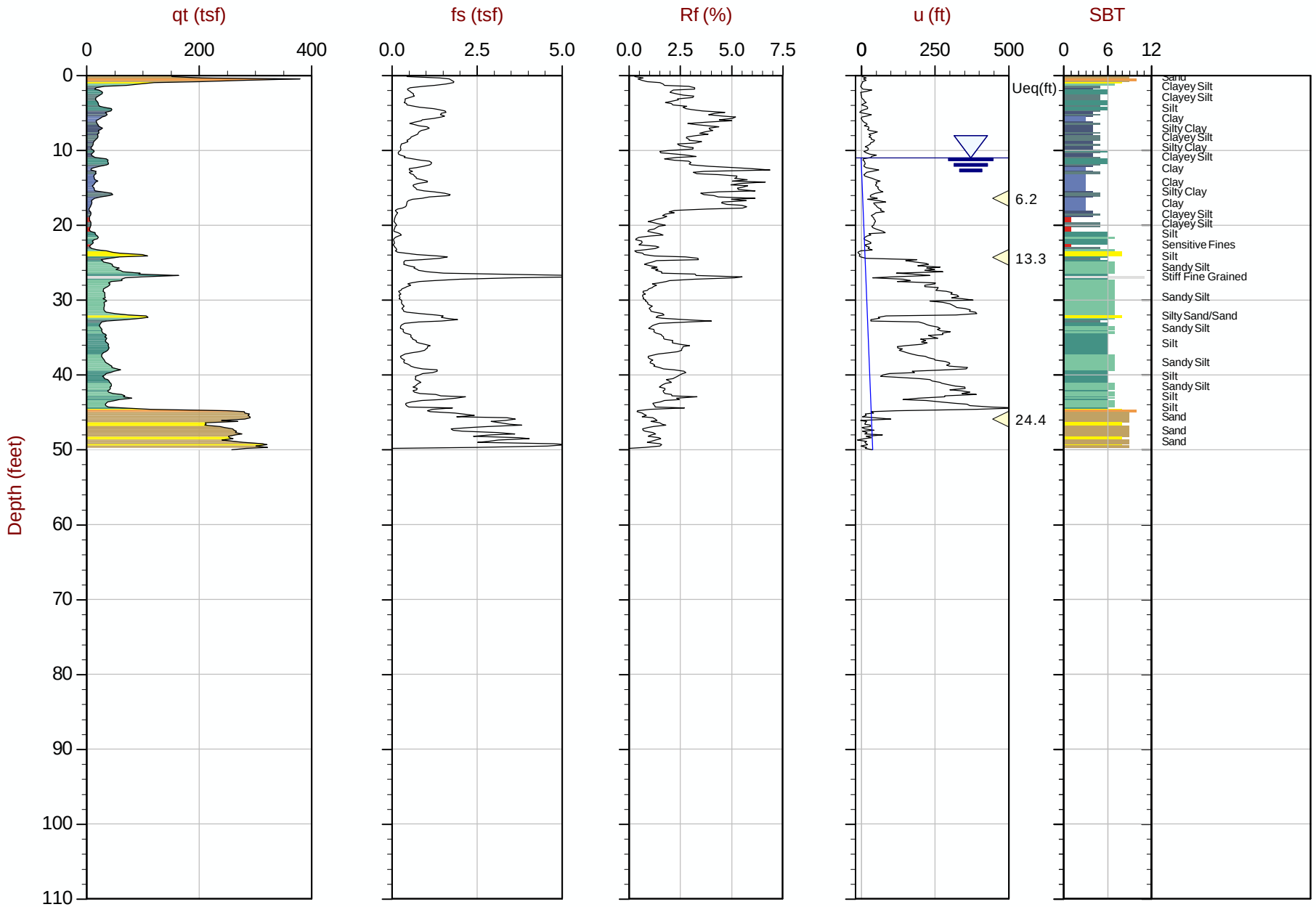
CONE PENETROMETER TESTS (CPT) DATA REPORT

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 15:17
Site: Dynegy Joppa IL

Sounding: JOP-C001
Cone: 392:T1500F15U500



Max Depth: 15.250 m / 50.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C001.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21030 Long: -88.85144

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

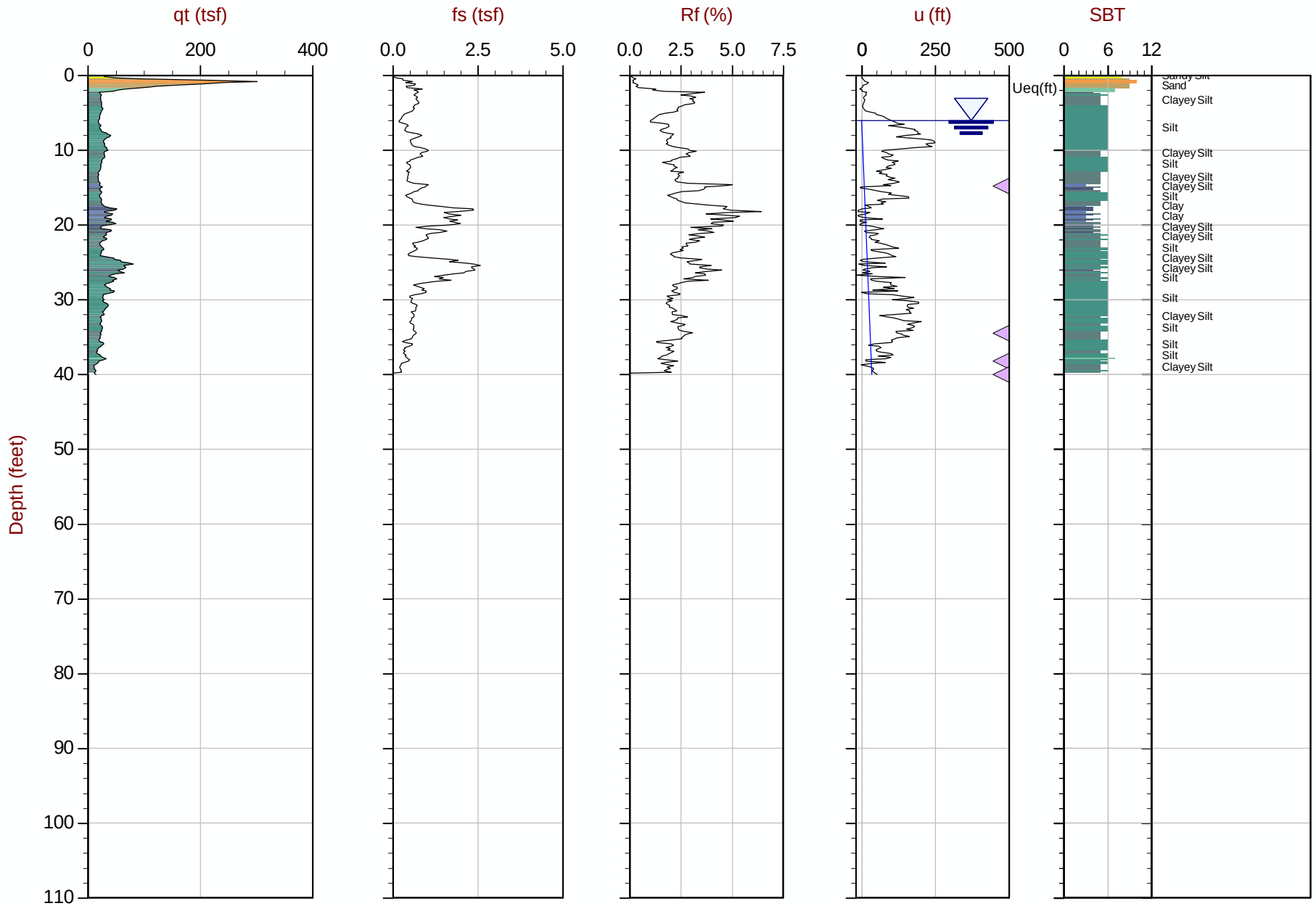
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 08:16
Site: Dynegy Joppa IL

Sounding: JOP-C003
Cone: 392:T1500F15U500



Max Depth: 12.200 m / 40.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C003.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21144 Long: -88.85068

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

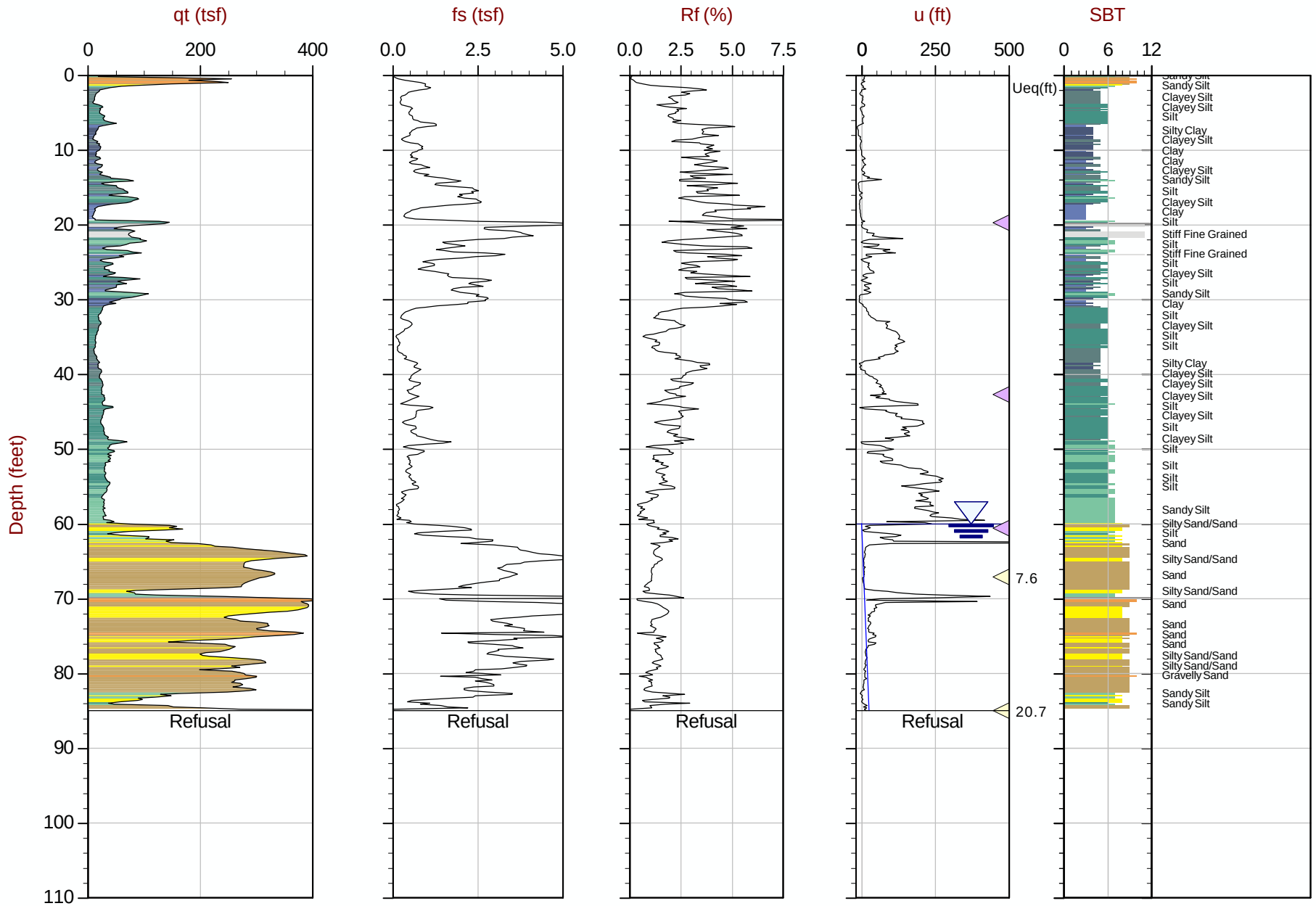
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:07:15 07:41
Site: Dynegy Joppa IL

Sounding: JOP-C004
Cone: 349:T1500F15U500



Max Depth: 25.900 m / 84.97 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C004.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21260 Long: -88.85030

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

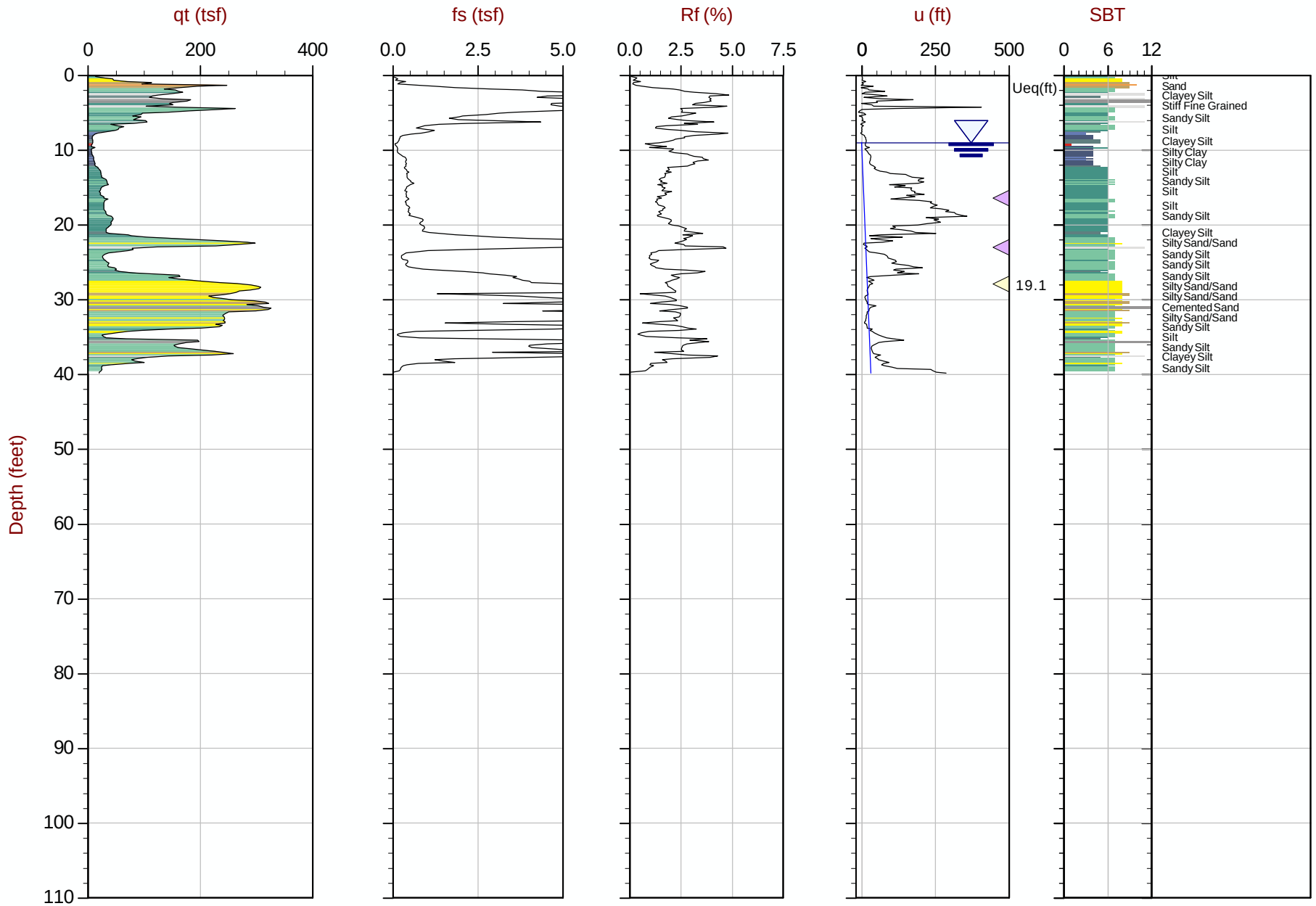
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:20:15 10:29
Site: Dynegy Joppa IL

Sounding: JOP-C005
Cone: 392:T1500F15U500



Max Depth: 12.150 m / 39.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C005.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21240 Long: -88.85047

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

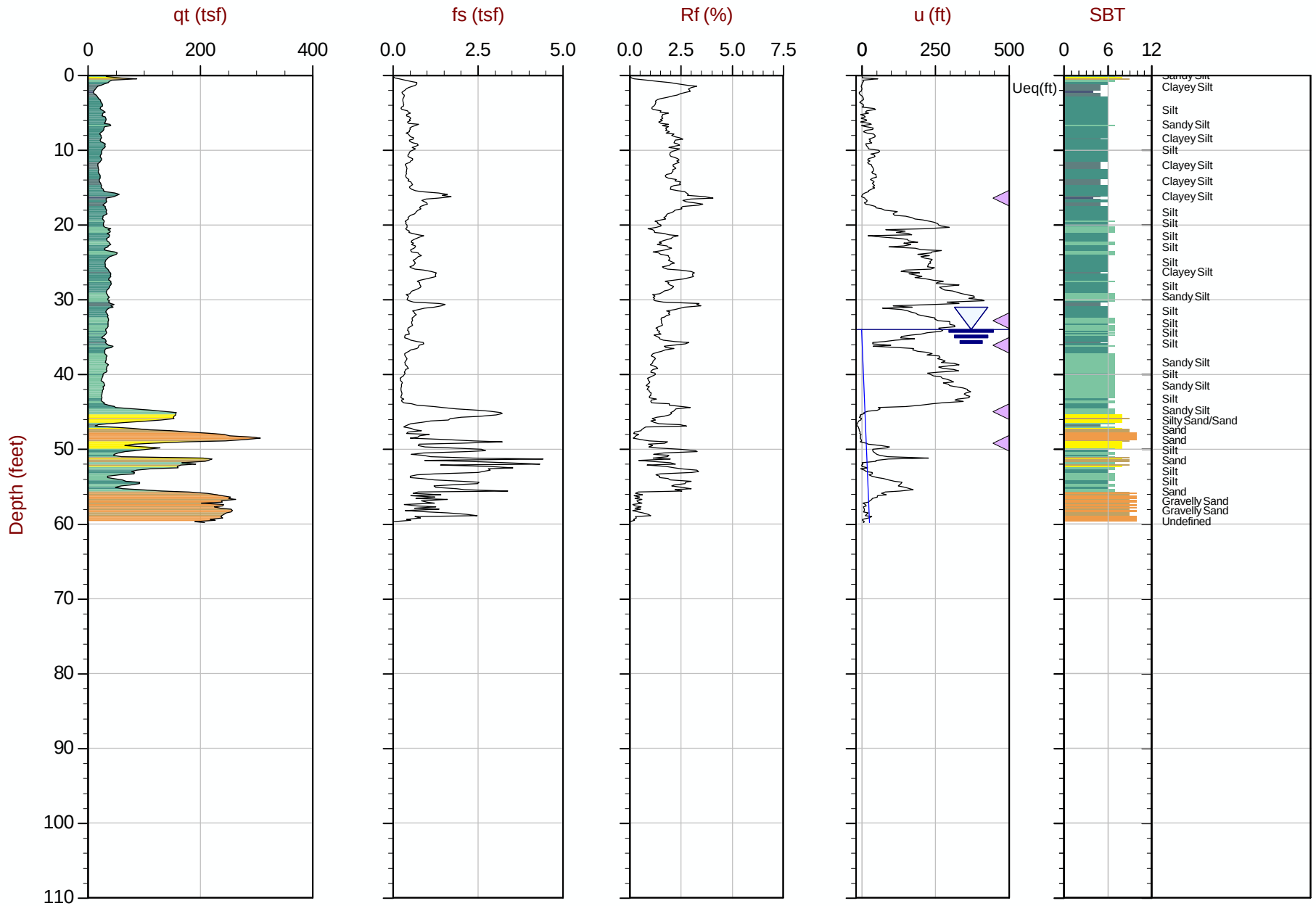
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:20:15 08:24
Site: Dynegy Joppa IL

Sounding: JOP-C006
Cone: 392:T1500F15U500



Max Depth: 18.250 m / 59.87 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C006.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21300 Long: -88.85003

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

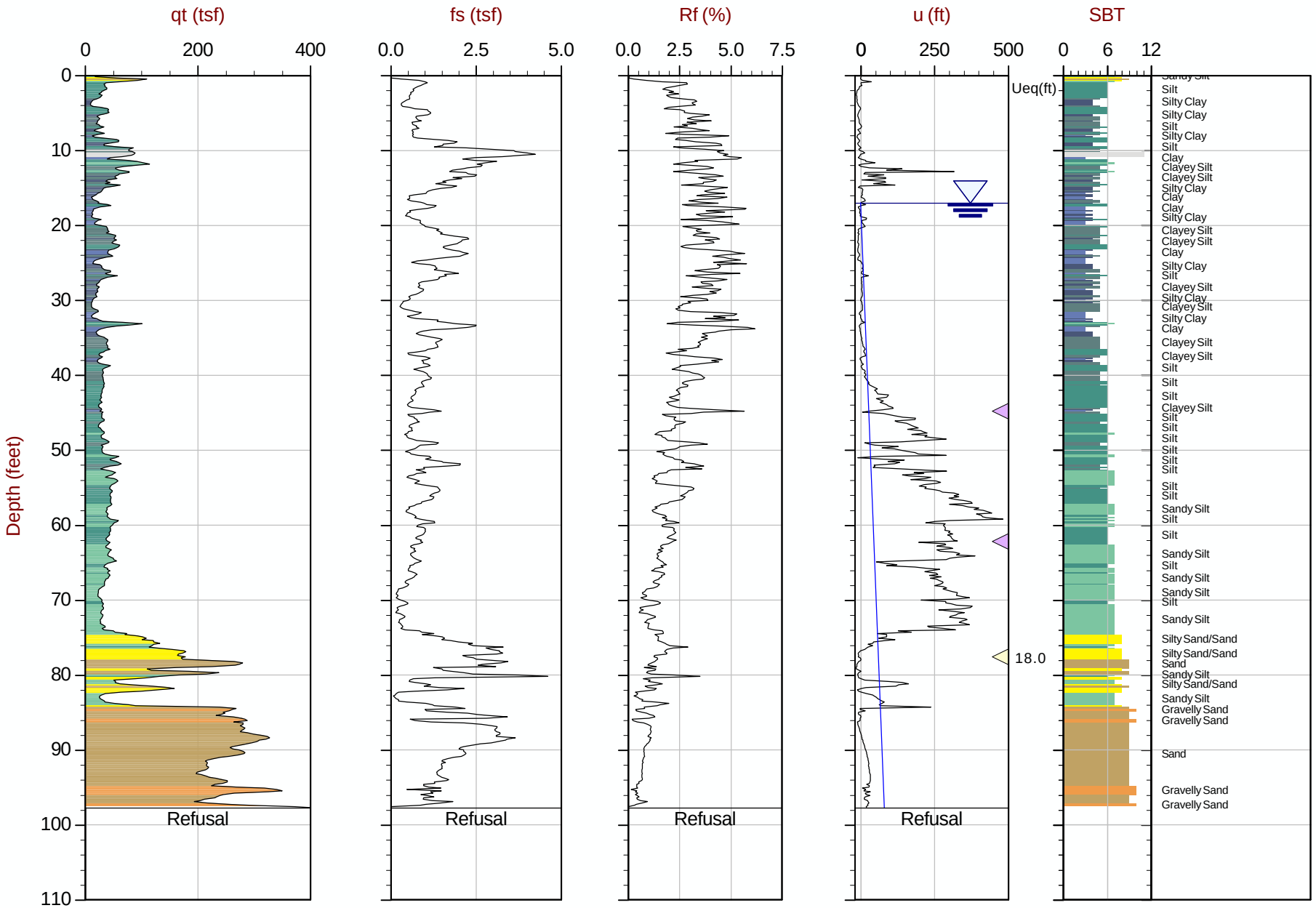
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:06:15 12:53
Site: Dynegy Joppa IL

Sounding: JOP-C007
Cone: 349:T1500F15U500



Max Depth: 29.800 m / 97.77 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C007.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21308 Long: -88.85030

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

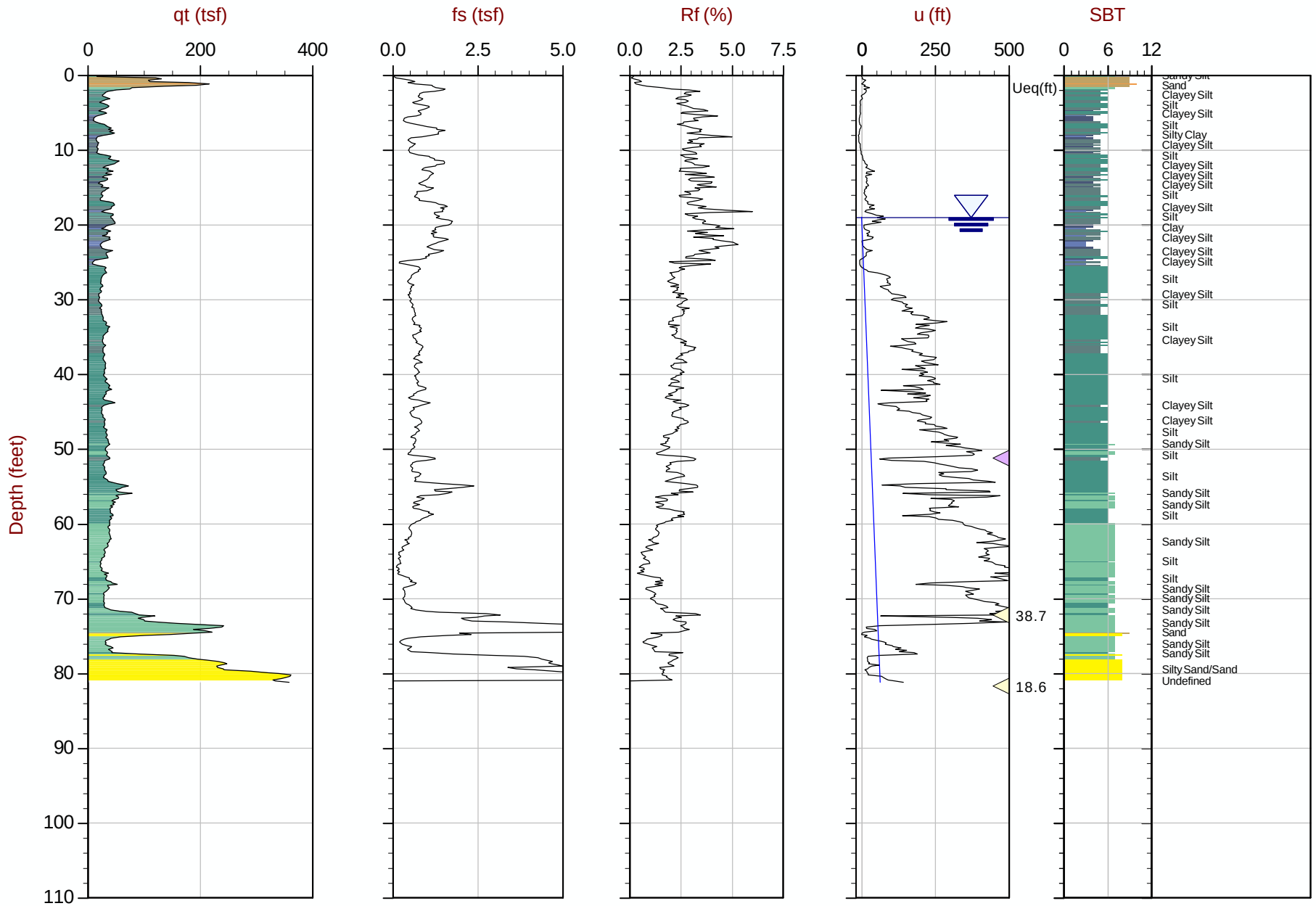
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 08:08
Site: Dynegy Joppa IL

Sounding: JOP-C008
Cone: 184:T1500F15U500



Max Depth: 24.750 m / 81.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C008.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21582 Long: -88.84955

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

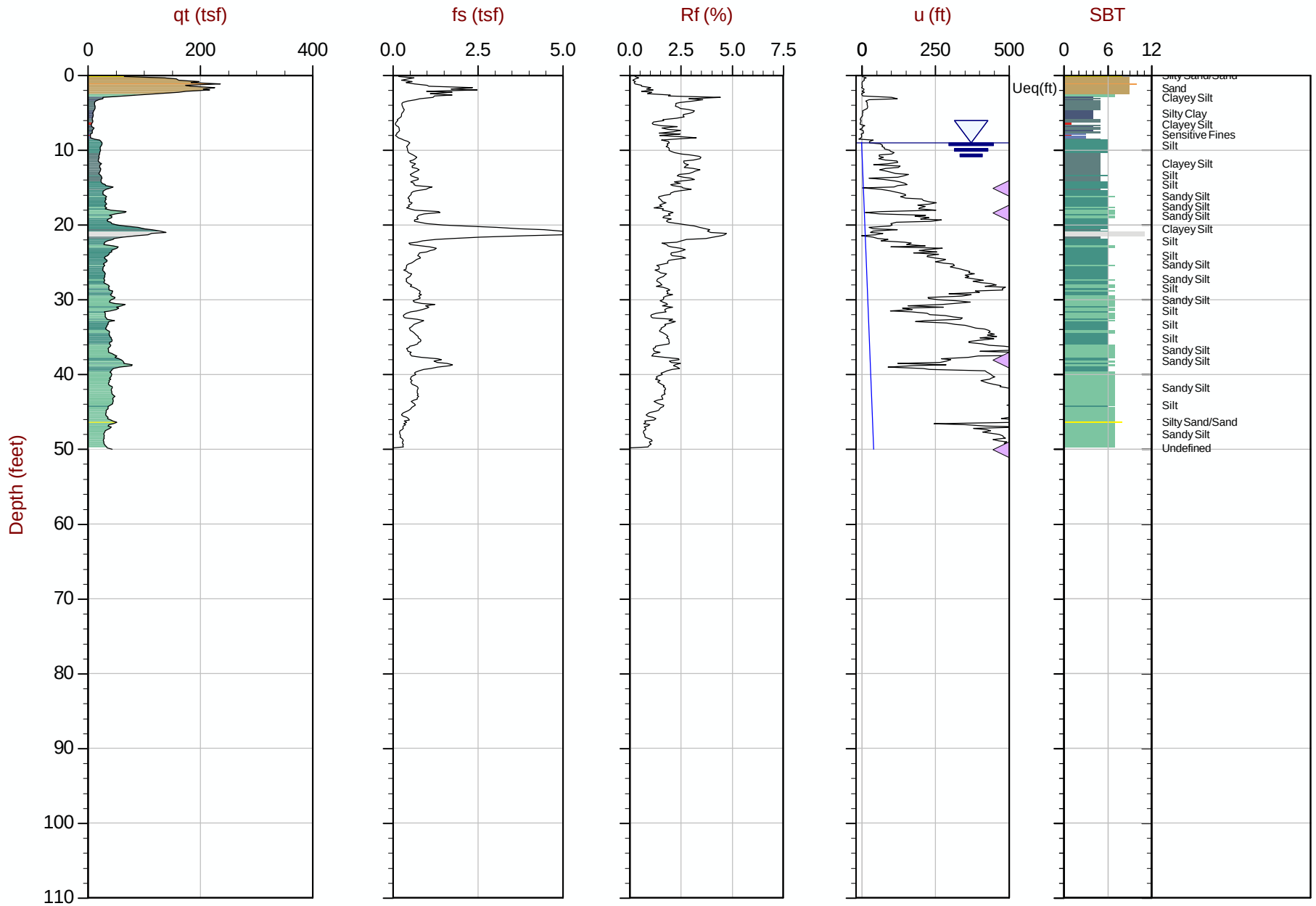
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 13:11
Site: Dynegy Joppa, I

Sounding: JOP-C009
Cone: 392:T1500F15U500



Max Depth: 15.250 m / 50.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C009.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21575 Long: -88.84934

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

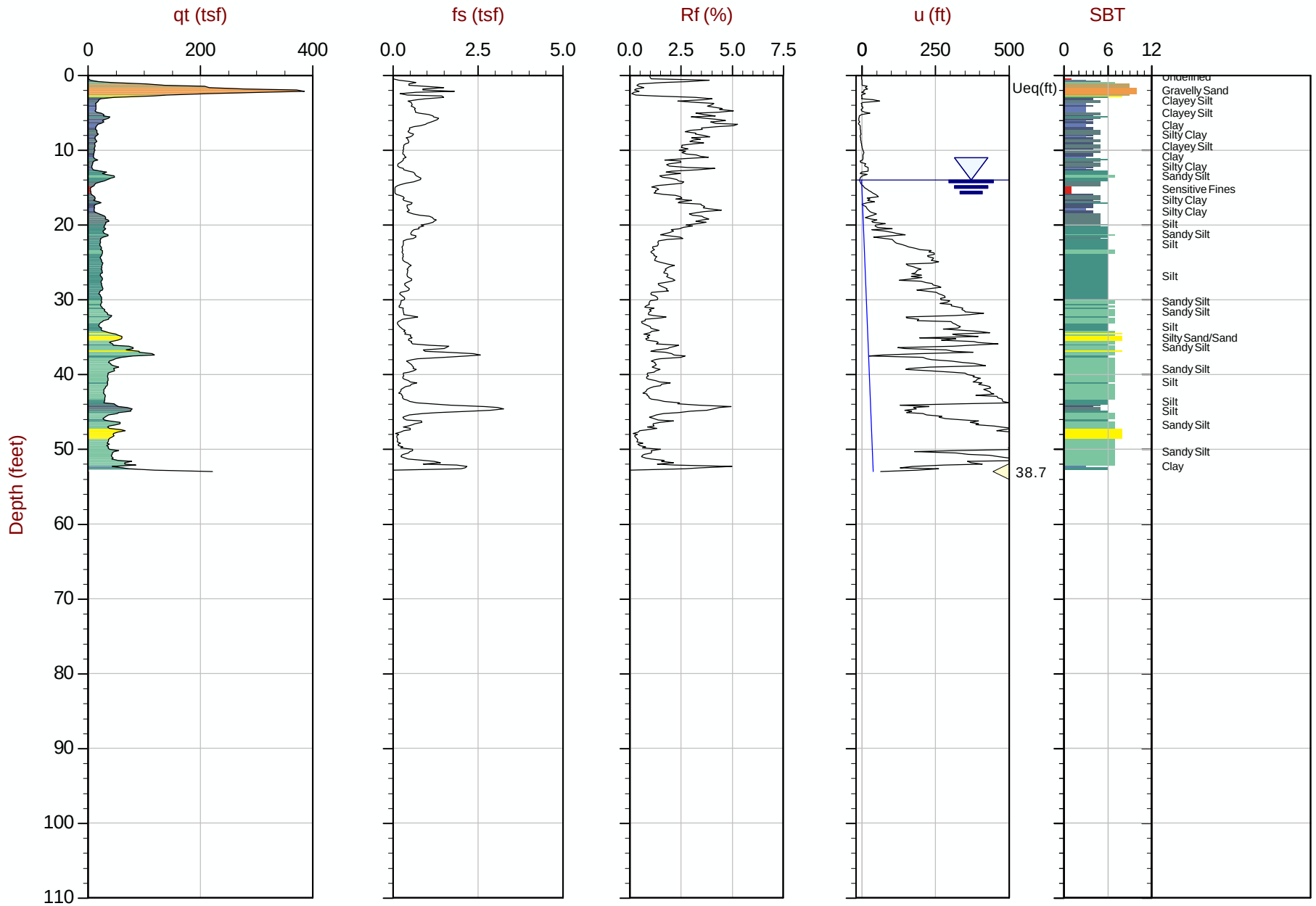
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:09:15 07:40
Site: Dynegy Joppa IL

Sounding: JOP-C011
Cone: 349:T1500F15U500



Max Depth: 16.150 m / 52.98 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C011.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21800 Long: -88.85388

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

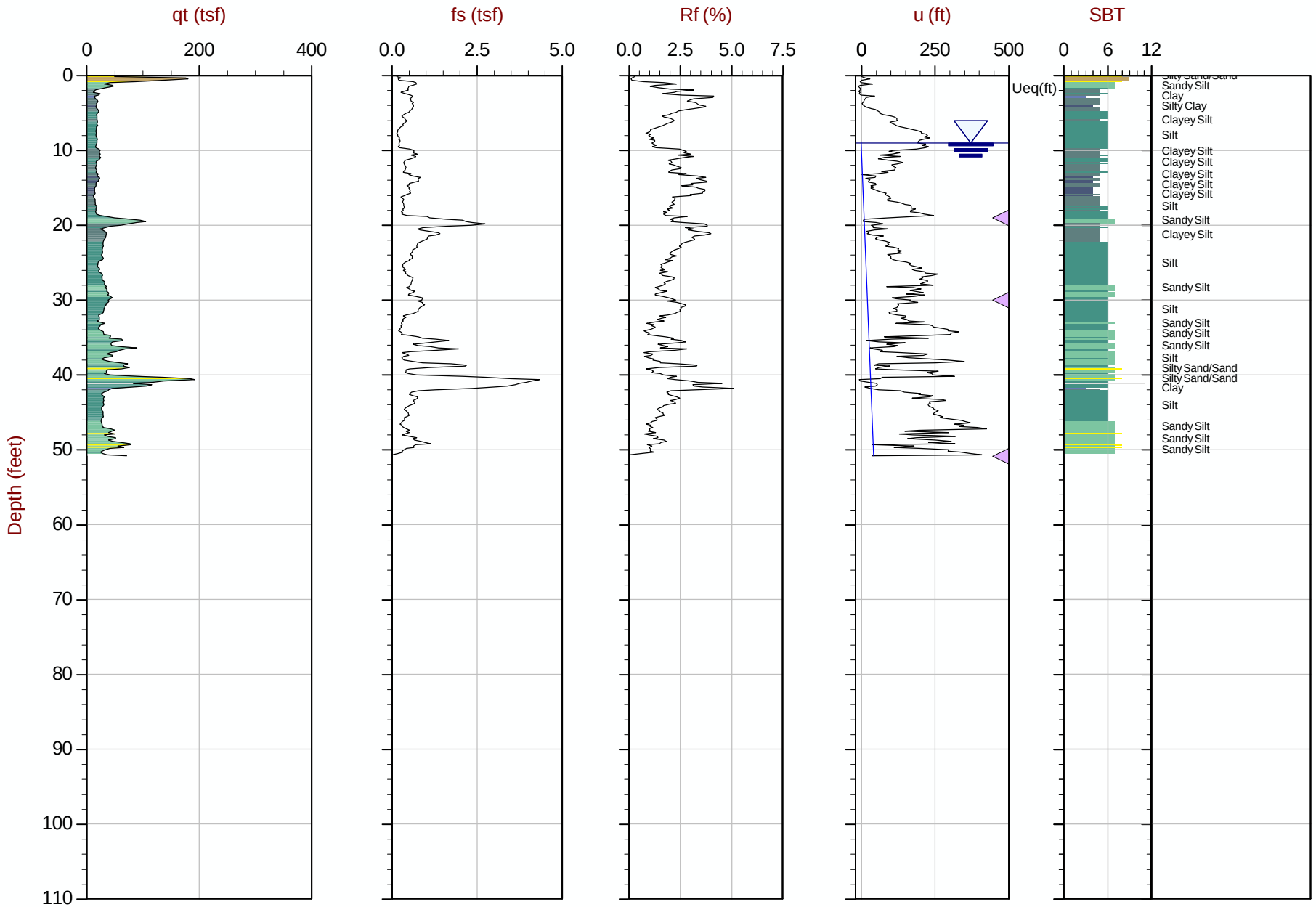
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:09:15 14:16
Site: Dynegy Joppa IL

Sounding: JOP-C013
Cone: 349:T1500F15U500



Max Depth: 15.500 m / 50.85 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C013.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21265 Long: -88.85710

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

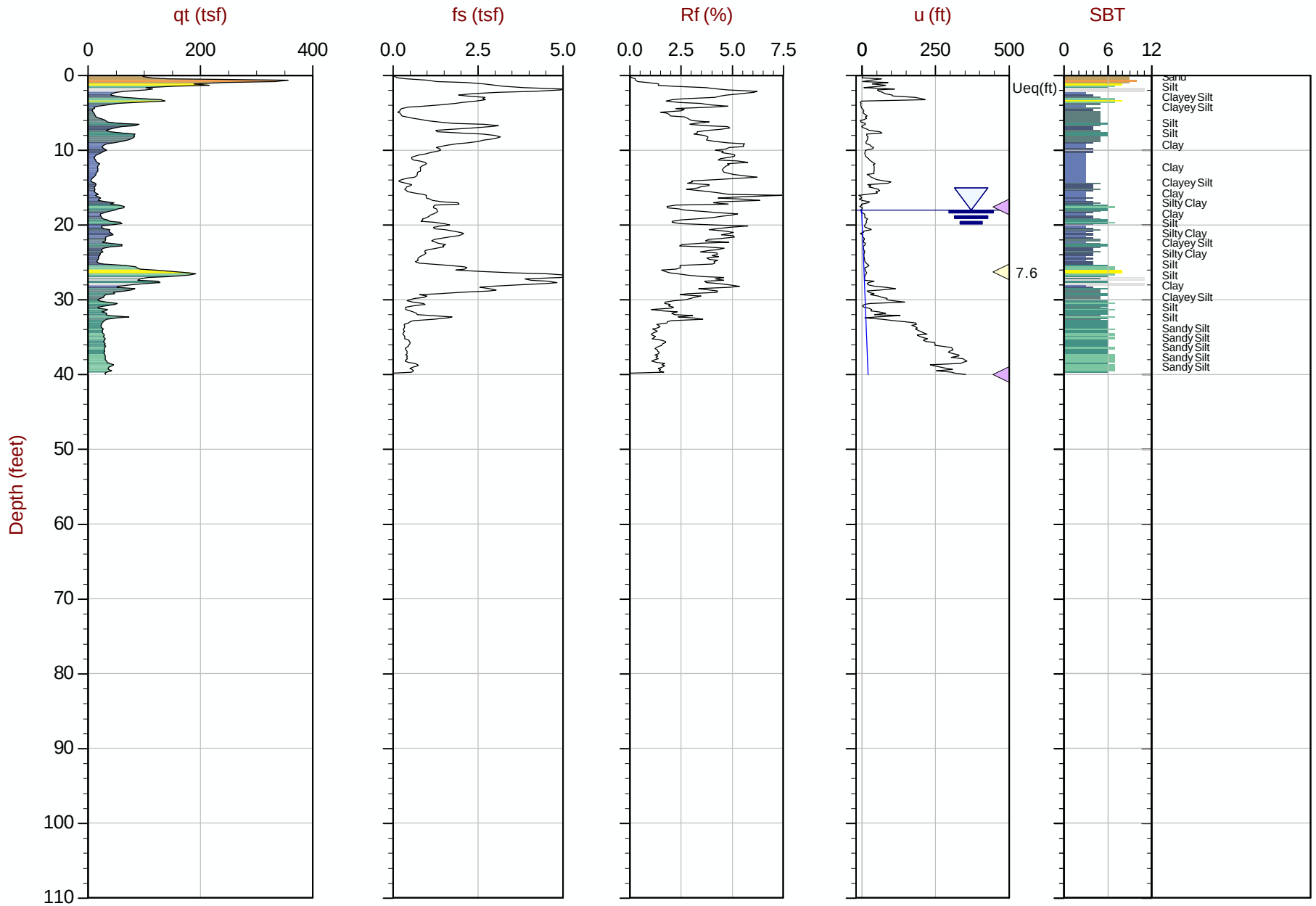
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 11:56
Site: Dynegy Joppa IL

Sounding: JOP-C014
Cone: 392:T1500F15U500



Max Depth: 12.200 m / 40.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C014.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21017 Long: -88.85277

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

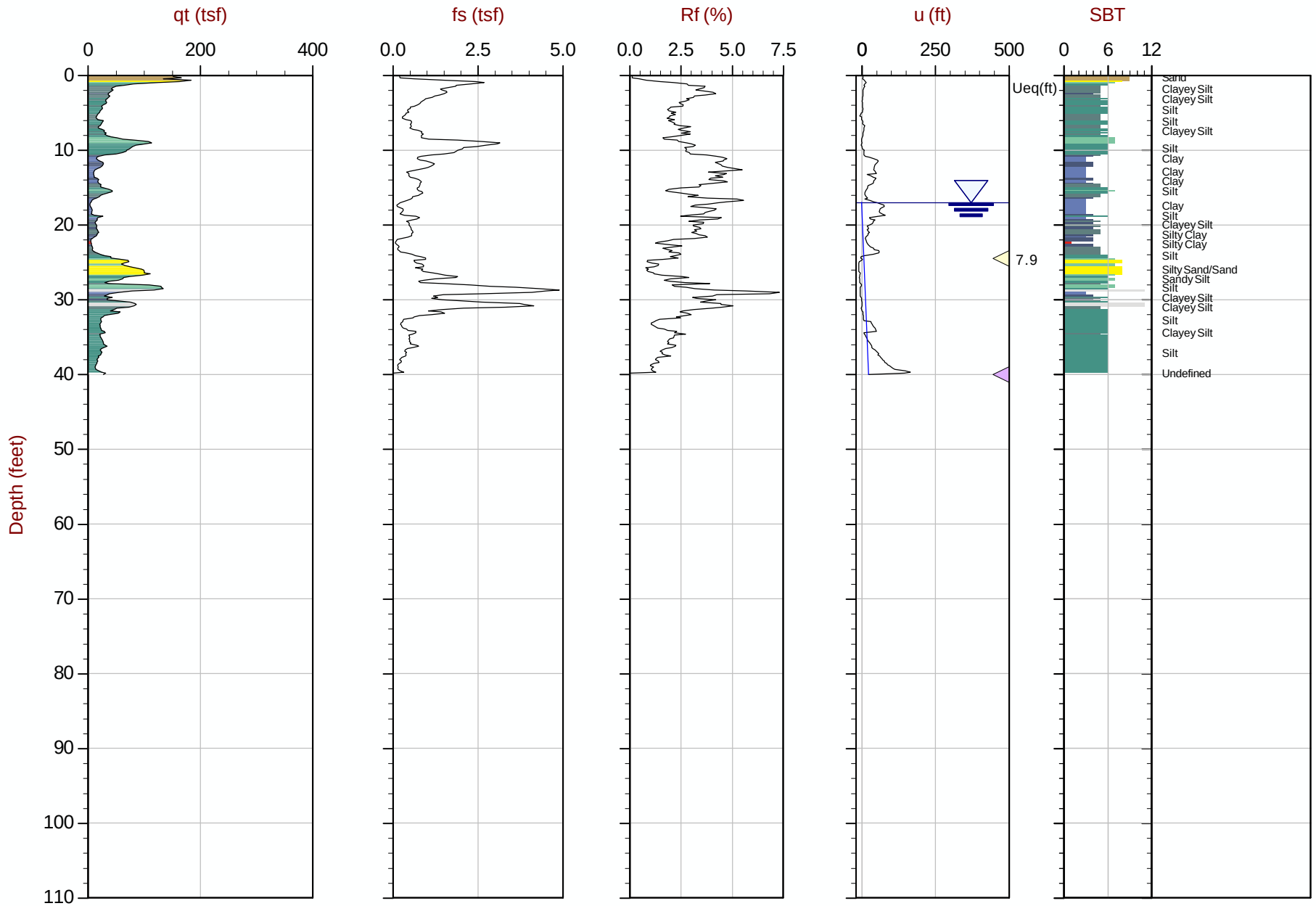
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 13:57
Site: Dynegy Joppa IL

Sounding: JOP-C015
Cone: 392:T1500F15U500



Max Depth: 12.200 m / 40.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C015.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.20992 Long: -88.85199

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

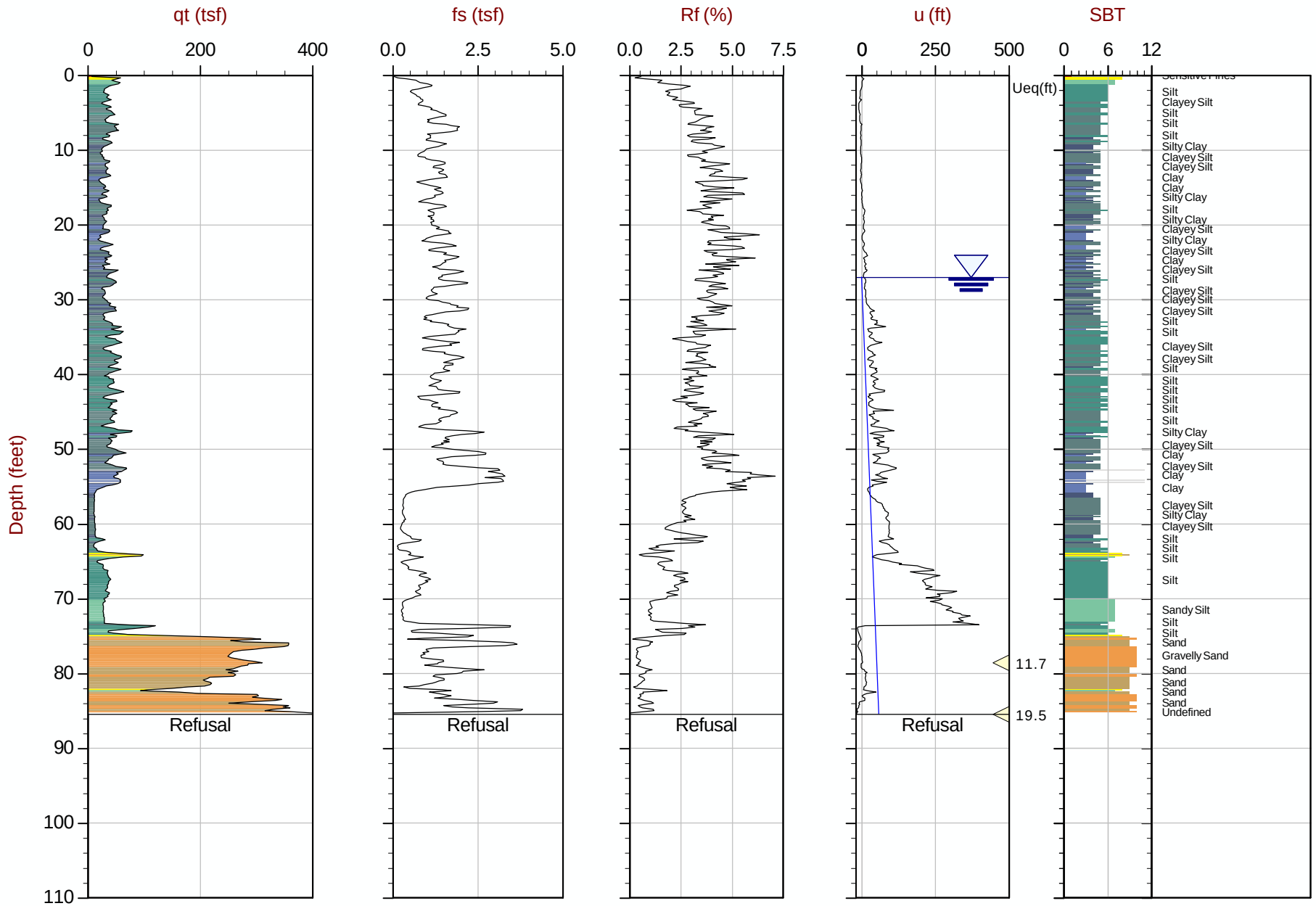
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:08:15 07:38
Site: Dynegy Joppa IL

Sounding: JOP-C016
Cone: 349:T1500F15U500



Max Depth: 26.050 m / 85.46 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C016.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21020 Long: -88.85280

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

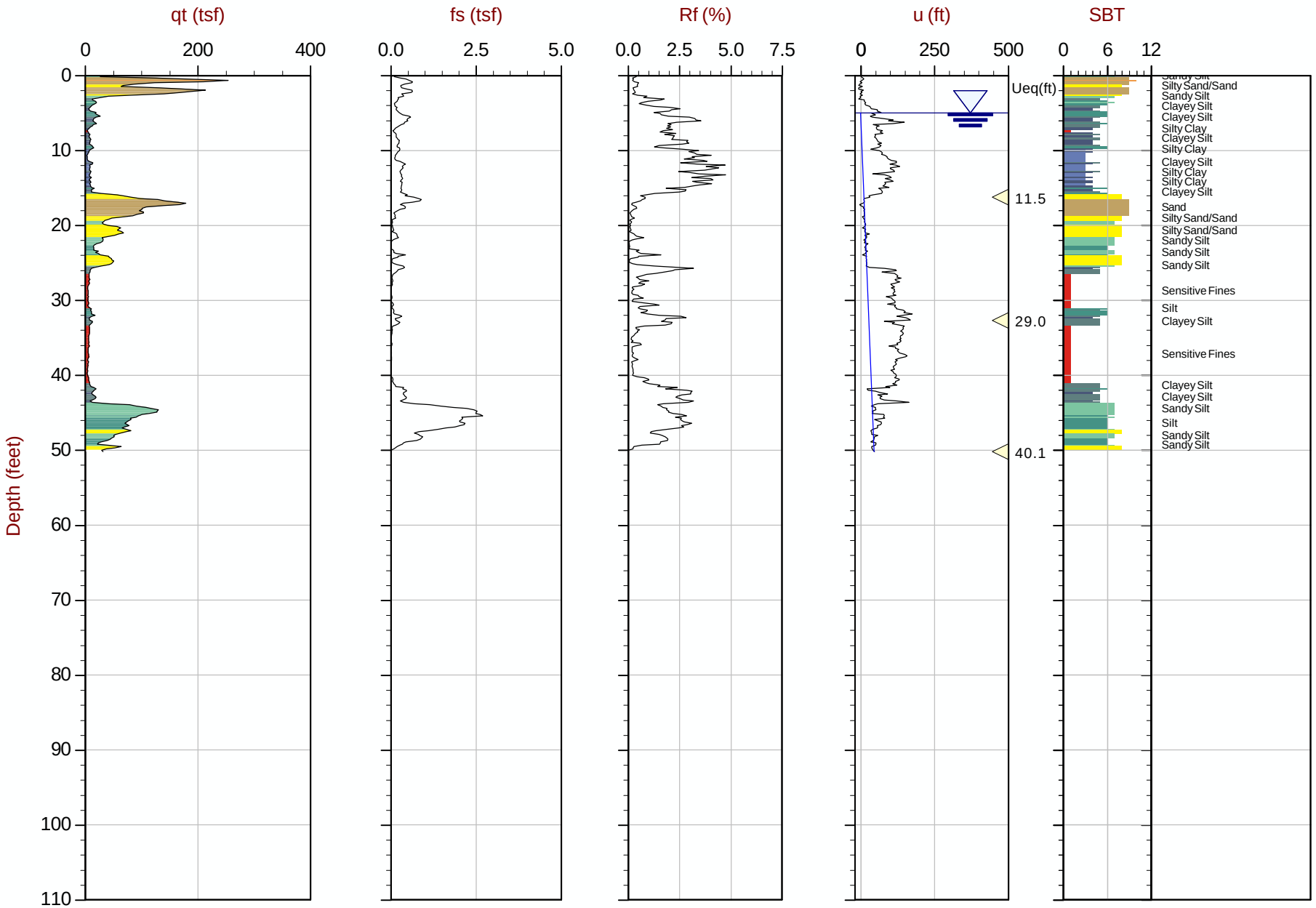
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:20:15 10:19
Site: Dynegy Joppa IL

Sounding: JOP-C017
Cone: 349:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C017.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21128 Long: -88.85363

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

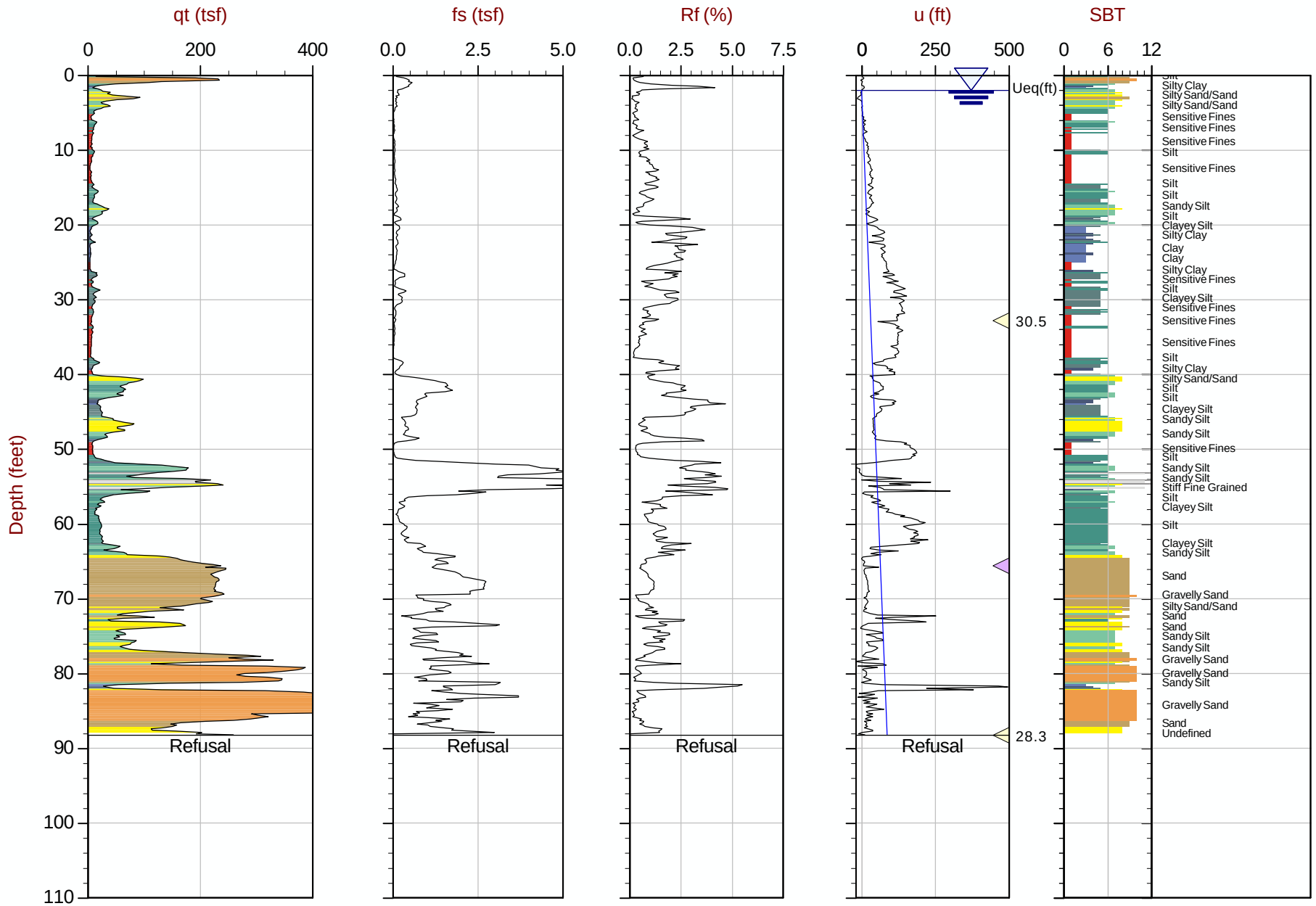
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:20:15 07:39
Site: Dynegy Joppa IL

Sounding: JOP-C018
Cone: 349:T1500F15U500



Max Depth: 26.900 m / 88.25 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C018.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21265 Long: -88.85275

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

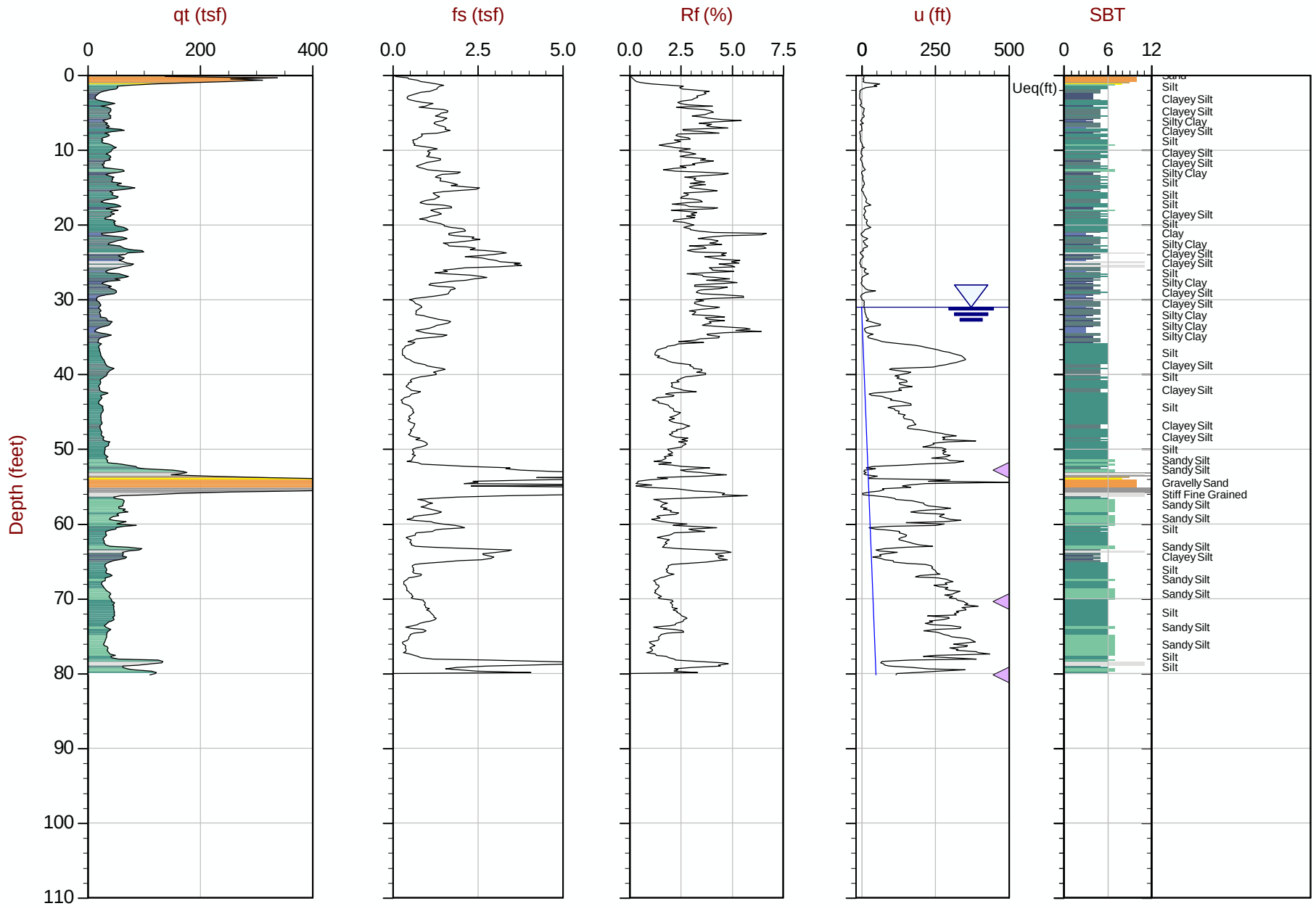
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:08:15 13:15
Site: Dynegy Joppa IL

Sounding: JOP-C019
Cone: 349:T1500F15U500



Max Depth: 24.450 m / 80.22 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C019.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21110 Long: -88.85490

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

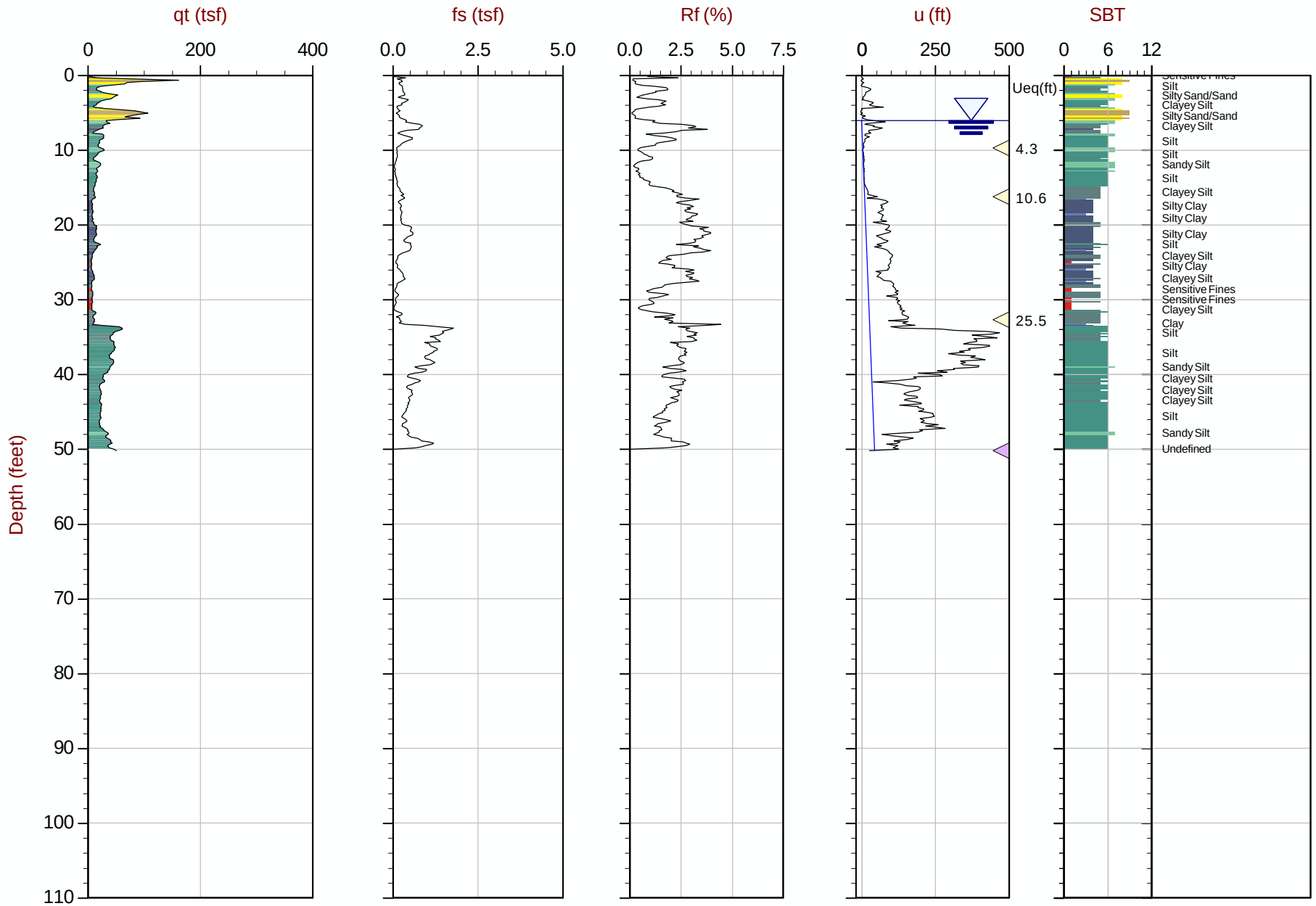
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 14:21
Site: Dynegy Joppa IL

Sounding: JOP-C020
Cone: 349:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C020.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21205 Long: -88.85517

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

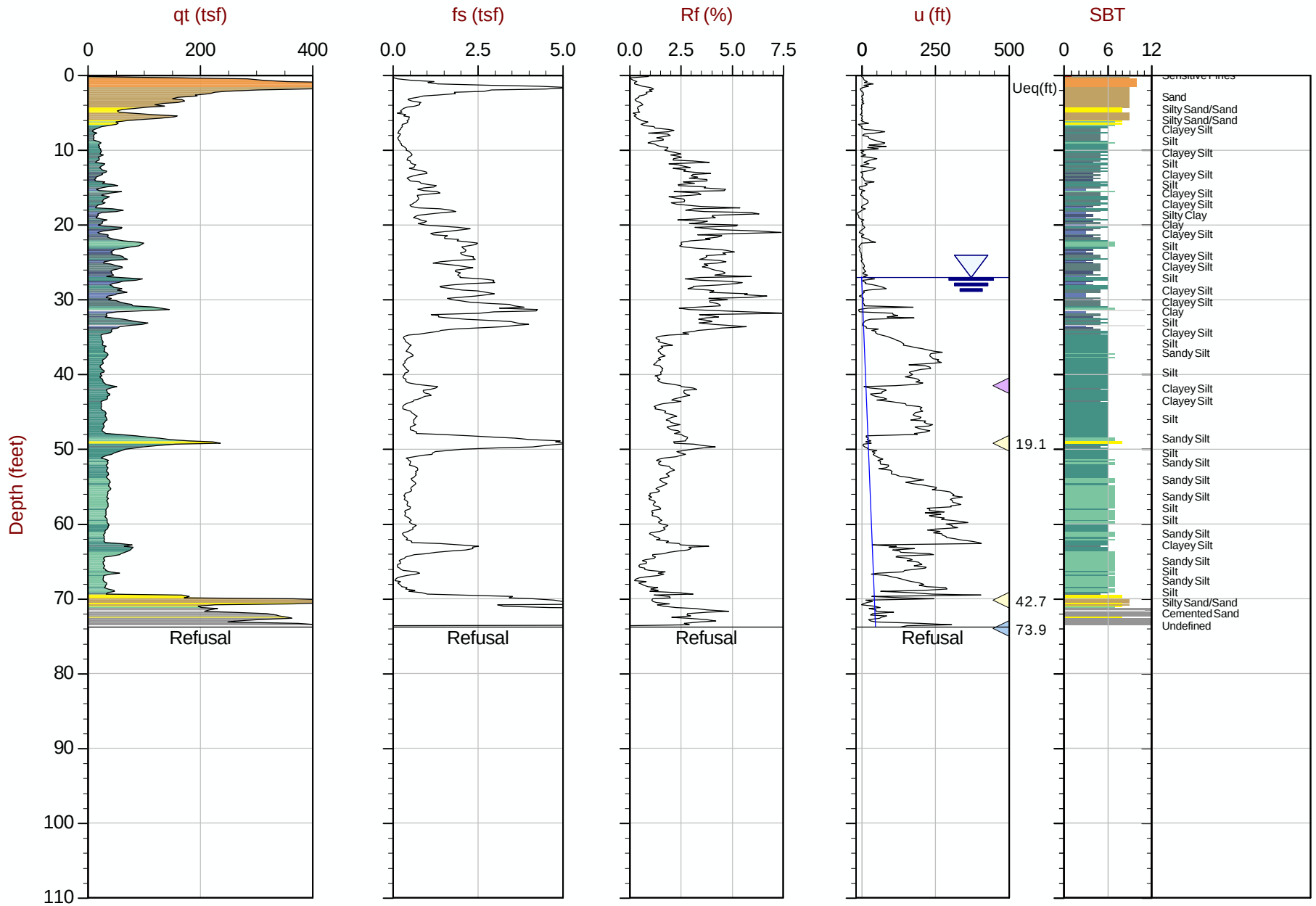
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:09:15 09:29
Site: Dynegy Joppa IL

Sounding: JOP-C021
Cone: 349:T1500F15U500



Max Depth: 22.500 m / 73.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C021.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21165 Long: -88.85580

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

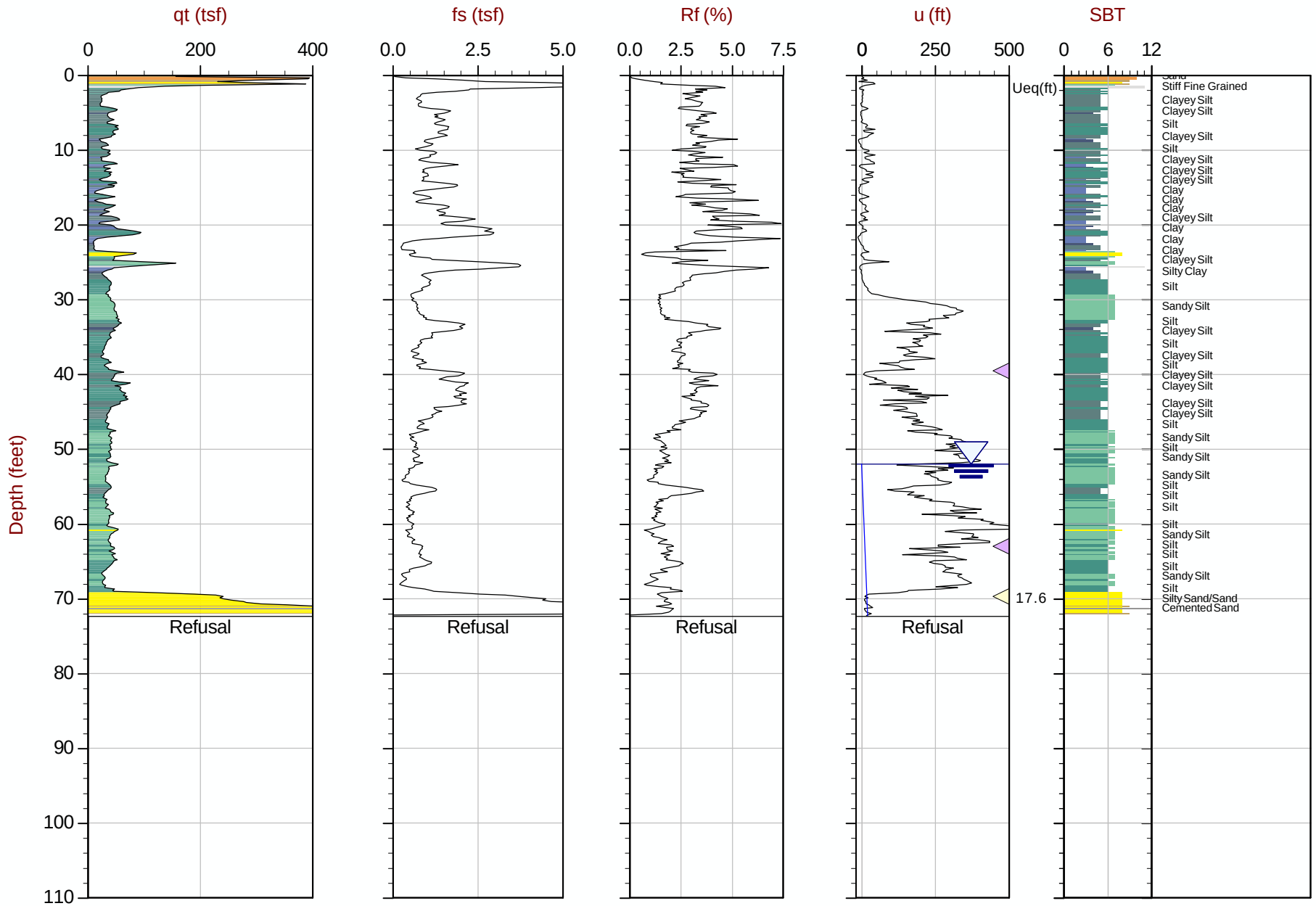
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:09:15 11:56
Site: Dynegy Joppa IL

Sounding: JOP-C022
Cone: 349:T1500F15U500



Max Depth: 22.050 m / 72.34 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C022.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21403 Long: -88.85622

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

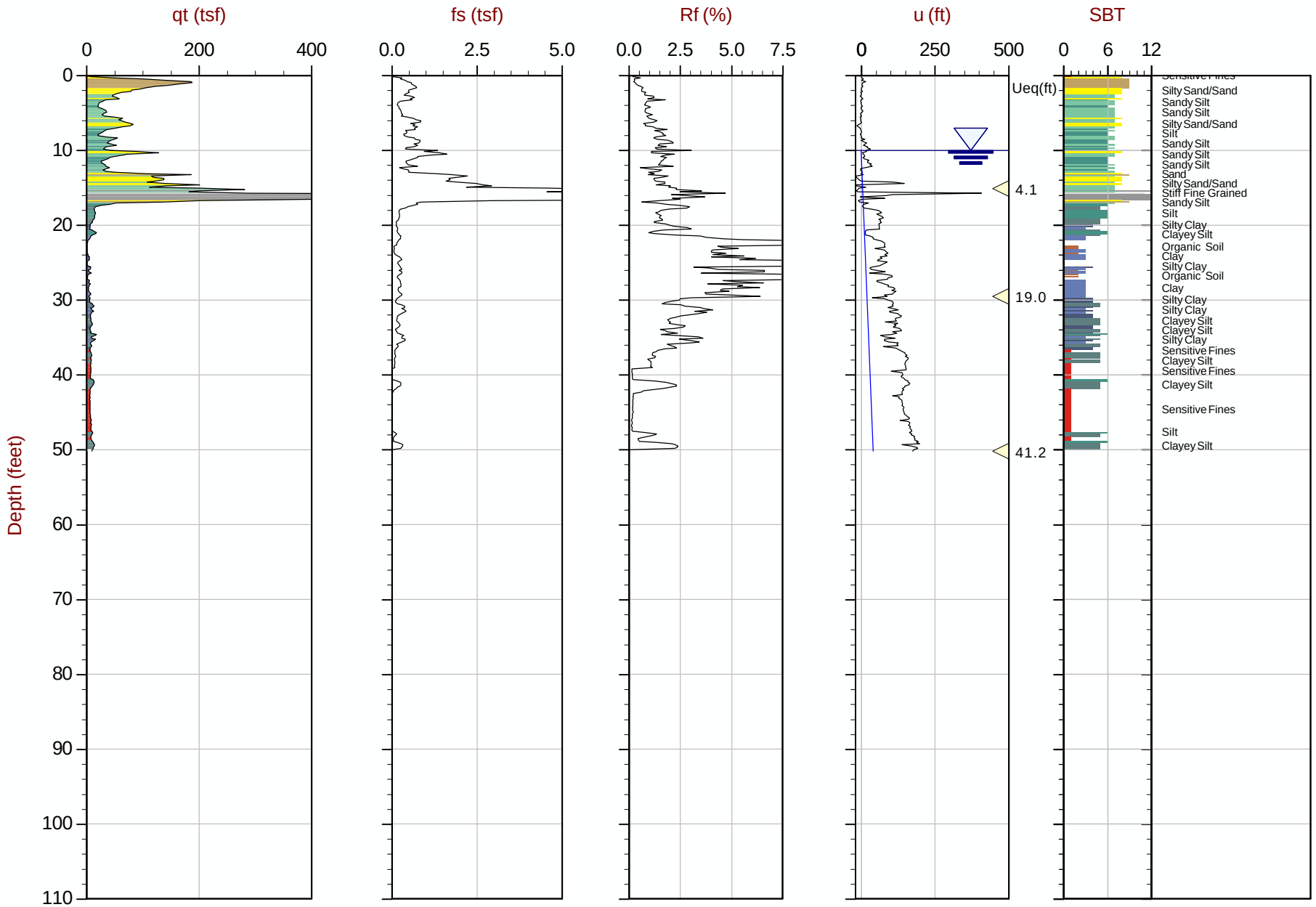
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 09:59
Site: Dynegy Joppa IL

Sounding: JOP-C023
Cone: 349:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C023.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21560 Long: -88.85370

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

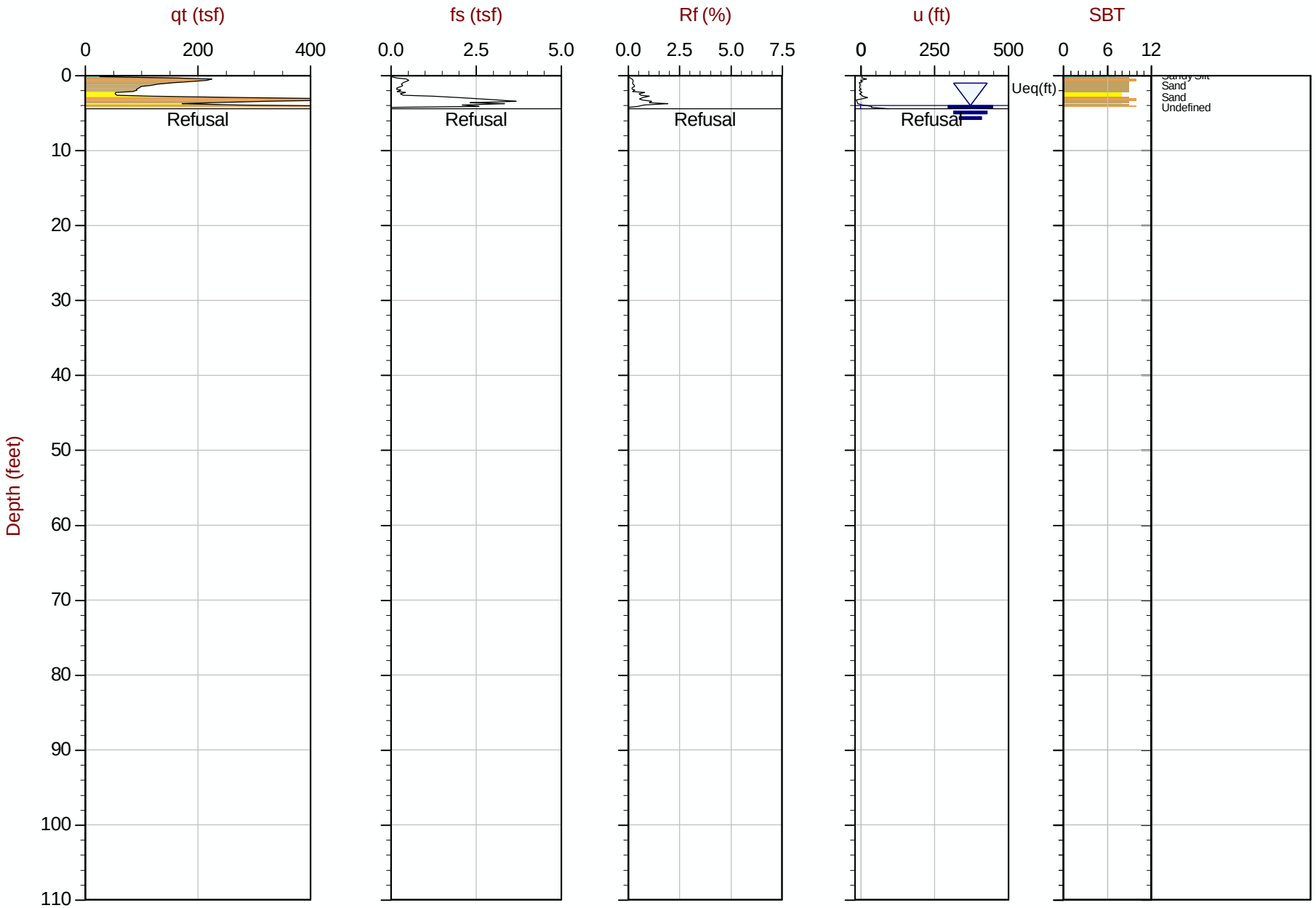
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 07:54
Site: Dynegy Joppa IL

Sounding: JOP-C024
Cone: 184:T1500F15U500



Max Depth: 1.350 m / 4.43 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C024.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21665 Long: -88.85482

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

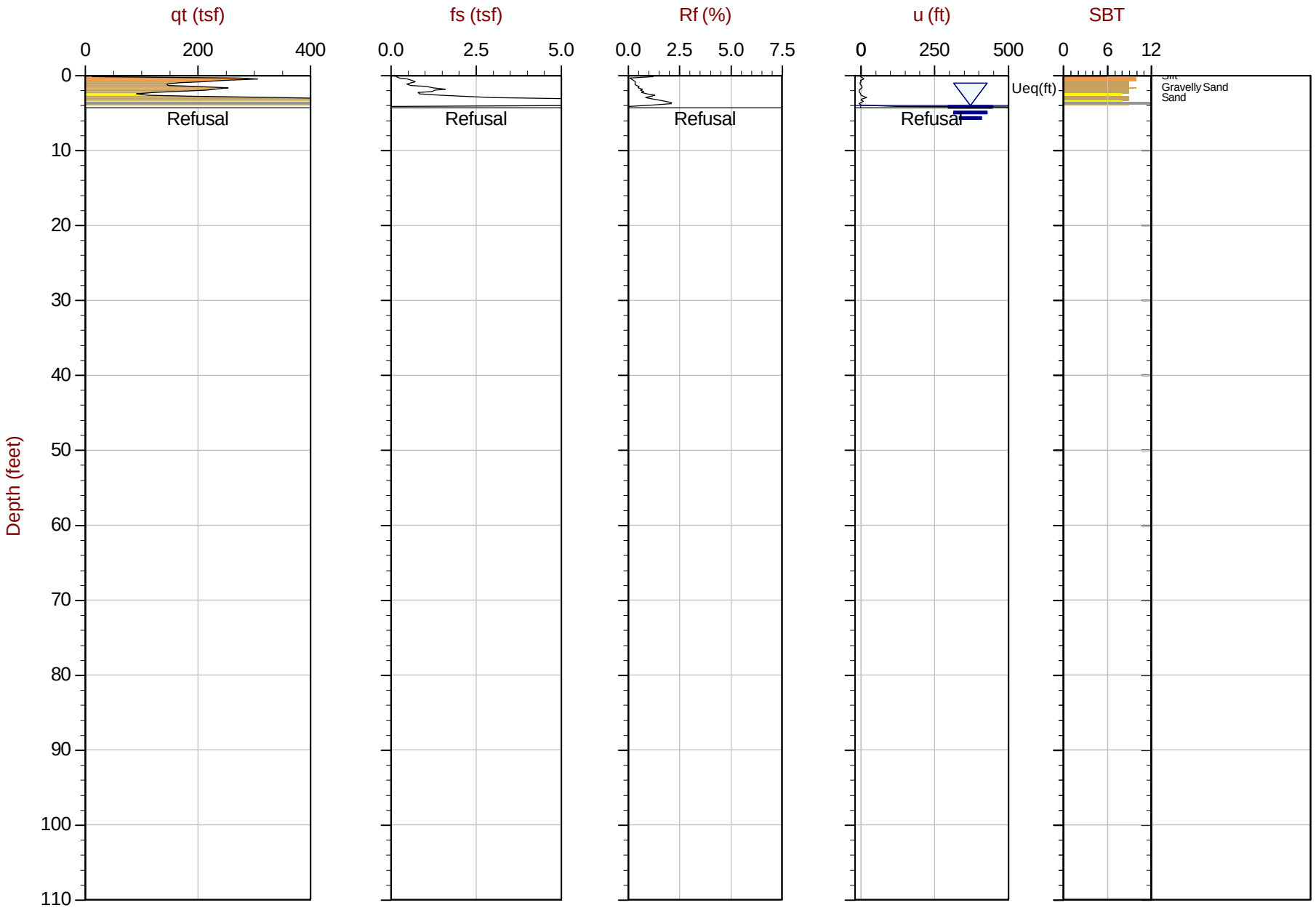
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 08:27
Site: Dynegy Joppa IL

Sounding: JOP-C024A
Cone: 349:T1500F15U500



Max Depth: 1.300 m / 4.27 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C024A.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21665 Long: -88.85482

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

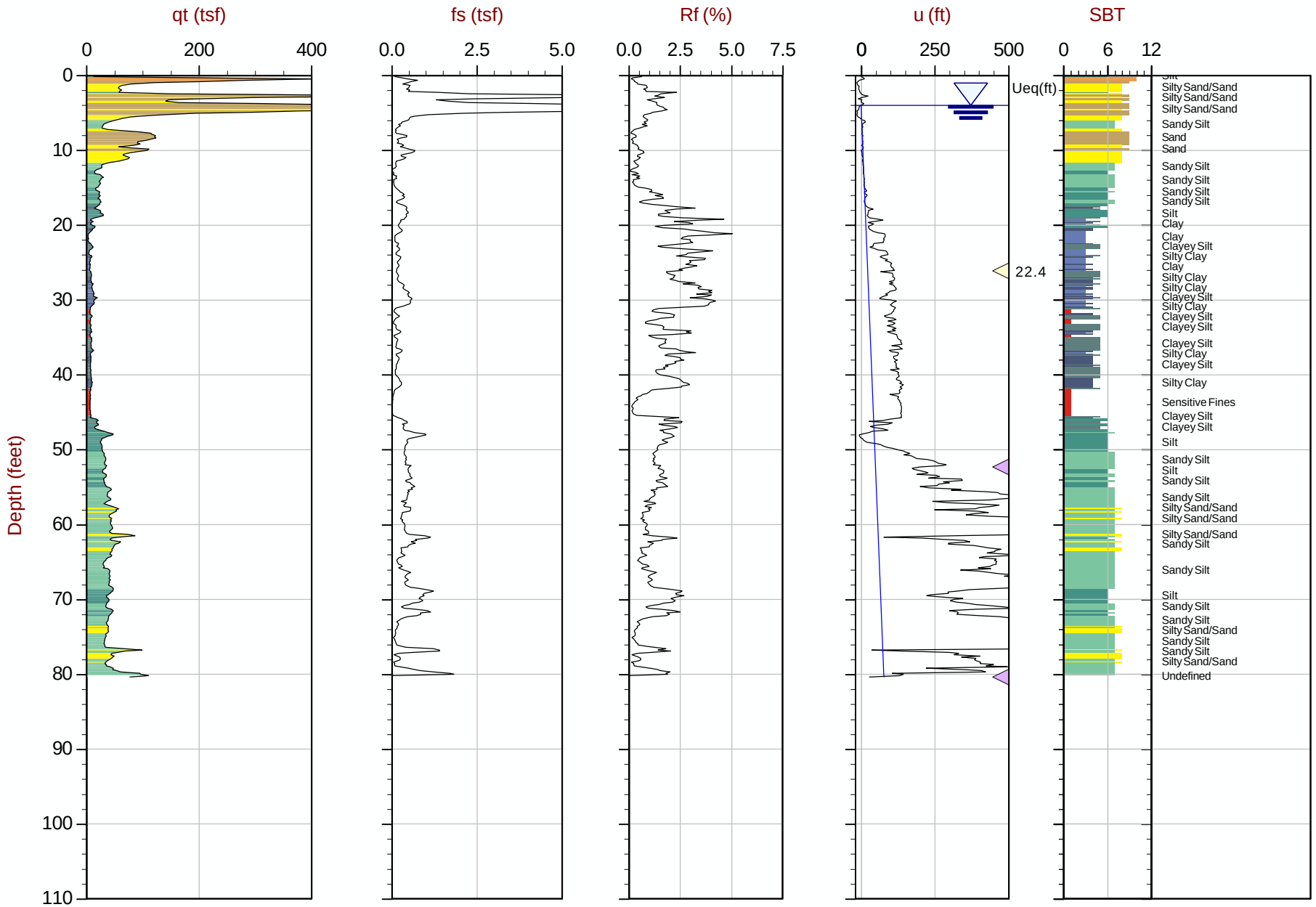
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 11:08
Site: Dynegy Joppa IL

Sounding: JOP-C024B
Cone: 349:T1500F15U500



Max Depth: 24.500 m / 80.38 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C024B.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21658 Long: -88.85478

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

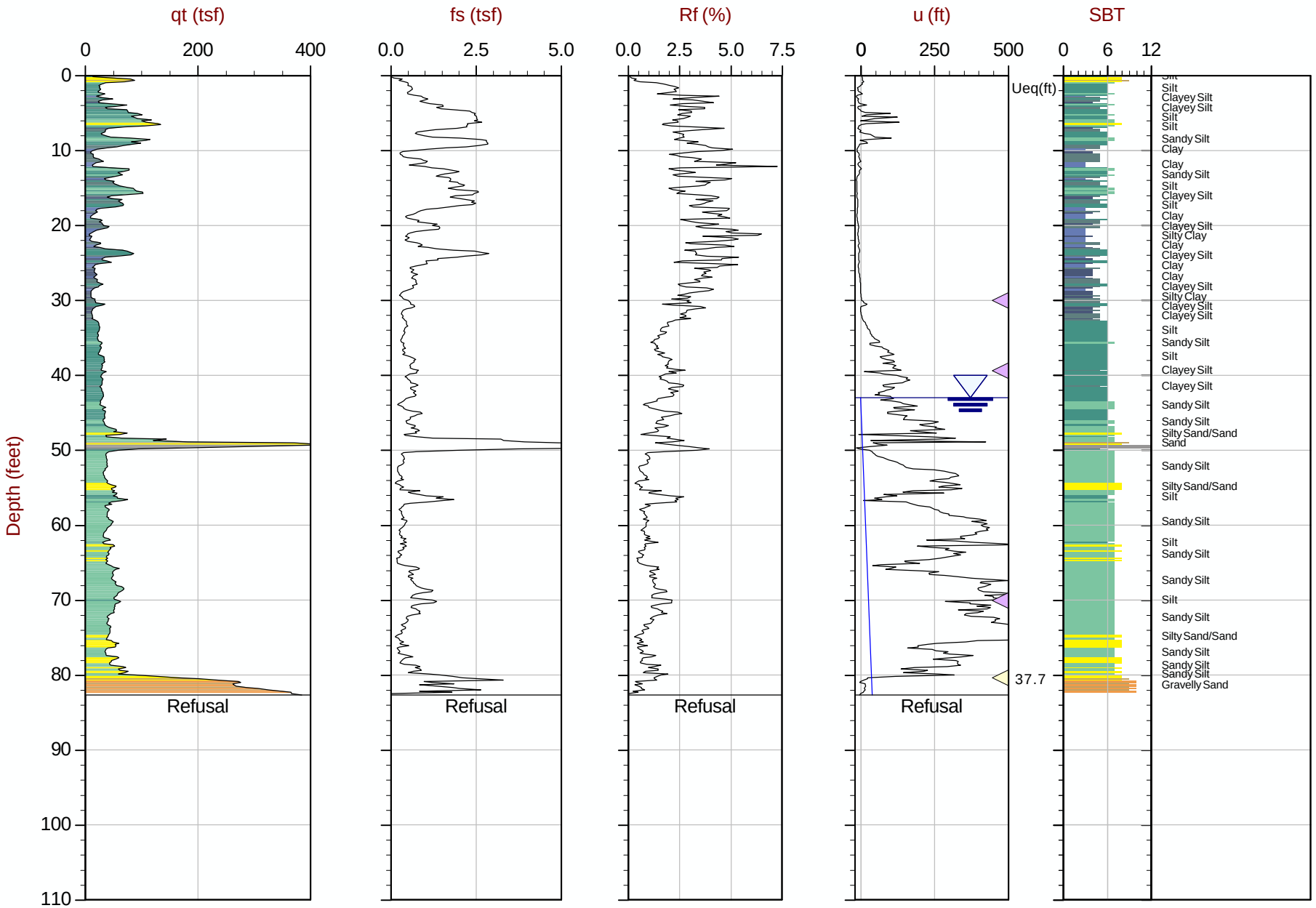
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:06:15 09:22
Site: Dynegy Joppa IL

Sounding: JOP-C025
Cone: 349:T1500F15U500



Max Depth: 25.200 m / 82.68 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C025.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21422 Long: -88.84995

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

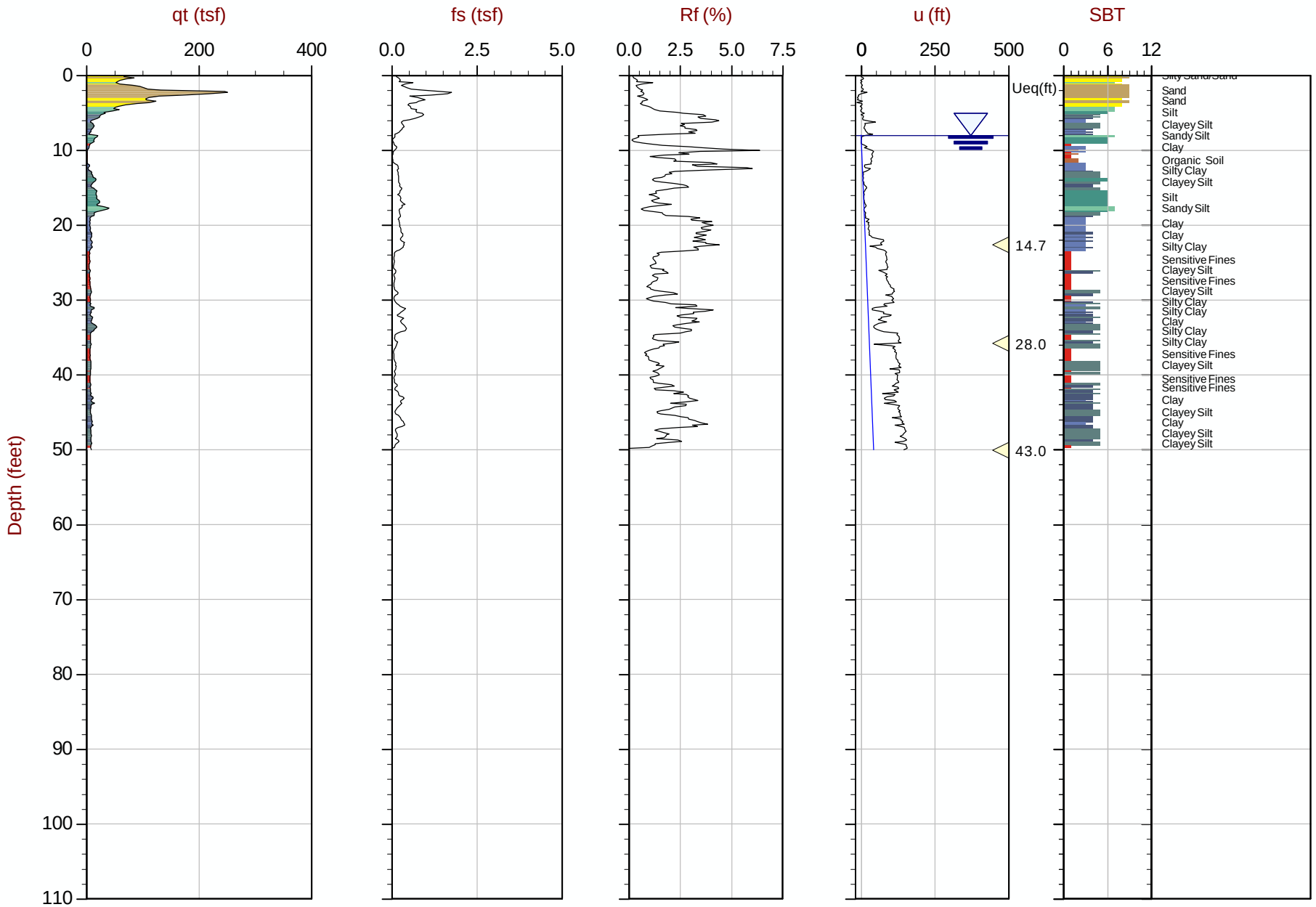
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 10:34
Site: Dynegy Joppa IL

Sounding: JOP-C026
Cone: 184:T1500F15U500



Max Depth: 15.250 m / 50.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C026.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21593 Long: -88.85098

△ Dissipation with estimated Ueq value

▲ Dissipation, equilibrium not achieved

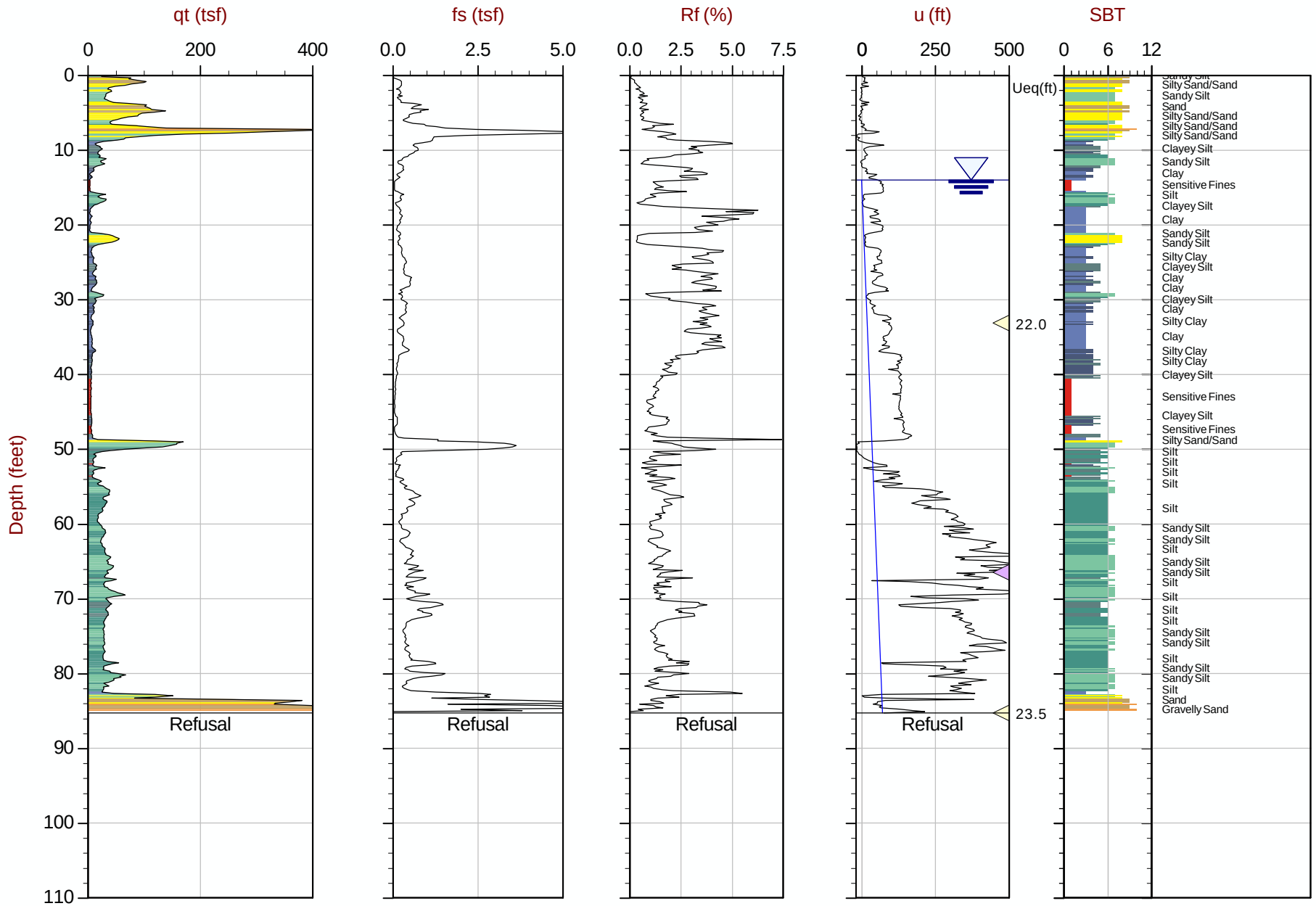
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:13:15 07:28
Site: Dynegy Joppa IL

Sounding: JOP-C027
Cone: 184:T1500F15U500



Max Depth: 26.000 m / 85.30 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C027.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21673 Long: -88.85213

△ Dissipation with estimated Ueq value
△ Dissipation, equilibrium not achieved

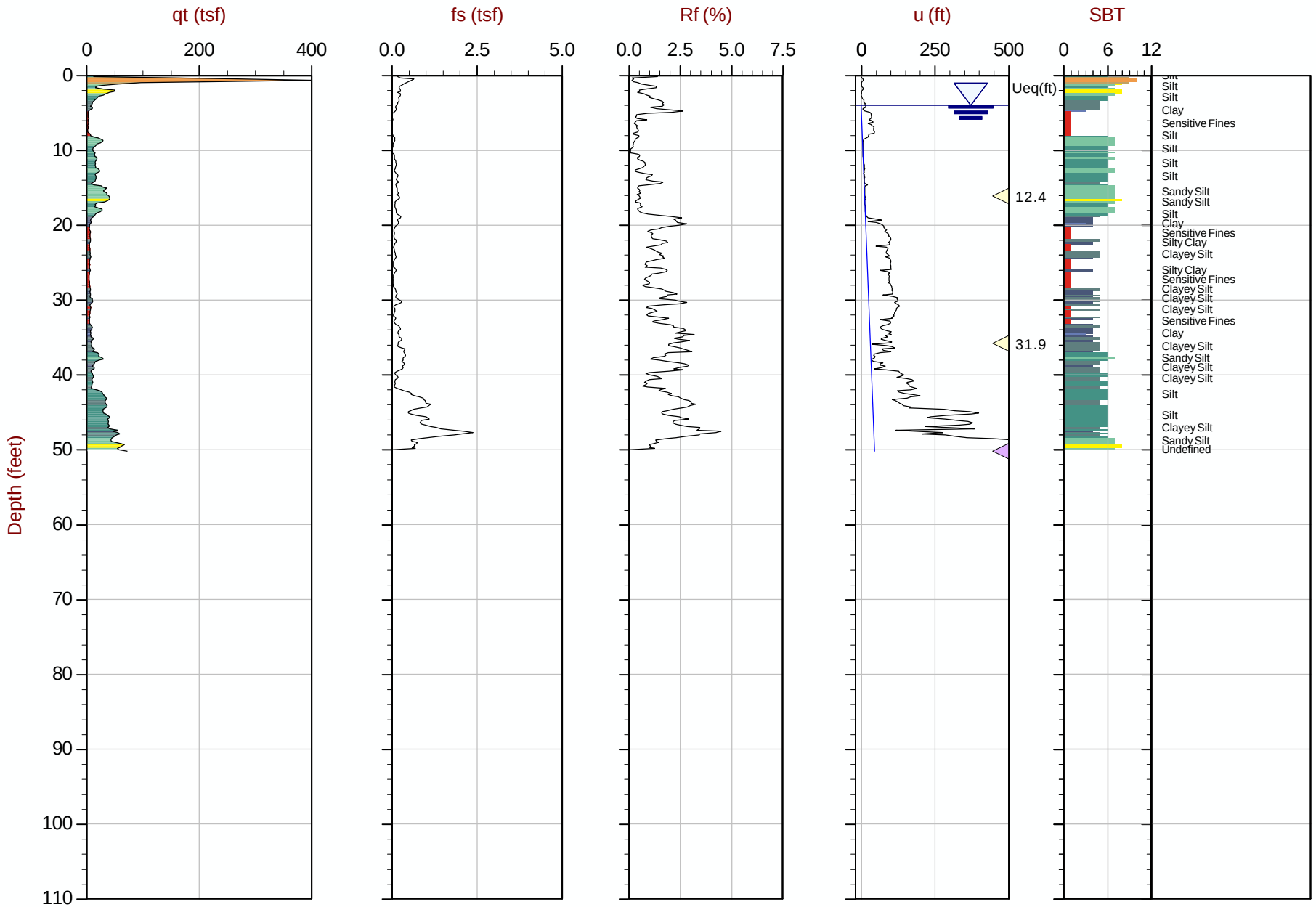
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:19:15 08:59
Site: Dynegy Joppa IL

Sounding: JOP-C028
Cone: 349:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C028.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21715 Long: -88.85305

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

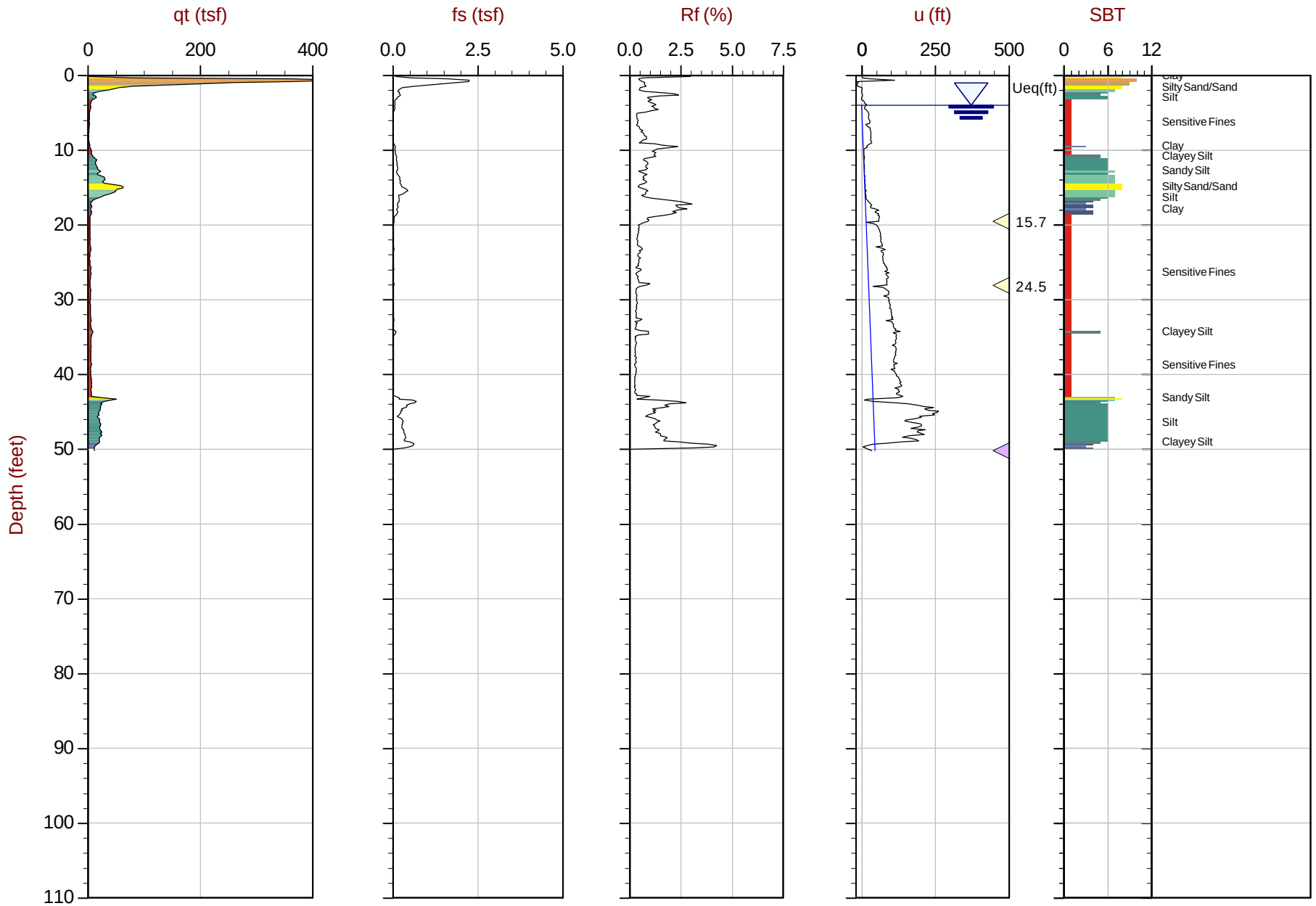
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 13:54
Site: Dynegy Joppa IL

Sounding: JOP-C029
Cone: 184:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C029.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21818 Long: -88.85203

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

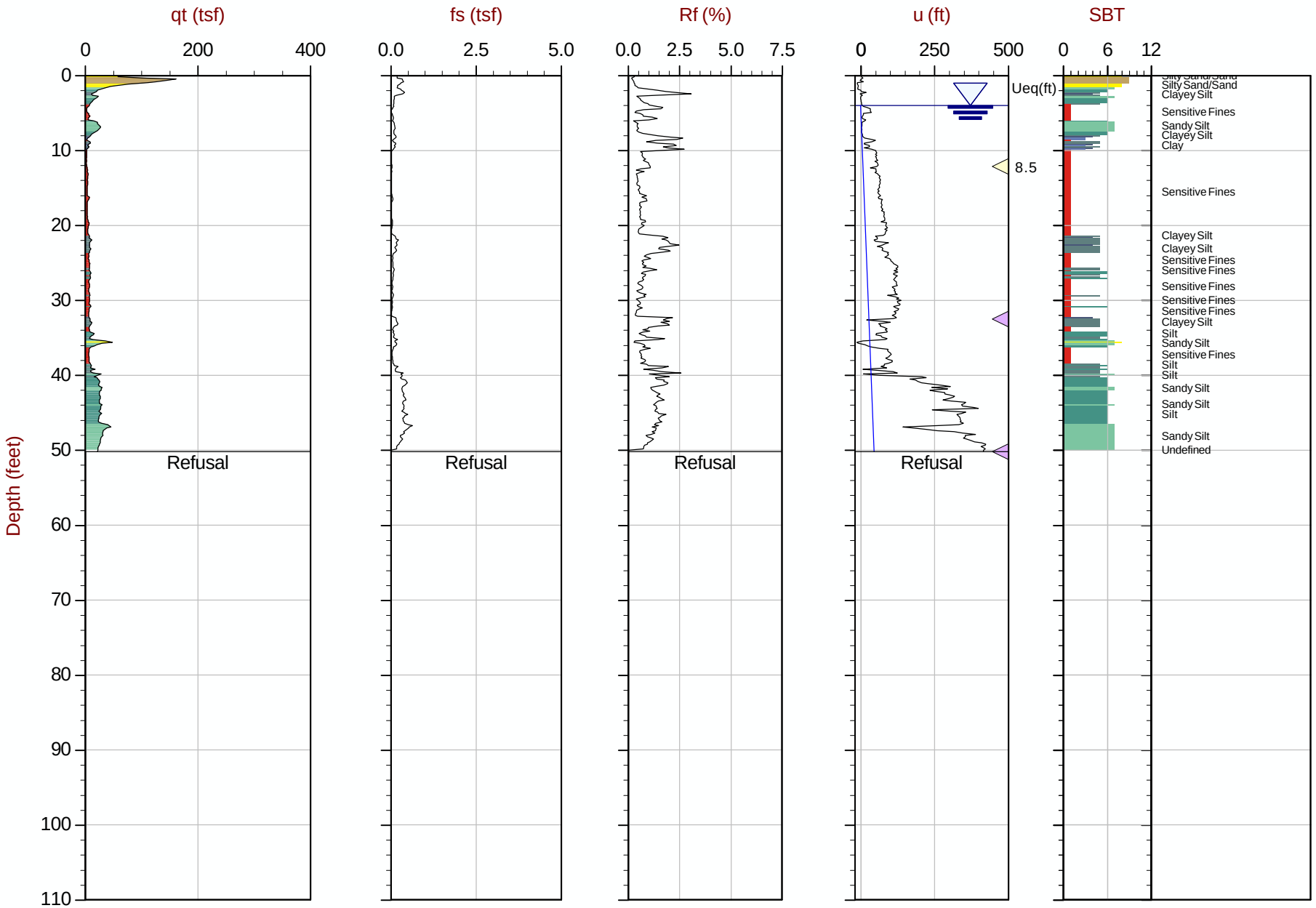
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 12:21
Site: Dynegy Joppa IL

Sounding: JOP-C030
Cone: 184:T1500F15U500



Max Depth: 15.300 m / 50.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C030.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21757 Long: -88.85053

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

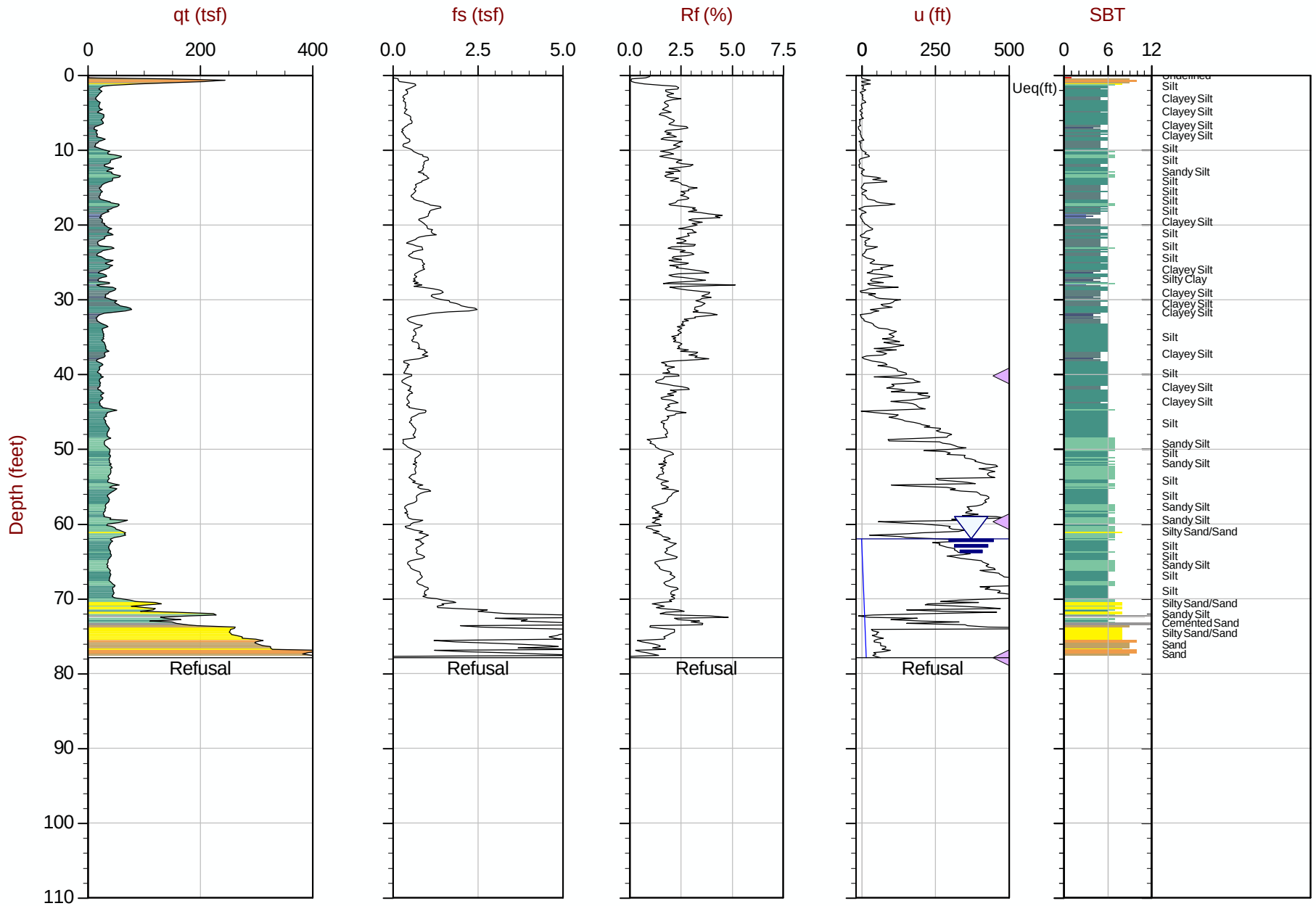
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:11:15 13:50
Site: Dynegy Joppa IL

Sounding: JOP-C031
Cone: 184:T1500F15U500



Max Depth: 23.750 m / 77.92 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C031A.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21702 Long: -88.84940

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

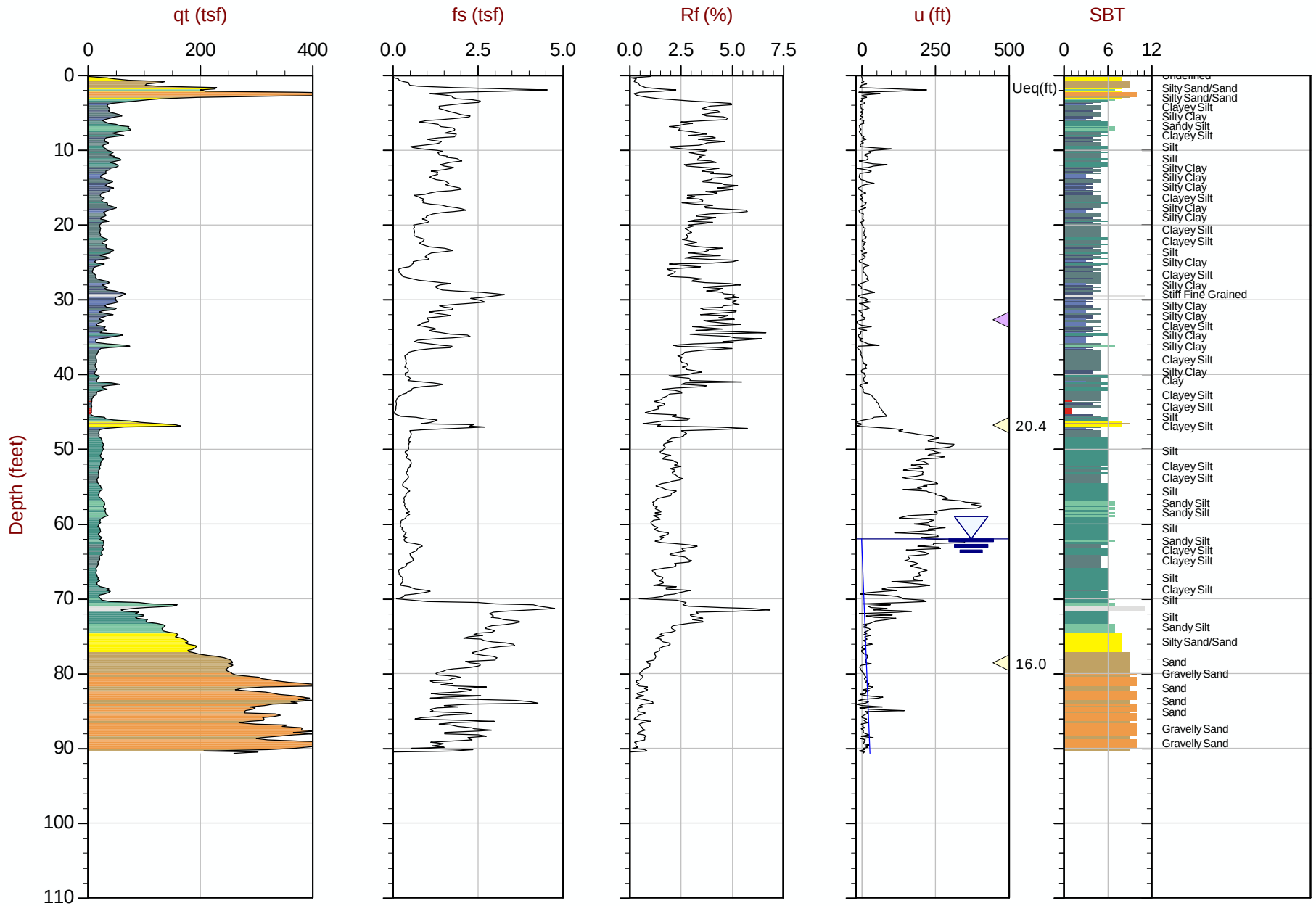
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:11:15 10:44
Site: Dynegy Joppa IL

Sounding: JOP-C032
Cone: 184:T1500F15U500



Max Depth: 27.650 m / 90.71 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C032.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21863 Long: -88.84977

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

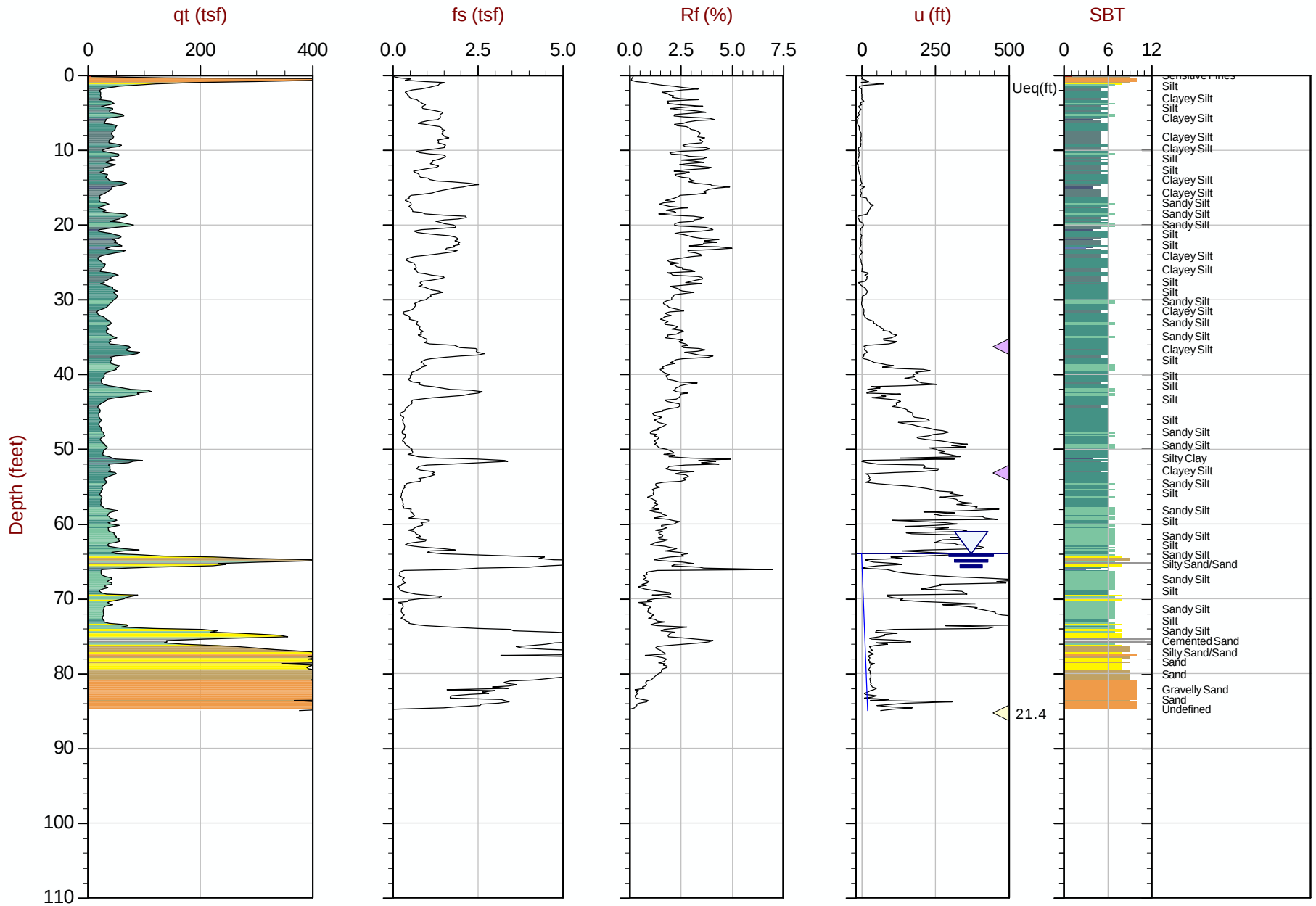
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:10:15 11:14
Site: Dynegy Joppa IL

Sounding: JOP-C033
Cone: 184:T1500F15U500



Max Depth: 25.900 m / 84.97 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C033.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21907 Long: -88.85207

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

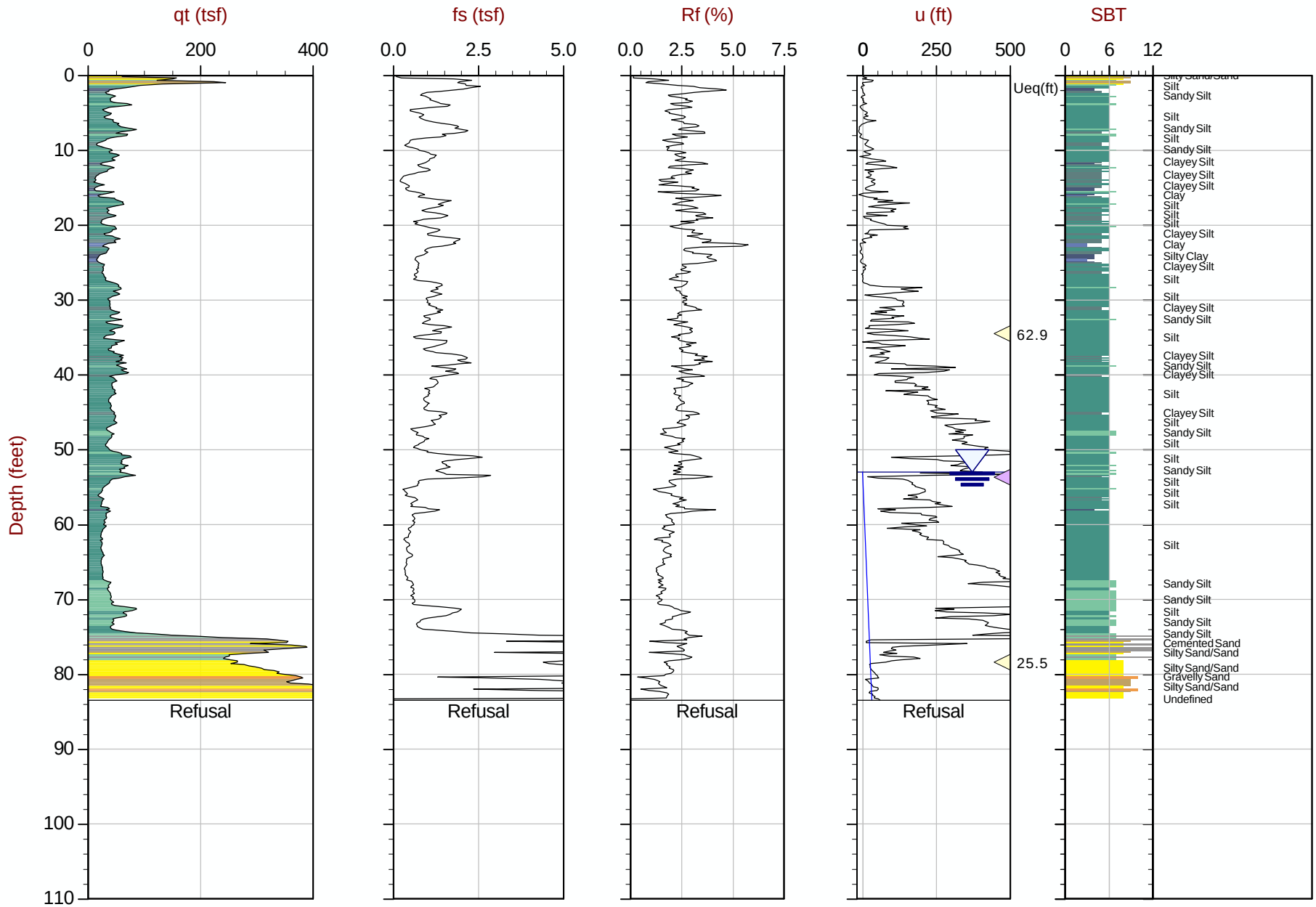
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:10:15 14:05
Site: Dynegy Joppa IL

Sounding: JOP-C034
Cone: 184:T1500F15U500



Max Depth: 25.450 m / 83.50 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C034.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.22028 Long: -88.85073

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

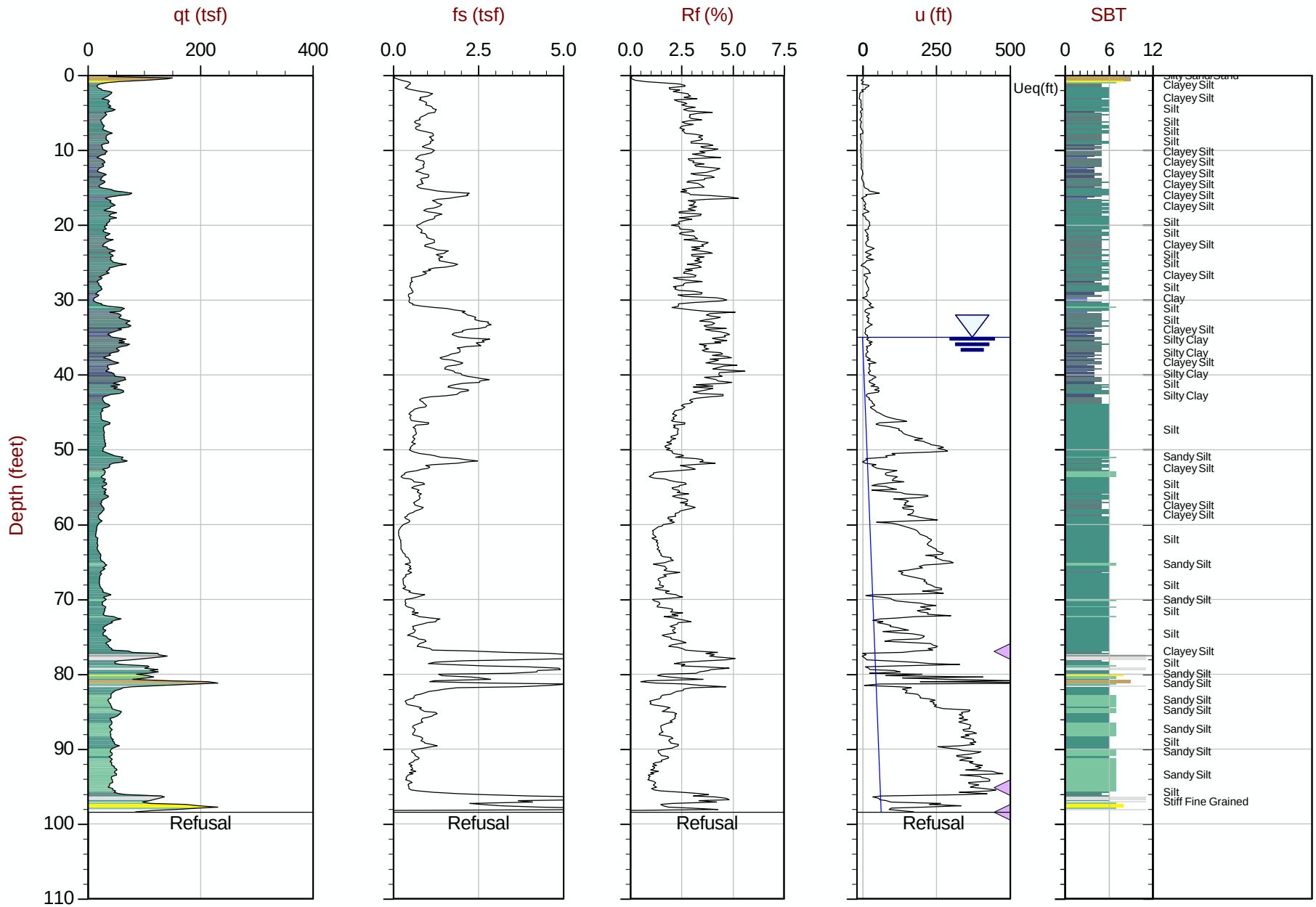
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:08:15 10:23
Site: Dynegy Joppa IL

Sounding: JOP-C035
Cone: 349:T1500F15U500



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C035.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21080 Long: -88.85160

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

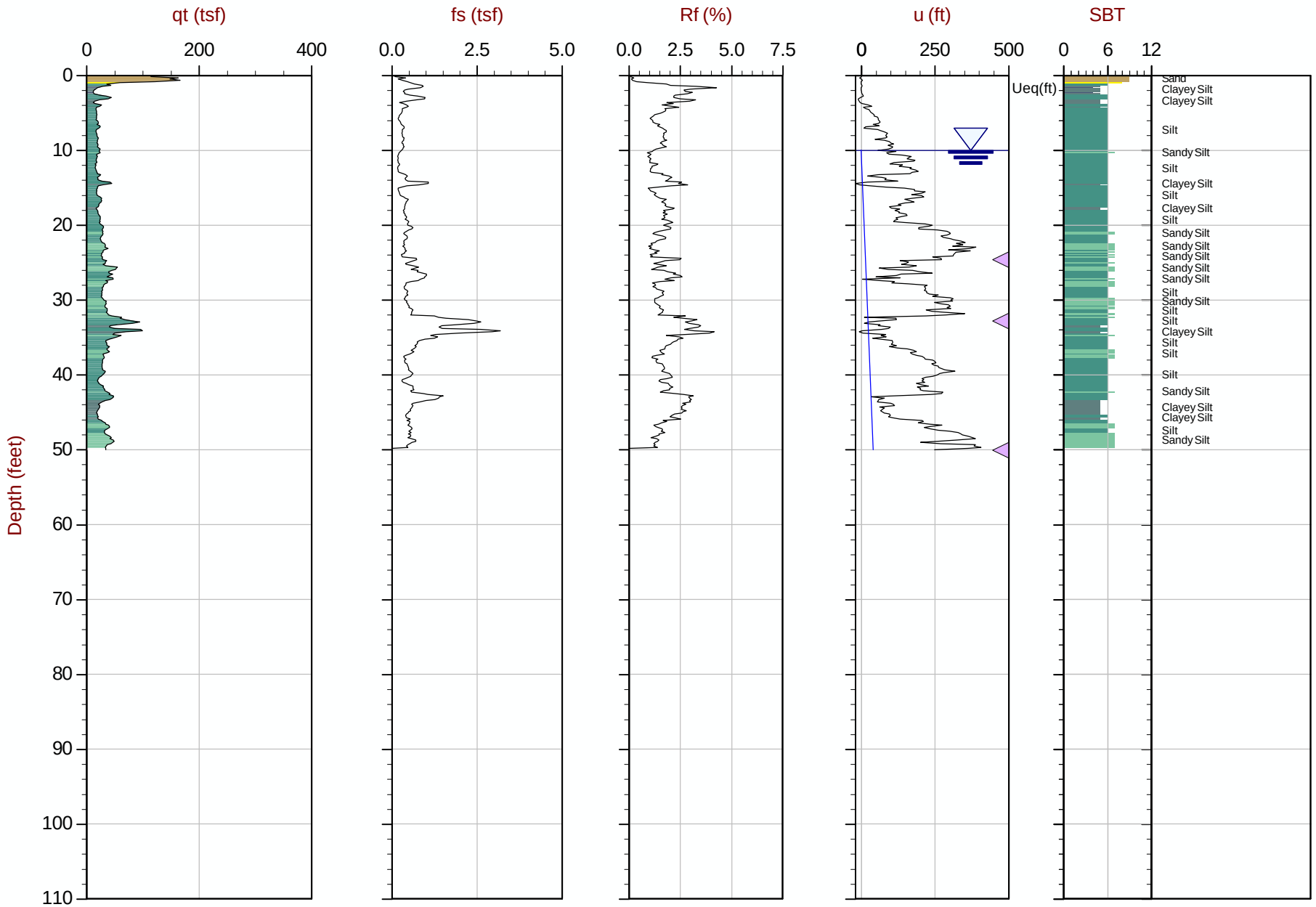
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:13:15 07:34
Site: Dynegy Joppa IL

Sounding: JOP-C036
Cone: 392:T1500F15U500



Max Depth: 15.250 m / 50.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C036.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21084 Long: -88.85111

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

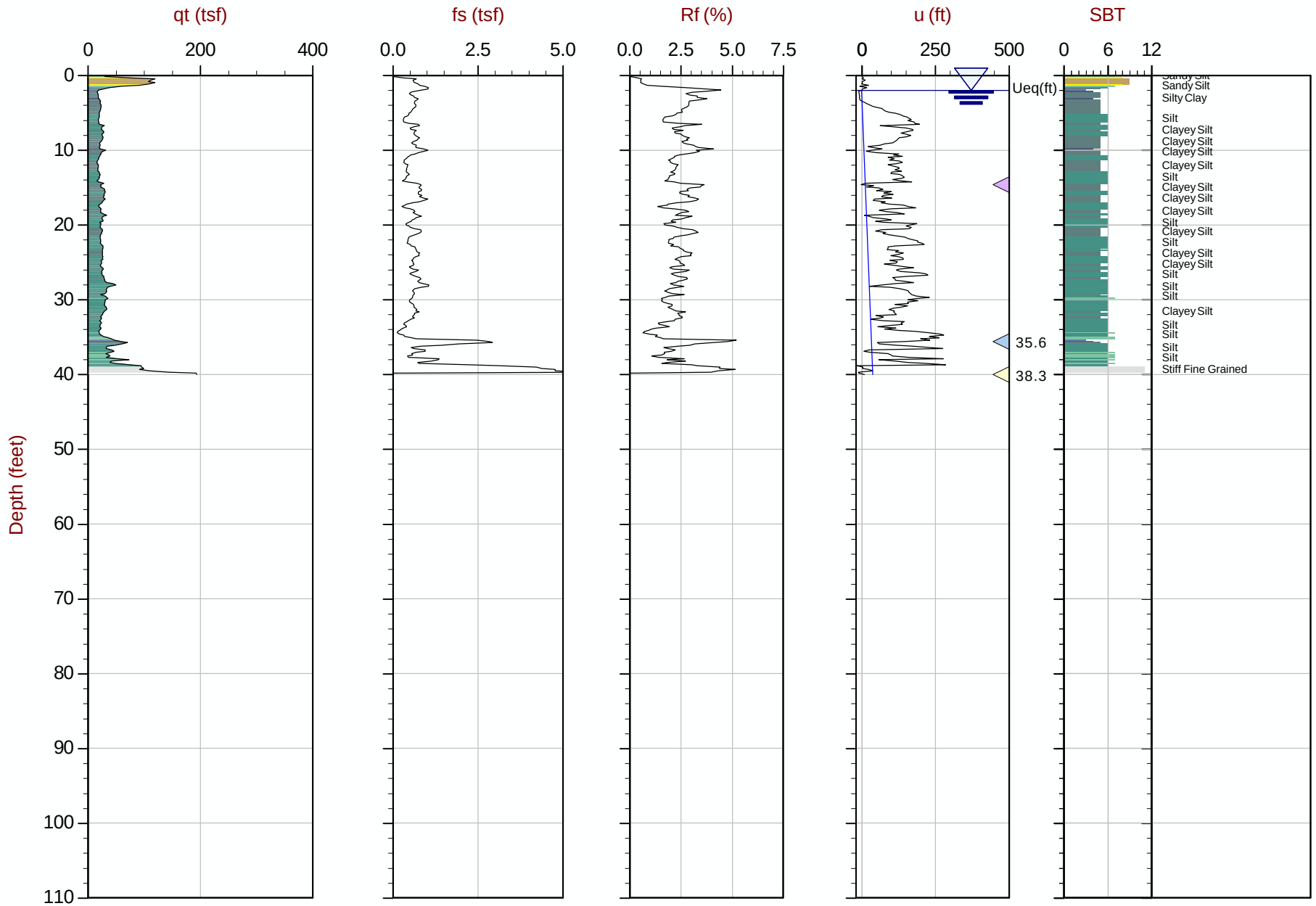
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 09:31
Site: Dynegy Joppa IL

Sounding: JOP-C037
Cone: 392:T1500F15U500



Max Depth: 12.200 m / 40.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C037.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21276 Long: -88.85729

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

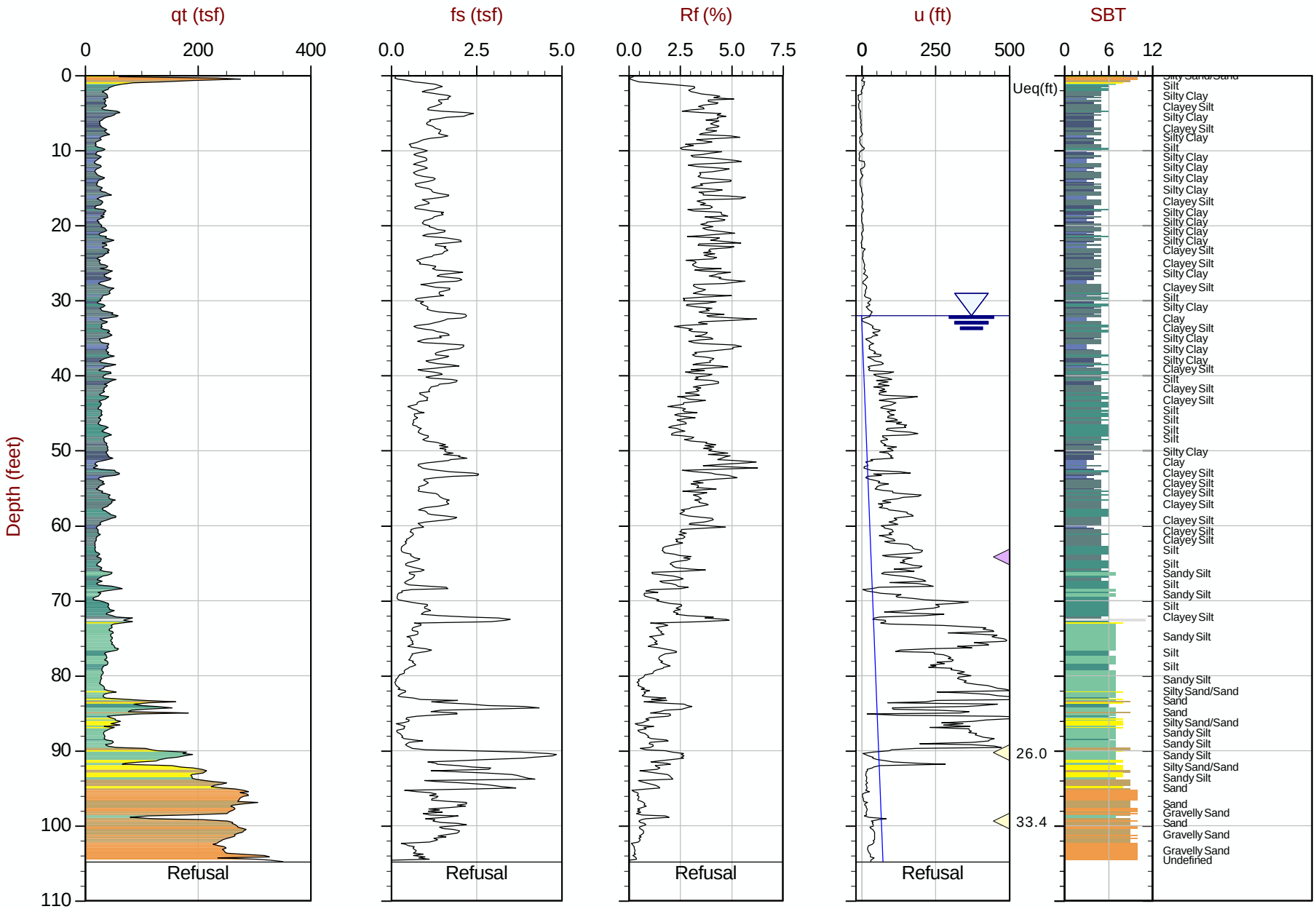
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:07:15 11:37
Site: Dynegy Joppa IL

Sounding: JOP-SC002
Cone: 349:T1500F15U500



Max Depth: 31.950 m / 104.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC002.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21070 Long: -88.85180

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

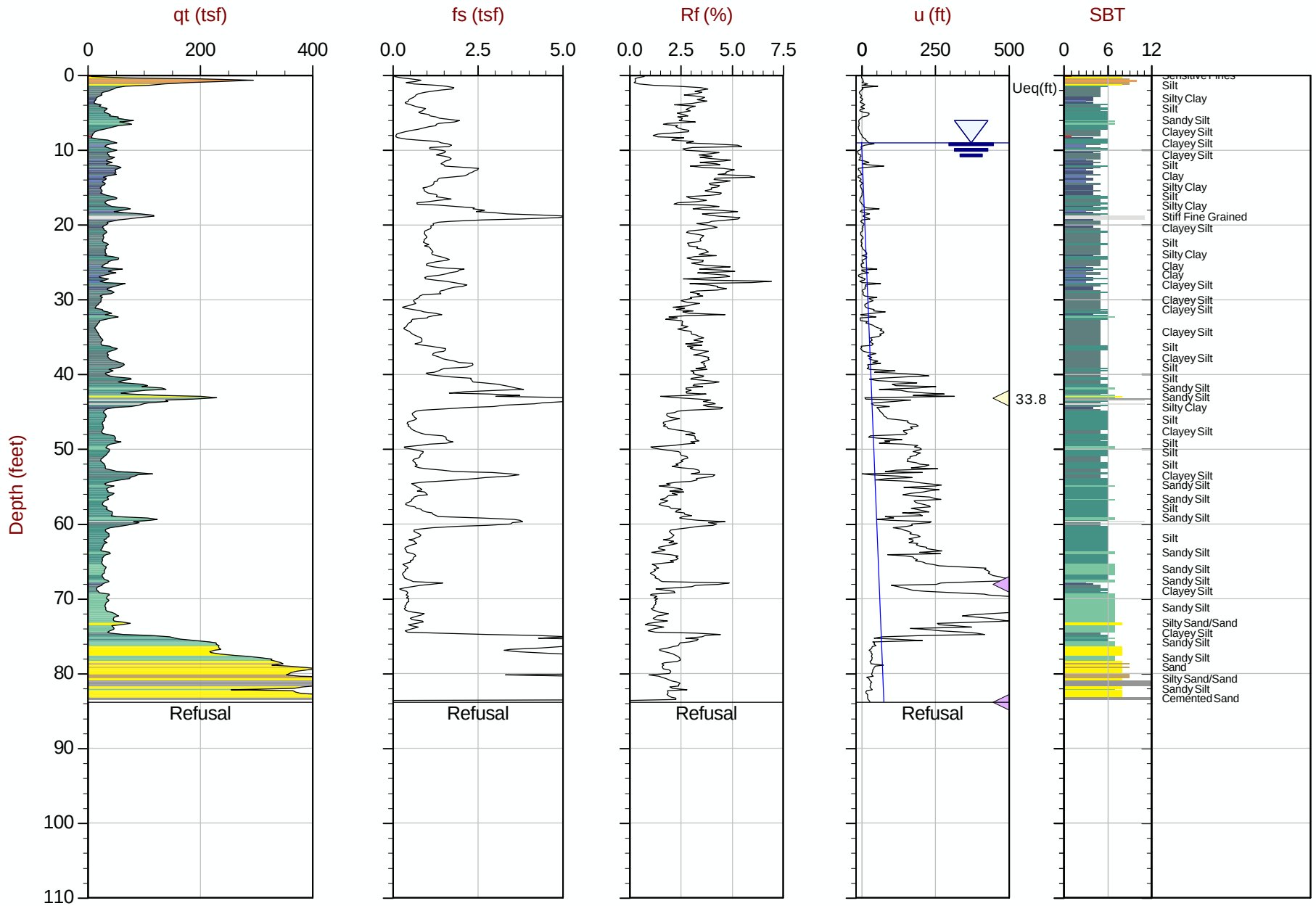
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:11:15 07:46
Site: Dynegy Joppa IL

Sounding: JOP-SC010
Cone: 184:T1500F15U500



Max Depth: 25.550 m / 83.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC010.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21962 Long: -88.85043

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

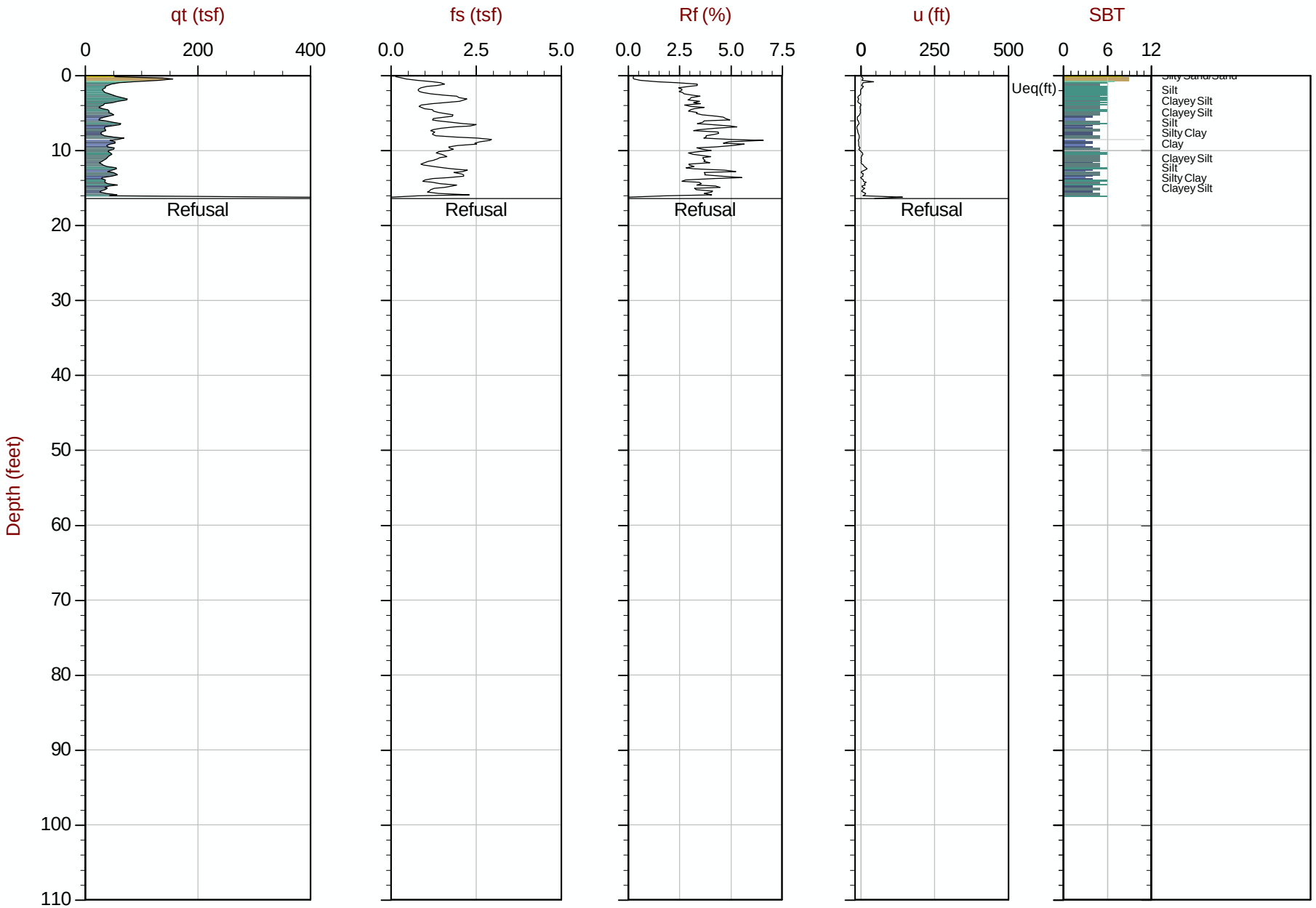
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:10:15 07:42
Site: Dynegy Joppa IL

Sounding: JOP-SC012
Cone: 349:T1500F15U500



Max Depth: 5.000 m / 16.40 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC012.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21535 Long: -88.85573

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

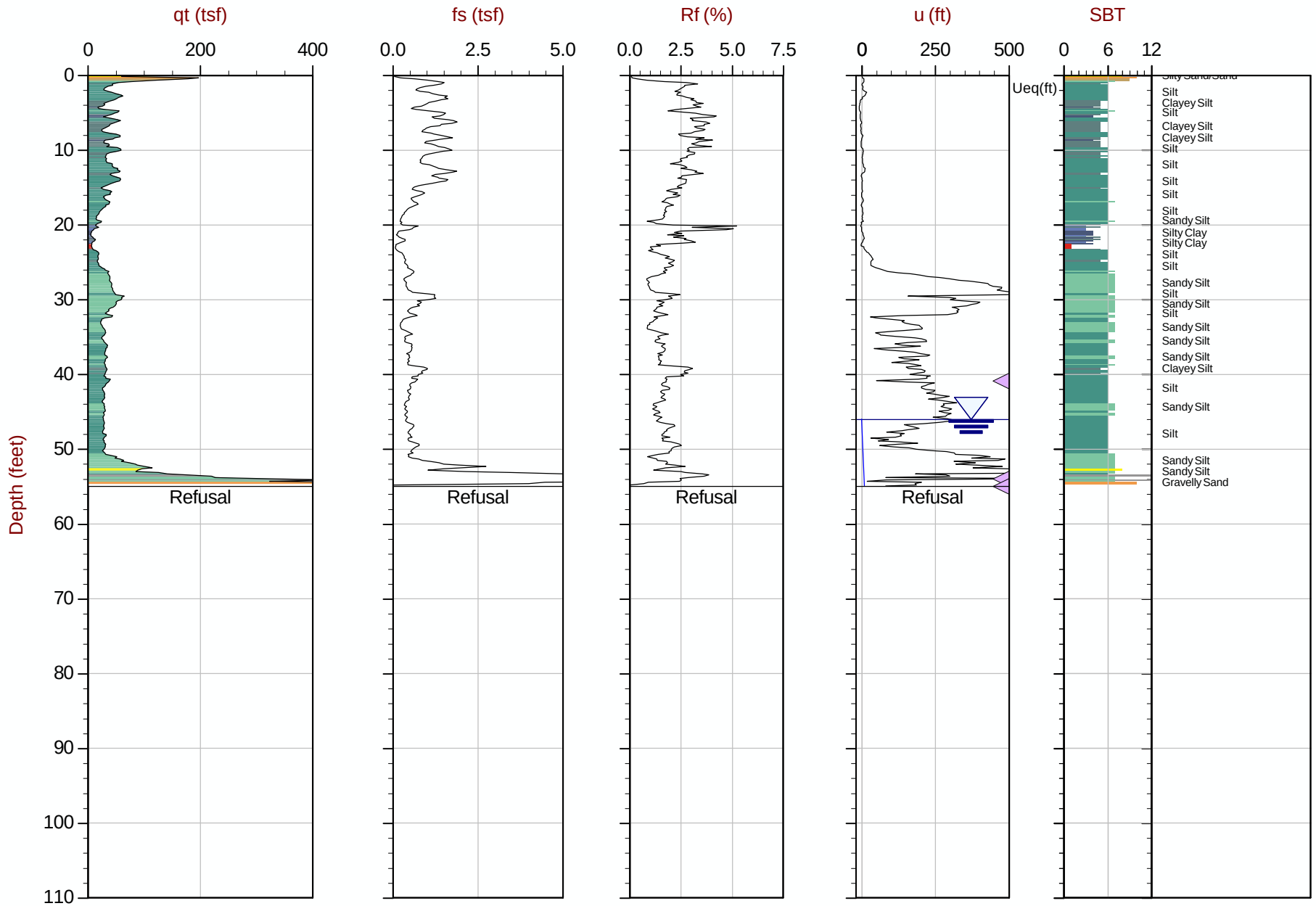
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:10:15 08:43
Site: Dynegy Joppa IL

Sounding: JOP-SC012A
Cone: 184:T1500F15U500



Max Depth: 16.750 m / 54.95 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC012A.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21535 Long: -88.85572

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

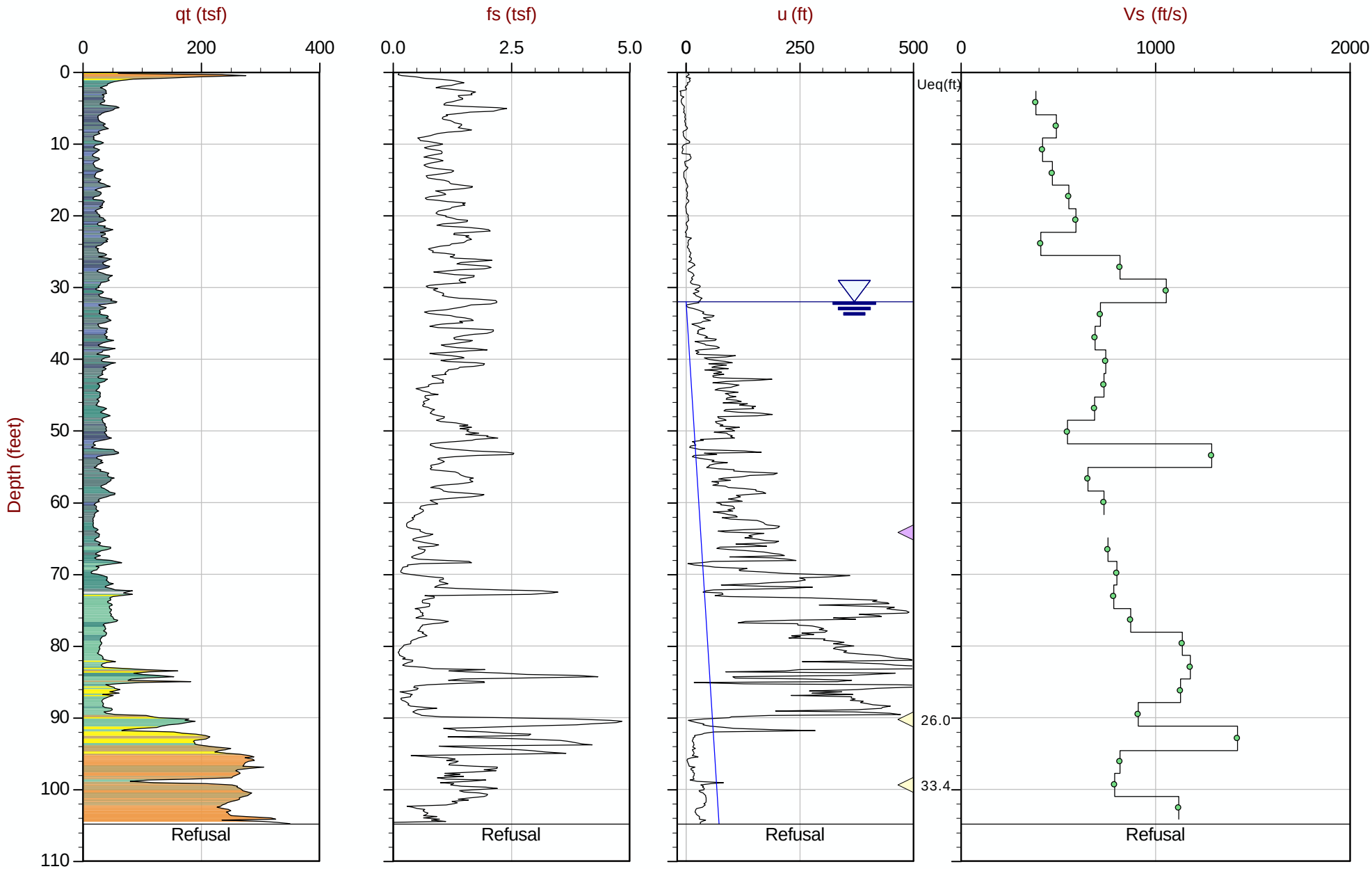
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:07:15 11:37
Site: Dynegy Joppa IL

Sounding: JOP-SC002
Cone: 349:T1500F15U500



Max Depth: 31.950 m / 104.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC002.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21070 Long: -88.85180

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

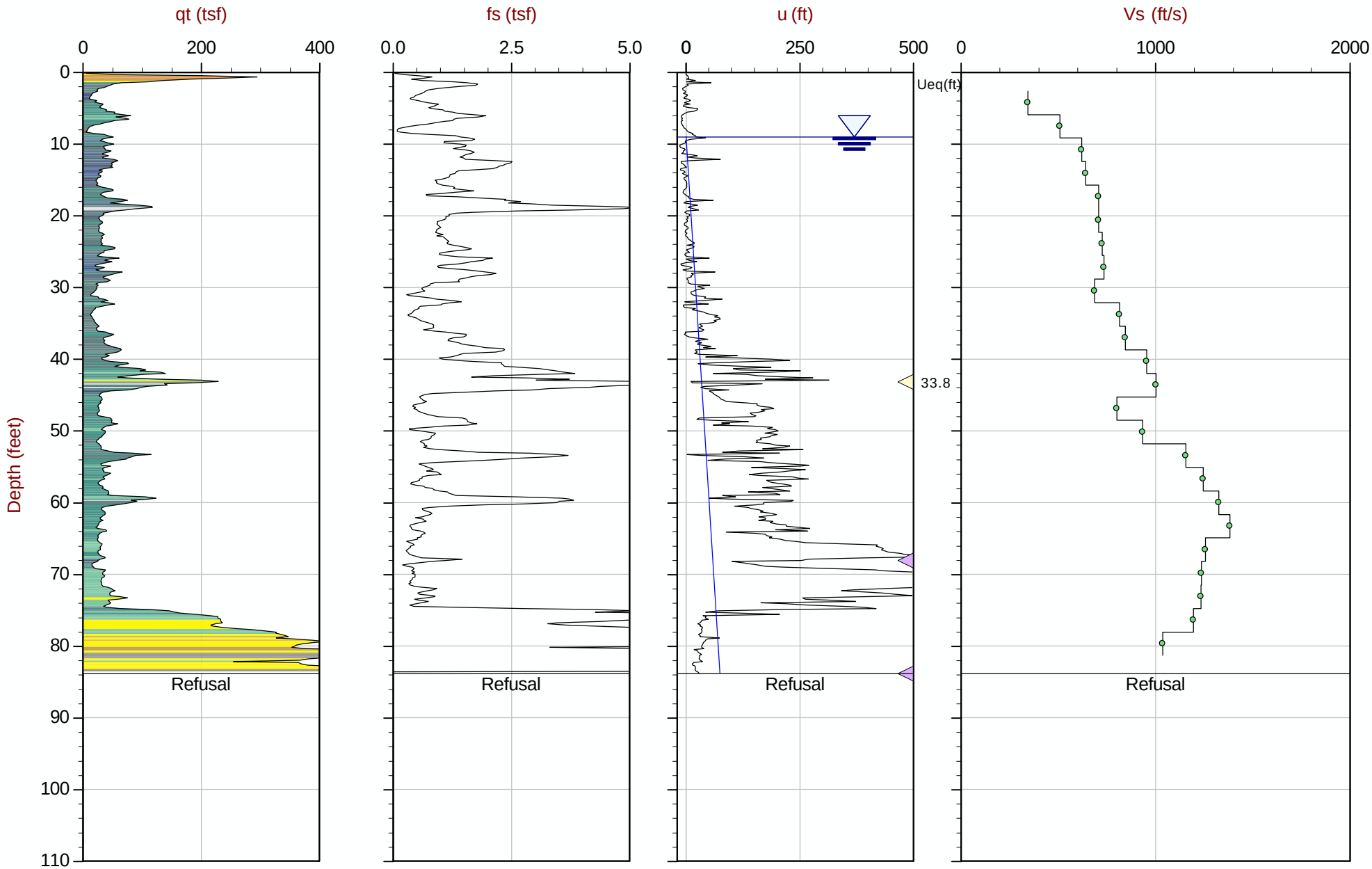
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:11:15 07:46
Site: Dynegy Joppa IL

Sounding: JOP-SC010
Cone: 184:T1500F15U500



Max Depth: 25.550 m / 83.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC010.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21962 Long: -88.85043

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

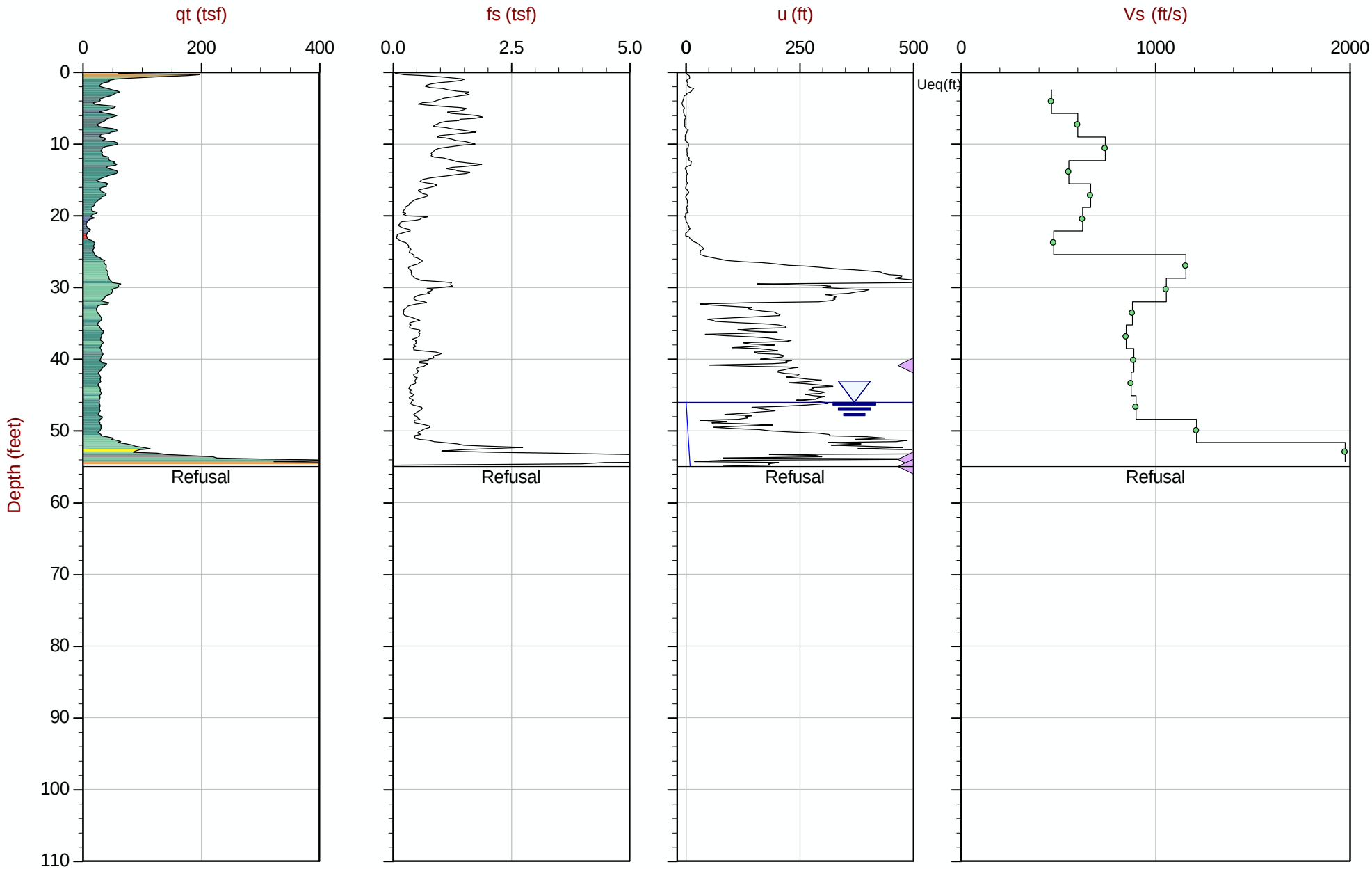
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08:10:15 08:43
Site: Dynegy Joppa IL

Sounding: JOP-SC012A
Cone: 184:T1500F15U500



Max Depth: 16.750 m / 54.95 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC012A.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21535 Long: -88.85572

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

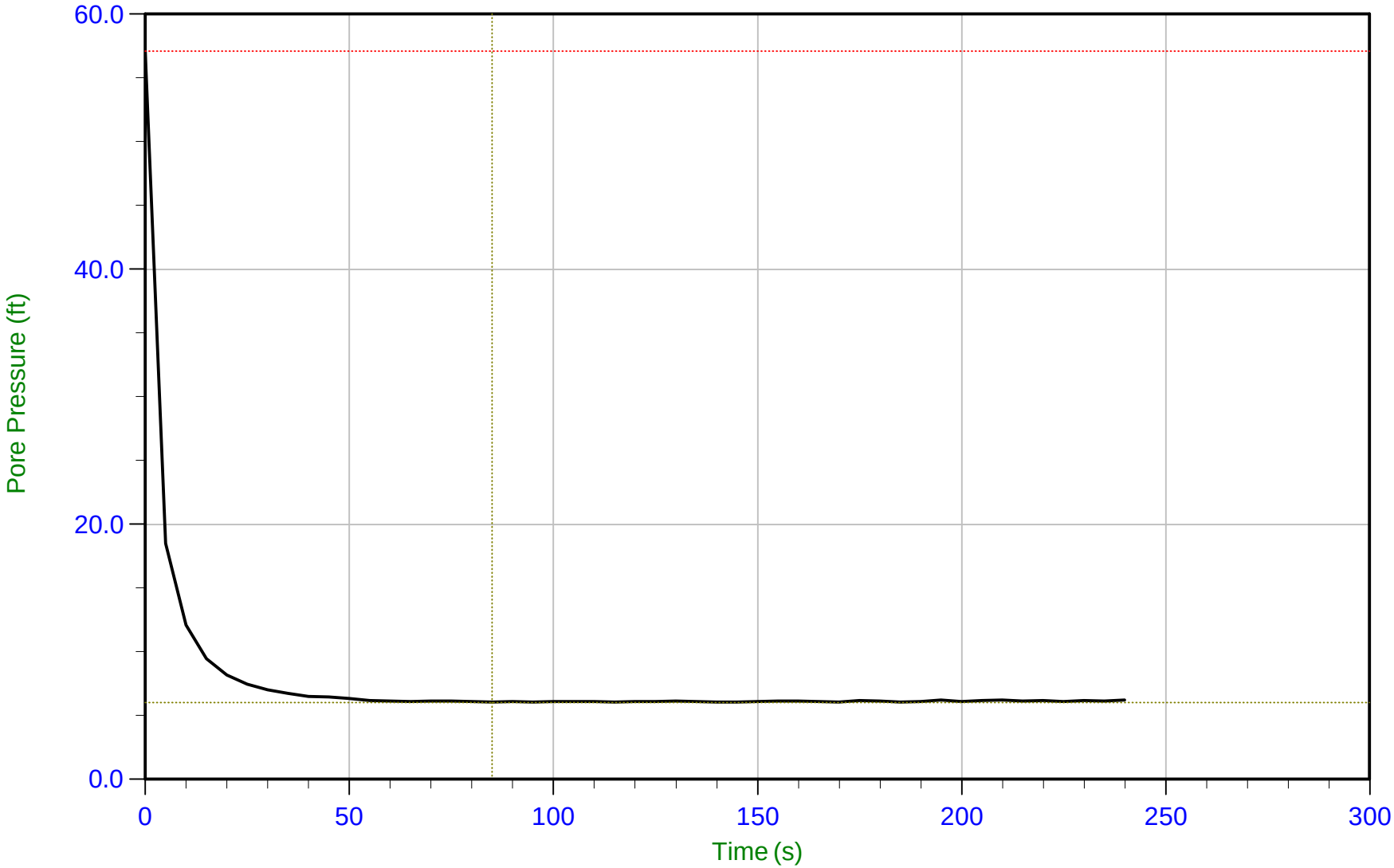
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 15:17
Site: Dynegy Joppa, I

Sounding: JOP-C001
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C001.PPD
Depth: 5.000 m / 16.404 ft
Duration: 240.0 s

U Min: 6.0 ft
U Max: 57.1 ft

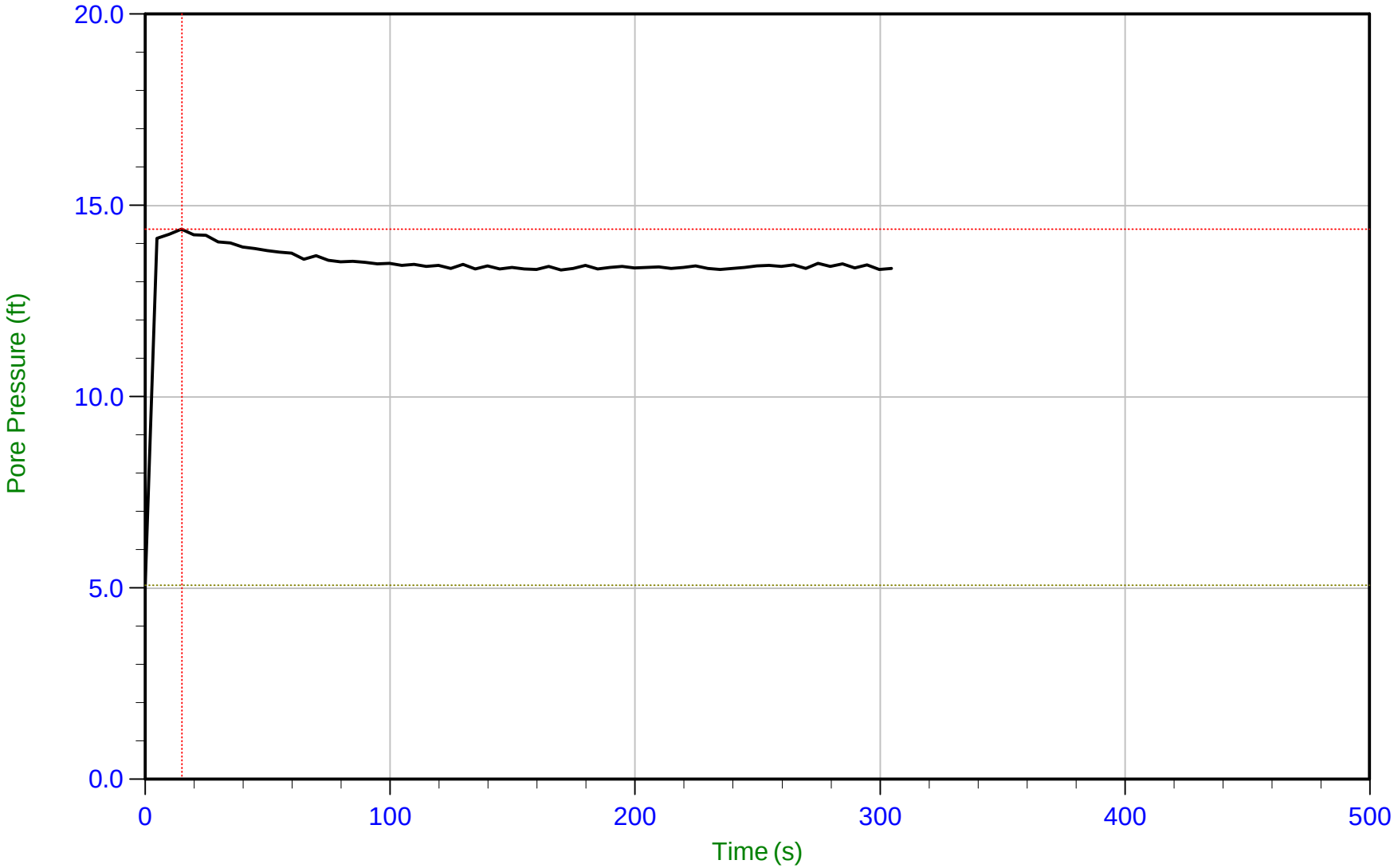
WT: 3.112 m / 10.210 ft
Ueq: 6.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 15:17
Site: Dynegy Joppa, I

Sounding: JOP-C001
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C001.PPD
Depth: 7.400 m / 24.278 ft
Duration: 305.0 s

U Min: 5.1 ft
U Max: 14.4 ft

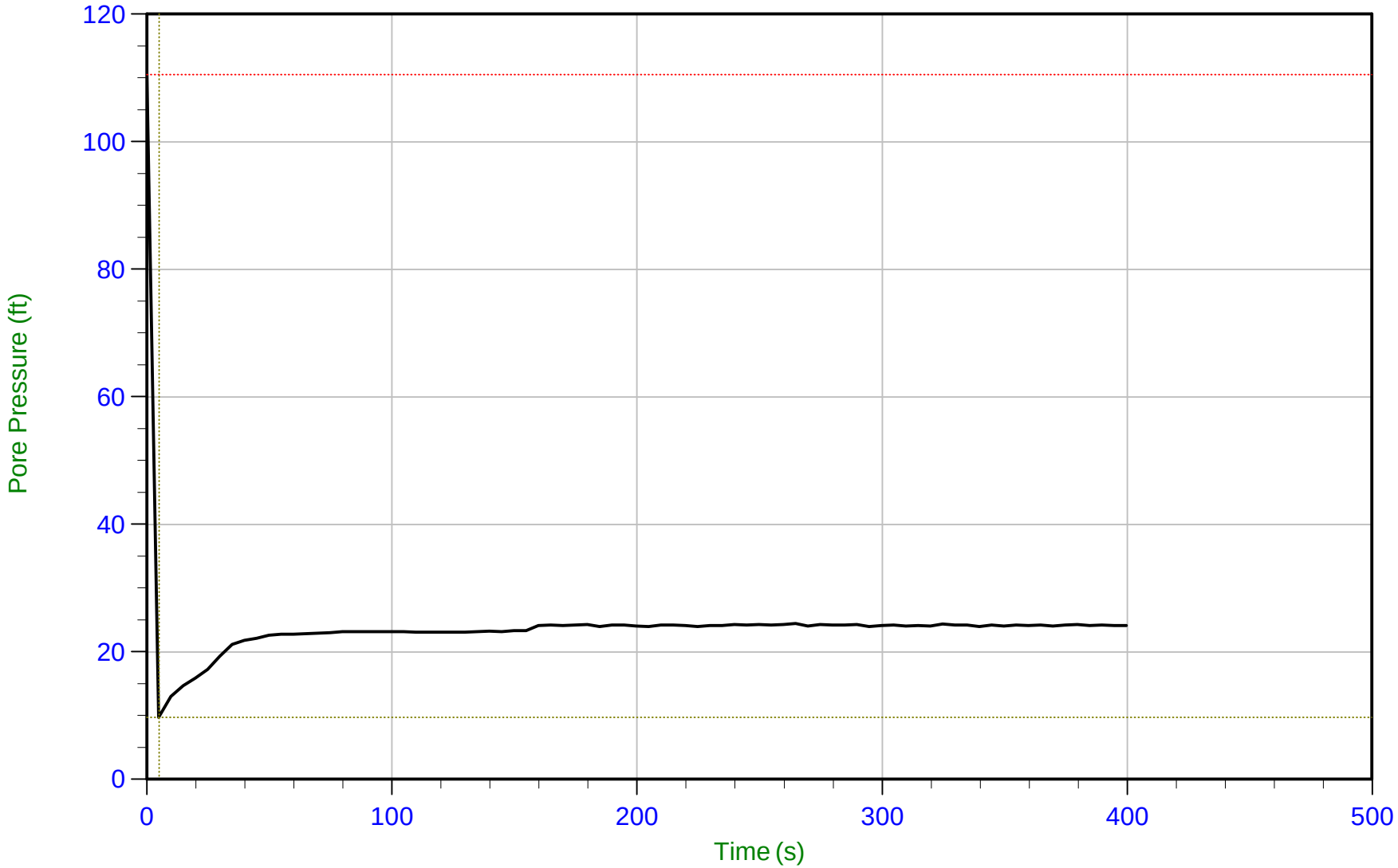
WT: 3.329 m / 10.922 ft
Ueq: 13.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 15:17
Site: Dynegy Joppa, I

Sounding: JOP-C001
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C001.PPD
Depth: 14.000 m / 45.931 ft
Duration: 400.0 s

U Min: 9.7 ft
U Max: 110.6 ft

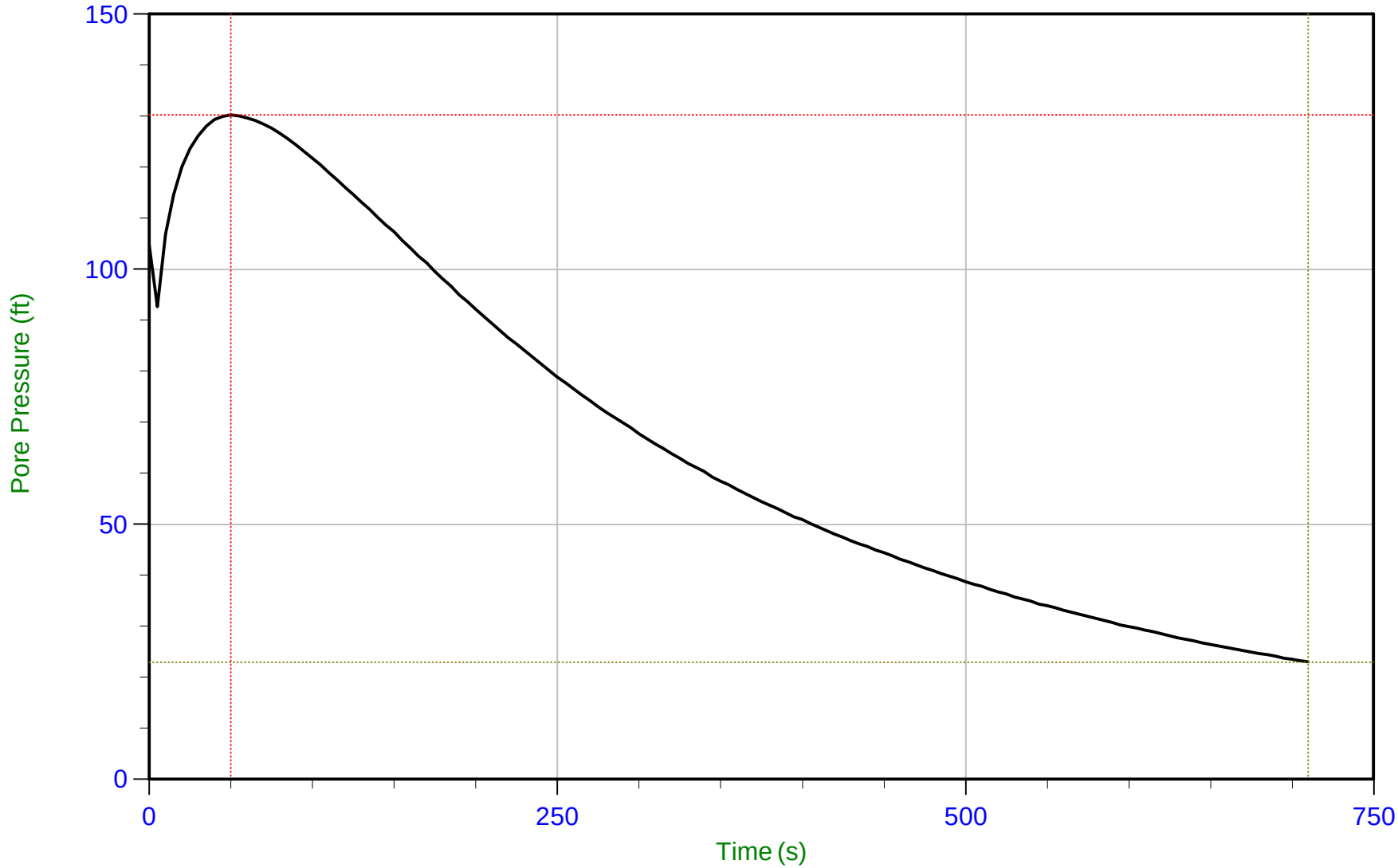
WT: 6.567 m / 21.545 ft
Ueq: 24.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 08:16
Site: Dynegy Joppa, I

Sounding: JOP-C003
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

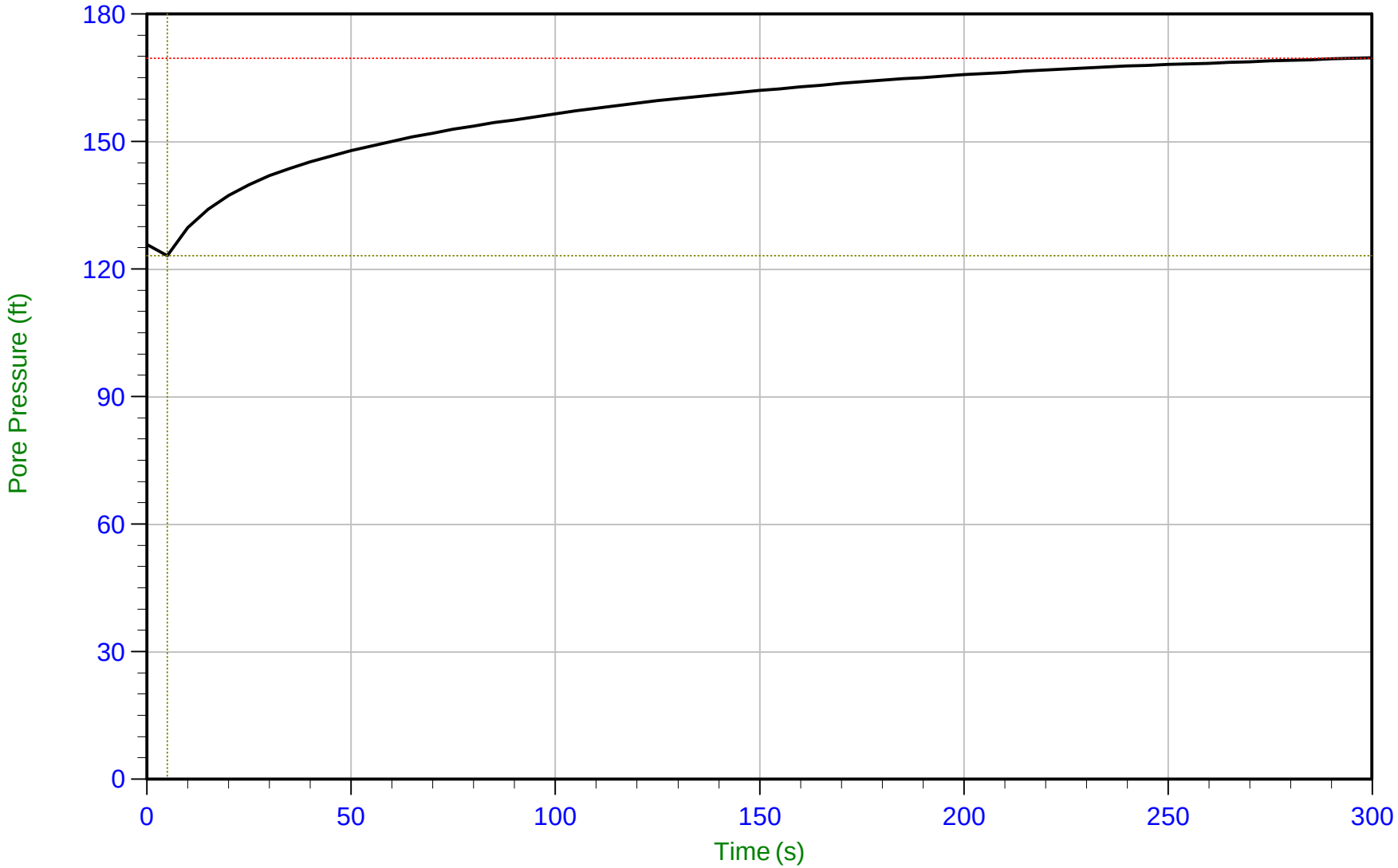
Filename: 15-54071_CP JOP-C003.PPD
Depth: 4.500 m / 14.764 ft
Duration: 710.0 s
U Min: 23.0 ft
U Max: 130.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 08:16
Site: Dynegy Joppa, I

Sounding: JOP-C003
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C003.PPD
Depth: 10.500 m / 34.448 ft
Duration: 300.0 s

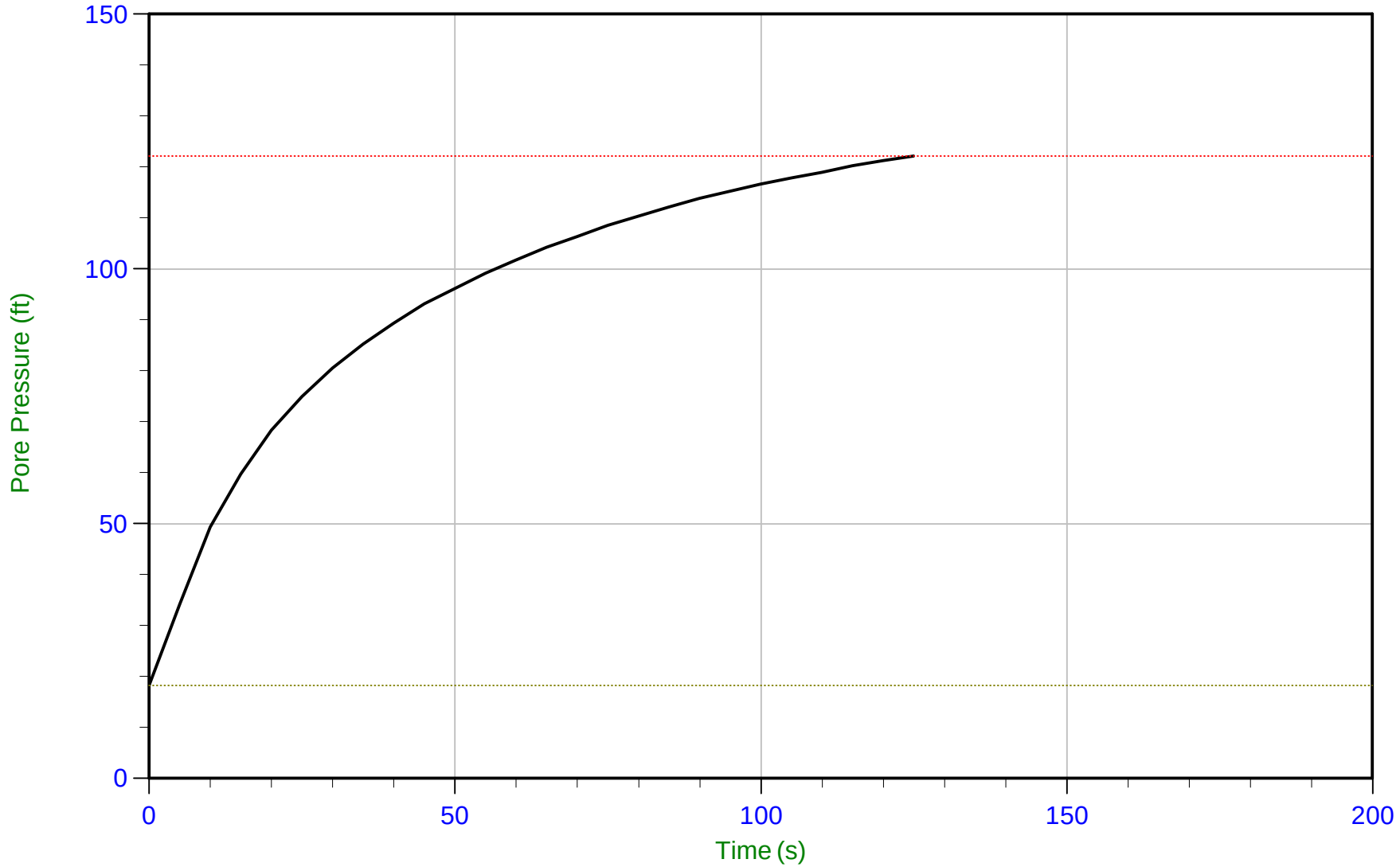
U Min: 123.2 ft
U Max: 169.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 08:16
Site: Dynegy Joppa, I

Sounding: JOP-C003
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C003.PPD
Depth: 11.650 m / 38.221 ft
Duration: 125.0 s

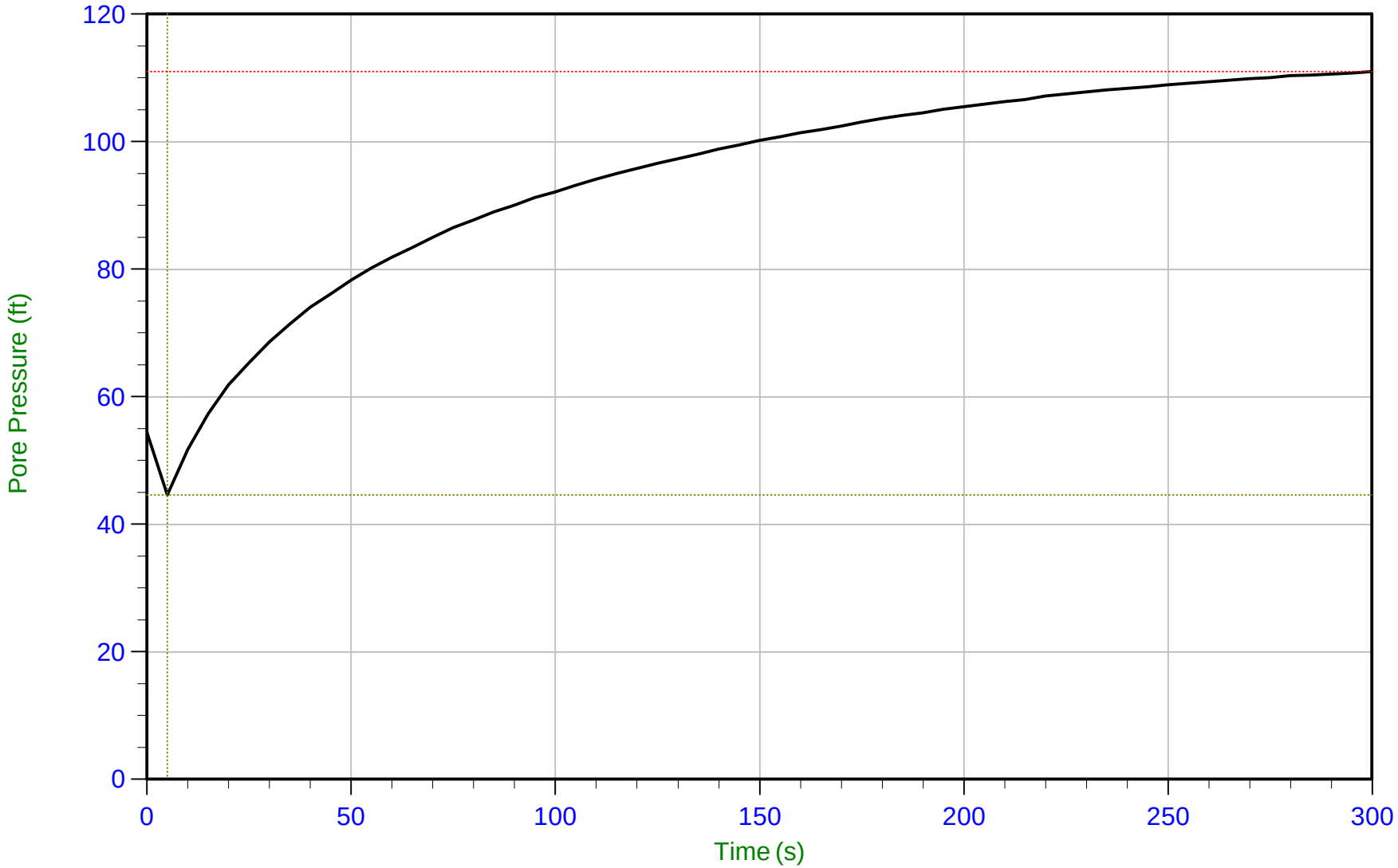
U Min: 18.3 ft
U Max: 122.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 08:16
Site: Dynegy Joppa, I

Sounding: JOP-C003
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C003.PPD
Depth: 12.200 m / 40.026 ft
Duration: 300.0 s

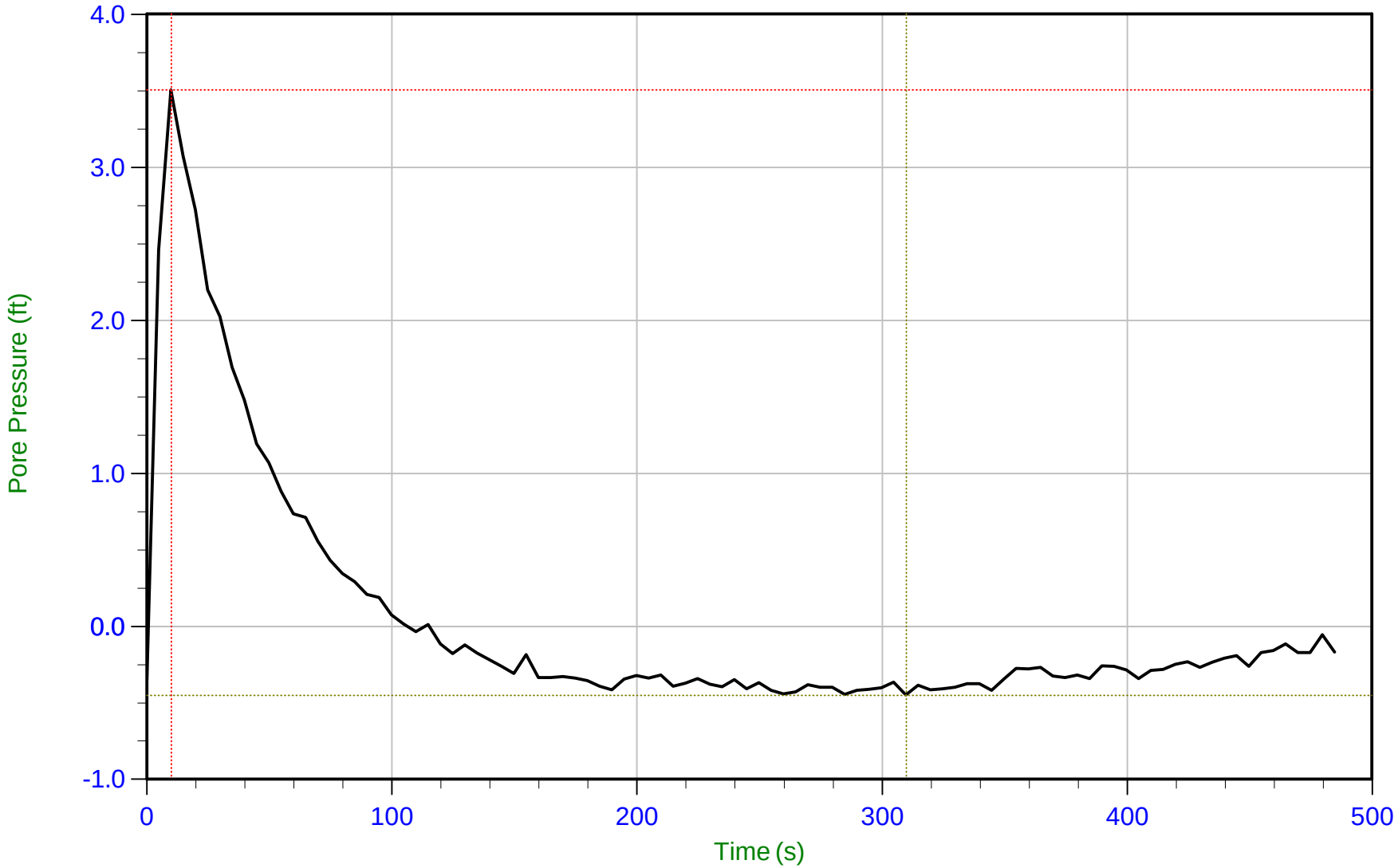
U Min: 44.6 ft
U Max: 111.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/07/2015 07:41
Site: Dynegy Joppa IL

Sounding: JOP-C004
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C004.PPD
Depth: 6.000 m / 19.685 ft
Duration: 485.0 s

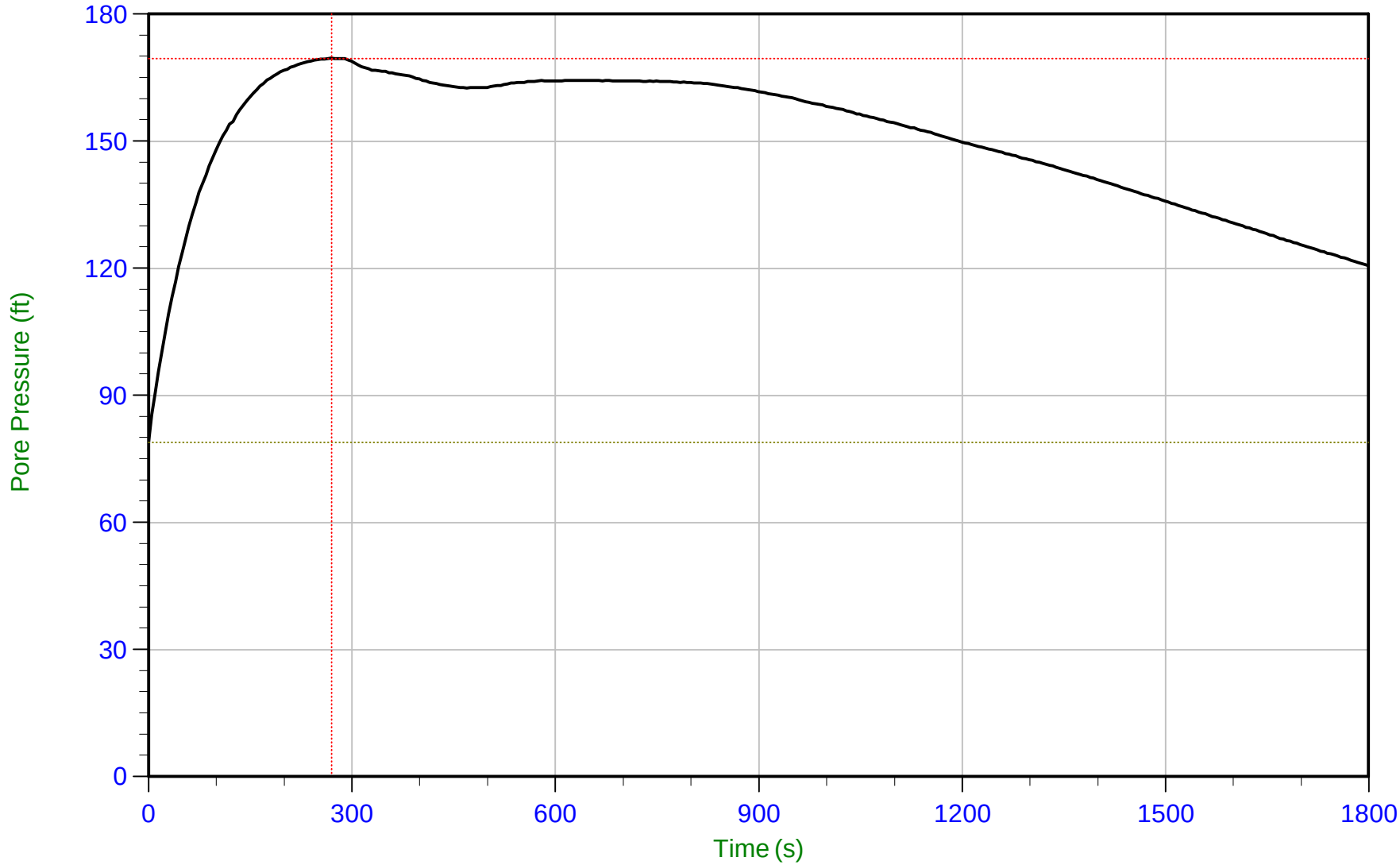
U Min: -0.4 ft
U Max: 3.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/07/2015 07:41
Site: Dynegy Joppa IL

Sounding: JOP-C004
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C004.PPD
Depth: 13.000 m / 42.650 ft
Duration: 1800.0 s

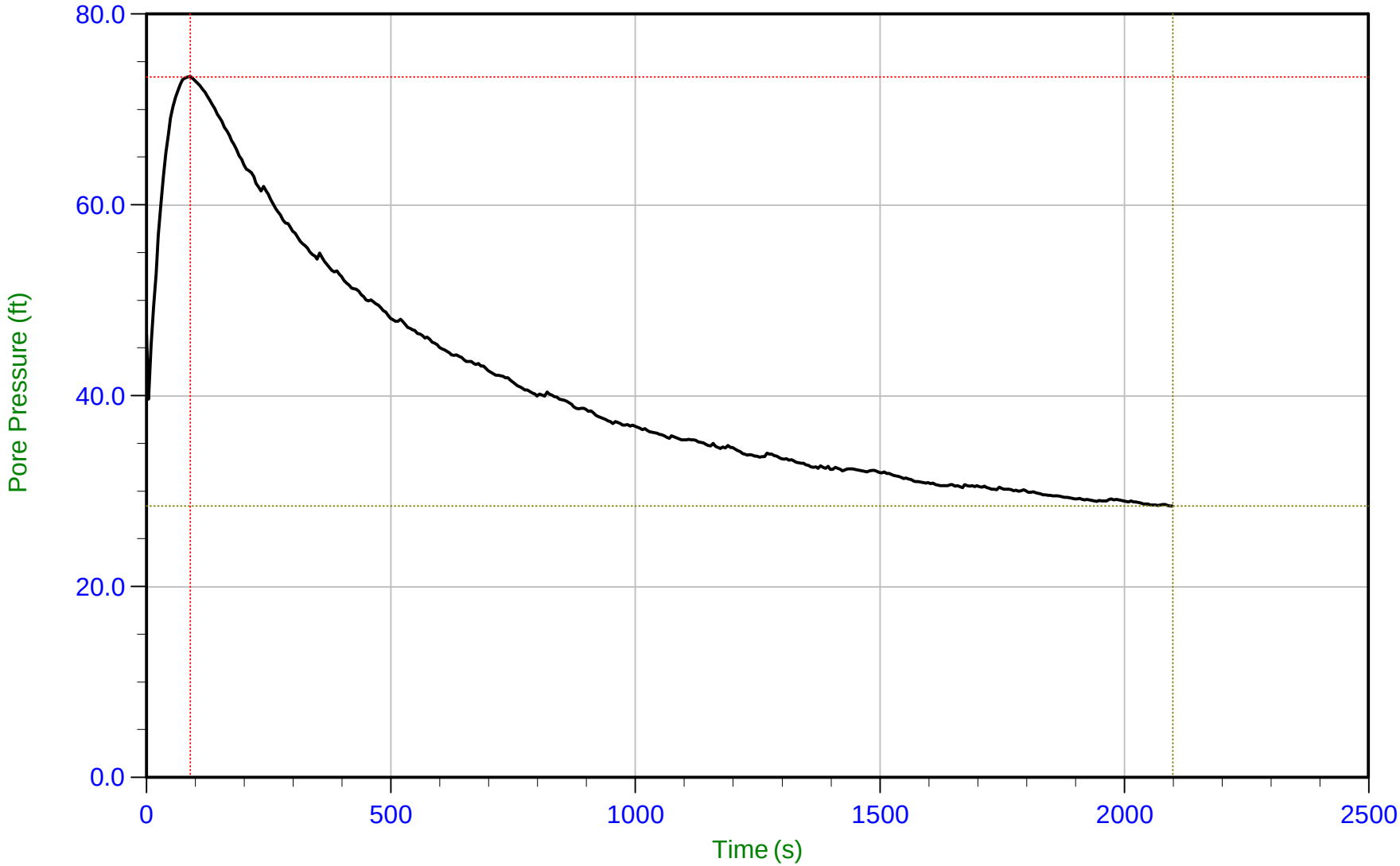
U Min: 79.0 ft
U Max: 169.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/07/2015 07:41
Site: Dynegy Joppa IL

Sounding: JOP-C004
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C004.PPD
Depth: 18.450 m / 60.531 ft
Duration: 2100.0 s

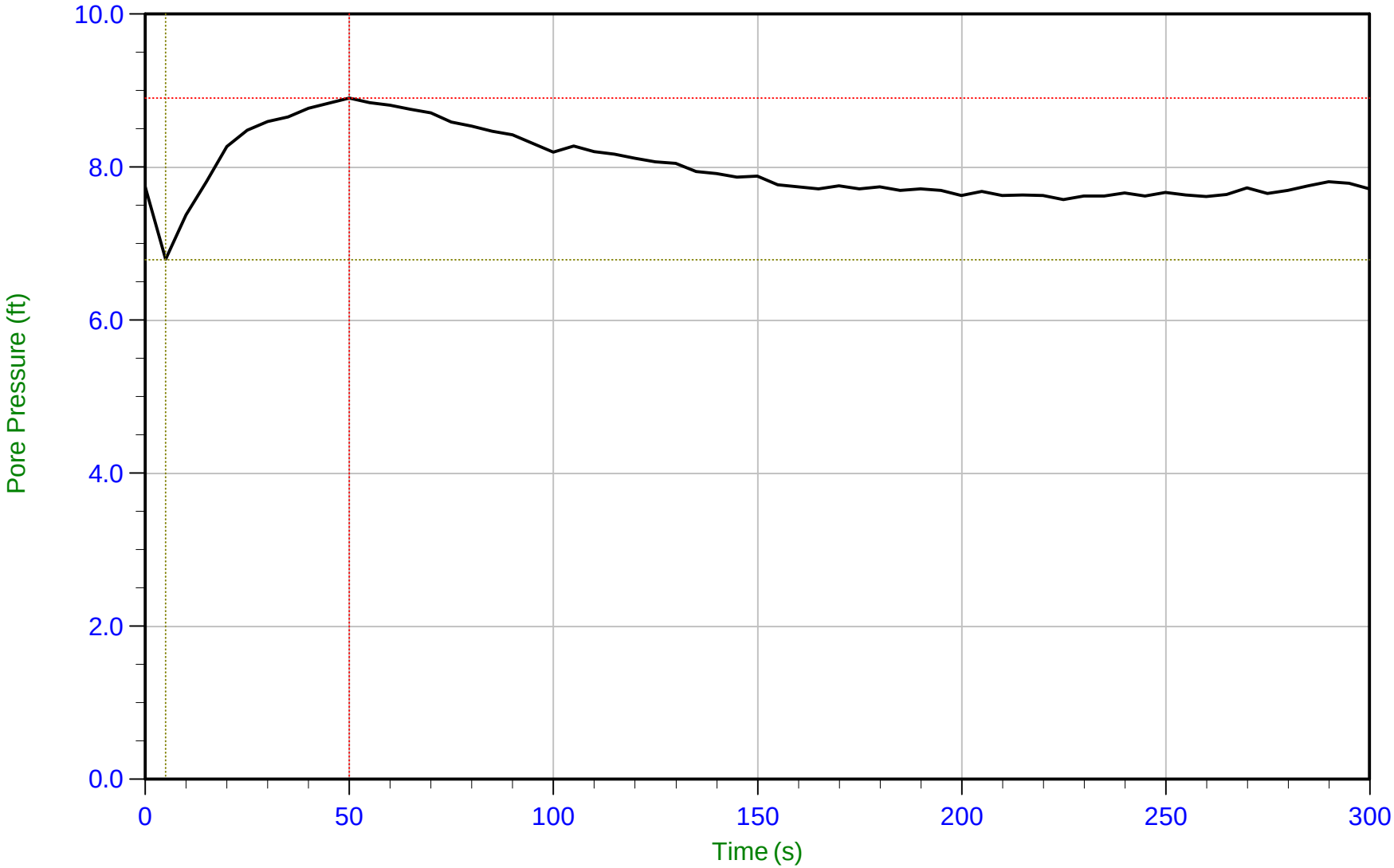
U Min: 28.5 ft
U Max: 73.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/07/2015 07:41
Site: Dynegy Joppa IL

Sounding: JOP-C004
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C004.PPD
Depth: 20.450 m / 67.092 ft
Duration: 300.0 s

U Min: 6.8 ft
U Max: 8.9 ft

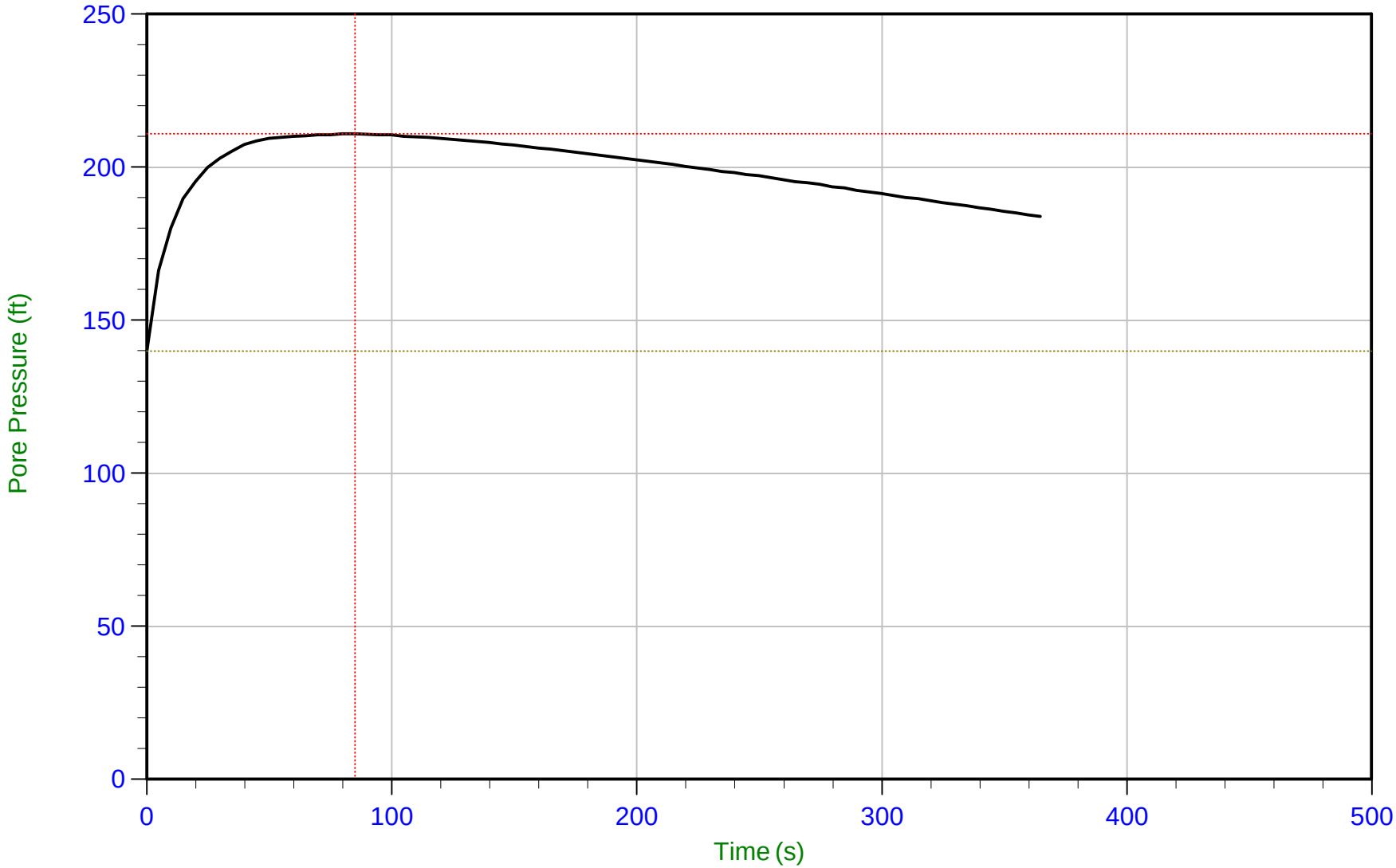
WT: 18.130 m / 59.480 ft
Ueq: 7.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 10:29
Site: Dynegy Joppa, I

Sounding: JOP-C005
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C005.PPD
Depth: 5.000 m / 16.404 ft
Duration: 365.0 s

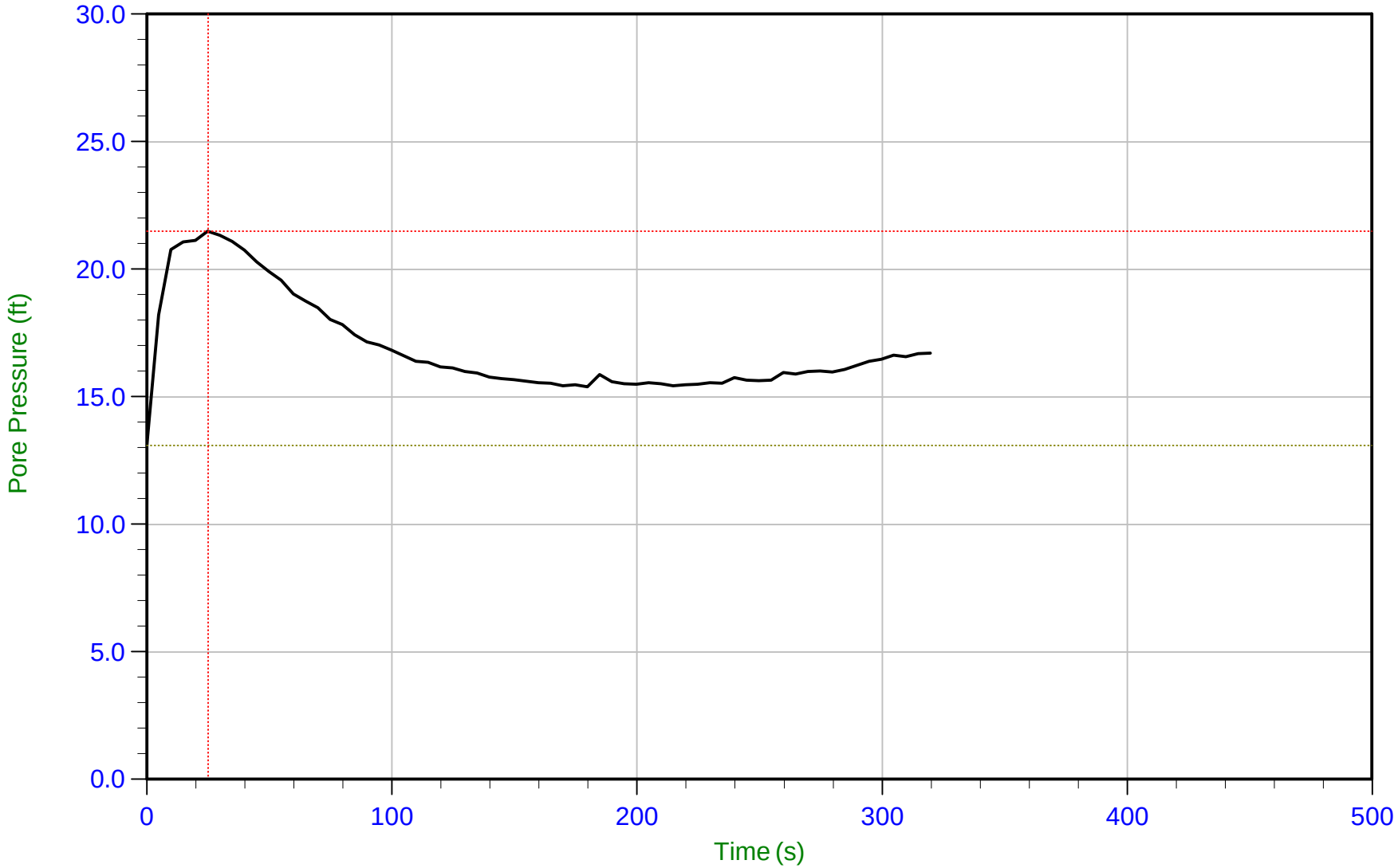
U Min: 140.0 ft
U Max: 210.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 10:29
Site: Dynegy Joppa, I

Sounding: JOP-C005
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C005.PPD
Depth: 7.000 m / 22.966 ft
Duration: 320.0 s

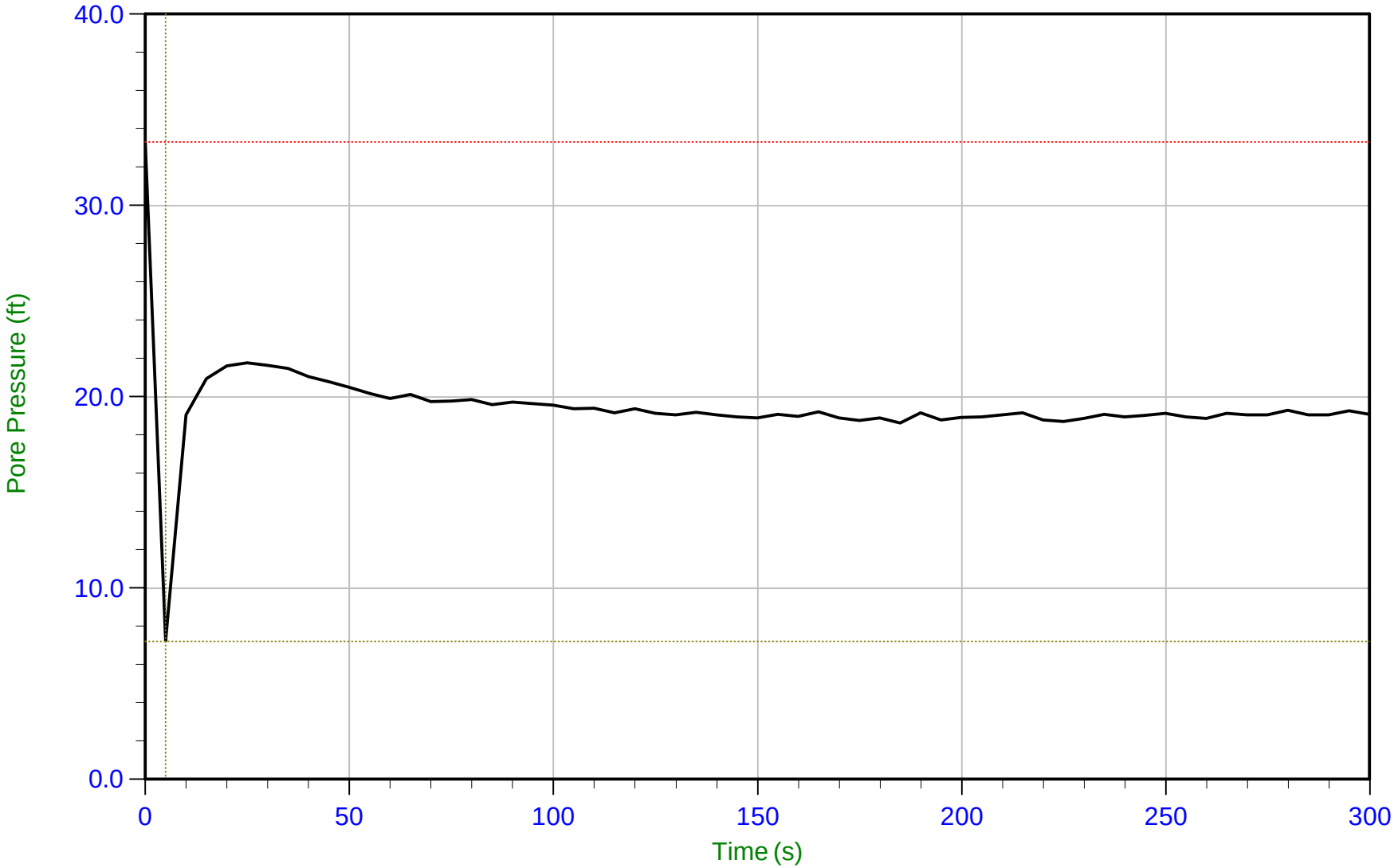
U Min: 13.1 ft
U Max: 21.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 10:29
Site: Dynegy Joppa, I

Sounding: JOP-C005
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C005.PPD
Depth: 8.500 m / 27.887 ft
Duration: 300.0 s

U Min: 7.2 ft
U Max: 33.3 ft

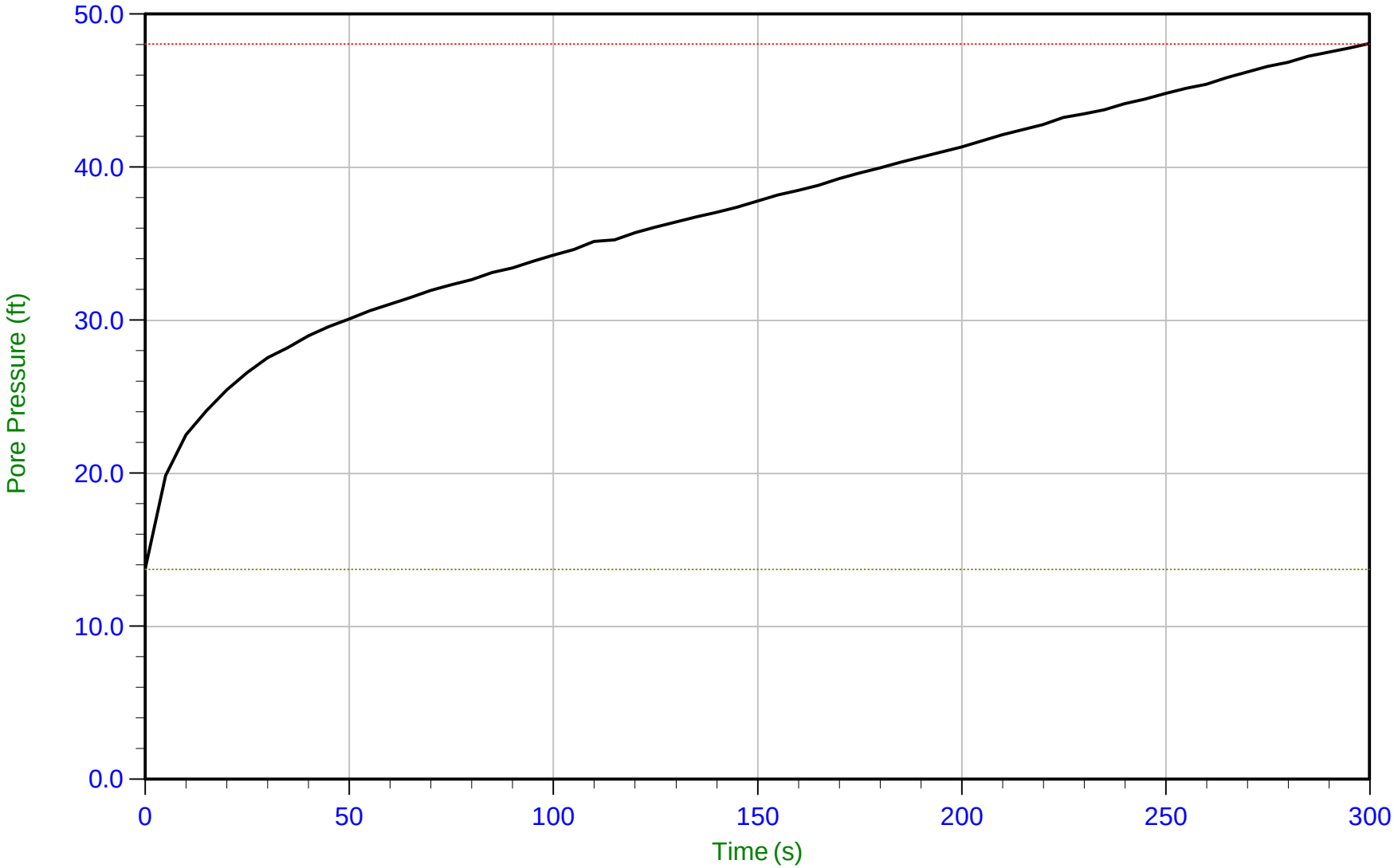
WT: 2.679 m / 8.790 ft
Ueq: 19.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 08:24
Site: Dynegy Joppa, I

Sounding: JOP-C006
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C006.PPD
Depth: 5.000 m / 16.404 ft
Duration: 300.0 s

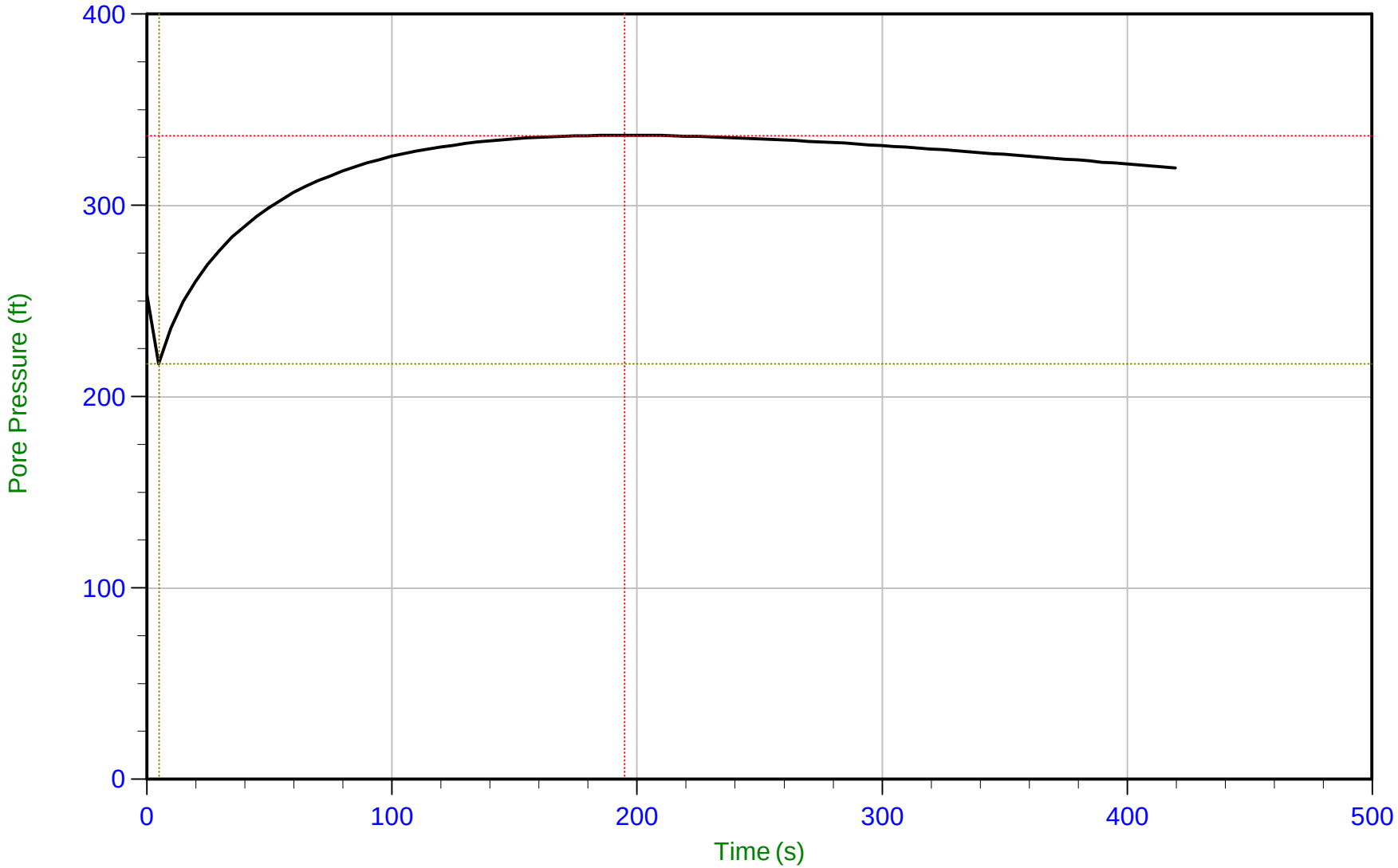
U Min: 13.7 ft
U Max: 48.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 08:24
Site: Dynegy Joppa, I

Sounding: JOP-C006
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C006.PPD
Depth: 10.000 m / 32.808 ft
Duration: 420.0 s

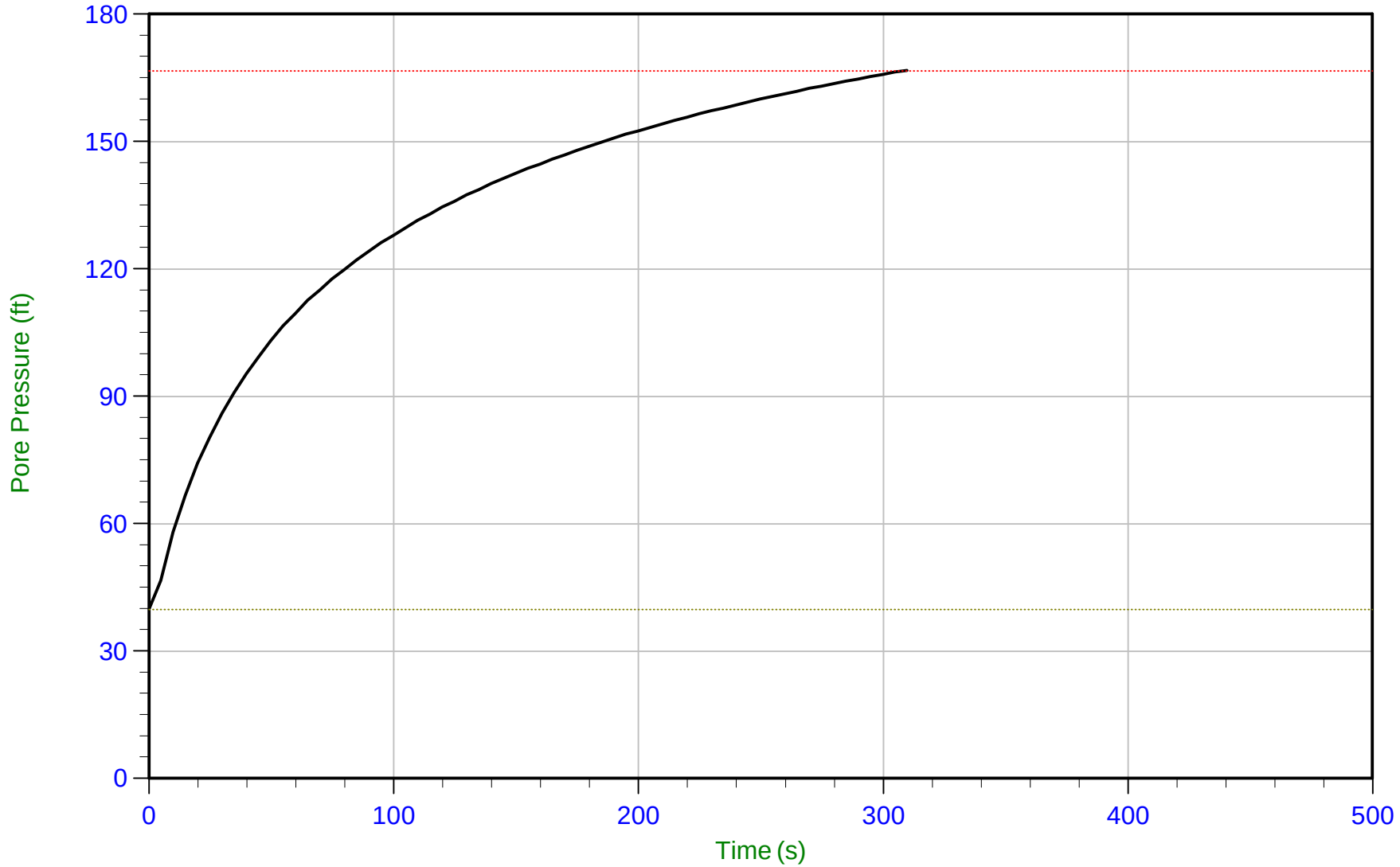
U Min: 217.2 ft
U Max: 336.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 08:24
Site: Dynegy Joppa, I

Sounding: JOP-C006
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C006.PPD
Depth: 11.000 m / 36.089 ft
Duration: 310.0 s

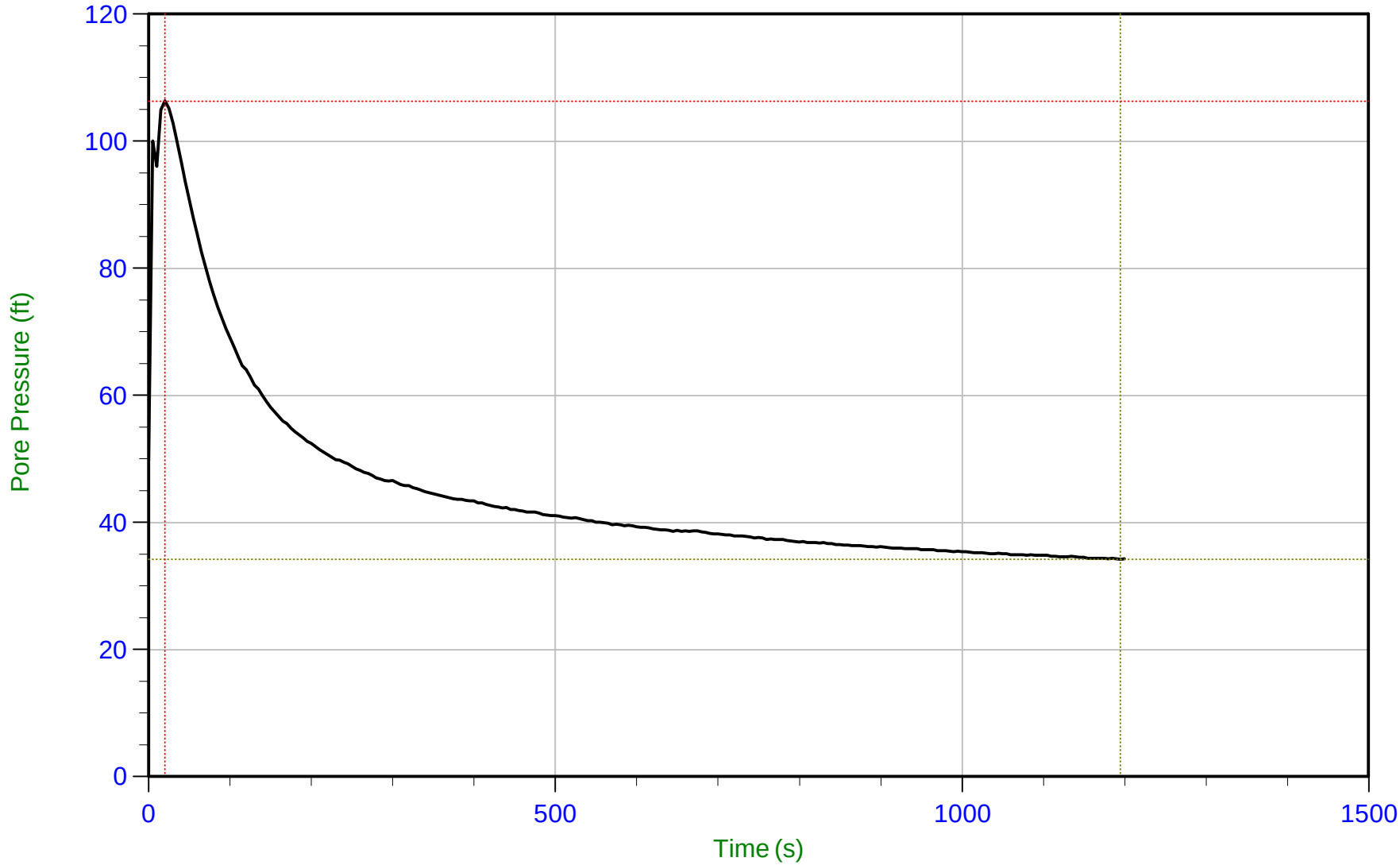
U Min: 39.9 ft
U Max: 166.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 08:24
Site: Dynegy Joppa, I

Sounding: JOP-C006
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C006.PPD
Depth: 13.700 m / 44.947 ft
Duration: 1200.0 s

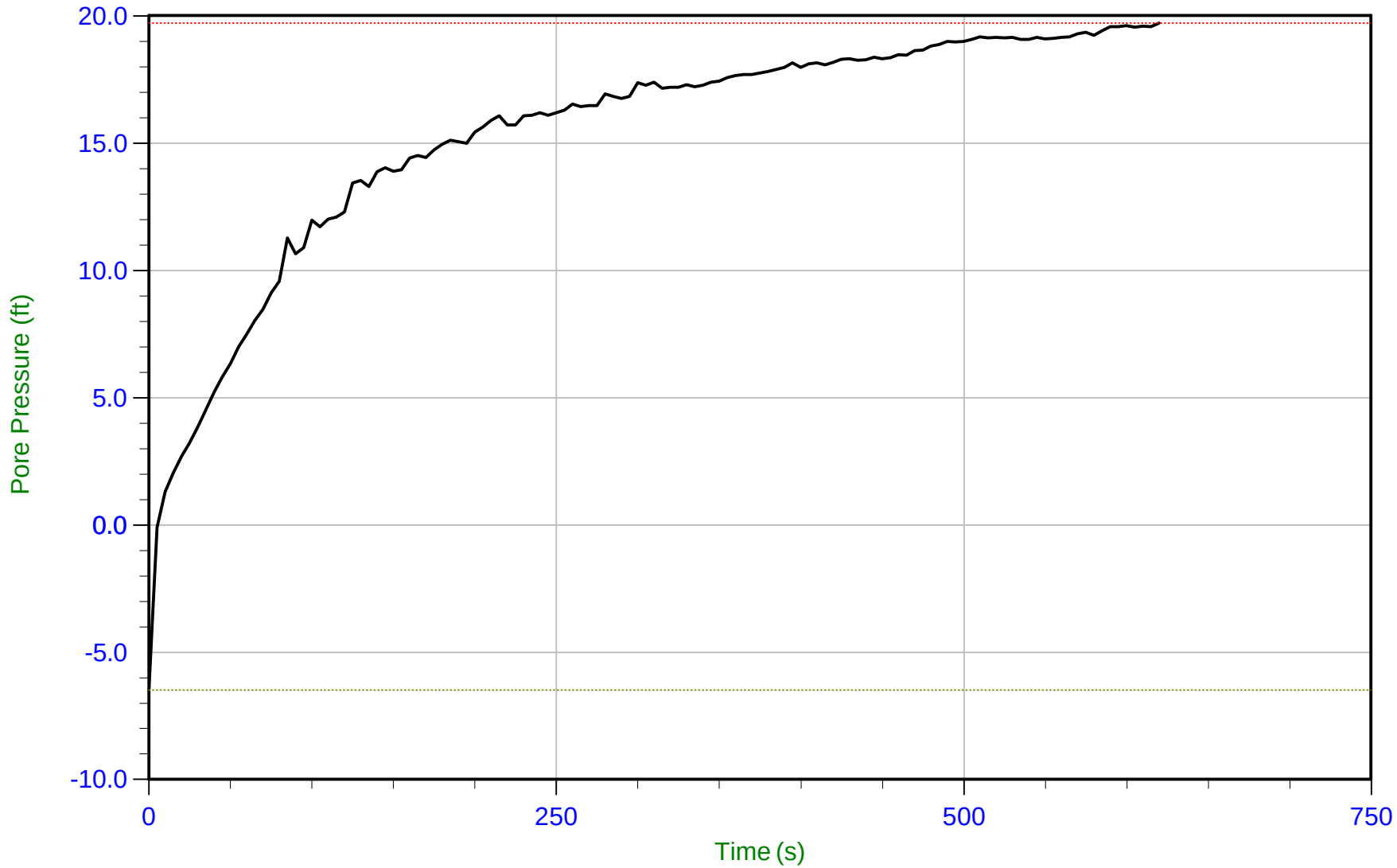
U Min: 34.2 ft
U Max: 106.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 08:24
Site: Dynegy Joppa, I

Sounding: JOP-C006
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C006.PPD
Depth: 15.000 m / 49.212 ft
Duration: 620.0 s

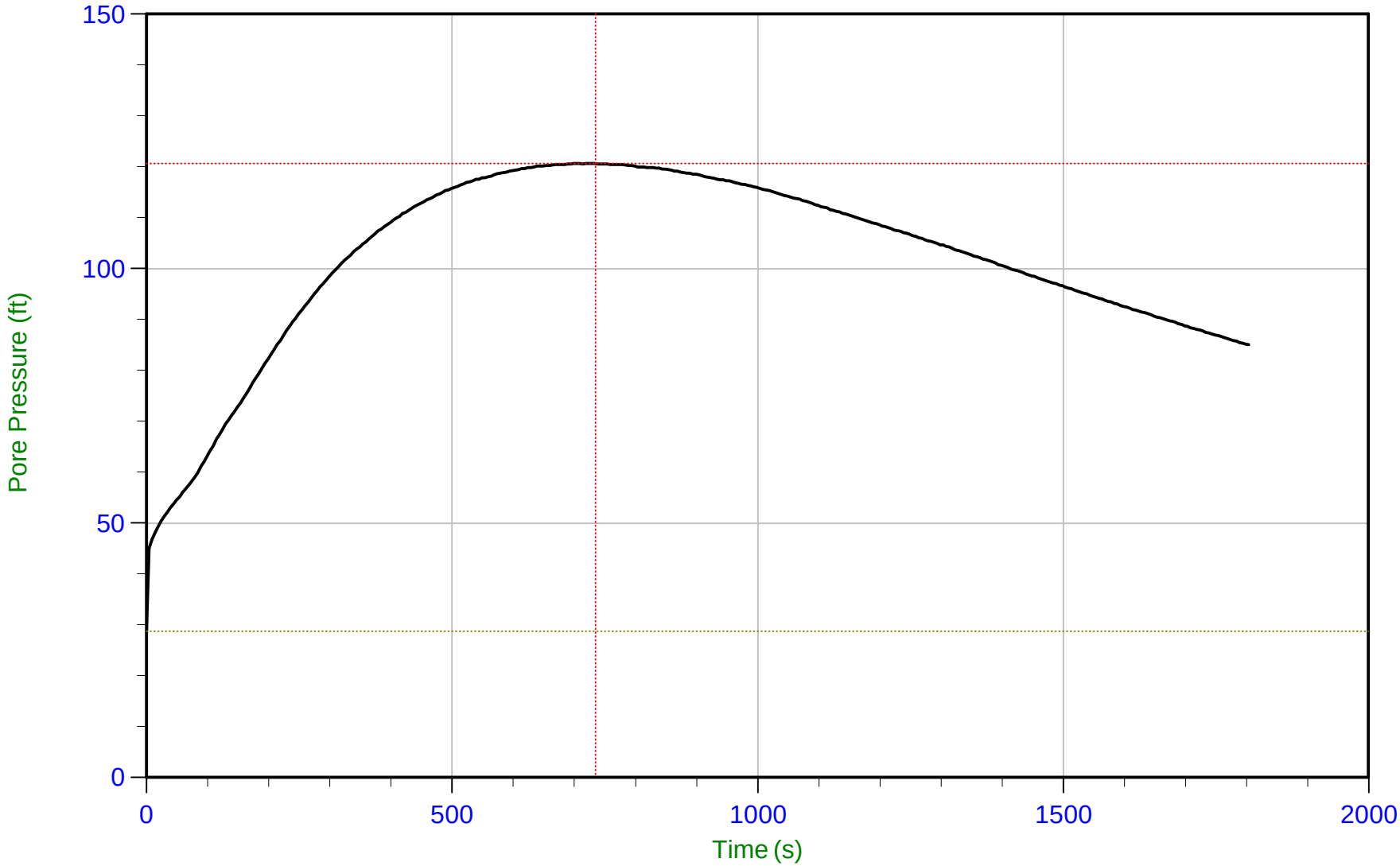
U Min: -6.5 ft
U Max: 19.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/06/2015 12:53
Site: Dynegy Joppa IL

Sounding: JOP-C007
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C007.PPD
Depth: 13.650 m / 44.783 ft
Duration: 1805.0 s

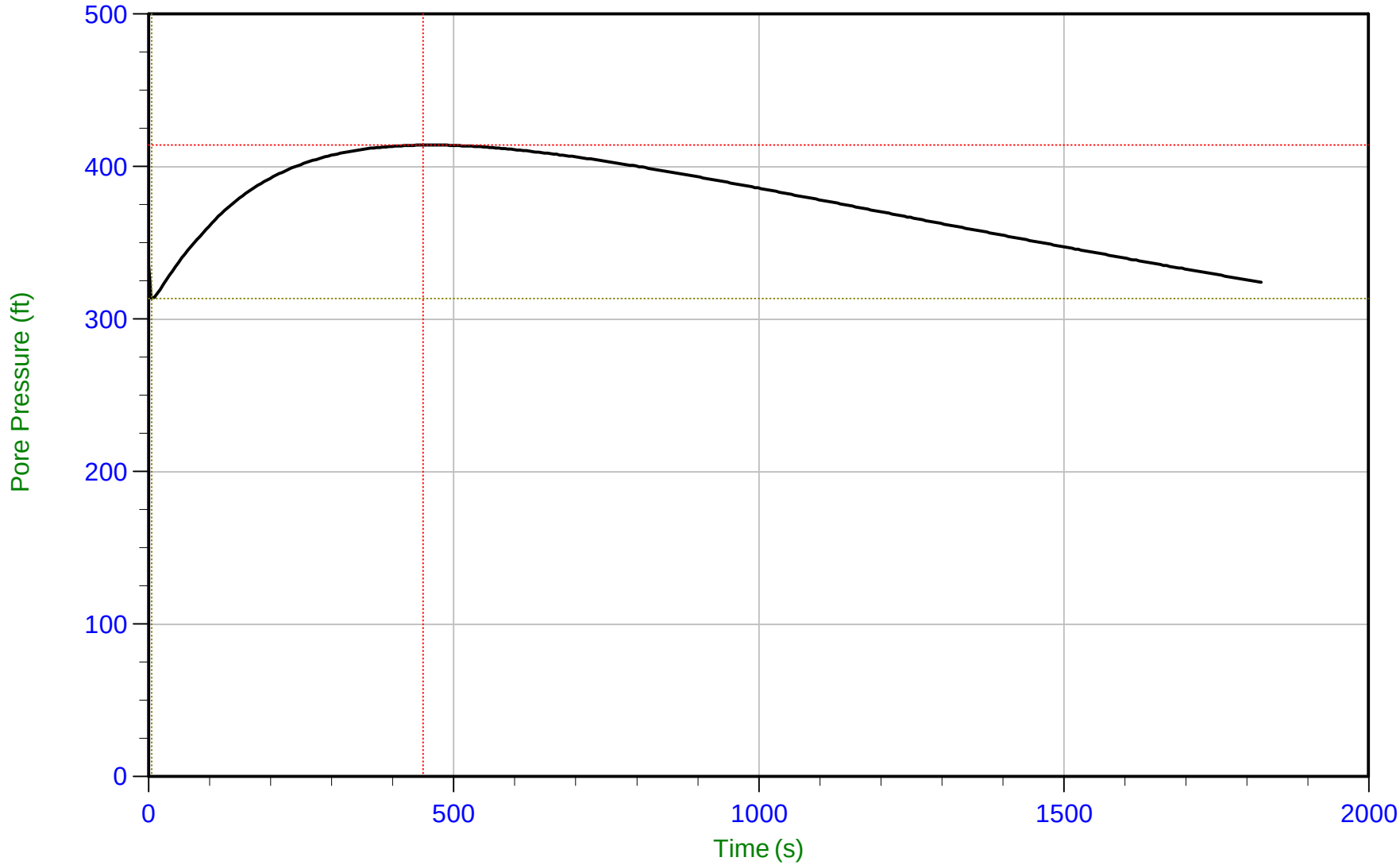
U Min: 28.8 ft
U Max: 120.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/06/2015 12:53
Site: Dynegy Joppa IL

Sounding: JOP-C007
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C007.PPD
Depth: 18.950 m / 62.171 ft
Duration: 1825.0 s

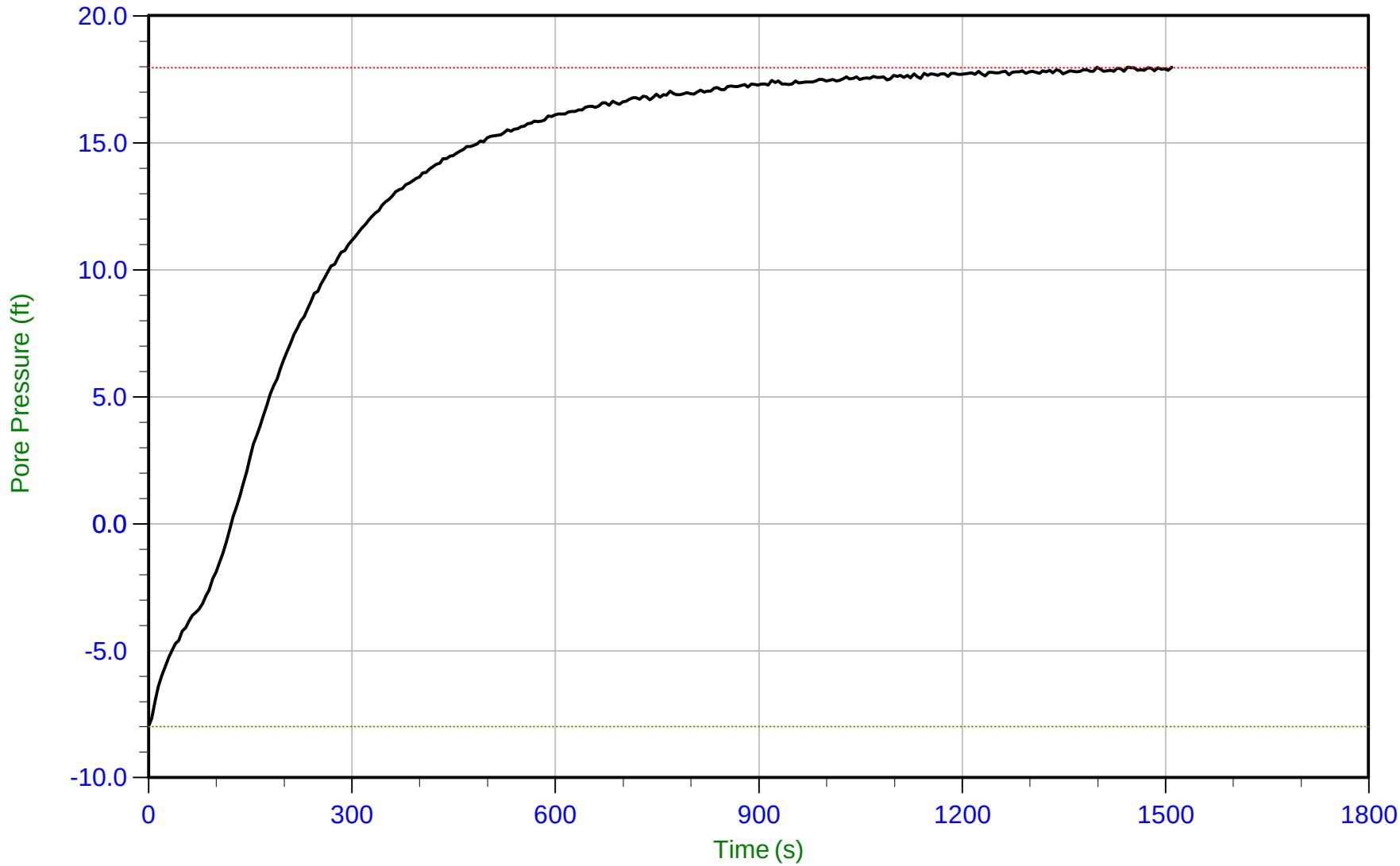
U Min: 313.7 ft
U Max: 414.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/06/2015 12:53
Site: Dynegy Joppa IL

Sounding: JOP-C007
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C007.PPD
Depth: 23.650 m / 77.591 ft
Duration: 1510.0 s

U Min: -8.0 ft
U Max: 18.0 ft

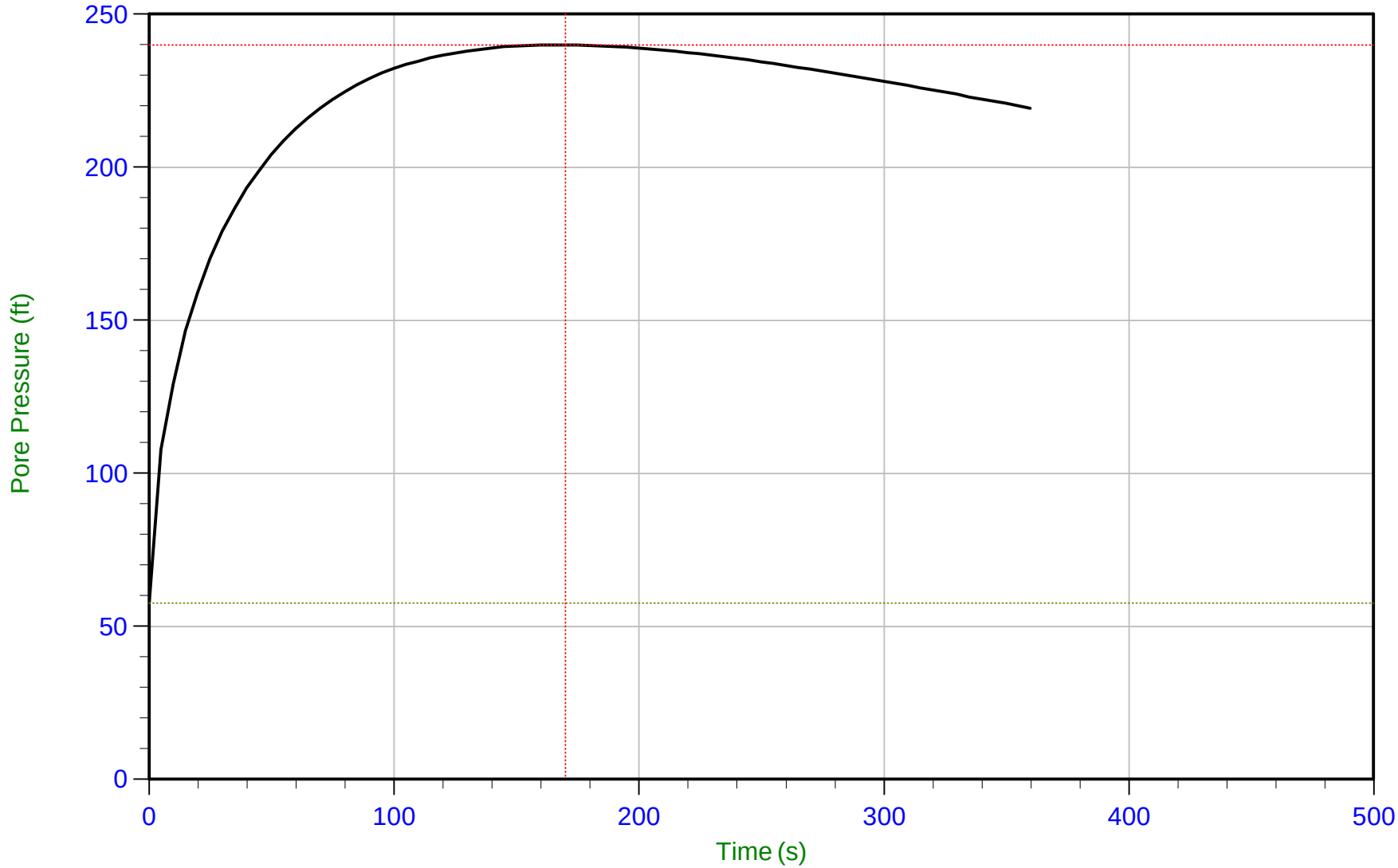
WT: 18.173 m / 59.623 ft
Ueq: 18.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 08:08
Site: Dynegy Joppa IL

Sounding: JOP-C008
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C008.PPD
Depth: 15.600 m / 51.180 ft
Duration: 360.0 s

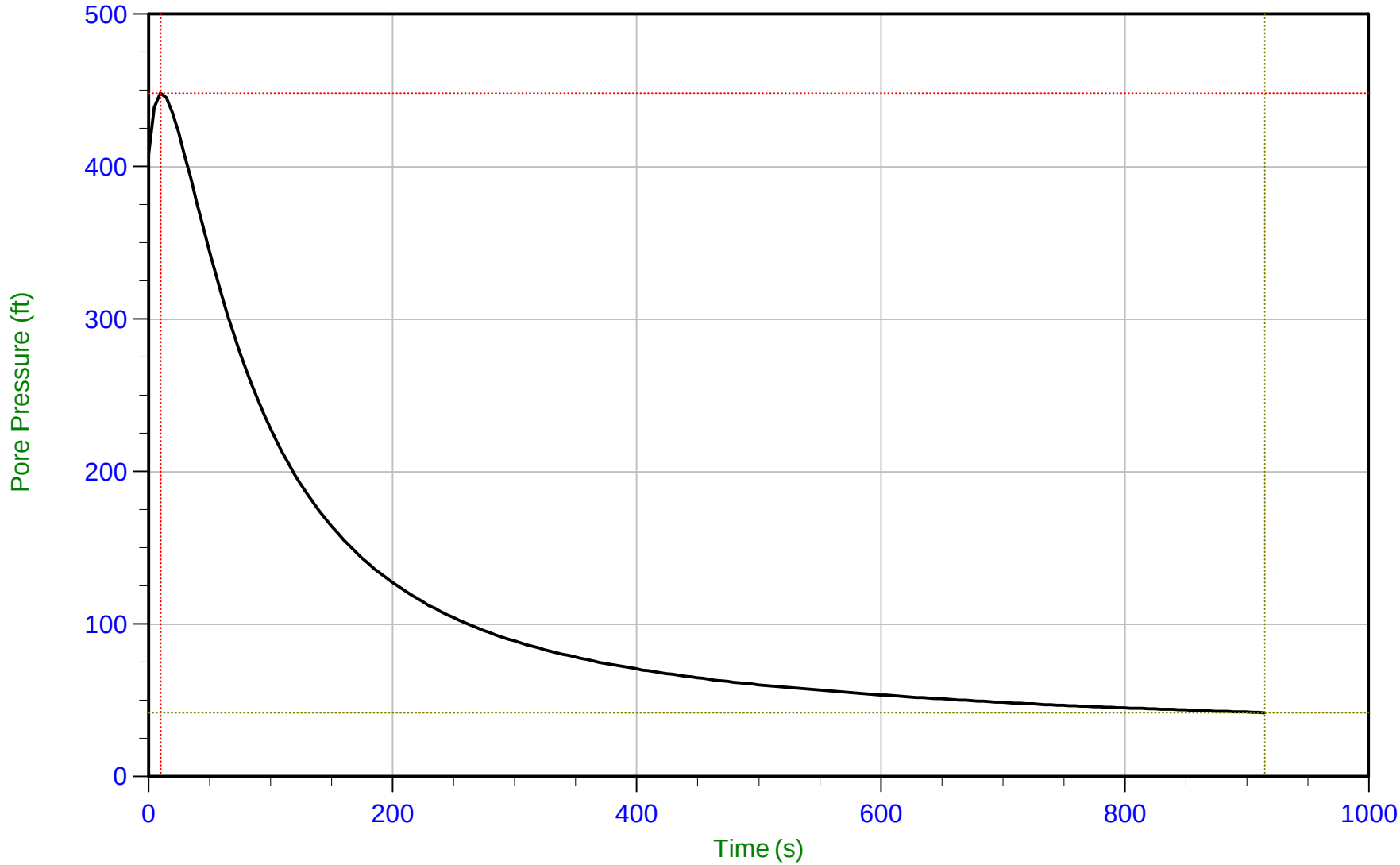
U Min: 57.6 ft
U Max: 240.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 08:08
Site: Dynegy Joppa IL

Sounding: JOP-C008
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C008.PPD
Depth: 22.000 m / 72.178 ft
Duration: 915.0 s

U Min: 41.9 ft
U Max: 448.2 ft

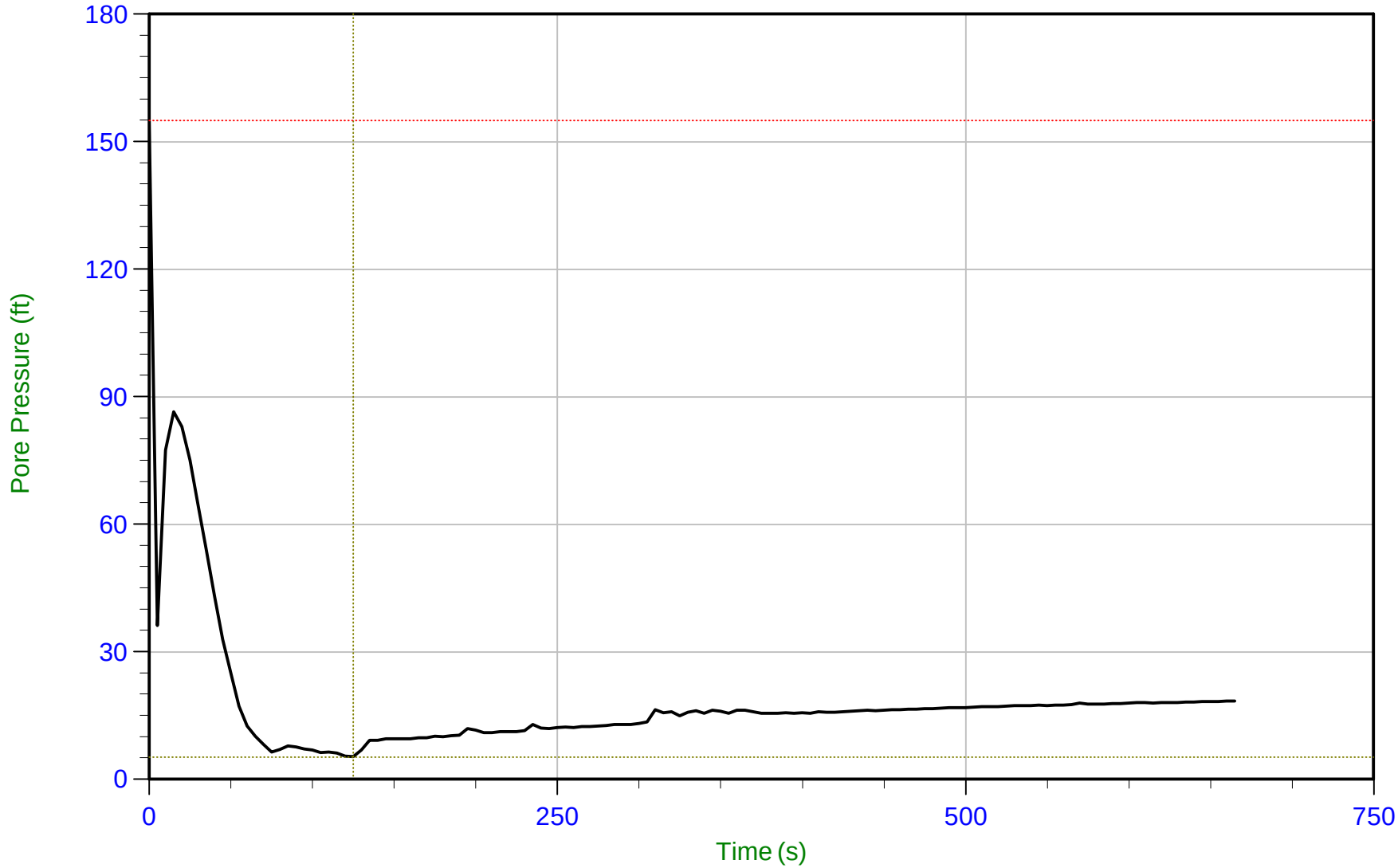
WT: 10.201 m / 33.467 ft
Ueq: 38.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 08:08
Site: Dynegy Joppa IL

Sounding: JOP-C008
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C008.PPD
Depth: 24.900 m / 81.692 ft
Duration: 665.0 s

U Min: 5.3 ft
U Max: 155.0 ft

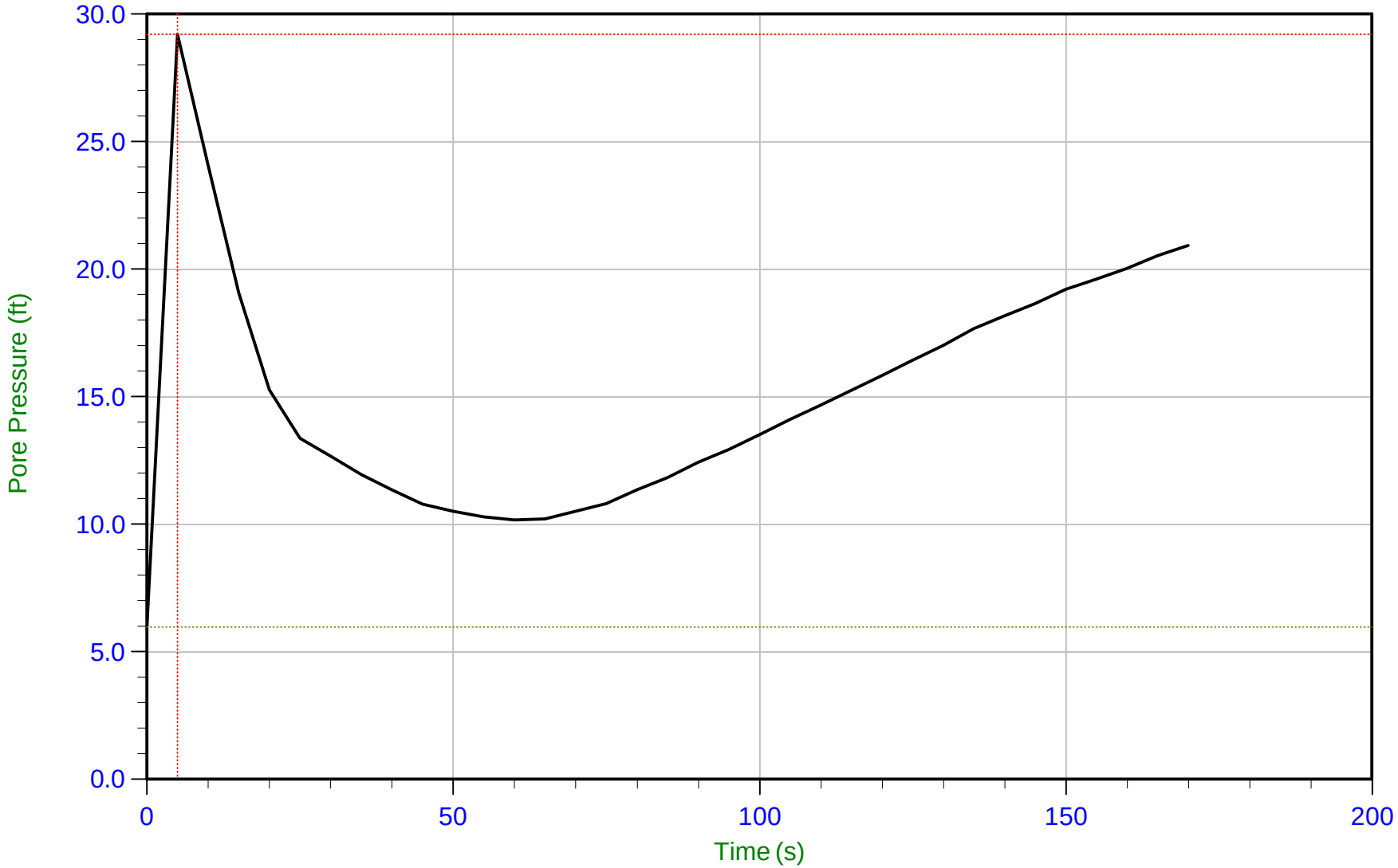
WT: 19.237 m / 63.113 ft
Ueq: 18.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 13:11
Site: Dynegy Joppa, I

Sounding: JOP-C009
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C009.PPD
Depth: 4.600 m / 15.092 ft
Duration: 170.0 s

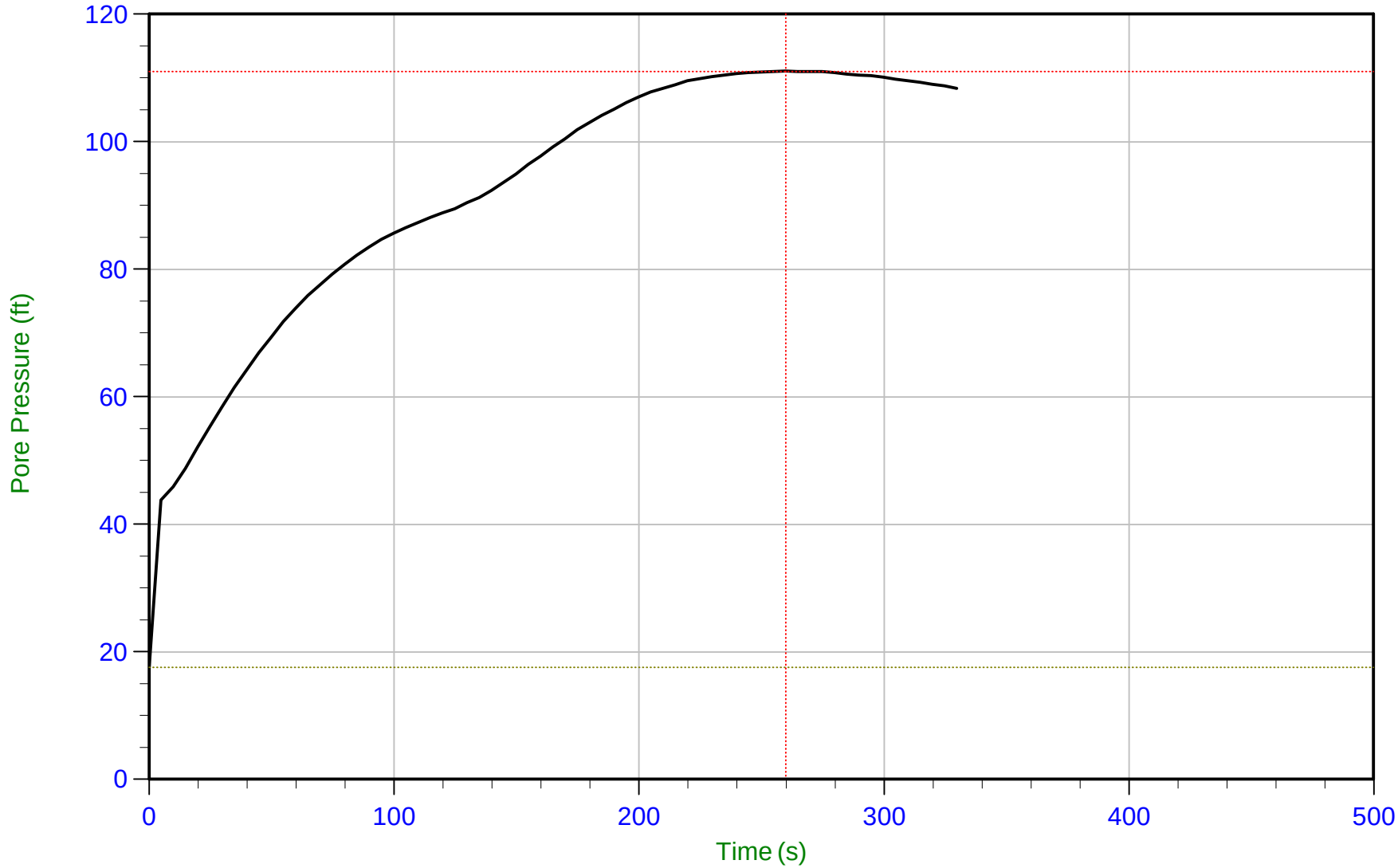
U Min: 6.0 ft
U Max: 29.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 13:11
Site: Dynegy Joppa, I

Sounding: JOP-C009
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C009.PPD
Depth: 5.600 m / 18.372 ft
Duration: 330.0 s

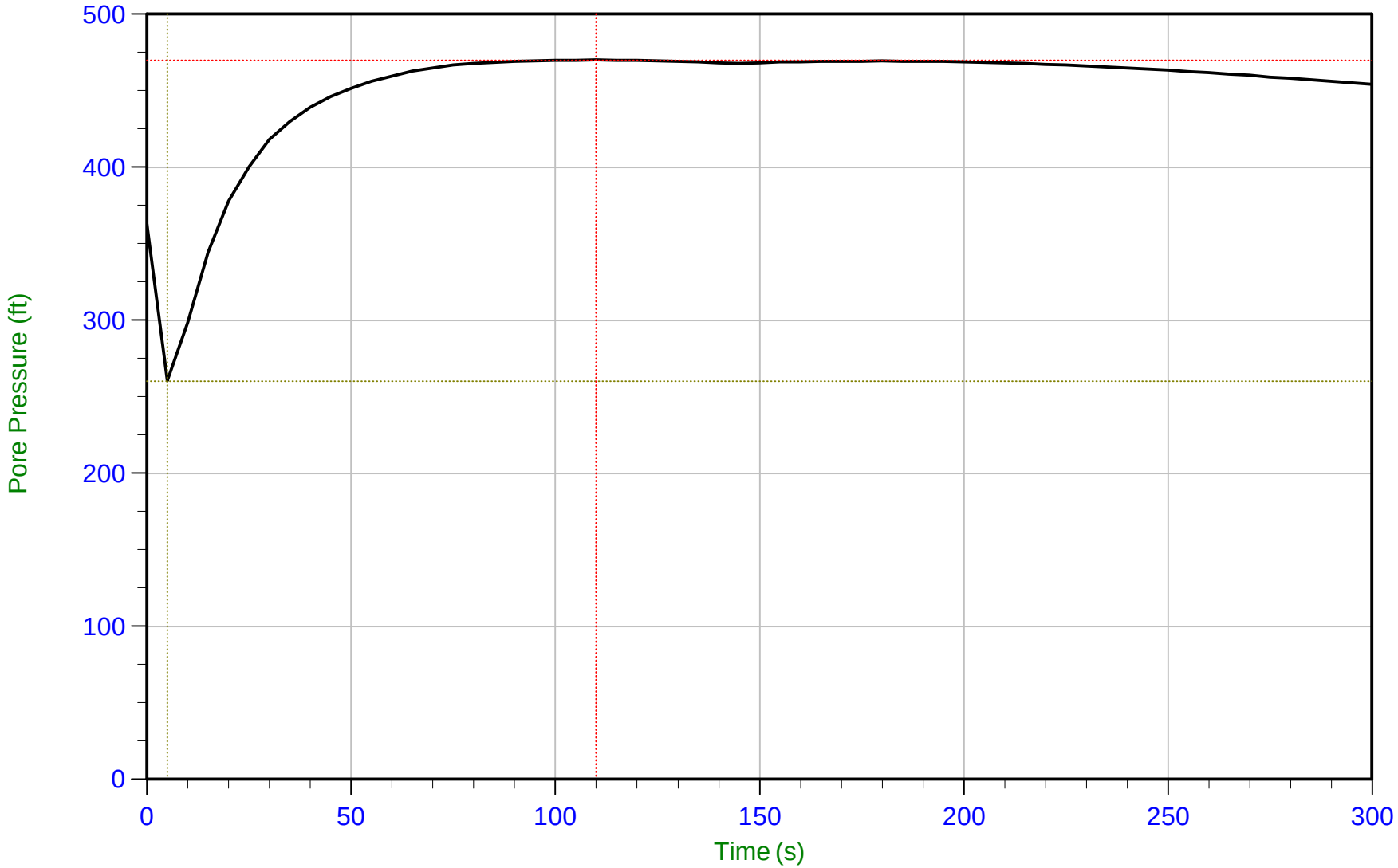
U Min: 17.6 ft
U Max: 111.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 13:11
Site: Dynegy Joppa, I

Sounding: JOP-C009
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C009.PPD
Depth: 11.600 m / 38.057 ft
Duration: 300.0 s

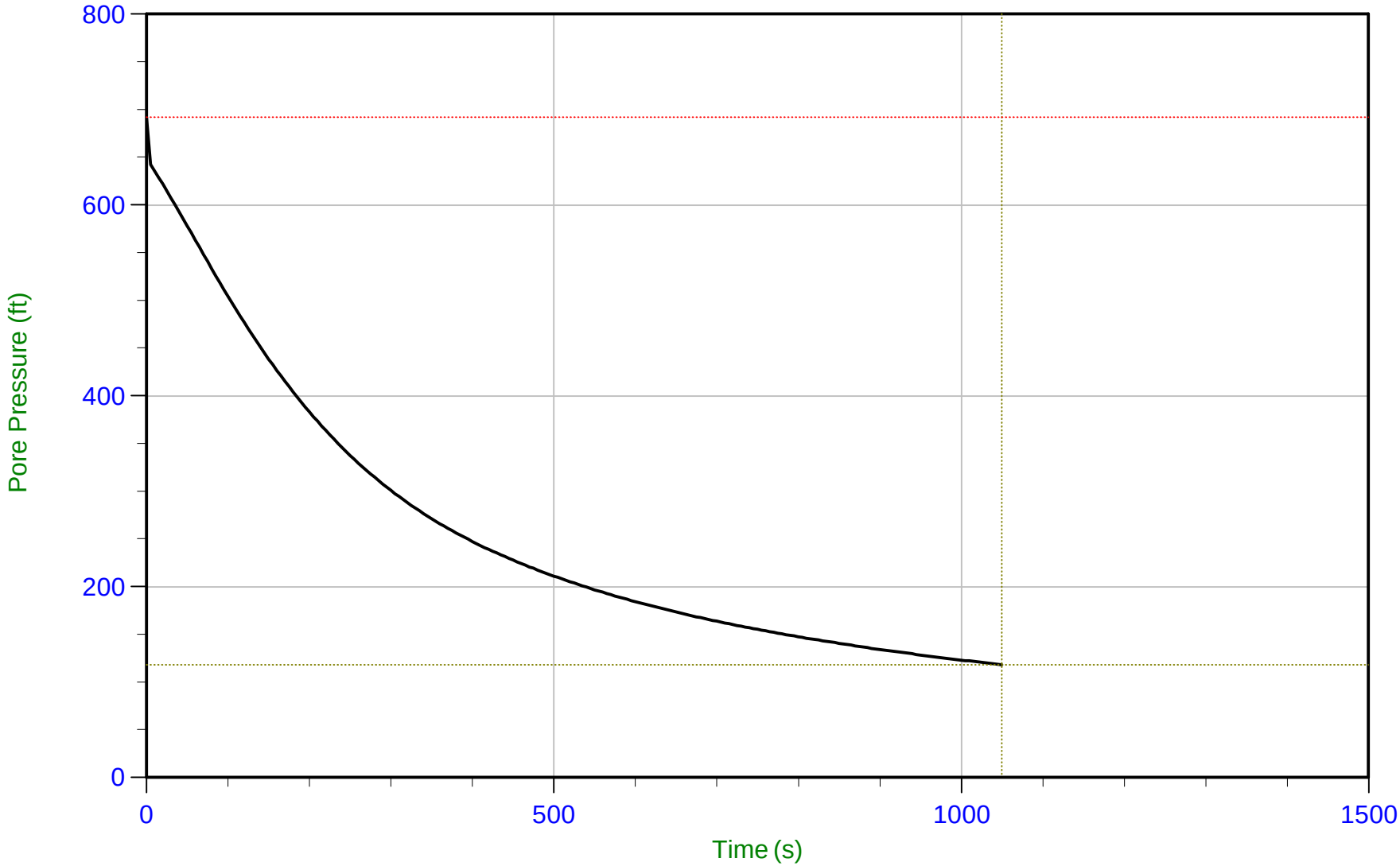
U Min: 260.5 ft
U Max: 470.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 13:11
Site: Dynegy Joppa, I

Sounding: JOP-C009
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C009.PPD
Depth: 15.250 m / 50.032 ft
Duration: 1050.0 s

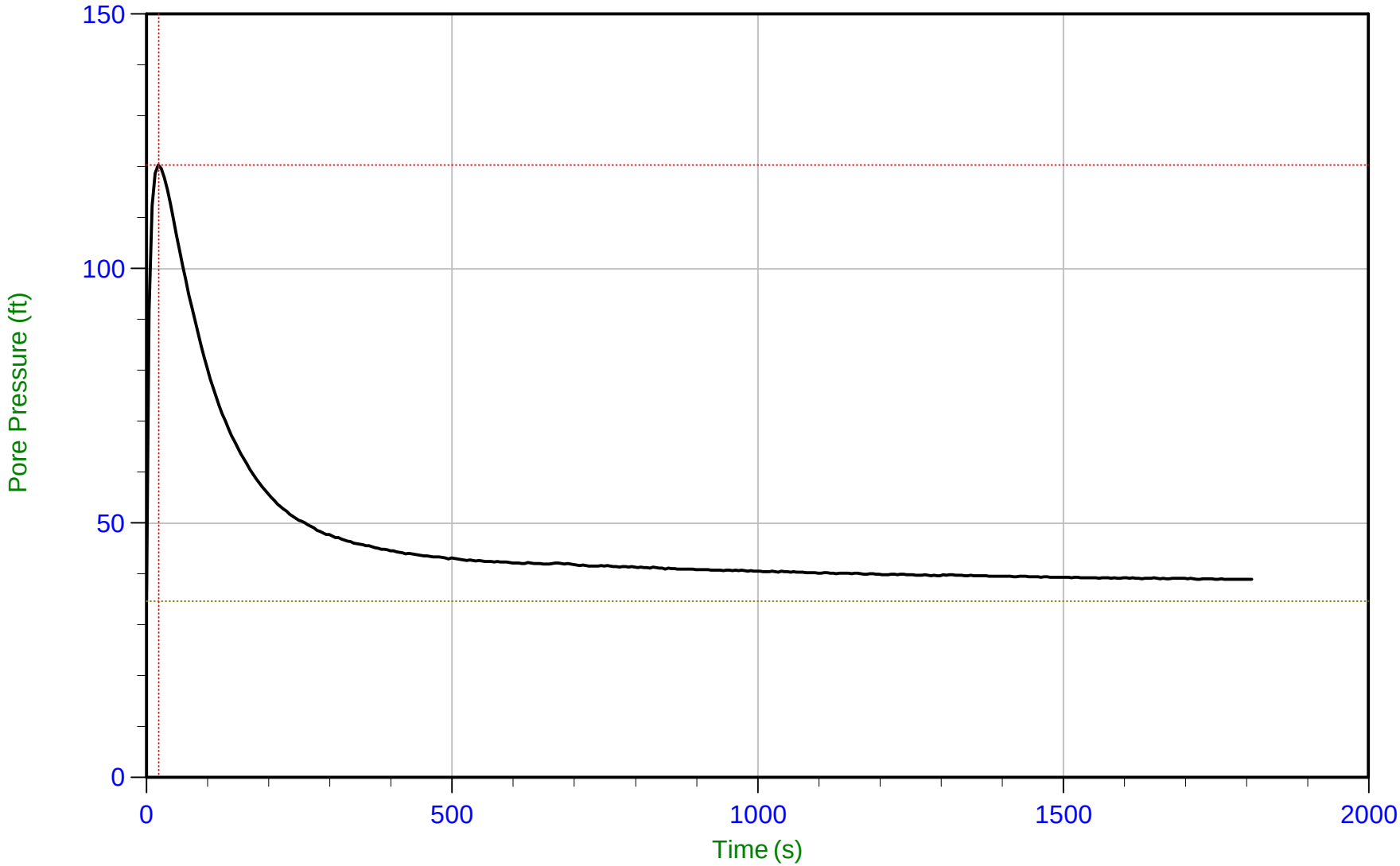
U Min: 118.4 ft
U Max: 692.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 07:40
Site: Dynegy Joppa IL

Sounding: JOP-C011
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C011.PPD
Depth: 16.150 m / 52.985 ft
Duration: 1810.0 s

U Min: 34.7 ft
U Max: 120.4 ft

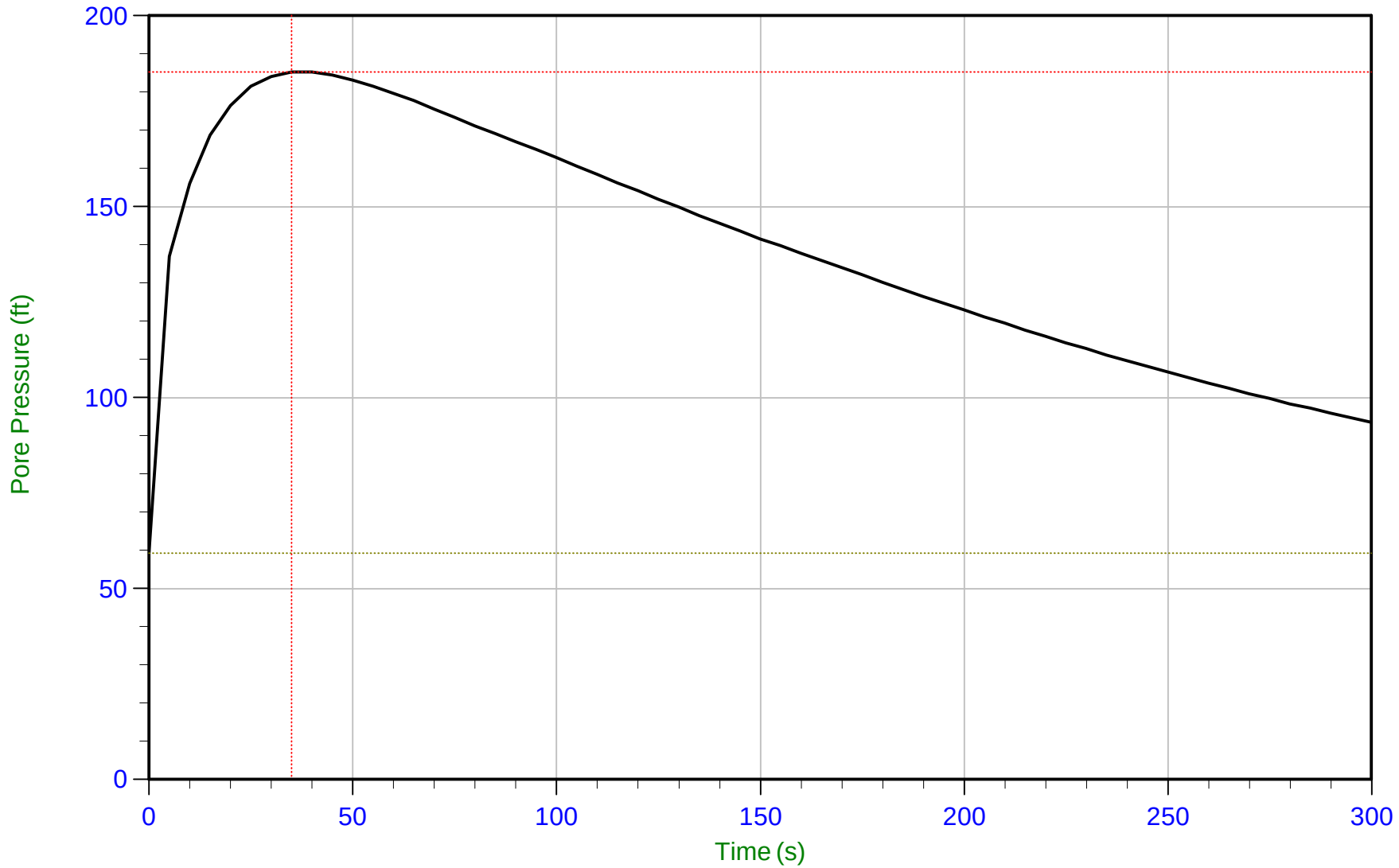
WT: 4.204 m / 13.792 ft
Ueq: 39.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 14:16
Site: Dynegy Joppa IL

Sounding: JOP-C013
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C013.PPD
Depth: 5.800 m / 19.029 ft
Duration: 300.0 s

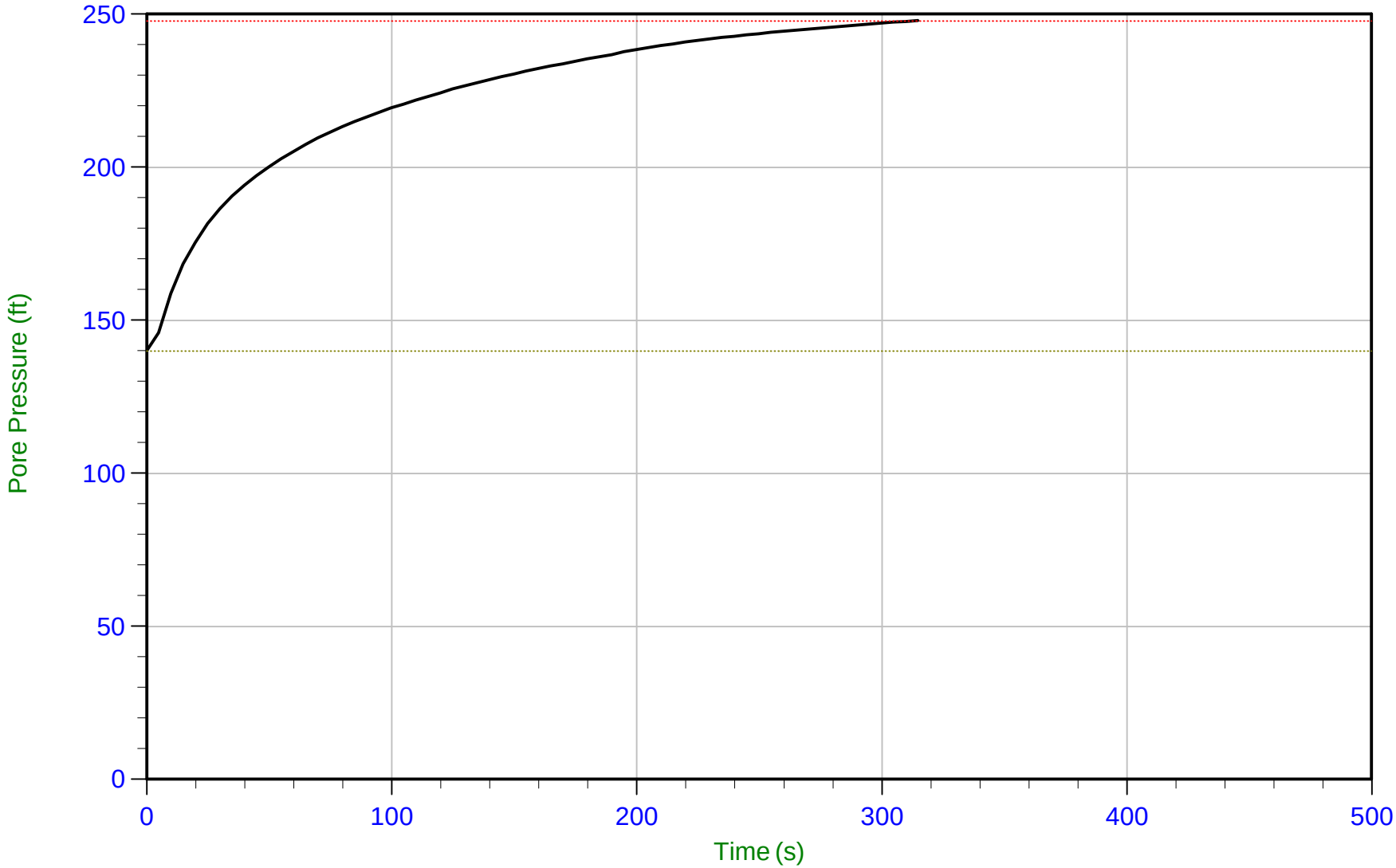
U Min: 59.3 ft
U Max: 185.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 14:16
Site: Dynegy Joppa IL

Sounding: JOP-C013
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C013.PPD
Depth: 9.150 m / 30.019 ft
Duration: 315.0 s

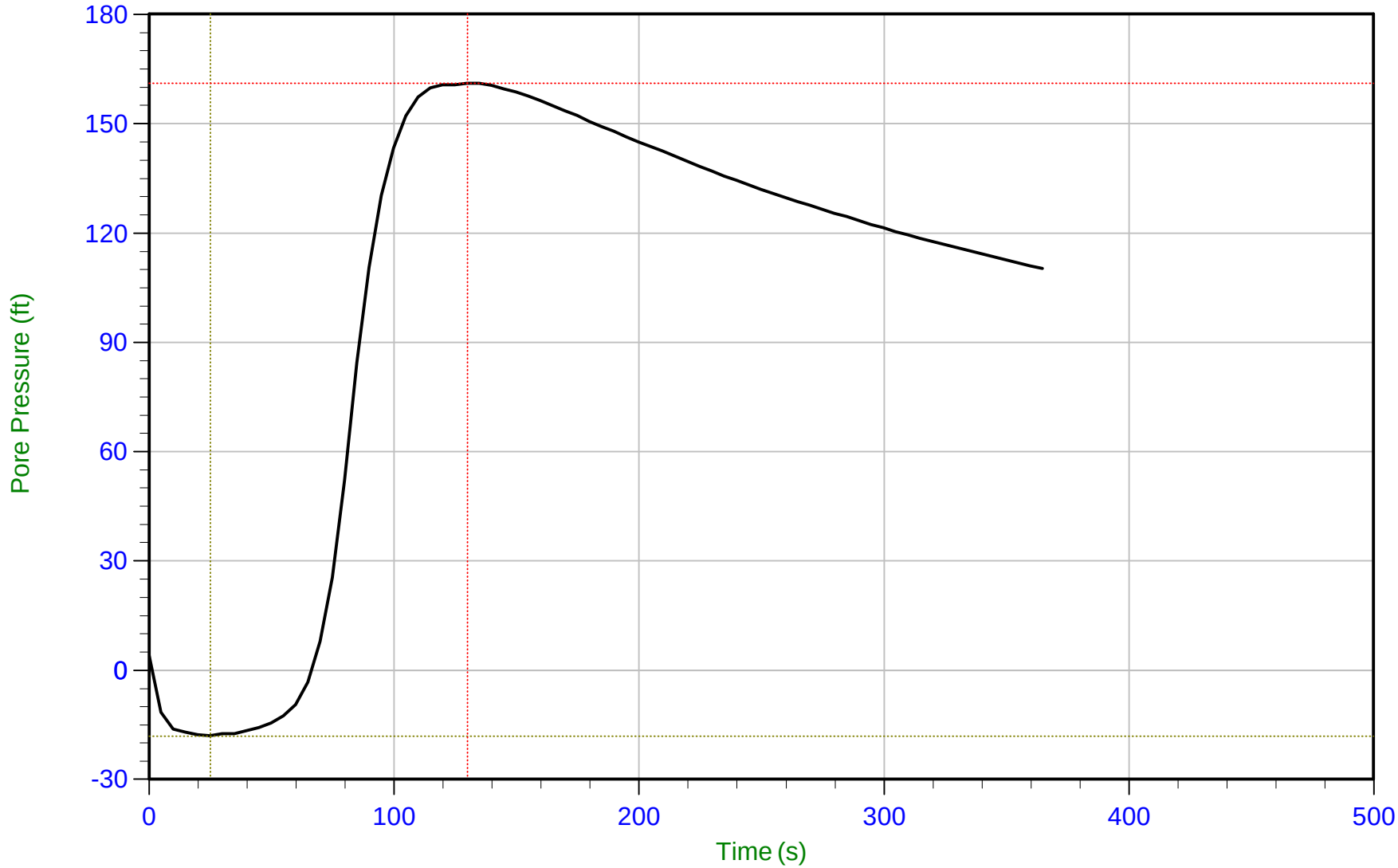
U Min: 140.0 ft
U Max: 247.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 14:16
Site: Dynegy Joppa IL

Sounding: JOP-C013
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C013.PPD
Depth: 15.500 m / 50.852 ft
Duration: 365.0 s

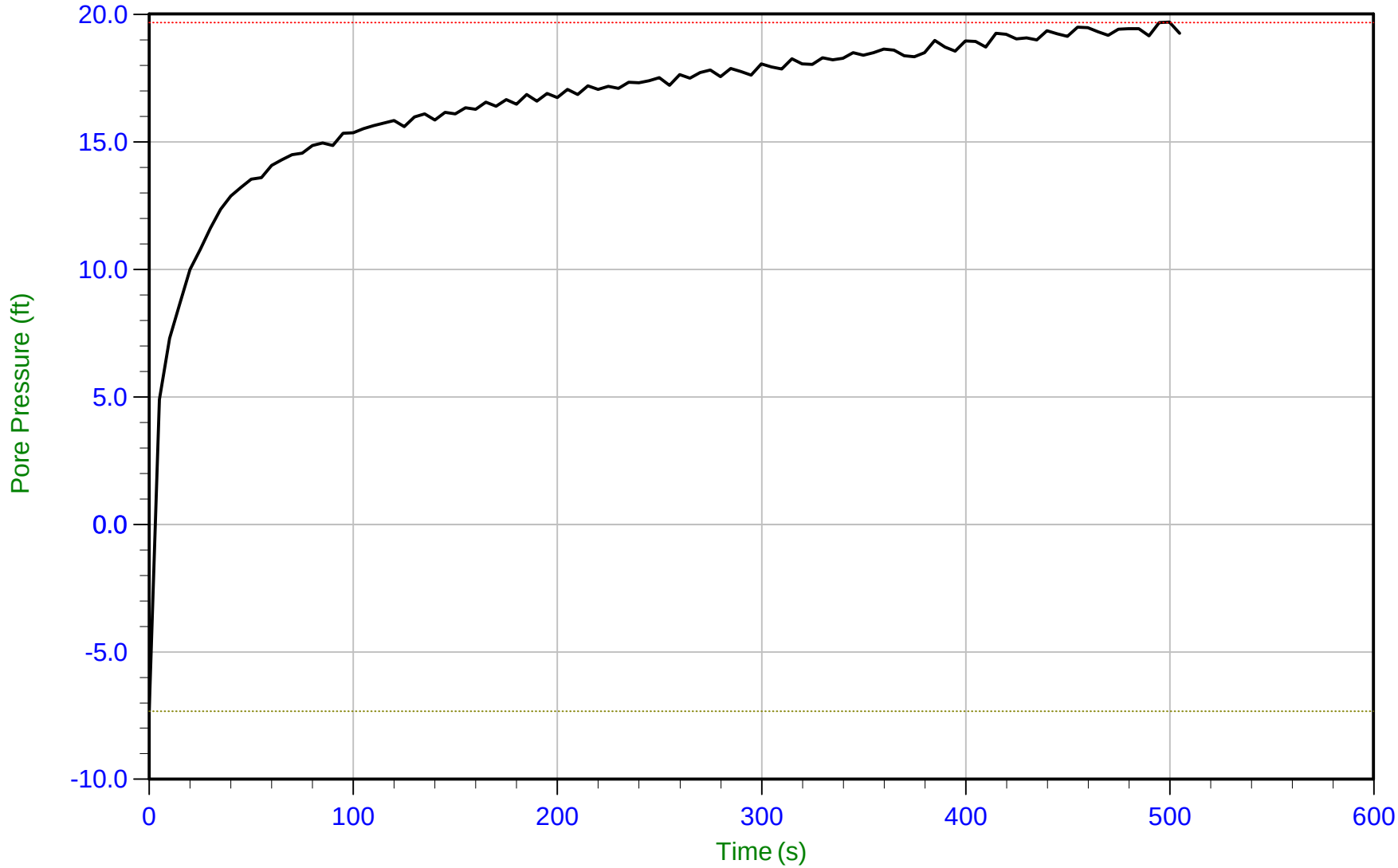
U Min: -18.1 ft
U Max: 161.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 11:56
Site: Dynegy Joppa, I

Sounding: JOP-C014
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C014.PPD
Depth: 5.350 m / 17.552 ft
Duration: 505.0 s

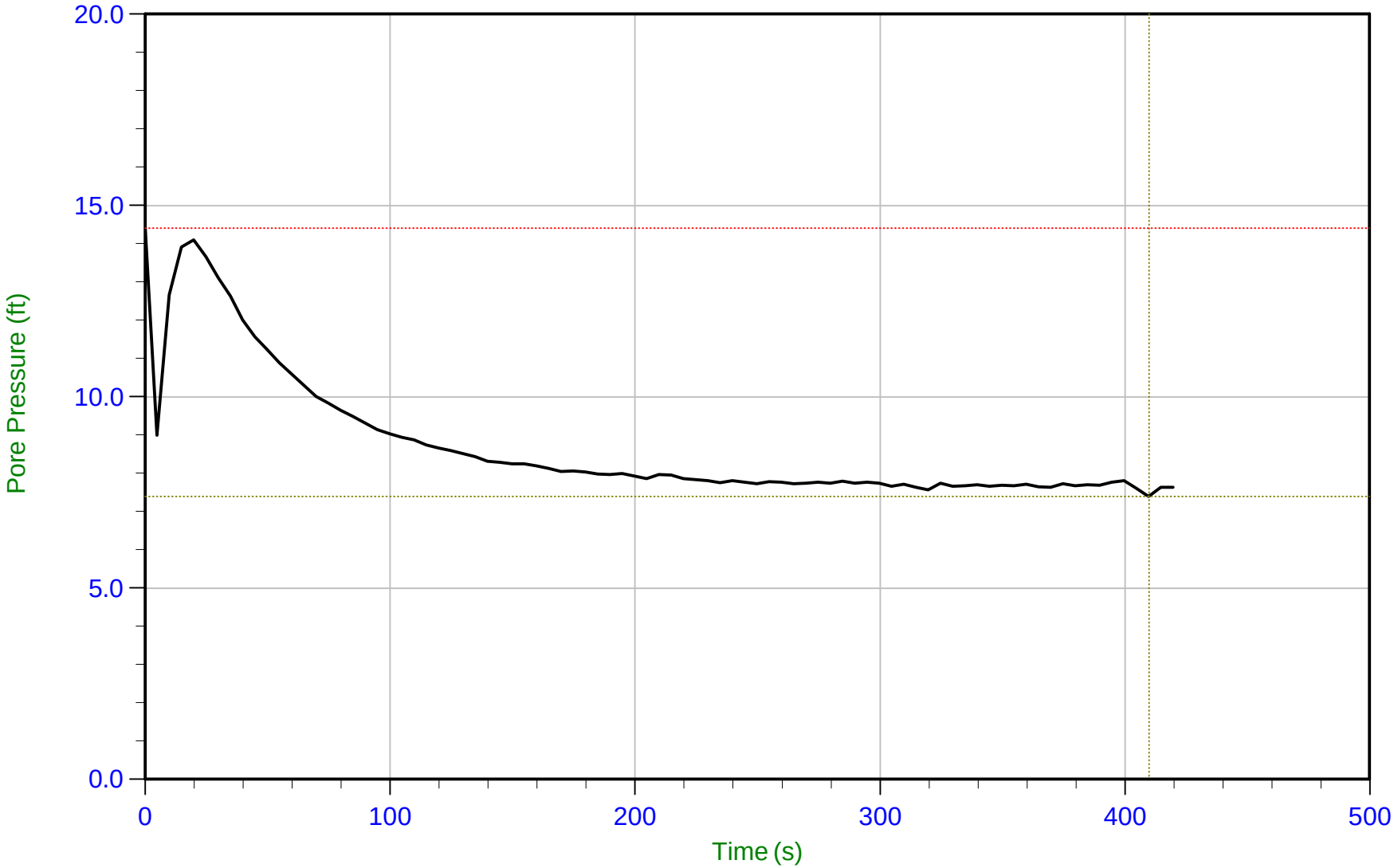
U Min: -7.3 ft
U Max: 19.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 11:56
Site: Dynegy Joppa, I

Sounding: JOP-C014
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C014.PPD
Depth: 8.000 m / 26.246 ft
Duration: 420.0 s

U Min: 7.4 ft
U Max: 14.4 ft

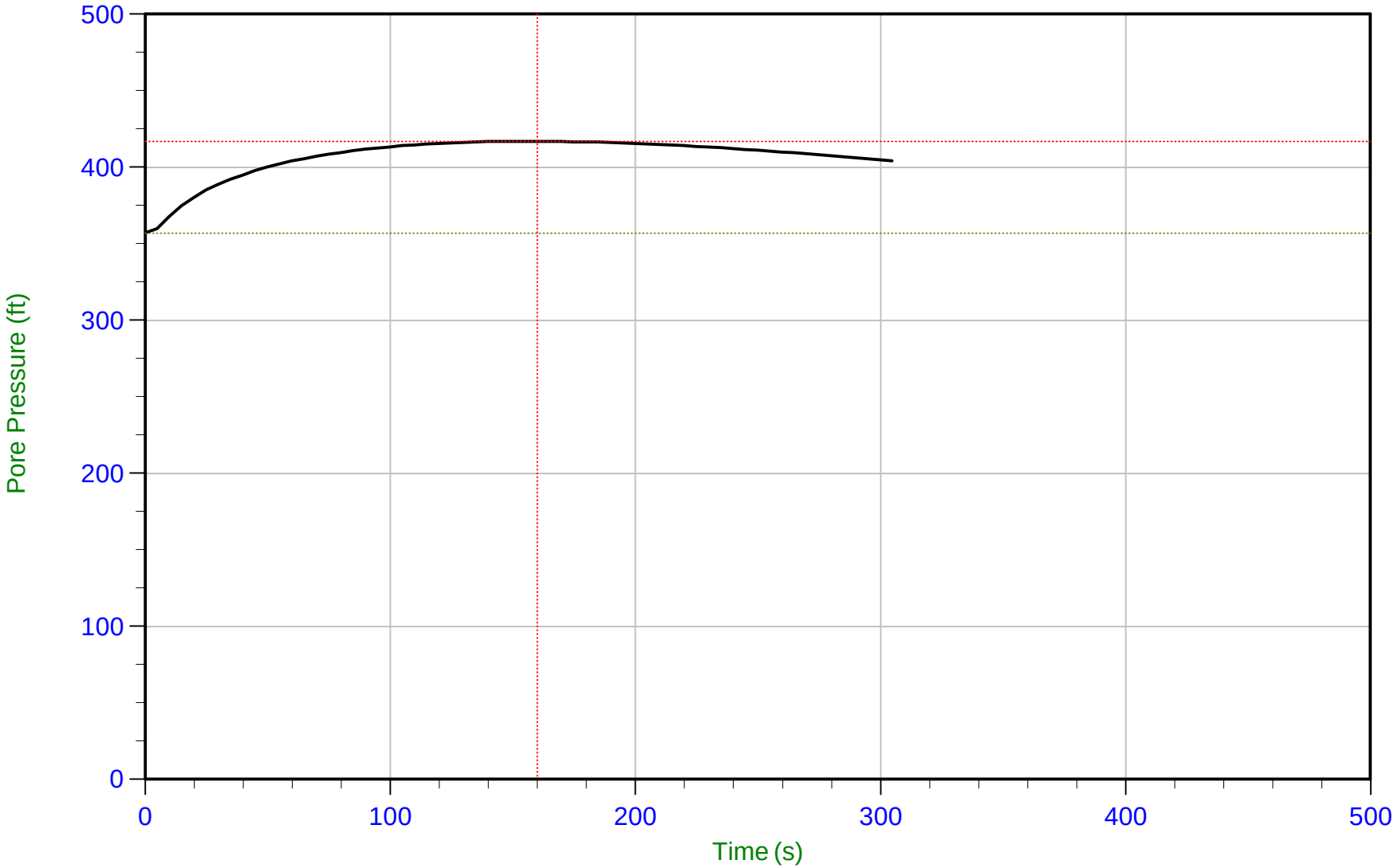
WT: 5.680 m / 18.635 ft
Ueq: 7.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 11:56
Site: Dynegy Joppa, I

Sounding: JOP-C014
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C014.PPD
Depth: 12.200 m / 40.026 ft
Duration: 305.0 s

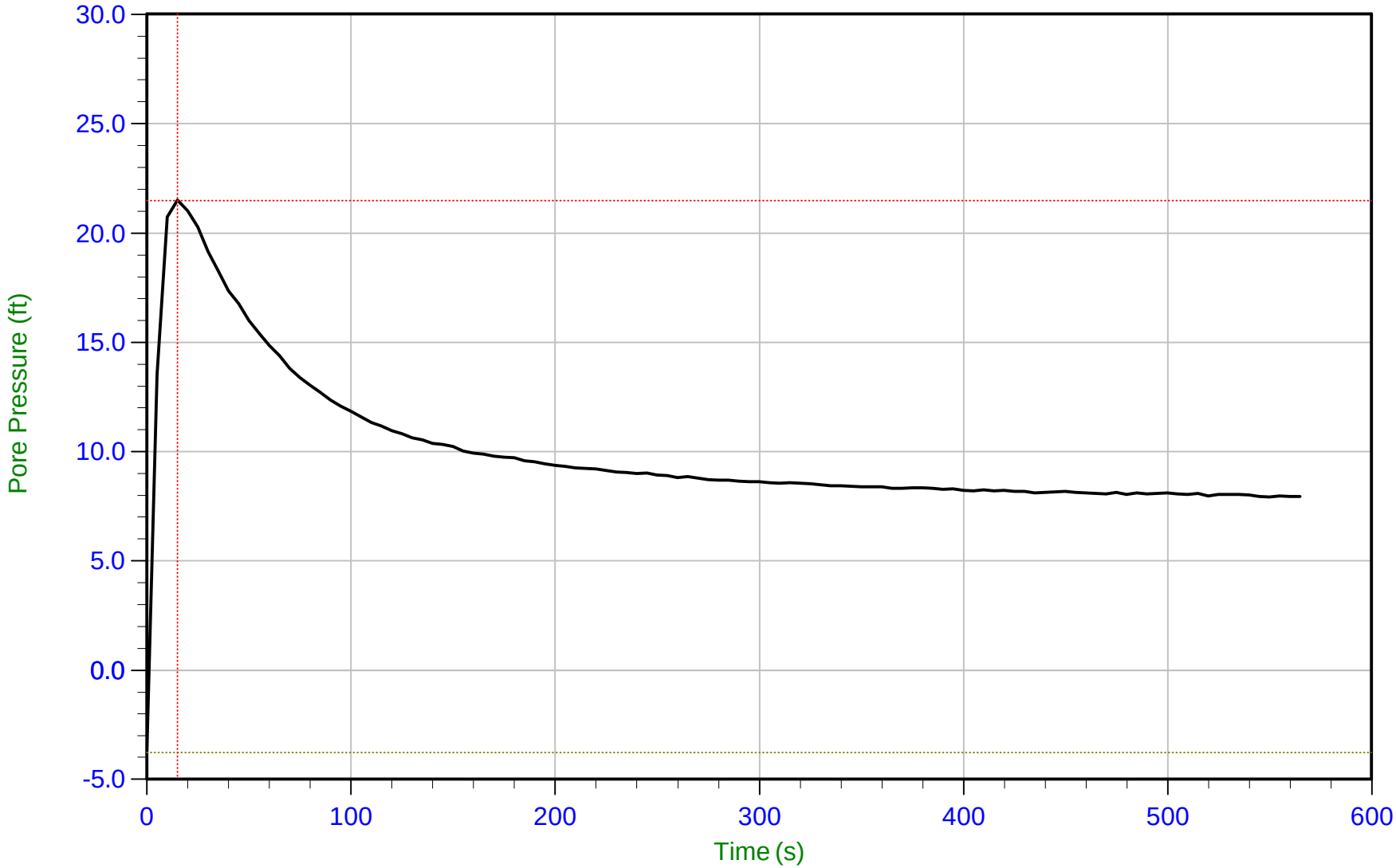
U Min: 357.0 ft
U Max: 417.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 13:57
Site: Dynegy Joppa, I

Sounding: JOP-C015
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C015.PPD
Depth: 7.450 m / 24.442 ft
Duration: 565.0 s

U Min: -3.8 ft
U Max: 21.5 ft

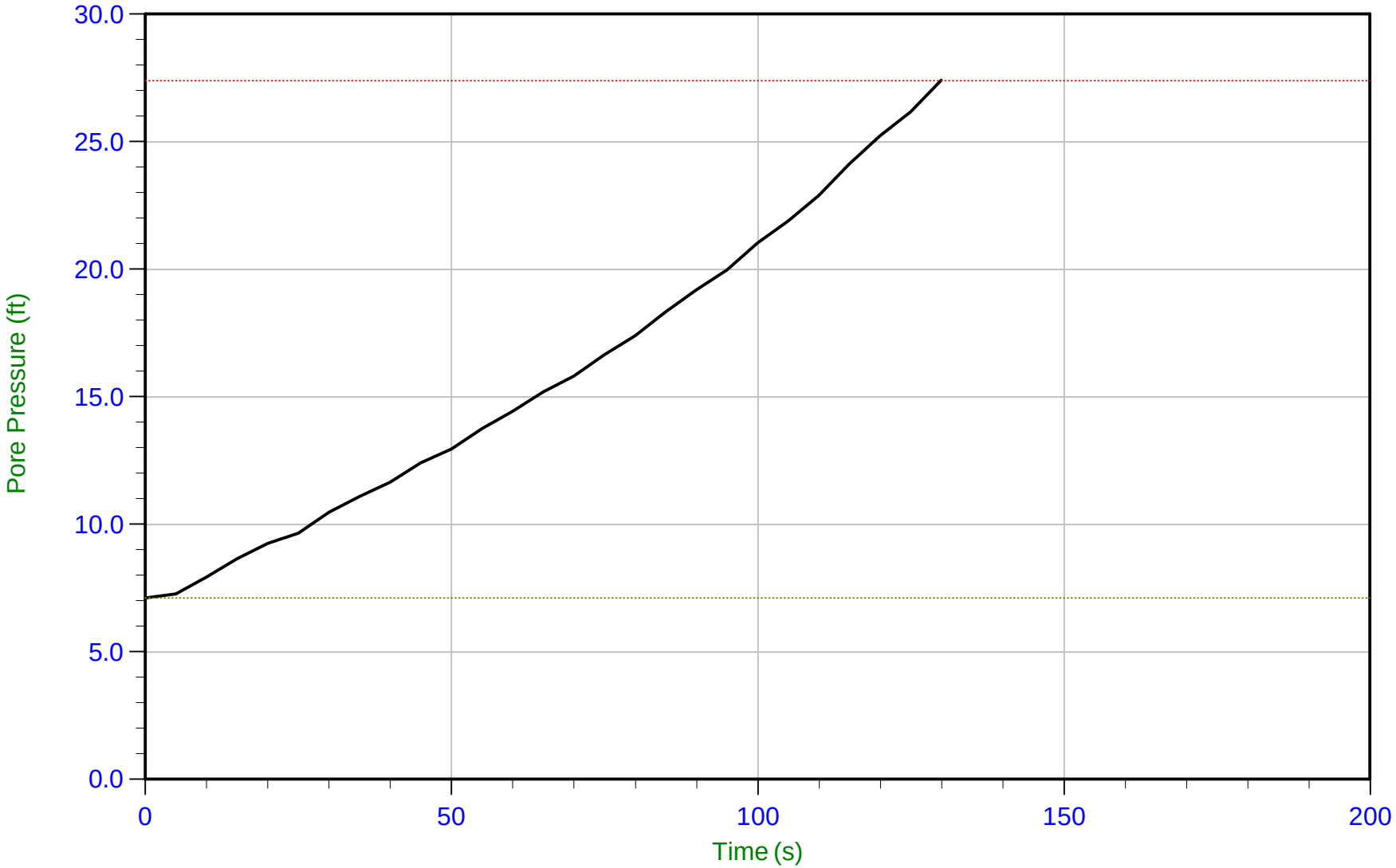
WT: 5.051 m / 16.571 ft
Ueq: 7.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 13:57
Site: Dynegy Joppa, I

Sounding: JOP-C015
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C015.PPD
Depth: 10.000 m / 32.808 ft
Duration: 130.0 s

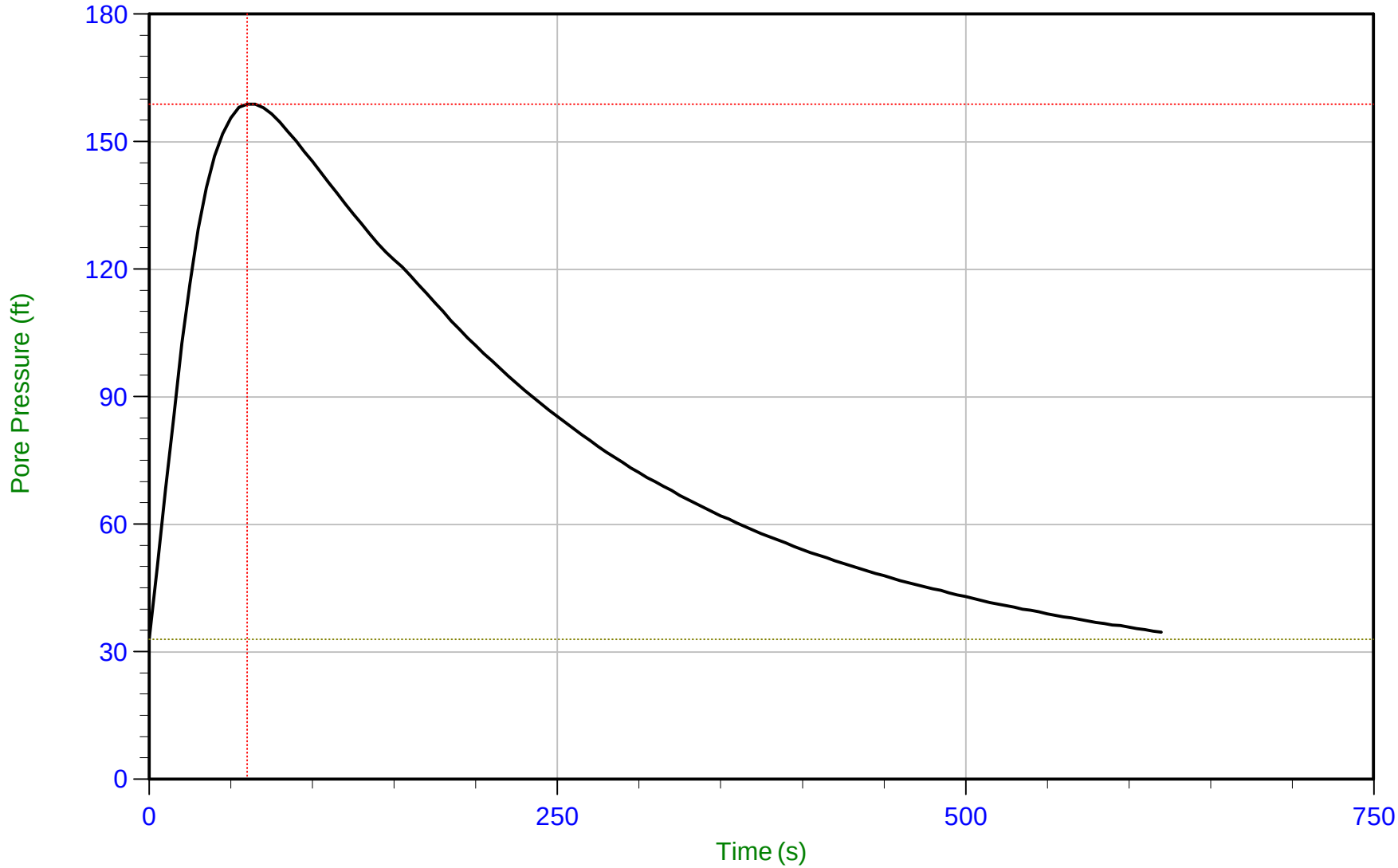
U Min: 7.1 ft
U Max: 27.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 13:57
Site: Dynegy Joppa, I

Sounding: JOP-C015
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C015.PPD
Depth: 12.200 m / 40.026 ft
Duration: 620.0 s

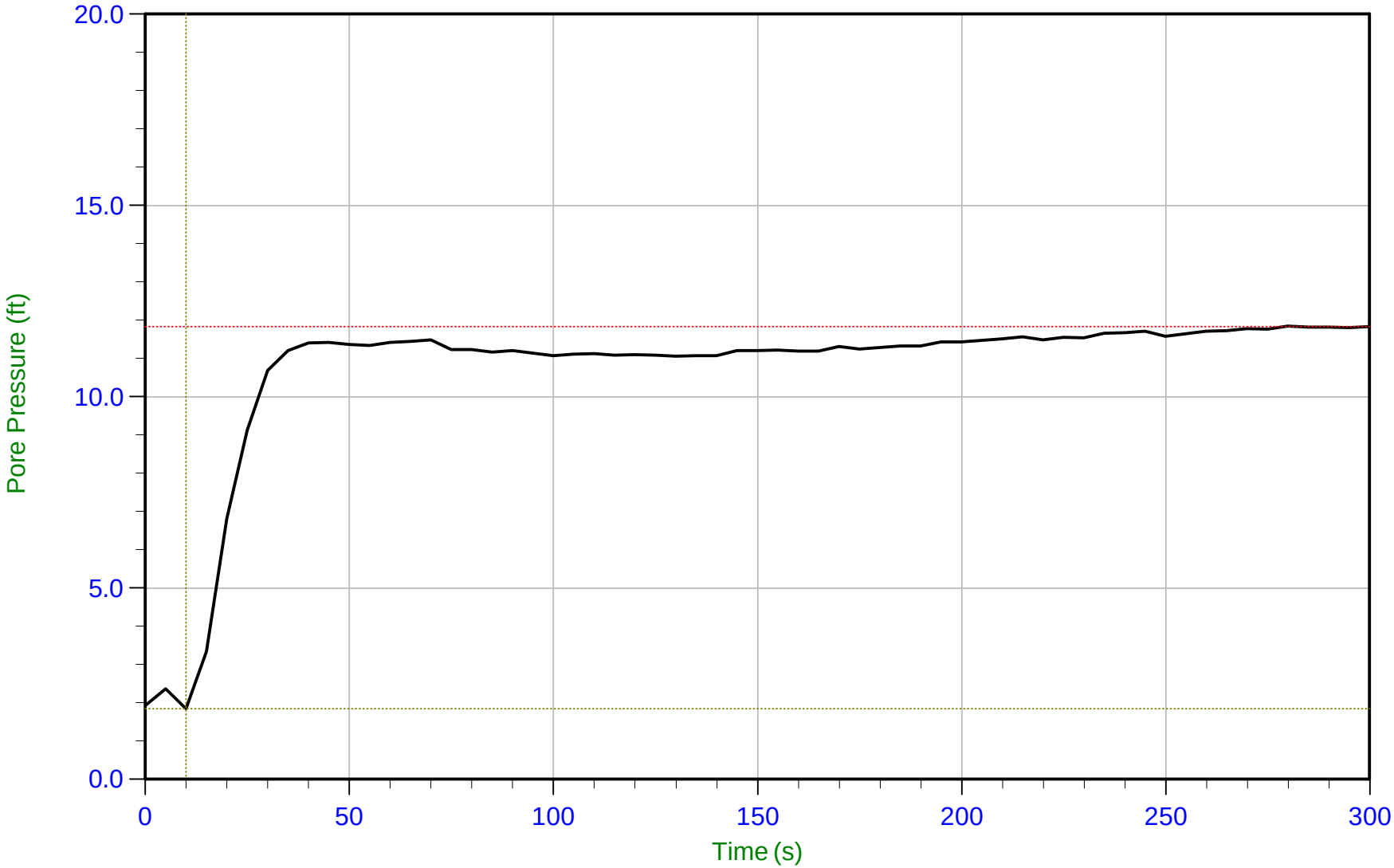
U Min: 33.0 ft
U Max: 158.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/08/2015 07:38
Site: Dynegy Joppa IL

Sounding: JOP-C016
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C016.PPD
Depth: 23.950 m / 78.575 ft
Duration: 300.0 s

U Min: 1.8 ft
U Max: 11.8 ft

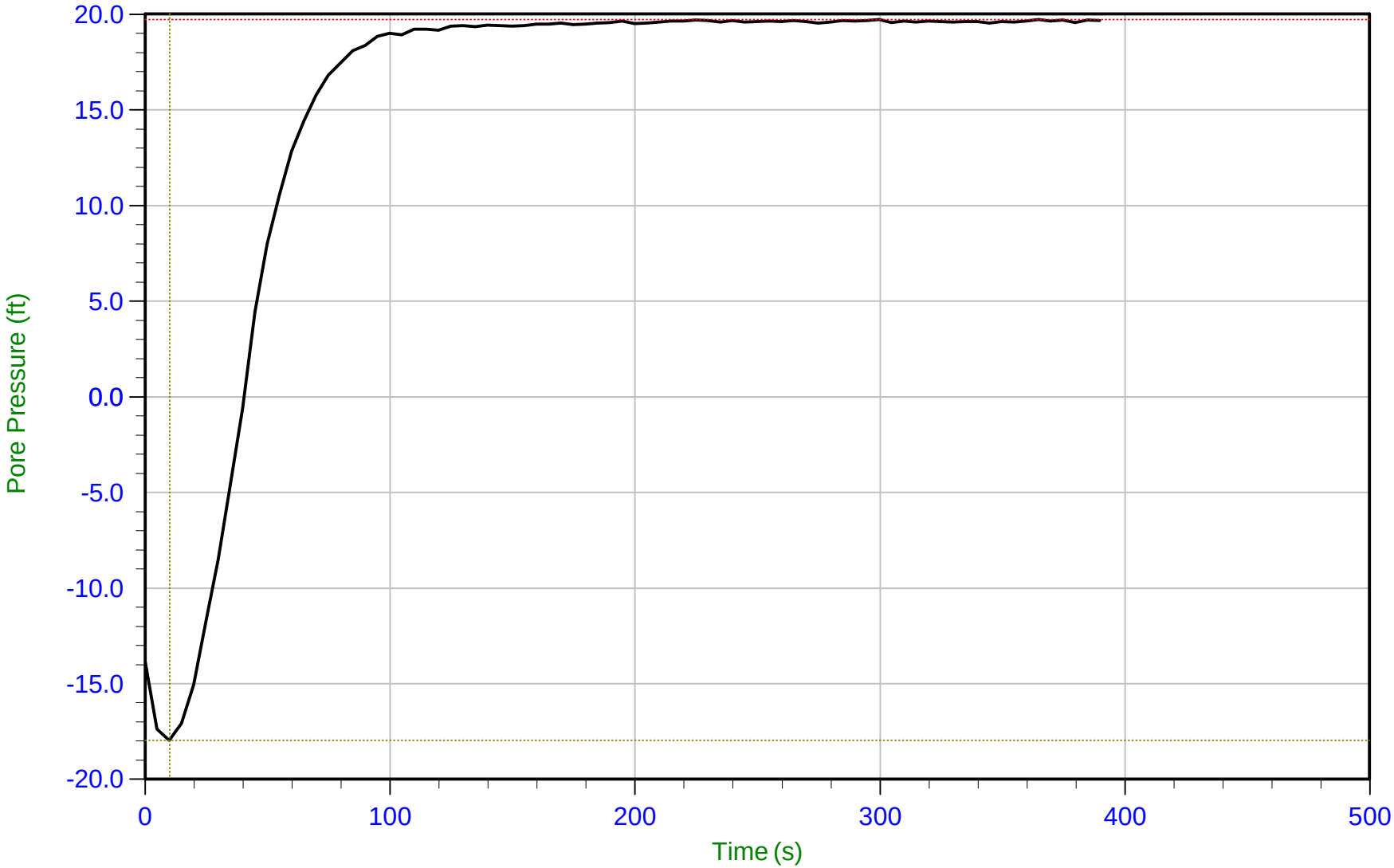
WT: 20.351 m / 66.769 ft
Ueq: 11.8 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/08/2015 07:38
Site: Dynegy Joppa IL

Sounding: JOP-C016
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C016.PPD
Depth: 26.050 m / 85.465 ft
Duration: 390.0 s

U Min: -18.0 ft
U Max: 19.7 ft

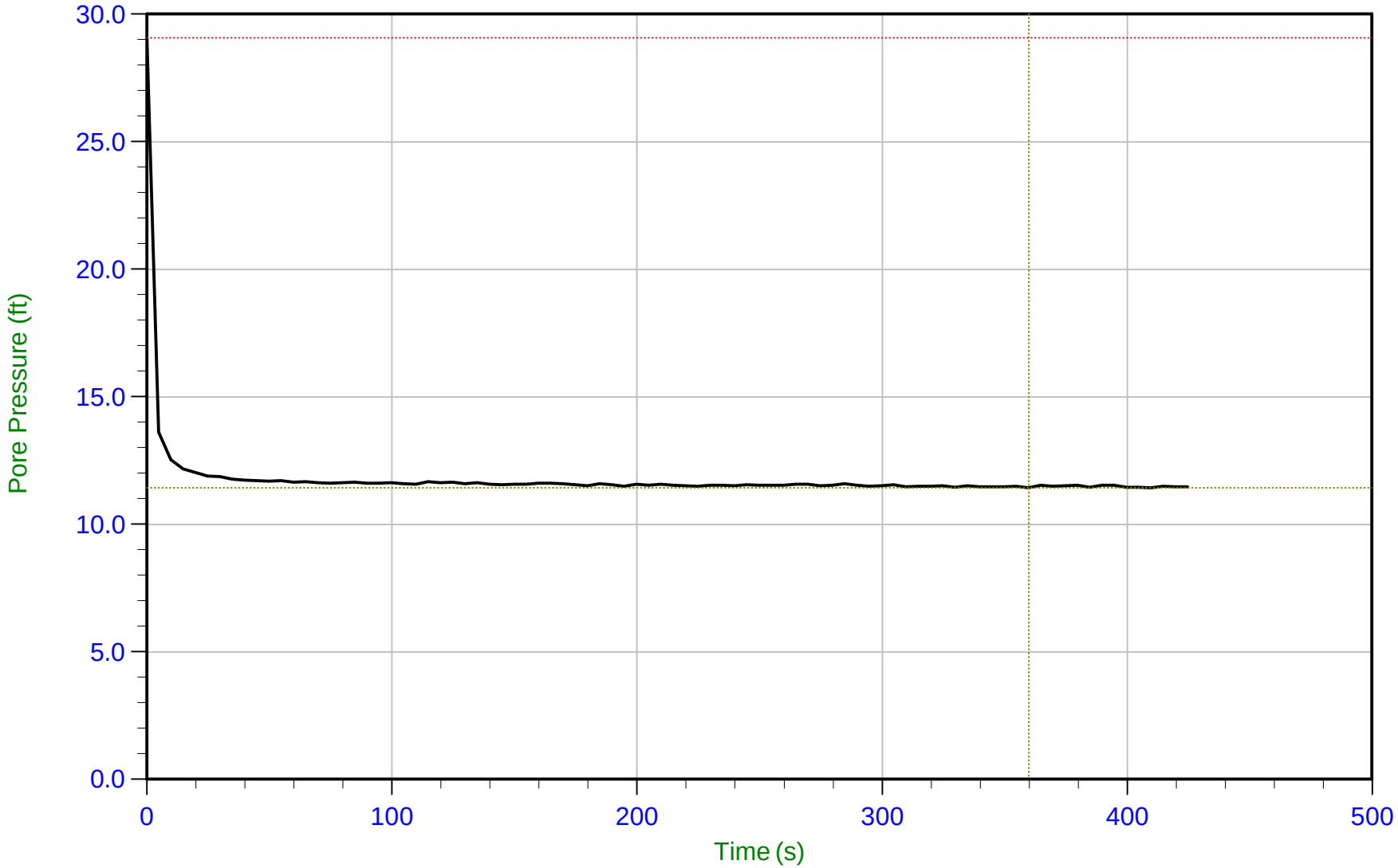
WT: 20.111 m / 65.981 ft
Ueq: 19.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 10:19
Site: Dynegy Joppa IL

Sounding: JOP-C017
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C017.PPD
Depth: 4.950 m / 16.240 ft
Duration: 425.0 s

U Min: 11.4 ft
U Max: 29.1 ft

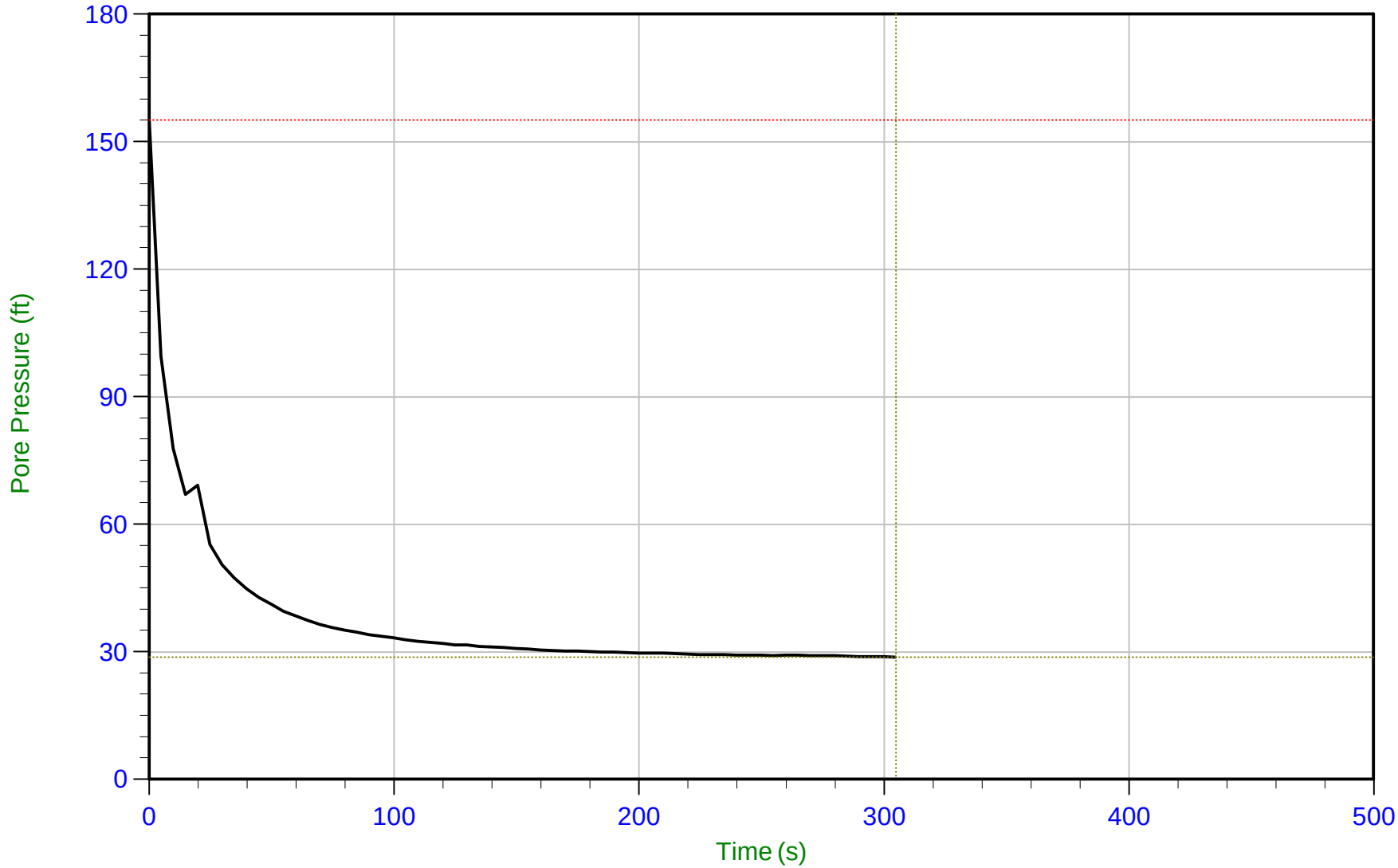
WT: 1.440 m / 4.724 ft
Ueq: 11.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 10:19
Site: Dynegy Joppa IL

Sounding: JOP-C017
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C017.PPD
Depth: 9.950 m / 32.644 ft
Duration: 305.0 s

U Min: 28.8 ft
U Max: 155.2 ft

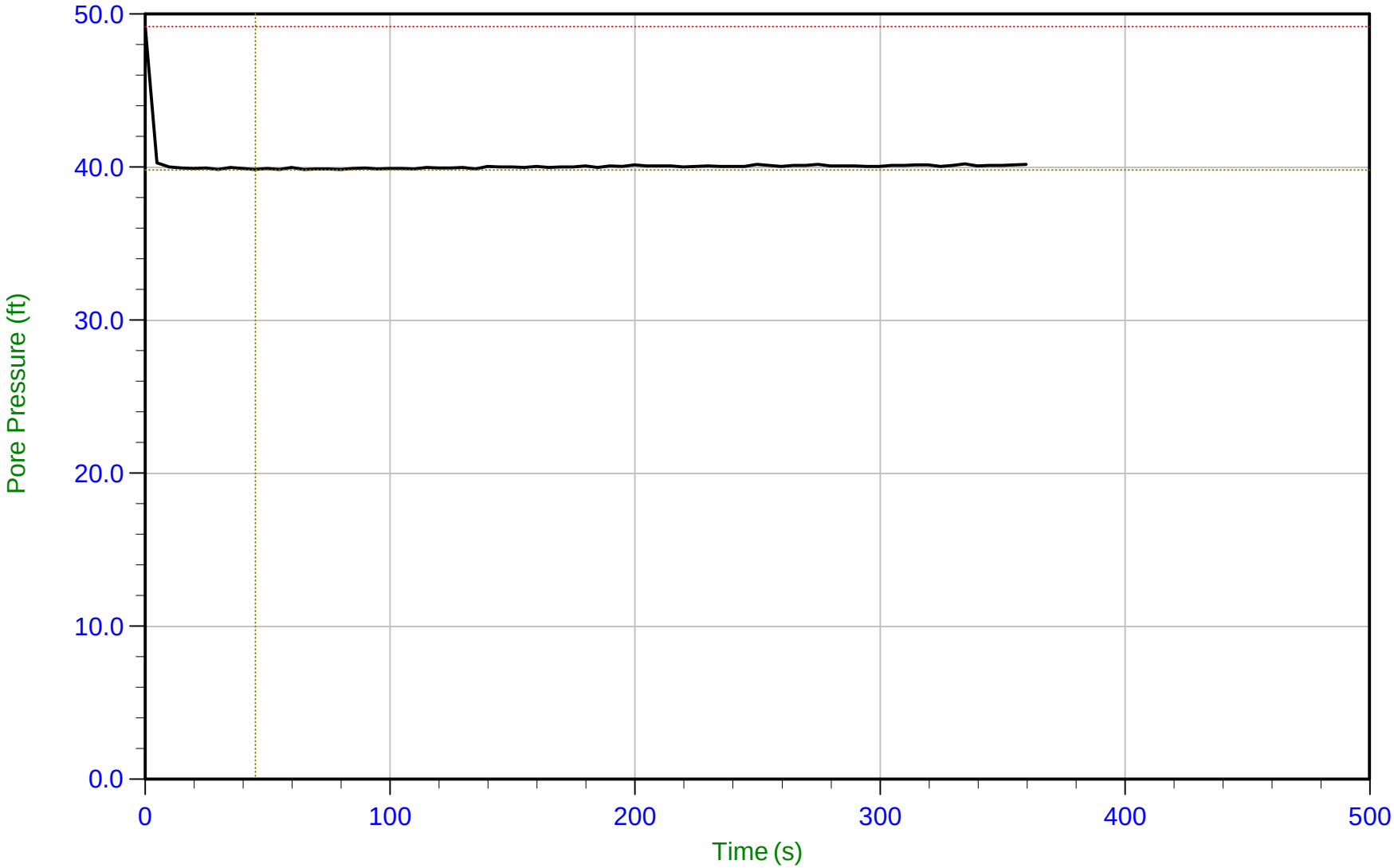
WT: 1.101 m / 3.612 ft
Ueq: 29.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 10:19
Site: Dynegy Joppa IL

Sounding: JOP-C017
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C017.PPD
Depth: 15.300 m / 50.196 ft
Duration: 360.0 s

U Min: 39.8 ft
U Max: 49.2 ft

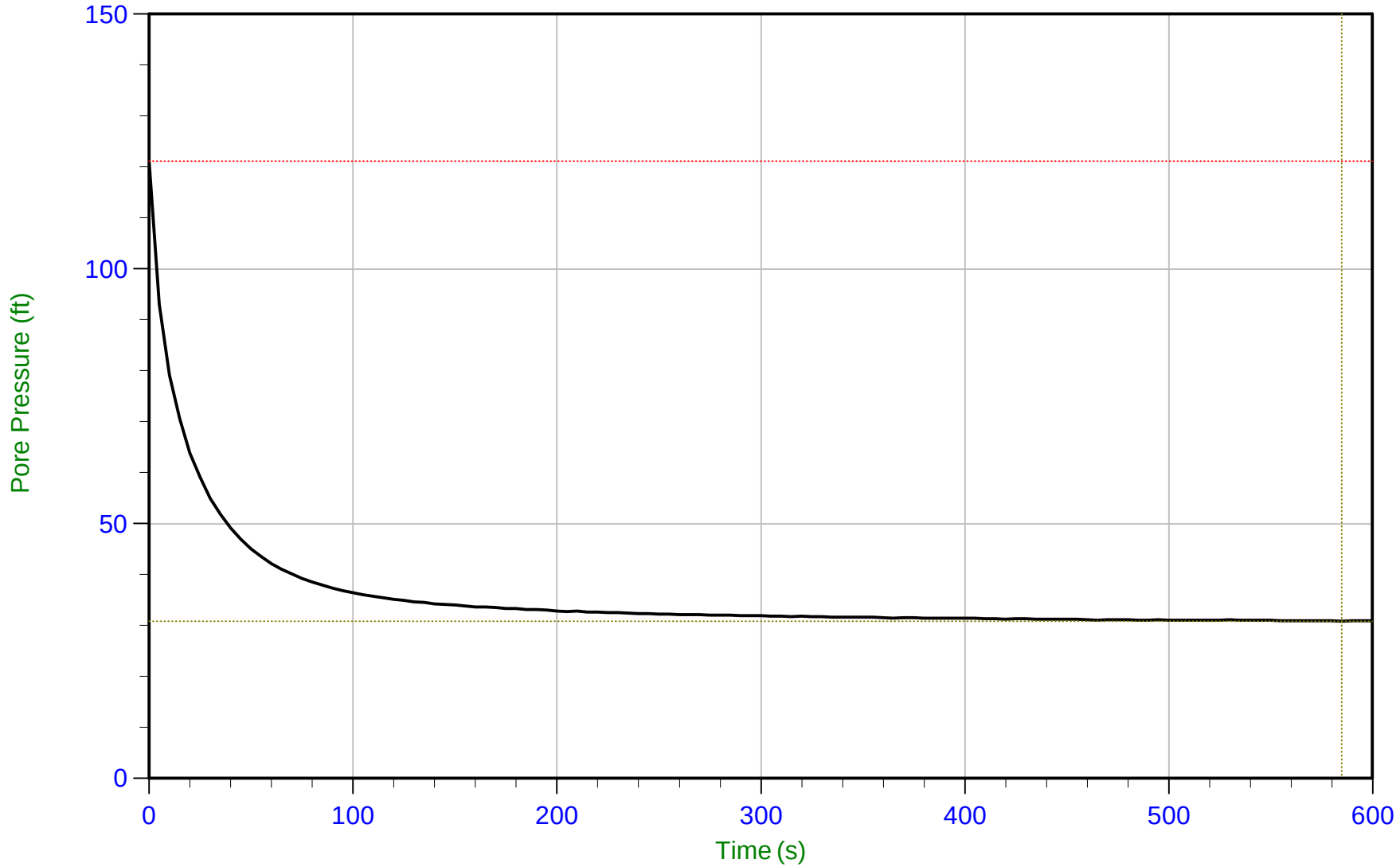
WT: 3.059 m / 10.035 ft
Ueq: 40.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 07:39
Site: Dynegy Joppa IL

Sounding: JOP-C018
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C018.PPD
Depth: 10.000 m / 32.808 ft
Duration: 600.0 s

U Min: 30.9 ft
U Max: 121.2 ft

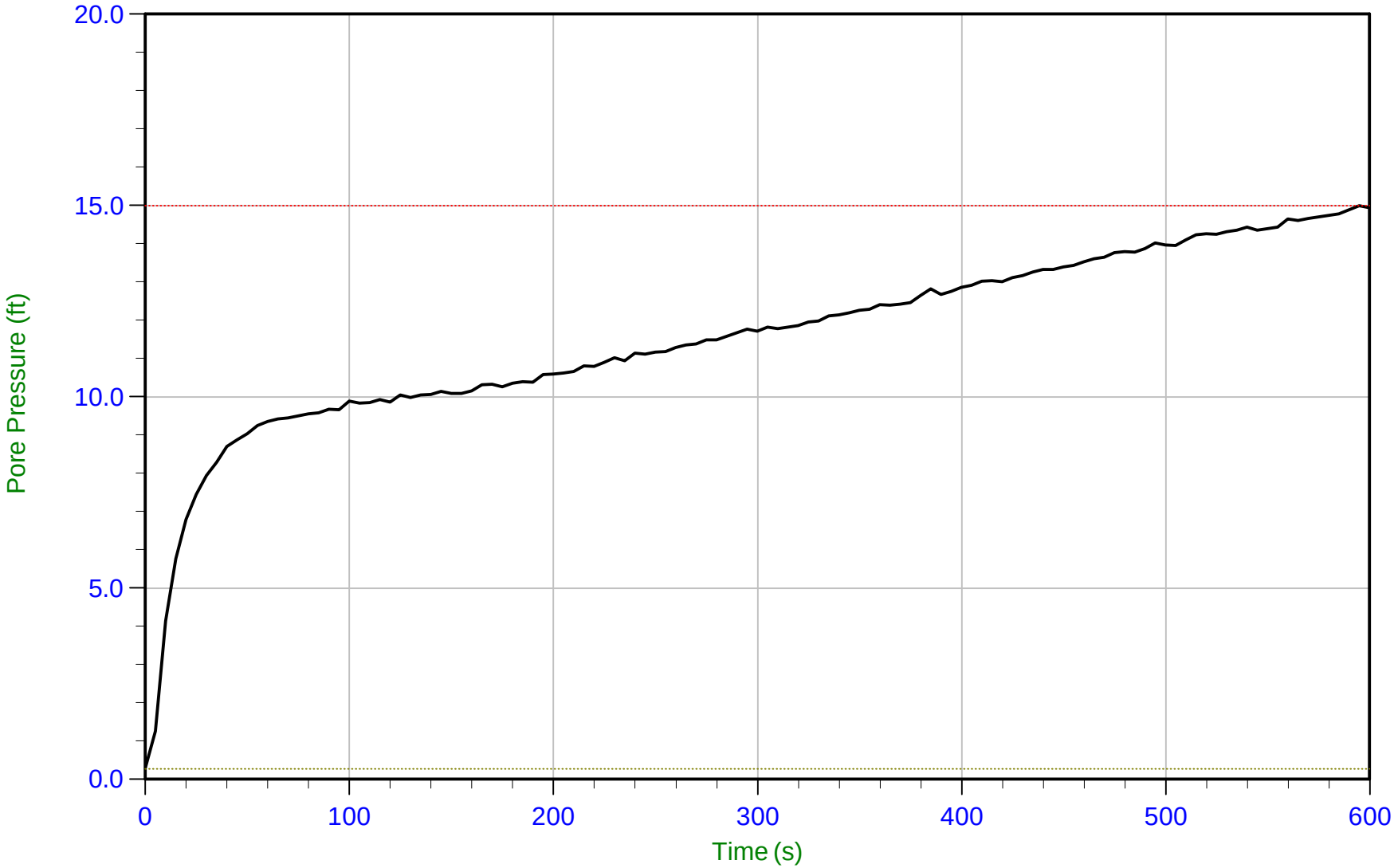
WT: 0.709 m / 2.324 ft
Ueq: 30.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 07:39
Site: Dynegy Joppa IL

Sounding: JOP-C018
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C018.PPD
Depth: 20.000 m / 65.616 ft
Duration: 600.0 s

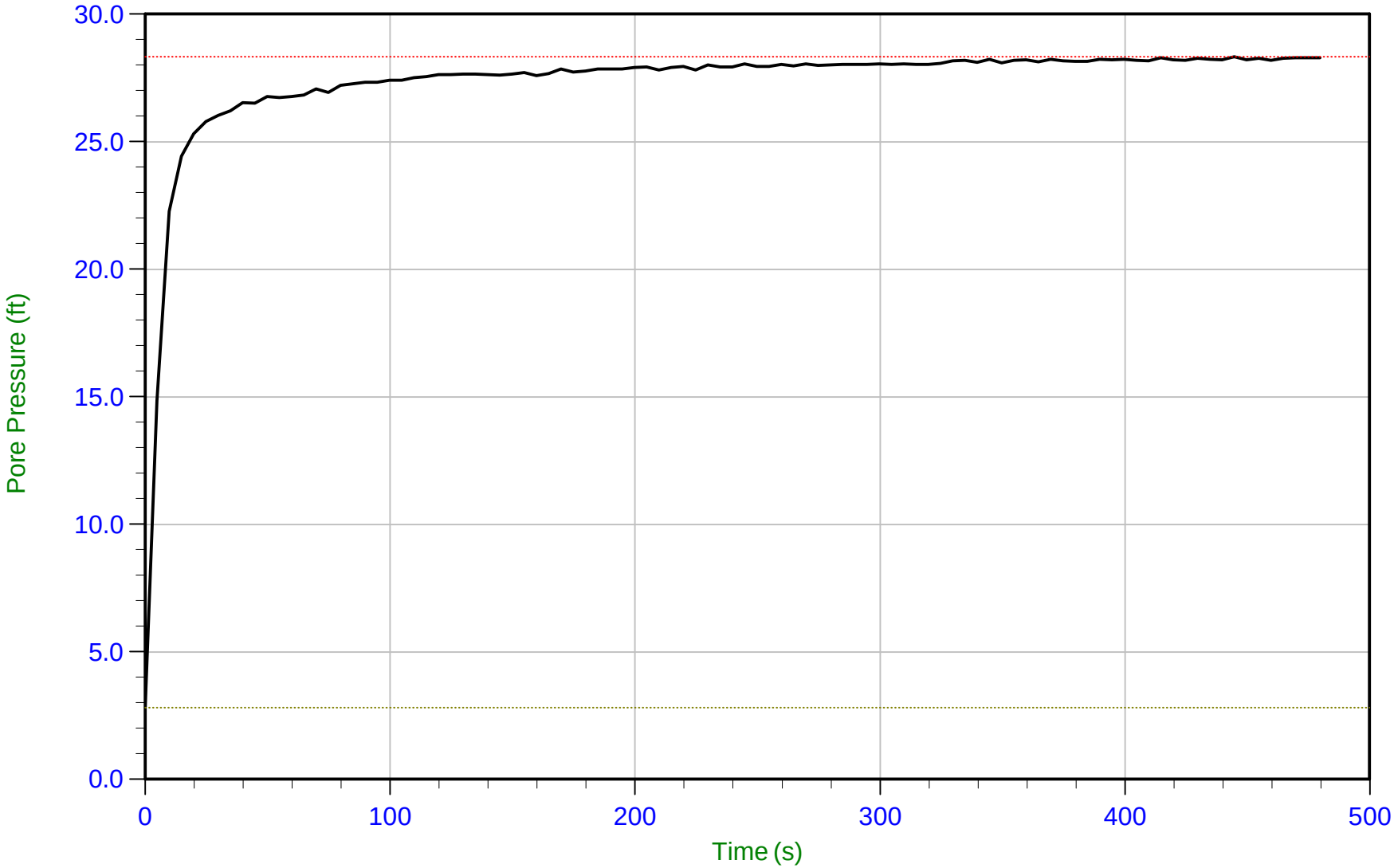
U Min: 0.3 ft
U Max: 15.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/20/2015 07:39
Site: Dynegy Joppa IL

Sounding: JOP-C018
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C018.PPD
Depth: 26.900 m / 88.254 ft
Duration: 480.0 s

U Min: 2.8 ft
U Max: 28.3 ft

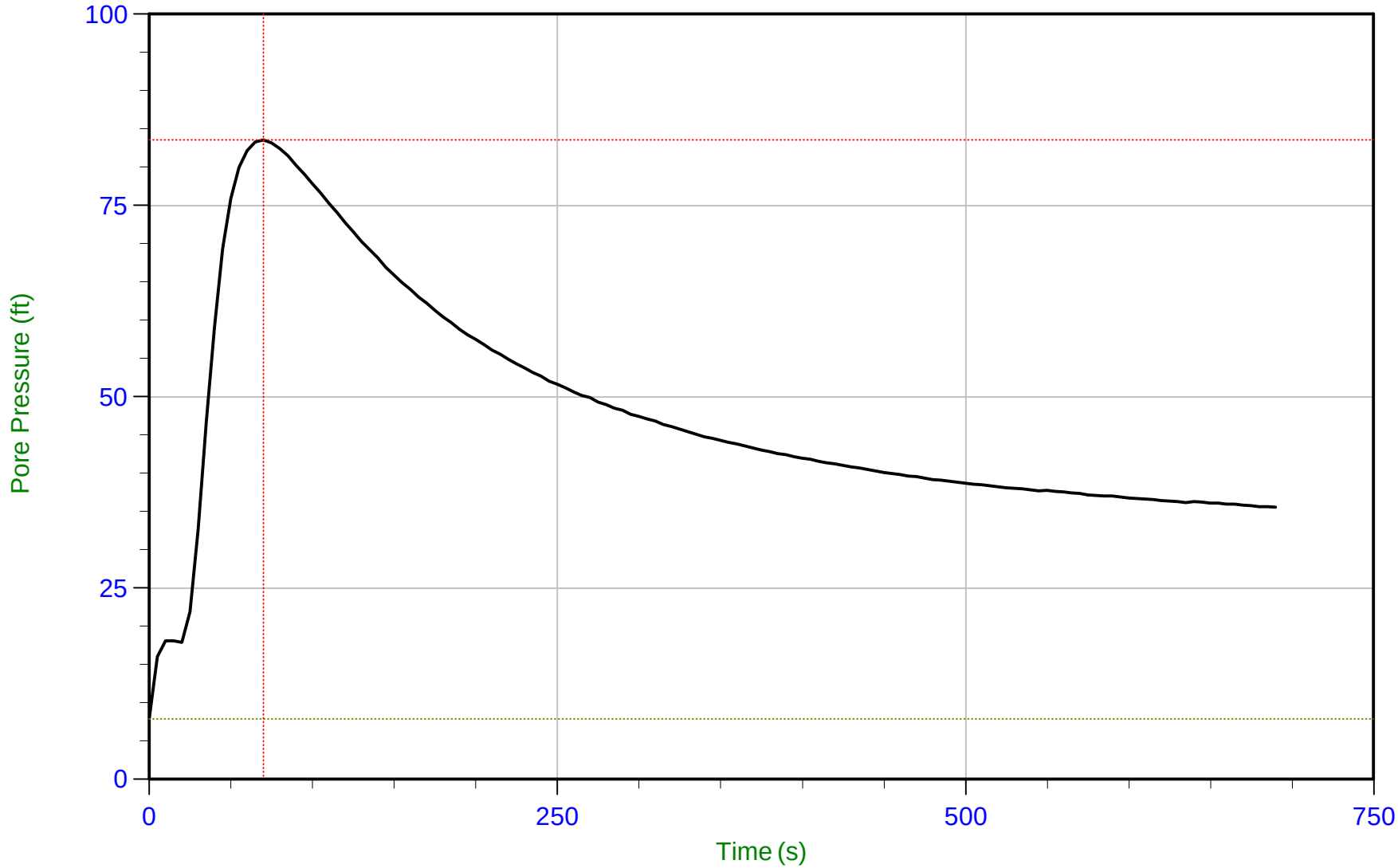
WT: 18.257 m / 59.899 ft
Ueq: 28.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/08/2015 13:15
Site: Dynegy Joppa IL

Sounding: JOP-C019
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C019.PPD
Depth: 16.100 m / 52.821 ft
Duration: 690.0 s

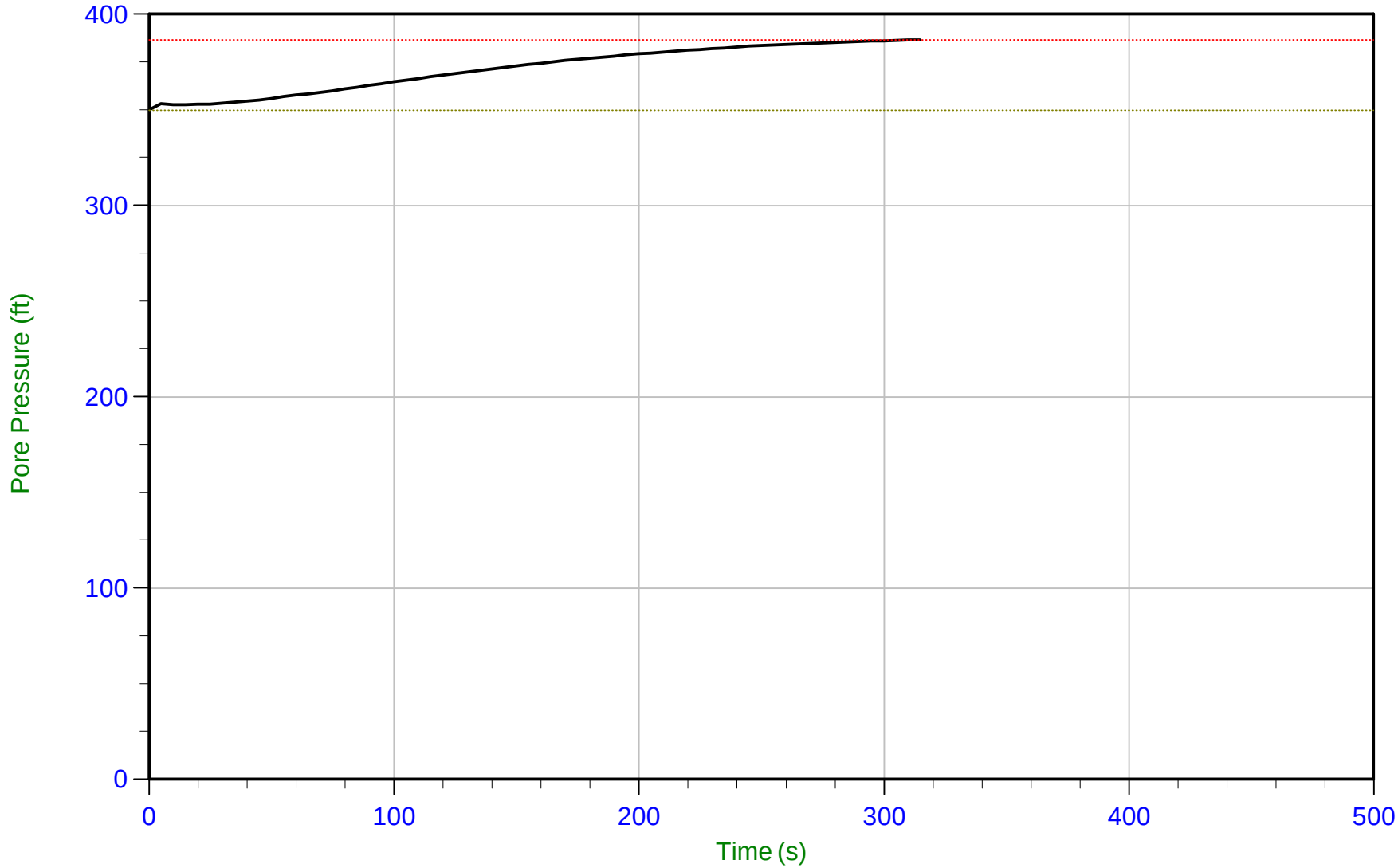
U Min: 7.9 ft
U Max: 83.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/08/2015 13:15
Site: Dynegy Joppa IL

Sounding: JOP-C019
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C019.PPD
Depth: 21.450 m / 70.373 ft
Duration: 315.0 s

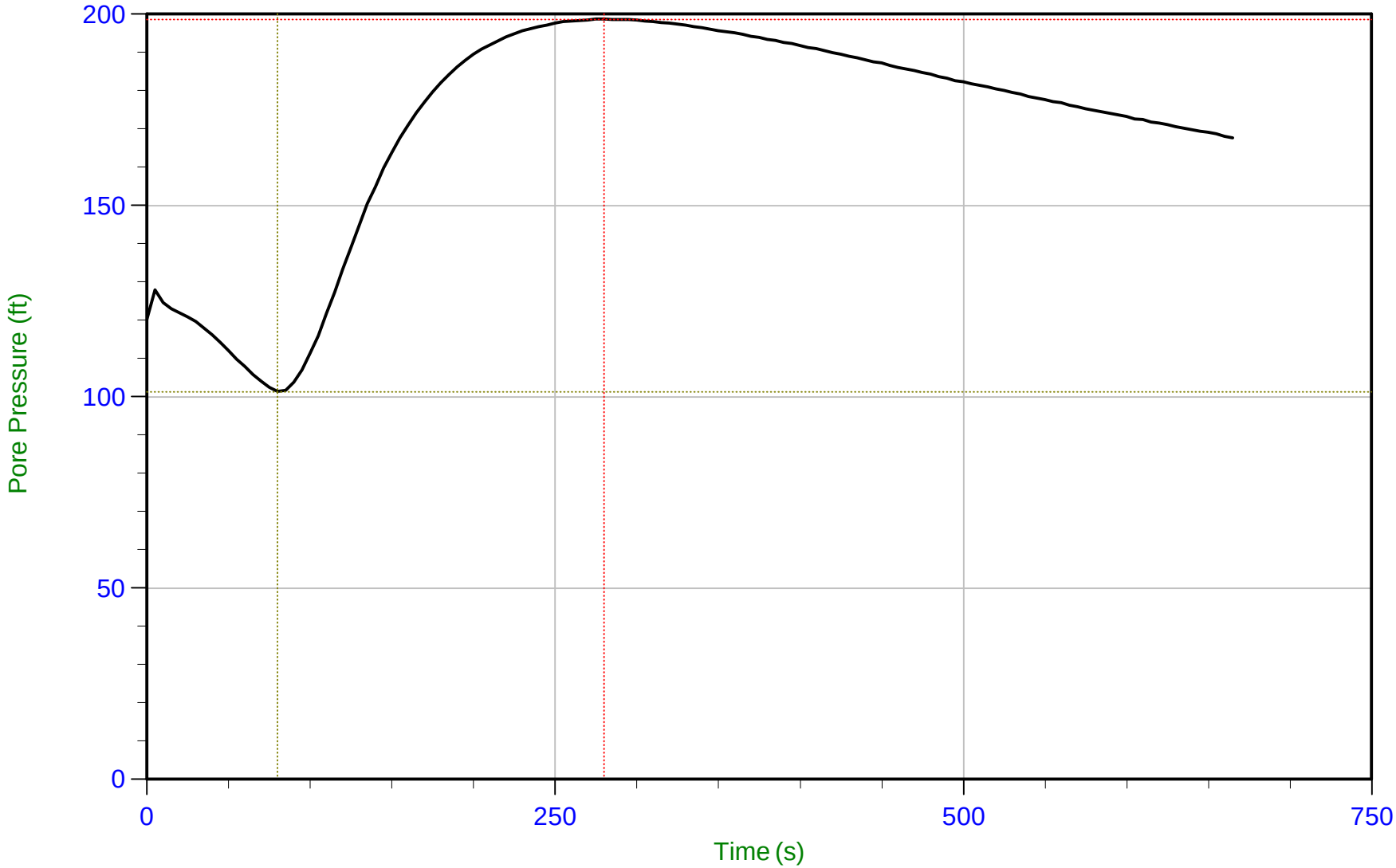
U Min: 349.9 ft
U Max: 386.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/08/2015 13:15
Site: Dynegy Joppa IL

Sounding: JOP-C019
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C019.PPD
Depth: 24.450 m / 80.216 ft
Duration: 665.0 s

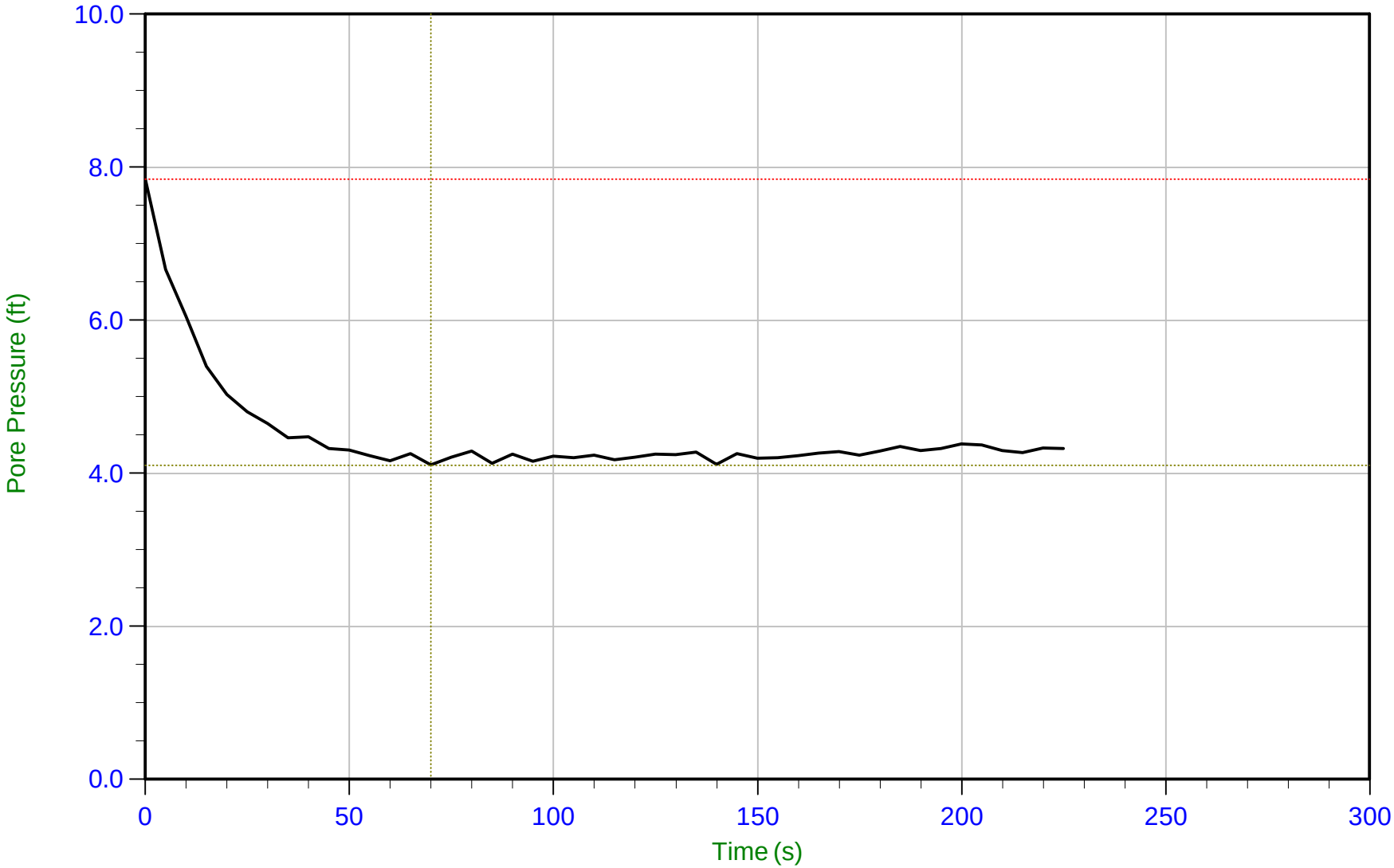
U Min: 101.4 ft
U Max: 198.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 14:21
Site: Dynegy Joppa IL

Sounding: JOP-C020
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C020.PPD
Depth: 2.950 m / 9.678 ft
Duration: 225.0 s

U Min: 4.1 ft
U Max: 7.8 ft

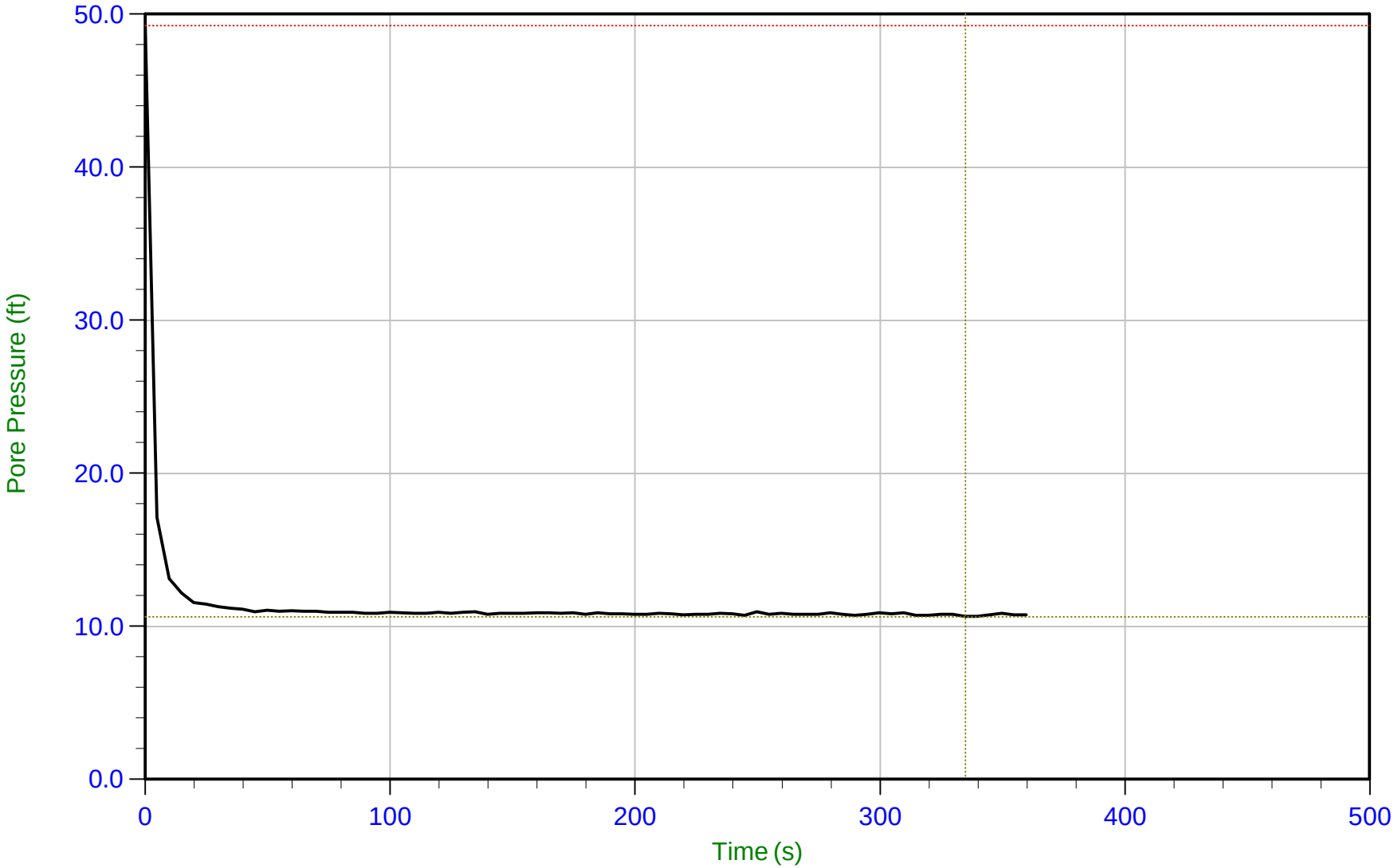
WT: 1.632 m / 5.356 ft
Ueq: 4.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 14:21
Site: Dynegy Joppa IL

Sounding: JOP-C020
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C020.PPD
Depth: 4.950 m / 16.240 ft
Duration: 360.0 s

U Min: 10.6 ft
U Max: 49.3 ft

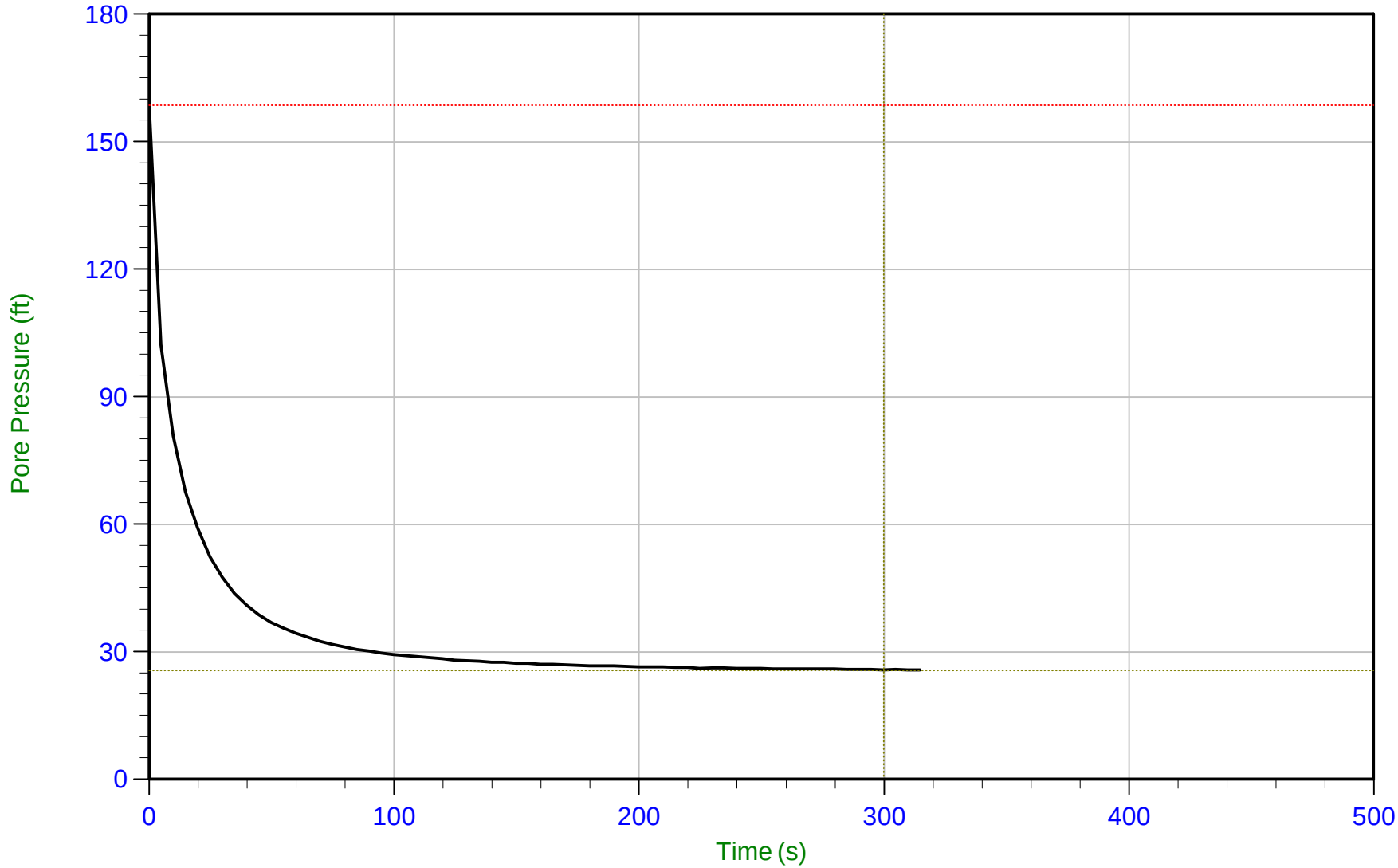
WT: 1.705 m / 5.595 ft
Ueq: 10.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 14:21
Site: Dynegy Joppa IL

Sounding: JOP-C020
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C020.PPD
Depth: 9.950 m / 32.644 ft
Duration: 315.0 s

U Min: 25.7 ft
U Max: 158.6 ft

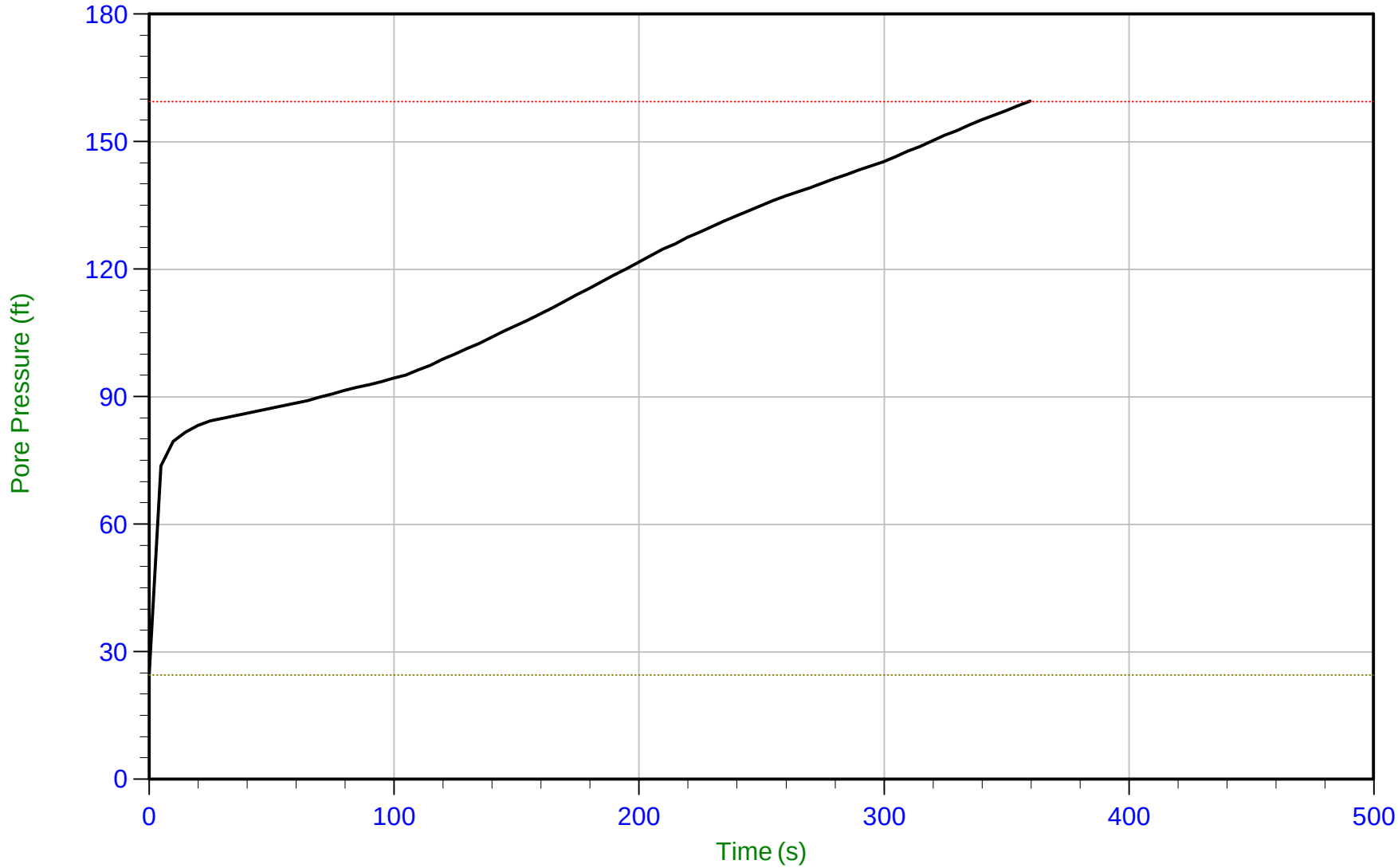
WT: 2.163 m / 7.096 ft
Ueq: 25.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 14:21
Site: Dynegy Joppa IL

Sounding: JOP-C020
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C020.PPD
Depth: 15.300 m / 50.196 ft
Duration: 360.0 s

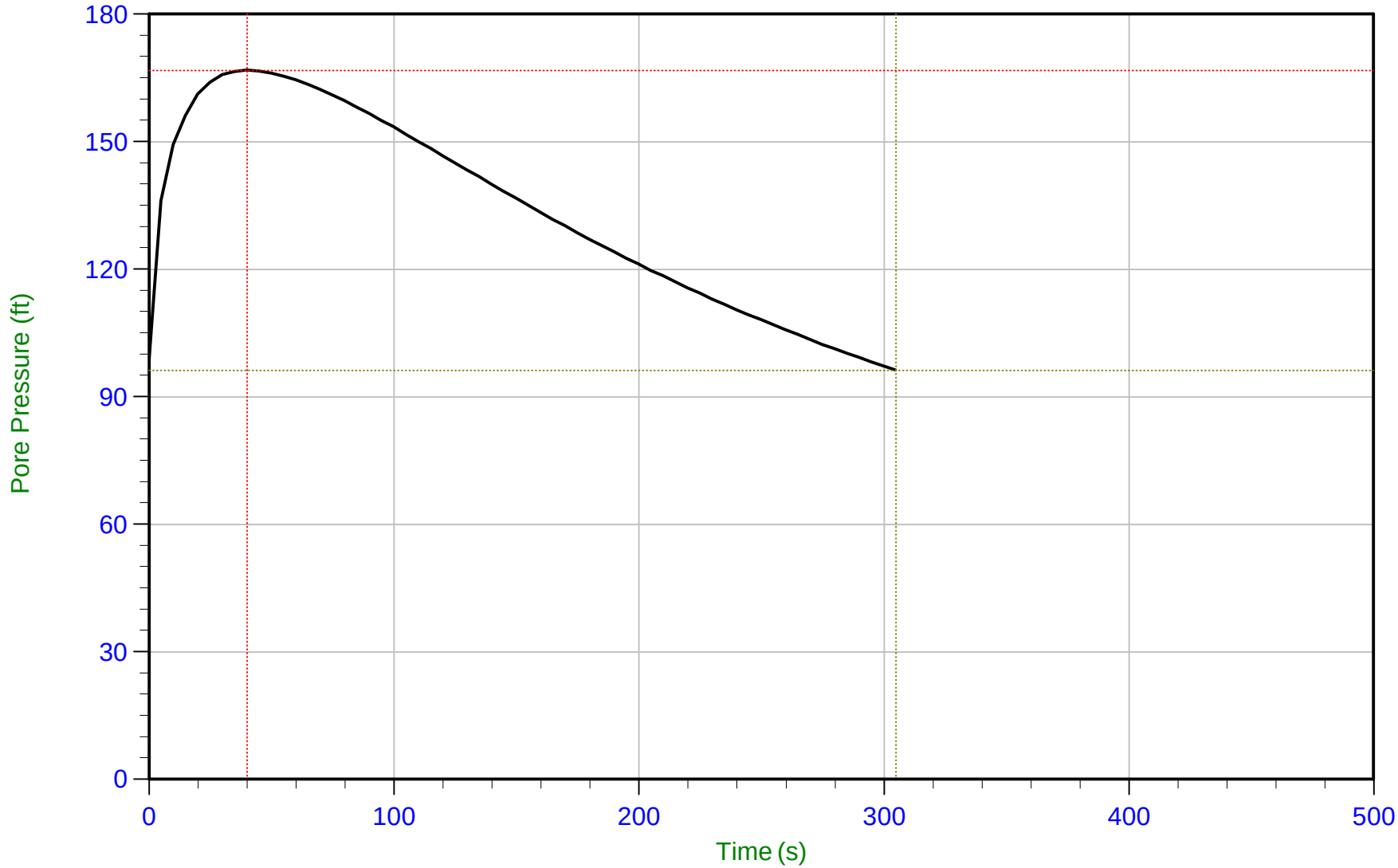
U Min: 24.6 ft
U Max: 159.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 09:29
Site: Dynegy Joppa IL

Sounding: JOP-C021
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C021.PPD
Depth: 12.650 m / 41.502 ft
Duration: 305.0 s

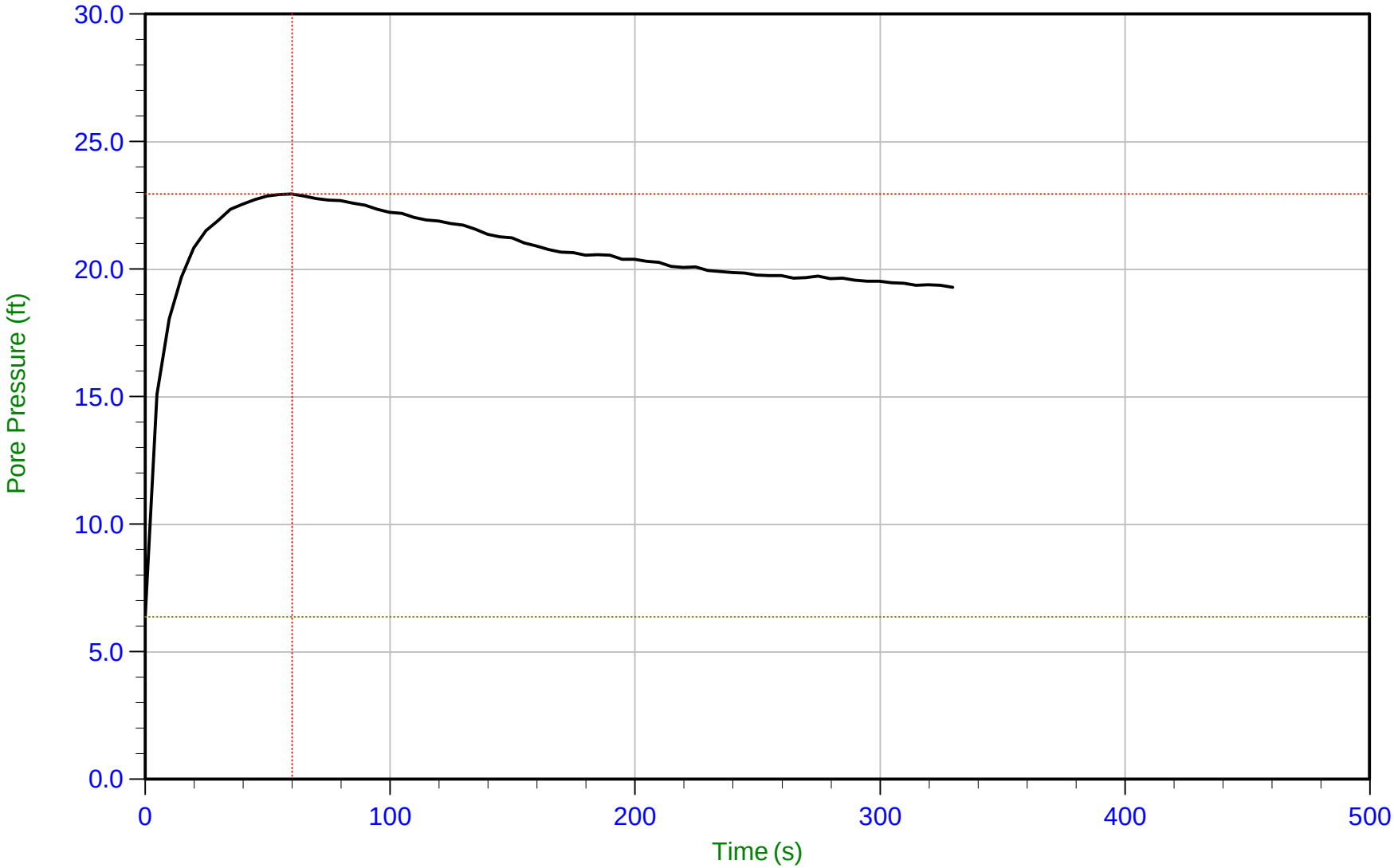
U Min: 96.3 ft
U Max: 166.8 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 09:29
Site: Dynegy Joppa IL

Sounding: JOP-C021
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C021.PPD
Depth: 15.000 m / 49.212 ft
Duration: 330.0 s

U Min: 6.4 ft
U Max: 23.0 ft

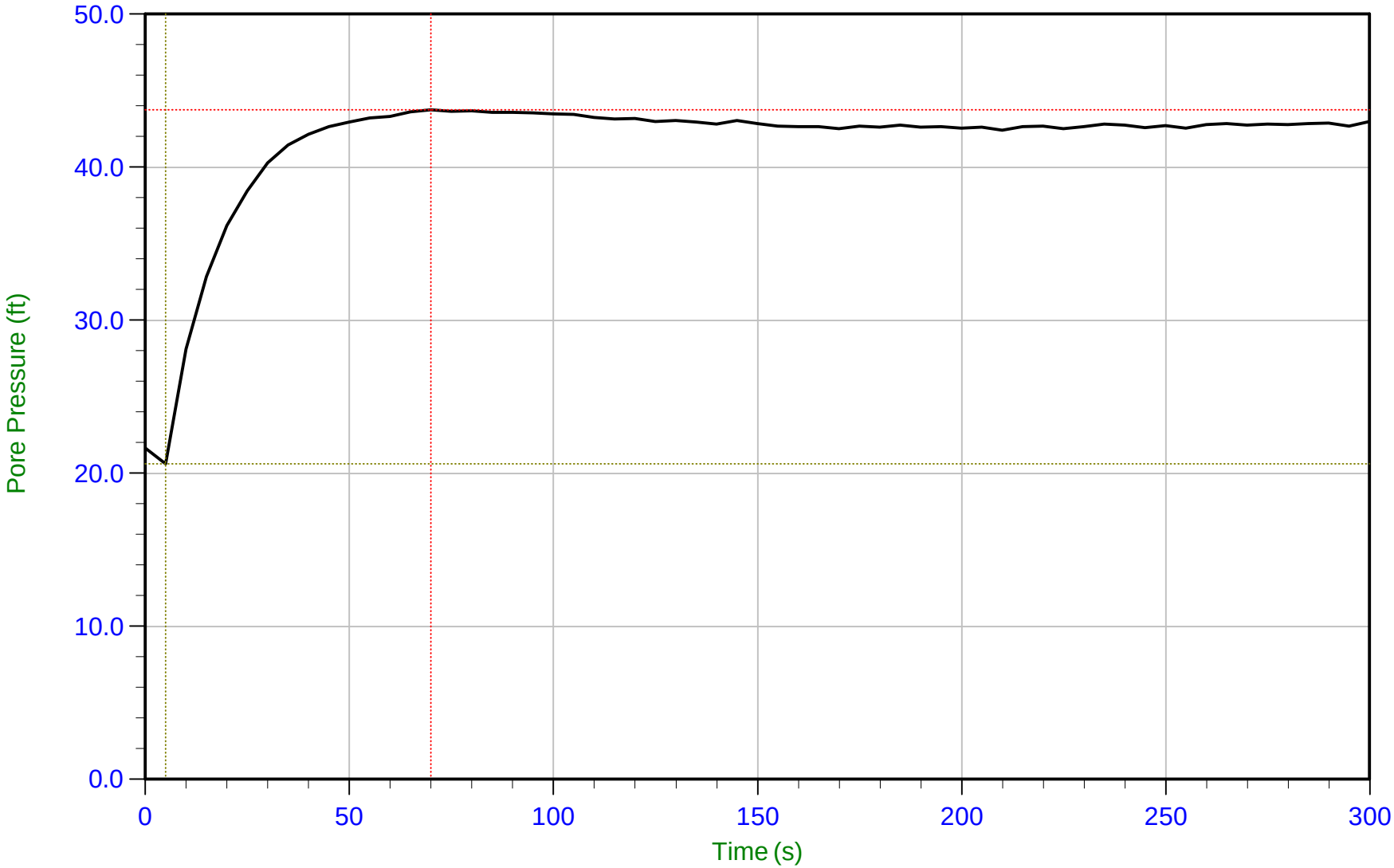
WT: 9.189 m / 30.148 ft
Ueq: 19.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 09:29
Site: Dynegy Joppa IL

Sounding: JOP-C021
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C021.PPD
Depth: 21.400 m / 70.209 ft
Duration: 300.0 s

U Min: 20.6 ft
U Max: 43.8 ft

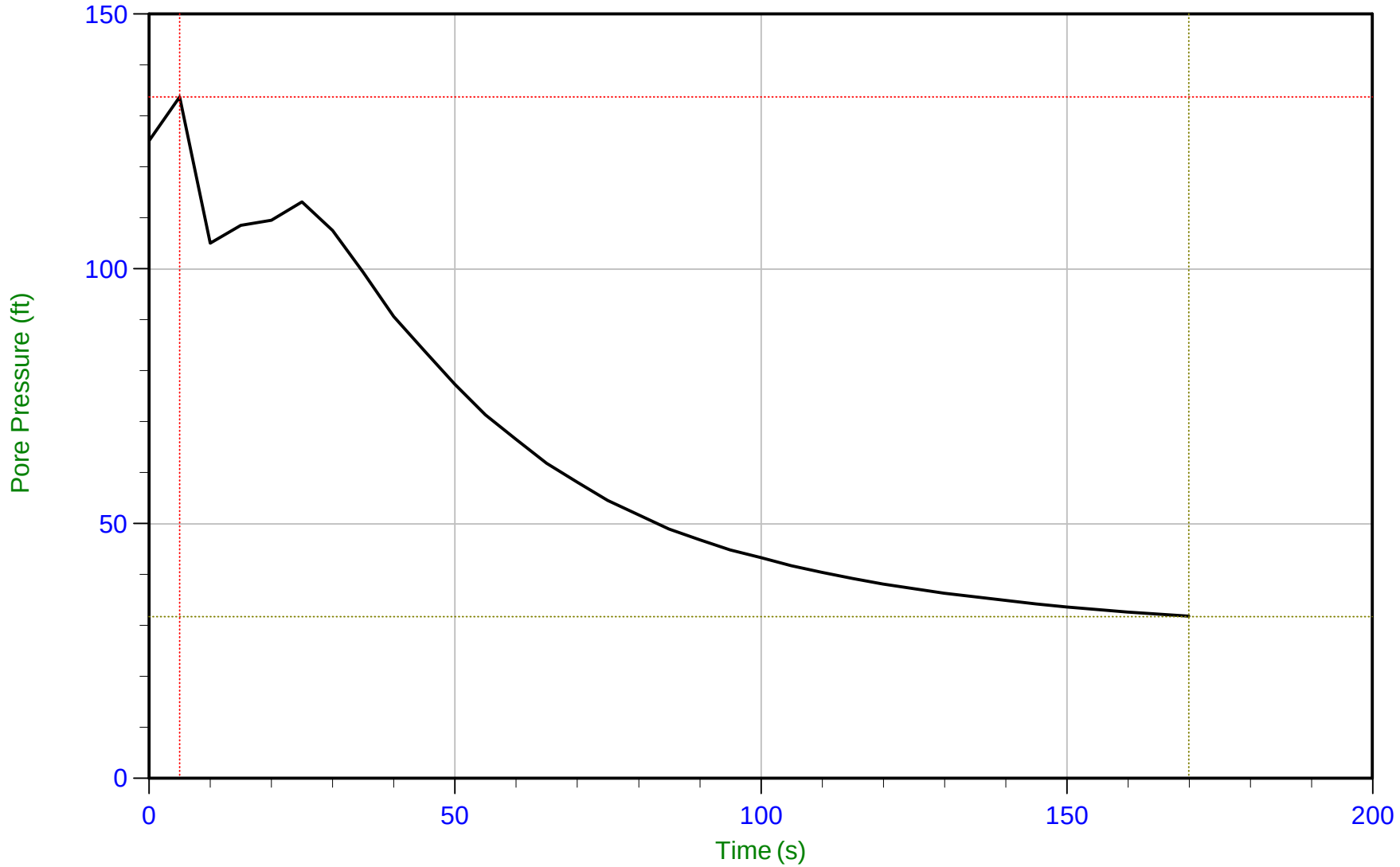
WT: 8.372 m / 27.468 ft
Ueq: 42.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 09:29
Site: Dynegy Joppa IL

Sounding: JOP-C021
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C021.PPD
Depth: 22.550 m / 73.982 ft
Duration: 170.0 s

U Min: 31.8 ft
U Max: 133.8 ft

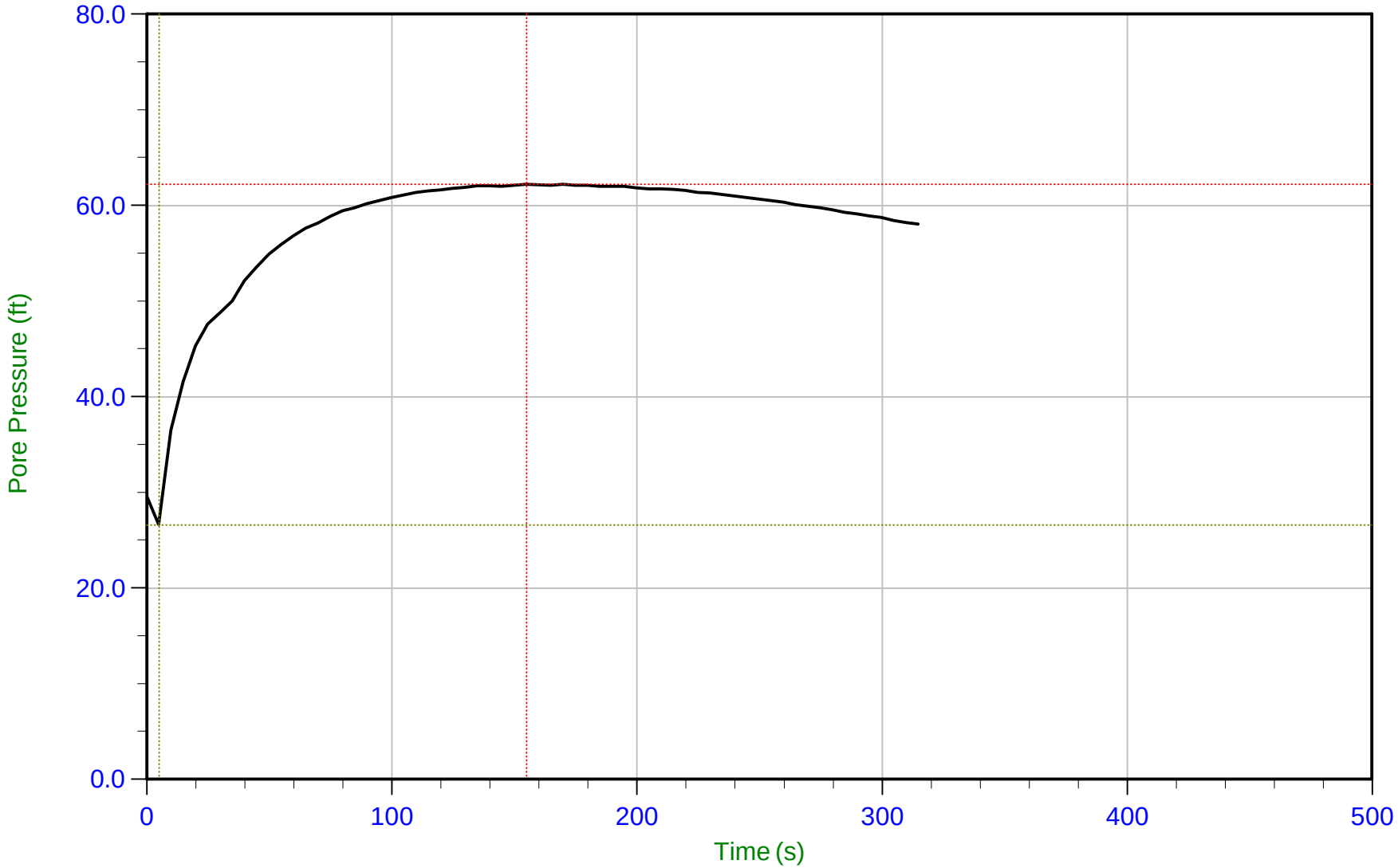
WT: 60.960 m / 200.000 ft
Ueq: -126.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 11:56
Site: Dynegy Joppa IL

Sounding: JOP-C022
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C022.PPD
Depth: 12.050 m / 39.534 ft
Duration: 315.0 s

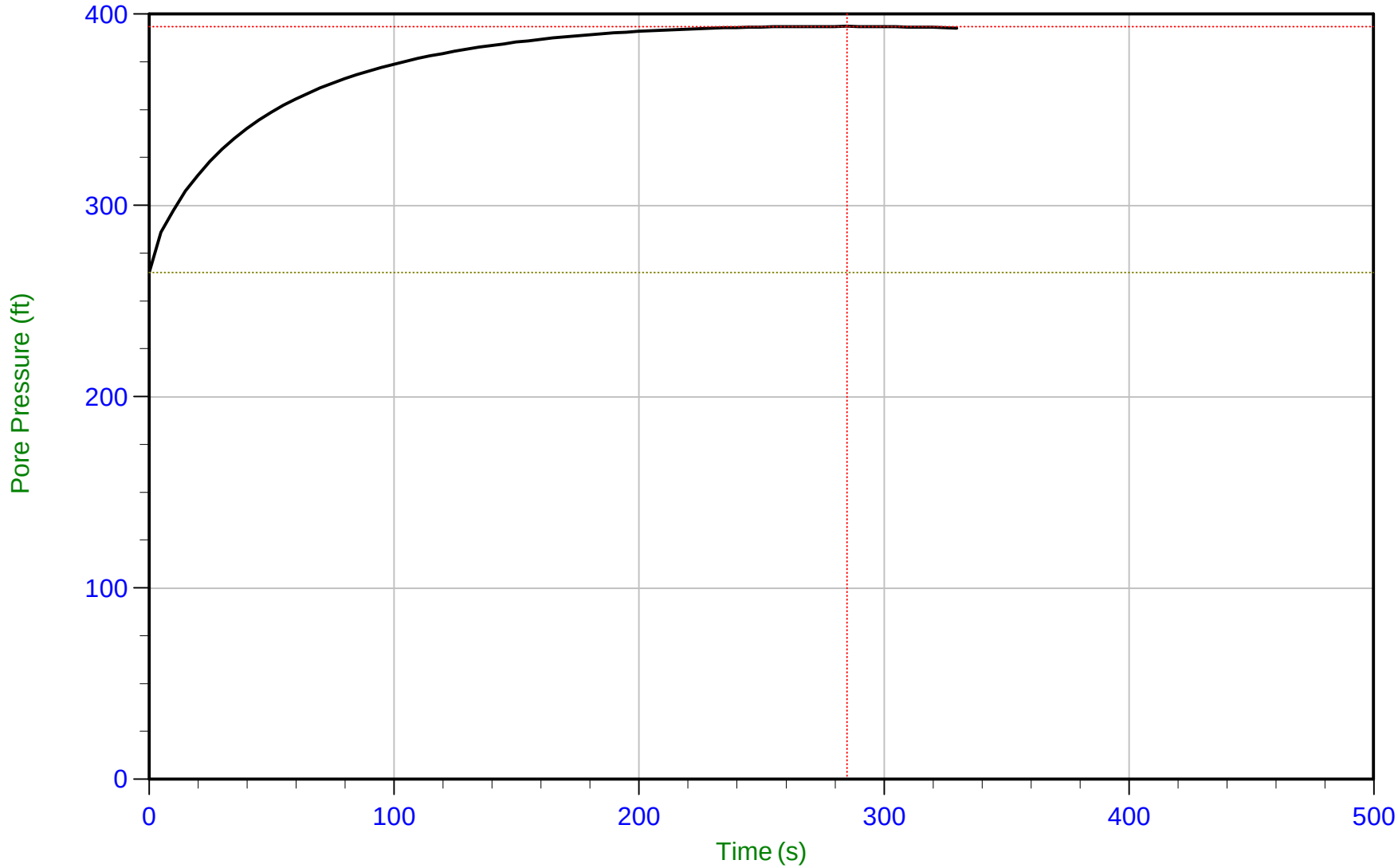
U Min: 26.6 ft
U Max: 62.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 11:56
Site: Dynegy Joppa IL

Sounding: JOP-C022
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C022.PPD
Depth: 19.200 m / 62.991 ft
Duration: 330.0 s

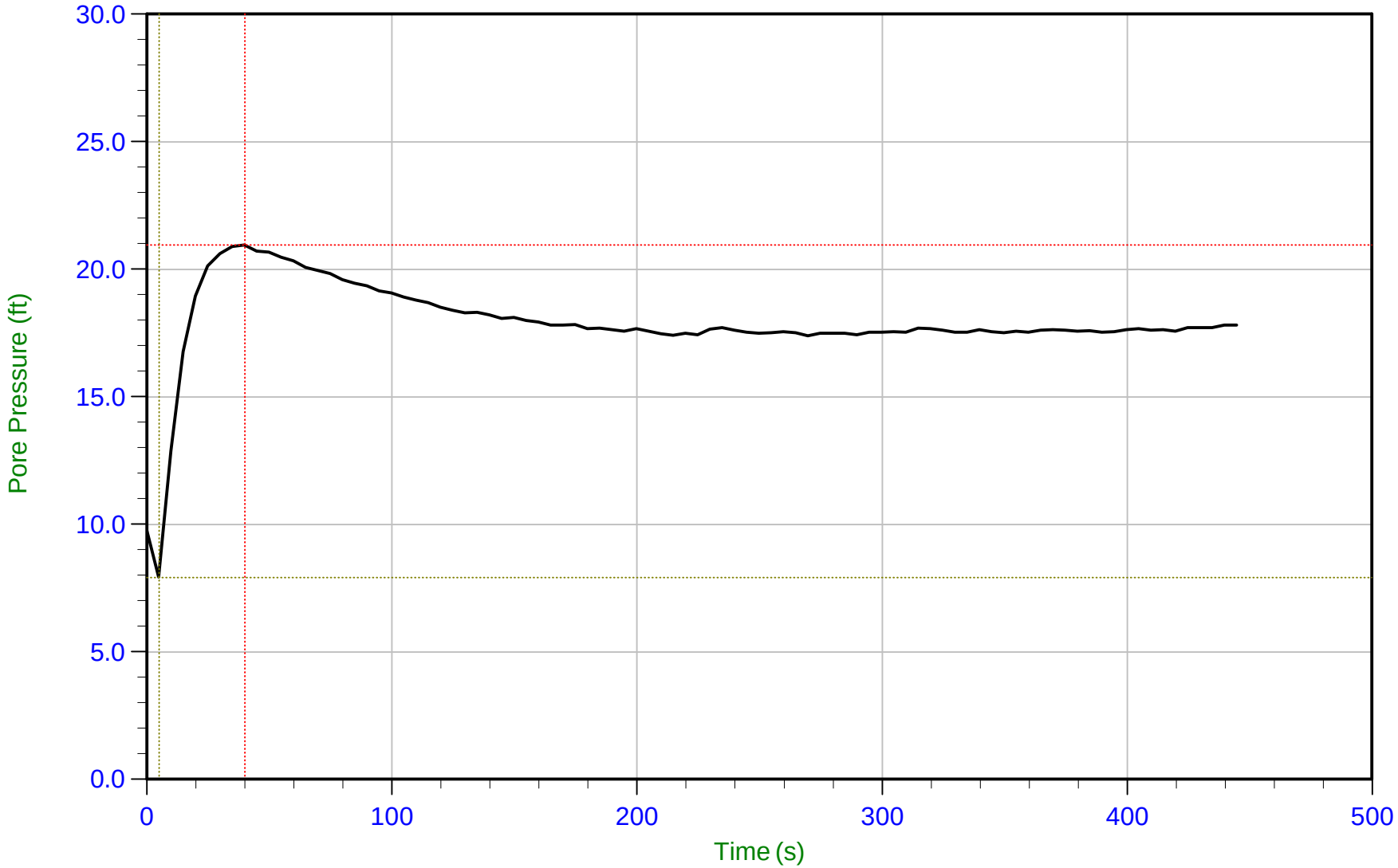
U Min: 265.0 ft
U Max: 393.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/09/2015 11:56
Site: Dynegy Joppa IL

Sounding: JOP-C022
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C022.PPD
Depth: 21.250 m / 69.717 ft
Duration: 445.0 s

U Min: 7.9 ft
U Max: 21.0 ft

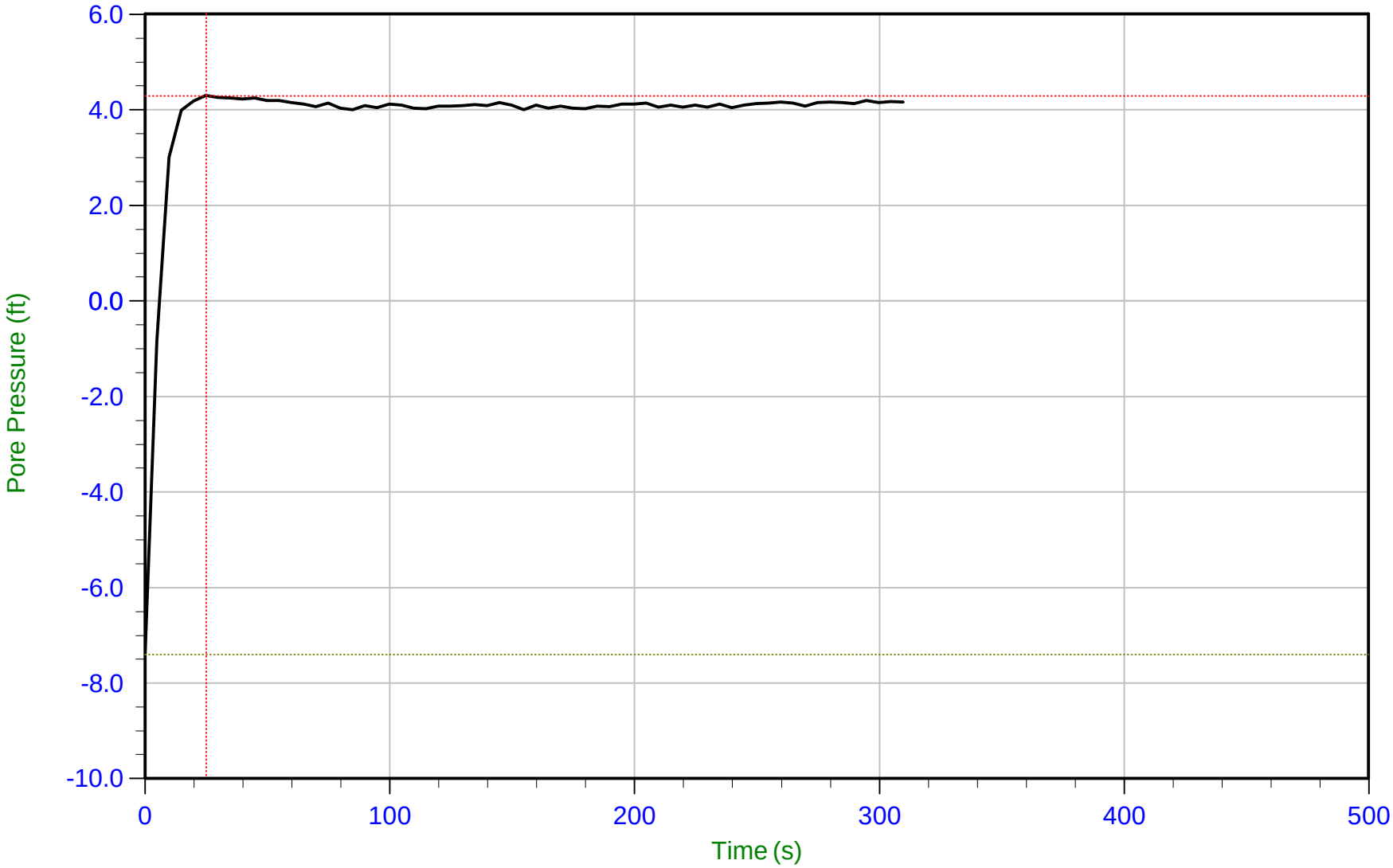
WT: 15.882 m / 52.104 ft
Ueq: 17.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 09:59
Site: Dynegy Joppa IL

Sounding: JOP-C023
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C023.PPD
Depth: 4.600 m / 15.092 ft
Duration: 310.0 s

U Min: -7.4 ft
U Max: 4.3 ft

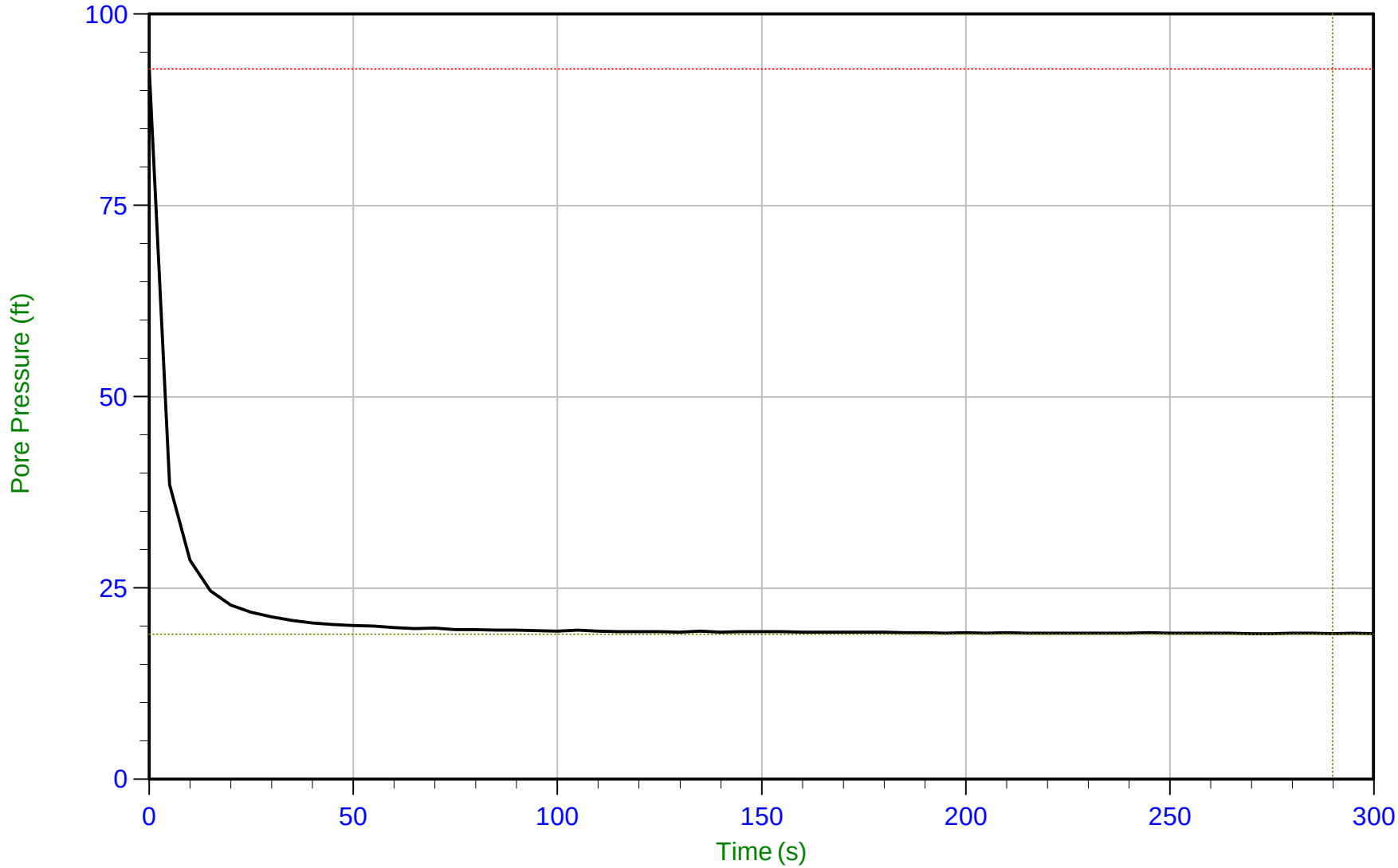
WT: 3.338 m / 10.950 ft
Ueq: 4.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 09:59
Site: Dynegy Joppa IL

Sounding: JOP-C023
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C023.PPD
Depth: 9.000 m / 29.527 ft
Duration: 300.0 s

U Min: 19.0 ft
U Max: 92.9 ft

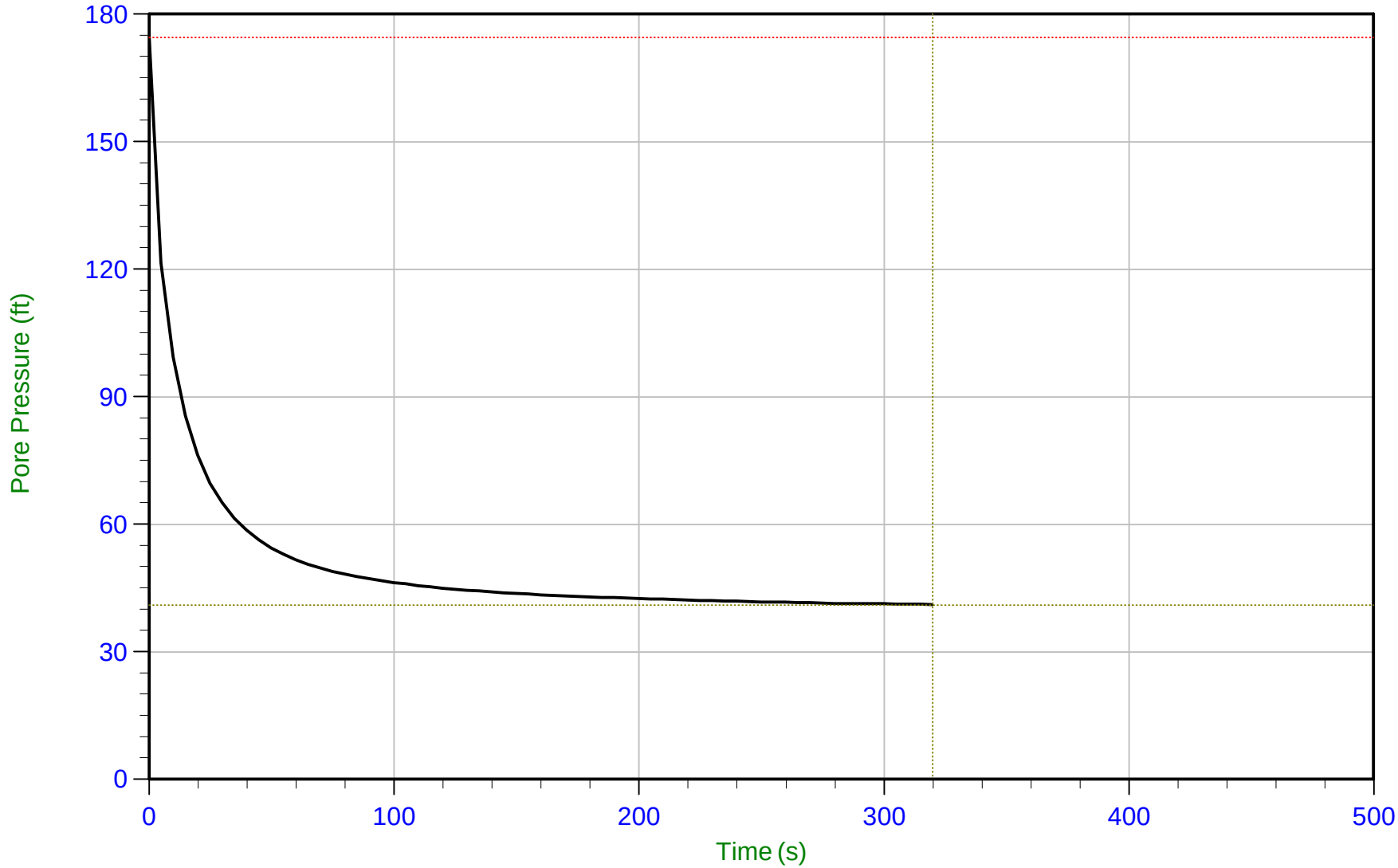
WT: 3.199 m / 10.495 ft
Ueq: 19.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 09:59
Site: Dynegy Joppa IL

Sounding: JOP-C023
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C023.PPD
Depth: 15.300 m / 50.196 ft
Duration: 320.0 s

U Min: 41.1 ft
U Max: 174.6 ft

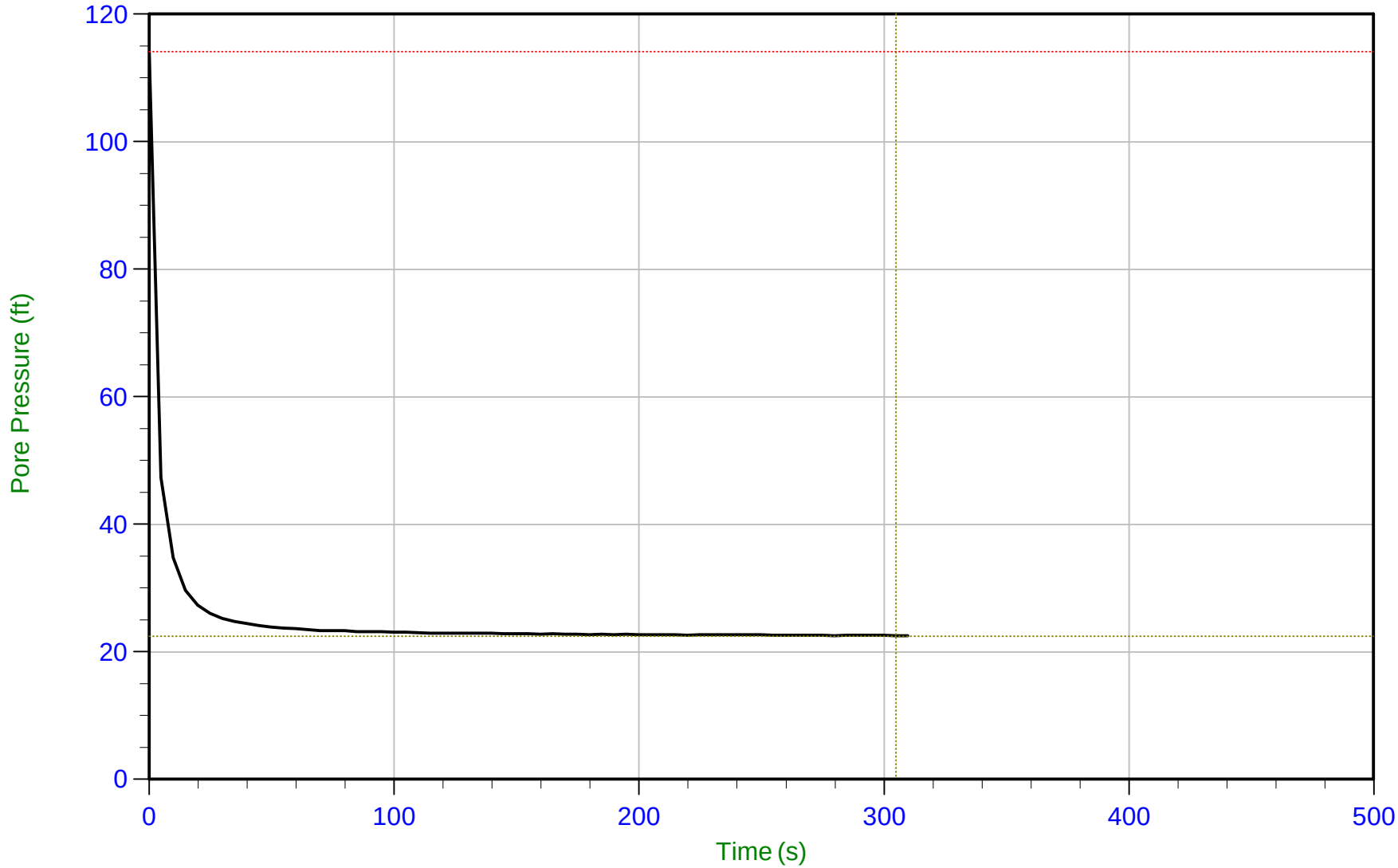
WT: 2.734 m / 8.971 ft
Ueq: 41.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 11:08
Site: Dynegy Joppa IL

Sounding: JOP-C024B
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C024B.PPD
Depth: 7.950 m / 26.082 ft
Duration: 310.0 s

U Min: 22.5 ft
U Max: 114.2 ft

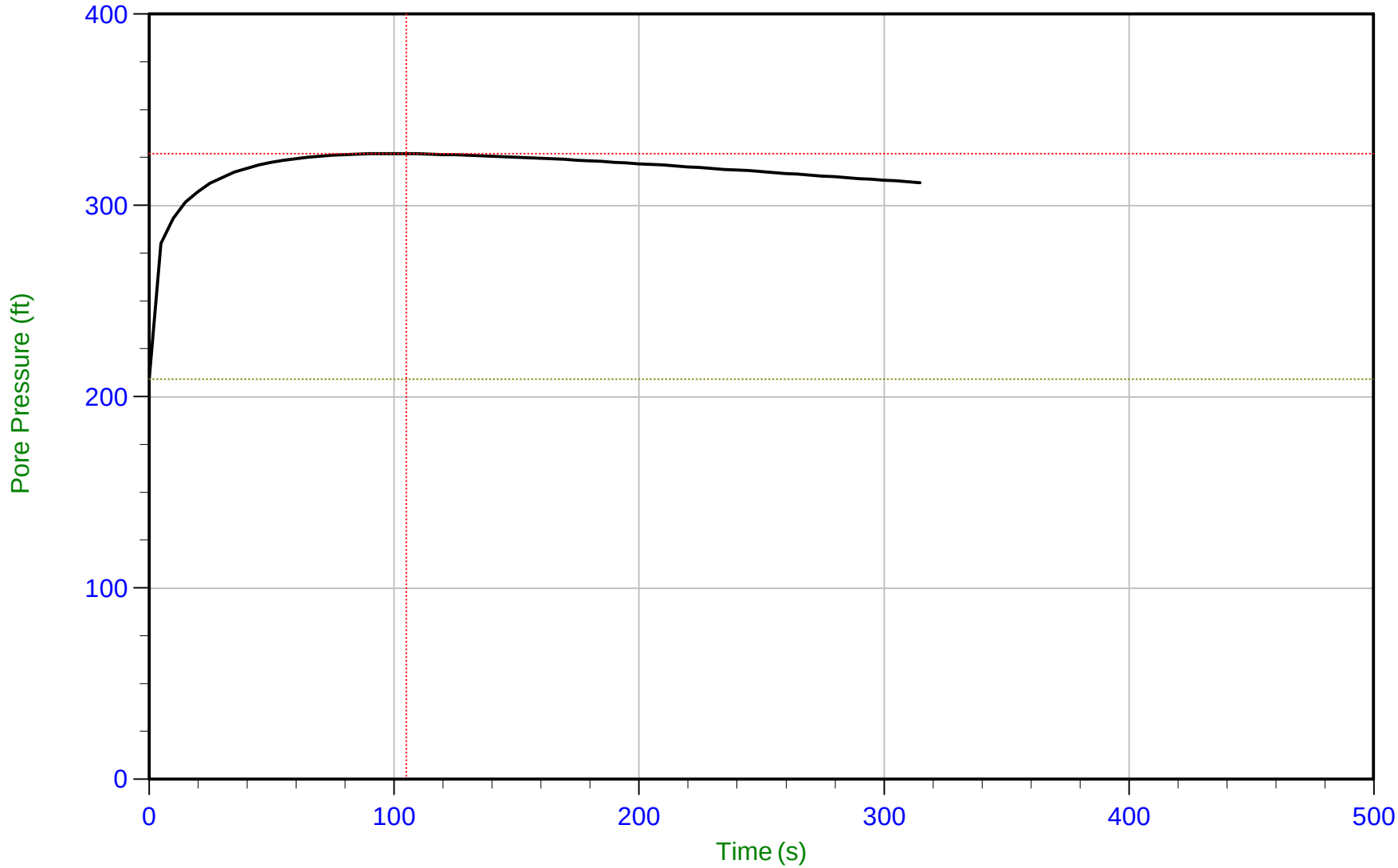
WT: 1.107 m / 3.631 ft
Ueq: 22.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 11:08
Site: Dynegy Joppa IL

Sounding: JOP-C024B
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C024B.PPD
Depth: 15.950 m / 52.329 ft
Duration: 315.0 s

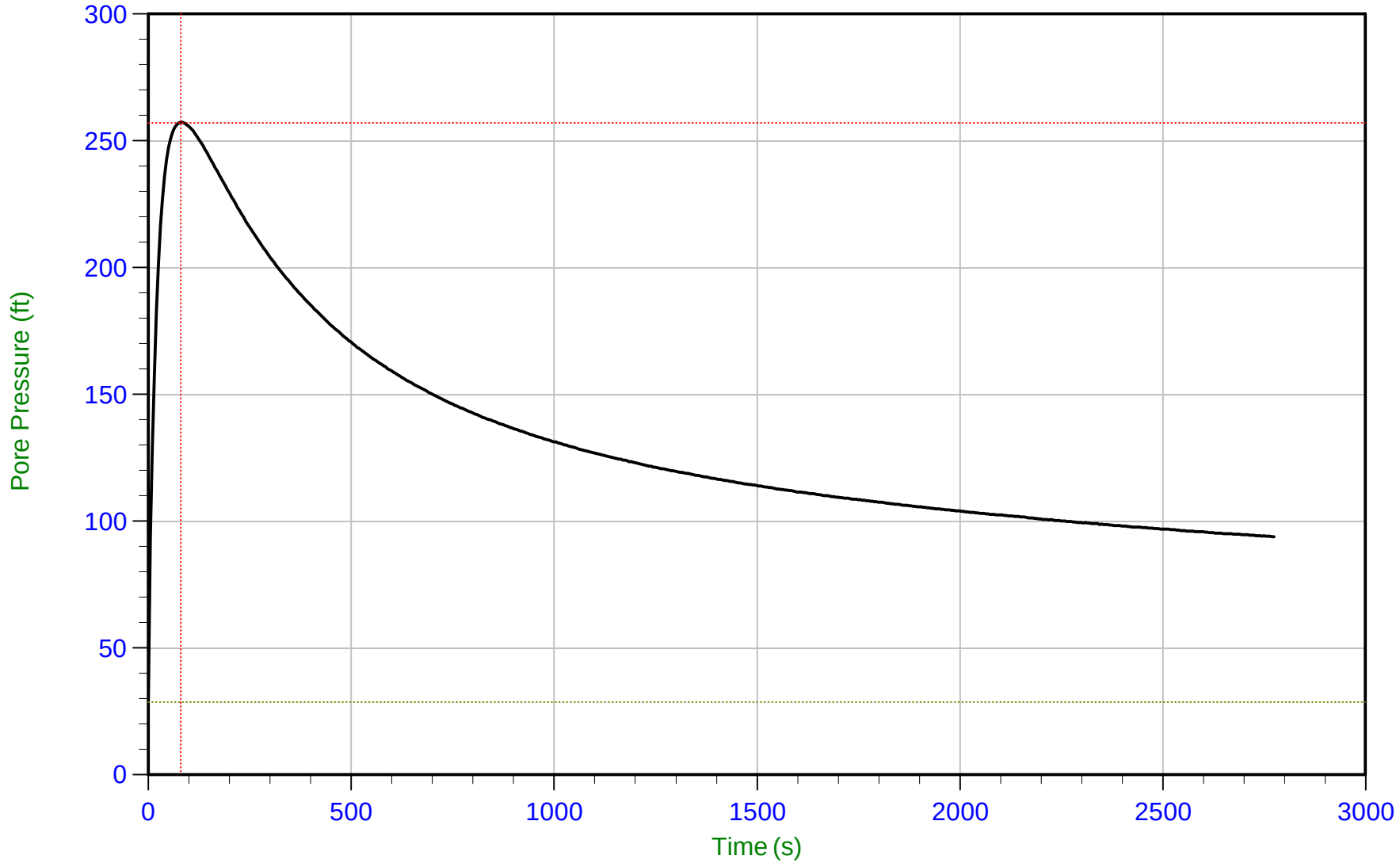
U Min: 209.3 ft
U Max: 327.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 11:08
Site: Dynegy Joppa IL

Sounding: JOP-C024B
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C024B.PPD
Depth: 24.500 m / 80.380 ft
Duration: 2775.0 s

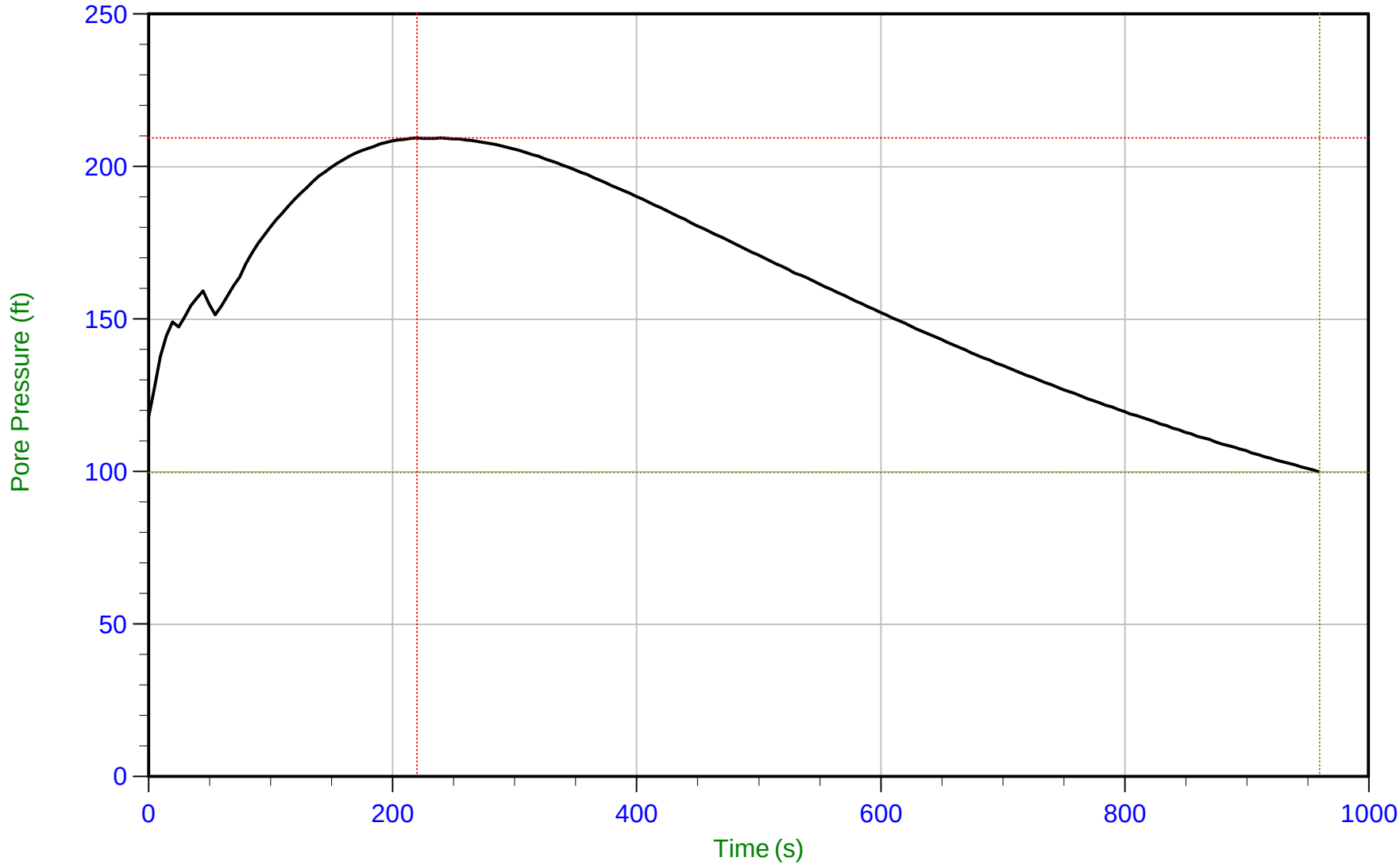
U Min: 28.8 ft
U Max: 257.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/06/2015 09:22
Site: Dynegy Joppa IL

Sounding: JOP-C025
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C025.PPD
Depth: 12.000 m / 39.370 ft
Duration: 960.0 s

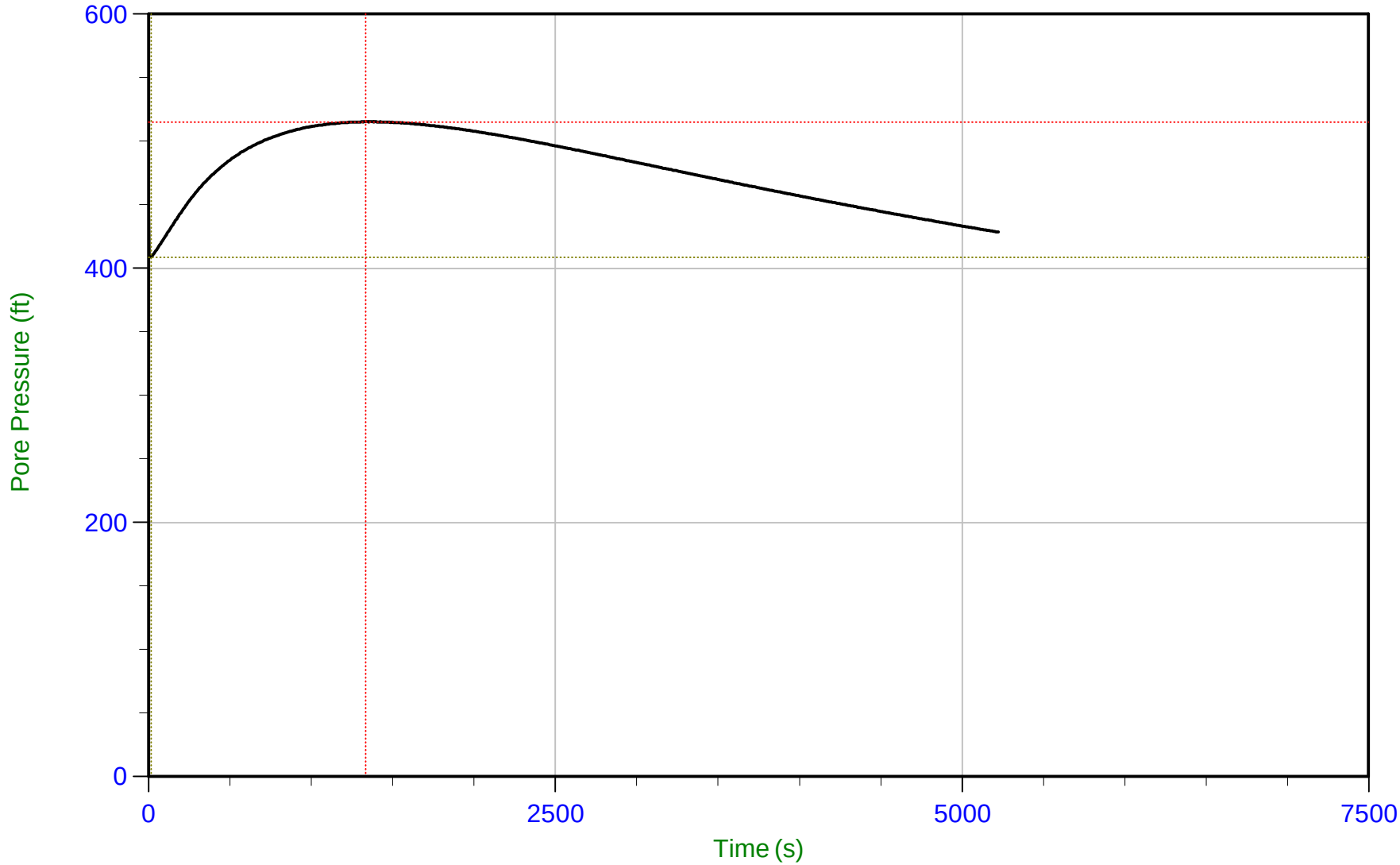
U Min: 99.9 ft
U Max: 209.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/06/2015 09:22
Site: Dynegy Joppa IL

Sounding: JOP-C025
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C025.PPD
Depth: 21.350 m / 70.045 ft
Duration: 5225.0 s

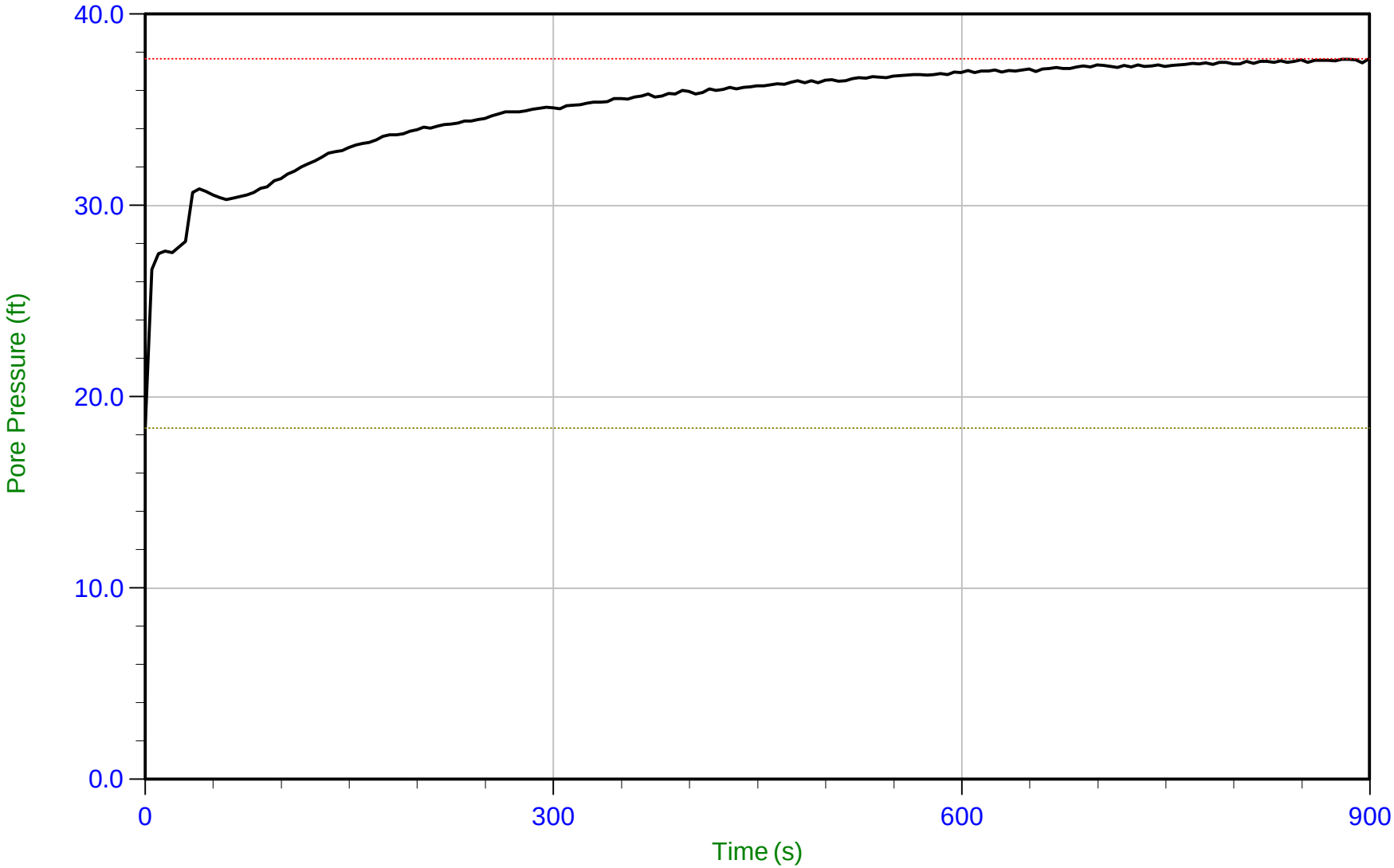
U Min: 408.9 ft
U Max: 515.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/06/2015 09:22
Site: Dynegy Joppa IL

Sounding: JOP-C025
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C025.PPD
Depth: 24.500 m / 80.380 ft
Duration: 900.0 s

U Min: 18.4 ft
U Max: 37.7 ft

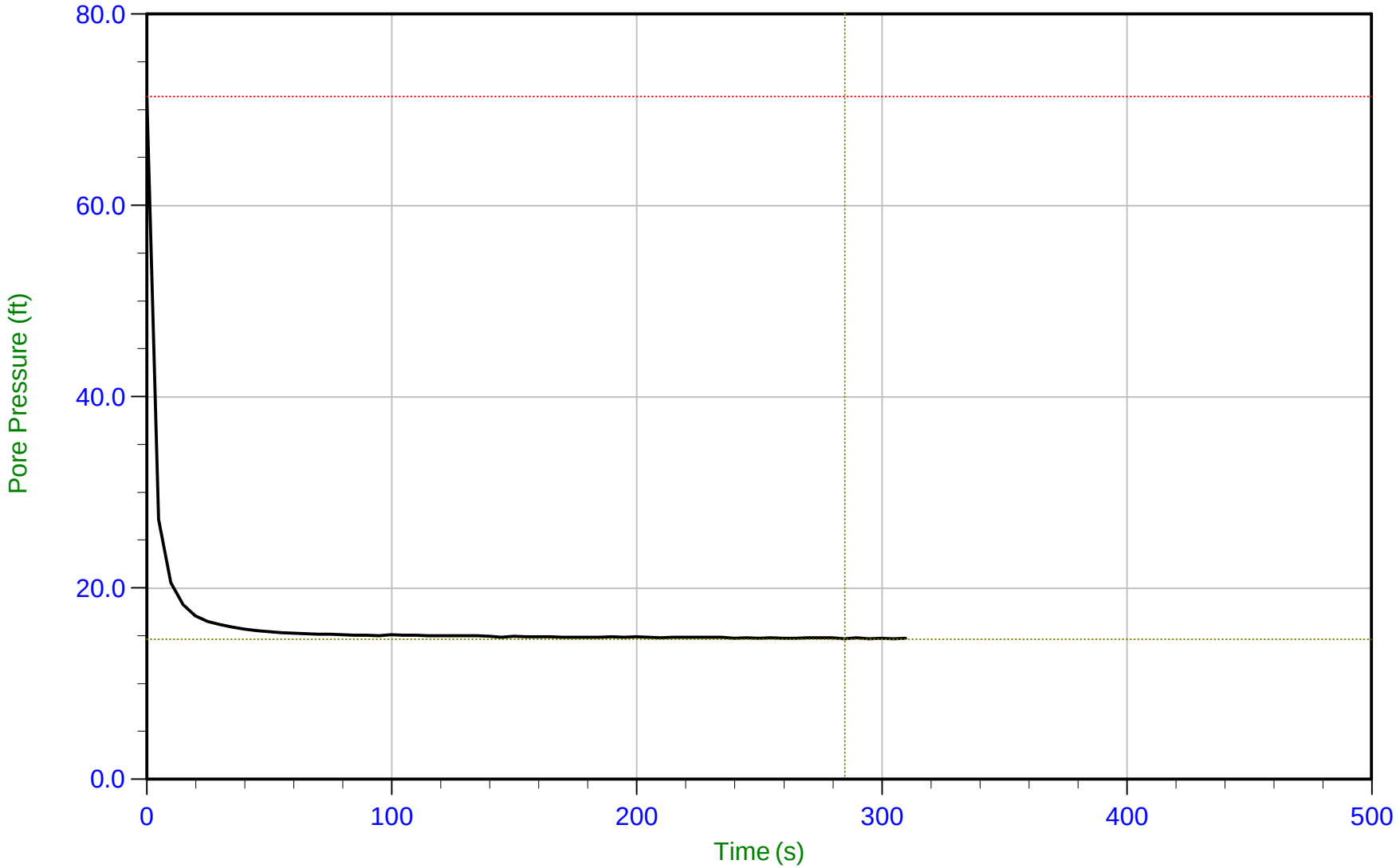
WT: 13.016 m / 42.703 ft
Ueq: 37.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 10:34
Site: Dynegy Joppa IL

Sounding: JOP-C026
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C026.PPD
Depth: 6.900 m / 22.638 ft
Duration: 310.0 s

U Min: 14.7 ft
U Max: 71.4 ft

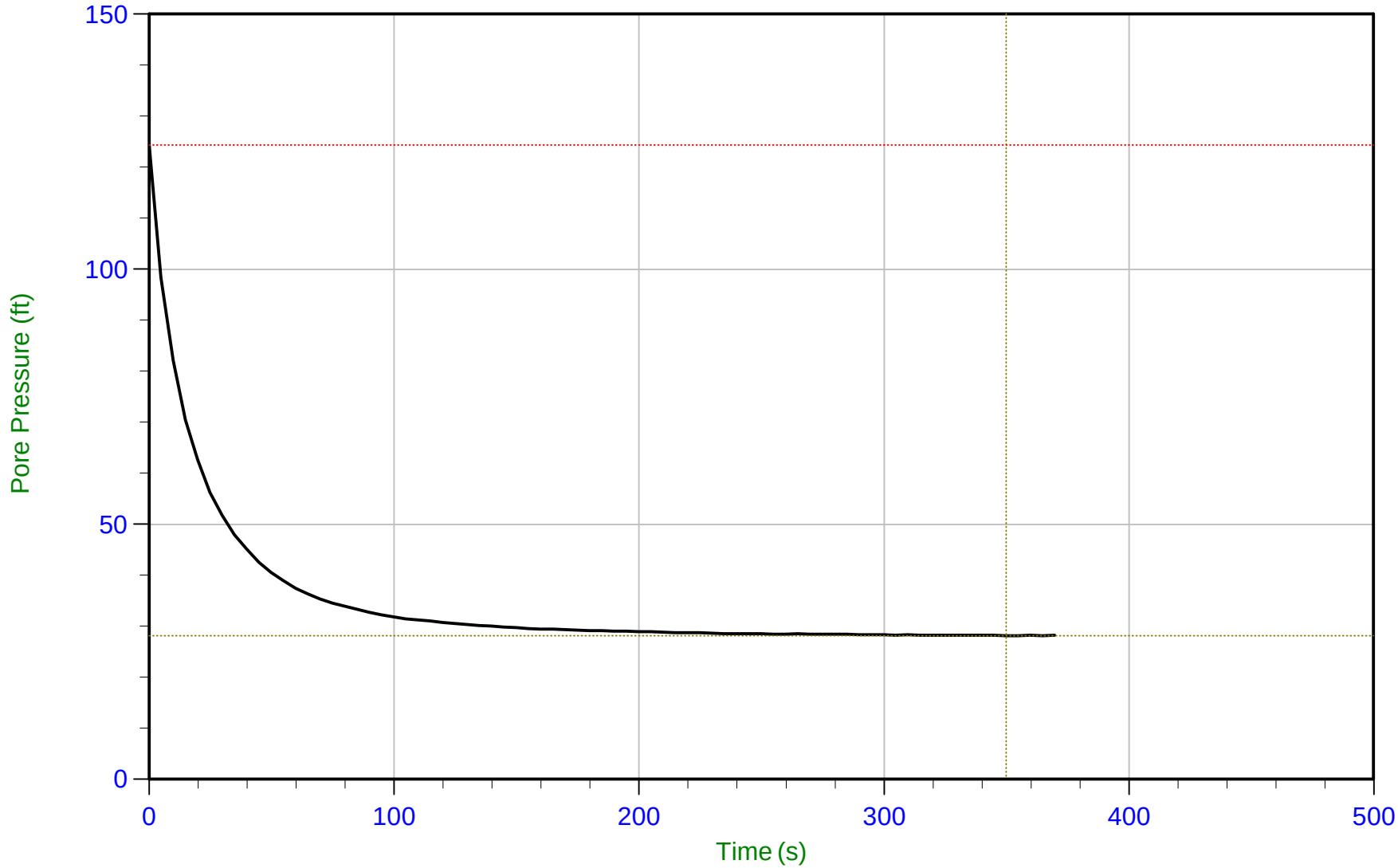
WT: 2.416 m / 7.926 ft
Ueq: 14.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 10:34
Site: Dynegy Joppa IL

Sounding: JOP-C026
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C026.PPD
Depth: 10.900 m / 35.761 ft
Duration: 370.0 s

U Min: 28.2 ft
U Max: 124.4 ft

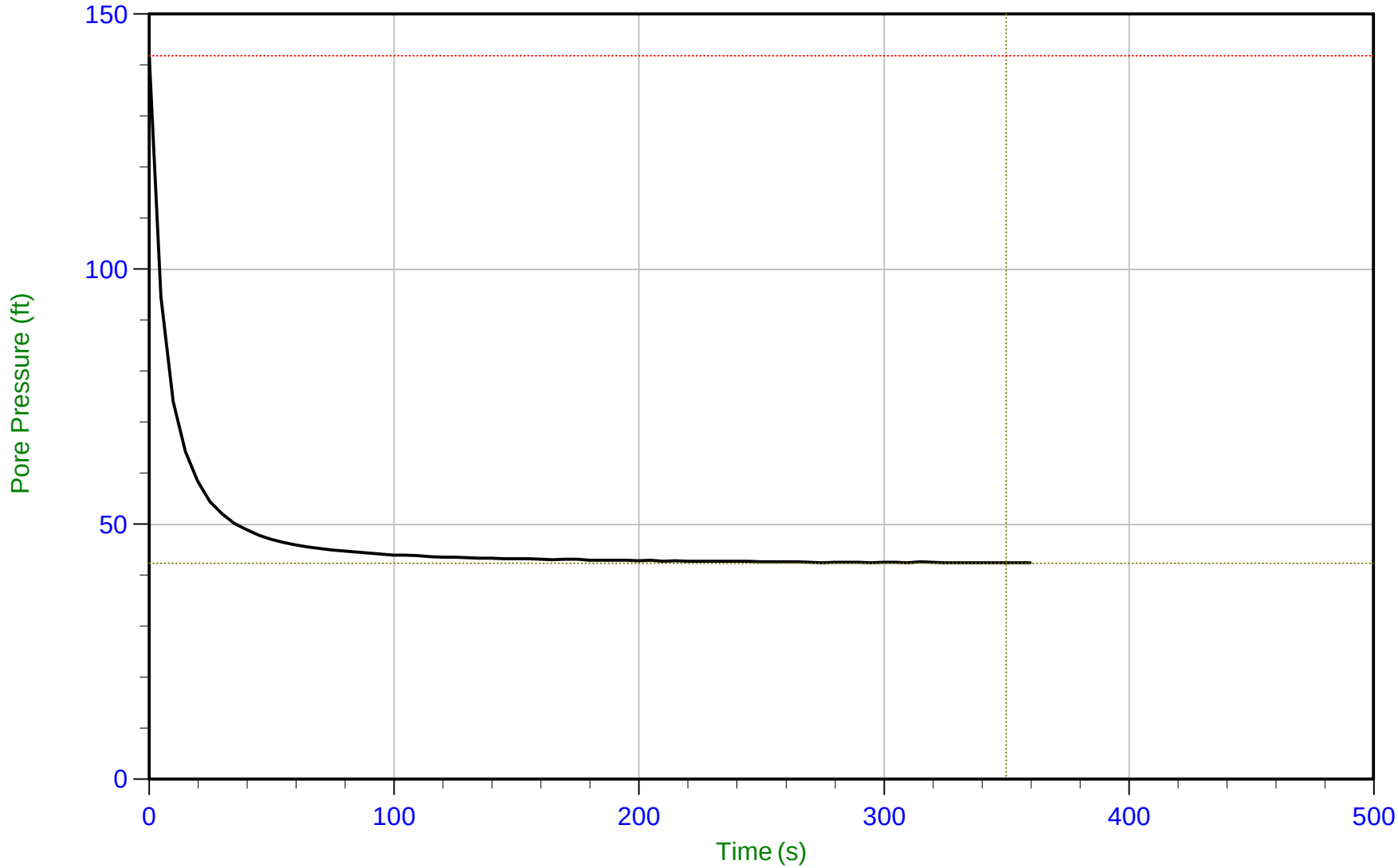
WT: 2.346 m / 7.697 ft
Ueq: 28.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 10:34
Site: Dynegy Joppa IL

Sounding: JOP-C026
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C026.PPD
Depth: 15.250 m / 50.032 ft
Duration: 360.0 s

U Min: 42.4 ft
U Max: 141.9 ft

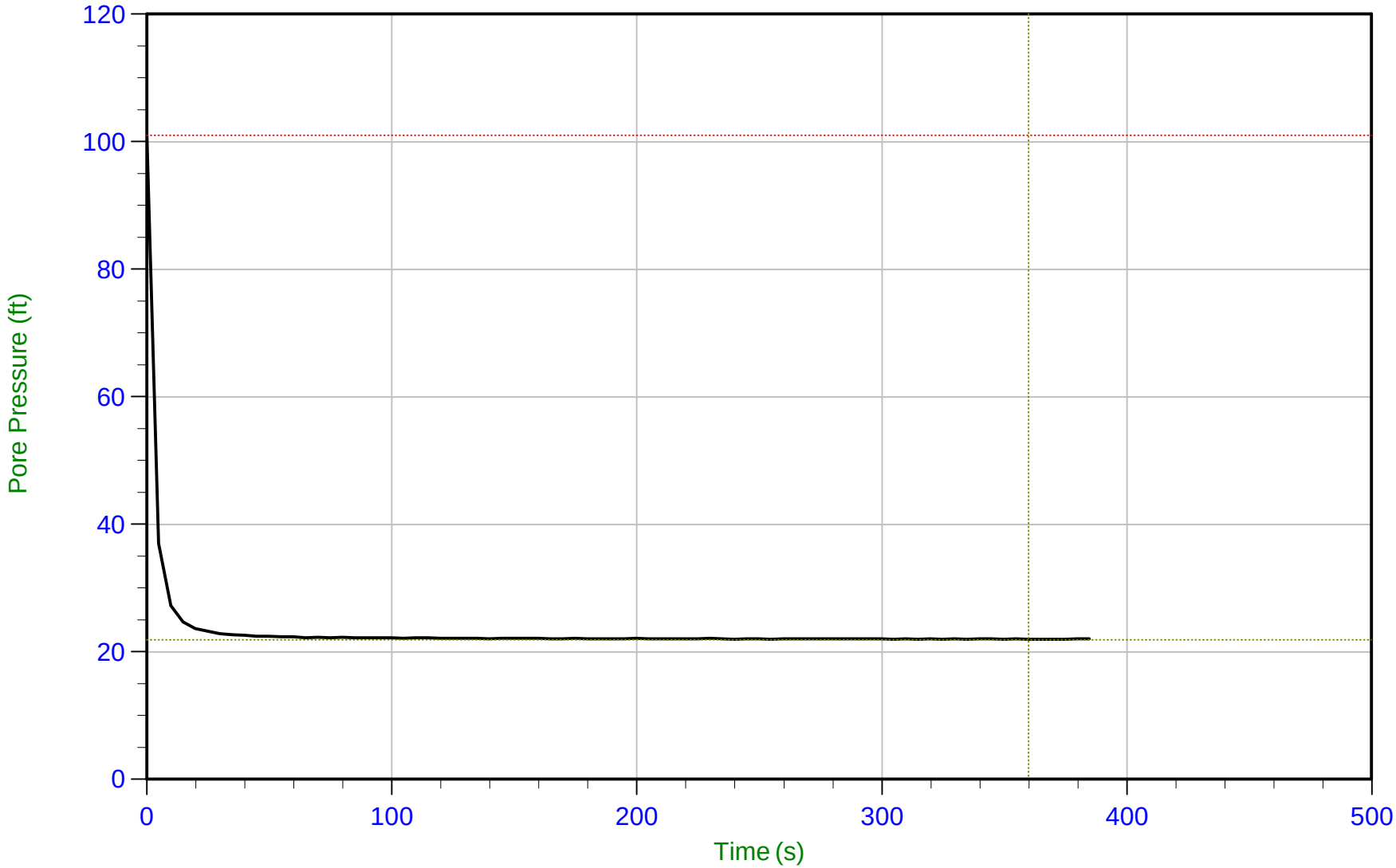
WT: 2.124 m / 6.968 ft
Ueq: 43.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/13/2015 07:28
Site: Dynegy Joppa IL

Sounding: JOP-C027
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C027.PPD
Depth: 10.100 m / 33.136 ft
Duration: 385.0 s

U Min: 21.9 ft
U Max: 101.1 ft

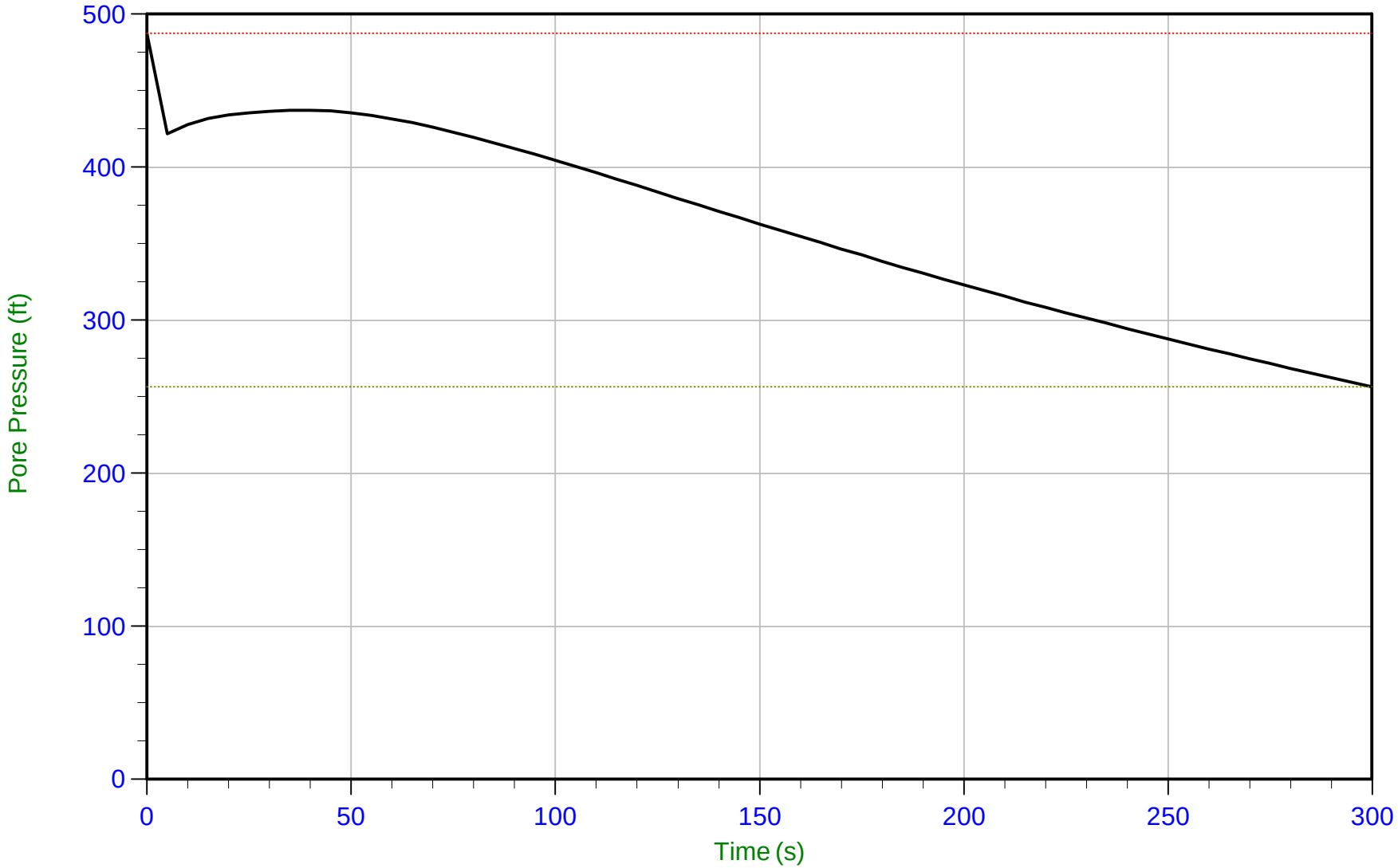
WT: 3.375 m / 11.072 ft
Ueq: 22.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/13/2015 07:28
Site: Dynegy Joppa IL

Sounding: JOP-C027
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C027.PPD
Depth: 20.250 m / 66.436 ft
Duration: 300.0 s

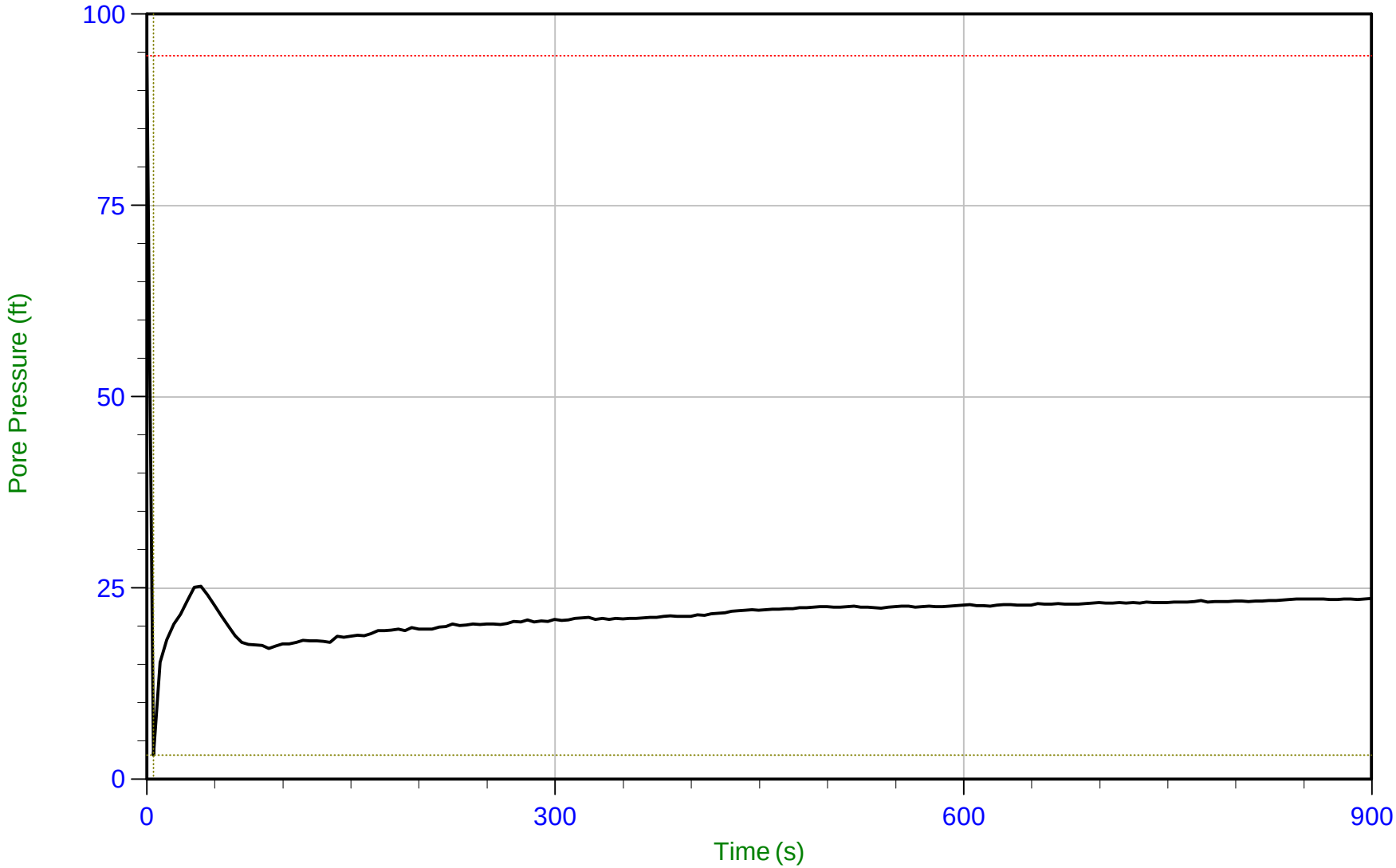
U Min: 256.7 ft
U Max: 487.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/13/2015 07:28
Site: Dynegy Joppa IL

Sounding: JOP-C027
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C027.PPD
Depth: 26.000 m / 85.301 ft
Duration: 900.0 s

U Min: 3.2 ft
U Max: 94.6 ft

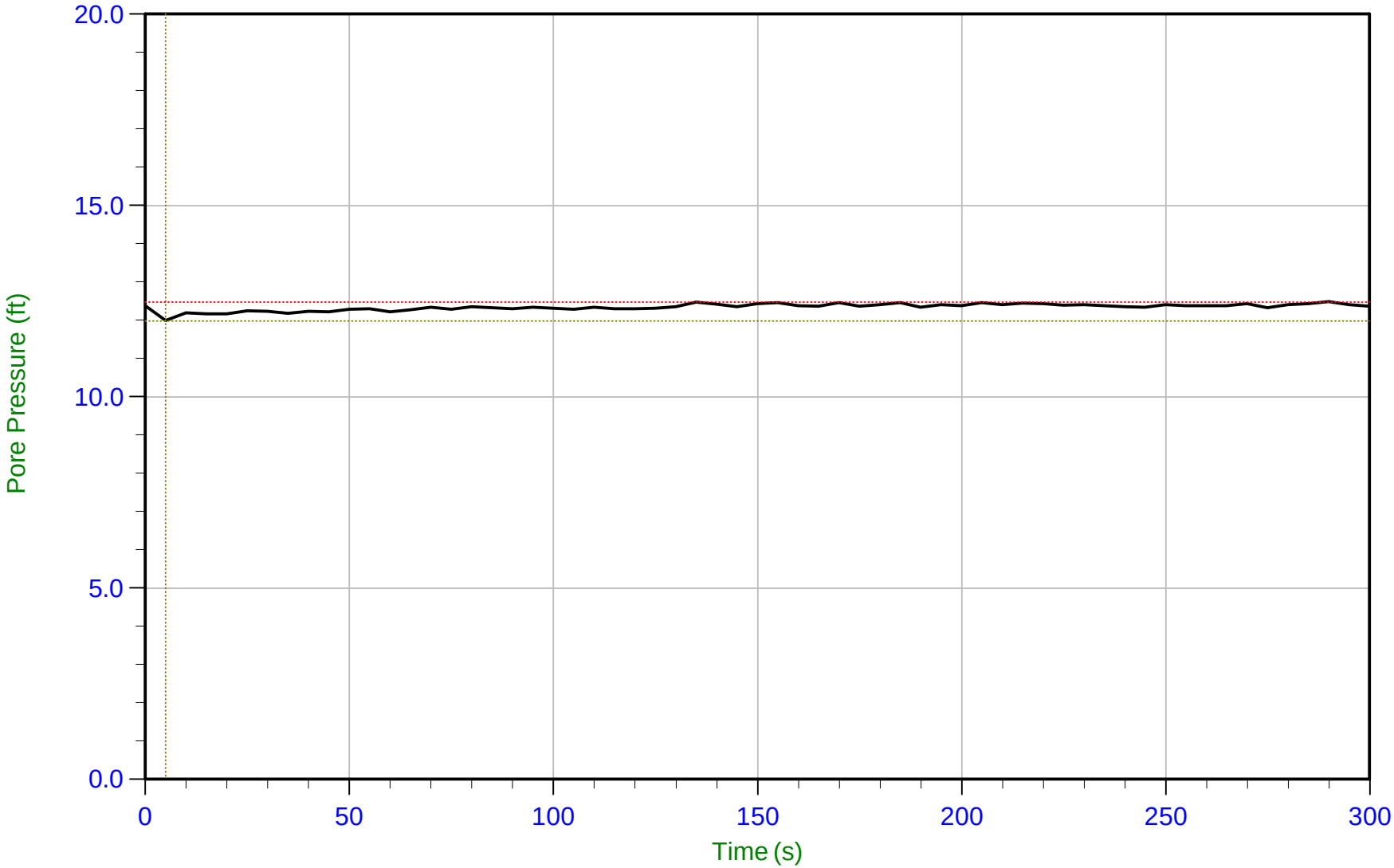
WT: 18.822 m / 61.753 ft
Ueq: 23.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 08:59
Site: Dynegy Joppa IL

Sounding: JOP-C028
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C028.PPD
Depth: 4.900 m / 16.076 ft
Duration: 300.0 s

U Min: 12.0 ft
U Max: 12.5 ft

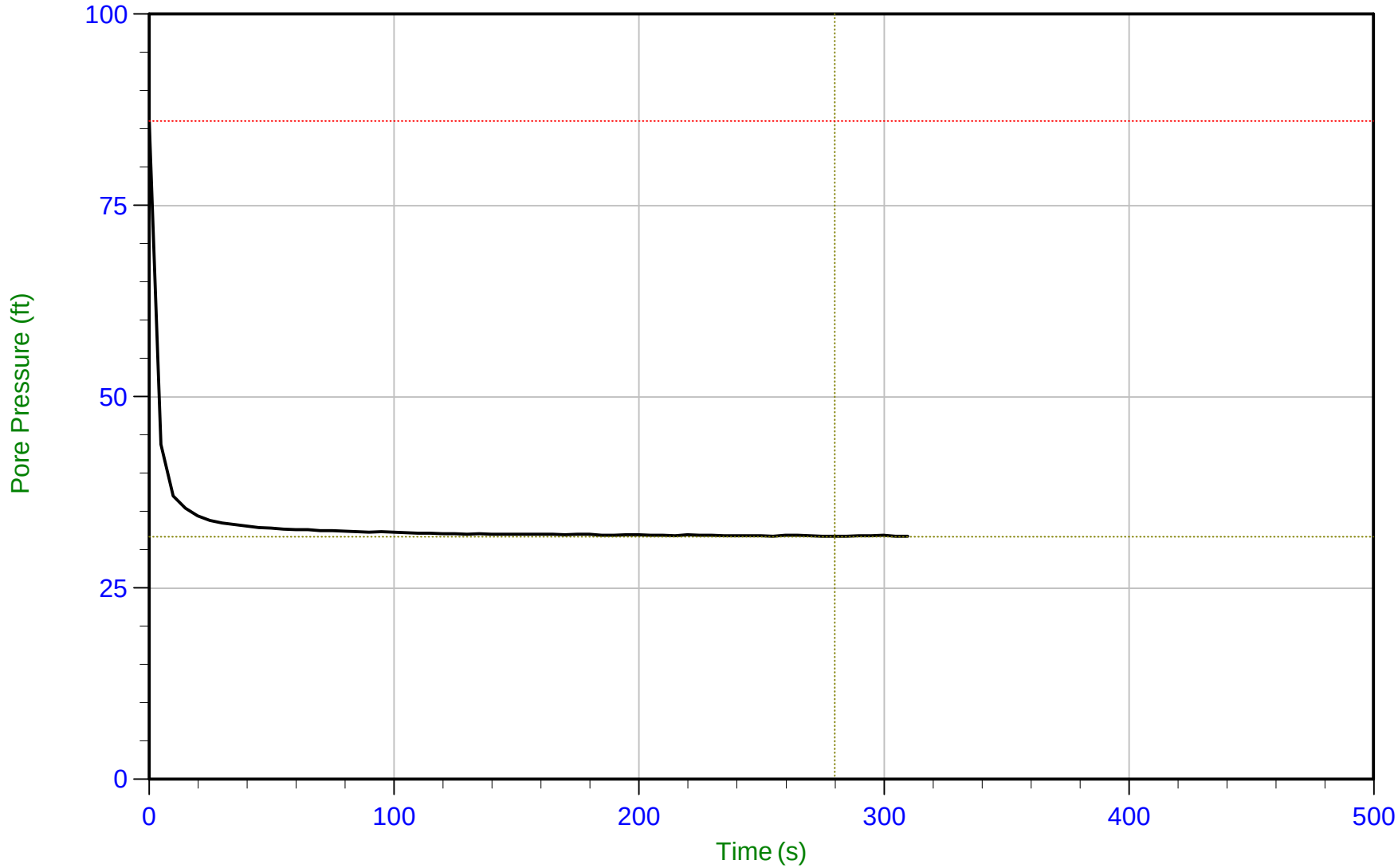
WT: 1.124 m / 3.689 ft
Ueq: 12.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 08:59
Site: Dynegy Joppa IL

Sounding: JOP-C028
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C028.PPD
Depth: 10.900 m / 35.761 ft
Duration: 310.0 s

U Min: 31.8 ft
U Max: 86.1 ft

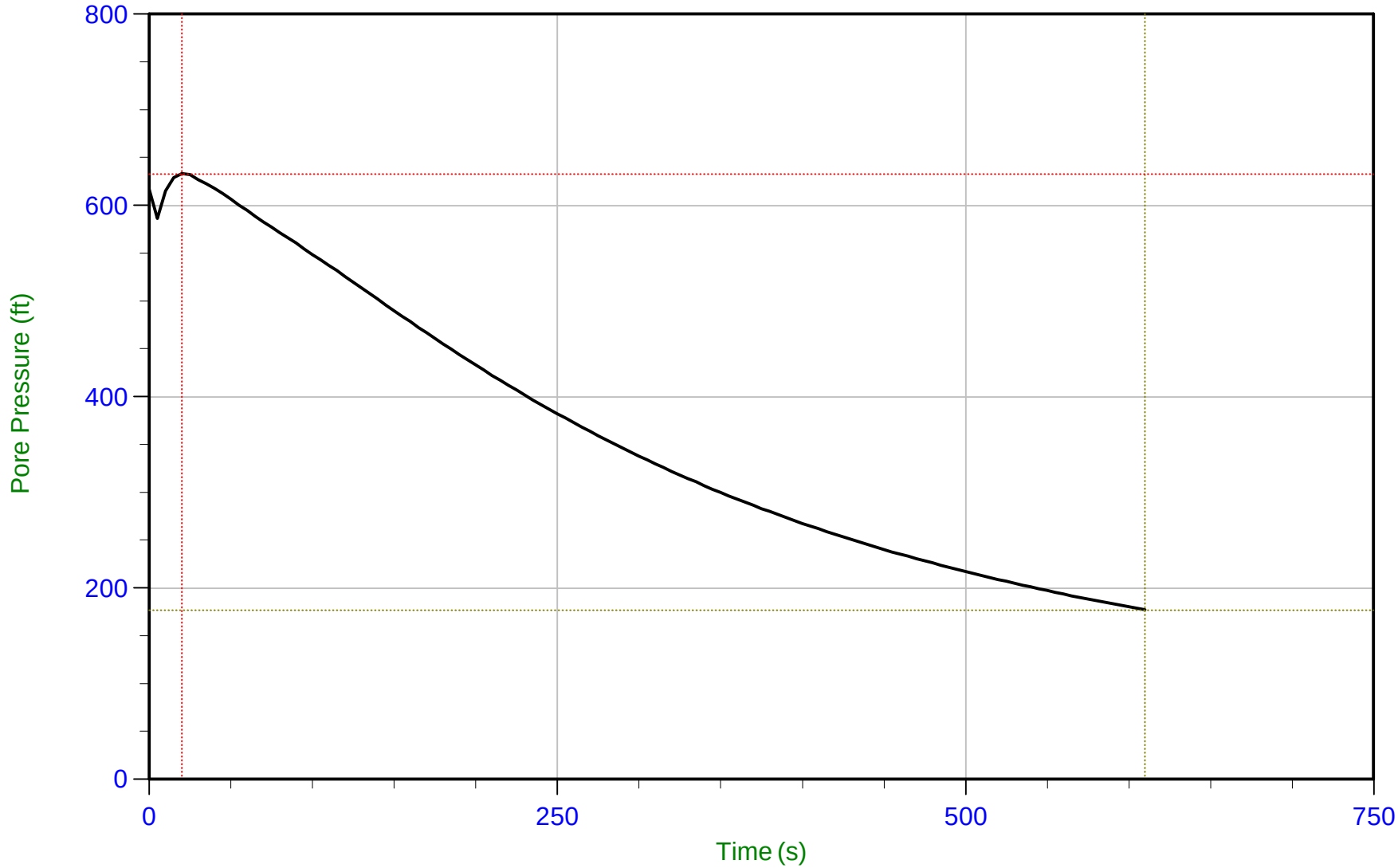
WT: 1.166 m / 3.826 ft
Ueq: 31.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/19/2015 08:59
Site: Dynegy Joppa IL

Sounding: JOP-C028
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C028.PPD
Depth: 15.300 m / 50.196 ft
Duration: 610.0 s

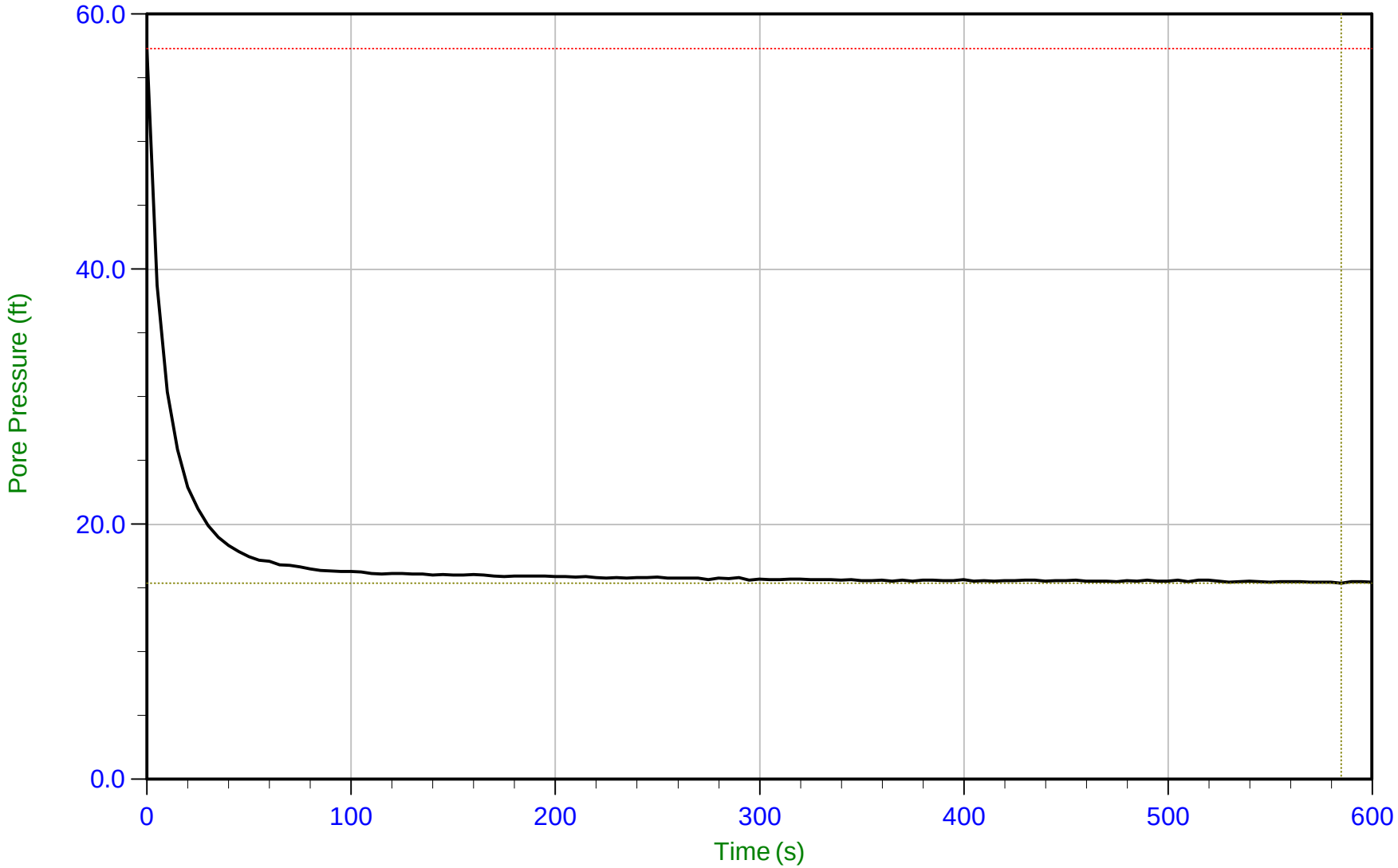
U Min: 177.1 ft
U Max: 633.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 13:54
Site: Dynegy Joppa IL

Sounding: JOP-C029
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C029.PPD
Depth: 5.950 m / 19.521 ft
Duration: 600.0 s

U Min: 15.4 ft
U Max: 57.3 ft

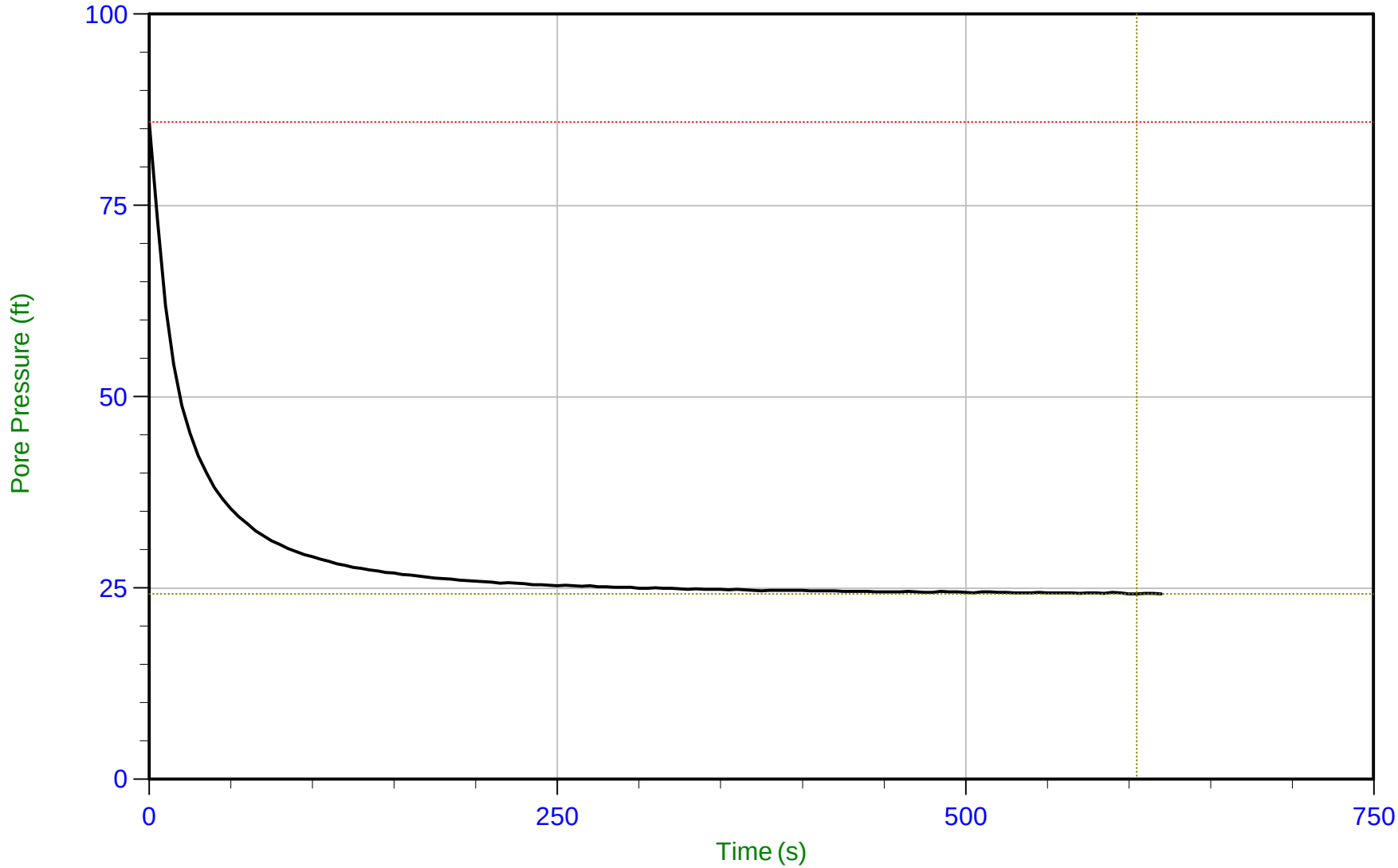
WT: 1.172 m / 3.845 ft
Ueq: 15.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 13:54
Site: Dynegy Joppa IL

Sounding: JOP-C029
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C029.PPD
Depth: 8.550 m / 28.051 ft
Duration: 620.0 s

U Min: 24.2 ft
U Max: 85.9 ft

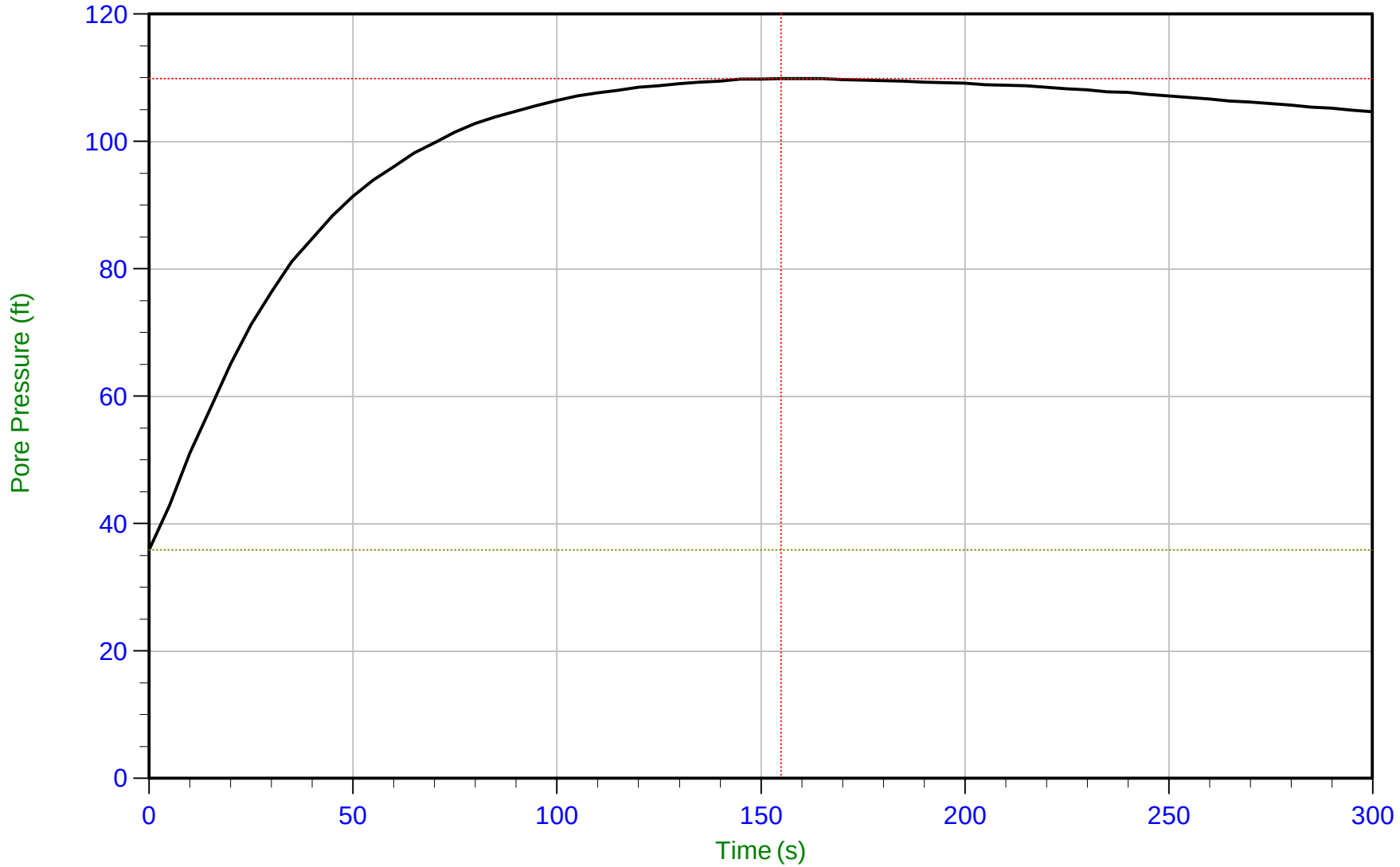
WT: 1.077 m / 3.533 ft
Ueq: 24.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 13:54
Site: Dynegy Joppa IL

Sounding: JOP-C029
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C029.PPD
Depth: 15.300 m / 50.196 ft
Duration: 300.0 s

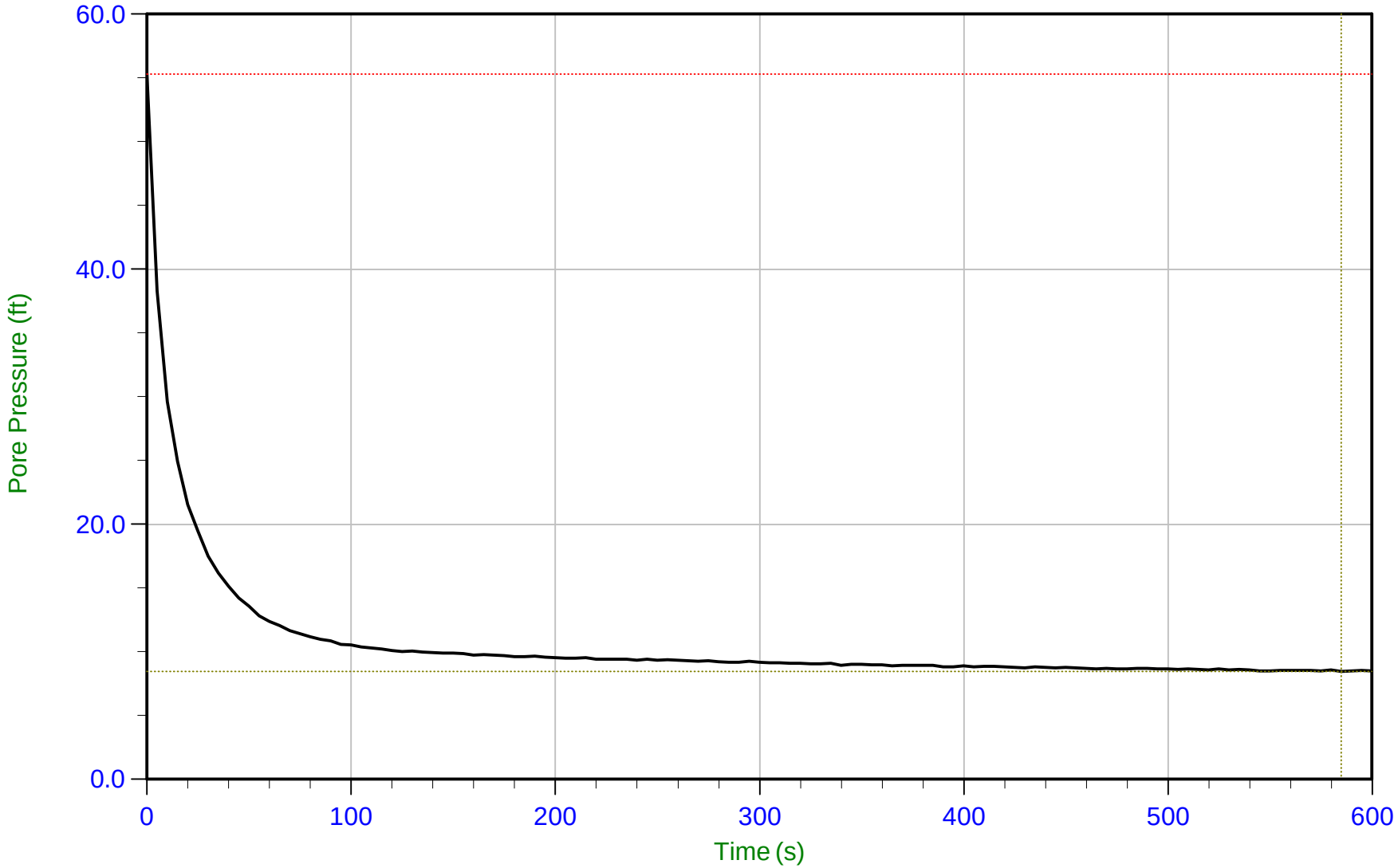
U Min: 35.9 ft
U Max: 109.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 12:21
Site: Dynegy Joppa IL

Sounding: JOP-C030
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C030.PPD
Depth: 3.700 m / 12.139 ft
Duration: 600.0 s

U Min: 8.5 ft
U Max: 55.3 ft

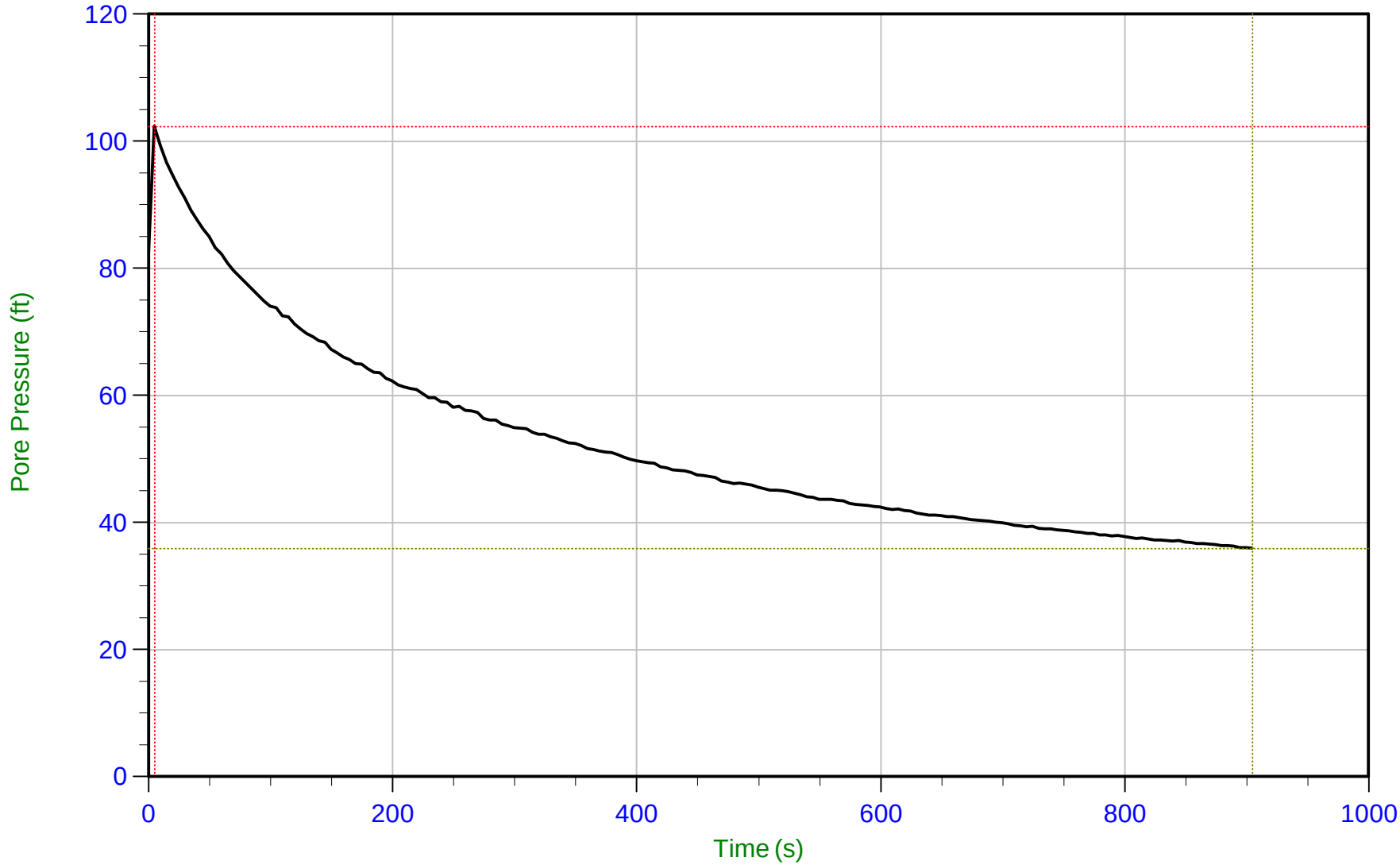
WT: 1.104 m / 3.622 ft
Ueq: 8.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 12:21
Site: Dynegy Joppa IL

Sounding: JOP-C030
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C030.PPD
Depth: 9.900 m / 32.480 ft
Duration: 905.0 s

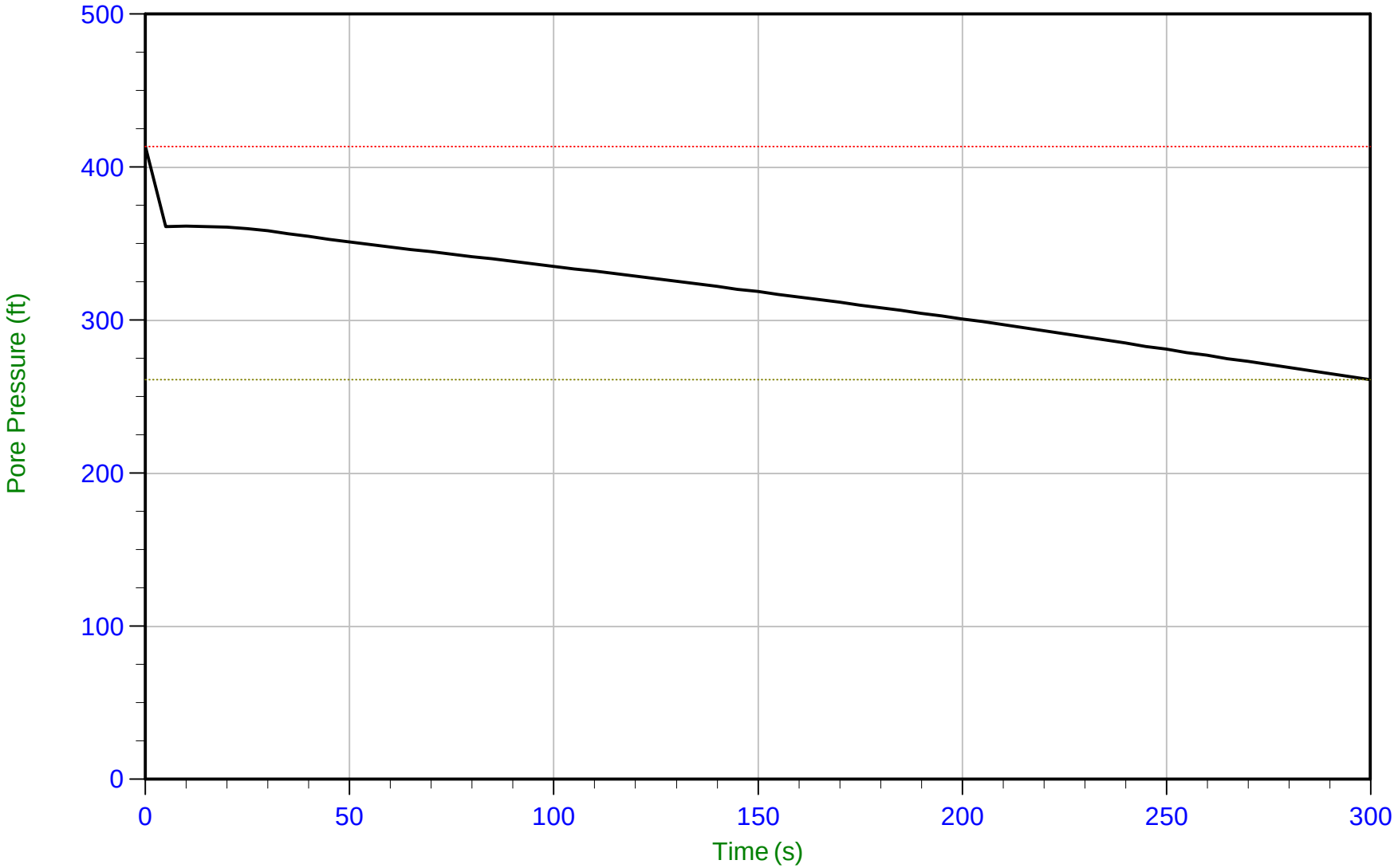
U Min: 35.9 ft
U Max: 102.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 12:21
Site: Dynegy Joppa IL

Sounding: JOP-C030
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C030.PPD
Depth: 15.300 m / 50.196 ft
Duration: 300.0 s

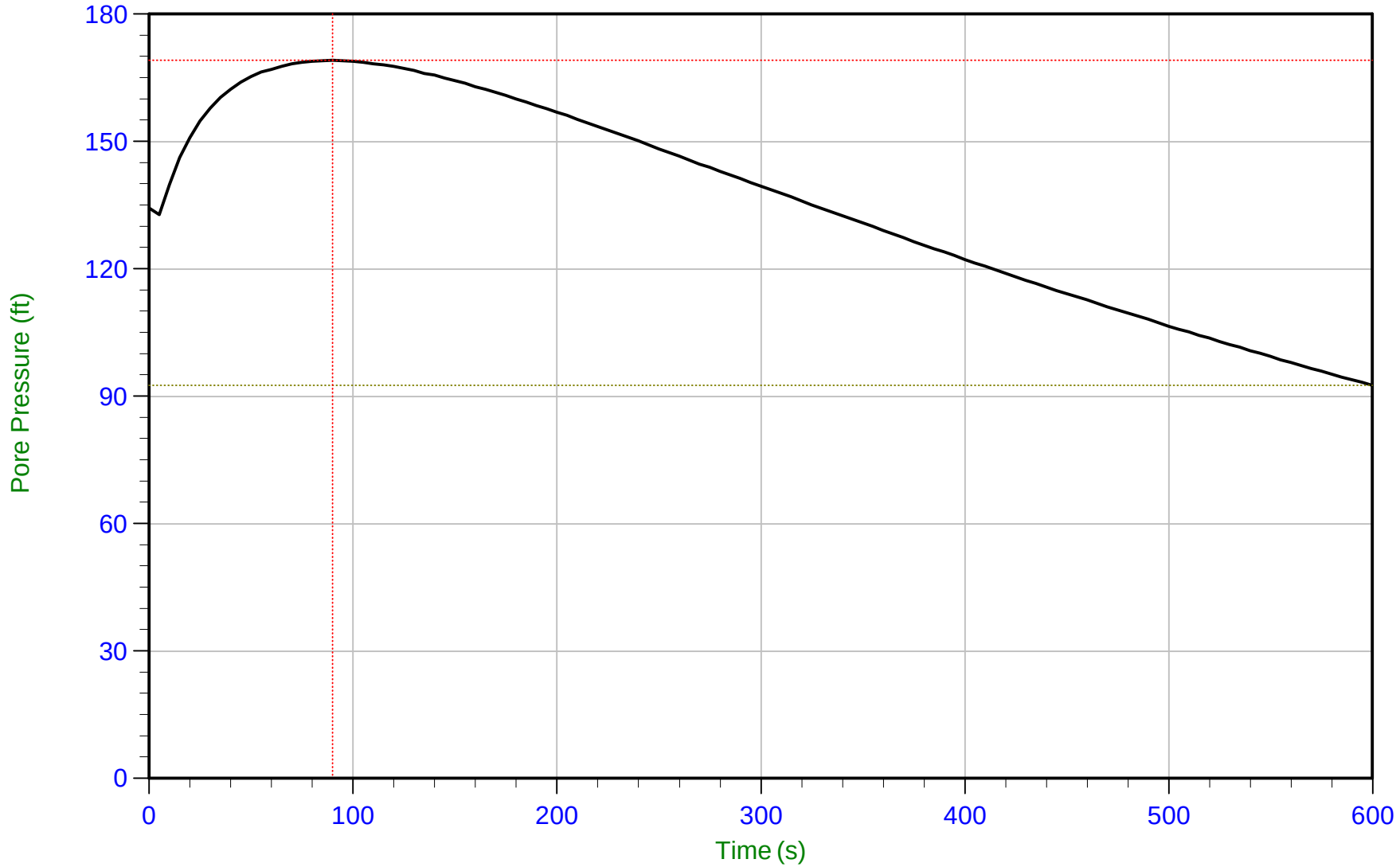
U Min: 261.3 ft
U Max: 413.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 13:50
Site: Dynegy Joppa IL

Sounding: JOP-C031
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C031A.PPD
Depth: 12.250 m / 40.190 ft
Duration: 600.0 s

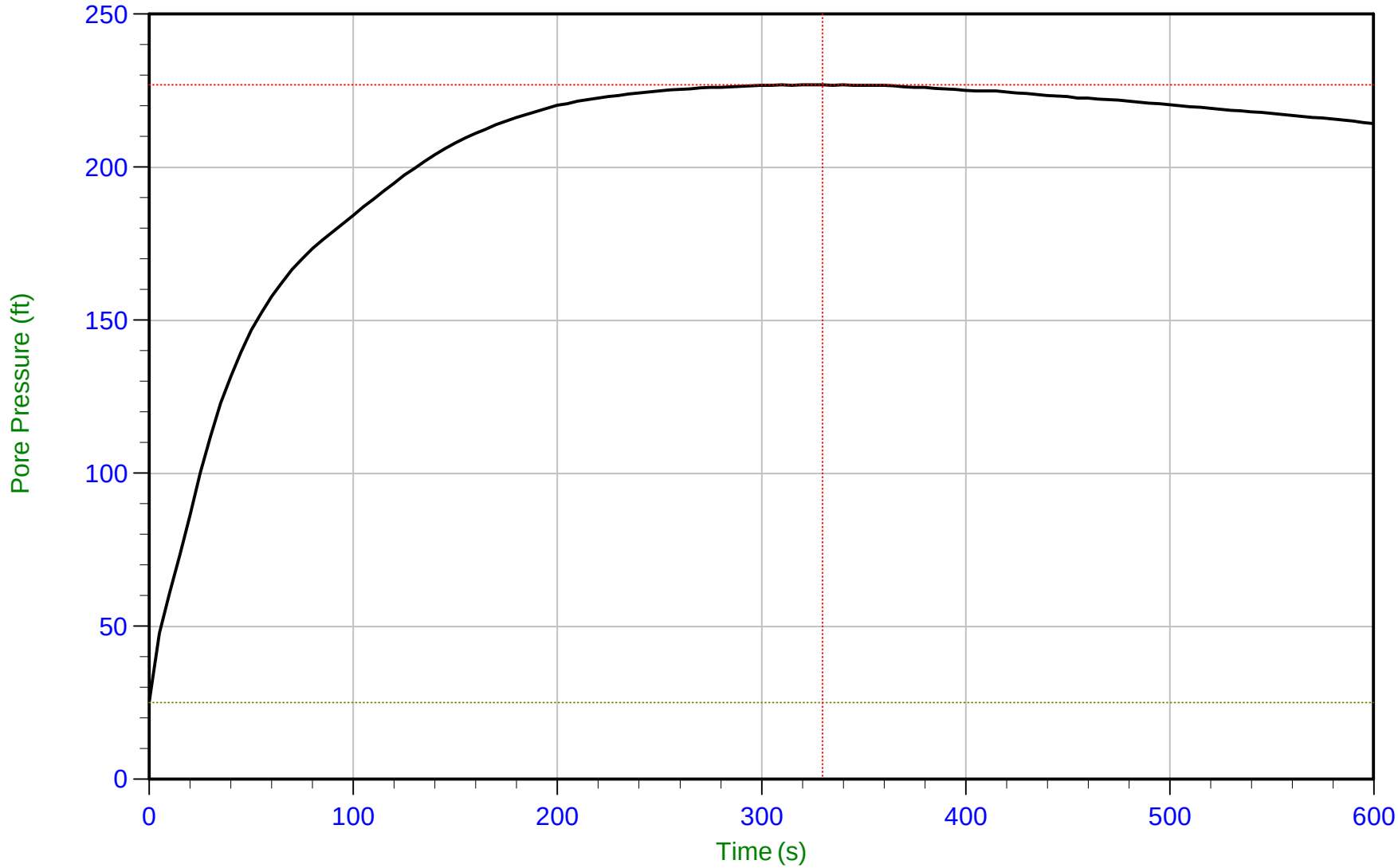
U Min: 92.6 ft
U Max: 169.2 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 13:50
Site: Dynegy Joppa IL

Sounding: JOP-C031
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C031A.PPD
Depth: 18.200 m / 59.711 ft
Duration: 600.0 s

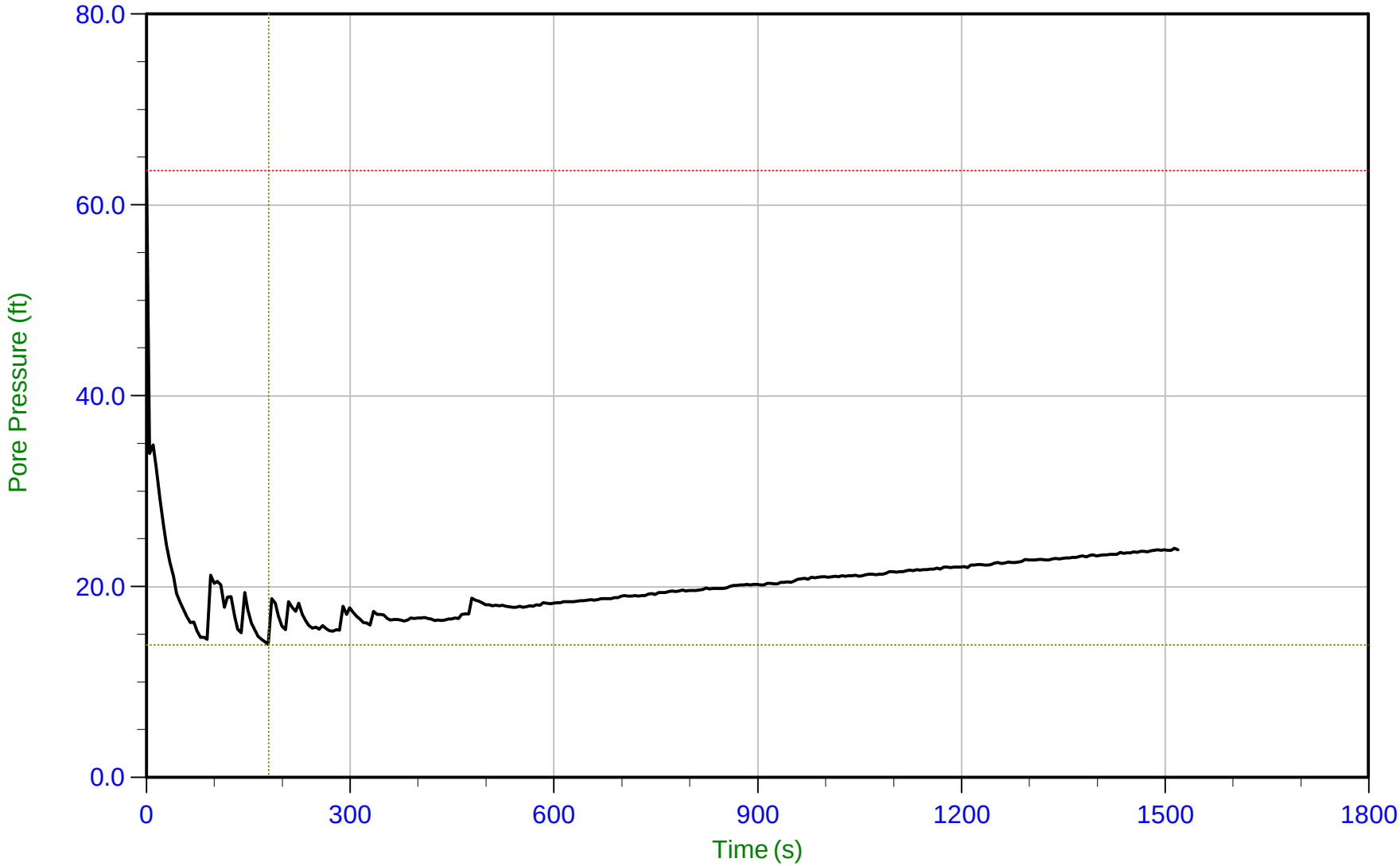
U Min: 25.2 ft
U Max: 226.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 13:50
Site: Dynegy Joppa IL

Sounding: JOP-C031
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C031A.PPD
Depth: 23.750 m / 77.919 ft
Duration: 1520.0 s

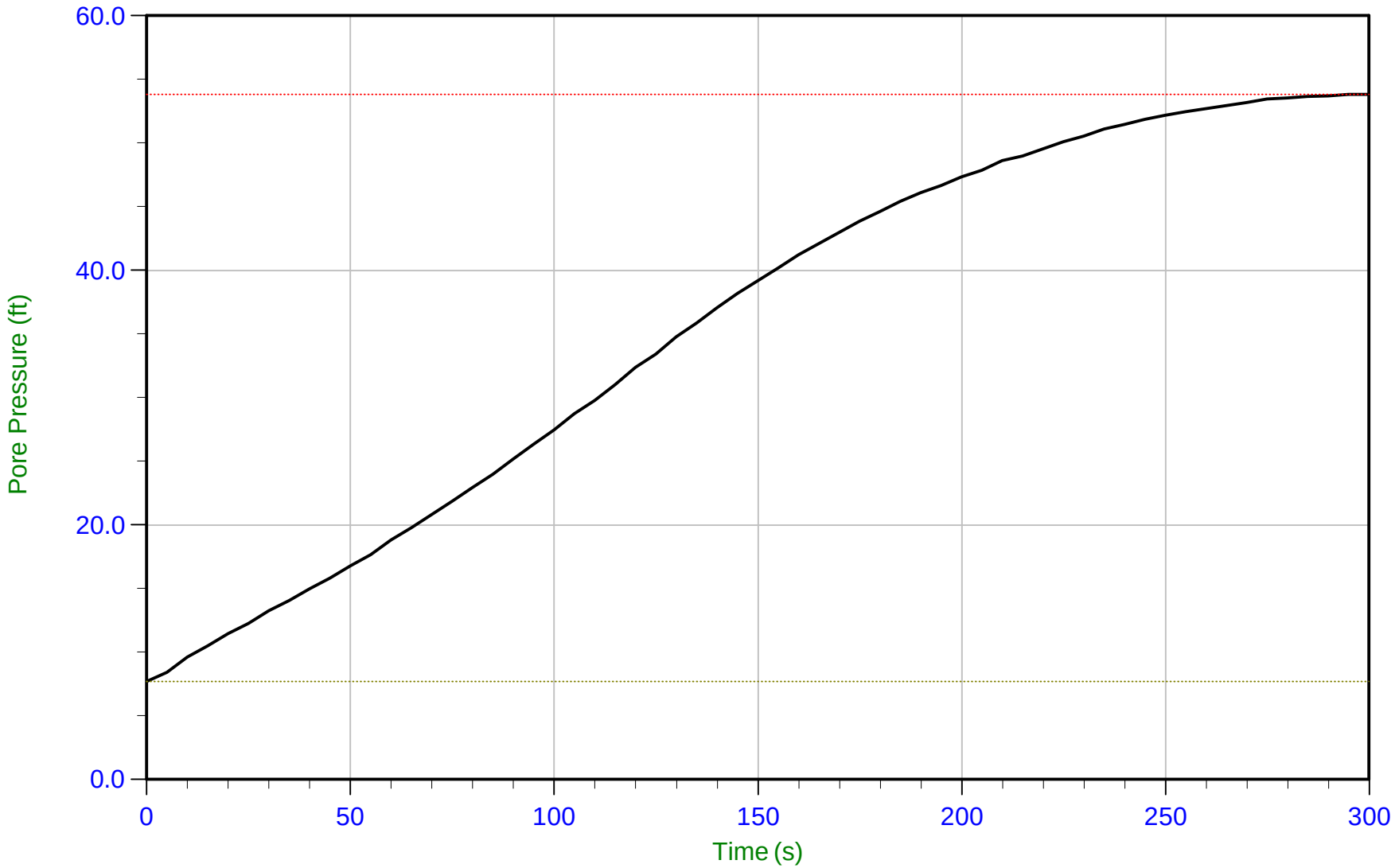
U Min: 13.9 ft
U Max: 63.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 10:44
Site: Dynegy Joppa IL

Sounding: JOP-C032
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C032.PPD
Depth: 9.950 m / 32.644 ft
Duration: 300.0 s

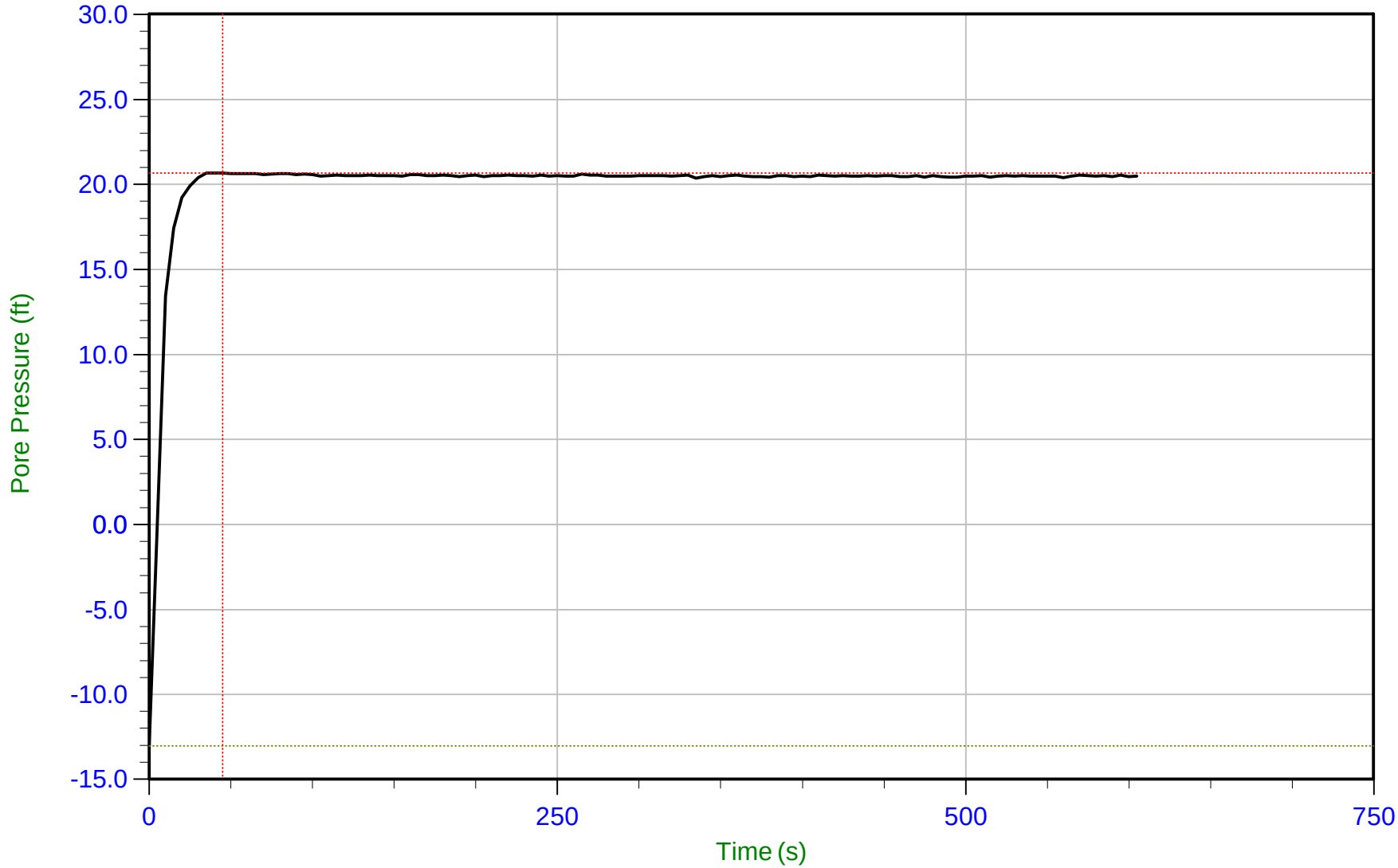
U Min: 7.7 ft
U Max: 53.8 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 10:44
Site: Dynegy Joppa IL

Sounding: JOP-C032
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C032.PPD
Depth: 14.250 m / 46.751 ft
Duration: 605.0 s

U Min: -13.0 ft
U Max: 20.7 ft

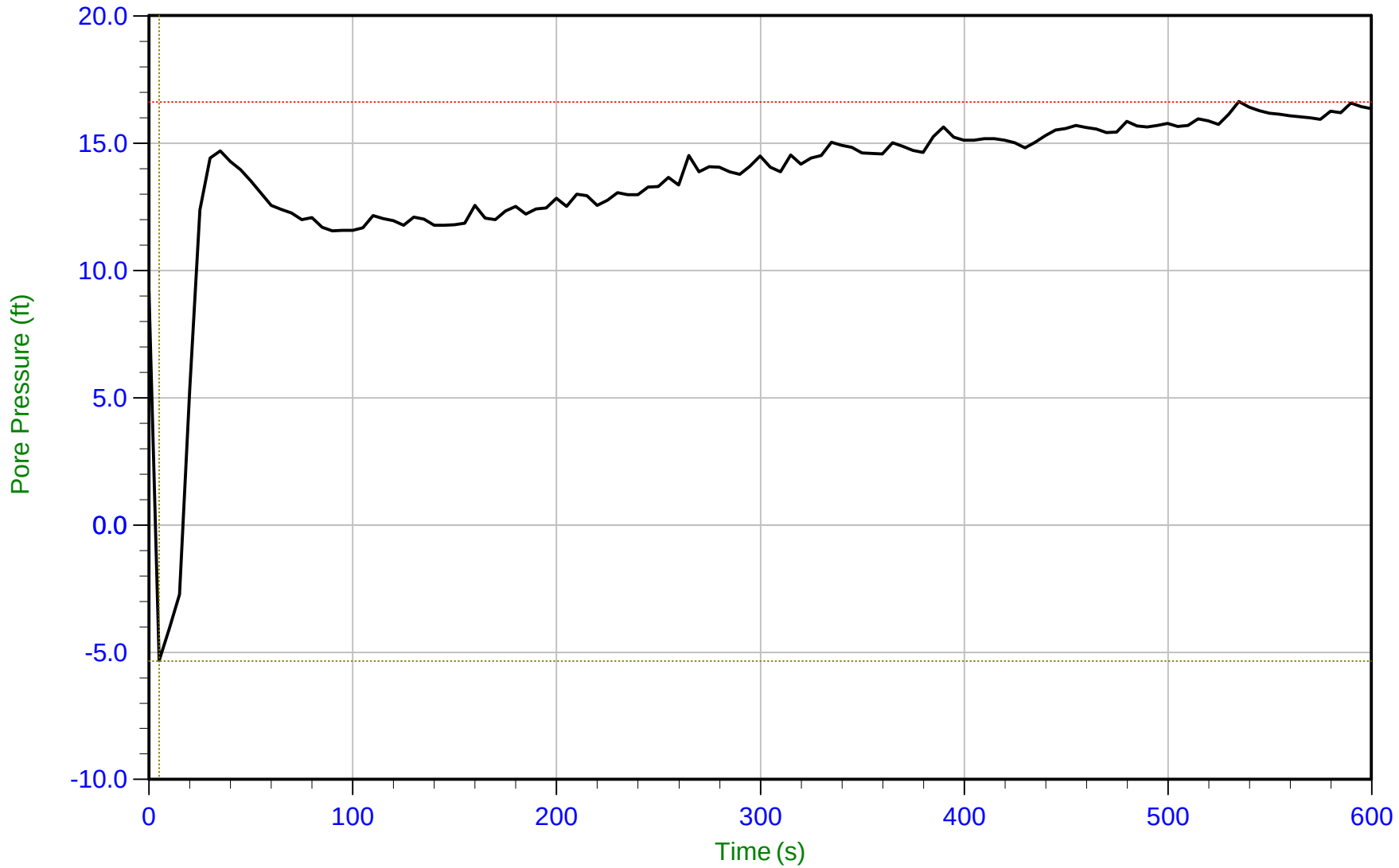
WT: 8.026 m / 26.332 ft
Ueq: 20.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 10:44
Site: Dynegy Joppa IL

Sounding: JOP-C032
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C032.PPD
Depth: 23.950 m / 78.575 ft
Duration: 600.0 s

U Min: -5.3 ft
U Max: 16.6 ft

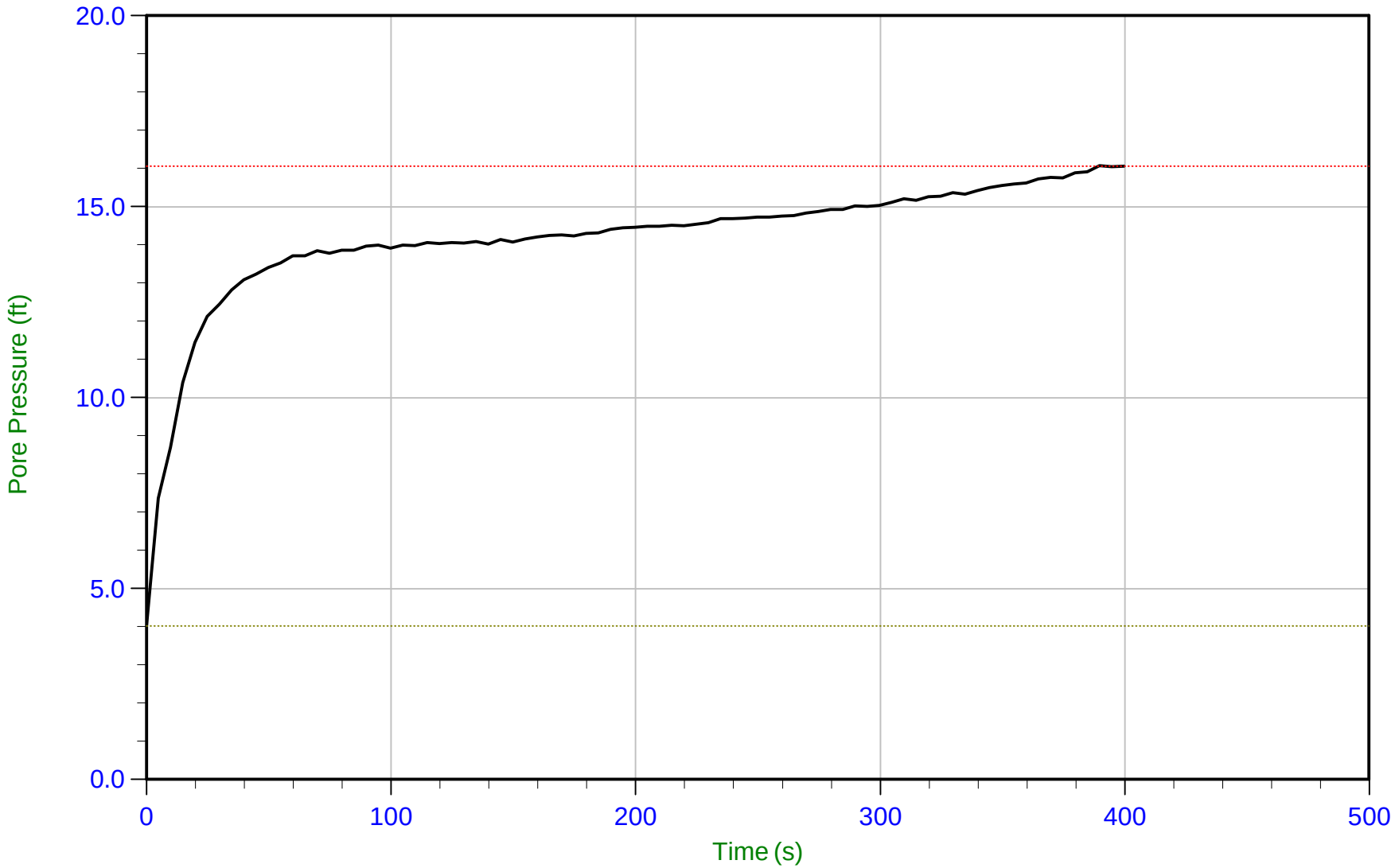
WT: 19.063 m / 62.542 ft
Ueq: 16.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 11:14
Site: Dynegy Joppa IL

Sounding: JOP-C033
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C033.PPD
Depth: 11.050 m / 36.253 ft
Duration: 400.0 s

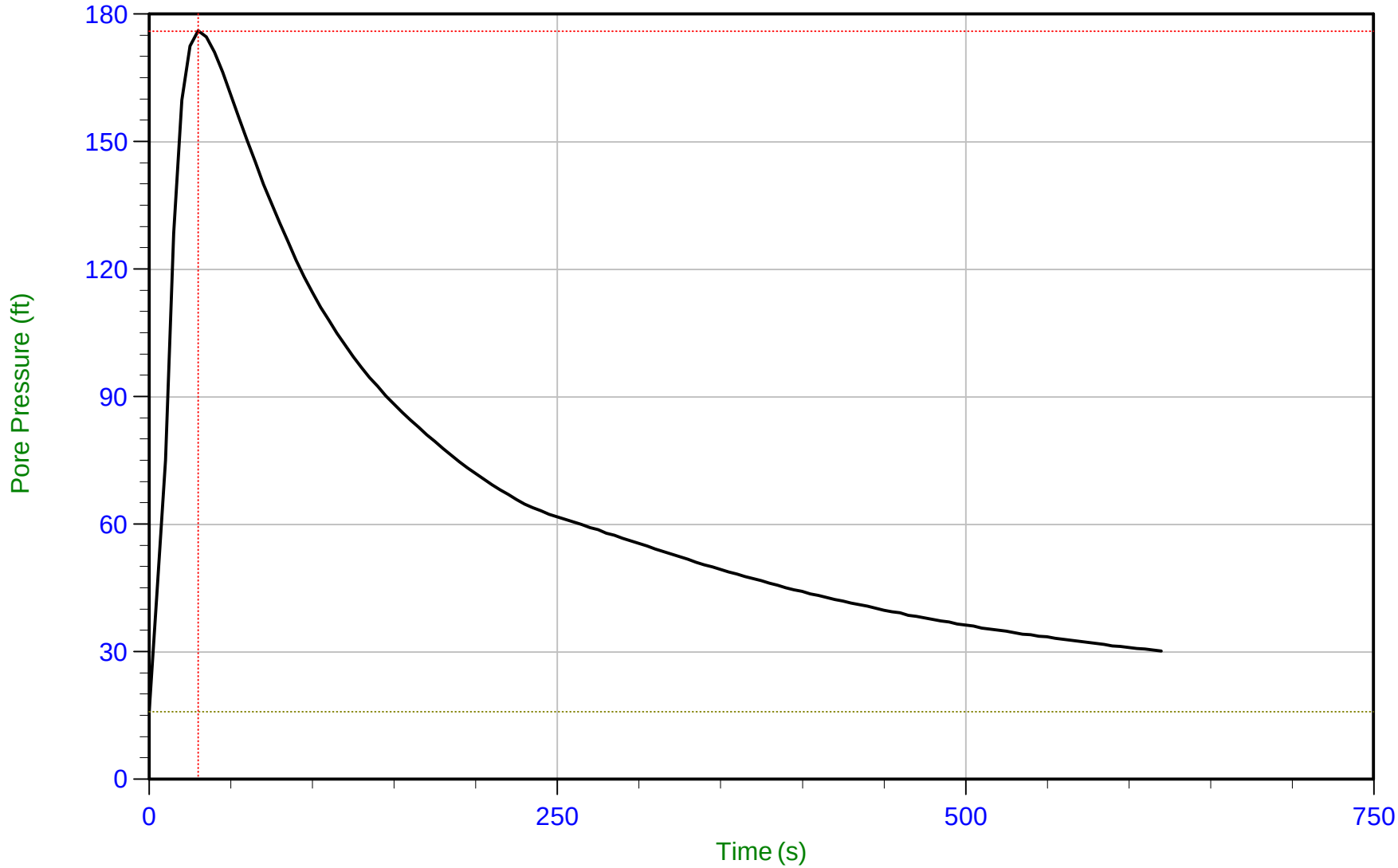
U Min: 4.0 ft
U Max: 16.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 11:14
Site: Dynegy Joppa IL

Sounding: JOP-C033
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C033.PPD
Depth: 16.200 m / 53.149 ft
Duration: 620.0 s

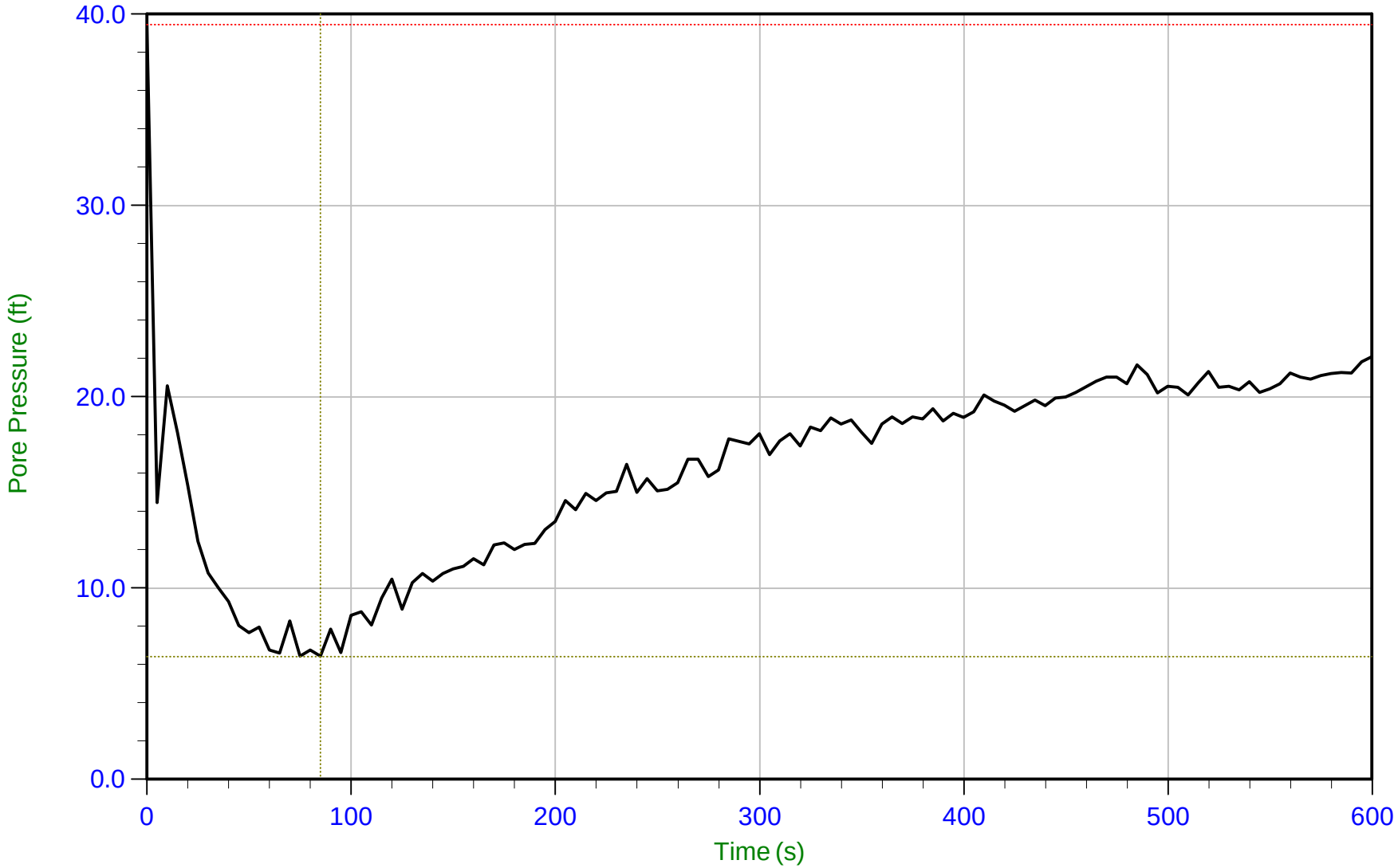
U Min: 15.9 ft
U Max: 176.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 11:14
Site: Dynegy Joppa IL

Sounding: JOP-C033
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C033.PPD
Depth: 26.000 m / 85.301 ft
Duration: 600.0 s

U Min: 6.4 ft
U Max: 39.5 ft

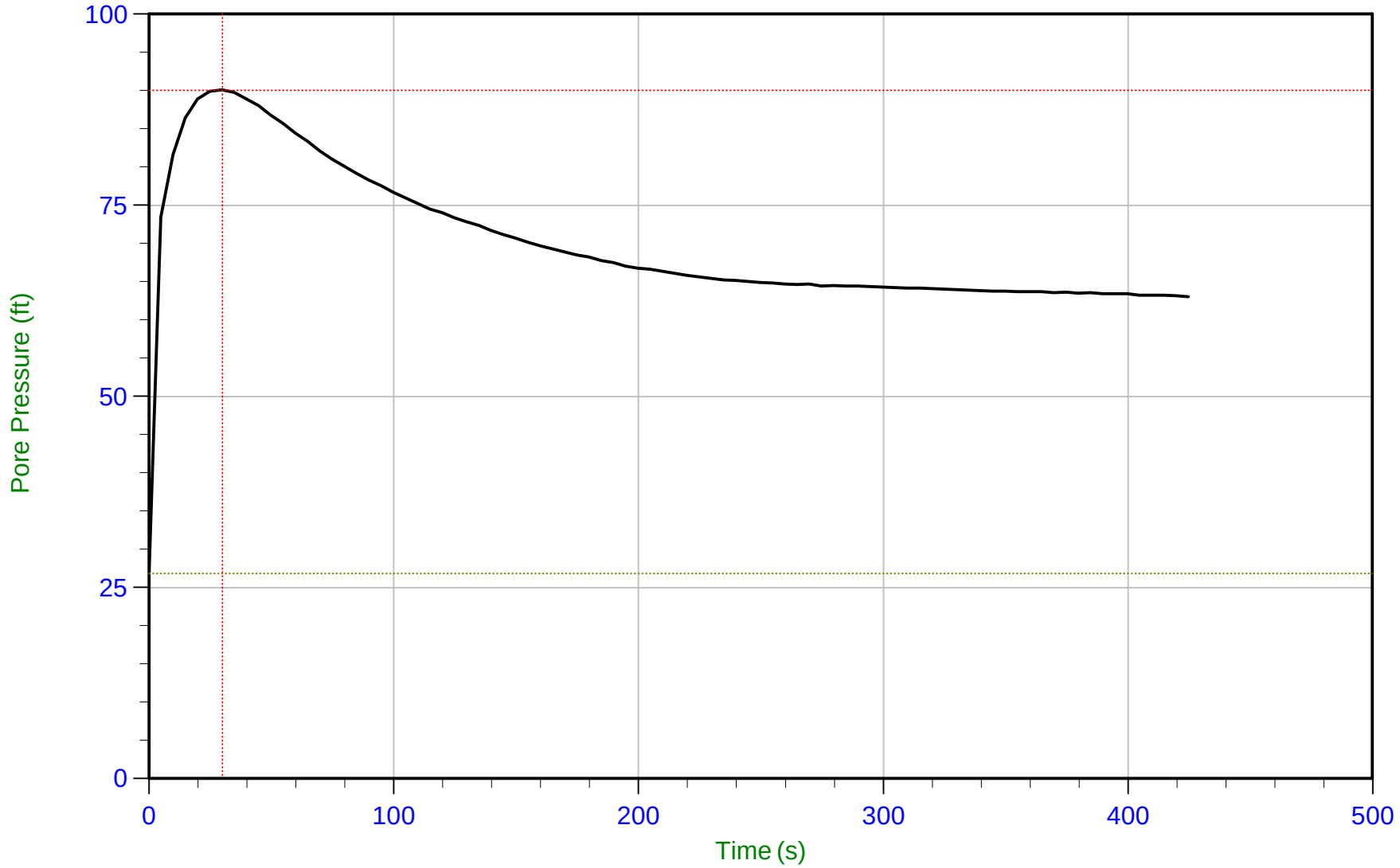
WT: 19.471 m / 63.882 ft
Ueq: 21.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 14:05
Site: Dynegy Joppa IL

Sounding: JOP-C034
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C034.PPD
Depth: 10.500 m / 34.448 ft
Duration: 425.0 s

U Min: 26.9 ft
U Max: 90.1 ft

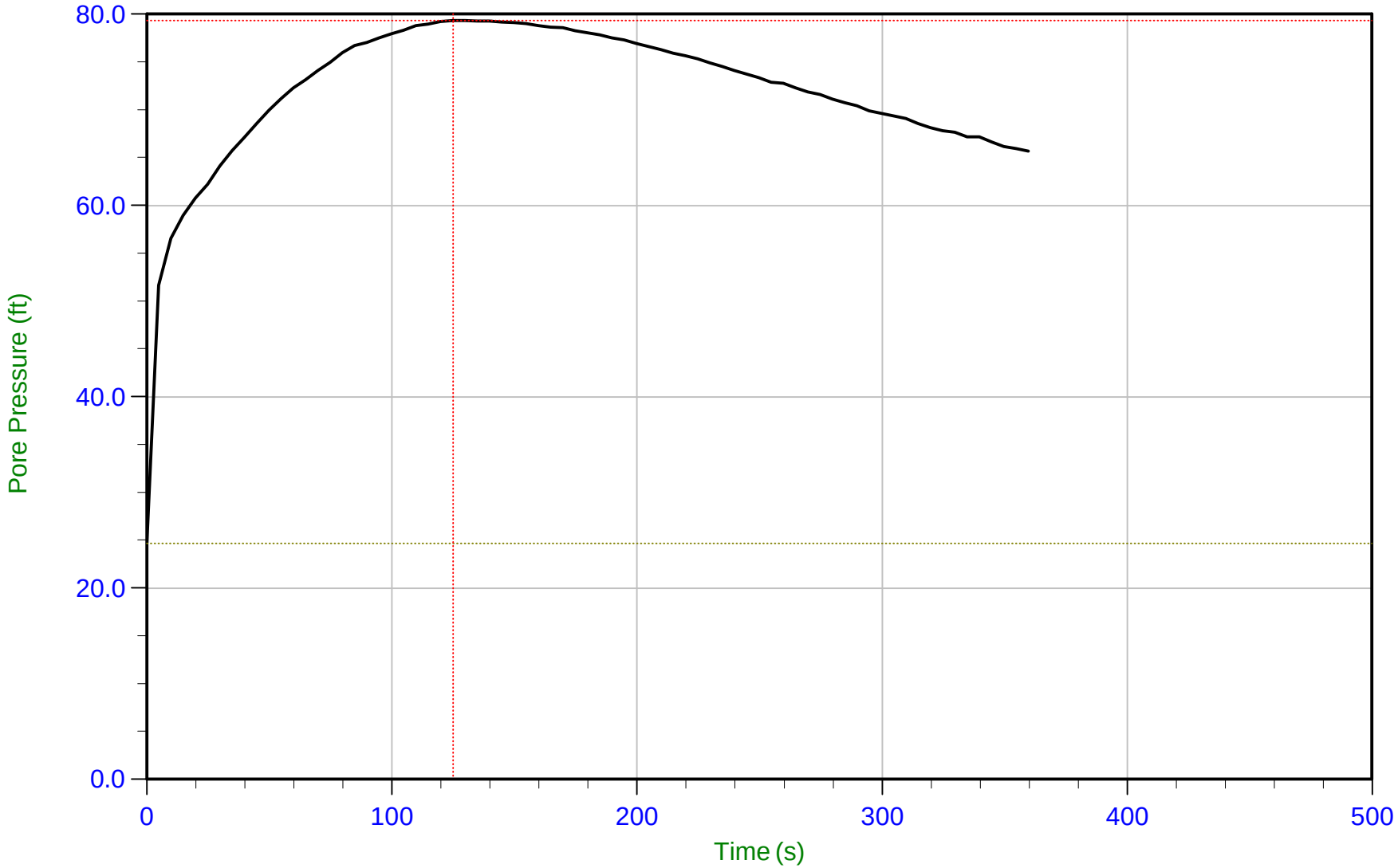
WT: -8.673 m / -28.454 ft
Ueq: 62.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 14:05
Site: Dynegy Joppa IL

Sounding: JOP-C034
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C034.PPD
Depth: 16.350 m / 53.641 ft
Duration: 360.0 s

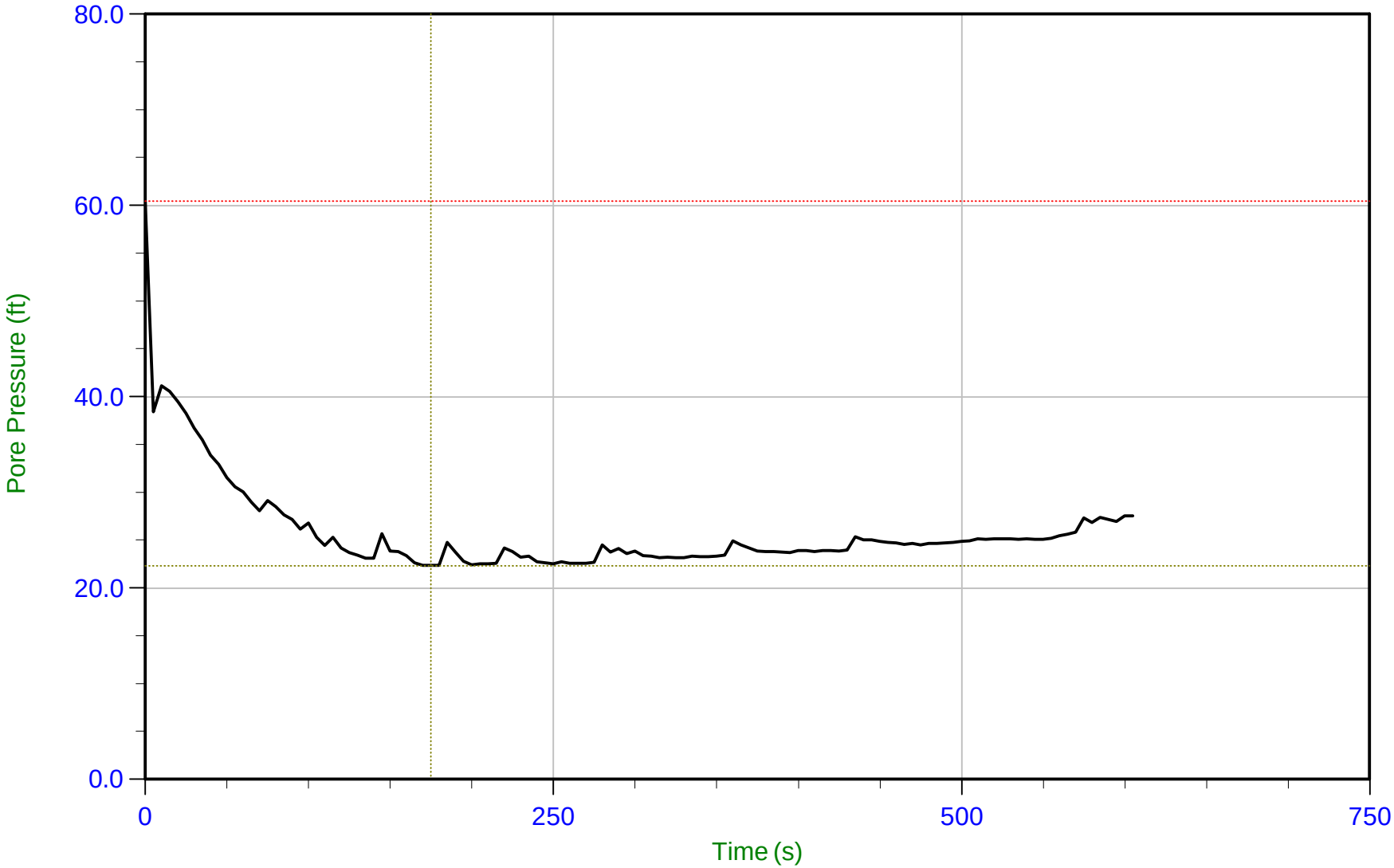
U Min: 24.7 ft
U Max: 79.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 14:05
Site: Dynegy Joppa IL

Sounding: JOP-C034
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C034.PPD
Depth: 23.900 m / 78.411 ft
Duration: 605.0 s

U Min: 22.4 ft
U Max: 60.5 ft

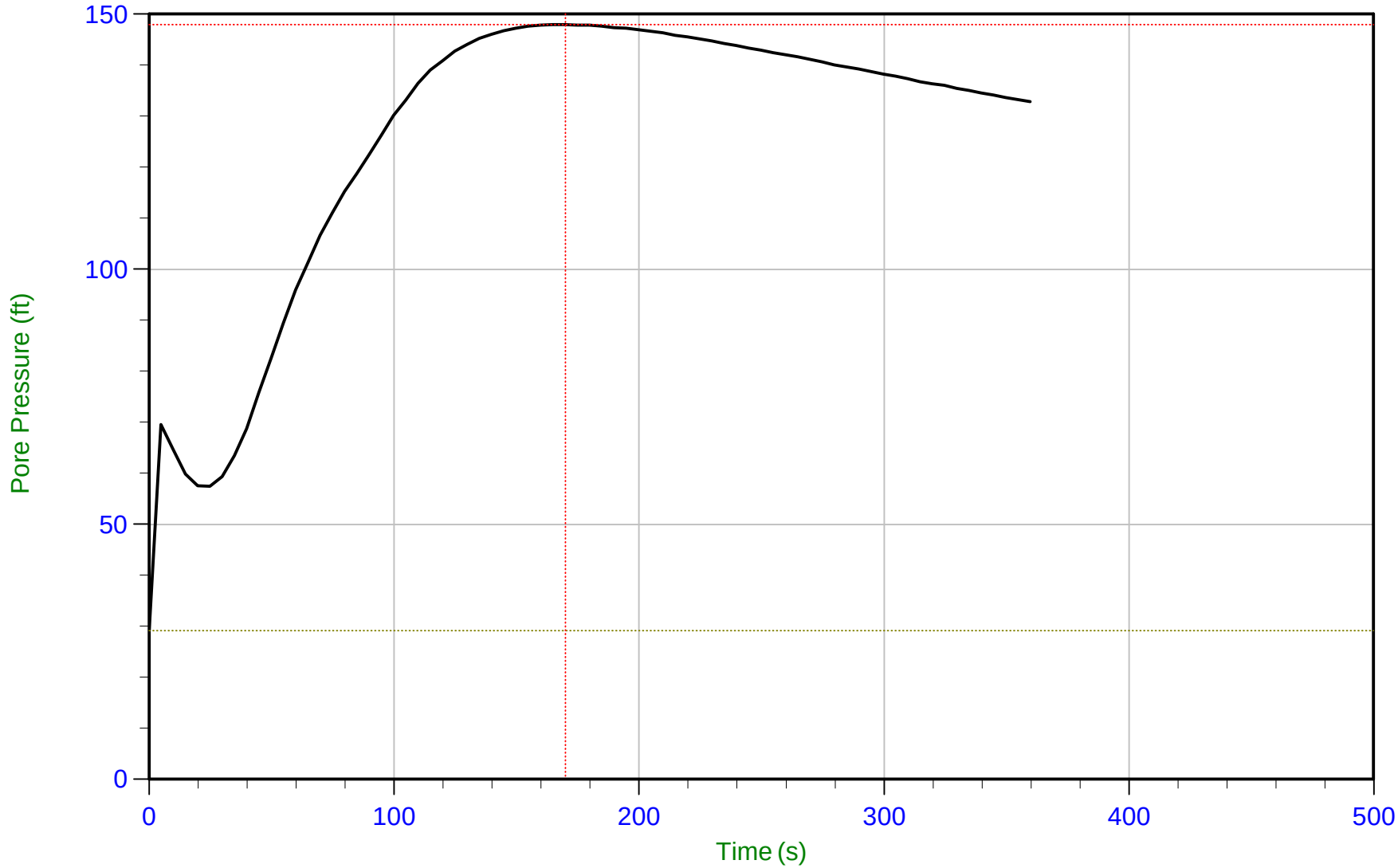
WT: 16.113 m / 52.863 ft
Ueq: 25.5 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/08/2015 10:23
Site: Dynegy Joppa IL

Sounding: JOP-C035
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C035.PPD
Depth: 23.450 m / 76.935 ft
Duration: 360.0 s

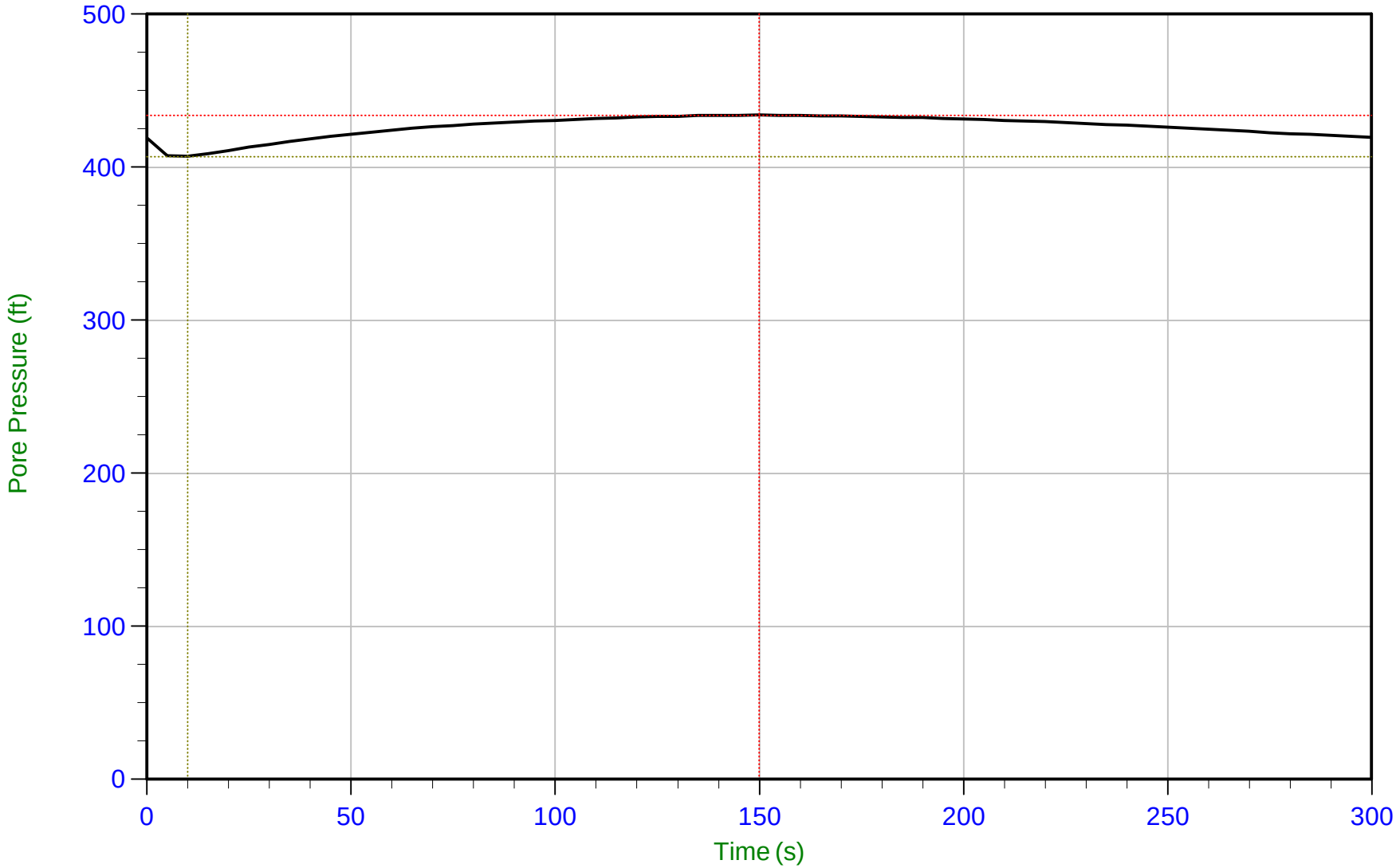
U Min: 29.2 ft
U Max: 148.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/08/2015 10:23
Site: Dynegy Joppa IL

Sounding: JOP-C035
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C035.PPD
Depth: 29.000 m / 95.143 ft
Duration: 300.0 s

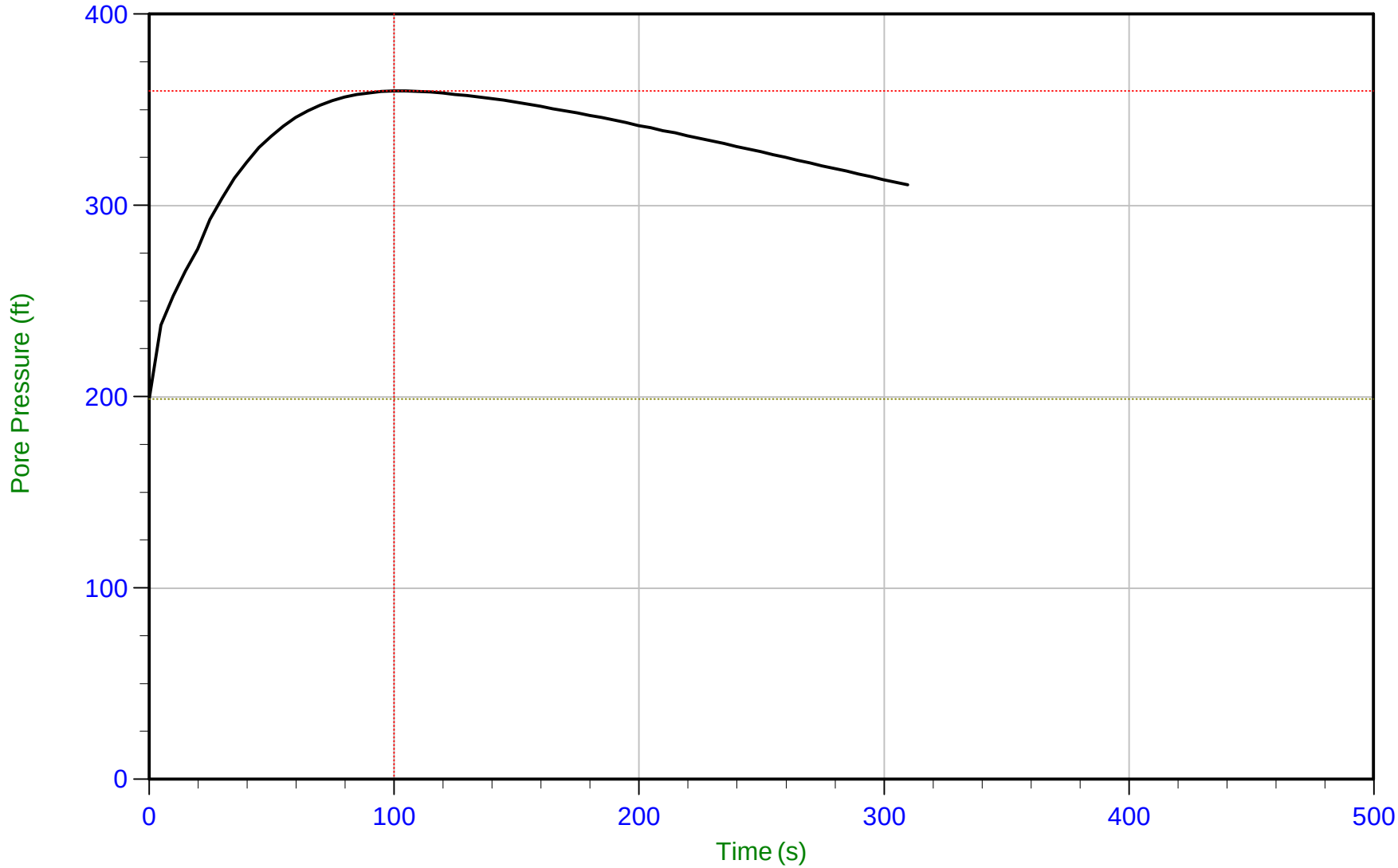
U Min: 407.1 ft
U Max: 434.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/08/2015 10:23
Site: Dynegy Joppa IL

Sounding: JOP-C035
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C035.PPD
Depth: 30.000 m / 98.424 ft
Duration: 310.0 s

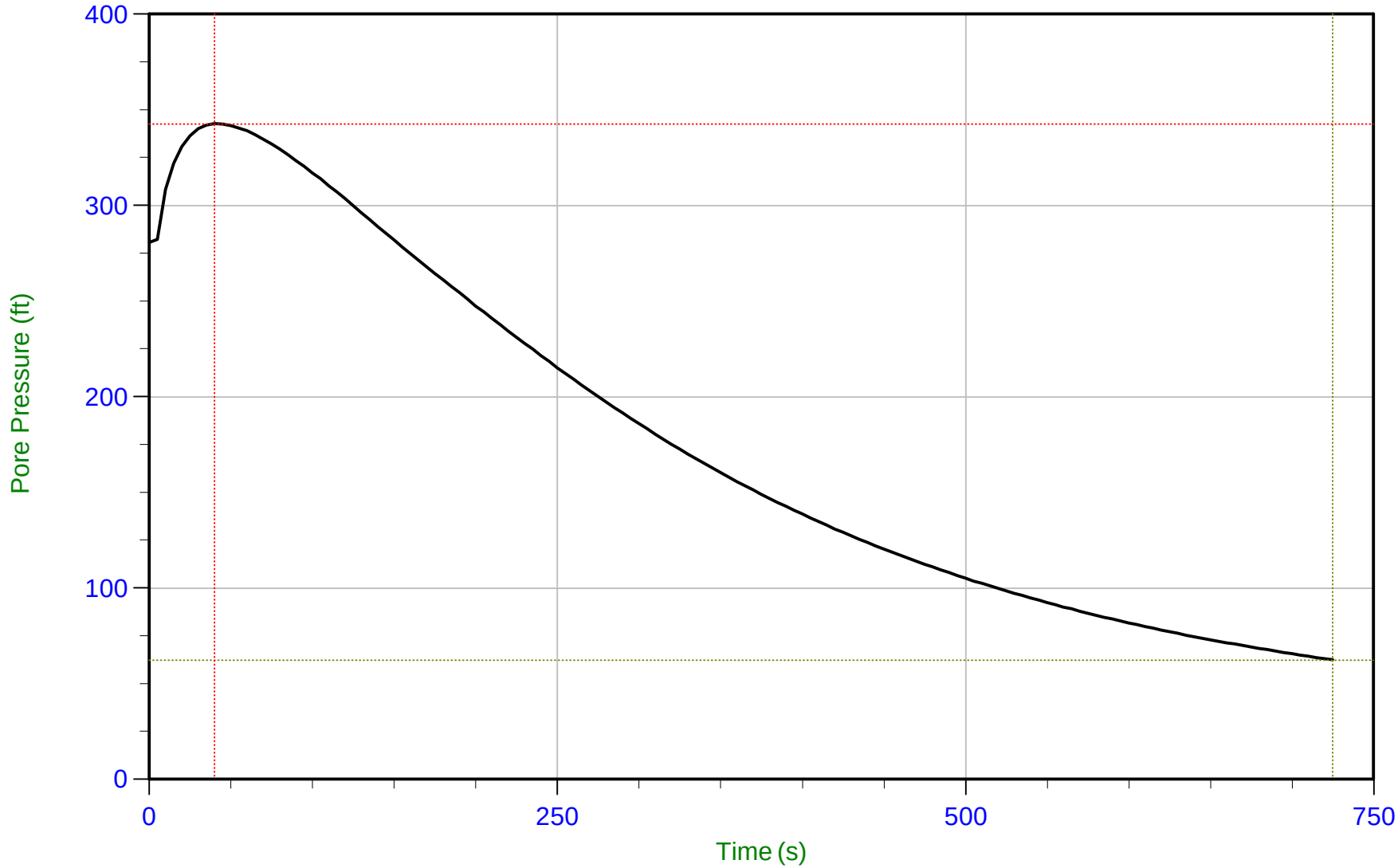
U Min: 198.8 ft
U Max: 360.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/13/2015 07:34
Site: Dynegy Joppa, I

Sounding: JOP-C036
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C036.PPD
Depth: 7.500 m / 24.606 ft
Duration: 725.0 s

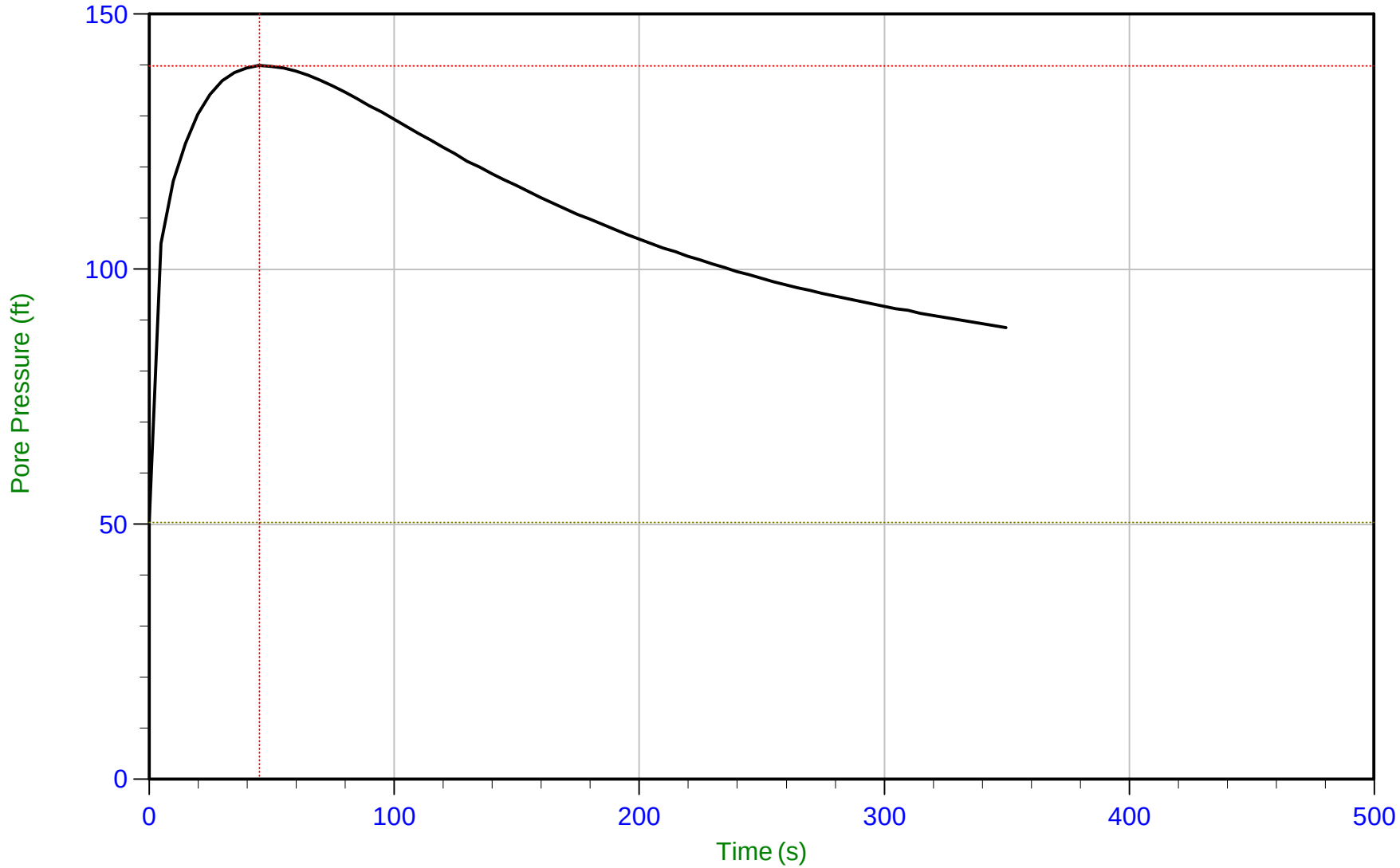
U Min: 62.4 ft
U Max: 342.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/13/2015 07:34
Site: Dynegy Joppa, I

Sounding: JOP-C036
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C036.PPD
Depth: 10.000 m / 32.808 ft
Duration: 350.0 s

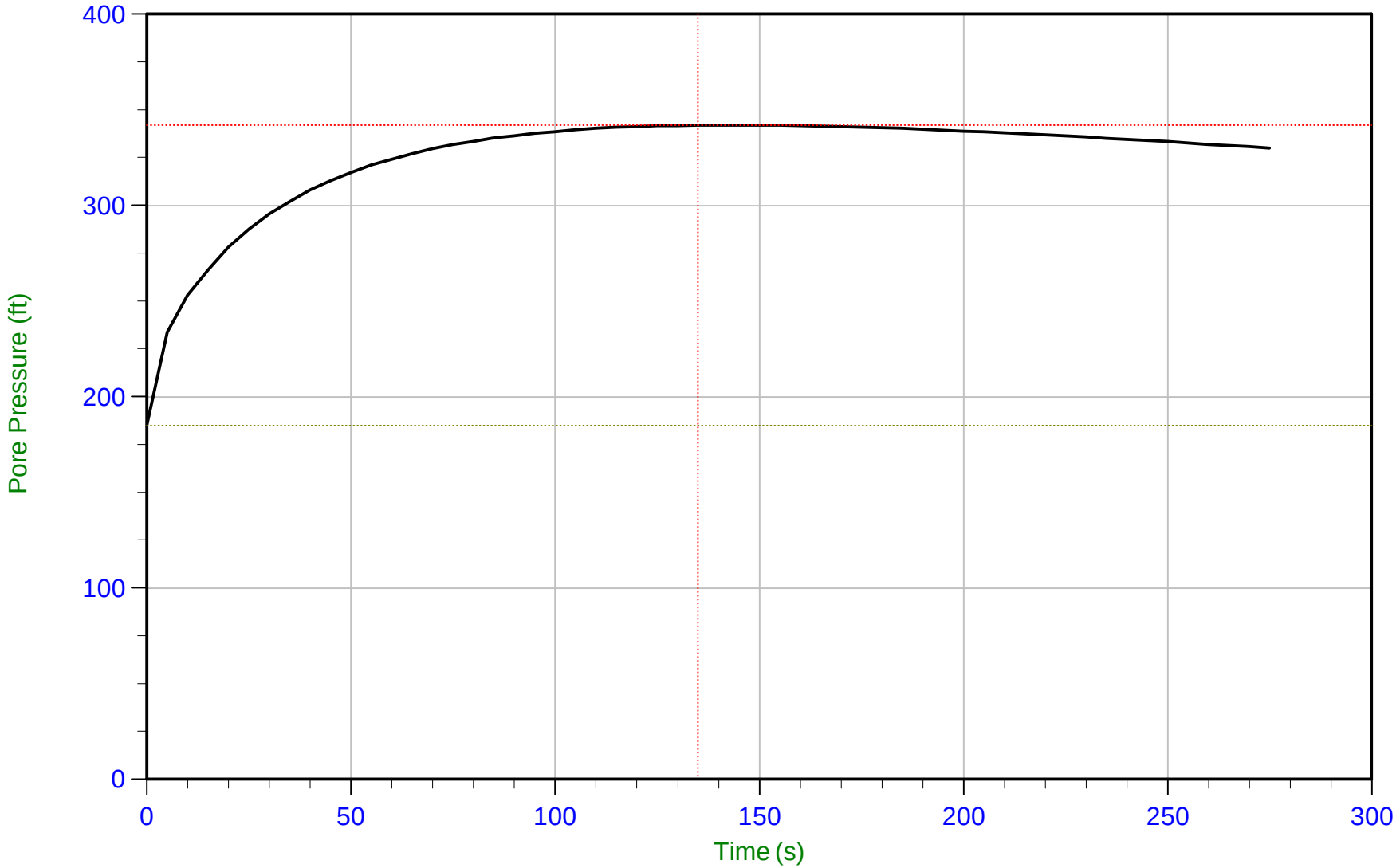
U Min: 50.4 ft
U Max: 139.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/13/2015 07:34
Site: Dynegy Joppa, I

Sounding: JOP-C036
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C036.PPD
Depth: 15.250 m / 50.032 ft
Duration: 275.0 s

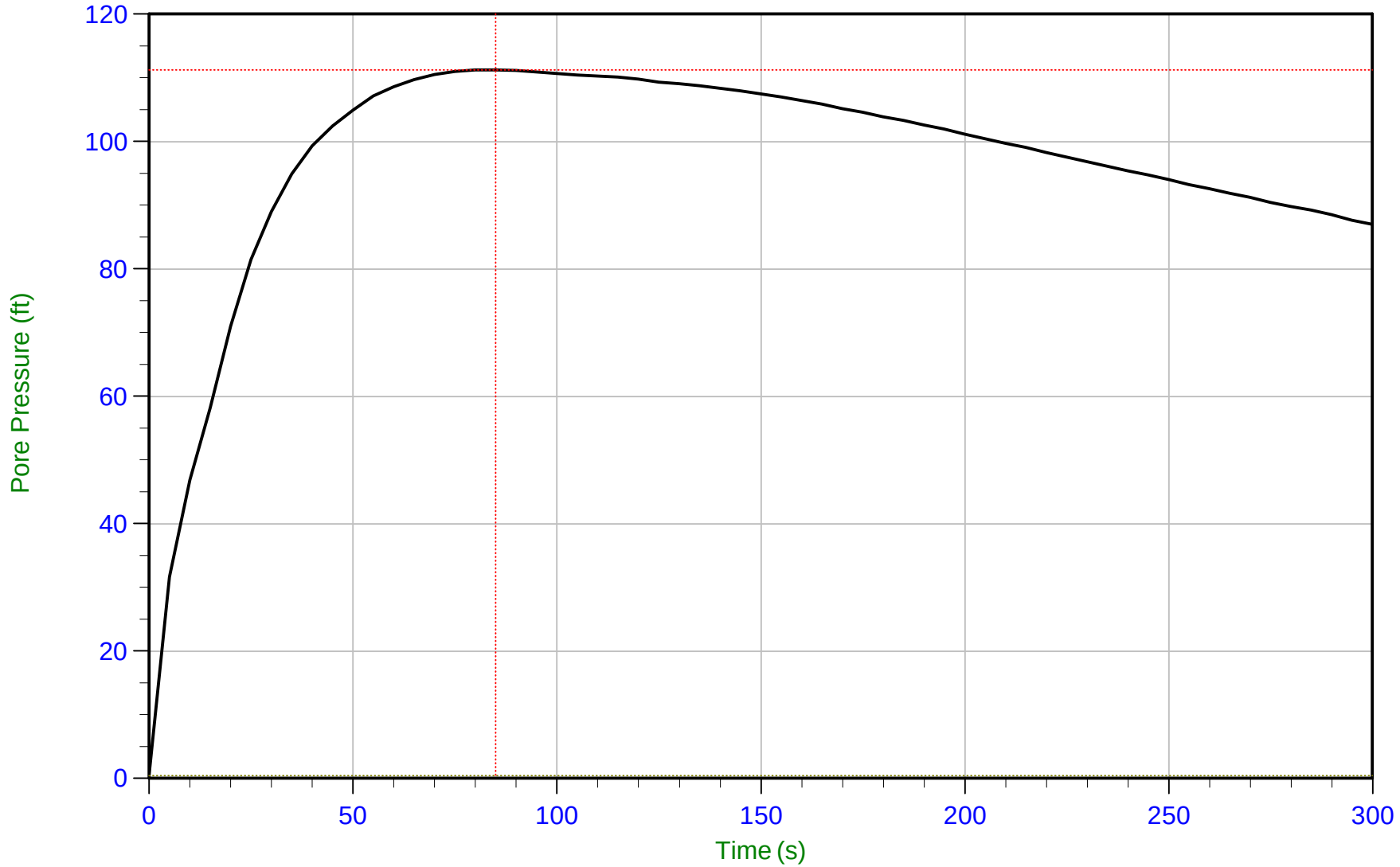
U Min: 185.2 ft
U Max: 342.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 09:31
Site: Dynegy Joppa, I

Sounding: JOP-C037
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C037.PPD
Depth: 4.450 m / 14.600 ft
Duration: 300.0 s

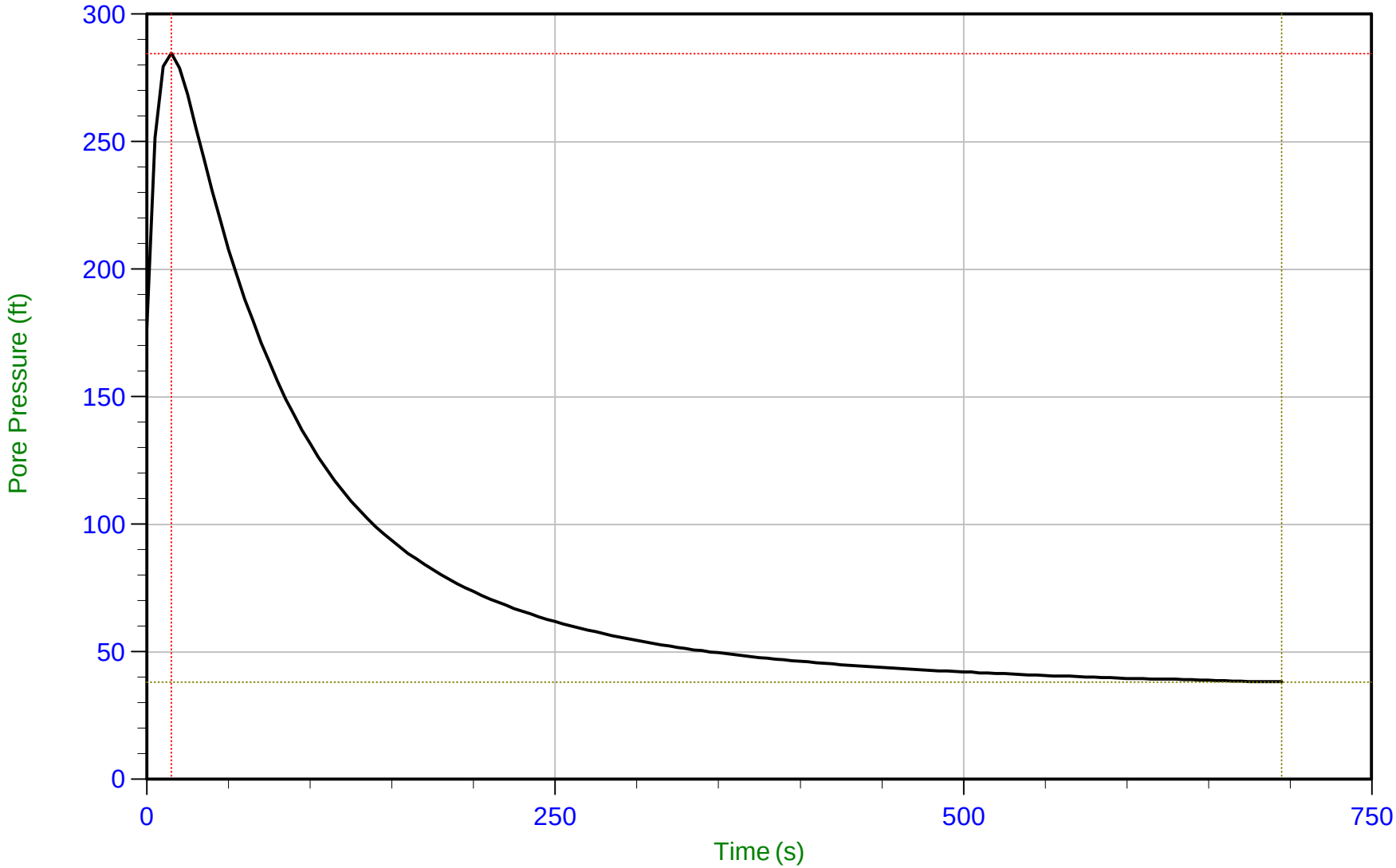
U Min: 0.5 ft
U Max: 111.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 09:31
Site: Dynegy Joppa, I

Sounding: JOP-C037
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C037.PPD
Depth: 10.850 m / 35.597 ft
Duration: 695.0 s

U Min: 38.2 ft
U Max: 284.6 ft

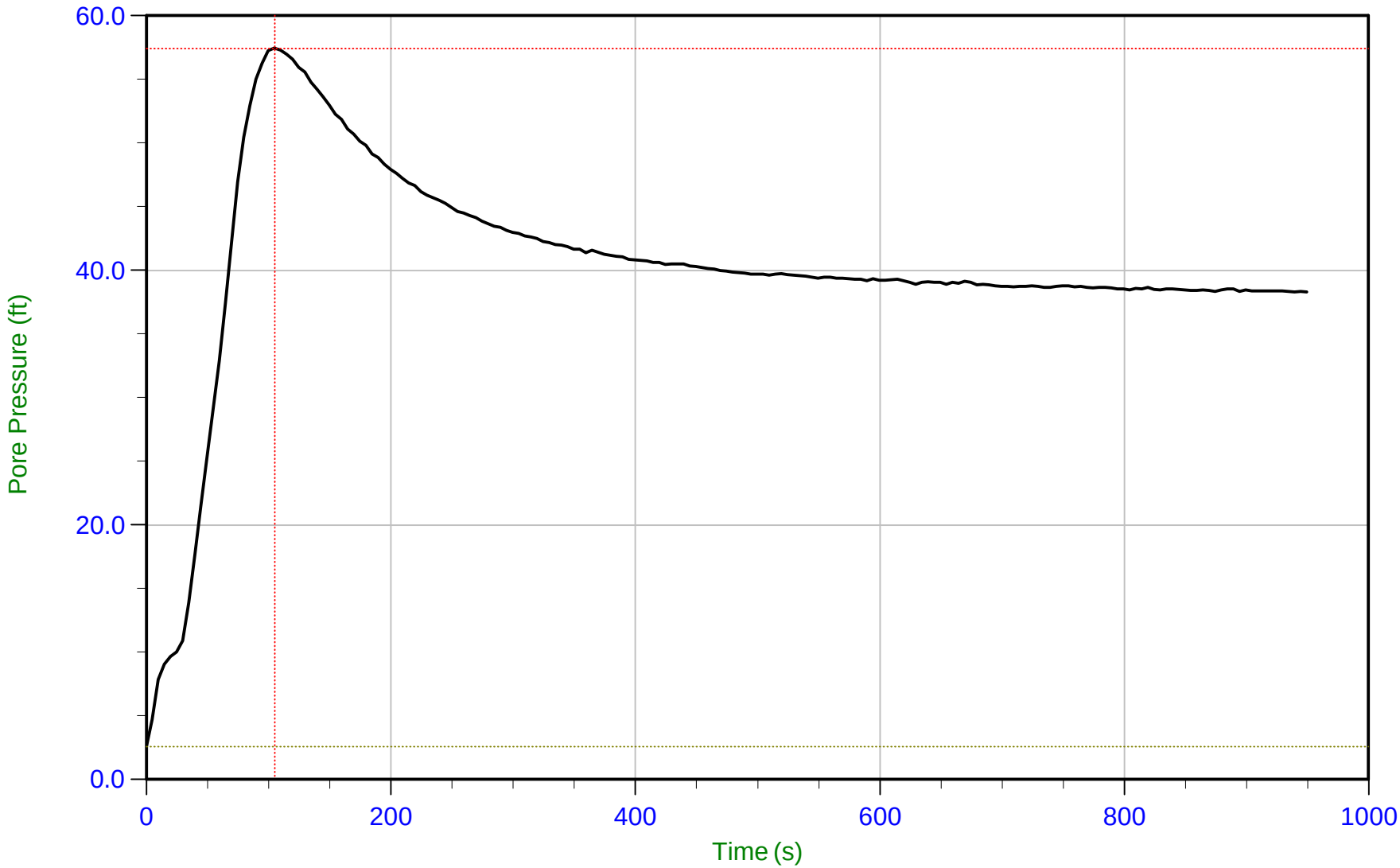
WT: 0.000 m / 0.000 ft
Ueq: 35.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/12/2015 09:31
Site: Dynegy Joppa, I

Sounding: JOP-C037
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C037.PPD
Depth: 12.200 m / 40.026 ft
Duration: 950.0 s

U Min: 2.6 ft
U Max: 57.4 ft

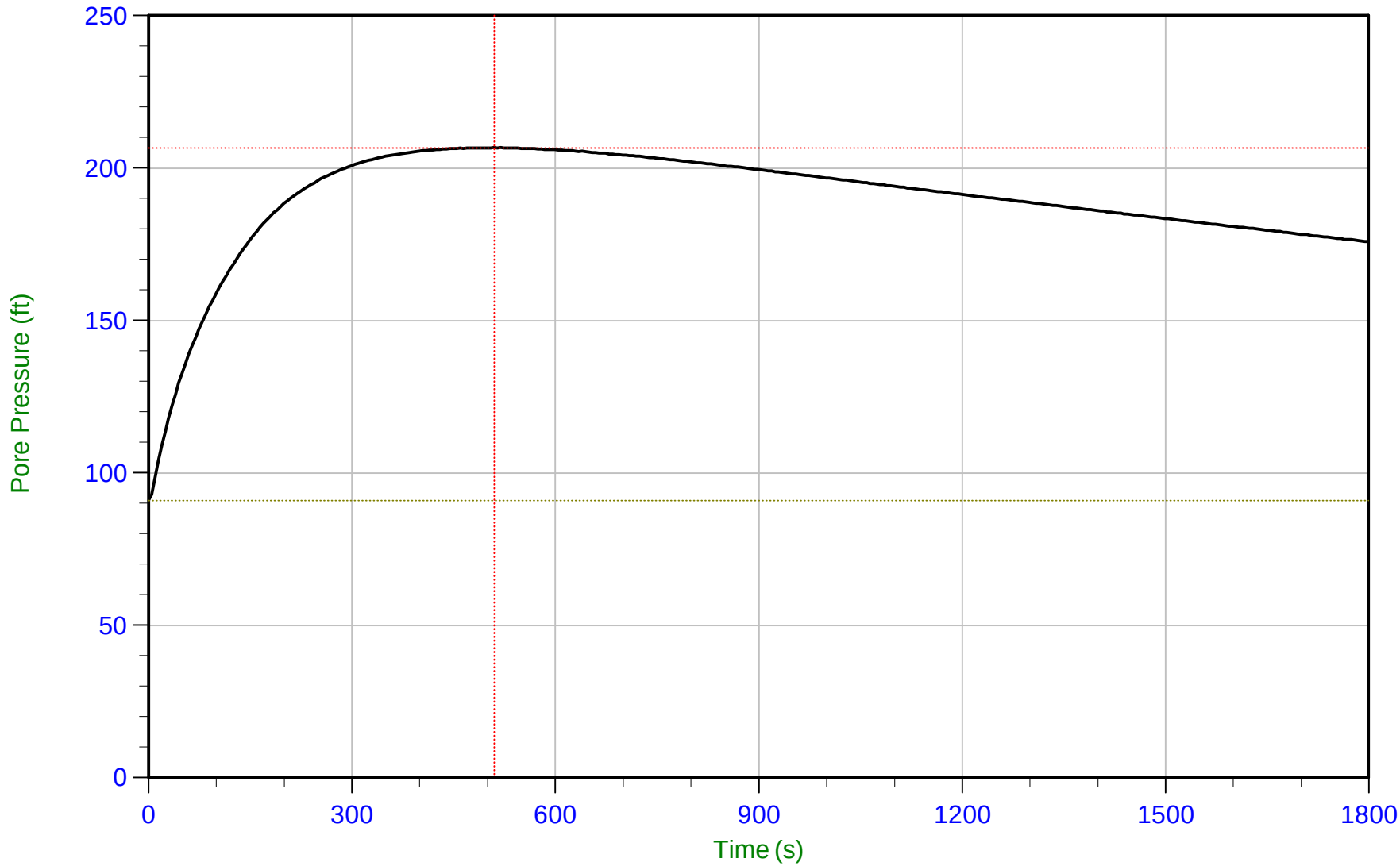
WT: 0.519 m / 1.703 ft
Ueq: 38.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/07/2015 11:37
Site: Dynegy Joppa IL

Sounding: JOP-SC002
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC002.PPD
Depth: 19.550 m / 64.140 ft
Duration: 1800.0 s

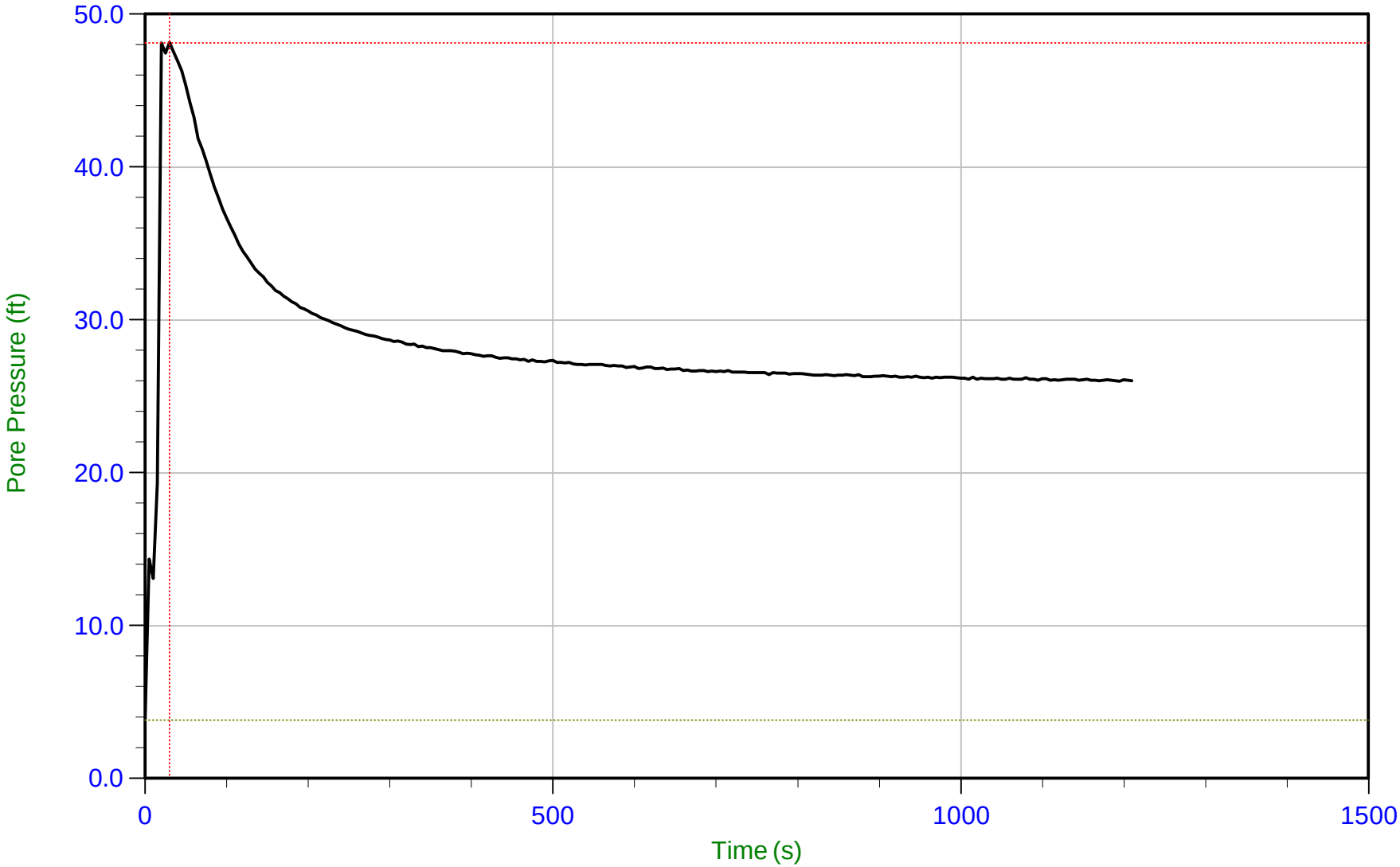
U Min: 91.0 ft
U Max: 206.7 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/07/2015 11:37
Site: Dynegy Joppa IL

Sounding: JOP-SC002
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC002.PPD
Depth: 27.500 m / 90.222 ft
Duration: 1210.0 s

U Min: 3.8 ft
U Max: 48.1 ft

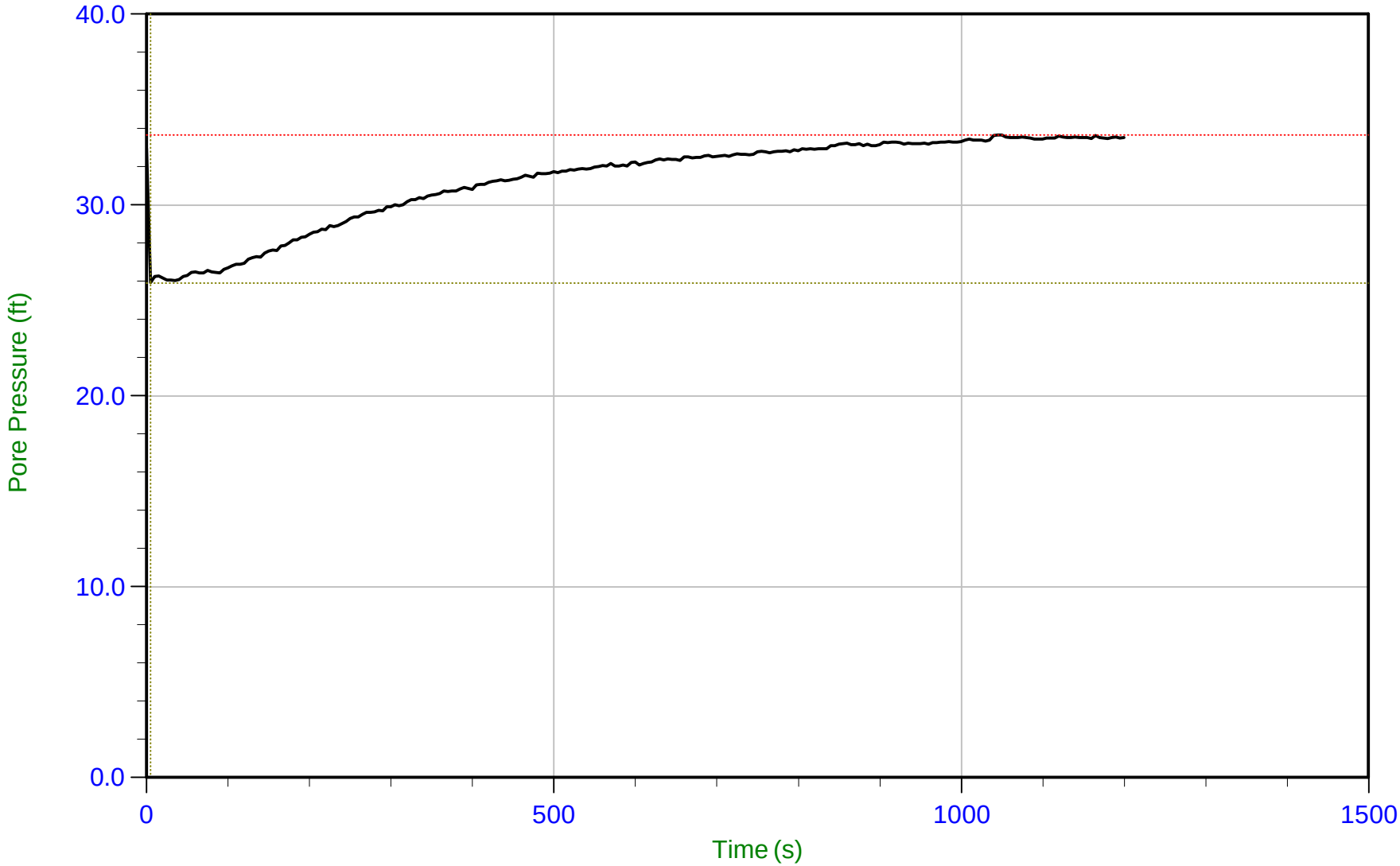
WT: 19.585 m / 64.255 ft
Ueq: 26.0 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/07/2015 11:37
Site: Dynegy Joppa IL

Sounding: JOP-SC002
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC002.PPD
Depth: 30.300 m / 99.408 ft
Duration: 1200.0 s

U Min: 25.9 ft
U Max: 33.7 ft

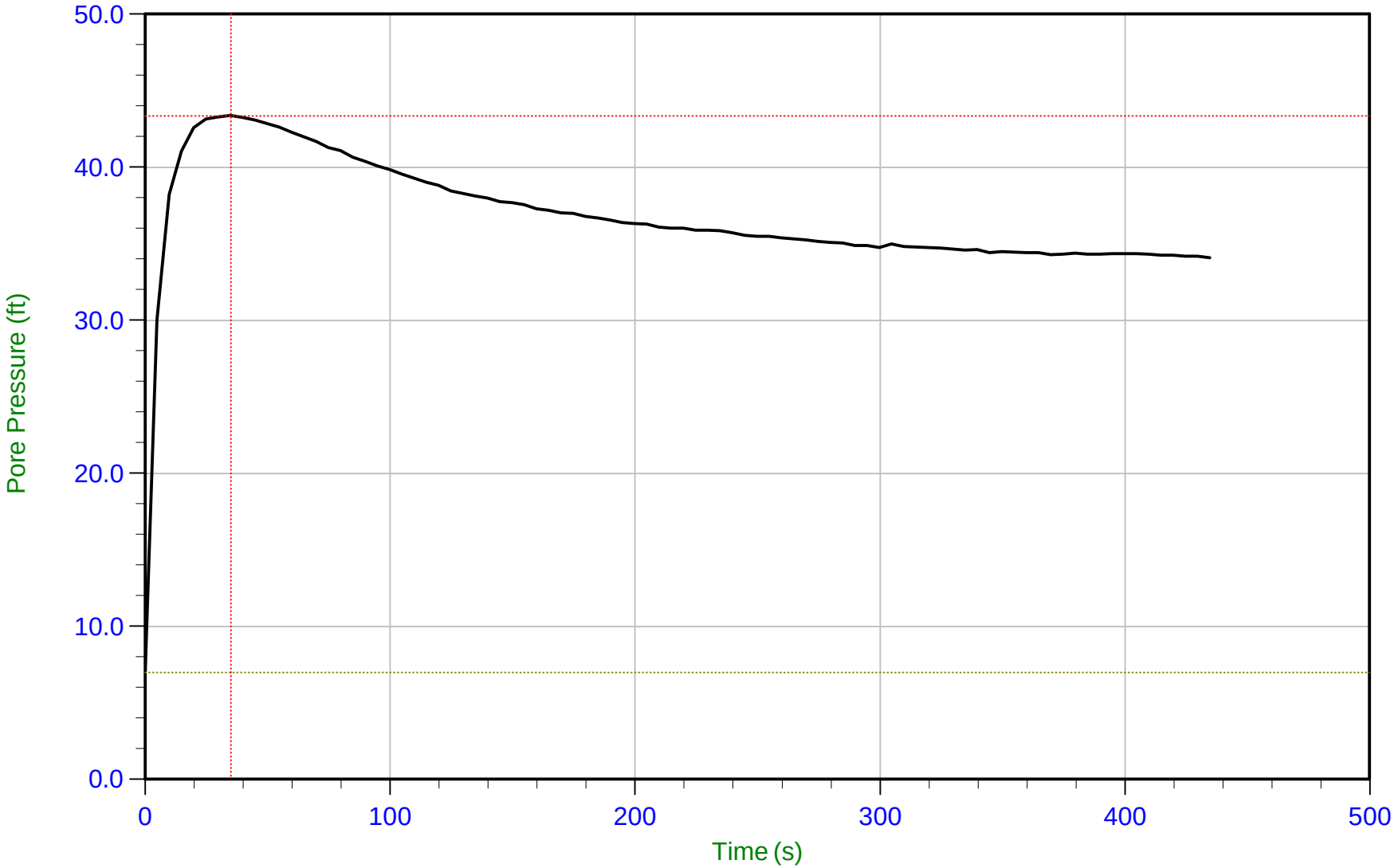
WT: 20.114 m / 65.989 ft
Ueq: 33.4 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 07:46
Site: Dynegy Joppa IL

Sounding: JOP-SC010
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC010.PPD
Depth: 13.150 m / 43.143 ft
Duration: 435.0 s

U Min: 7.0 ft
U Max: 43.4 ft

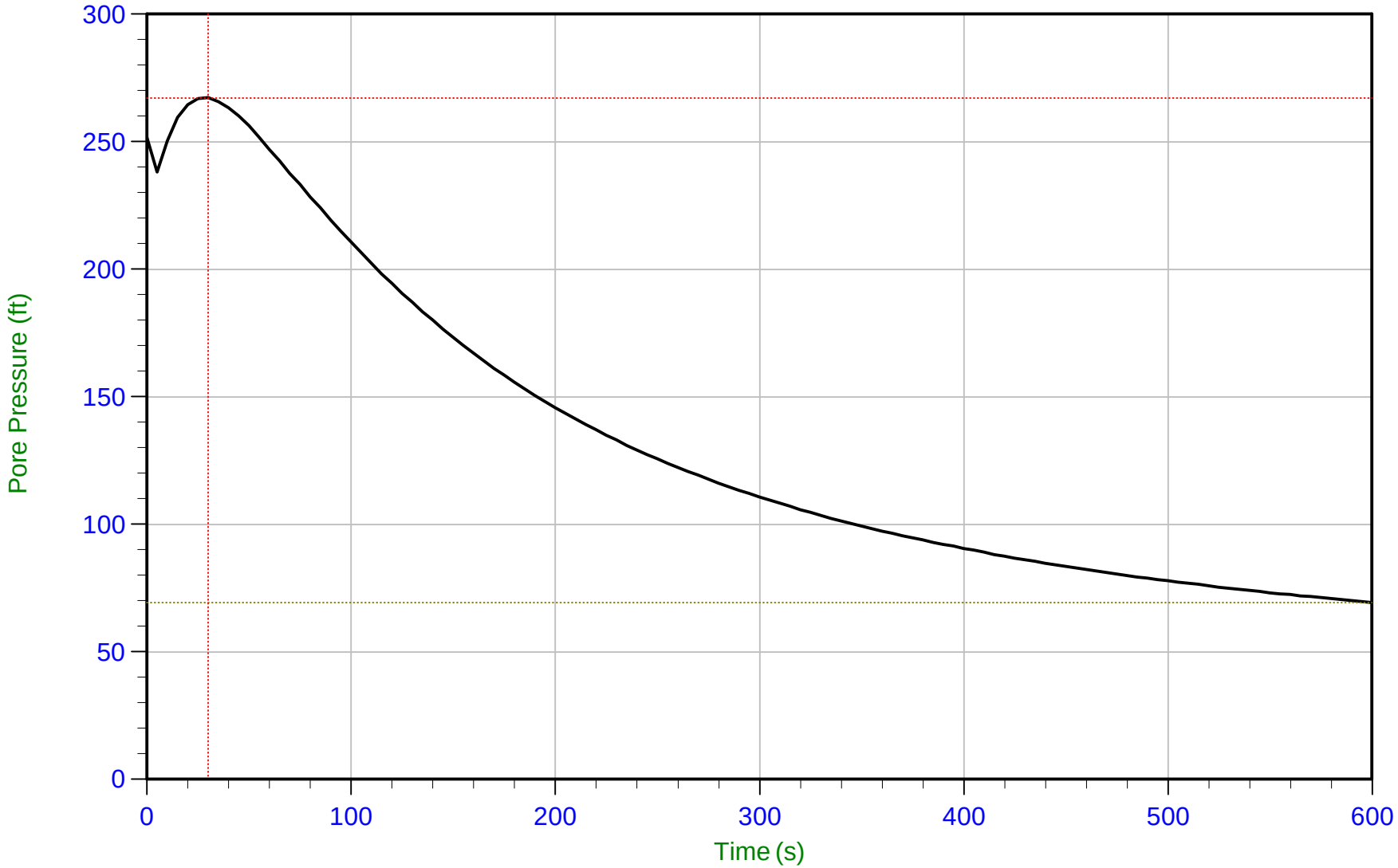
WT: 2.826 m / 9.272 ft
Ueq: 33.9 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 07:46
Site: Dynegy Joppa IL

Sounding: JOP-SC010
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC010.PPD
Depth: 20.750 m / 68.077 ft
Duration: 600.0 s

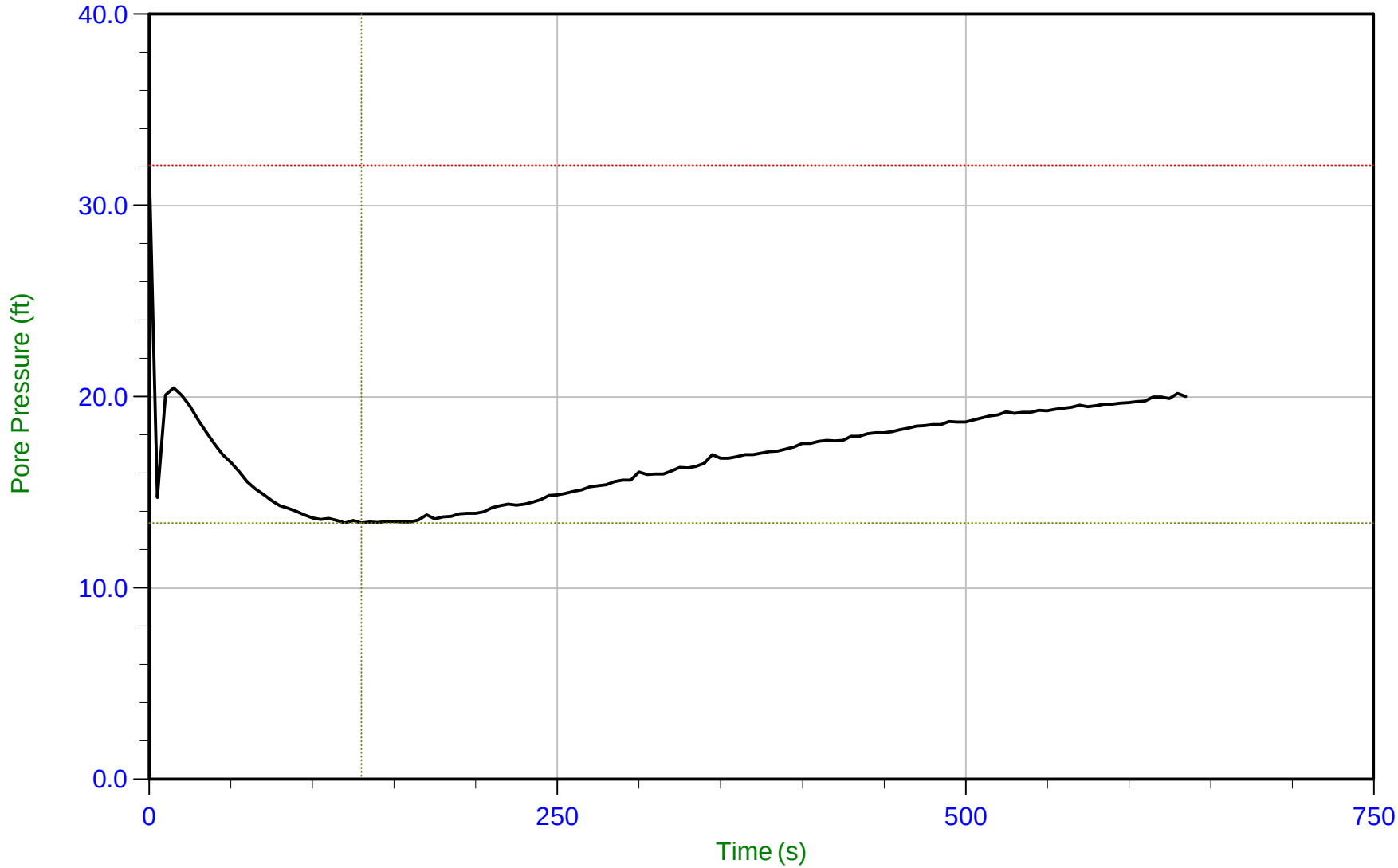
U Min: 69.4 ft
U Max: 267.3 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/11/2015 07:46
Site: Dynegy Joppa IL

Sounding: JOP-SC010
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC010.PPD
Depth: 25.550 m / 83.824 ft
Duration: 635.0 s

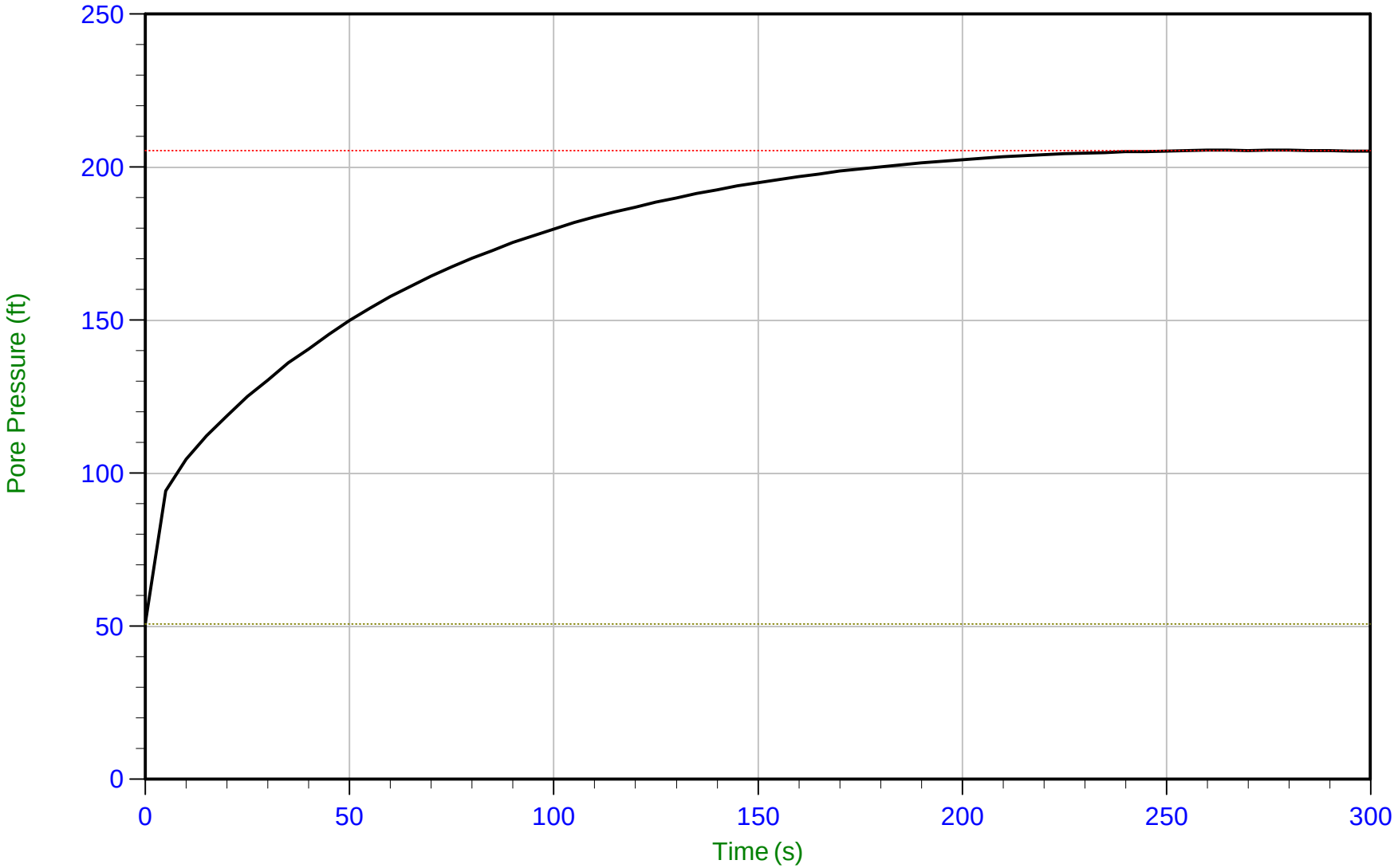
U Min: 13.4 ft
U Max: 32.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 08:43
Site: Dynegy Joppa IL

Sounding: JOP-SC012A
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC012A.PPD
Depth: 12.450 m / 40.846 ft
Duration: 300.0 s

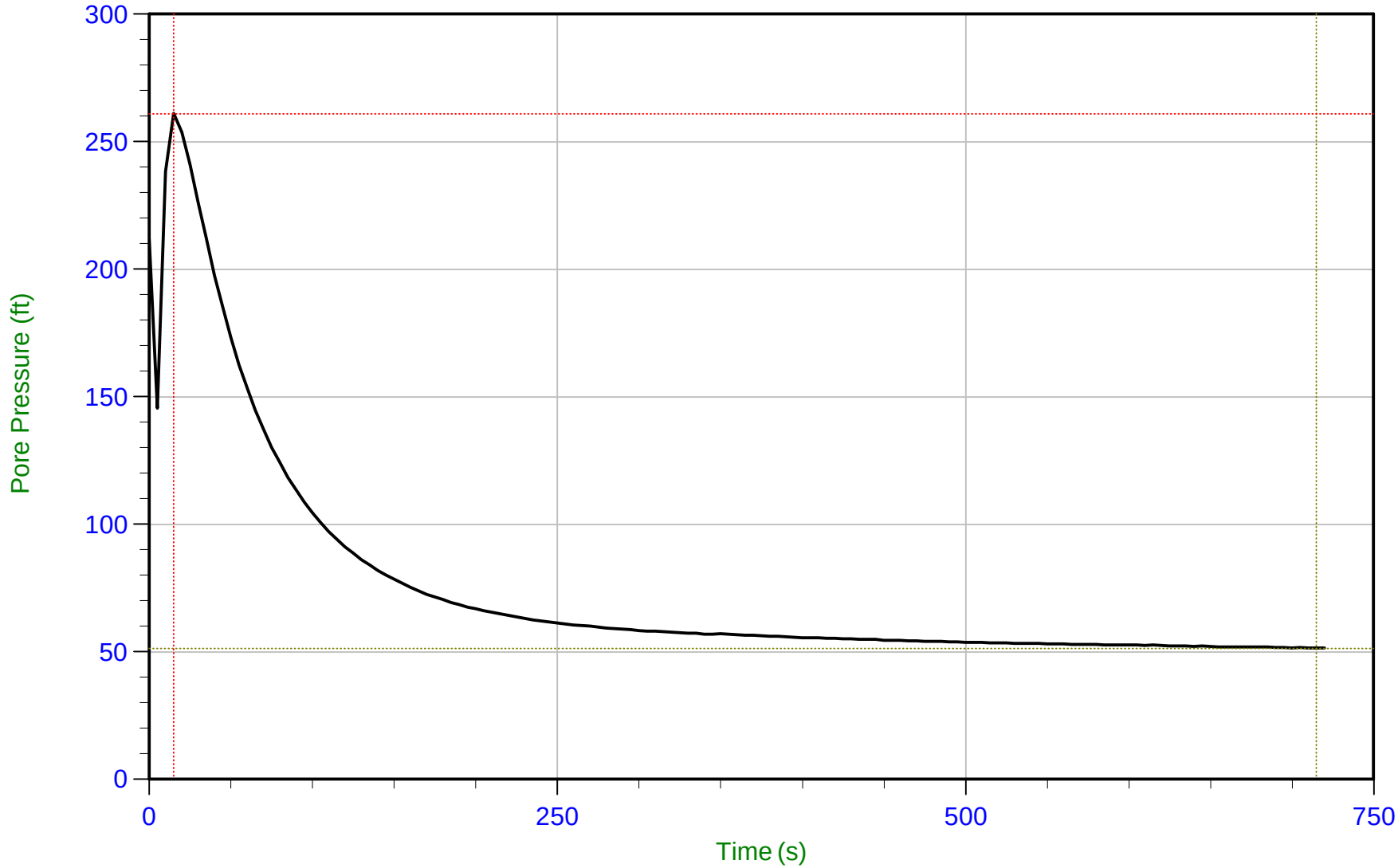
U Min: 50.9 ft
U Max: 205.6 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 08:43
Site: Dynegy Joppa IL

Sounding: JOP-SC012A
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC012A.PPD
Depth: 16.450 m / 53.969 ft
Duration: 720.0 s

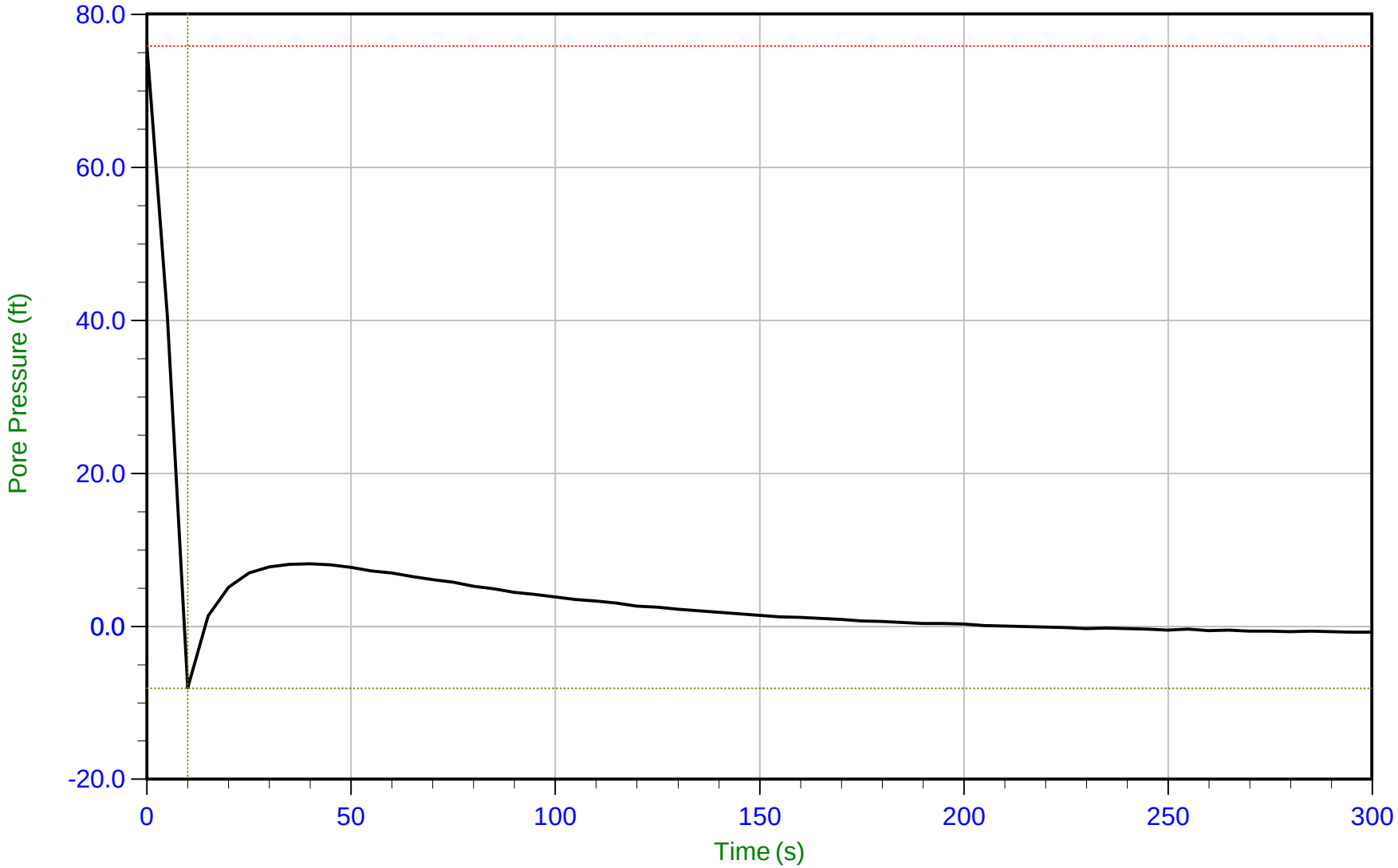
U Min: 51.5 ft
U Max: 261.1 ft

CONETEC

AECOM

Job No: 15-54071
Date: 08/10/2015 08:43
Site: Dynegy Joppa IL

Sounding: JOP-SC012A
Cone: 184:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_SP JOP-SC012A.PPD
Depth: 16.750 m / 54.953 ft
Duration: 300.0 s

U Min: -8.1 ft
U Max: 75.9 ft

ATTACHMENT E

LABORATORY TEST DATA

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB.	MINUS	% MINUS	UNIT	UNIT	GRAVITY		TYPE @	SHEAR	@ PEAK	SHEAR	VOID	SATUR-	
							(1)	NO. 200	2 μm	WEIGHT	WEIGHT			STRESS	STRESS	STRESS	STRESS	RATIO	ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B001	ST-1	3.5-5								131.4										
JOP-B001	ST-1B	4.45	18.5	34	17	17	CL	80.4		127.8	107.8		4.8E-7							P10579
JOP-B001	ST-1	4.75	19.4																	
JOP-B001	ST-1C	5.0	21.1				CL			123.6	102.1			UU@0.5	2.1	4.2				UU252e
JOP-B001	S-2	6-7.5	30.5				CL	85.2												
JOP-B001	S-4	18.5-20	23.4	27	18	9	CL	84.6												
JOP-B001	S-6	33.5-35	21.3				CL	81.8												
JOP-B001	ST-4	43-45								123.5										
JOP-B001	ST-4	43.55	14.6																	
JOP-B001	ST-4	44.1	13.6																	
JOP-B001	ST-4C	44.35	14.5	29	12	17	SC	38.5	18	131.5	114.8	2.640		CIU@6	5.5	22.1				T3841
JOP-B001	S-8	48.5-50	16.5				SP	2.8												
JOP-B002	ST-2	8-10								117.2										
JOP-B002	ST-2	8.4	24.1																	
JOP-B002	ST-2	8.85	23.5																	
JOP-B002	ST-2B	9.2	24.3				CL			123.0	98.9			UU@3.0	1.2	7.5				UU281c
JOP-B002	ST-2	9.5	23.7																	
JOP-B002	ST-2C	9.75	22.7	34	17	17	CL			125.9	102.6		8.4E-8							P10603
JOP-B002	S-1	13.5-15	25.6				CL	91.0												
JOP-B002	S-3	23.5-25	20.1	28	13	15	CL													
JOP-B002	ST-3	38-40								130.2										
JOP-B002	ST-3	38.2	26.6																	
JOP-B002	ST-3	38.75	22.2																	
JOP-B002	ST-3	39.3	21.2																	
JOP-B002	ST-3C	39.55	21.4	35	17	18	CL	92.1	21	127.9	105.4	2.622		CIU@3	4.8	12.8				T3909
JOP-B002	S-6	43.5-45	20.8				CL	93.9												
JOP-B002	S-8	53.5-55	22.4	35	16	19	CL													
JOP-B002	S-10	63.5-65	17.9				ML	56.7												
JOP-B003	ST-1	3-5								126.7										
JOP-B003	ST-1	3.2	15.9																	
JOP-B003	ST-1	3.75	17.2																	
JOP-B003	ST-1B	3.5	15.6	41	17	24	CL	82.0												
JOP-B003	S-2	13.5-15	13.4	40	16	24	CL													
JOP-B003	ST-2	18-20								129.7										
JOP-B003	ST-2	18.8	18.4																	

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B003	ST-2	19.35	16.1																	
JOP-B003	ST-2B	19.05	16.2				CL	85.7		126.5	108.9			CIU@1.5	4.0	19.6				T3918
JOP-B003	ST-2C	19.6	14.7											LV	4.7		1.7			
JOP-B003	S-4	28.5-30	17.4				ML	87.6	22											
JOP-B003	ST-3	33-35								147.0										
JOP-B003	ST-3	33.45	12.7																	
JOP-B003	ST-3	34.0	24.7																	
JOP-B003	ST-3B	34.25	18.0	38	19	19	CL	96.2	28											
JOP-B003	ST-3	34.55	16.2																	
JOP-B003	S-5	38.5-40	17.4																	
JOP-B003	S-7	48.5-50	20.6				CL	95.2	21			2.625								
JOP-B003	ST-4	50-52								102.9										disturbed
JOP-B003	ST-4A	50.3	23.1	34	17	17	CL					2.630								
JOP-B003	S-9	58.5-60	28.2	41	16	25	CL													
JOP-B003	S-11	68.5-70	23.2				CL	91.8												
JOP-B003	S-14	83.5-85	21.7	37	16	21	CL													
JOP-B003	S-15	88.5-90	20.6				CL	96.5												
JOP-B003	S-18	103.5-105	21.0	36	15	21	CL													
JOP-B003	S-19	108.5-110	20.2				CL	96.8												
JOP-B004	S-2	8.5-10	16.0																	
JOP-B004	ST-4	18-20								132.2										
JOP-B004	ST-4	18.15	17.2																	
JOP-B004	ST-4A	18.4	15.8											LV	5.2		2.1			
JOP-B004	ST-4	18.7	14.7																	
JOP-B004	ST-4	19.05	15.7																	
JOP-B004	ST-4C	19.6	16.6	36	14	22	CL	83.8		133.3	114.3			CIU@1.5	3.9	21.7				T3853
JOP-B004	S-5	23.5-25	16.2	37	14	23	CL	81.0												
JOP-B004	S-6	28.5-30	16.3	34	14	20	CL													
JOP-B004	S-8	38.5-40	16.8				CL	82.5												
JOP-B004	S-9	43.5-45	17.3	33	13	20	CL	77.3												
JOP-B004	ST-10	48-50								127.9										
JOP-B004	ST-10	48.3																		
JOP-B004	ST-10	48.9	16.0																	
JOP-B004	ST-10B	49.15	15.7				CL			134.8	116.6			UU@1.5	3.6	15.0				UU236f
JOP-B004	ST-10	49.45	15.9																	

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	UNIT WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B004	ST-10C	49.7	16.2	34	16	18	CL	83.8		133.4	114.8			CIU@3	9.2	21.4				T3842
JOP-B004	S-11	53.5-55	17.0	31	13	18	CL	69.3												
JOP-B004	ST-12	58-60								106.0										
JOP-B004	ST-12A	58.3	19.9	37	14	23	CL	81.5		134.6	112.3			CIU@6	3.1	21.7				T3854
JOP-B004	ST-12	59.65	57.9																disturbed section	
JOP-B004	ST-12C	59.9	29.0							119.5	92.6		6.1E-9							P10575
JOP-B004	S-13B	64-65	25.7	24	19	5	CL-ML	76.9												
JOP-B004	ST-14	65-67								123.7										
JOP-B004	ST-14	65.65	25.2																	
JOP-B004	ST-14B	65.9	22.7	25	19	6	CL-ML	80.4		123.3	100.5			CIU@5.5	6.0	20.9				T4000
JOP-B004	S-15	67-68.5	20.0				CL	61.5												
JOP-B004	ST-16	68.5-70.5																		
JOP-B004	ST-16	68.65	28.2																	
JOP-B004	ST-16	69.2	21.3																	
JOP-B004	ST-16	69.85	19.9																	
JOP-B004	ST-16C	70.1	19.2	32	16	16	CL	93.1	18	131.1	110.0			CIU@12	8.9	7.6				T3855
JOP-B004	S-19	93.5-95	19.8	21	19	2	SM	19.4												
JOP-B005	ST-2	8-9.5								121.0										
JOP-B005	ST-2A	8.3	16.4				CL			130.5	112.1			UU@0.5	2.8	15.0				UU247e
JOP-B005	ST-2B	9.0	17.7				CL	96.1		127.5	108.3			CIU@1.5	4.3	21.0				T3866
JOP-B005	S-3	13.5-15	17.3																	
JOP-B005	ST-4	18-19.5								125.9										
JOP-B005	ST-4	18.25	19.6																	
JOP-B005	ST-4	18.85	19.9																	
JOP-B005	ST-4B	19.15	20.1	37	21	16	CL	95.3	18	129.1	107.4			CIU@3	6.7	21.5				T3845
JOP-B005	ST-7	33-34.5								128.6										
JOP-B005	ST-7	33.05	15.8																	
JOP-B005	ST-7A	33.3	21.4				CL			124.0	102.1			UU@3.0	2.4	15.0				UU247a
JOP-B005	ST-7	33.65	20.0																	
JOP-B005	ST-7B		18.7	38	19	19	CL	97.5		129.6	109.1			CIU@6	12.4	17.9				T3867
JOP-B005	S-8	36-37.5	23.4	36	17	19	CL	90.6												
JOP-B005	S-9	38.5-40	22.3	37	17	20	CL													
JOP-B005	ST-10	43-45								129.1										
JOP-B005	ST-10	43.35	22.2																	
JOP-B005	ST-10A	43.6	21.0											LV	4.1		1.2			

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B005	ST-10	43.9	20.8																	
JOP-B005	ST-10	44.45	20.9																	
JOP-B005	ST-10C	44.7	20.6	39	14	25	CL	81.2		129.4	107.3			CIU@6	4.4	9.6				T3856
JOP-B005	S-11	48.5-50	19.3				CL	90.4												
JOP-B005	S-12	53.5-55	23.3	35	15	20	CL													
JOP-B005	S-14	63.5-65	19.7	33	13	20	CL	89.0												
JOP-B005	S-15	68.5-70	16.4	31	12	19	CL	77.9												
JOP-B005	S-16	73.5-75	17.2	21	9	12	CL	57.5												
JOP-B005	S-17	78.5-80	15.3	19	18	1	SM	23.9												
JOP-B006	S-2	6-7.5	25.2				CL	98.3												
JOP-B006	ST-1	8-10								114.1										
JOP-B006	ST-1	8.3	26.1																	
JOP-B006	ST-1A	8.75	26.2	33	23	10	CL													
JOP-B006	ST-1	9.15	26.5																	
JOP-B006	S-4	18.5-20	18.9	39	15	24	CL													
JOP-B006	ST-2	28-30								118.1										
JOP-B006	ST-2	28.45	19.4																	
JOP-B006	ST-2	29.0	18.7																	
JOP-B006	ST-2B	29.25	18.0	39	13	26	CL	85.7												
JOP-B006	ST-2	29.55	17.4																	
JOP-B006	S-6	33.5-35	18.0				CL	83.9	19											
JOP-B006	S-7	38.5-40	14.7				SM	24.8												
JOP-B007	S-2	6-7.5	20.0	40	16	24	CL													
JOP-B007	ST-2	8.5-10								131.0										
JOP-B007	ST-2	8.75	21.4																	
JOP-B007	ST-2	9.3	20.2																	
JOP-B007	ST-2B	9.55	19.7				CL	93.1	24	128.0	107.0		2.8E-6							P10582
JOP-B007	ST-2	9.85	19.9																	
JOP-B007	ST-2C	10.05	18.6	36	16	20	CL			127.9	107.8	2.626						0.520	94	C15151
JOP-B007	ST-2C	10.1	20.6				CL			117.0	97.0			DSS@1.5	1.5	15.9				DSS847
JOP-B007	S-3	13.5-15	18.3	36	14	22	CL	84.9												
JOP-B007	S-5	23.5-25	18.5	38	14	24	CL	73.5												
JOP-B007	ST-3	28-29.5								128.2										
JOP-B007	ST-3A	28.5	16.8											LV	6.7		2.4			
JOP-B007	ST-3	28.8	18.0																	

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B007	ST-3	29.35	18.3																	
JOP-B007	ST-3C	29.6	18.7	37	15	22	CL	91.0		129.8	109.3			CIU@1.5	4.5	20.4				T3868
JOP-B007	S-6	33.5-35	17.6	37	12	25	CL	84.1												
JOP-B007	S-8	43.5-45	15.6	18	16	2	SM	23.8												
JOP-B008	S-1	3.5-5	24.3																	
JOP-B008	ST-1	8-10								139.3										
JOP-B008	ST-1	8.45	17.5																	
JOP-B008	ST-1	9.0	16.4																	
JOP-B008	ST-1	9.55	20.0																	
JOP-B008	S-3	18.5-20	19.6	37	18	19	CL													
JOP-B008	S-4	23.5-25	17.1	39	19	20	CL	96.9	21											
JOP-B008	ST-2	25.5-27.5								127.2										
JOP-B008	ST-2	25.9	18.4																	
JOP-B008	ST-2	26.45	17.6																	
JOP-B008	ST-2B	26.7	18.8	41	18	23	CL	91.2		129.5	109.1			UU @ 1.5	2.7	12.2				UU279e
JOP-B008	S-5	28.5-30	17.3	41	18	23	CL	93.5												
JOP-B008	S-6	33.5-35	25.8	34	20	14	CL													
JOP-B008	ST-3	38-40								128.4										
JOP-B008	ST-3	38.45	21.4																	
JOP-B008	ST-3A	38.7	21.1							127.5	105.2		7.3E-6							P10587
JOP-B008	ST-3	39.0	21.8																	
JOP-B008	ST-3B	39.25	21.3				CL			127.3	104.9			UU@4.5	6.7	15.0				UU261f
JOP-B008	ST-3	39.55	21.6																	
JOP-B008	ST-3C	39.8	20.6				CL	95.8	21	125.3	103.9							0.604	91	C15159
JOP-B008	ST-4	43-45								96.8										
JOP-B008	ST-4	43.1	23.1																	
JOP-B008	ST-4	43.65	22.4																	
JOP-B008	ST-4B	43.9	22.2	42	16	26	CL							LV	2.6		0.7			
JOP-B008	ST-4	44.2	22.0																	
JOP-B008	ST-4	44.75	22.3																	
JOP-B008	S-8	48.5-50	17.6	35	15	20	CL	91.0	23											
JOP-B008	ST-5	63-65								135.9										
JOP-B008	ST-5	63.4	16.3																	
JOP-B008	ST-5	63.95	16.0																	
JOP-B008	ST-5B	64.2	17.6											LV	2.4		0.4			

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B008	ST-5	64.5	19.6				CL													
JOP-B008	ST-5C	64.75	19.3				CL	93.5	22	130.1	109.0			CIU@6.0	4.3	8.2				T3919
JOP-B008	S-11	68.5-70	18.3				ML	89.7												
JOP-B008	ST-6	78-80								135.6										
JOP-B008	ST-6	78.15	17.3																	
JOP-B008	ST-6	78.7	16.3																	
JOP-B008	ST-6	79.25	16.8																	
JOP-B008	ST-6C	79.5	15.1	21	15	6	SC-SM	36.2	11					LV	2.9		0.4			
JOP-B008	ST-6	79.8	14.2																	
JOP-B009	S-1	3.5-5	14.8				CL	69.6												
JOP-B009	ST-3	13-15								140.3										
JOP-B009	ST-3	13.55	14.8																	
JOP-B009	ST-3B	13.8	16.9				CL			134.2	114.9			CIU@0.5	3.0	21.4				T3843
JOP-B009	ST-3	14.1	15.2																	
JOP-B009	ST-3C	14.35	15.5	34	14	20	CL	76.5	20	134.9	116.8			CIU@1.5	2.8	22.2				T3844
JOP-B009	S-4	18.5-20	15.4	35	14	21	CL	91.1												
JOP-B009	S-7	31-32.5	20.8	39	17	22	CL	81.3	26											
JOP-B009	S-9	38.5-40	20.3	34	14	20	CL	87.7												
JOP-B009	ST-11	48-50								126.3										
JOP-B009	ST-11	48.6	19.5																	
JOP-B009	ST-11	49.15	19.8																	
JOP-B009	ST-11C	49.3	18.2				CL			128.6	108.8			UU@6.0	3.7	12.9				UU272e
JOP-B009	ST-11	49.6	18.4																	
JOP-B009	ST-11D	49.85	20.1	37	15	22	CL	87.0		127.9	106.5			DSS@6.44	2.6	13.3				DSS852
JOP-B009	S-12	53.5-55	21.3	38	13	25	CL	94.5	22											
JOP-B009	ST-14	63-65								129.5										
JOP-B009	ST-14	63.4	18.5																	
JOP-B009	ST-14	63.95	18.4																	
JOP-B009	ST-14B	64.2	18.9				CL			128.3	107.9			UU@12	3.8	4.4				UU251c
JOP-B009	ST-14	64.6	17.9																	
JOP-B009	ST-14C	64.85	17.8	27	10	17	CL	69.1		130.6	110.9			CIU@12	4.3	5.2				T3869
JOP-B009	S-15	68.5-70	18.7	29	11	18	SC	46.7												
JOP-B009	S-17	78.5-80	20.7	-	-	NP	SM	23.7												
JOP-B010	ST-1	0.5-2.5								119.2										
JOP-B010	ST-1B	1.1	20.7				CL	88.6	24	122.5	101.5		8.8E-6							P10581

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	UNIT WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B010	ST-1C	1.4	20.2	37	15	22	CL			122.5	101.9							0.606	87	C15152
JOP-B010	ST-1D	1.65	19.8				CL			122.5	102.2			DS@.5	0.5					DS1608
JOP-B010	ST-1E	1.9	18.1				CL			122.6	103.8			DS@1.5	1.1					DS1609
JOP-B010	ST-1F	2.2	18.0				CL			124.8	105.8			DS@3	2.1					DS1610
JOP-B010	S-1	3.5-5	18.5	38	15	23	CL	82.6										See Corrosion summary		
JOP-B010	S-3	13.5-15	15.2				CL	87.6												
JOP-B010	S-4	18.5-20	17.1	33	14	19	CL	76.9												
JOP-B010	S-6	28.5-30	17.6	26	10	16	CL	52.9												
JOP-B010	ST-3	33.5-35								132.4										
JOP-B010	ST-3B	34.35	15.8				CL			120.3	13.9			DSS@3	1.3	10.8				DSS848
JOP-B010	ST-3	34.6	16.1																	
JOP-B010	ST-3C	34.8	15.1	27	11	16	CL			130.5	113.3							0.482	85	C15153
JOP-B010	ST-3	35.1	15.8																	
JOP-B010	ST-3D	35.35	16.7				CL	53.5		132.9	113.9			CIU@3	2.8	17.5				T3870
JOP-B010	S-9	48.5-50	27.6	-	-	NP	SP-SM	9.9												
JOP-B011	S-3	13.5-15	16.0	34	16	18	CL	83.6												
JOP-B011	ST-5	23-25								126.5										
JOP-B011	ST-5	23.45	17.8																	
JOP-B011	ST-5B	23.8	17.8				CL			126.1	107.0			UU@1.5	2.8	8.2				UU252d
JOP-B011	ST-5	24	18.2																	
JOP-B011	ST-5C	24.25	18.0	33	18	15	CL	92.7		129.4	109.6			CIU@3	8.1	19.8				T3871
JOP-B011	S-6	28.5-30	18.5				CL	84.1												
JOP-B011	S-7	33.5-35	22.6	36	21	15	CL	97.7												
JOP-B011	S-8	38.5-40	19.9				CL	83.6												
JOP-B011	ST-9	43-45																		
JOP-B011	ST-9	43.45	17.1																	
JOP-B011	ST-9	44	18.0																	
JOP-B011	ST-9B	44.25	18.8							128.6	108.2		3.6E-8							P10569
JOP-B011	ST-9	44.55	18.7																	
JOP-B011	ST-9C	44.8	18.3	36	14	22	CL	87.6	22	128.9	109.0			CIU@3	3.2	18.6				T3846
JOP-B011	S-10	48.5-50	17.5	35	14	21	CL	79.6												
JOP-B011	S-11	53.5-55	22.6	34	11	23	CL	54.9												
JOP-B011	ST-14	68-70								125.3										
JOP-B011	ST-14	68.45	20.2																	
JOP-B011	ST-14	69	17.4																	

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB.	MINUS	% MINUS	UNIT	UNIT	GRAVITY		TYPE @	SHEAR	@ PEAK	SHEAR	VOID	SATUR-	
							(1)	NO. 200	2 μm	WEIGHT	WEIGHT			STRESS	STRESS	STRESS	STRESS	RATIO	ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B011	ST-14B	69.25	16.8											LV	2.2		0.6			
JOP-B011	ST-14	69.55	16.6																	
JOP-B011	ST-14C	69.8	16.4	34	11	23	SC	45.3		130.2	111.9			DSS@12	3.9	6.0				DSS854
JOP-B012	ST-3	15-17								131.6										
JOP-B012	ST-3A	15.25	16.7											LV	3.1		1.2			
JOP-B012	ST-3	15.6	17.9																	
JOP-B012	ST-3B	15.85	16.6							130.8	112.2		7.5E-8							P10577
JOP-B012	ST-3	16.2	17.7																	
JOP-B012	ST-3C	16.45	17.4	37	13	24	CL	72.8		131.9	112.3			CIU@6	4.7	19.7				T3872
JOP-B012	S-4	18.5-20	16.2	35	16	19	CL	78.7												
JOP-B012	S-5	23.5-25	15.3				CL	78.6												
JOP-B012	S-6	28.5-30	17.0	38	18	20	CL	91.7												
JOP-B012	ST-8	32-34																		
JOP-B012	ST-8	32.25	27.3																	
JOP-B012	ST-8	32.8	28.7																	
JOP-B012	ST-8B	33.05	28.8				CL			121.0	94.0			UU@3.0	0.5	15.0				UU253d
JOP-B012	ST-8	33.35	29.4																	
JOP-B012	ST-8C	33.6	29.1	40	19	21	CL	98.2	26	120.8	93.6	2.653		CIU@1.5	0.8	16.1				T3873
JOP-B012	S-9	36-37.5	26.1	33	21	12	CL	95.9												
JOP-B012	S-11	43.5-45	21.0	44	14	30	CL	91.7												
JOP-B012	S-12	48.5-50	21.7				ML	69.3												
JOP-B012	ST-13	53-55								135.8										
JOP-B012	ST-13	53.15	18.6																	
JOP-B012	ST-13A	53.4	16.8											LV	3.5		0.7			
JOP-B012	ST-13	53.7	17.0																	
JOP-B012	ST-13B	53.95	17.0	27	12	15	CL	63.9		132.3	113.1			CIU@3	3.1	13.1				T3874
JOP-B012	ST-13	54.3	17.4																	
JOP-B012	ST-13C	54.55	17.4				CL			132.0	112.4			CIU@6	3.2	13.1				T3785
JOP-B012	S-14	58.5-60	17.3	33	11	22	SC	36.7												
JOP-B012	ST-16	65-67								126.5										
JOP-B012	ST-16	65.25	21.2																	
JOP-B012	ST-16	65.8	20.2																	
JOP-B012	ST-16	66.35	18.2																	
JOP-B012	ST-16C	66.6	20.0	33	13	20	CL	62.7		126.8	105.7			CIU@12	4.0	1.8				T3876
JOP-B013	S-2	8.5-10	14.7				CL	67.8	22											

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B013	ST-1	13-15								147.4										
JOP-B013	ST-1	13.2	15.9																	
JOP-B013	ST-1	13.75	16.1																	
JOP-B013	ST-1	14.3	15.8																	
JOP-B013	ST-1C	14.55	15.4									2.639								
JOP-B013	S-4	23.5-25	23.1				CL	95.8												
JOP-B013	ST-2	28-30								114.4										
JOP-B013	ST-2A	28.3	21.6	33	20	13	CL													
JOP-B013	ST-2	28.5	21.1																	
JOP-B013	ST-2	28.85	21.9																	
JOP-B013	ST-2	29.4	19.9																	
JOP-B013	S-5	33.5-35	20.8	38	17	21	CL													
JOP-B013	ST-3	40.5-42.5								125.1										
JOP-B013	ST-3	40.15	18.9																	
JOP-B013	ST-3	40.7	20.5																	
JOP-B013	ST-3	41.25	20.7																	
JOP-B013	ST-3C	41.5	19.9	35	16	19	CL													
JOP-B013	S-7	43.5-45	19.8				CL	85.4												
JOP-B013	S-9	53.5-55	12.7	27	11	16	CL													
JOP-B013	S-10	58.5-60	19.5	37	13	24	CL													
JOP-B013	S-12	68.5-70	17.1				CL	50.9	23											
JOP-B013	S-13	73.5-75	16.3				SM	27.9												
JOP-B014	S-2	6.5-7.5	23.4	31	22	9	CL	96.8												
JOP-B014	ST-2	8.5-10								123.9										
JOP-B014	ST-2	8.95	23.3																	
JOP-B014	ST-2	9.5	20.8																	
JOP-B014	ST-2B	9.75	20.7											LV	2.1		0.9	See Corrosion summary		
JOP-B014	ST-2	10.05	20.8																	
JOP-B014	ST-2C	10.3	21.5	33	20	13	CL	91.8		126.8	104.4			DSS@1.5	1.1	13.5				DSS850
JOP-B014	S-4	18.5-20	20.1	47	14	33	CL	88.8												
JOP-B014	S-6	28.5-30	20.8	39	15	24	CL	85.0												
JOP-B014	ST-3	33-35																		
JOP-B014	ST-3	33.25	14.9																	
JOP-B014	ST-3A	33.5	13.8	26	11	15	SC			126.7	111.3							0.498	74	C15137
JOP-B014	ST-3	33.8	14.1																	

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB.	MINUS	% MINUS	UNIT	UNIT	GRAVITY		TYPE @	SHEAR	@ PEAK	SHEAR	VOID	SATUR-	
							(1)	NO. 200	2 μm	WEIGHT	WEIGHT			STRESS	STRESS	STRESS	STRESS	RATIO	ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B014	ST-3B	34.05	14.9							130.4	113.4		1.9E-7							P10567
JOP-B014	ST-3	34.4	17.4																	
JOP-B014	ST-3C	34.65	16.1				SC	45.2		130.2	112.2			UU@6	4.3	6.2				UU237f
JOP-B014	ST-4	43-45								132.6										
JOP-B014	ST-4	43.25	17.2																	
JOP-B014	ST-4	43.8	18.8																	
JOP-B014	ST-4A	43.9	17.6											LV	3.4		1.0			
JOP-B014	ST-4	44.35	17.9																	
JOP-B014	ST-4C	44.6	16.7	33	12	21	CL	63.7		132.5	113.6			CIU@6	4.1	10.8				T3877
JOP-B014	S-8	48.5-50	16.2	26	11	15	CL	54.6												
JOP-B015	S-2	8.5-10	19.4	41	16	25	CL													
JOP-B015	ST-1	18-20								128.9										
JOP-B015	ST-1	18.55	16.5																	
JOP-B015	ST-1	19.1	16.8																	
JOP-B015	ST-1A	18.25	17.4											LV	4.1		1.4			
JOP-B016	ST-1A	18.8	16.5				CL			132.2	113.4			UU@1.5	4.2	14.0				UU282d
JOP-B015	ST-1C	19.35	18.7	38	17	21	CL			128.4	108.2			CIU@3.0	4.0	20.1				T3920
JOP-B015	S-4	23.5-25	16.7				CL	94.1	23											
JOP-B015	S-6	33.5-35	8.5	33	20	13	CL													
JOP-B015	S-7	38.5-40	20.8																	
JOP-B015	ST-2	40.5-42.5								125.0										
JOP-B015	ST-2	40.9	23.8																	
JOP-B015	ST-2	41.45	23.7																	
JOP-B015	ST-2B	41.7	23.3				CL			122.7	99.5			CIU@3.0	2.6	19.0				T3925
JOP-B015	ST-2	42.0	23.0																	
JOP-B015	S-8	43.5-45	22.7																	
JOP-B015	ST-3	45.5-47.5								126.3										
JOP-B015	ST-3	45.95	21.4																	
JOP-B015	ST-3	46.5	21.1																	
JOP-B015	ST-3B	46.75	20.1											LV	1.6		0.3			
JOP-B015	ST-3	47.05	20.6																	
JOP-B015	ST-3C	47.3	19.5	31	15	16	CL			128.0	107.1			CIU@1.5	2.4	19.5				T3926
JOP-B015	S-12	63.5-65	17.2				SM	48.4												
JOP-B015	ST-4	68-70								124.9										
JOP-B015	ST-4	68.45	22.4																	

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B015	ST-4	69	19.9																	
JOP-B015	ST-4B	69.25	21.4				CL	91.0		124.7	102.7			CIU@8	4.8	6.6				T3927
JOP-B015	ST-4	69.55	21.5																	
JOP-B015	S-13	73.5-75	18.6	26	15	11	CL	62.8	13											
JOP-B015	S-14	78.5-80	24.3	35	16	19	CL													
JOP-B016	ST-1	3.5-5																		
JOP-B016	ST-1B	4.25	25.2	33	21	12	CL			120.9	96.5							0.772	89	C15140
JOP-B016	ST-1B	4.35	25.8							124.2	98.8		2.2E-6							P10568
JOP-B016	ST-1	4.55	25.8																	
JOP-B016	ST-1C	4.8	26.6				CL	98.3		123.7	97.7			UU@0.5	1.1	3.6				UU239d
JOP-B016	S-2	6-7.5	21.1	30	20	10	CL	96.3												
JOP-B016	S-4	18.5-20	21.1	30	16	14	CL	90.0												
JOP-B016	ST-3	23-25								131.3										
JOP-B016	ST-3A	23.2	23.0											LV	1.1		0.4			
JOP-B016	ST-3	23.45	19.7																	
JOP-B016	ST-3B	23.7	19.5	35	15	20	CL	98.8	25	127.5	106.7	2.632		CIU@1.5	4.0	19.3				T3897
JOP-B016	ST-3	24.05	19.2																	
JOP-B016	ST-3C	24.15	19.1				CL			129.1	108.4			DS@3	1.9					DS1615
JOP-B016	ST-3D	24.5	17.6				CL			127.5	108.4			DS@6	3.7					DS1616
JOP-B016	ST-3E	24.8	18.2				CL			129.2	109.3			DS@12	6.8					DS1618
JOP-B016	S-5	28.5-30	21.3	40	14	26	CL	97.0												
JOP-B016	ST-4	43-45								134.3										
JOP-B016	ST-4	43.25	21.0																	
JOP-B016	ST-4	43.8	20.1																	
JOP-B016	ST-4	44.35	18.0																	
JOP-B016	ST-4C	44.6	18.1	27	17	10	CL	88.1		129.2	109.4			DSS@5.97	3.2	8.3				DSS853
JOP-B017	S-2	5.5-7	30.8	-	-	NP	ML	83.1												
JOP-B017	ST-2	8-10																		
JOP-B017	ST-2A	8.25	22.5	33	17	16	CL			123.0	100.4							0.585	98	C15136
JOP-B017	ST-2B	8.85	17.1				CL	67.1		129.6	110.7			CIU@2	1.3	21.6				T3847
JOP-B017	S-3	13.5-15	27.3	38	18	20	CL	94.7												
JOP-B017	ST-3	23-25								128.5										
JOP-B017	ST-3	23.45	17.9																	
JOP-B017	ST-3	24.0	21.4																	
JOP-B017	ST-3	24.55	20.3																	

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	UNIT WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B017	ST-3C	24.8	21.3	34	14	20	CL	93.3		127.2	104.8			CIU@1.5	1.6	15.9				T3848
JOP-B017	S-5	28.5-30	19.5	35	12	23	CL	60.4												
JOP-B017	ST-4	33-35								136.4										
JOP-B017	ST-4	33.5	15.2																	
JOP-B017	ST-4	34.05	15.0																	
JOP-B017	ST-4	34.6	17.4																	
JOP-B017	ST-4D	34.85	21.2	35	14	21	CL	82.4		128.1	105.7			CIU@3.0	4.0	14.2				T3928
JOP-B018	ST-1	3-5								145.5										
JOP-B018	ST-1	3.7	14.6																	
JOP-B018	ST-1	4.25	15.1																	
JOP-B018	S-1	10-11.5	14.0	38	13	25	CL													
JOP-B018	ST-2	18-20								130.8										
JOP-B018	ST-2	18.5	15.4																	
JOP-B018	ST-2A	18.75	14.7				CL	90.6	25											
JOP-B018	ST-2	19.05	15.0																	
JOP-B018	S-4	28.5-30	15.2	37	13	24	CL													
JOP-B018	ST-3	33-35								132.1										
JOP-B018	ST-3	33.25	13.5																	
JOP-B018	ST-3	33.8	13.5																	
JOP-B018	ST-3	34.25	17.7																	
JOP-B018	ST-3C	34.5	15.6	38	14	24	CL			133.9	115.9			UU@3	4.5	6.3				UU280c
JOP-B018	S-5	38.5-40	14.2				CL	75.3	22											
JOP-B018	S-6	43.5-45	17.3	35	14	21	CL													
JOP-B018	ST-4	48-50								135.8										
JOP-B018	ST-4	48.55	17.5																	
JOP-B018	ST-4A	48.8	16.8	35	15	20	CL													
JOP-B018	ST-4	49.15	16.6																	
JOP-B018	S-7	53.5-55	25.7	44	19	25	CL													
JOP-B018	ST-5	58-60								141.3										
JOP-B018	ST-5	58.3	44.4																	
JOP-B018	ST-5A	58.55	19.6				CL	88.6	13											
JOP-B018	ST-5	58.85	17.8																	
JOP-B018	ST-5	59.35	16.8																	
JOP-B018	S-10B	74-75	21.5				CL	89.7	25											
JOP-B018	S-11	78.5-80	19.5	-	18	NP	ML													

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	UNIT WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B019	S-1	3.5-5	48.2	-	-	NP	ML	51.4												
JOP-B019	ST-1	8-10								87.7										
JOP-B019	ST-1A	8.15	106.0	-	-	NP	ML	94.5												
JOP-B019	S-2	13.5-15	102.0	-	-	NP	SM													
JOP-B019	S-5	28.5-30	43.4				CL	97.6												
JOP-B019	S-7	38.5-40	36.8	-	25	NP	ML	70.8												
JOP-B019	ST-2	43-45								106.8										
JOP-B019	ST-2A	43.25	41.8							109.6	77.3			DSS@3.93	2.2	12.1				DSS851
JOP-B019	ST-2	43.55	46.0																	
JOP-B019	ST-2B	43.8	54.5	-	35	NP	ML	83.5		102.9	66.6			CIU@4.0	1.7	10.3				T3898
JOP-B019	S-9	53.5-55	18.9				CL	64.2												
JOP-B019	S-11	58.5-60	17.7	24	11	13	CL	61.1												
JOP-B019	S-14	73.5-75	20.9	22	16	6	CL-ML	71.5												
JOP-B019	S-16	83.5-85	13.3	33	17	16	SP-SC	7.6												
JOP-B020	ST-1	3-5								129.9										
JOP-B020	ST-1A	3.4	16.5											LV	6.8		0.2			*Gravel
JOP-B020	ST-1	3.7	15.3																	
JOP-B020	ST-1B	3.95	15.8	35	16	19	CL			134.3	116.0			UU @ .5	4.8	4.3				UU280d
JOP-B020	S-2	13.5-15	16.2	36	15	21	CL													
JOP-B020	ST-2	18-20								129.5										
JOP-B020	ST-2	18.45	15.7																	
JOP-B020	ST-2	19.0	13.7																	
JOP-B020	ST-2B	19.25	15.3				CL	97.8	21	130.3	113.0			CIU@4.5	8.9	21.0				T3929
JOP-B020	S-4	28.5-30	14.3				CL	95.6	25											
JOP-B020	ST-3	33-35								138.7										
JOP-B020	ST-3	33.4	15.2																	
JOP-B020	ST-3A	33.65	18.0	34	13	21	CL													
JOP-B020	ST-3	33.95	14.6																	
JOP-B020	ST-3	34.5	16.7																	
JOP-B020	S-6	43.5-45	14.0	34	13	21	CL													
JOP-B020	ST-4	48-50								131.9										
JOP-B020	ST-4	48.4	15.5																	
JOP-B020	ST-4	48.95	15.9																	
JOP-B020	ST-4	49.5	12.6																	
JOP-B020	ST-4C	49.75	13.3	31	14	17	CL			134.0	118.2	2.624		CIU@6.0	10.9	20.2				T3930

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	UNIT WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B020	S-7	53.5-55	20.2				CL	93.1	27											
JOP-B020	S-8	58.5-60	20.7	38	13	25	CL													
JOP-B020	S-9B	64-65	20.9	36	13	23	CL													
JOP-B020	ST-5	68-70								128.9										
JOP-B020	ST-5	68.45	25.9																	
JOP-B020	ST-5	69.0	18.8																	
JOP-B020	ST-5	69.55	17.5																	
JOP-B020	ST-5C	69.8	18.2				CL	82.9	22	128.6	108.8			CIU@9.0	7.3	9.0				T3931
JOP-B020	S-10	70-71.5	22.8	41	12	29	CL													
JOP-B020	S-12	78.5-80	21.4				SP-SM	7.7												
JOP-B021	ST-1	3-5								126.8										
JOP-B021	ST-1A	3.25	19.5											LV	2.3		0.6			
JOP-B021	ST-1B	3.75	16.6				CL			129.6	111.1			UU@0.5	1.9	15.0				UU286c
JOP-B021	ST-1C	4.25	15.0	39	13	26	CL			131.5	114.3			CIU@1.5	5.9	21.1				T3923
JOP-B021	S-2	6-7.5	23.7	42	16	26	CL													
JOP-B021	S-3	8.5-10	49.8	-	-	NP	ML													
JOP-B021	ST-2	13-15								118.4										
JOP-B021	ST-2A	13.55	44.8				CL			106.9	73.8			UU@0.5	0.3	15.0				UU261e
JOP-B021	ST-2B	14.1	25.1				CL			124.3	99.4							0.715	96	C15160
JOP-B021	ST-2	14.35	24.7																	
JOP-B021	ST-2C	14.6	23.1				CL	99.0		125.4	101.9			CIU@2.0	2.4	19.9				T3900
JOP-B021	S-5	23.5-25	21.0				CL	90.7	18											
JOP-B021	ST-3	33-35								135.0										
JOP-B021	ST-3	33.3	16.3																	
JOP-B021	ST-3	33.85	14.7																	
JOP-B021	ST-3B	34.1	15.0	22	13	9	CL	62.2	14	127.6	111.0			CIU@3.0	5.7	12.3				T3924
JOP-B021	ST-3	34.4	17.6																	
JOP-B021	ST-3C	34.65	18.9											LV	3.0		0.3			
JOP-B021	S-8	43.5-45	18.0	25	16	9	CL													
JOP-B021	S-9	48.5-50	17.7	-	-	NP	SP-SM	8.2												
JOP-B022	S-2	5.5-7	23.9				CH	96.7												
JOP-B022	ST-2	8-10								132.3										
JOP-B022	ST-2	8.05	22.4																	
JOP-B022	ST-2A	8.3	20.8				CL			127.1	105.2							0.590	95	C15138
JOP-B022	ST-2	8.6	21.5																	

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	DRY	SPECIFIC		TEST	PEAK	STRAIN	RESIDUAL	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	INDEX	SYMB. (1)	MINUS NO. 200	% MINUS 2 μm	UNIT WEIGHT	UNIT WEIGHT	GRAVITY		TYPE @ STRESS	SHEAR STRESS	@ PEAK STRESS	SHEAR STRESS	VOID RATIO	SATUR-ATION	
		(ft)	(%)	(-)	(-)	(-)		(%)	(%)	(pcf)	(pcf)	(-)	(cm/sec)	(ksf)	(ksf)	(%)	(ksf)	(-)	(%)	
JOP-B022	ST-2B	8.85	21.3				CL			128.3	105.8			UU@0.5	2.3	15.0				UU237g
JOP-B022	ST-2	9.15	21.7																	
JOP-B022	ST-2C	9.4	21.4	35	18	17	CL	93.7		128.2	105.6			CIU@0.5	2.9	21.4				T3849
JOP-B022	S-4	18.5-20	20.6	35	15	20	CL													
JOP-B022	ST-3	23-25								127.3										
JOP-B022	ST-3	23.65	19.7																	
JOP-B022	ST-3B	23.9	19.3				CL			129.1	108.2			UU@1.5	1.8	15.0				UU258h
JOP-B022	ST-3	24.25	18.9																	
JOP-B022	ST-3C	24.5	19.5	38	14	24	CL	92.4		130.6	109.6			CIU@1.5	3.4	20.7				T3878
JOP-B022	S-5	28.5-30	15.9				CL	80.1												
JOP-B022	ST-4	38-40								123.2										
JOP-B022	ST-4	38.6	14.9																	
JOP-B022	ST-4B	38.8	18.0	23	14	9	CL	71.0		131.8	111.7			UU@3.0	2.2	14.1				UU258j
JOP-B023	S-3	13.5-15	26.6	-	-	NP	ML	94.5												
JOP-B023	S-5	23.5-25	31.3				ML	57.4												
JOP-B023	S-8	38.5-40	37.6	-	-	NP	ML	97.3												
JOP-B023	ST-1	43-45								109.9										
JOP-B023	ST-1A	43.2	57.5							104.2	66.2		2.2E-6							P10580
JOP-B023	ST-1B	43.7	27.1	32	22	10	CL	93.0		123.2	97.0			CIU@1	1.5	21.7				T3879
JOP-B023	ST-2	48-50	13.6				CL			137.9										
JOP-B023	ST-2	48.2	20.5																	
JOP-B023	ST-2A	48.45	20.9				CL			129.6	107.2			UU@4.0	2.2	15.0				UU260d
JOP-B023	ST-2	48.75	19.9																	
JOP-B023	ST-2B	49.0	18.1	35	14	21	CL	74.0		132.1	111.9			CIU@8	6.0	20.8				T3899
JOP-B023	S-9	53.5-55	17.4	22	10	12	SC	49.7												
JOP-B023	S-11	63.5-65	19.9				SC	49.7												
JOP-B023	S-12	68.5-70	19.5	28	11	17	CL	52.4												
JOP-B023	S-13	73.5-75	24.5				CL	93.1												
JOP-B023	S-14	78.5-80	16.7				SC	37.5												

Note: (1) USCS symbol based on visual observation and Sieve and Atterberg limits reported.

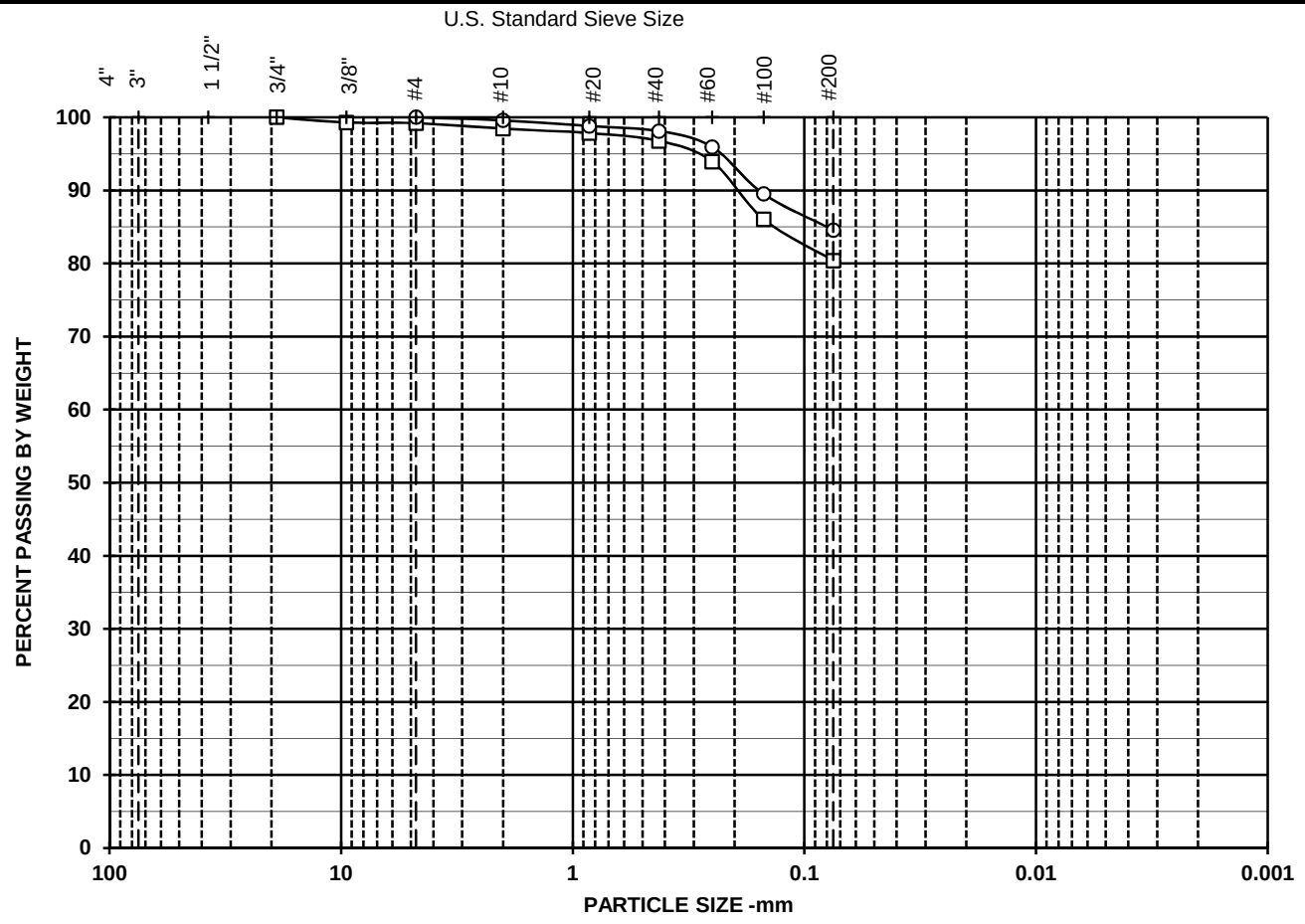
AECOM #60428794-107
Dynegy CCR - Joppa
Summary of Corrosion Testing

SAMPLE ID			RESISTIVITY TESTS					CHEMICAL TESTS							REMARKS
Boring No.	Sample No.	Depth	Test Method	As-Received		@ Minimum Resistivity		pH		Awwa Appendix A					
								ASTM G51		Redox Potential				Sulfide	
				Water Content	Resistivity	Water Content	Resistivity	pH	Temperature	R1	R2	R3	Average	Response	
		(ft)		(%)	(kΩ - cm)	(%)	(kΩ - cm)	(pH units)	(^{o}C)	(mV)	(mV)	(mV)	(mV)	(visual)	
JOP-B010	S-1	3.5-5.0	ASTM G57	18.5	1.5	25.4	1.4	7.3	22.4	142	160	166	151	none	
JOP-B014	ST-2	9.75	ASTM G57	20.1	1.9	27.4	1.9	6.3	23.2	159	157	155	158	trace to none	

Prepared by: CMJ
Reviewed by: GET
Date: 11/23/2015

TerraSense, LLC
45H Commerce Way
Totowa, NJ 07512
(973) 812-1818

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B001		JOP-B001
Sample	ST-1B		S-4
Depth	4.45		18.5-20
% +3"	0.0		0.0
% Gravel	0.8		0.0
% SAND	18.8		15.4
%C SAND	0.8		0.4
%M SAND	1.7		1.5
%F SAND	16.4		13.5
% FINES	80.4		84.6
% -2μ			
D_{100} (mm)	19.00		4.75
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"	100.0		
3/8"	99.3		
4	99.2		100.0
10	98.4		99.6
20	97.8		98.8
40	96.8		98.1
60	93.9		95.9
100	86.1		89.5
200	80.4		84.6

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		34	17	17	CL	Grayish brown, Lean clay with sand	9/11/2015
■							
○	23.4	27	18	9	CL	Grayish brown, Lean clay with sand	8/19/2015

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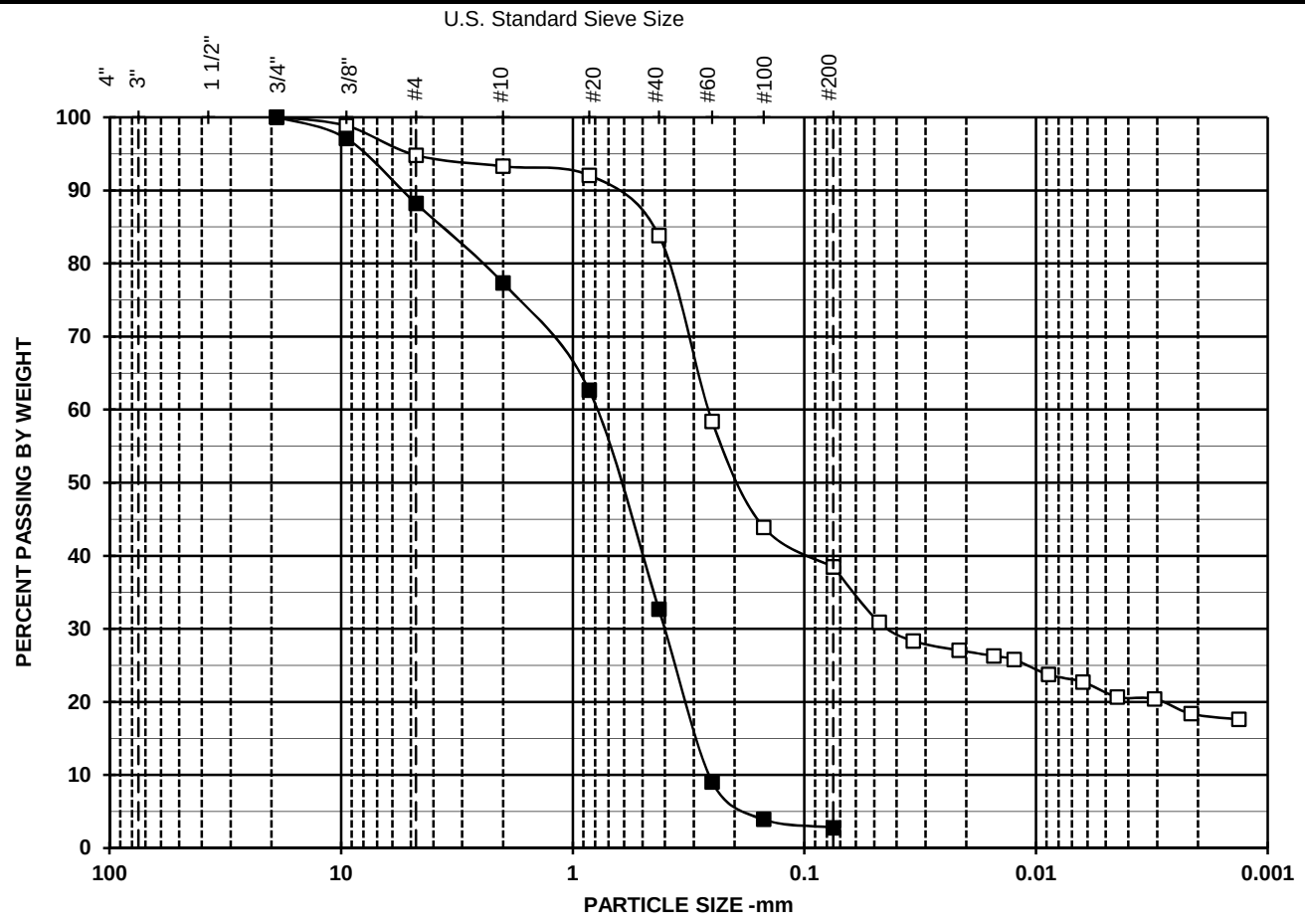
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B001	JOP-B001	
Sample	ST-4C	S-8	
Depth	44.35	48.5-50	
% +3"	0.0	0.0	
% Gravel	5.2	11.8	
% SAND	56.3	85.4	
%C SAND	1.5	10.9	
%M SAND	9.5	44.6	
%F SAND	45.3	29.9	
% FINES	38.5	2.8	
% -2μ	18		
D_{100} (mm)	19.00	19.00	
D_{60} (mm)	0.26	0.81	
D_{30} (mm)	0.04	0.41	
D_{10} (mm)		0.26	
Cc		0.8	
Cu		3.2	

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"	100.0	100.0	
3/8"	98.8	97.1	
4	94.8	88.2	
10	93.3	77.3	
20	92.1	62.7	
40	83.8	32.7	
60	58.4	9.0	
100	43.9	3.9	
200	38.5	2.8	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		29	12	17	SC	Light gray, Clayey sand	8/31/2015
■	16.5				SP	Light brown, Poorly graded sand	8/21/2015
○							

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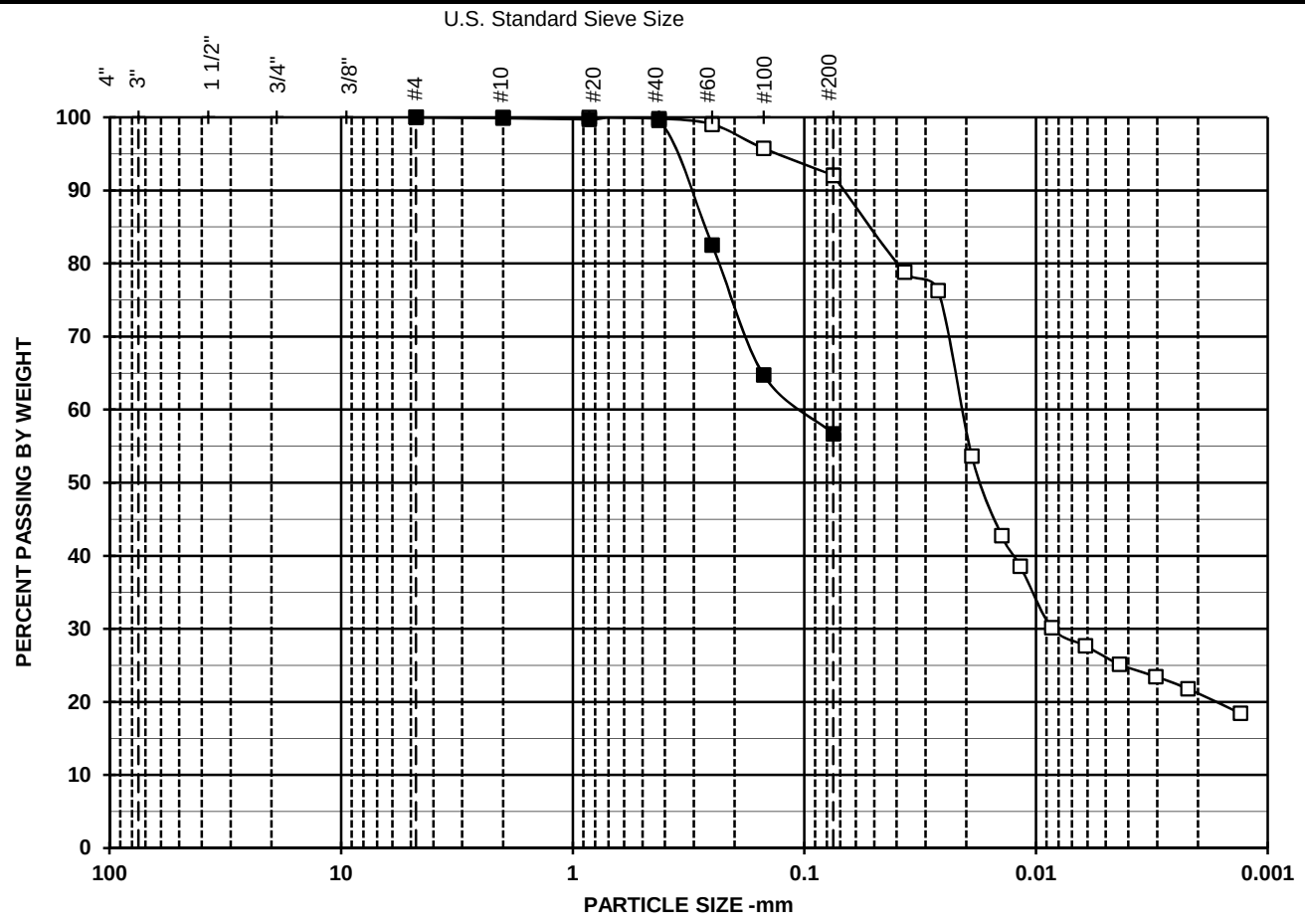
Analysis File: 3SV-MasterRev4b

Siev001b.xls 11/15/2015

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		35	17	18	CL	Brown, Lean clay	10/7/2015
■	17.9				ML	Light gray, Sandy silt	9/23/2015
○							

Symbol	□	■	○
Boring	JOP-B002	JOP-B002	
Sample	ST-3C	S-10	
Depth	39.55	63.5-65	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	7.9	43.3	
%C SAND	0.0	0.1	
%M SAND	0.2	0.3	
%F SAND	7.8	42.9	
% FINES	92.1	56.7	
% -2μ	21		
D_{100} (mm)	4.75	4.75	
D_{60} (mm)	0.02	0.11	
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0	100.0	
10	100.0	99.9	
20	100.0	99.7	
40	99.8	99.6	
60	99.0	82.5	
100	95.7	64.7	
200	92.1	56.7	

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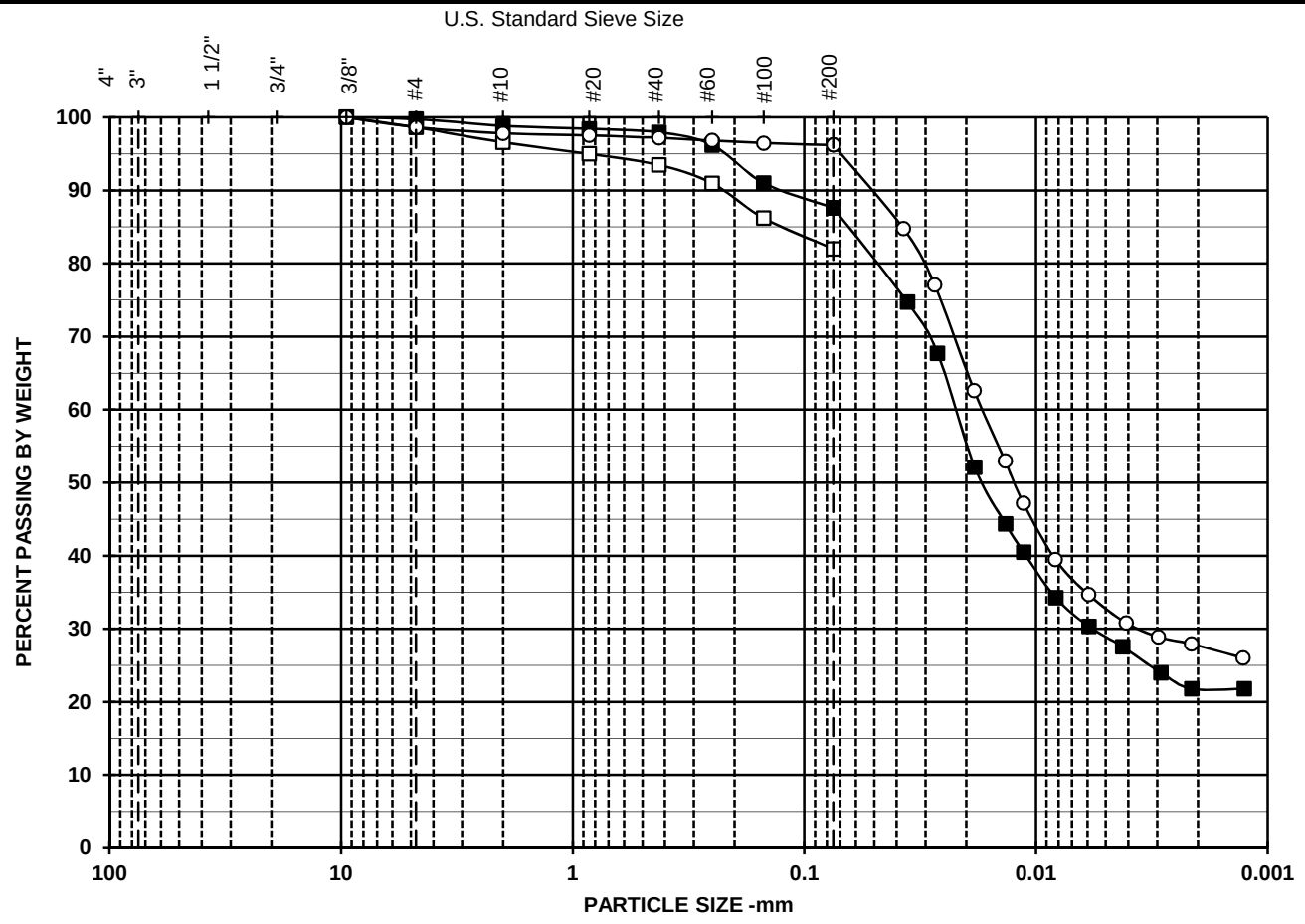
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B003	JOP-B003	JOP-B003
Sample	ST-1B	S-4	ST-3B
Depth	3.5	28.5-30	34.25
% +3"	0.0	0.0	0.0
% Gravel	1.4	0.3	1.4
% SAND	16.6	12.1	2.4
%C SAND	2.1	0.9	0.8
%M SAND	3.1	0.9	0.6
%F SAND	11.5	10.3	1.0
% FINES	82.0	87.6	96.2
% -2μ		22	28
D_{100} (mm)	9.50	9.50	9.50
D_{60} (mm)		0.02	0.02
D_{30} (mm)		0.01	0.00
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0	100.0	100.0
4	98.6	99.7	98.6
10	96.6	98.8	97.8
20	95.0	98.4	97.5
40	93.5	97.9	97.2
60	91.0	96.2	96.8
100	86.2	91.0	96.5
200	82.0	87.6	96.2

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	15.6	41	17	24	CL	Brown, Lean clay with sand	10/8/2015
■	17.4				ML	Dark grayish brown, Silt	10/2/2015
○	18.0	38	19	19	CL	Light brown clay, Lean clay	10/9/2015

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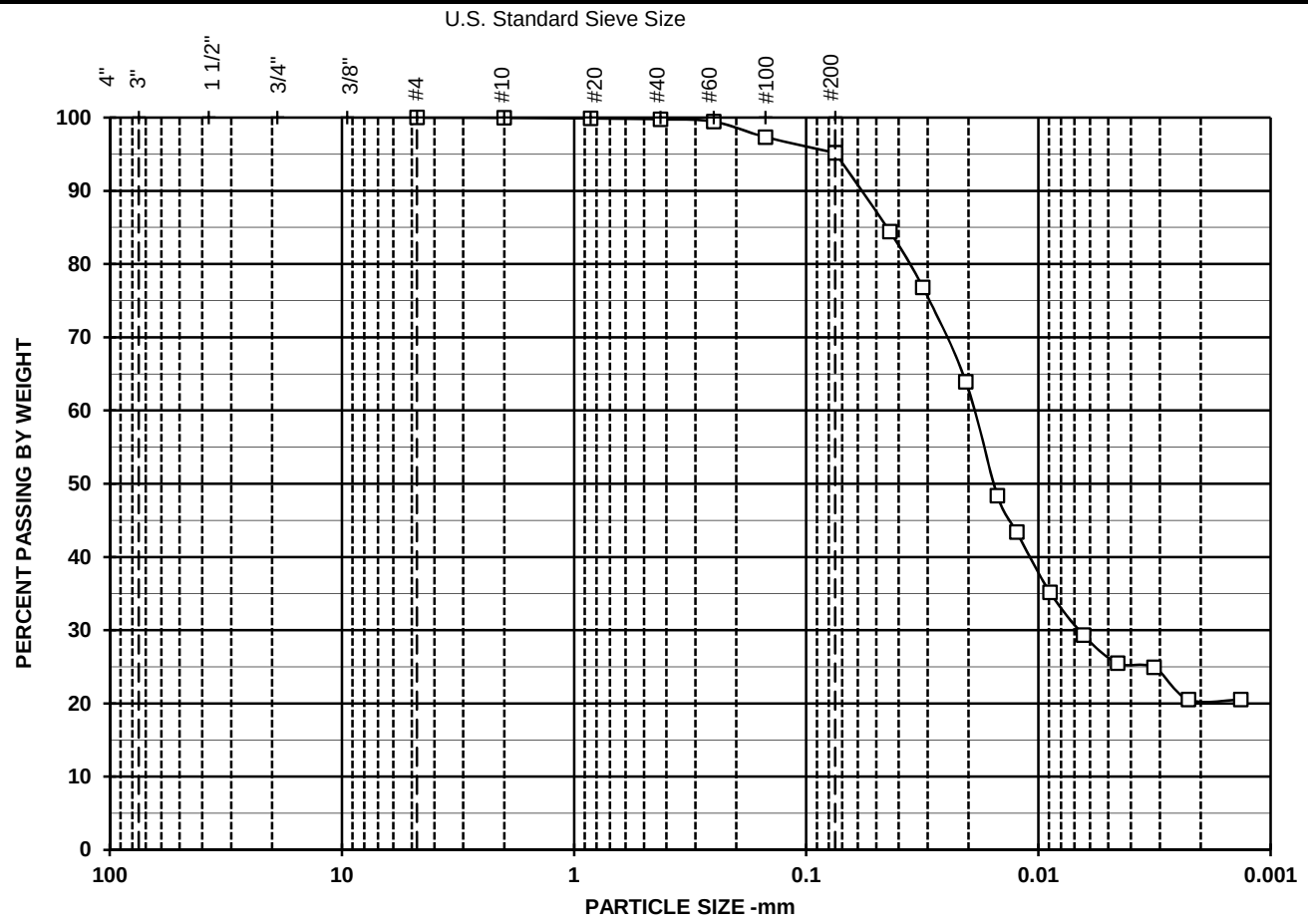
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B003		
Sample	S-7		
Depth	48.5-50		
% +3"	0.0		
% Gravel	0.0		
% SAND	4.8		
%C SAND	0.0		
%M SAND	0.2		
%F SAND	4.6		
% FINES	95.2		
% -2μ	21		
D_{100} (mm)	4.75		
D_{60} (mm)	0.02		
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0		
10	100.0		
20	99.9		
40	99.8		
60	99.4		
100	97.3		
200	95.2		

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	20.6				CL	Brown, Lean clay	9/29/2015
■							
○							

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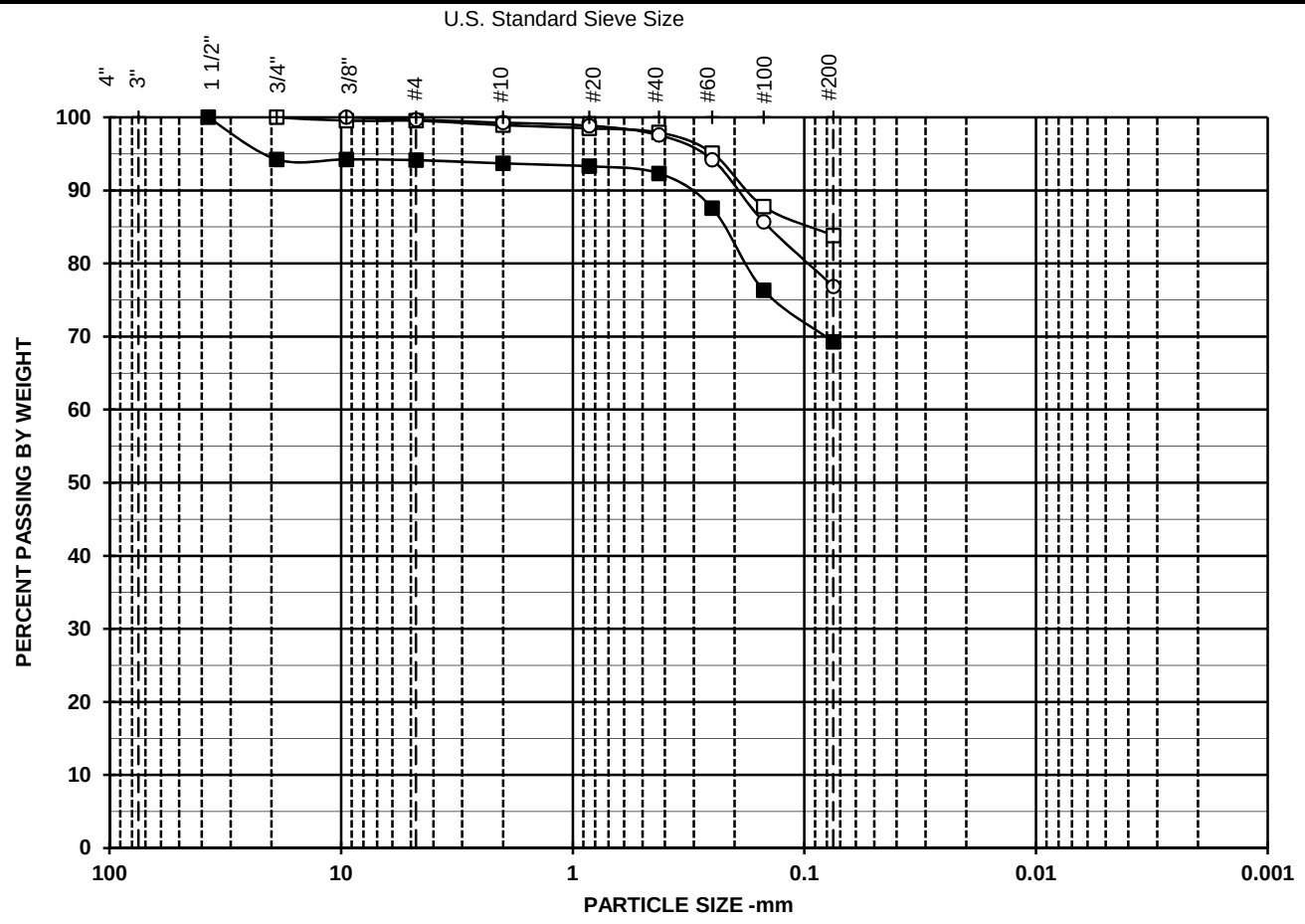
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B004	JOP-B004	JOP-B004
Sample	ST-10C	S-11	S-13B
Depth	49.7	53.5-55	64-65
% +3"	0.0	0.0	0.0
% Gravel	0.5	5.9	0.3
% SAND	15.7	24.8	22.8
%C SAND	0.6	0.4	0.4
%M SAND	1.0	1.4	1.7
%F SAND	14.1	23.1	20.7
% FINES	83.8	69.3	76.9
% -2μ			
D_{100} (mm)	19.00	37.50	9.50
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"		100.0	
3/4"	100.0	94.2	
3/8"	99.5	94.2	100.0
4	99.5	94.1	99.7
10	98.9	93.7	99.3
20	98.5	93.3	98.9
40	97.9	92.3	97.6
60	95.1	87.6	94.2
100	87.8	76.3	85.7
200	83.8	69.3	76.9

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		34	16	18	CL	Gray brown, Lean clay with sand	8/31/2015
■	17.0	31	13	18	CL	Brown, Sandy lean clay	8/19/2015
○	25.7	24	19	5	CL-ML	Dark gray, Silty clay with sand	8/19/2015

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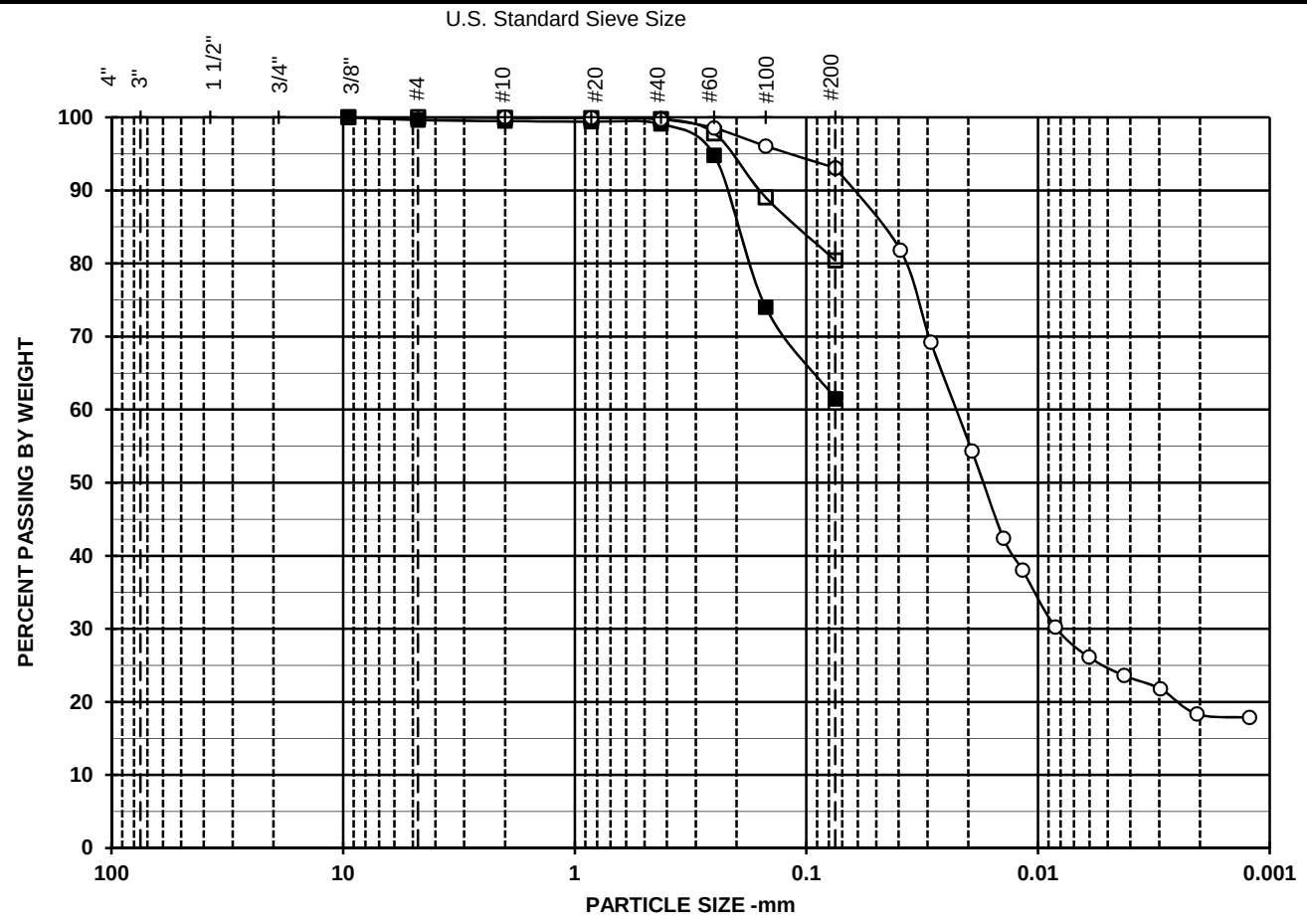
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B004	JOP-B004	JOP-B004
Sample	ST-14	S-15	ST-16C
Depth	65.9	67-68.5	70.1
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.4	0.0
% SAND	19.6	38.1	6.9
%C SAND	0.1	0.1	0.0
%M SAND	0.2	0.4	0.3
%F SAND	19.3	37.6	6.7
% FINES	80.4	61.5	93.1
% -2μ			18
D_{100} (mm)	4.75	9.50	2.00
D_{60} (mm)			0.02
D_{30} (mm)			0.01
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0	100.0	
4	100.0	99.6	
10	99.9	99.5	100.0
20	99.9	99.4	99.9
40	99.8	99.1	99.7
60	97.8	94.8	98.5
100	89.0	74.0	96.1
200	80.4	61.5	93.1

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		25	19	6	CL-ML	Black, Silty clay with sand	8/21/2015
■	20.0				CL	Gray, Sandy lean clay	8/21/2015
○		32	16	16	CL	Light gray brown, Lean clay	9/3/2015

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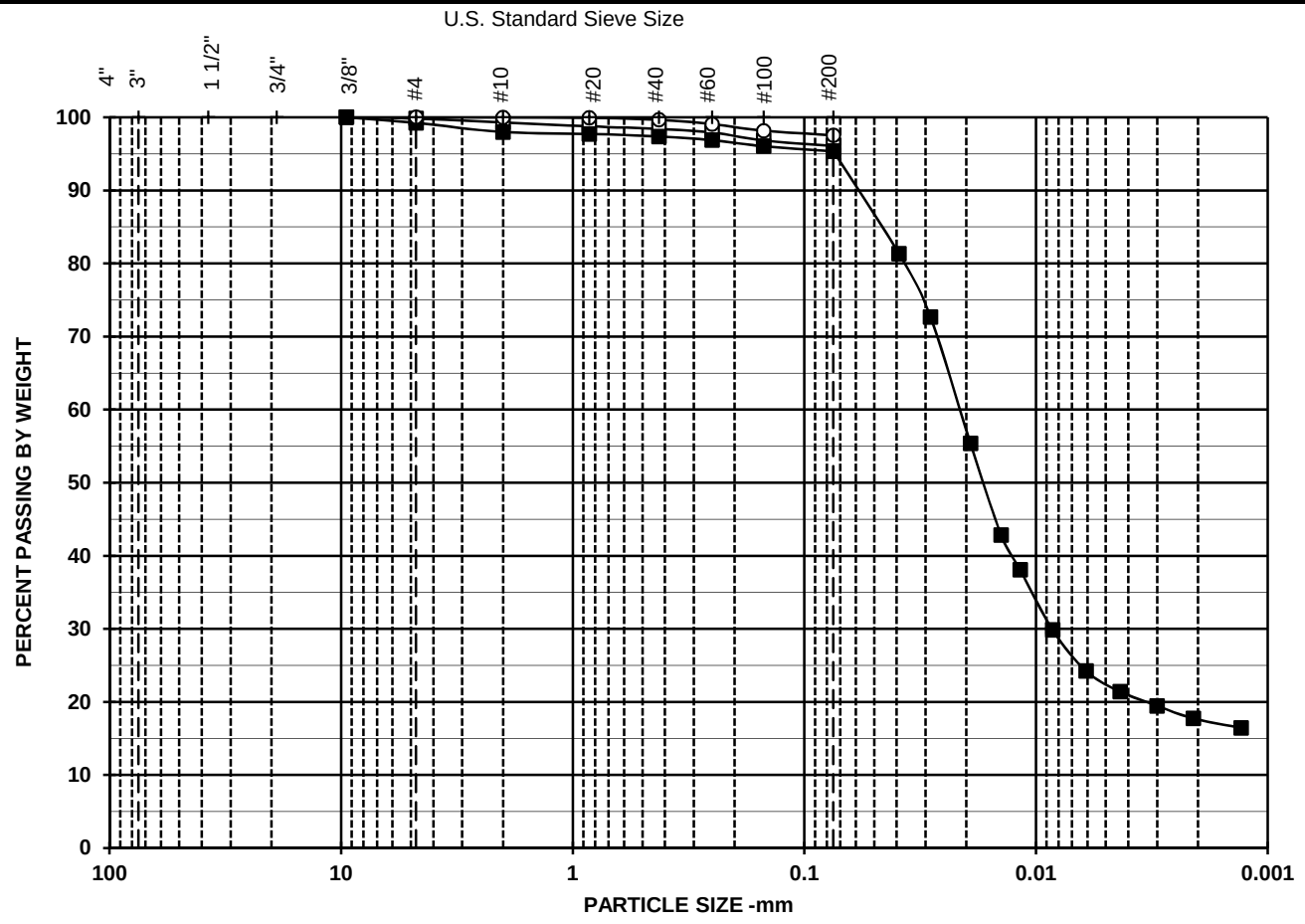
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B005	JOP-B005	JOP-B005
Sample	ST-2B	ST-4B	ST-7B
Depth	9.0	19.15	33.9
% +3"	0.0	0.0	0.0
% Gravel	0.2	0.8	0.0
% SAND	3.7	3.9	2.5
%C SAND	0.5	1.3	0.0
%M SAND	0.9	0.6	0.3
%F SAND	2.3	2.0	2.1
% FINES	96.1	95.3	97.5
% -2μ		18	
D_{100} (mm)	9.50	9.50	4.75
D_{60} (mm)		0.02	
D_{30} (mm)		0.01	
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0	100.0	
4	99.8	99.2	100.0
10	99.3	98.0	100.0
20	98.8	97.7	99.9
40	98.4	97.4	99.7
60	97.9	96.9	99.1
100	96.8	96.0	98.2
200	96.1	95.3	97.5

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□					CL	Grayish brown, Lean clay	9/11/2015
■		37	21	16	CL	Gray and brown, Lean clay	8/31/2015
○		38	19	19	CL	Gray and brown, Lean clay	9/14/2015

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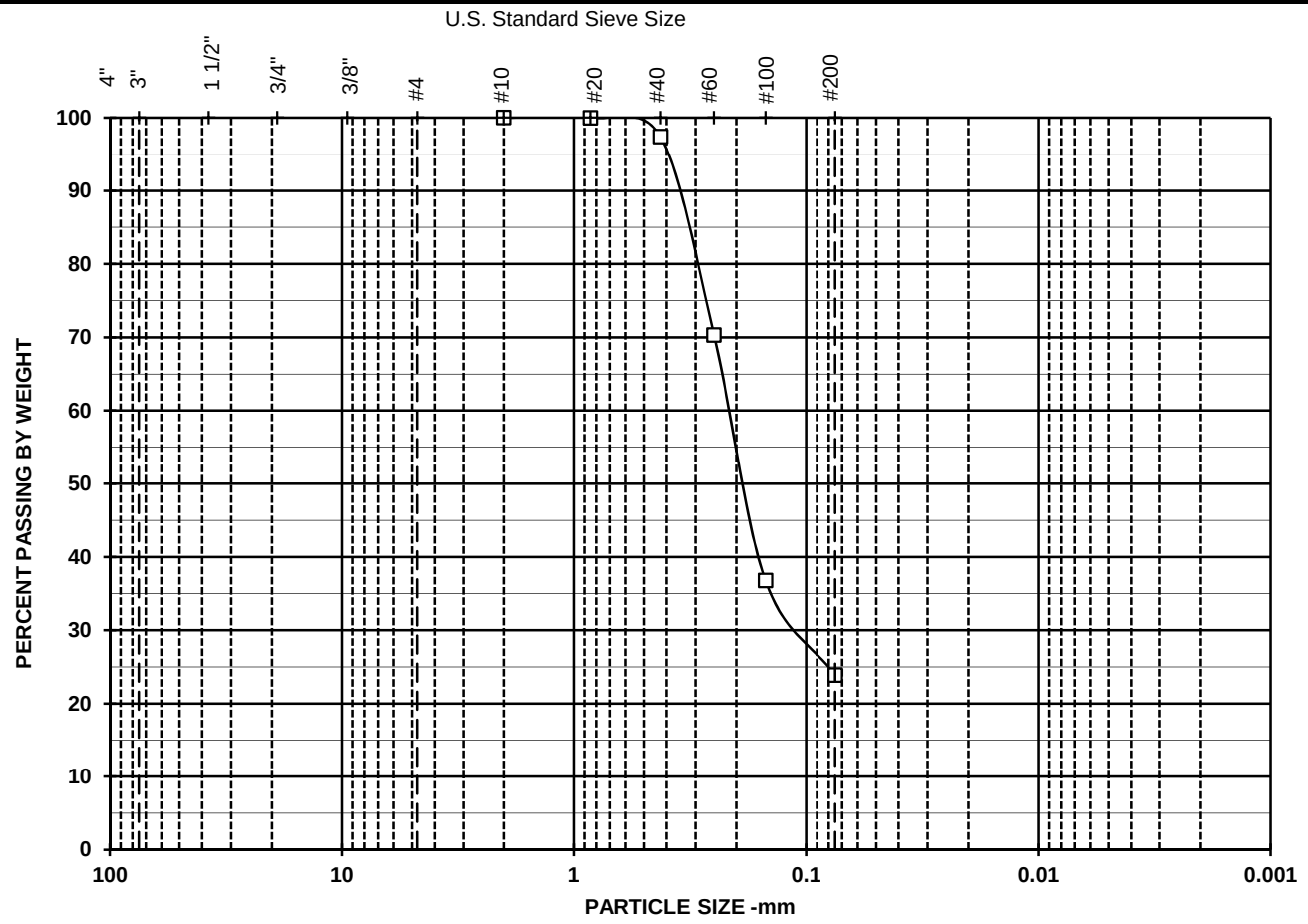
T60428794	60428794-107

PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	15.3	19	18	1	SM	Light gray, Silty sand	8/19/2015
■							
○							

Symbol	□	■	○
Boring	JOP-B005		
Sample	S-17		
Depth	78.5-80		
% +3"	0.0		
% Gravel	0.0		
% SAND	76.1		
%C SAND	0.0		
%M SAND	2.6		
%F SAND	73.5		
% FINES	23.9		
% -2μ			
D_{100} (mm)	2.00		
D_{60} (mm)	0.22		
D_{30} (mm)	0.11		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4			
10	100.0		
20	100.0		
40	97.4		
60	70.3		
100	36.8		
200	23.9		

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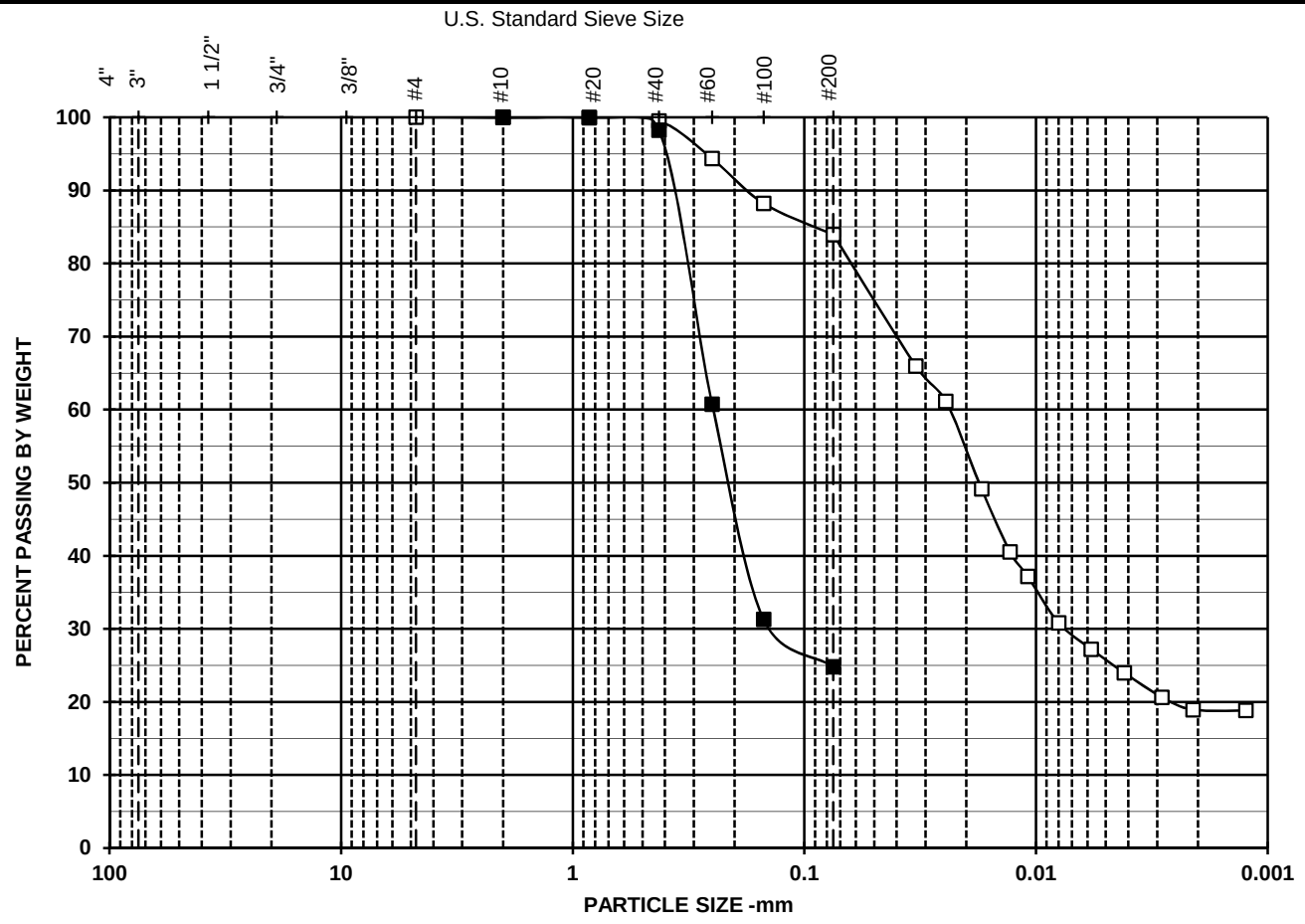
T60428794	60428794-107

PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	18.0				CL	Light grayish brown, Lean clay with sand	10/2/2015
■	14.7				SM	Light brown, Silty sand	9/23/2015
○							

Symbol	□	■	○
Boring	JOP-B006	JOP-B006	
Sample	S-6	S-7	
Depth	33.5-35	38.5-40	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	16.1	75.2	
%C SAND	0.0	0.0	
%M SAND	0.5	1.7	
%F SAND	15.5	73.5	
% FINES	83.9	24.8	
% -2μ	19		
D_{100} (mm)	4.75	2.00	
D_{60} (mm)	0.02	0.25	
D_{30} (mm)	0.01	0.14	
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0		
10	100.0	100.0	
20	99.9	100.0	
40	99.5	98.3	
60	94.3	60.7	
100	88.2	31.3	
200	83.9	24.8	

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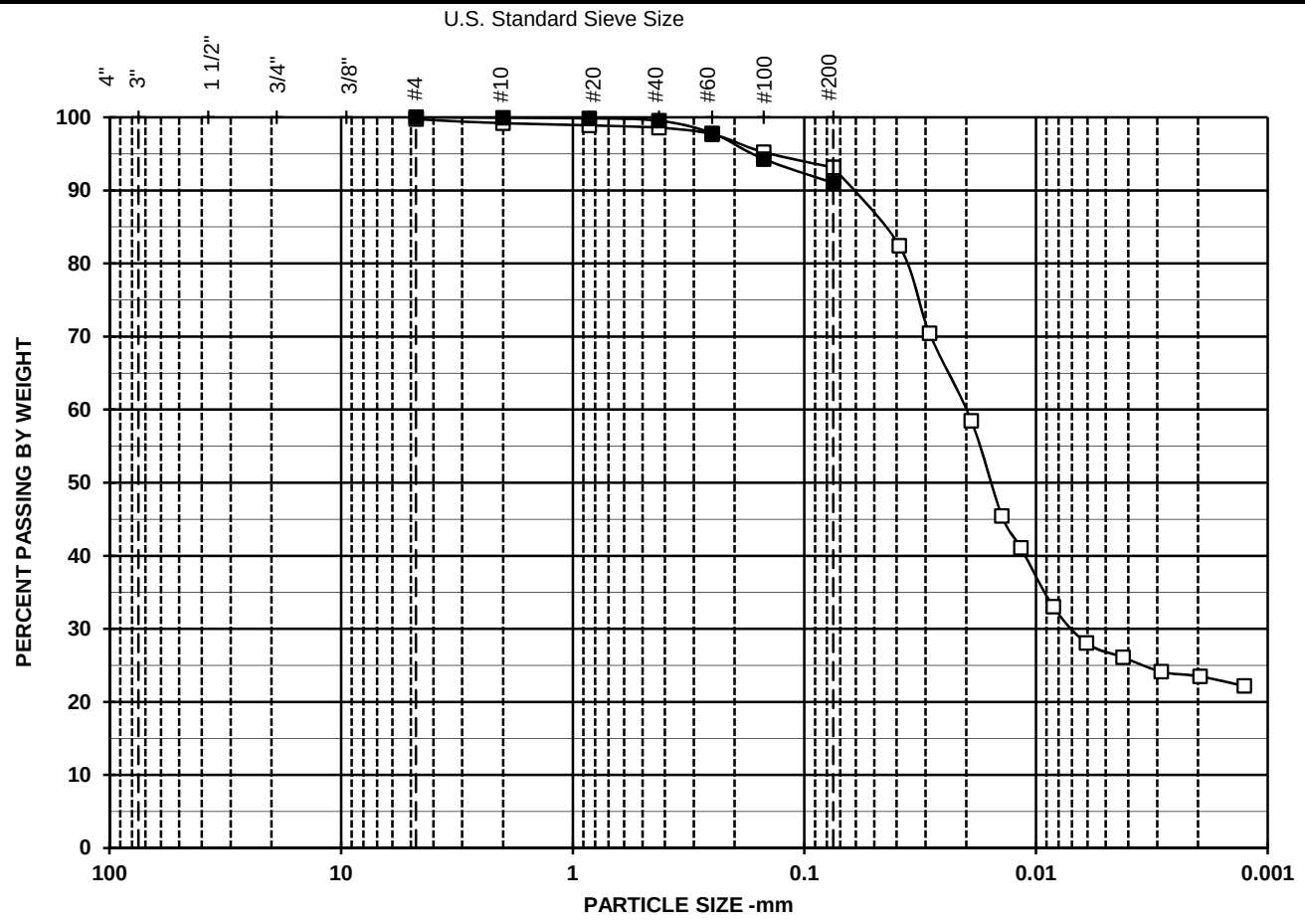
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□					CL	Gray orange brown, Lean clay	9/16/2015
■		37	15	22	CL	Gray, Lean clay	9/11/2015
○							

Symbol	□	■	○
Boring	JOP-B007	JOP-B007	
Sample	ST-2B	ST-3C	
Depth	9.55	29.6	
% +3"	0.0	0.0	
% Gravel	0.2	0.0	
% SAND	6.7	9.0	
%C SAND	0.6	0.1	
%M SAND	0.6	0.4	
%F SAND	5.5	8.5	
% FINES	93.1	91.0	
% -2μ	24		
D_{100} (mm)	9.50	4.75	
D_{60} (mm)	0.02		
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	99.8	100.0	
10	99.2	99.9	
20	98.9	99.8	
40	98.6	99.5	
60	97.7	97.8	
100	95.2	94.3	
200	93.1	91.0	

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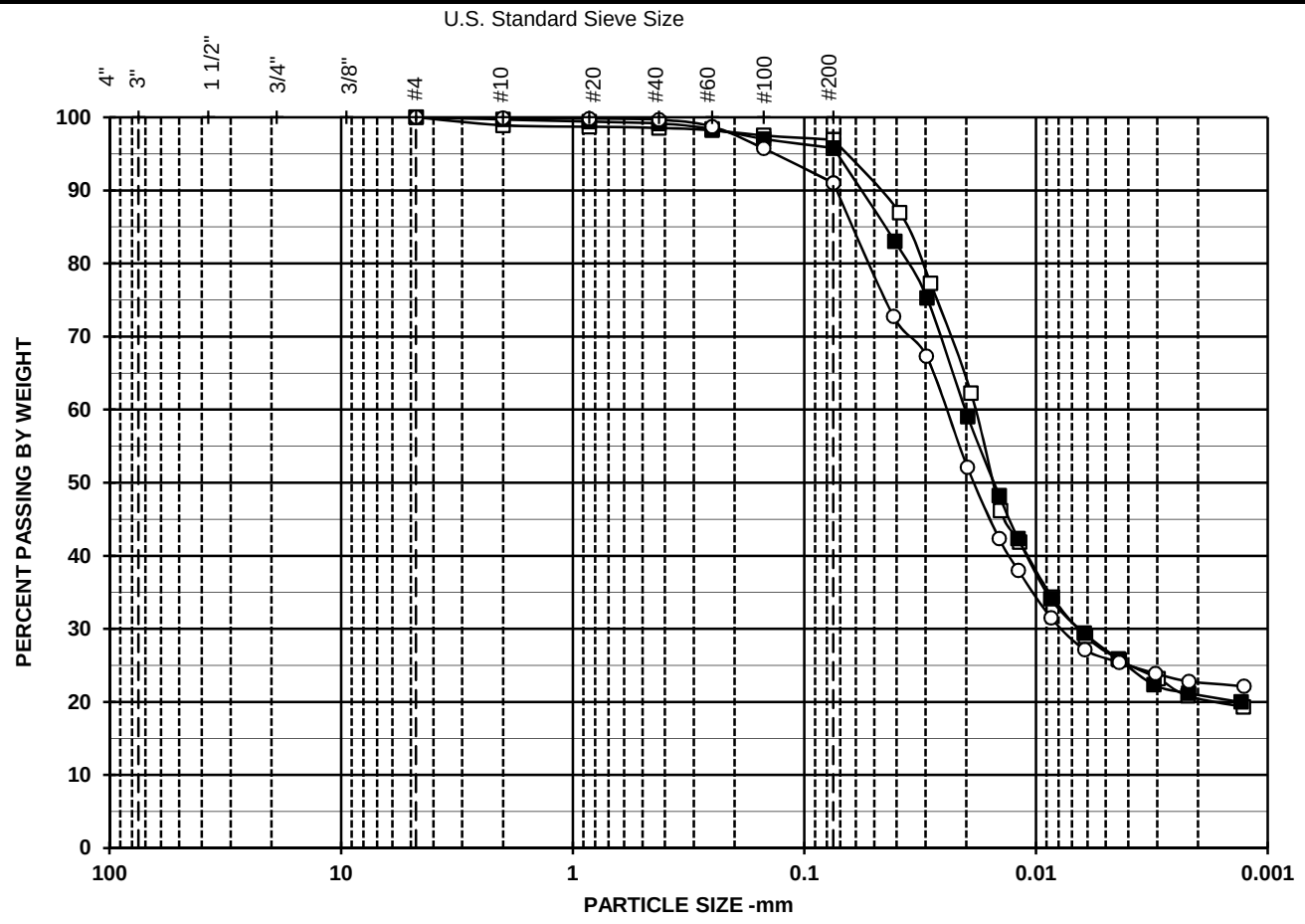
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	17.1	39	19	20	CL	Light brown , Lean clay	9/30/2015
■					CL	Yellowish brown, Lean clay	9/23/2015
○	17.6	35	15	20	CL	Light brown , Lean clay	9/30/2015

Symbol	□	■	○
Boring	JOP-B008	JOP-B008	JOP-B008
Sample	S-4	ST-3C	S-8
Depth	23.5-25	39.8	48.5-50
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% SAND	3.1	4.2	9.0
%C SAND	1.1	0.3	0.1
%M SAND	0.4	0.5	0.2
%F SAND	1.6	3.4	8.6
% FINES	96.9	95.8	91.0
% -2μ	21	21	23
D_{100} (mm)	4.75	4.75	4.75
D_{60} (mm)	0.02	0.02	0.02
D_{30} (mm)	0.01	0.01	0.01
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0	100.0	100.0
10	98.9	99.7	99.9
20	98.7	99.4	99.8
40	98.5	99.2	99.7
60	98.2	98.4	98.7
100	97.5	97.0	95.7
200	96.9	95.8	91.0

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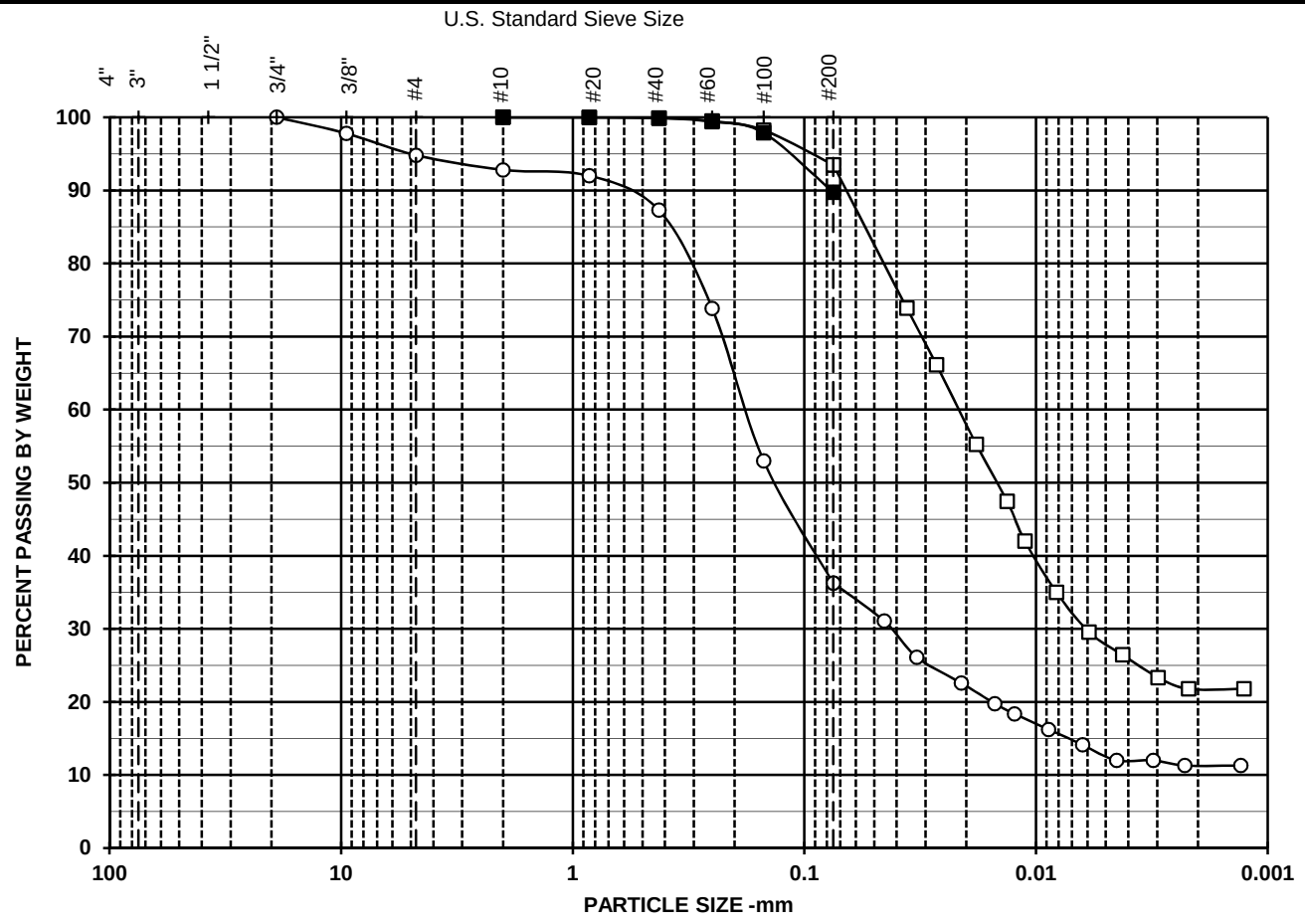
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B008	JOP-B008	JOP-B008
Sample	ST-5C	S-11	ST-6C
Depth	64.75	68.5-70	79.5
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	5.2
% SAND	6.5	10.3	58.6
%C SAND	0.0	0.0	2.0
%M SAND	0.1	0.1	5.5
%F SAND	6.4	10.2	51.1
% FINES	93.5	89.7	36.2
% -2μ	22		11
D_{100} (mm)	2.00	2.00	19.00
D_{60} (mm)	0.02		0.18
D_{30} (mm)	0.01		0.04
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			100.0
3/8"			97.8
4			94.8
10	100.0	100.0	92.8
20	100.0	100.0	92.0
40	99.9	99.9	87.3
60	99.5	99.4	73.9
100	98.2	97.9	53.0
200	93.5	89.7	36.2

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□					CL	Light brown, Lean clay	10/14/2015
■	18.3				ML	Light gray, Silt	9/23/2015
○	13.8	21	15	6	SC-SM	Light gray, Silty, clayey sand	10/14/2015

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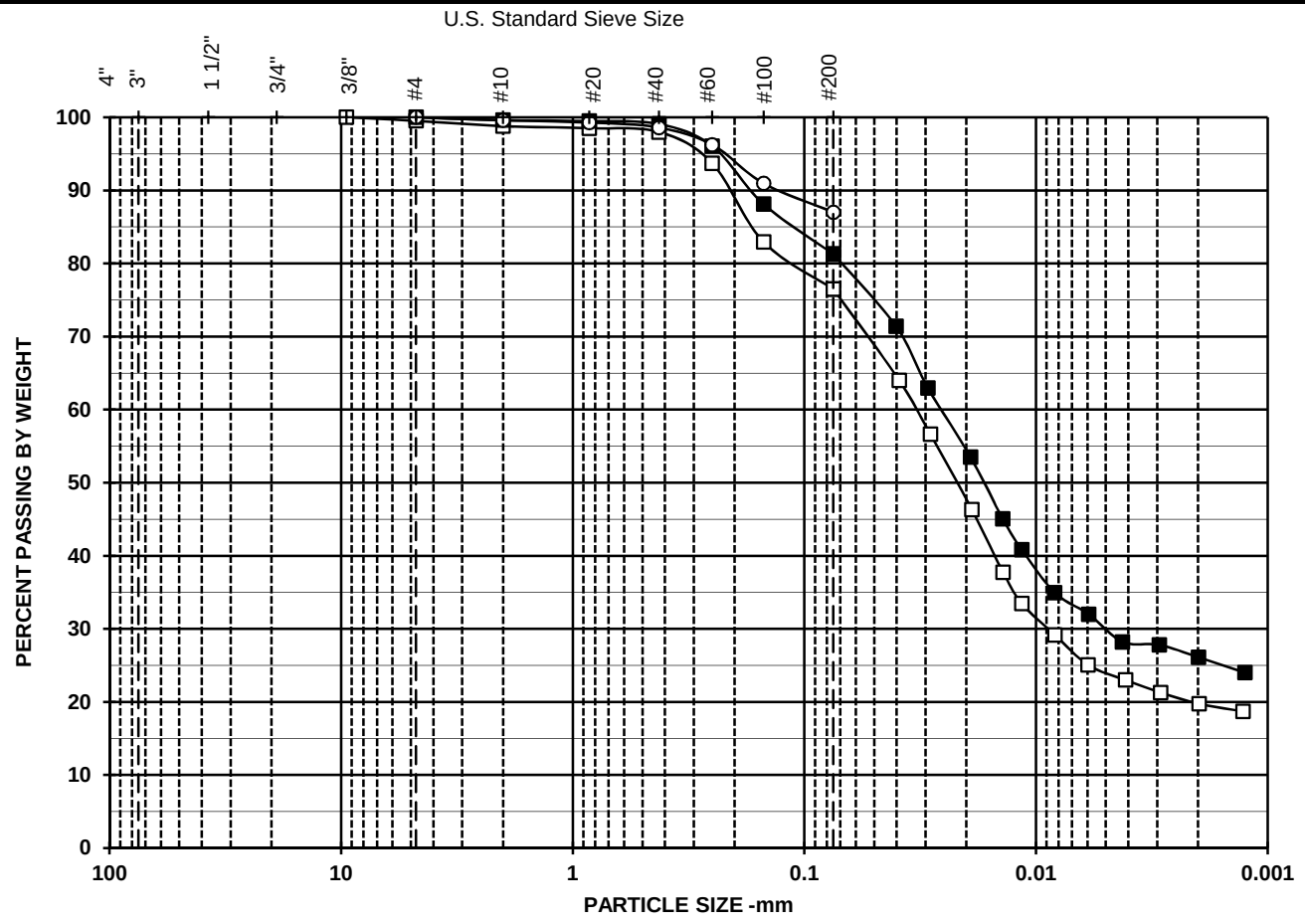
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		34	14	20	CL	Brown, Lean clay with sand	9/1/2015
■	20.8	39	17	22	CL	Brown, Lean clay with sand	8/19/2015
○		37	15	22	CL	Yellowish brown, Lean clay	9/30/2015

Symbol	□	■	○
Boring	JOP-B009	JOP-B009	JOP-B009
Sample	ST-3C	S-7	ST-11D
Depth	14.35	31-32.5	49.85
% +3"	0.0	0.0	0.0
% Gravel	0.5	0.0	0.0
% SAND	23.0	18.7	13.0
%C SAND	0.7	0.4	0.4
%M SAND	0.8	0.5	1.0
%F SAND	21.5	17.8	11.6
% FINES	76.5	81.3	87.0
% -2μ	20	26	
D_{100} (mm)	9.50	4.75	4.75
D_{60} (mm)	0.03	0.03	
D_{30} (mm)	0.01	0.01	
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0		
4	99.5	100.0	100.0
10	98.8	99.6	99.6
20	98.5	99.5	99.3
40	98.0	99.1	98.6
60	93.7	96.1	96.2
100	82.9	88.1	90.9
200	76.5	81.3	87.0

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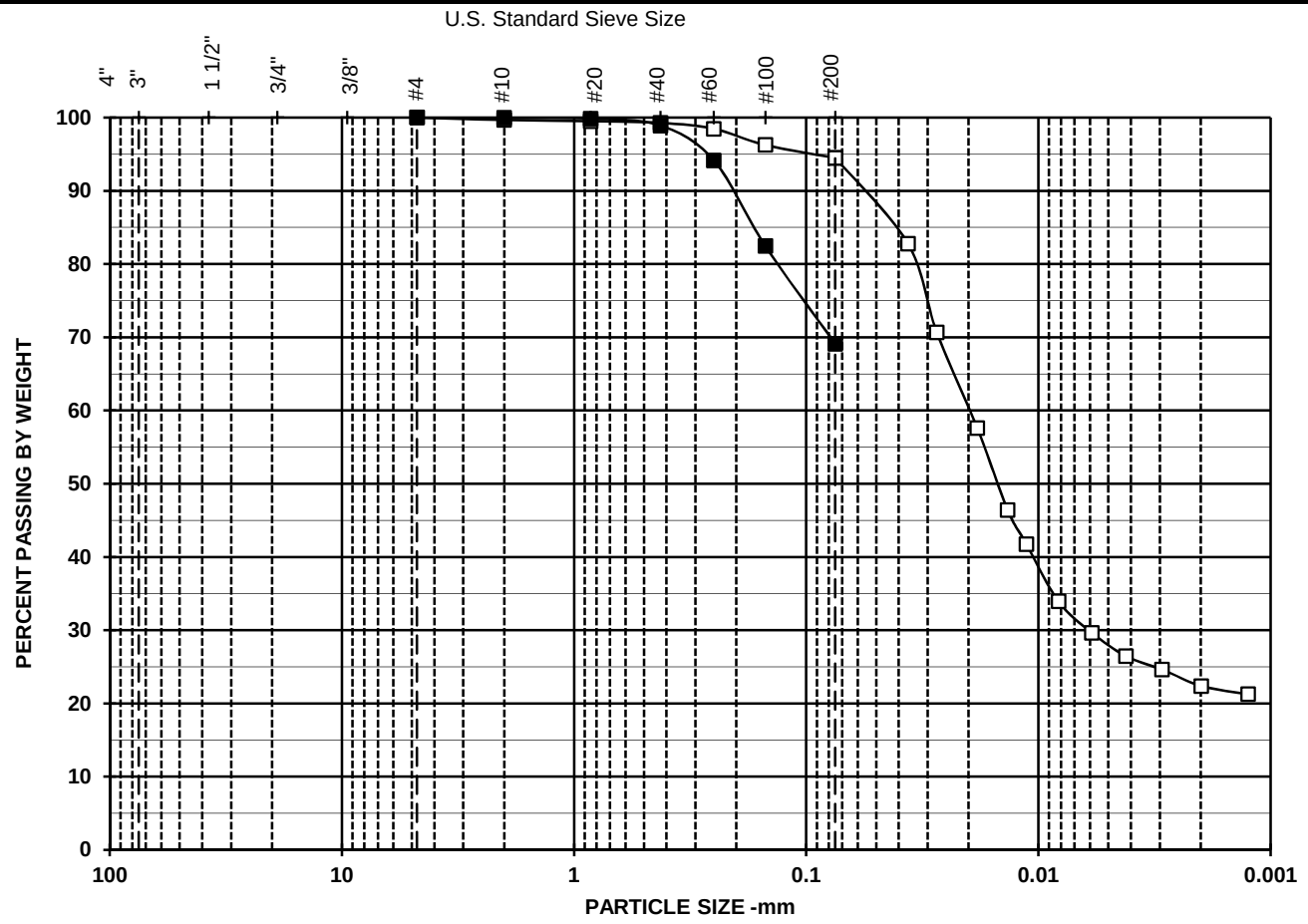
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	21.3	38	13	25	CL	Brown, Lean clay	8/18/2015
■		27	10	17	CL	Gray, Sandy lean clay	9/14/2015
○							

Symbol	□	■	○
Boring	JOP-B009	JOP-B009	
Sample	S-12	ST-14C	
Depth	53.5-55	64.85	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	5.5	30.9	
%C SAND	0.3	0.0	
%M SAND	0.4	1.1	
%F SAND	4.8	29.8	
% FINES	94.5	69.1	
% -2μ	22		
D_{100} (mm)	4.75	4.75	
D_{60} (mm)	0.02		
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0	100.0	
10	99.7	100.0	
20	99.5	99.8	
40	99.3	98.9	
60	98.5	94.1	
100	96.3	82.4	
200	94.5	69.1	

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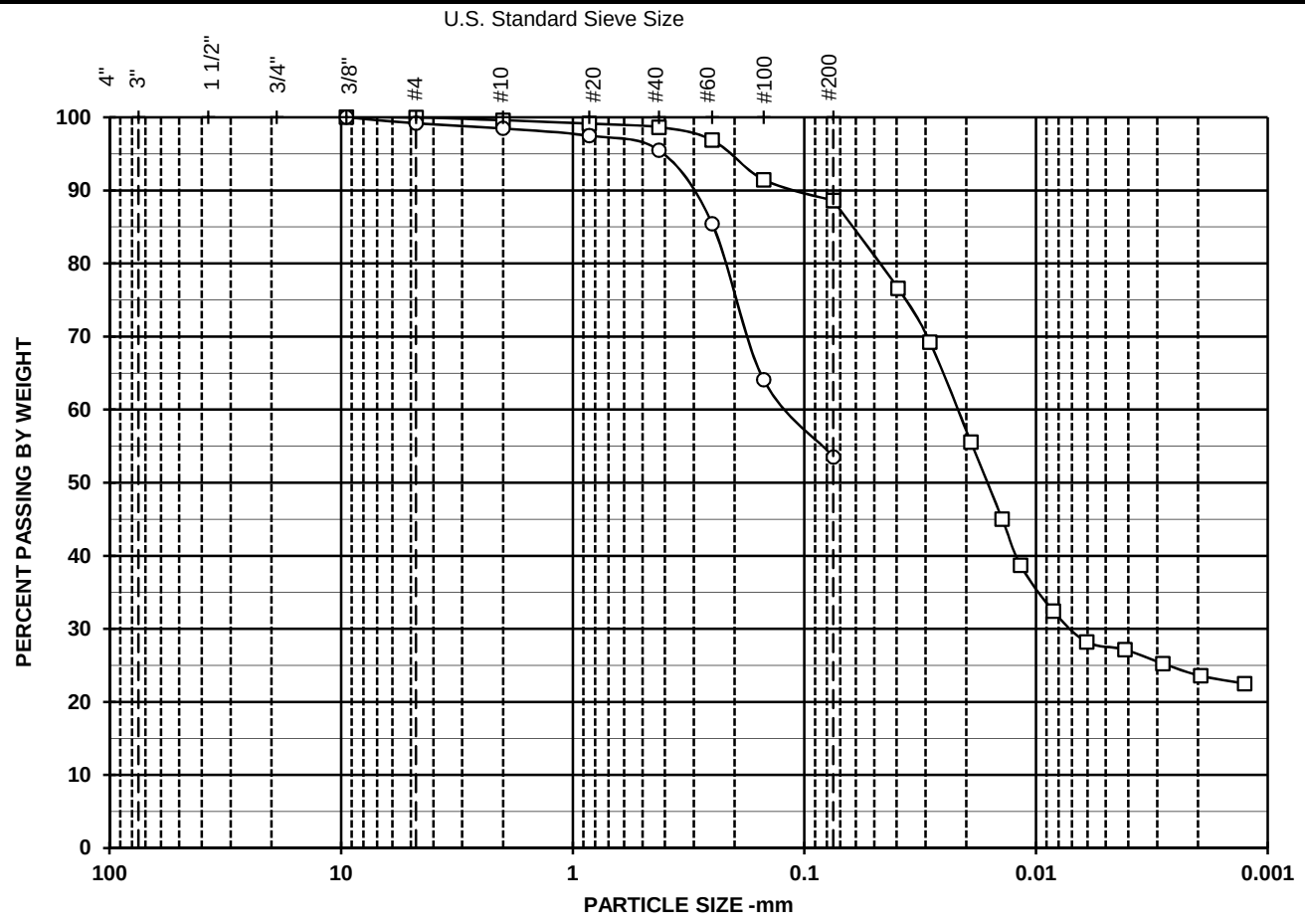
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B010		JOP-B010
Sample	ST-1B		ST-3D
Depth	1.1		35.35
% +3"	0.0		0.0
% Gravel	0.0		0.8
% SAND	11.4		45.7
%C SAND	0.4		0.7
%M SAND	1.0		3.0
%F SAND	10.1		42.0
% FINES	88.6		53.5
% -2μ	24		
D_{100} (mm)	9.50		9.50
D_{60} (mm)	0.02		0.12
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0		100.0
4	100.0		99.2
10	99.6		98.5
20	99.1		97.5
40	98.6		95.5
60	96.9		85.4
100	91.5		64.1
200	88.6		53.5

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□					CL	Brown, Lean clay	9/15/2015
■							
○					CL	Brown, Sandy lean clay	9/18/2015

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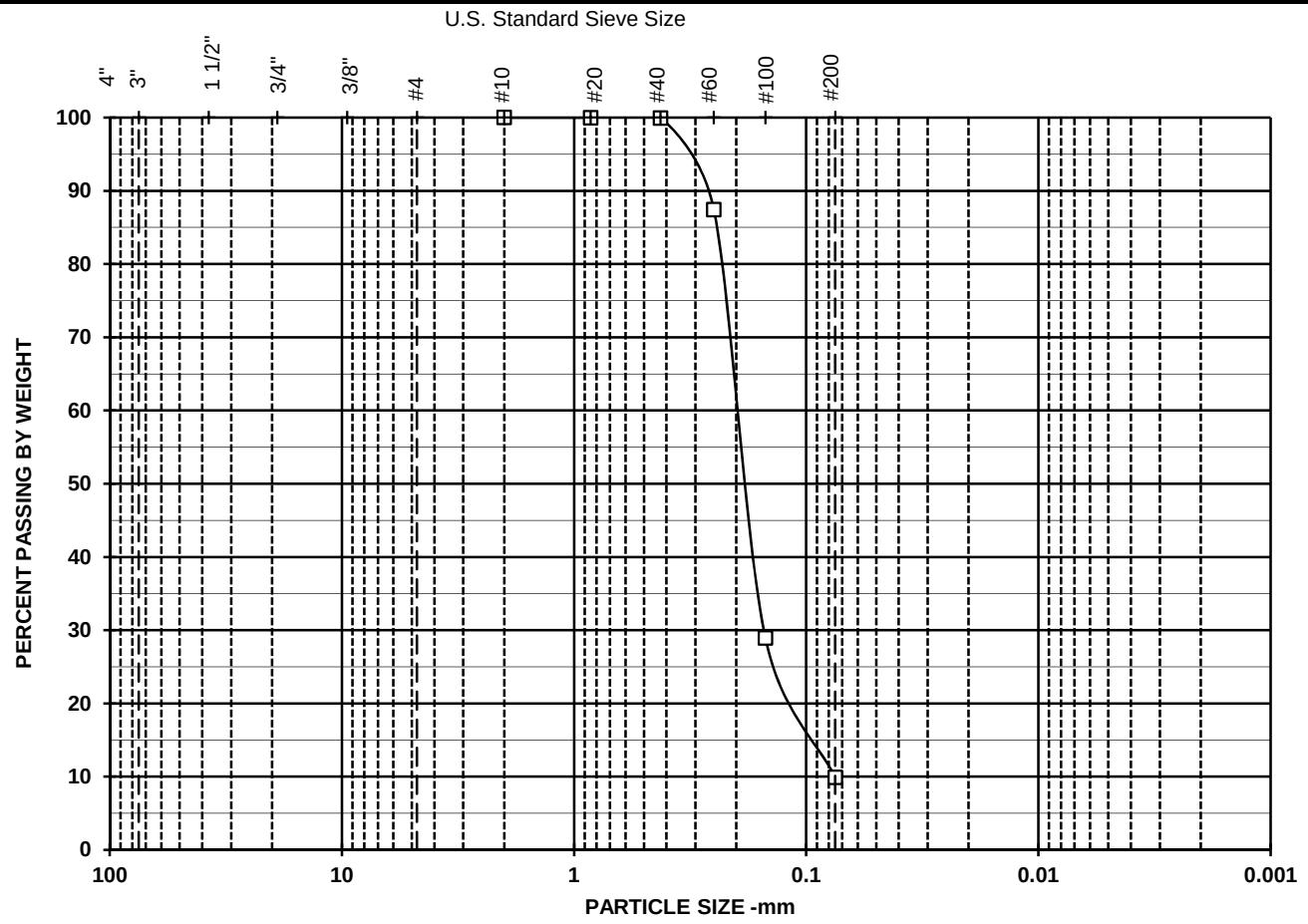
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	27.6		26	NP	SP-SM	Brown, Poorly-graded sand with silt	8/19/2015
■							
○							

Symbol	□	■	○
Boring	JOP-010		
Sample	S-9		
Depth	48.5-50		
% +3"	0.0		
% Gravel	0.0		
% SAND	90.1		
%C SAND	0.0		
%M SAND	0.1		
%F SAND	90.0		
% FINES	9.9		
% -2μ			
D_{100} (mm)	2.00		
D_{60} (mm)	0.20		
D_{30} (mm)	0.15		
D_{10} (mm)	0.08		
Cc	1.5		
Cu	2.7		

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4			
10	100.0		
20	100.0		
40	99.9		
60	87.4		
100	29.0		
200	9.9		

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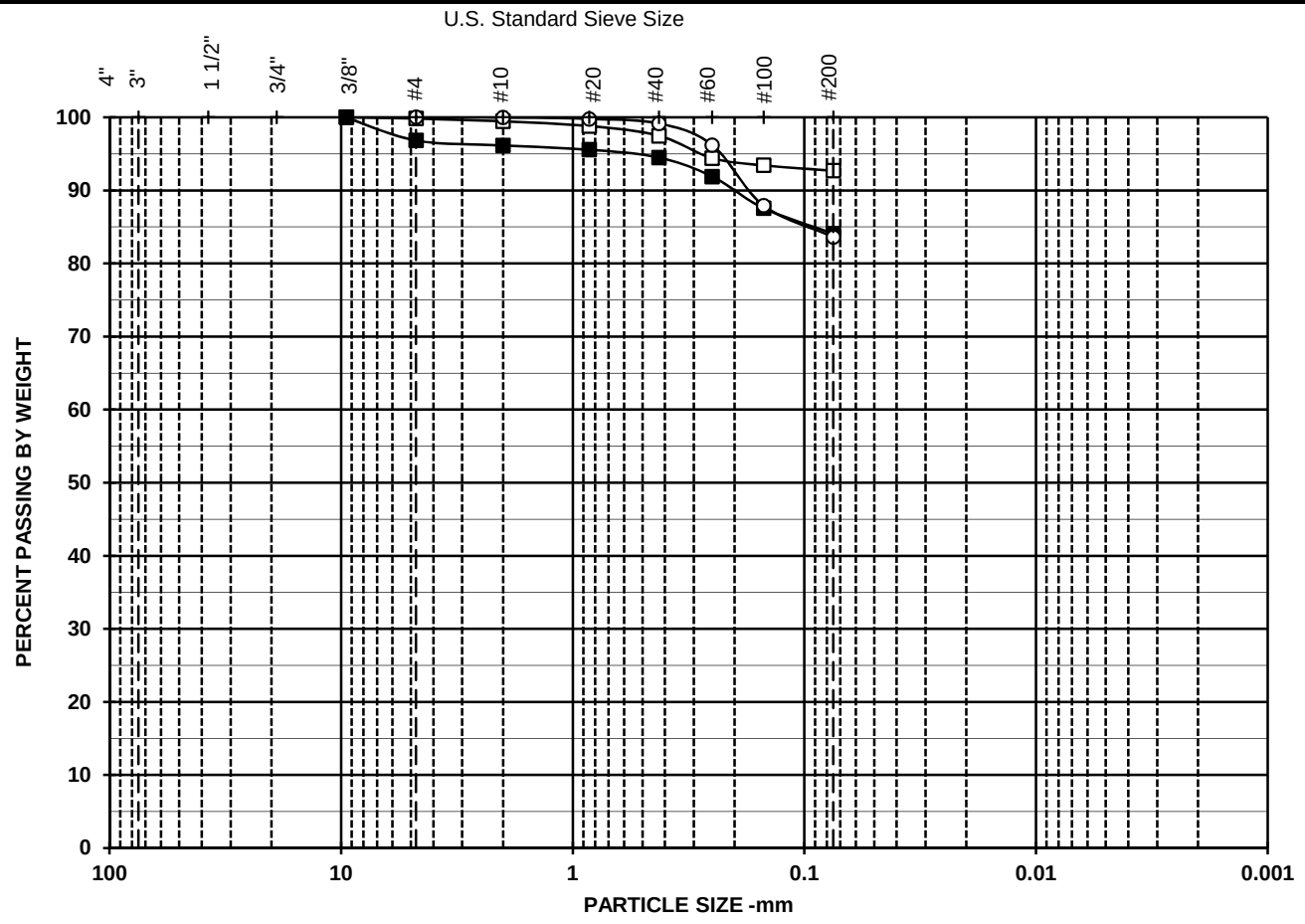
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B011	JOP-B011	JOP-B011
Sample	ST-5C	S-6	S-8
Depth	24.25	28.5-30	38.5-40
% +3"	0.0	0.0	0.0
% Gravel	0.2	3.2	0.0
% SAND	7.1	12.7	16.4
%C SAND	0.4	0.7	0.0
%M SAND	2.0	1.7	0.8
%F SAND	4.8	10.4	15.5
% FINES	92.7	84.1	83.6
% -2μ			
D_{100} (mm)	9.50	9.50	4.75
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0	100.0	
4	99.8	96.8	100.0
10	99.5	96.2	100.0
20	98.8	95.6	99.8
40	97.5	94.5	99.2
60	94.4	91.9	96.2
100	93.4	87.6	87.9
200	92.7	84.1	83.6

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		33	18	15	CL	Brown, Lean clay	9/15/2015
■	18.5				CL	Light brown, Lean clay with sand	8/21/2015
○	19.9				CL	Light brown, Lean clay with sand	8/21/2015

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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

Analysis File: 3SV-MasterRev4b

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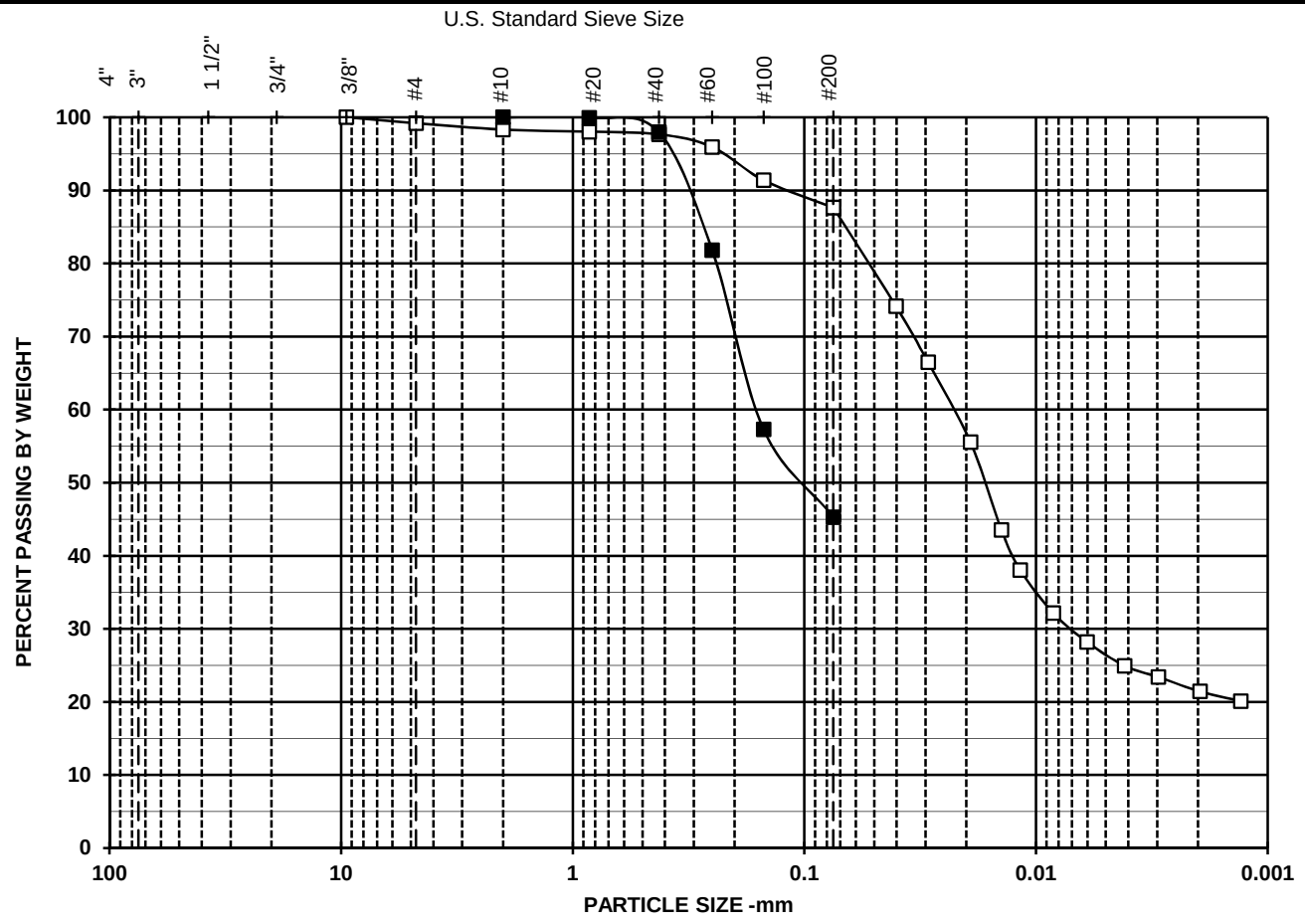
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B011	JOP-B011	
Sample	ST-9C	ST-14C	
Depth	44.8	69.8	
% +3"	0.0	0.0	
% Gravel	0.8	0.0	
% SAND	11.6	54.7	
%C SAND	0.9	0.0	
%M SAND	0.6	2.0	
%F SAND	10.0	52.7	
% FINES	87.6	45.3	
% -2μ	22		
D_{100} (mm)	9.50	2.00	
D_{60} (mm)	0.02	0.16	
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0		
4	99.2		
10	98.3	100.0	
20	98.0	100.0	
40	97.7	98.0	
60	95.9	81.8	
100	91.4	57.3	
200	87.6	45.3	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		36	14	22	CL	Brown, Lean clay	9/1/2015
■		34	11	23	SC	Reddish gray, Clayey sand	10/6/2015
○							

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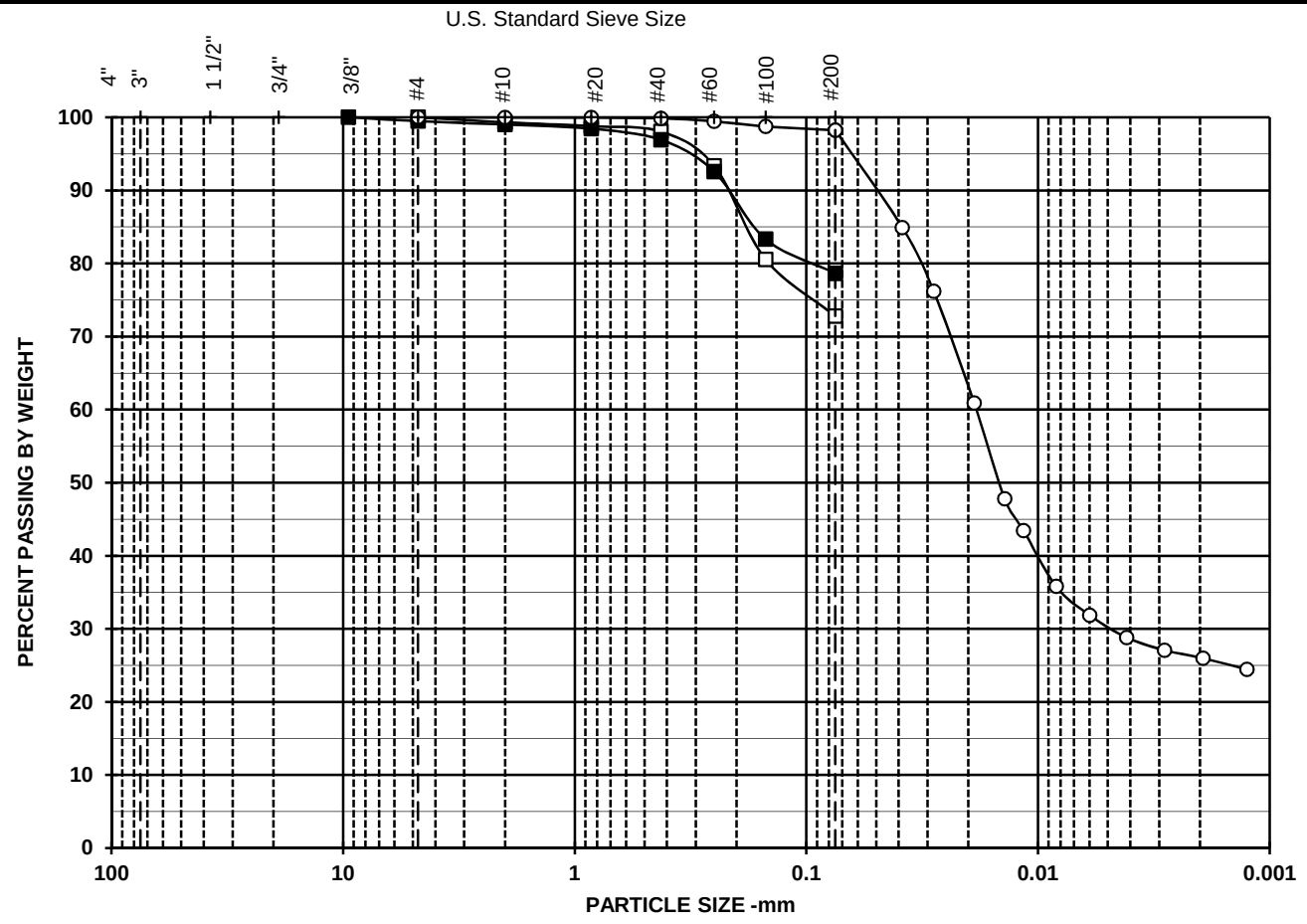
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B012	JOP-B012	JOP-B012
Sample	ST-3C	S-5	ST-8C
Depth	16.45	23.5-25	33.6
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.5	0.0
% SAND	27.2	20.9	1.8
%C SAND	0.7	0.5	0.0
%M SAND	1.3	2.1	0.1
%F SAND	25.3	18.3	1.6
% FINES	72.8	78.6	98.2
% -2μ			26
D_{100} (mm)	4.75	9.50	4.75
D_{60} (mm)			0.02
D_{30} (mm)			0.00
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"		100.0	
4	100.0	99.5	100.0
10	99.3	99.0	100.0
20	98.8	98.4	100.0
40	98.0	96.9	99.9
60	93.4	92.6	99.4
100	80.5	83.3	98.7
200	72.8	78.6	98.2

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		37	13	24	CL	Gray, Lean clay with sand	9/14/2015
■	15.3				CL	Light brown, Lean clay with sand	8/21/2015
○		40	19	21	CL	Brown gray, Lean clay	9/15/2015

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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

Analysis File: 3SV-MasterRev4b

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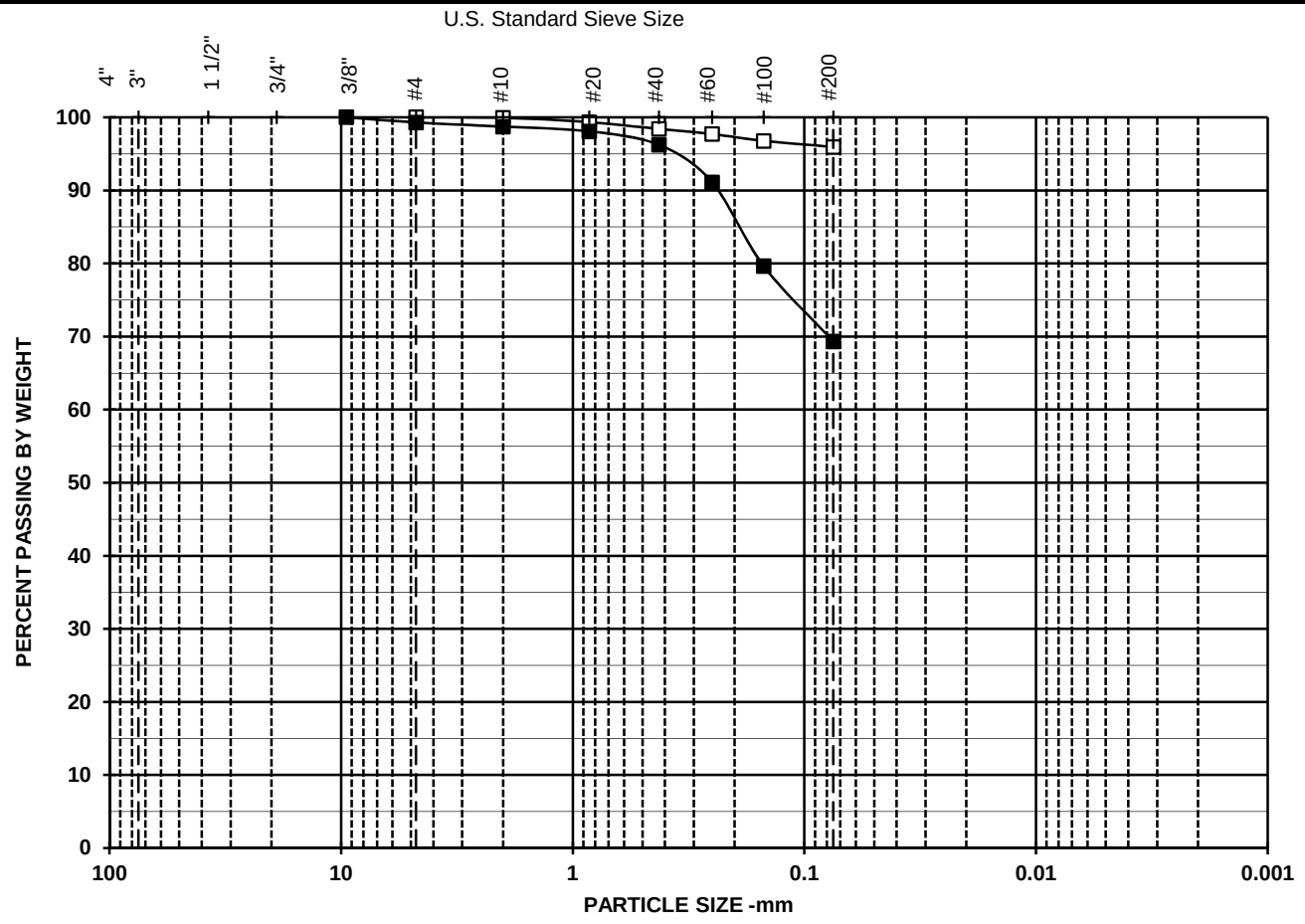
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B012	JOP-B012	
Sample	S-9	S-12	
Depth	36.37.5	48.5-50	
% +3"	0.0	0.0	
% Gravel	0.0	0.7	
% SAND	4.1	30.0	
%C SAND	0.0	0.6	
%M SAND	1.5	2.5	
%F SAND	2.5	26.9	
% FINES	95.9	69.3	
% -2μ			
D_{100} (mm)	4.75	9.50	
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"		100.0	
4	100.0	99.3	
10	100.0	98.7	
20	99.3	98.1	
40	98.4	96.2	
60	97.7	91.1	
100	96.8	79.7	
200	95.9	69.3	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	26.1	33	21	12	CL	Brown, Lean clay	8/19/2015
■	21.7				ML	Brown, Sandy silt	8/21/2015
○							

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PARTICLE SIZE DISTRIBUTION

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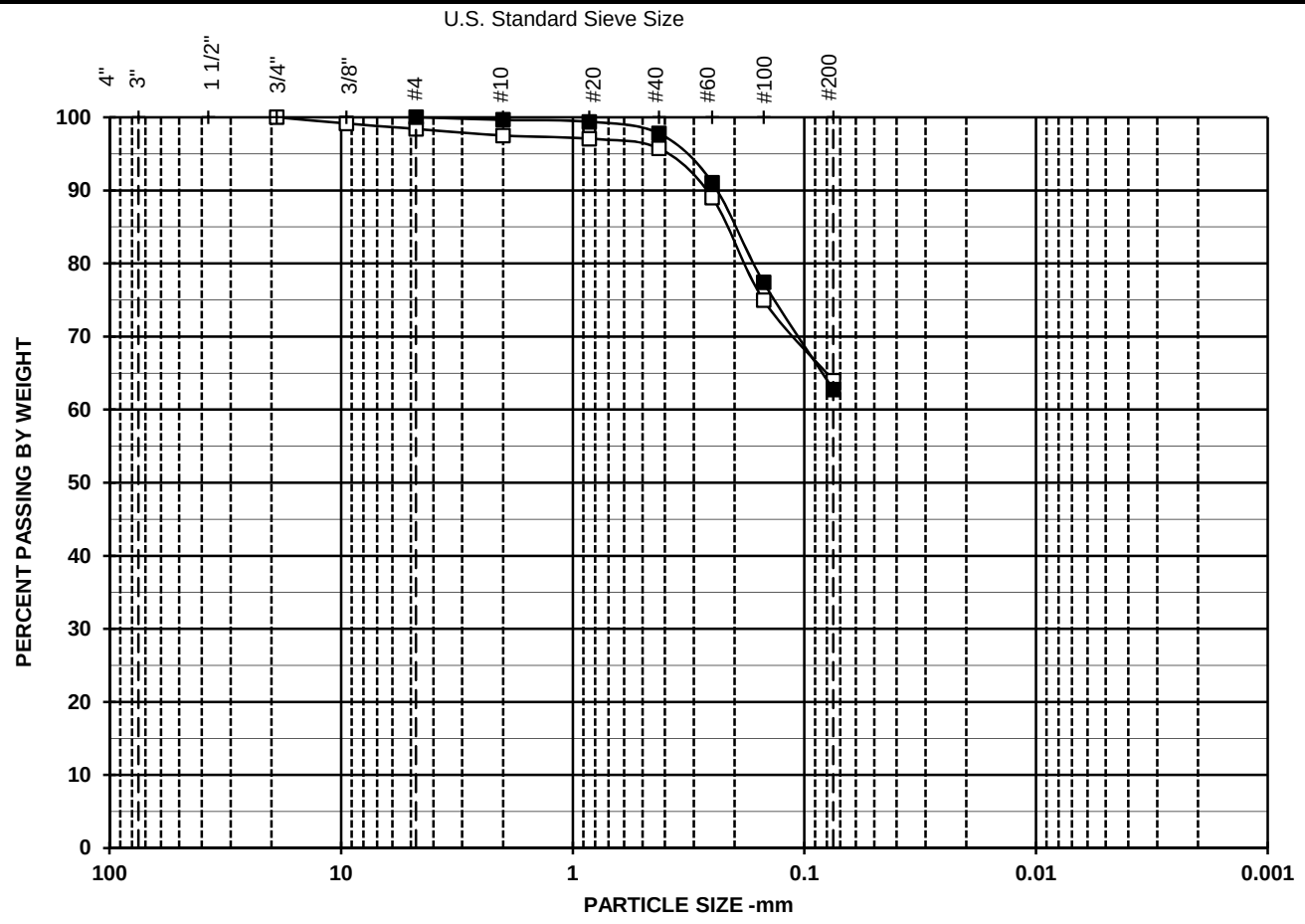
Siev012b.xls 11/15/2015

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B012	JOP-B012	
Sample	ST-13B	ST-16C	
Depth	53.95	66.6	
% +3"	0.0	0.0	
% Gravel	1.6	0.0	
% SAND	34.5	37.3	
%C SAND	0.9	0.3	
%M SAND	1.8	1.9	
%F SAND	31.8	35.1	
% FINES	63.9	62.7	
% -2μ			
D_{100} (mm)	19.00	4.75	
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"	100.0		
3/8"	99.1		
4	98.4	100.0	
10	97.5	99.7	
20	97.1	99.4	
40	95.7	97.8	
60	89.0	91.0	
100	75.0	77.4	
200	63.9	62.7	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		27	12	15	CL	Yellowish brown, Sandy lean clay	9/10/2015
■		33	13	20	CL	Gray brown, Sandy lean clay	9/17/2015
○							

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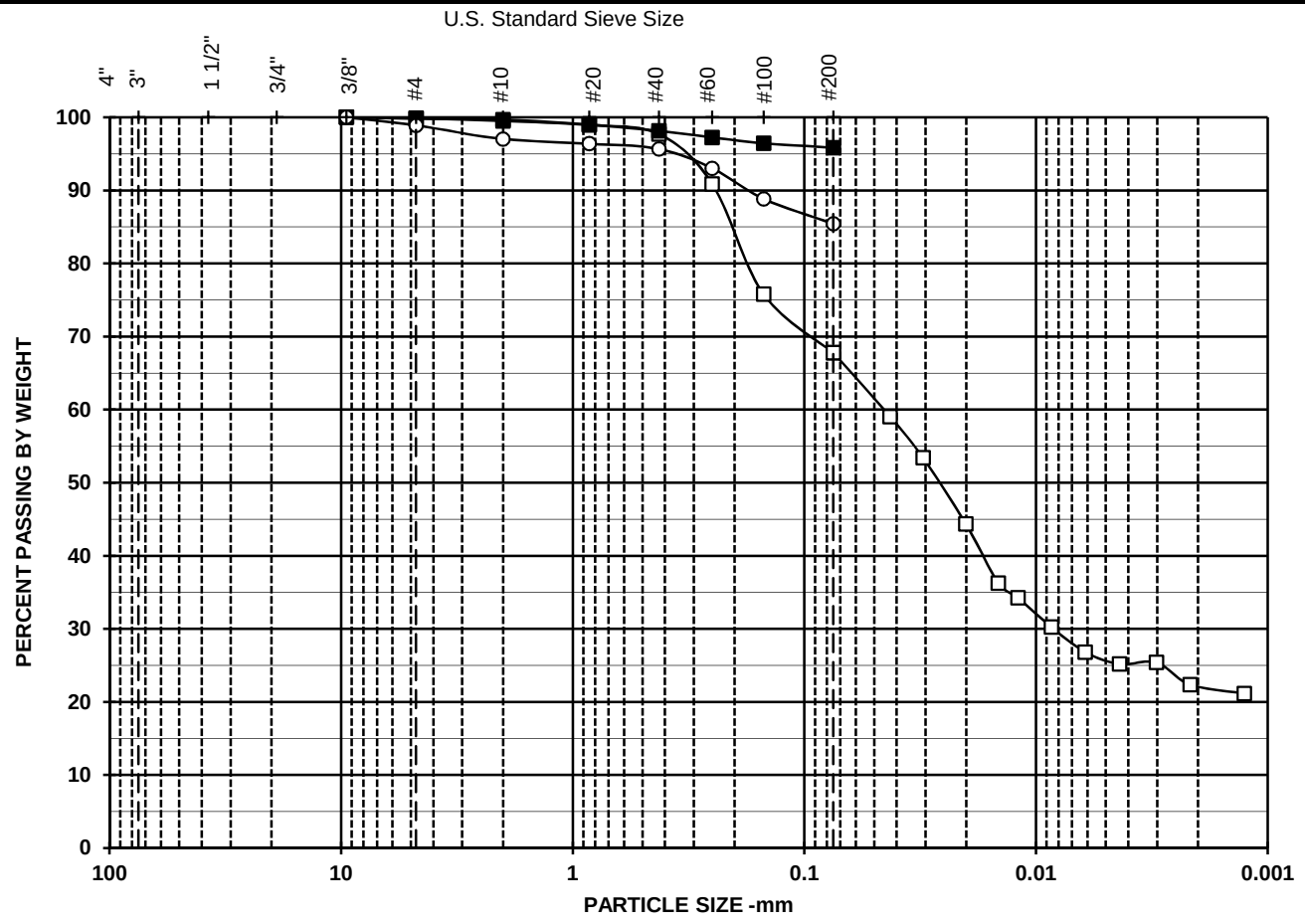
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

Analysis File: 3SV-MasterRev4b

Siev012c.xls 11/15/2015

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B013	JOP-B013	JOP-B013
Sample	S-2	S-4	S-7
Depth	8.5-10	23.5-25	43.5-45
% +3"	0.0	0.0	0.0
% Gravel	0.1	0.2	1.1
% SAND	32.1	4.0	13.5
%C SAND	0.4	0.1	1.9
%M SAND	1.8	1.6	1.4
%F SAND	29.9	2.3	10.2
% FINES	67.8	95.8	85.4
% -2μ	22		
D_{100} (mm)	9.50	9.50	9.50
D_{60} (mm)	0.05		
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0	100.0	100.0
4	99.9	99.8	98.9
10	99.5	99.7	97.0
20	99.0	99.0	96.4
40	97.7	98.1	95.7
60	90.9	97.3	93.0
100	75.8	96.4	88.8
200	67.8	95.8	85.4

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	14.7				CL	Light brown, Sandy lean clay	9/30/2015
■	23.1				CL	Grayish brown, Lean clay	9/23/2015
○	19.8				CL	Grayish brown, Lean clay	9/23/2015

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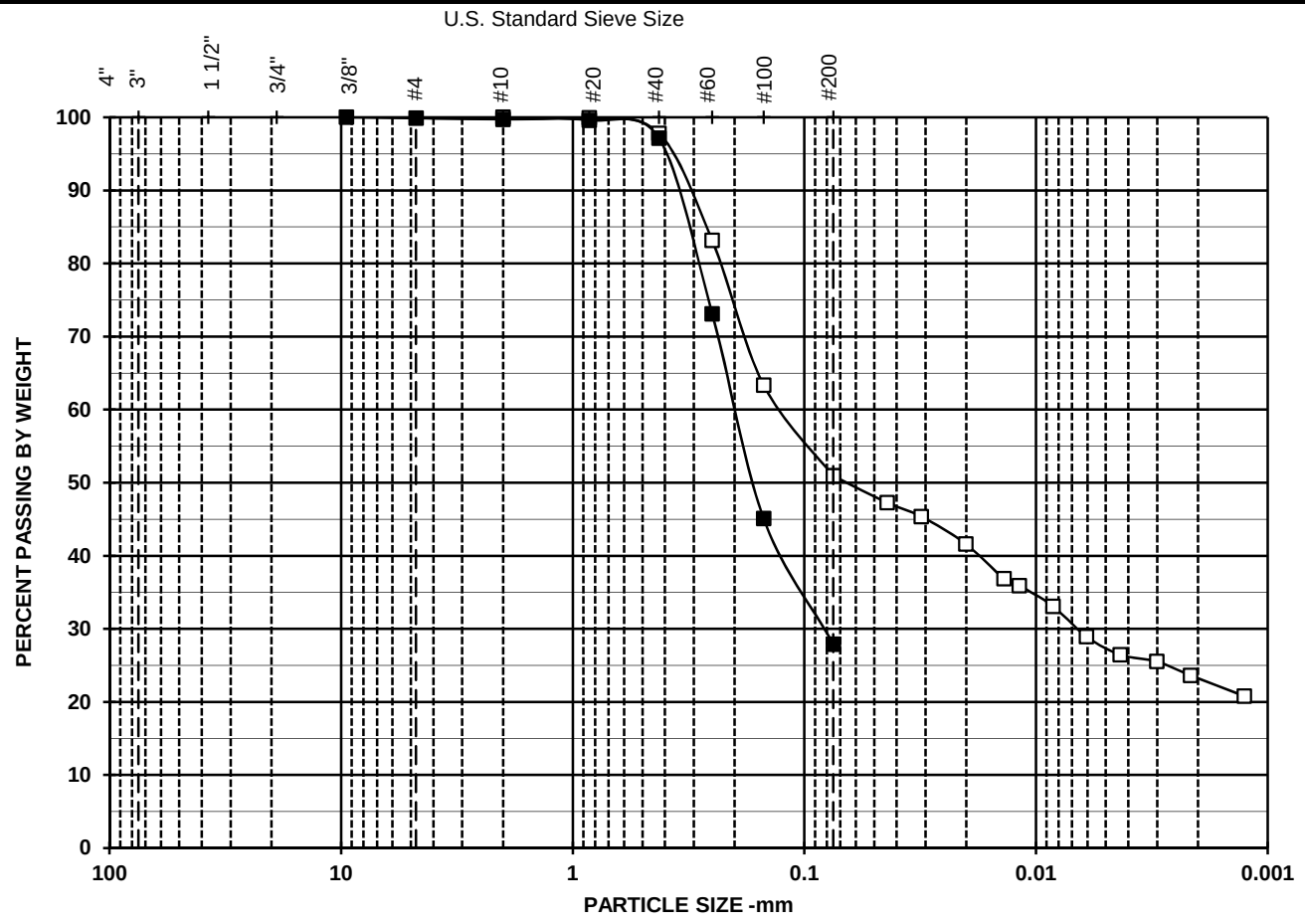
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B013	JOP-B013	
Sample	S-12	S-13	
Depth	68.5-70	73.5-75	
% +3"	0.0	0.0	
% Gravel	0.0	0.1	
% SAND	49.1	72.0	
%C SAND	0.0	0.2	
%M SAND	2.2	2.6	
%F SAND	46.9	69.3	
% FINES	50.9	27.9	
% -2μ	23		
D_{100} (mm)	2.00	9.50	
D_{60} (mm)	0.13	0.20	
D_{30} (mm)	0.01	0.08	
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"		100.0	
4		99.9	
10	100.0	99.7	
20	99.9	99.6	
40	97.8	97.1	
60	83.2	73.1	
100	63.3	45.1	
200	50.9	27.9	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	17.1				CL	Light brown, Sandy lean clay	9/30/2015
■	16.3				SM	Light brownish gray , Silty sand	9/23/2015
○							

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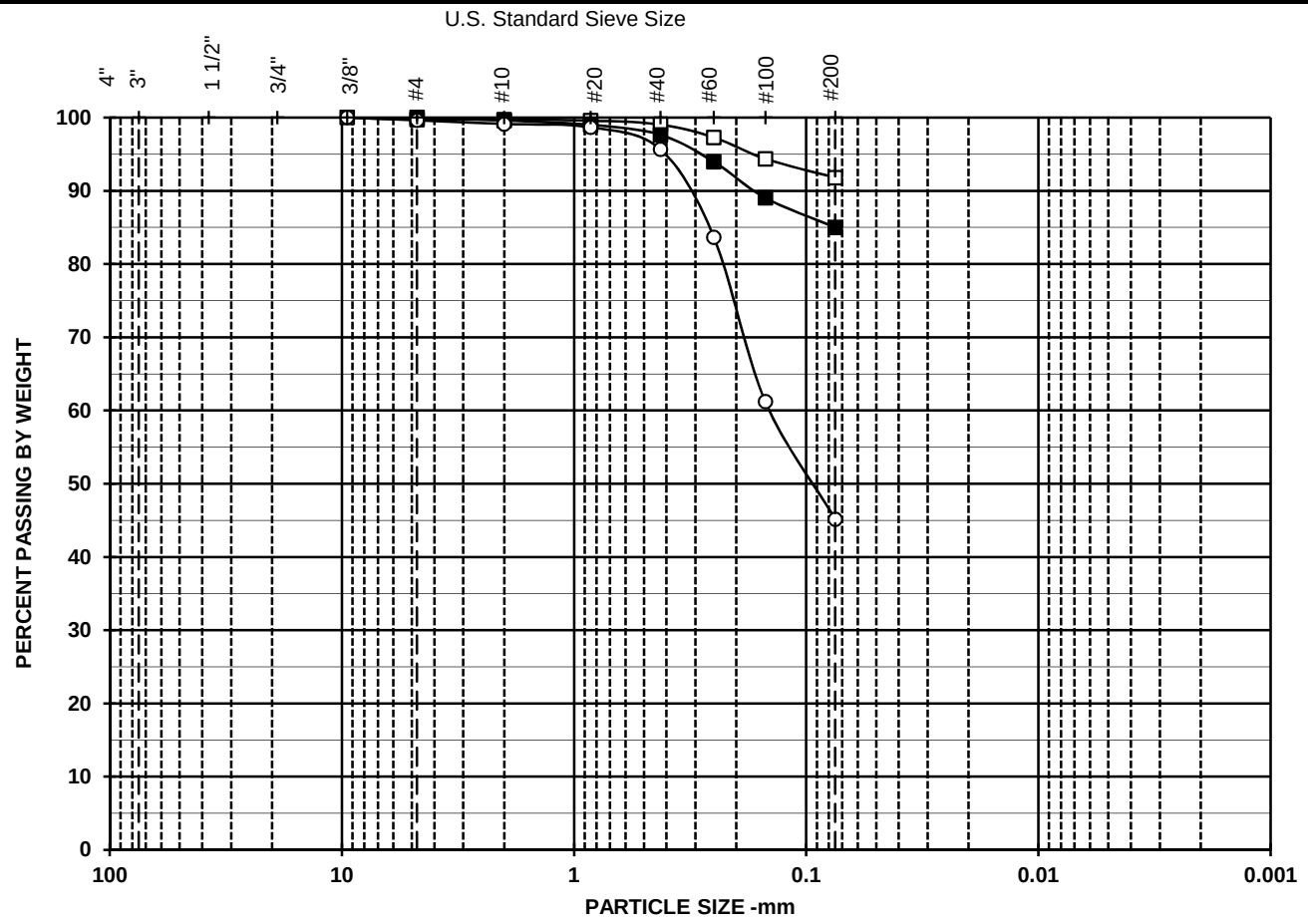
Analysis File: 3SV-MasterRev4b

Siev013b.xls 11/15/2015

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		33	20	13	CL	Light brown, Lean clay	9/30/2015
■	20.8	39	15	24	CL	Light gray, Lean clay with sand	8/19/2015
○					SC	Light grayish brown, Clayey sand	9/2/2015

Symbol	□	■	○
Boring	JOP-B014	JOP-B014	JOP-B014
Sample	ST-2C	S-6	ST-3C
Depth	10.3	28.5-30	34.65
% +3"	0.0	0.0	0.0
% Gravel	0.3	0.0	0.4
% SAND	7.9	15.0	54.4
%C SAND	0.0	0.4	0.5
%M SAND	0.7	2.0	3.5
%F SAND	7.3	12.6	50.5
% FINES	91.8	85.0	45.2
% -2μ			
D_{100} (mm)	9.50	4.75	9.50
D_{60} (mm)			0.14
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0		100.0
4	99.7	100.0	99.6
10	99.7	99.6	99.1
20	99.6	99.0	98.7
40	99.0	97.6	95.7
60	97.3	94.0	83.7
100	94.4	89.0	61.2
200	91.8	85.0	45.2

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PARTICLE SIZE DISTRIBUTION

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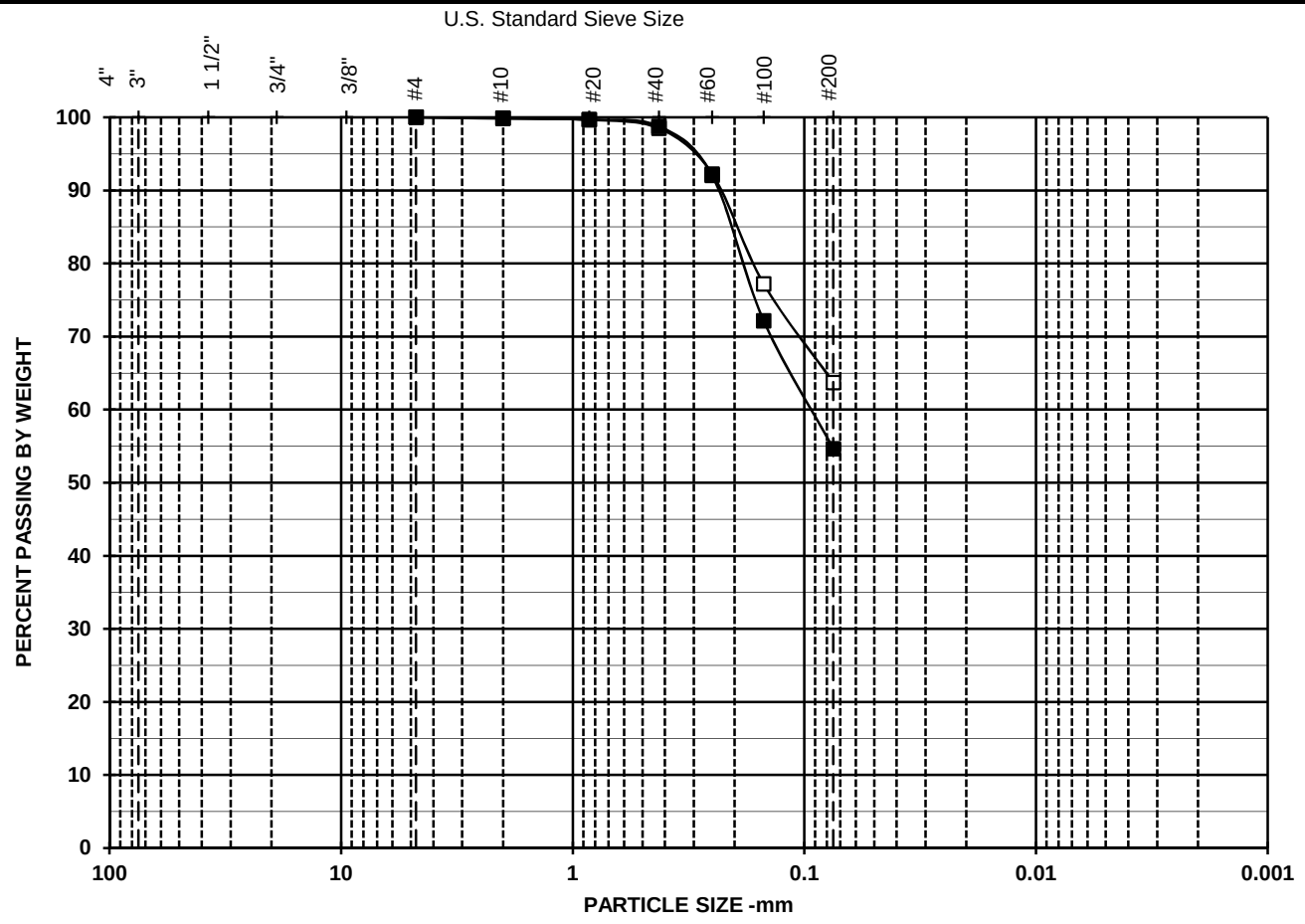
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B014	JOP-B014	
Sample	ST-4C	S-8	
Depth	44.6	48.5-50	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	36.3	45.4	
%C SAND	0.1	0.2	
%M SAND	1.4	1.1	
%F SAND	34.8	44.1	
% FINES	63.7	54.6	
% -2μ			
D_{100} (mm)	4.75	4.75	
D_{60} (mm)		0.10	
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0	100.0	
10	99.9	99.8	
20	99.7	99.7	
40	98.5	98.8	
60	92.2	92.0	
100	77.2	72.2	
200	63.7	54.6	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		33	12	21	CL	Gray brown, Sandy lean clay	9/17/2015
■	16.2	26	11	15	CL	Light brown, Sandy lean clay	8/27/2015
○							

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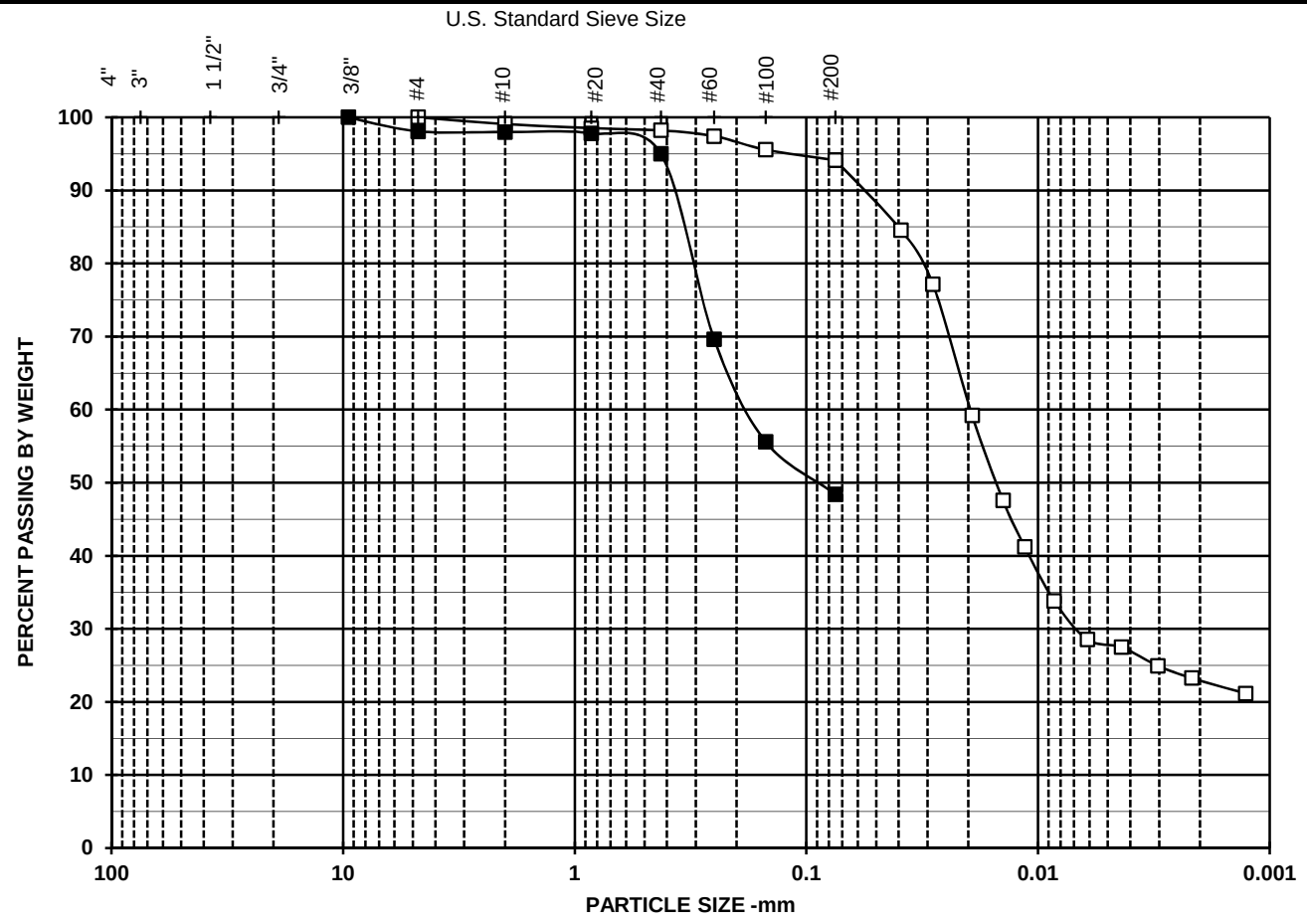
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B015	JOP-B015	
Sample	S-4	S-12	
Depth	23.5-25	63.5-65	
% +3"	0.0	0.0	
% Gravel	0.0	1.9	
% SAND	5.9	49.7	
%C SAND	0.9	0.1	
%M SAND	0.9	3.0	
%F SAND	4.1	46.6	
% FINES	94.1	48.4	
% -2μ	23		
D_{100} (mm)	4.75	9.50	
D_{60} (mm)	0.02	0.18	
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"		100.0	
4	100.0	98.1	
10	99.1	98.0	
20	98.5	97.8	
40	98.2	95.0	
60	97.4	69.6	
100	95.6	55.6	
200	94.1	48.4	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	16.7				CL	Light brown, Lean clay	9/30/2015
■	17.2				SM	Light grayish brown, Silty sand	9/23/2015
○							

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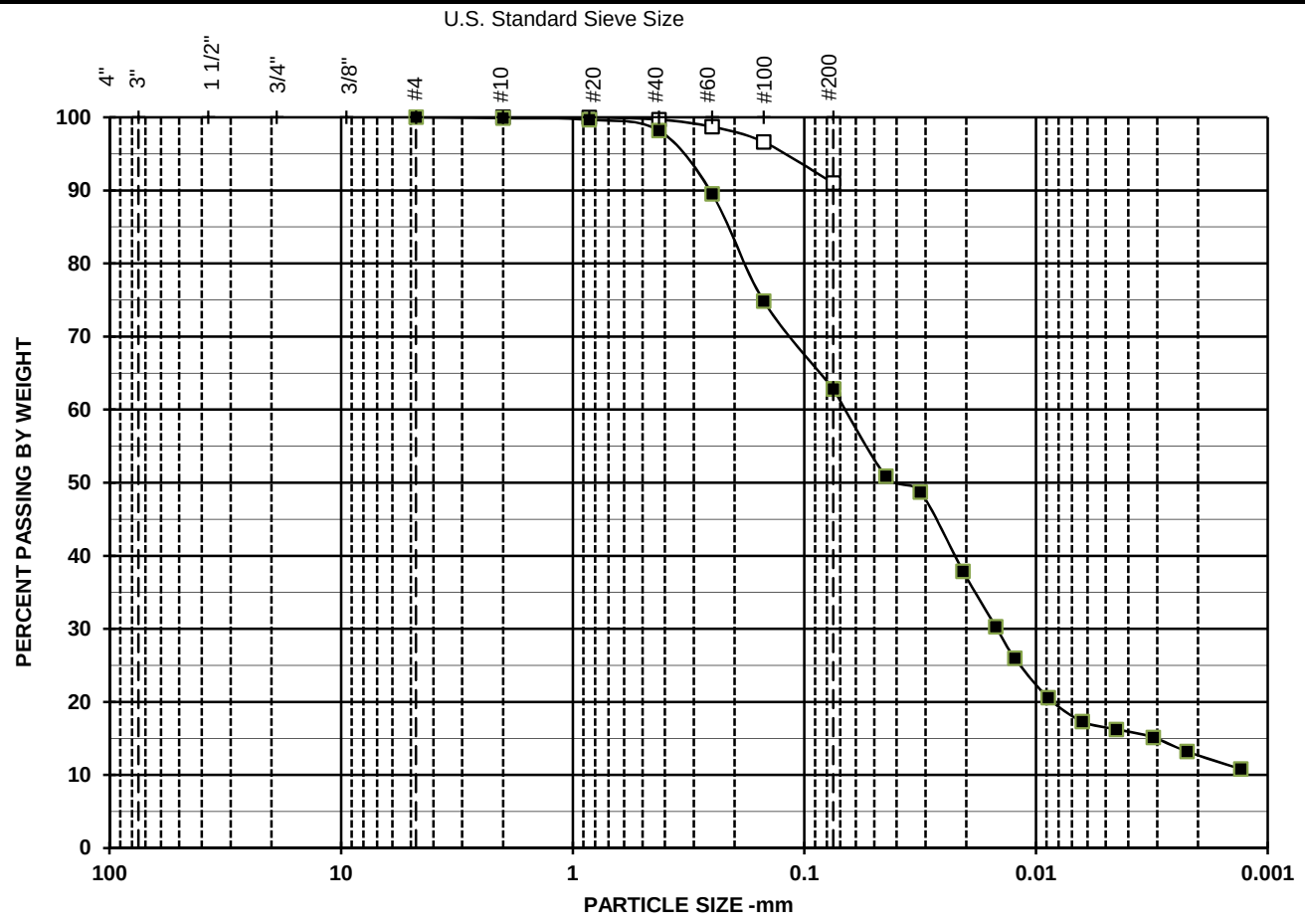
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B015	JOP-B015	
Sample	ST-4B	S-13	
Depth	69.25	73.5-75	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	9.0	37.2	
%C SAND	0.0	0.1	
%M SAND	0.3	1.7	
%F SAND	8.7	35.3	
% FINES	91.0	62.8	
% -2μ		13	
D_{100} (mm)	2.00	4.75	
D_{60} (mm)		0.07	
D_{30} (mm)		0.01	
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4		100.0	
10	100.0	99.9	
20	100.0	99.7	
40	99.7	98.2	
60	98.7	89.5	
100	96.6	74.9	
200	91.0	62.8	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□					CL	Light gray, Lean clay	10/19/2015
■	18.6	26	15	11	CL	Light brown, Sandy lean clay	9/30/2015
○							

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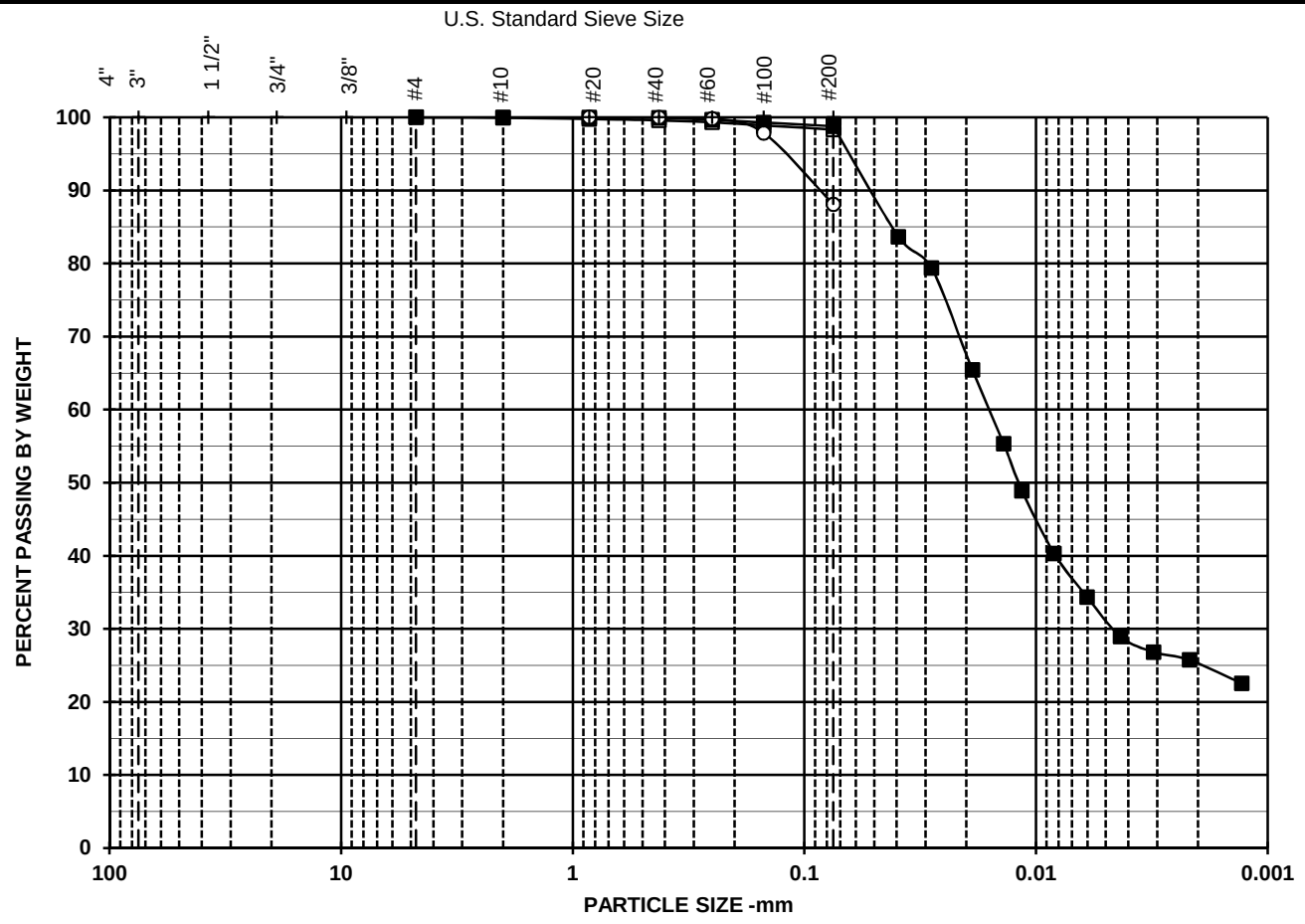
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B016	JOP-B016	JOP-B016
Sample	ST-1C	ST-3B	ST-4C
Depth	4.8	23.7	44.60
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% SAND	1.7	1.2	11.9
%C SAND	0.1	0.0	0.0
%M SAND	0.4	0.1	0.0
%F SAND	1.2	1.2	11.9
% FINES	98.3	98.8	88.1
% -2μ		25	
D_{100} (mm)	4.75	4.75	0.85
D_{60} (mm)		0.02	
D_{30} (mm)		0.00	
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0	100.0	
10	99.9	100.0	
20	99.8	100.0	100.0
40	99.6	99.9	100.0
60	99.3	99.7	99.8
100	98.9	99.3	97.9
200	98.3	98.8	88.1

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	26.6				CL	Oranish brown, Lean clay	8/28/2015
■		35	15	20	CL	Brown, Lean clay	9/28/2015
○		27	17	10	CL	Light gray, Lean clay	10/2/2015

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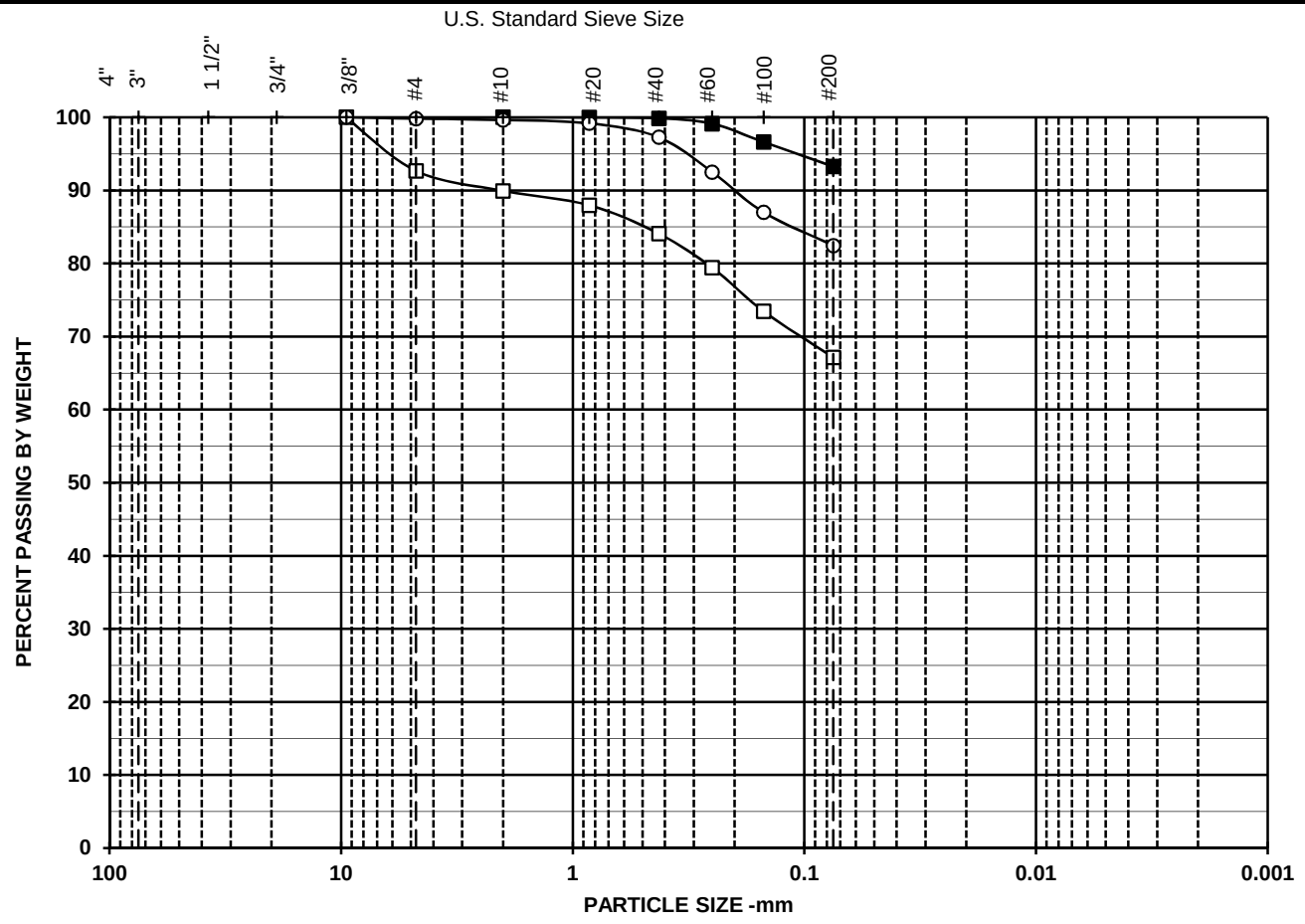
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-017	JOP-B017	JOP-B017
Sample	ST-2B	ST-3C	ST-4D
Depth	8.85	24.8	34.85
% +3"	0.0	0.0	0.0
% Gravel	7.3	0.0	0.2
% SAND	25.6	6.7	17.4
%C SAND	2.7	0.0	0.2
%M SAND	5.9	0.1	2.4
%F SAND	16.9	6.6	14.8
% FINES	67.1	93.3	82.4
% -2μ			
D_{100} (mm)	9.50	2.00	9.50
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0		100.0
4	92.7		99.8
10	89.9	100.0	99.6
20	88.0	100.0	99.2
40	84.1	99.9	97.3
60	79.4	99.1	92.5
100	73.4	96.6	87.0
200	67.1	93.3	82.4

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□					CL	Brown, Sandy lean clay	8/28/2015
■		34	14	20	CL	Light brown, Lean clay	8/31/2015
○		35	14	21	CL	Brown gray, Lean clay with sand	10/21/2015

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PARTICLE SIZE DISTRIBUTION

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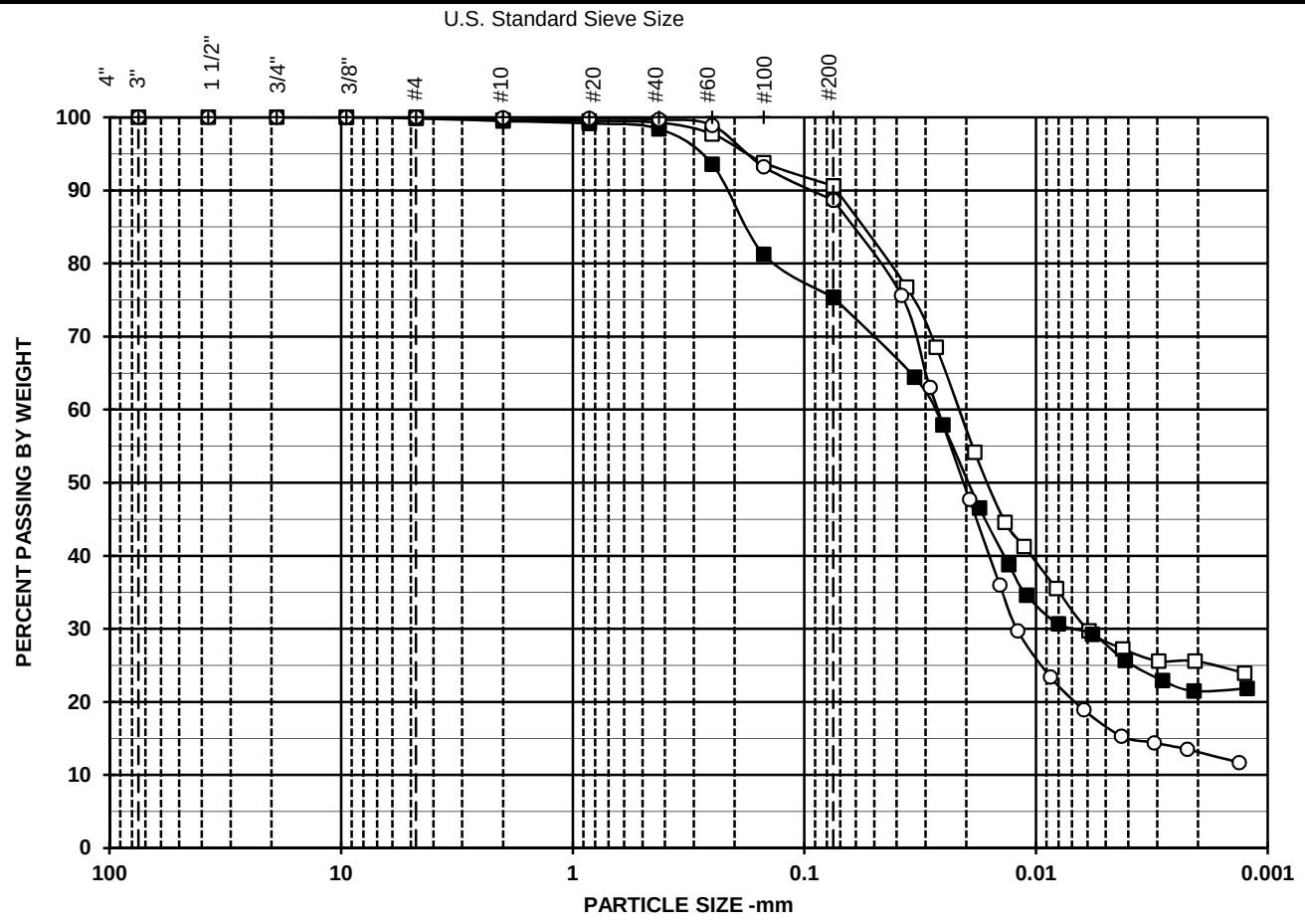
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	14.7				CL	Brown, Lean clay	10/12/2015
■	14.2				CL	Light brown, Lean clay with sand	10/2/2015
○	19.6				CL	Greenish gray clay , Lean clay	10/9/2015

Symbol	□	■	○
Boring	J0P-B018	JOP-B018	J0P-B018
Sample	ST-2A	S-5	ST-5A
Depth	18.75	38.5-40	58.55
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.1	0.0
% SAND	9.4	24.6	11.4
%C SAND	0.4	0.4	0.0
%M SAND	0.4	1.1	0.3
%F SAND	8.7	23.1	11.1
% FINES	90.6	75.3	88.6
% -2μ	25	22	13
D_{100} (mm)	4.75	9.50	4.75
D_{60} (mm)	0.02	0.03	0.03
D_{30} (mm)	0.01	0.01	0.01
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"	100.0		100.0
3"	100.0		100.0
1 1/2"	100.0		100.0
3/4"	100.0		100.0
3/8"	100.0	100.0	100.0
4	100.0	99.9	100.0
10	99.6	99.5	100.0
20	99.5	99.2	99.8
40	99.3	98.4	99.7
60	97.7	93.6	98.9
100	93.8	81.2	93.2
200	90.6	75.3	88.6

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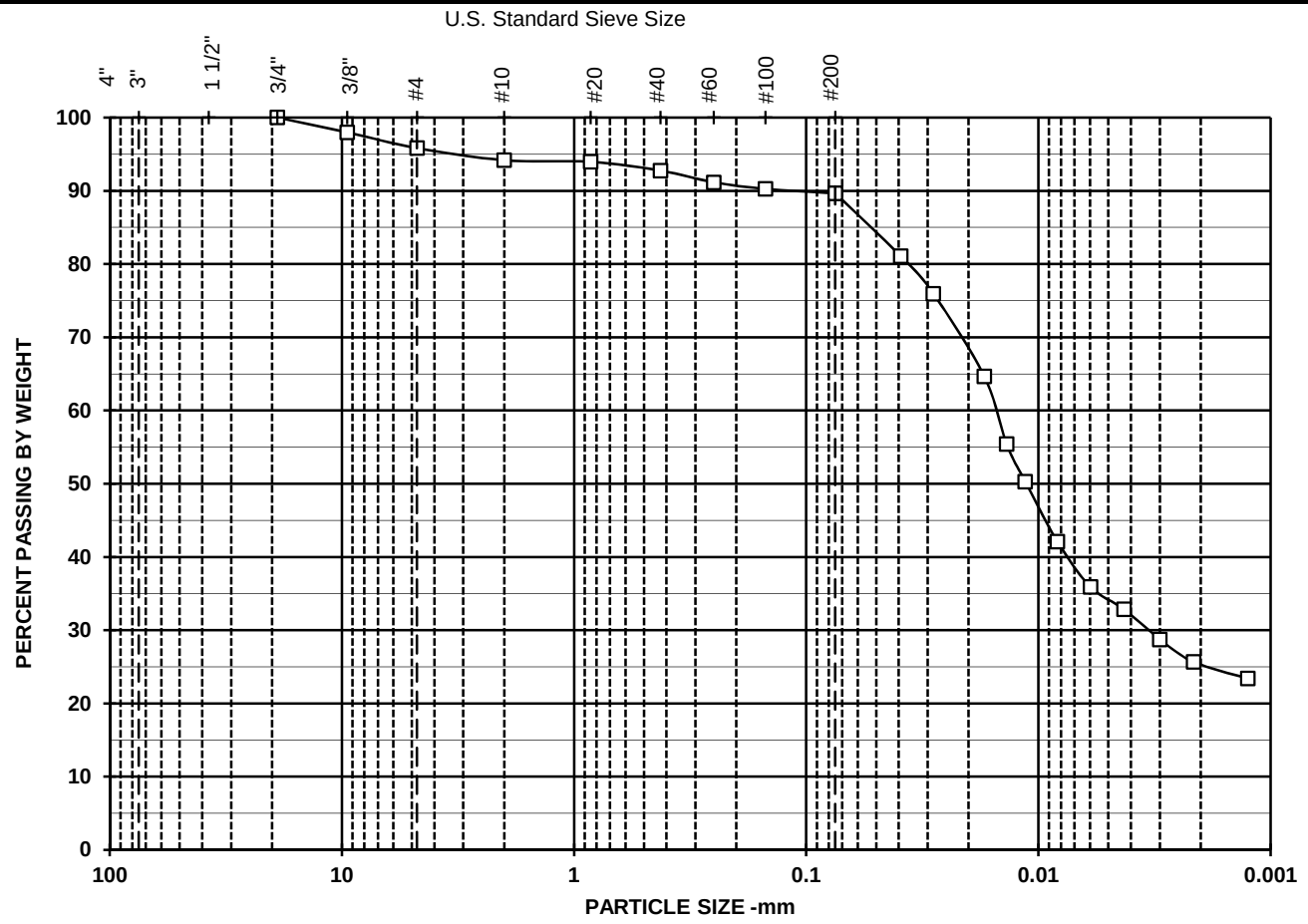
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	21.5				CL	Light brown, Lean clay	9/30/2015
■							
○							

Symbol	□	■	○
Boring	JOP-B018		
Sample	S-10B		
Depth	74-75		
% +3"	0.0		
% Gravel	4.2		
% SAND	6.1		
%C SAND	1.6		
%M SAND	1.4		
%F SAND	3.1		
% FINES	89.7		
% -2μ	25		
D_{100} (mm)	19.00		
D_{60} (mm)	0.02		
D_{30} (mm)	0.00		
D_{10} (mm)			
Cc			
Cu			

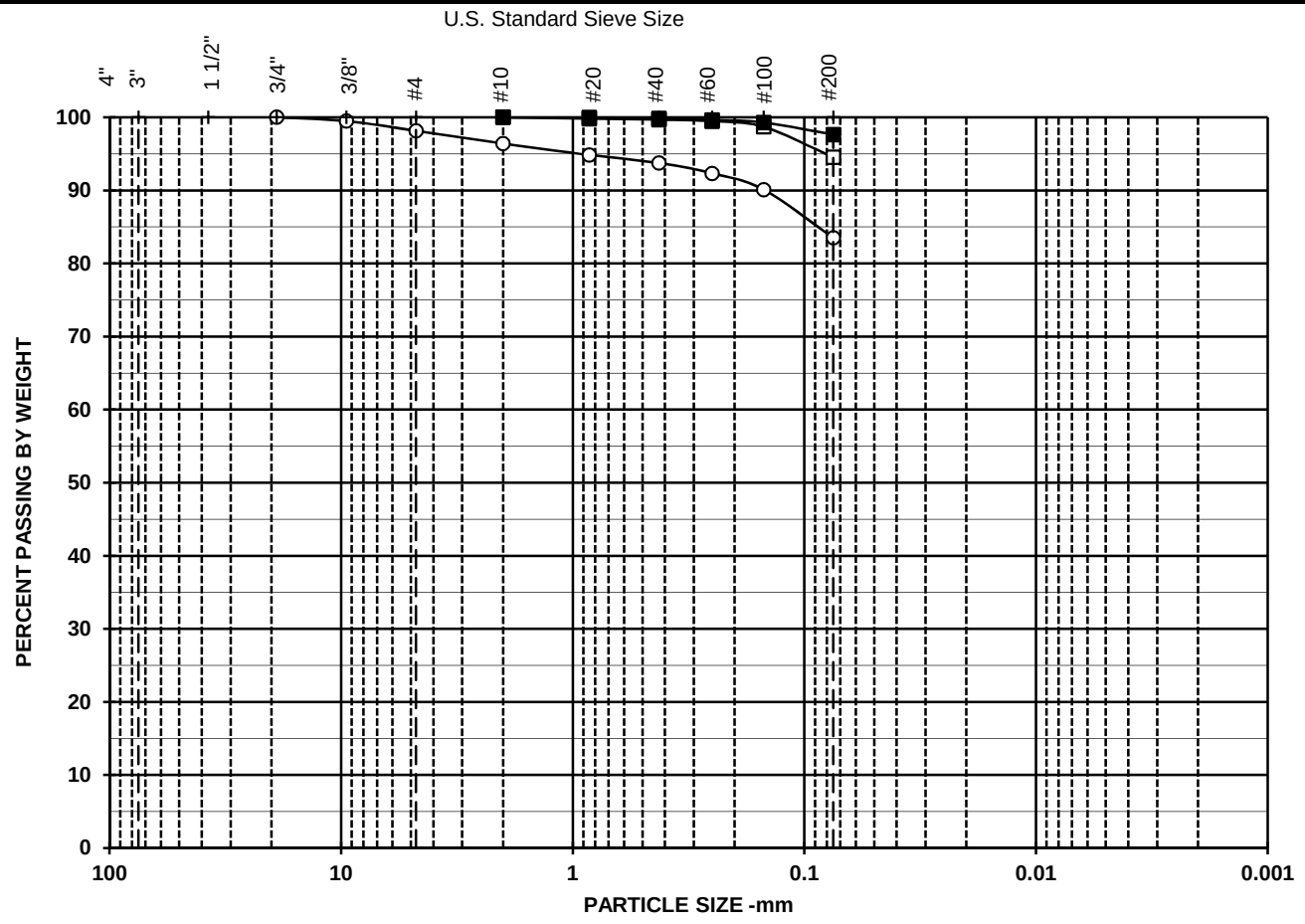
Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"	100.0		
3/8"	98.0		
4	95.8		
10	94.2		
20	94.0		
40	92.8		
60	91.2		
100	90.3		
200	89.7		

TerraSense, LLC	AECOM
T60428794	60428794-107

PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	106.0		54	NP	ML	Gray , Silt	9/17/2015
■	43.4				ML	Dark gray, Silt	8/21/2015
○		-	35	NP	ML	Gray, Silt with sand	10/1/2015

Symbol	□	■	○
Boring	JOP-B019	JOP-B019	JOP-B019
Sample	ST-1A	S-5	ST-2B
Depth	8.15	28.5-30	43.8
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	1.8
% SAND	5.5	2.4	14.7
%C SAND	0.0	0.0	1.8
%M SAND	0.3	0.2	2.7
%F SAND	5.2	2.2	10.2
% FINES	94.5	97.6	83.5
% -2μ			
D_{100} (mm)	2.00	2.00	19.00
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			100.0
3/8"			99.5
4			98.2
10	100.0	100.0	96.4
20	99.8	100.0	94.8
40	99.7	99.8	93.8
60	99.5	99.6	92.3
100	98.7	99.3	90.1
200	94.5	97.6	83.5

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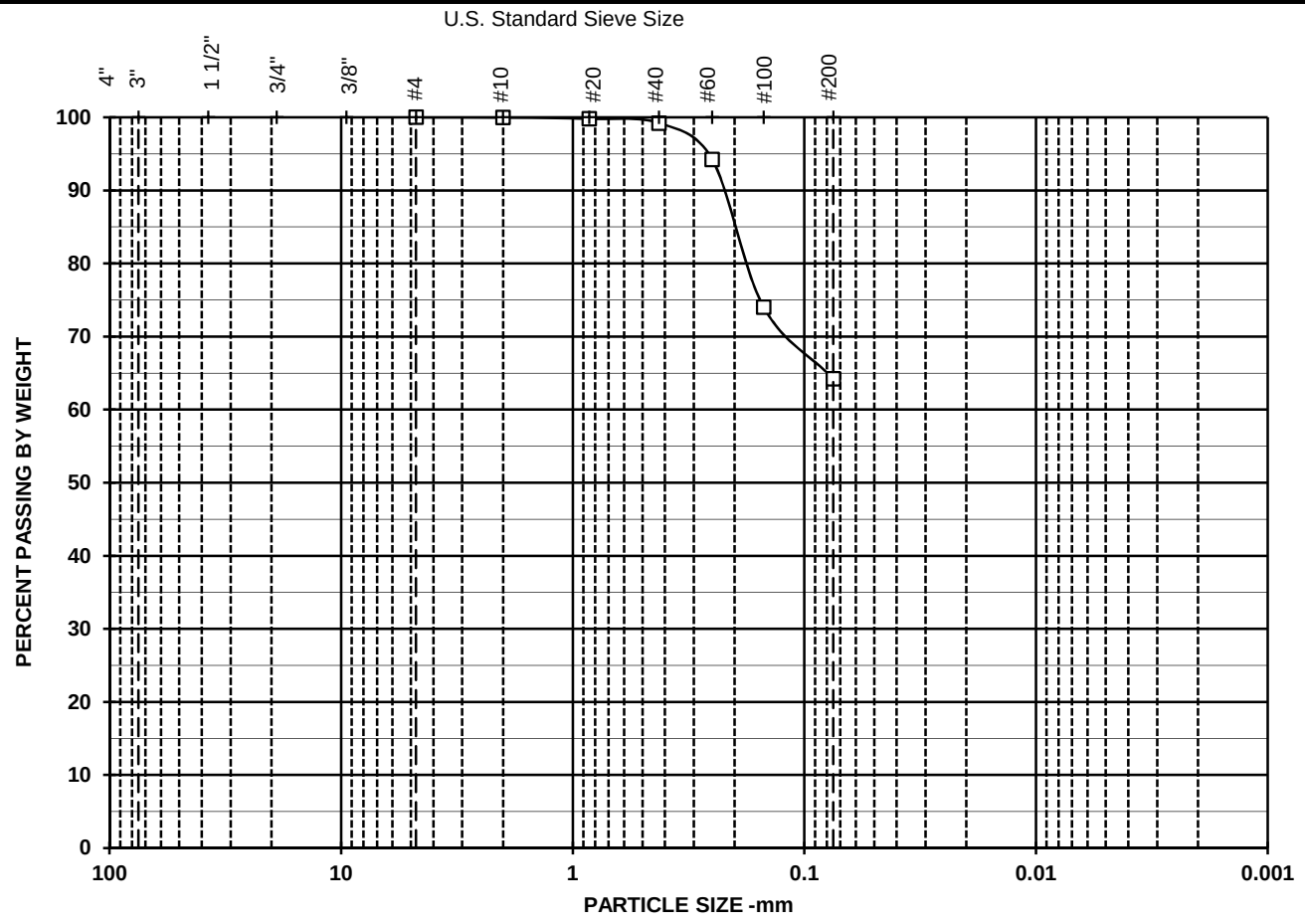
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	18.9				CL	Light brown, Sandy lean clay	8/21/2015
■							
○							

Symbol	□	■	○
Boring	JOP-B019		
Sample	S-9		
Depth	53.5-55		
% +3"	0.0		
% Gravel	0.0		
% SAND	35.8		
%C SAND	0.0		
%M SAND	0.8		
%F SAND	35.0		
% FINES	64.2		
% -2μ			
D_{100} (mm)	4.75		
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

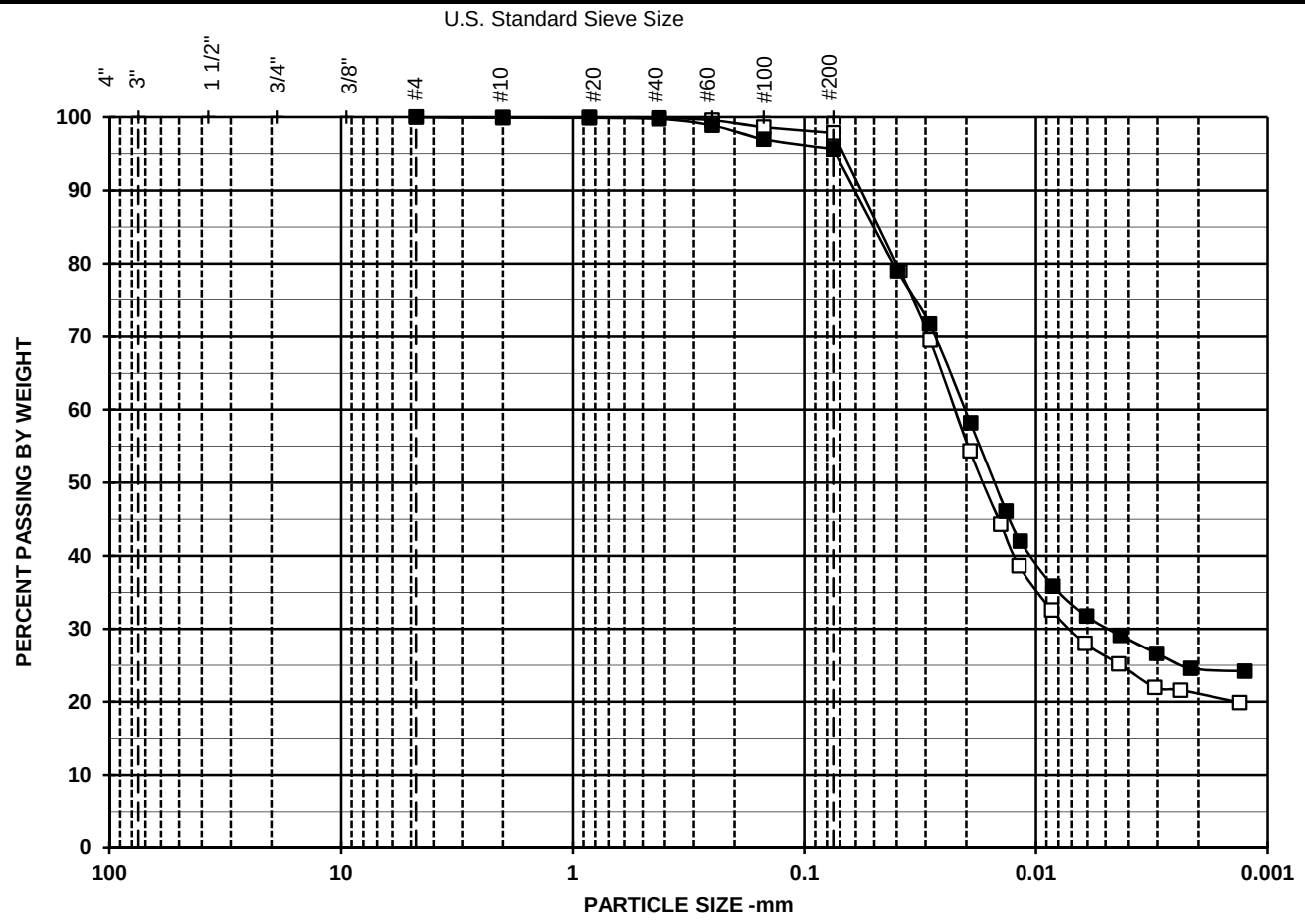
Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0		
10	100.0		
20	99.8		
40	99.2		
60	94.2		
100	74.0		
200	64.2		

TerraSense, LLC	AECOM
T60428794	60428794-107

PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□					CL	Gray-brown, Lean clay	10/20/2015
■	14.3				CL	Light brown, Lean clay	9/10/2015
○							

Symbol	□	■	○
Boring	JOP-B020	JOP-B020	
Sample	ST-2B	S-4	
Depth	19.25	28.5-30	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	2.2	4.4	
%C SAND	0.1	0.1	
%M SAND	0.0	0.2	
%F SAND	2.1	4.1	
% FINES	97.8	95.6	
% -2μ	21	25	
D_{100} (mm)	4.75	4.75	
D_{60} (mm)	0.02	0.02	
D_{30} (mm)	0.01	0.00	
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4	100.0	100.0	
10	99.9	99.9	
20	100.0	99.9	
40	99.9	99.7	
60	99.6	98.9	
100	98.6	97.0	
200	97.8	95.6	

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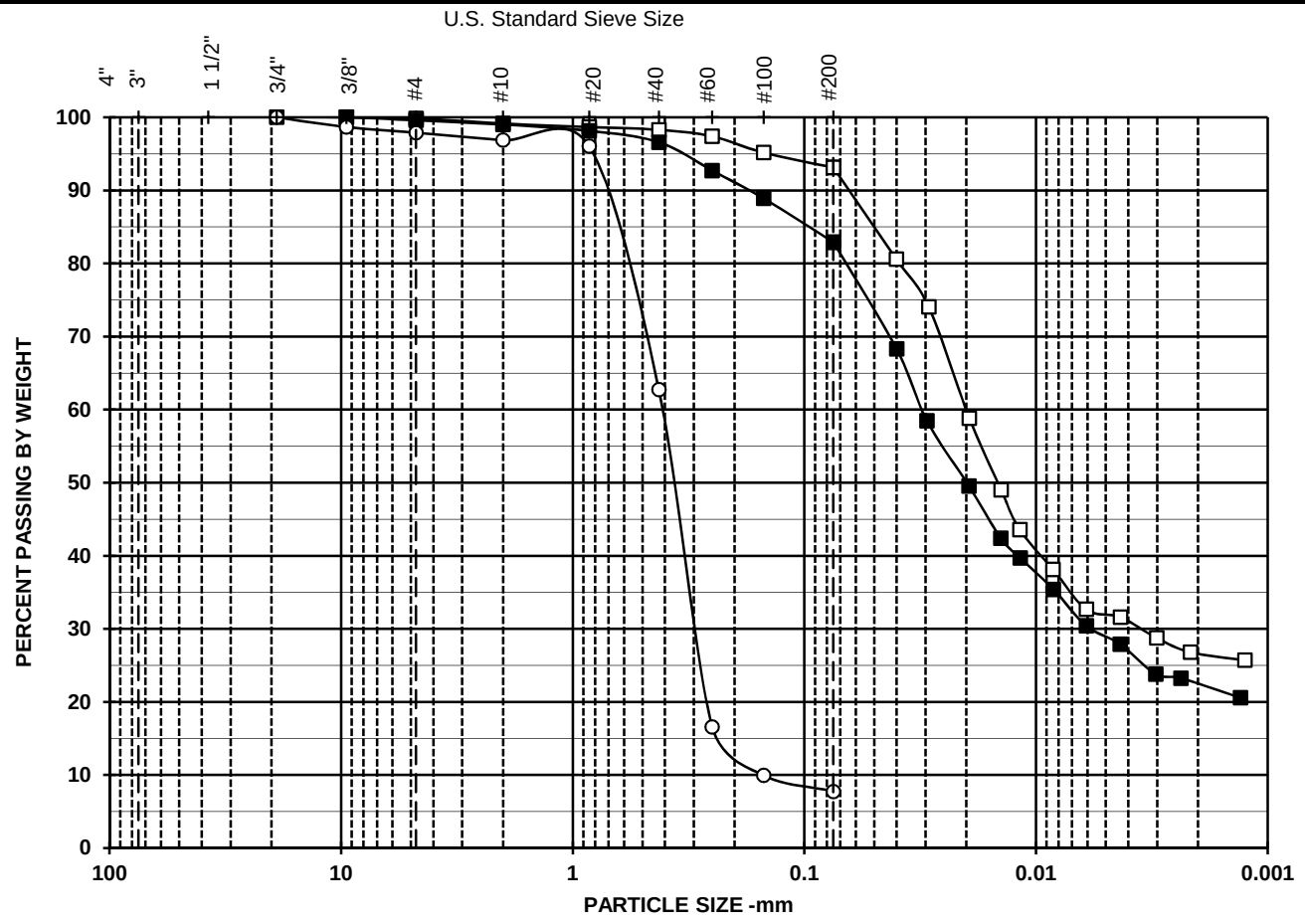
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B020	JOP-B020	JOP-B020
Sample	S-7	ST-5C	S-12
Depth	53.5-50	69.8	78.5-80
% +3"	0.0	0.0	0.0
% Gravel	0.1	0.4	2.1
% SAND	6.8	16.7	90.2
%C SAND	0.7	0.6	1.0
%M SAND	0.9	2.4	34.2
%F SAND	5.2	13.7	55.0
% FINES	93.1	82.9	7.7
% -2μ	27	22	
D_{100} (mm)	9.50	9.50	19.00
D_{60} (mm)	0.02	0.03	0.41
D_{30} (mm)	0.00	0.01	0.30
D_{10} (mm)			0.15
Cc			1.5
Cu			2.8

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"		100.0	100.0
3/8"	100.0	100.0	98.7
4	99.9	99.6	97.9
10	99.1	99.0	96.9
20	98.7	98.1	96.0
40	98.3	96.6	62.7
60	97.4	92.7	16.6
100	95.2	88.9	10.0
200	93.1	82.9	7.7

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	20.2				CL	Light brown, Lean clay	9/30/2015
■					CL	Light brown, Lean clay with sand	10/20/2015
○	21.4				SP-SM	Light brown, Poorly-graded sand with silt	9/23/2015

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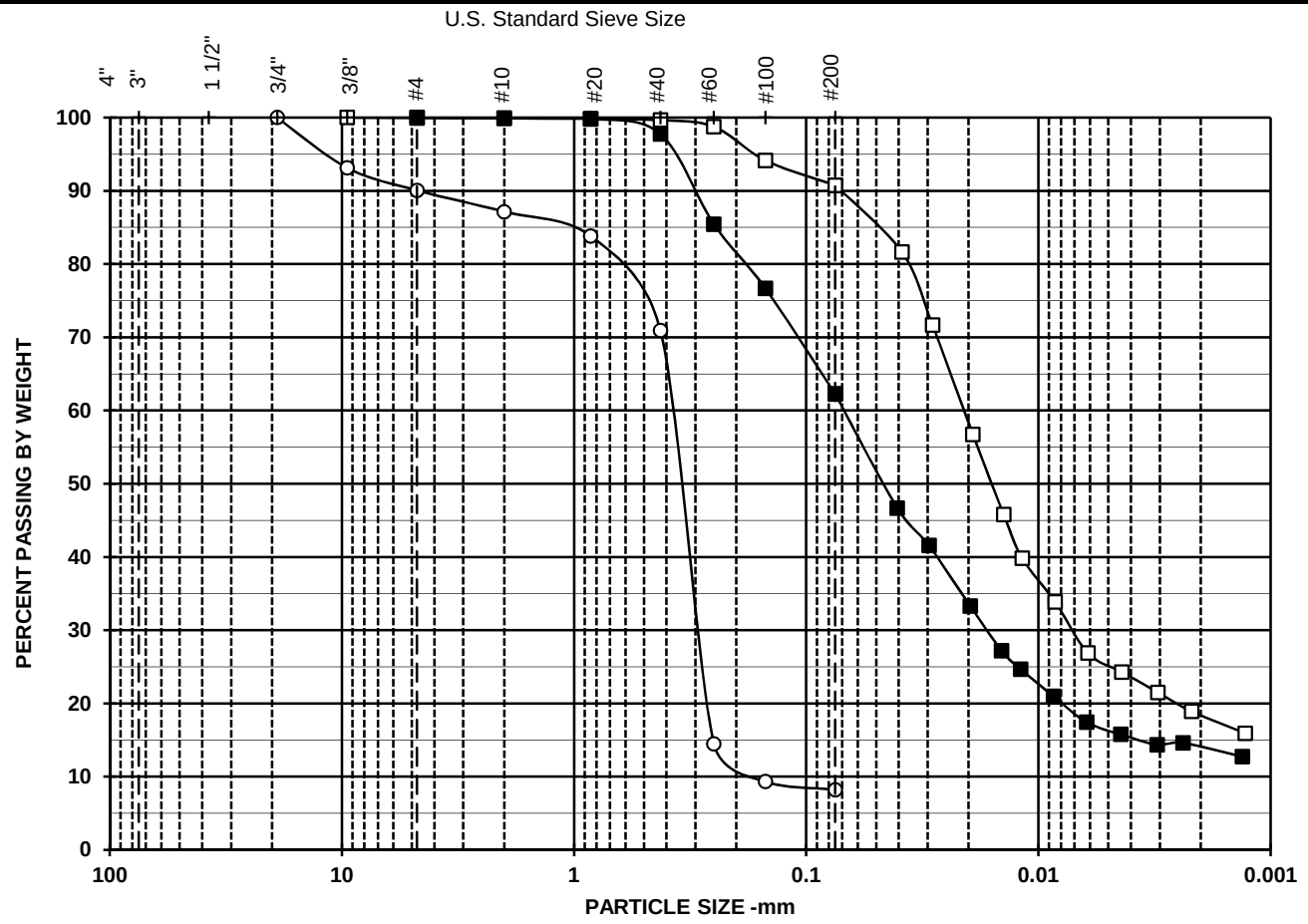
T60428794	60428794-107

PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B021	JOP-B021	JOP-B021
Sample	S-5	ST-3B	S-9
Depth	23.5-25	34.1	48.5-50
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	9.9
% SAND	9.3	37.8	81.9
%C SAND	0.1	0.1	2.9
%M SAND	0.2	2.2	16.2
%F SAND	8.9	35.5	62.7
% FINES	90.7	62.2	8.2
% -2μ	18	14	
D_{100} (mm)	9.50	4.75	19.00
D_{60} (mm)	0.02	0.07	0.39
D_{30} (mm)	0.01	0.02	0.30
D_{10} (mm)			0.16
Cc			1.4
Cu			2.4

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			100.0
3/8"	100.0		93.1
4	100.0	100.0	90.1
10	99.9	99.9	87.1
20	99.8	99.8	83.8
40	99.7	97.8	70.9
60	98.7	85.4	14.5
100	94.1	76.7	9.4
200	90.7	62.2	8.2

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	21.0				CL	Light brown, Lean clay	9/30/2015
■		22	13	9	CL	Brown, Sandy lean clay	10/19/2015
○	17.7			NP	SP-SM	Light yellowish brown, Poorly-graded sand with silt	9/23/2015

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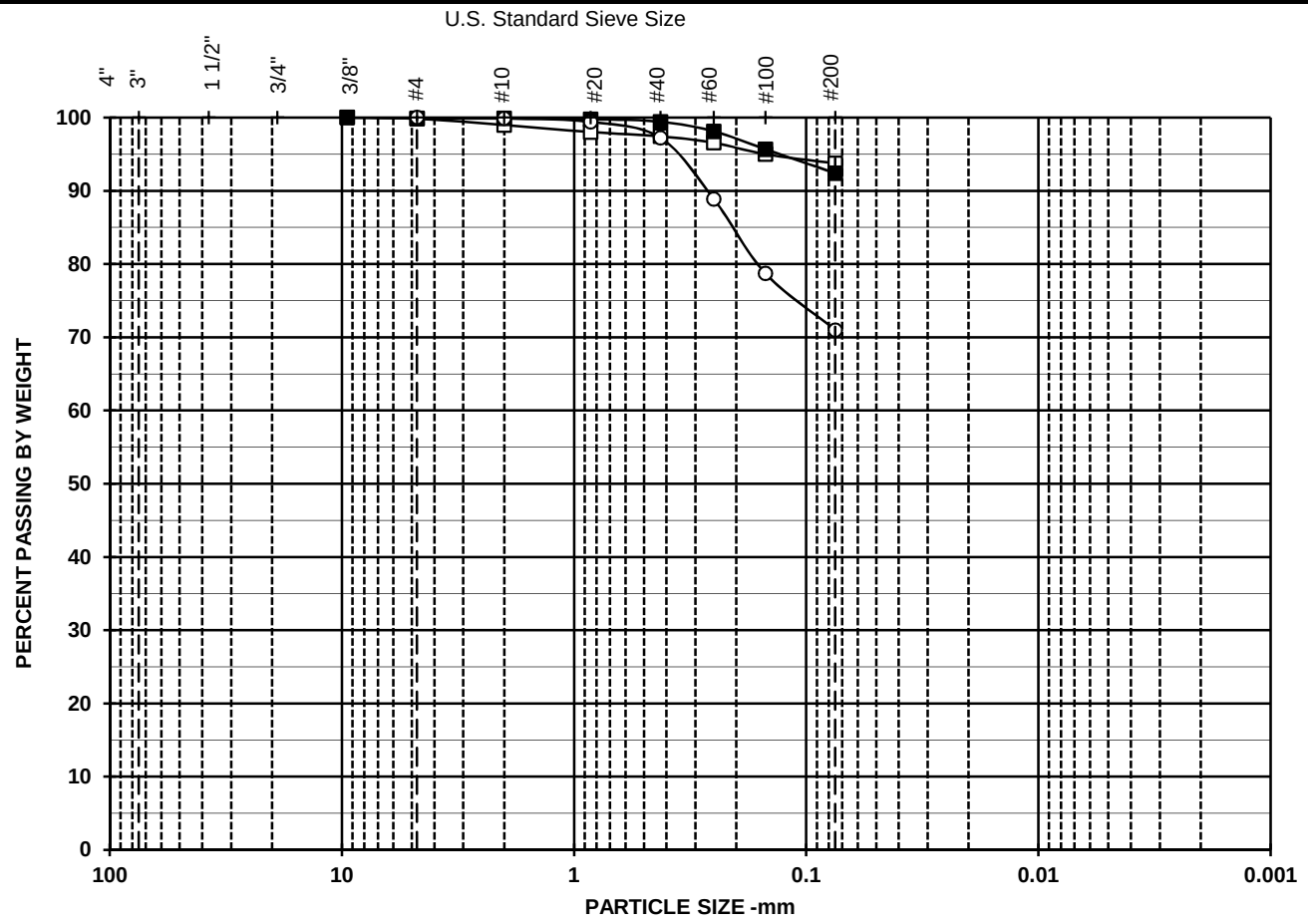
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B022	JOP-B022	JOP-B022
Sample	ST-2C	ST-3C	ST-4B
Depth	9.4	24.5	38.8
% +3"	0.0	0.0	0.0
% Gravel	0.1	0.1	0.0
% SAND	6.2	7.5	29.0
%C SAND	0.9	0.0	0.1
%M SAND	1.5	0.5	2.7
%F SAND	3.7	7.0	26.3
% FINES	93.7	92.4	71.0
% -2μ			
D_{100} (mm)	9.50	9.50	4.75
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0	100.0	
4	99.9	99.9	100.0
10	99.0	99.9	99.9
20	98.0	99.8	99.4
40	97.4	99.4	97.2
60	96.6	98.1	88.9
100	95.0	95.7	78.7
200	93.7	92.4	71.0

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□		35	18	17	CL	Brown, Lean clay	8/31/2015
■		38	14	24	CL	Brown gray, Lean clay	9/18/2015
○	18.0	23	14	9	CL	Brown, Lean clay with sand	9/16/2015

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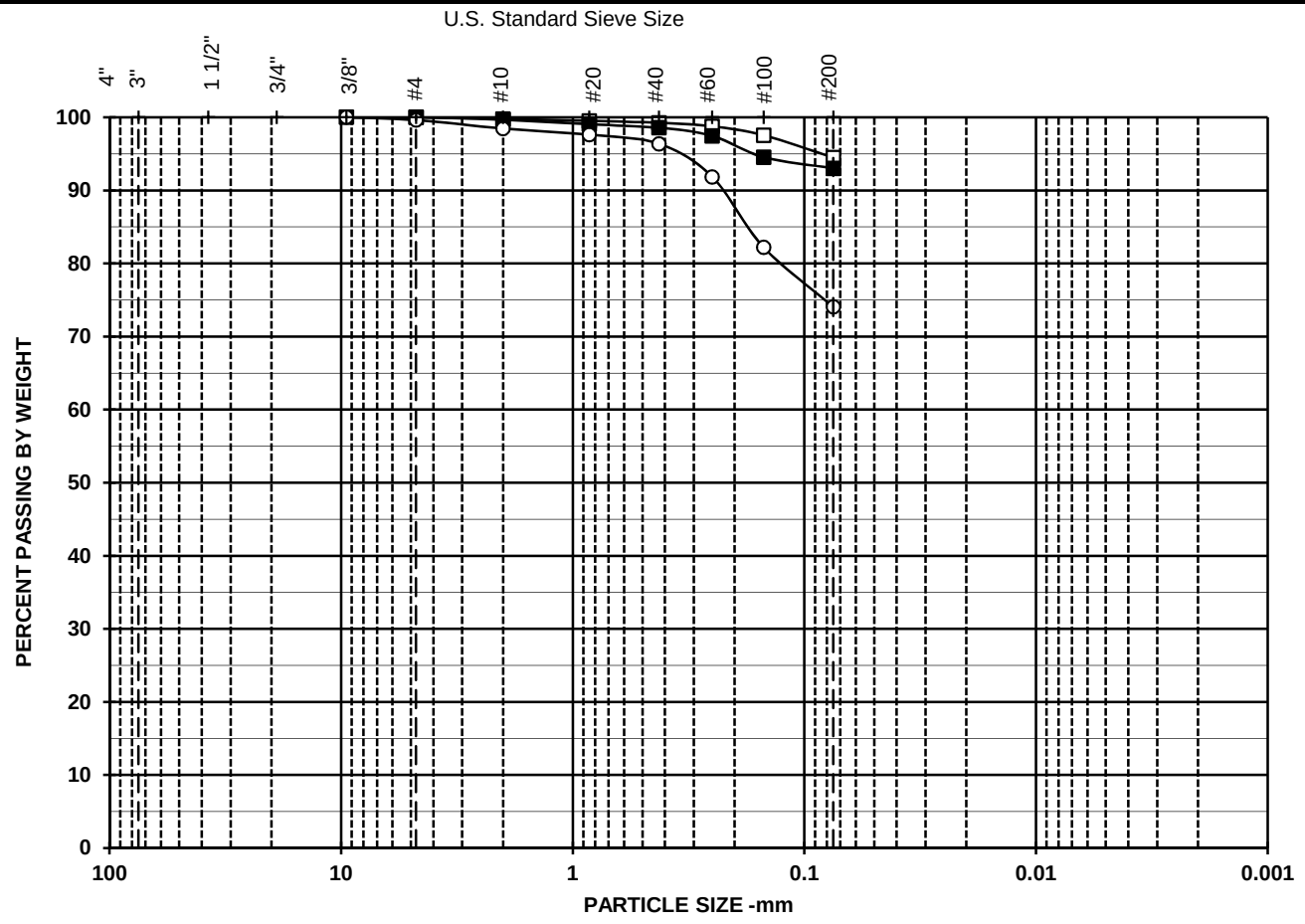
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B023	JOP-B023	JOP-B023
Sample	S-3	ST-1B	ST-2B
Depth	13.5-15	43.7	49
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.4
% SAND	5.5	7.0	25.6
%C SAND	0.2	0.3	1.2
%M SAND	0.5	1.1	2.1
%F SAND	4.8	5.6	22.3
% FINES	94.5	93.0	74.0
% -2μ			
D_{100} (mm)	4.75	9.50	9.50
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"		100.0	100.0
4	100.0	100.0	99.6
10	99.8	99.7	98.5
20	99.5	99.0	97.6
40	99.2	98.6	96.4
60	98.8	97.5	91.8
100	97.5	94.5	82.2
200	94.5	93.0	74.0

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	26.6		24	NP	ML	Dark gray, Silt	8/19/2015
■		32	22	10	CL	Gray, Lean clay	9/16/2015
○		35	14	21	CL	Brown gray, Lean clay with sand	9/23/2015

TerraSense, LLC	AECOM
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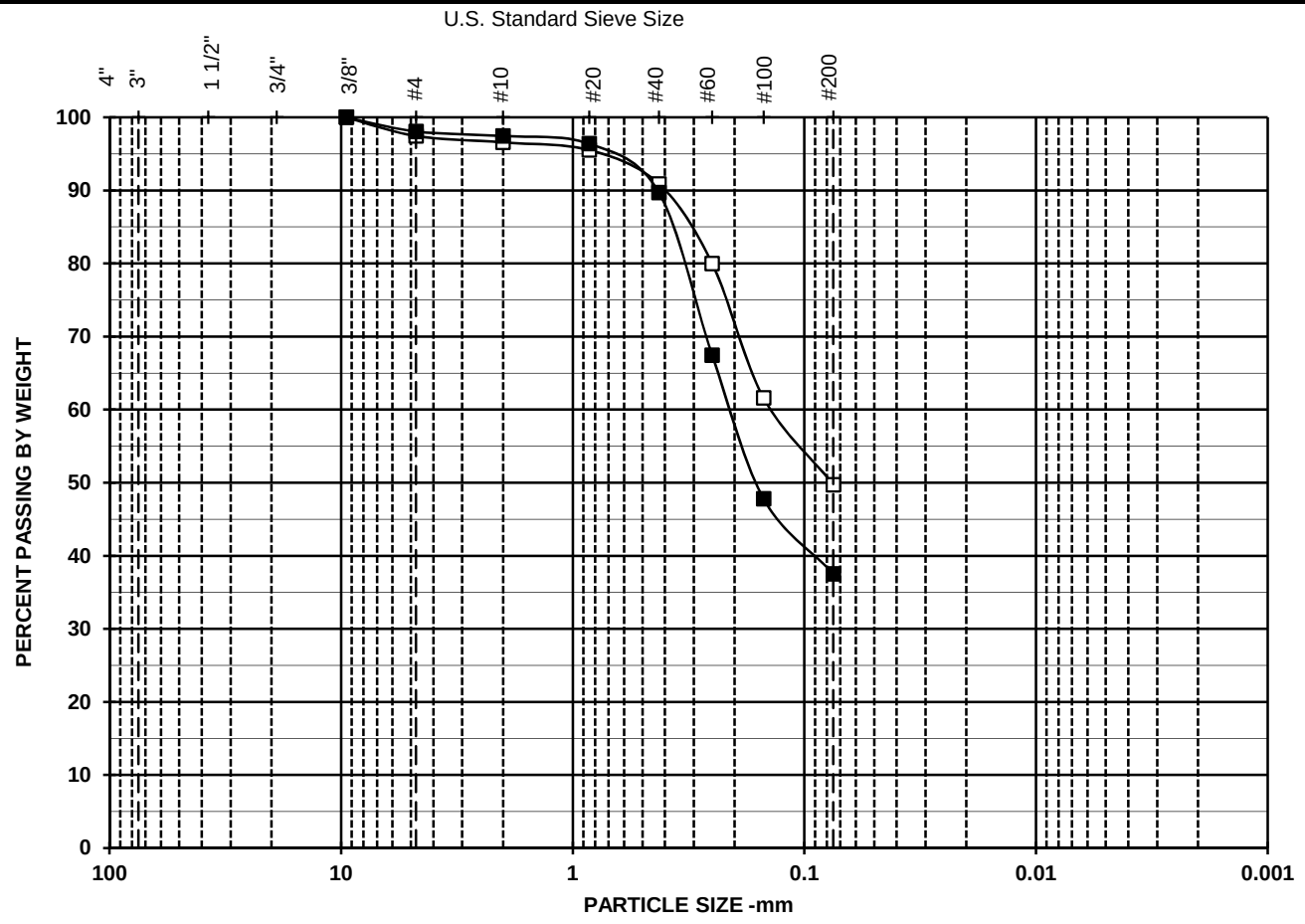
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	JOP-B023	JOP-B023	
Sample	S-11	S-14	
Depth	63.5-65	78.5-80	
% +3"	0.0	0.0	
% Gravel	2.6	1.9	
% SAND	47.7	60.6	
%C SAND	0.9	0.6	
%M SAND	5.7	7.7	
%F SAND	41.2	52.2	
% FINES	49.7	37.5	
% -2μ			
D_{100} (mm)	9.50	9.50	
D_{60} (mm)	0.14	0.21	
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"	100.0	100.0	
4	97.4	98.1	
10	96.6	97.4	
20	95.5	96.4	
40	90.9	89.7	
60	80.0	67.4	
100	61.6	47.8	
200	49.7	37.5	

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	19.9				SC	Light brown, Clayey sand	8/21/2015
■	16.7				SC	Light brown, Clayey sand	8/21/2015
○							

TerraSense, LLC	AECOM
T60428794	60428794-107

PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

Analysis File: 3SV-MasterRev4b

Siev023b.xls 11/15/2015

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B001 | Test No.: P10579

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-1B | DEPTH (ft): 4.45

Specimen - Apparatus set-up - Test Information | Cell No. E | Apparatus No. 3 | Stage No.: 2

Preliminary Length/Area Calculations

Lo =	4.018	in	Lo=	10.205	cm
dLc=	0.031	in	Ao =	41.76	cm^2
Lc=	3.987	in	Vo =	426.13	cm^3
			Lc=	10.126	cm
dVc = 3 Vo * (dLc/Lo)			dVc=	9.86	cm^3
			Vc =	416.27	cm^3
Sc =	0.246	cm^{-1}	Ac=	41.107	cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or			
	x	with stones or		Stones with filter paper or			top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination			
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes	
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only	
5) Direction of permeant :	x	Up during or		Down during permeation			
6) Permeant: water used	x	Tap		Distilled			
or		Demineralized		0.005 N calcium sulfate (CaSO4)			

Equations Used

Kt = - 0.0000755 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3132

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.4	9/10/15	09	20	00	106.9	100.0	64.35	47.26	1.01	5.33E-07
final	22.5	9/10/15	10	33	00			52.94	50.80		4.97E-07
1	RT = 0.945	dT =		73.00 min		σ'_c =	1.0 ksf	0.853	0.845	io= 21.2	4%
initial	22.5	9/10/15	10	34	00	106.9	100.0	62.50	47.80	1.00	4.93E-07
final	22.5	9/10/15	11	27	00			54.05	50.45		4.59E-07
2	RT = 0.943	dT =		53.00 min		σ'_c =	1.0 ksf	0.632	0.632	io= 18.3	-4%
initial	22.5	9/10/15	11	28	00	106.9	100.0	62.00	47.93	1.02	4.94E-07
final	22.5	9/10/15	11	53	00			56.80	49.53		4.60E-07
3	RT = 0.943	dT =		25.00 min		σ'_c =	1.0 ksf	0.389	0.382	io= 17.5	-4%
initial	22.5	9/10/15	11	54	00	106.9	100.0	62.00	47.93	0.96	5.30E-07
final	22.7	9/10/15	12	21	00			56.25	49.80		4.92E-07
4	RT = 0.941	dT =		27.00 min		σ'_c =	1.0 ksf	0.430	0.446	io= 17.5	3%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc = 10.126 cm ε_{axial} = 0.8%

Ac = 41.622 cm^2

Vc= 421.49 cm^3 ε_{vol} = 1.1%

Sc = 0.243 cm^{-1} Sc = Lc / Ac , final

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	18.54	127.8	107.8	92.0
PreTest	19.53	130.3	109.0	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **4.77E-07** cm/sec

(i_o)ave = 18.6

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B002 | Test No.: P10603

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-2C | DEPTH (ft): 9.75

Specimen - Apparatus set-up - Test Information | Cell No. B | Apparatus No. 7 | Stage No.: 3

Preliminary Length/Area Calculations

Lo =	3.986	in	Lo=	10.123	cm
dLc=	0.036	in	Ao =	41.28	cm^2
Lc=	3.950	in	Vo =	417.92	cm^3
			Lc=	10.032	cm
dVc = 3 Vo * (dLc/Lo)			dVc=	11.32	cm^3
			Vc =	406.60	cm^3
Sc =	0.248	cm^{-1}	Ac=	40.530	cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or			
	x	with stones or		Stones with filter paper or			top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination			
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes	
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only	
5) Direction of permeant :	x	Up during or		Down during permeation			
6) Permeant: water used	x	Tap		Distilled			
or		Demineralized		0.005 N calcium sulfate (CaSO4)			

Equations Used

Kt = - 0.0000760 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3158

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.3	10/9/15	09	47	00	103.9	90.0	58.92	41.45	1.01	8.80E-08
final	22.5	10/9/15	10	39	03			56.05	42.35		8.26E-08
1	RT = 0.946	dT =		52.05 min		σ'_c =	2.0 ksf	0.216	0.215	io= 21.9	-1%
initial	22.5	10/9/15	10	44	00	103.9	90.0	58.70	41.48	1.00	8.85E-08
final	22.5	10/9/15	11	54	40			55.00	42.65		8.28E-08
2	RT = 0.943	dT =		70.67 min		σ'_c =	2.0 ksf	0.279	0.279	io= 21.6	-1%
initial	22.5	10/9/15	11	58	00	103.9	90.0	58.10	41.65	0.98	9.01E-08
final	22.5	10/9/15	13	22	56			53.92	43.00		8.44E-08
3	RT = 0.943	dT =		84.93 min		σ'_c =	2.0 ksf	0.315	0.322	io= 20.6	1%
initial	22.5	10/9/15	13	25	00	103.9	90.0	59.12	41.32	0.98	9.07E-08
final	22.5	10/9/15	14	47	02			54.70	42.75		8.49E-08
4	RT = 0.943	dT =		82.03 min		σ'_c =	2.0 ksf	0.333	0.342	io= 22.3	1%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc =	10.032	cm	ε_{axial} =	0.9%	
Ac =	40.846	cm^2			
Vc=	409.77	cm^3	ε_{vol} =	2.0%	
Sc =	0.246	cm^{-1}	Sc = Lc / Ac , final		

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	22.73	125.9	102.6	98.4
PreTest	21.92	127.6	104.7	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **8.37E-08** cm/sec

(i_o)ave = 21.6

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B004 | Test No.: P10575

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-12C | DEPTH (ft): 59.9

Specimen - Apparatus set-up - Test Information | Cell No. E | Apparatus No. 1 | Stage No.: 5

Preliminary Length/Area Calculations

Lo =	3.939	in	Lo=	10.004 cm
dLc=	0.183	in	Ao =	42.47 cm^2
Lc=	3.756	in	Vo =	424.89 cm^3
			Lc=	9.539 cm
dVc = 3 Vo * (dLc/Lo)			dVc=	59.23 cm^3
			Vc =	365.67 cm^3
Sc =	0.249	cm^{-1}	Ac=	38.333 cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or		
	x	with stones or		Stones with filter paper or		top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination		
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only
5) Direction of permeant :	x	Up during or		Down during permeation		
6) Permeant: water used	x	Tap		Distilled		
or		Demineralized		0.005 N calcium sulfate (CaSO4)		Permeability

Equations Used

Kt = - 0.0000757 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3127

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	23.2	9/1/15	10	36	00	121.7	80.0	57.00	37.76	1.00	7.13E-09
final	23.7	9/1/15	15	27	00			55.47	38.24		6.68E-09
1	RT = 0.920	dT =		291.00 min		σ'_c =	6.0 ksf	0.115	0.115	io= 25.4	10%
initial	23.7	9/1/15	15	28	00	121.7	80.0	57.31	37.68	0.98	6.37E-09
final	23.5	9/1/15	21	09	00			55.68	38.20		5.94E-09
2	RT = 0.916	dT =		341.00 min		σ'_c =	6.0 ksf	0.122	0.125	io= 25.9	-2%
initial	23.5	9/1/15	21	10	00	121.7	80.0	58.53	37.34	1.05	6.13E-09
final	22.2	9/2/15	08	36	00			55.30	38.30		5.82E-09
3	RT = 0.934	dT =		686.00 min		σ'_c =	6.0 ksf	0.242	0.230	io= 27.9	-4%
initial	22.2	9/2/15	08	37	00	121.7	80.0	58.08	37.37	0.95	6.14E-09
final	24.0	9/2/15	17	33	00			55.55	38.20		5.80E-09
4	RT = 0.928	dT =		536.00 min		σ'_c =	6.0 ksf	0.190	0.199	io= 27.3	-4%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc =	9.539	cm	ε_{axial} =	4.6%	
Ac =	37.683	cm^2			
Vc=	359.47	cm^3	ε_{vol} =	15.4%	
Sc =	0.253	cm^{-1}	Sc = Lc / Ac , final		

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	29.01	119.5	92.6	97.8
PreTest	19.29	130.6	109.5	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **6.06E-09** cm/sec

(i_o)ave = 26.6

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B007 | Test No.: P10582

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-2B | DEPTH (ft): 9.55

Specimen - Apparatus set-up - Test Information | Cell No. C | Apparatus No. 1 | Stage No.: 5

Preliminary Length/Area Calculations

Lo =	3.979	in	Lo=	10.106	cm
dLc=	0.060	in	Ao =	41.96	cm^2
Lc=	3.919	in	Vo =	423.99	cm^3
			Lc=	9.953	cm
dVc = 3 Vo * (dLc/Lo)			dVc=	19.18	cm^3
			Vc =	404.80	cm^3
Sc =	0.245	cm^{-1}	Ac=	40.671	cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or				
	x	with stones or		Stones with filter paper or		top + bottom		
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination				
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes		
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only		
5) Direction of permeant :	x	Up during or		Down during permeation				
6) Permeant: water used	x	Tap		Distilled				
or		Demineralized		0.005 N calcium sulfate (CaSO4)				Permeability

Equations Used

Kt = - 0.0000757 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3127

Consol Stage-Trial No.	Temp. º C	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.5	9/15/15	10	28	00	120.8	100.0	49.00	40.28	0.99	3.03E-06
final	22.5	9/15/15	10	45	00			42.77	42.25		2.78E-06
1	RT = 0.943	dT =		17.00 min		σ'_c =	3.0 ksf	0.467	0.472	io= 11.0	-2%
initial	22.5	9/15/15	10	47	00	120.8	100.0	49.00	40.28	0.99	3.10E-06
final	22.5	9/15/15	10	50	35			46.00	41.23		2.85E-06
2	RT = 0.943	dT =		3.58 min		σ'_c =	3.0 ksf	0.225	0.228	io= 11.0	1%
initial	22.5	9/15/15	10	52	00	120.8	100.0	49.00	40.28	0.98	3.10E-06
final	22.5	9/15/15	10	54	49			46.50	41.08		2.85E-06
3	RT = 0.943	dT =		2.82 min		σ'_c =	3.0 ksf	0.187	0.192	io= 11.0	1%
initial	22.5	9/15/15	10	56	00	120.8	100.0	49.00	40.28	1.00	3.11E-06
final	22.5	9/15/15	11	00	30			45.48	41.38		2.85E-06
4	RT = 0.943	dT =		4.50 min		σ'_c =	3.0 ksf	0.264	0.264	io= 11.0	1%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc =	9.953	cm	ε_{axial} =	1.5%	
Ac =	41.755	cm^2			
Vc=	415.60	cm^3	ε_{vol} =	2.0%	
Sc =	0.238	cm^{-1}	Sc = Lc / Ac , final		

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	19.68	128.0	107.0	89.4
PreTest	20.85	131.9	109.1	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **2.83E-06** cm/sec

(i_o)ave = 11.0

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B008 | Test No.: P10587

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-3A | DEPTH (ft): 38.7

Specimen - Apparatus set-up - Test Information | Cell No. C | Apparatus No. 2 | Stage No.: 2

Preliminary Length/Area Calculations

Lo =	3.998	in	Lo=	10.155	cm
dLc=	0.062	in	Ao =	41.99	cm^2
Lc=	3.936	in	Vo =	426.40	cm^3
			Lc=	9.997	cm
dVc = 3 Vo * (dLc/Lo)			dVc=	19.84	cm^3
			Vc =	406.56	cm^3
Sc =	0.246	cm^{-1}	Ac=	40.667	cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or			
	x	with stones or		Stones with filter paper or			top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination			
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes	
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only	
5) Direction of permeant :	x	Up during or		Down during permeation			
6) Permeant: water used	x	Tap		Distilled			
or		Demineralized		0.005 N calcium sulfate (CaSO4)			

Equations Used

Kt = - 0.0000746 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3214

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	23.3	9/21/15	10	54	00	107.0	100.0	54.00	44.75	1.02	8.14E-06
final	23.4	9/21/15	10	57	00			48.85	46.37		7.33E-06
1	RT = 0.922	dT =	3.00 min			σ'_c =	1.0 ksf	0.383	0.375	io= 11.6	1%
initial	23.4	9/21/15	10	58	00	107.0	100.0	54.00	44.75	1.01	7.89E-06
final	23.4	9/21/15	11	04	00			47.53	46.80		7.09E-06
2	RT = 0.921	dT =	6.00 min			σ'_c =	1.0 ksf	0.481	0.475	io= 11.6	-2%
initial	23.4	9/21/15	11	05	00	107.0	100.0	54.00	44.75	0.98	8.32E-06
final	23.4	9/21/15	11	09	00			48.14	46.68		7.48E-06
3	RT = 0.921	dT =	4.00 min			σ'_c =	1.0 ksf	0.436	0.447	io= 11.6	3%
initial	23.4	9/21/15	11	10	00	107.0	100.0	54.00	44.75	1.00	7.93E-06
final	23.4	9/21/15	11	15	30			47.65	46.80		7.13E-06
4	RT = 0.921	dT =	5.50 min			σ'_c =	1.0 ksf	0.472	0.475	io= 11.6	-2%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc = 9.997 cm ε_{axial} = 1.6%

Ac = 41.678 cm^2

Vc= 416.67 cm^3 ε_{vol} = 2.3%

Sc = 0.240 cm^{-1} Sc = Lc / Ac , final

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	21.14	127.5	105.2	92.0
PreTest	21.61	131.0	107.7	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **7.26E-06** cm/sec

(i_o)ave = 11.6

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B010 | Test No.: P10581

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-1B | DEPTH (ft): 1.1

Specimen - Apparatus set-up - Test Information | Cell No. B | Apparatus No. 2 | Stage No.: 2

Preliminary Length/Area Calculations

Lo =	3.971	in	Lo=	10.087	cm
dLc=	0.028	in	Ao =	41.57	cm^2
Lc=	3.943	in	Vo =	419.35	cm^3
			Lc=	10.016	cm
dVc = 3 Vo * (dLc/Lo)			dVc=	8.87	cm^3
			Vc =	410.49	cm^3
Sc =	0.244	cm^{-1}	Ac=	40.982	cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or			
	x	with stones or		Stones with filter paper or			top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination			
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes	
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only	
5) Direction of permeant :	x	Up during or		Down during permeation			
6) Permeant: water used	x	Tap		Distilled			
or		Demineralized		0.005 N calcium sulfate (CaSO4)			

Equations Used

Kt = - 0.0000746 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3214

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.6	9/14/15	09	07	00	103.5	100.0	52.00	45.43	1.02	9.16E-06
final	22.6	9/14/15	09	10	00			48.13	46.65		8.56E-06
1	RT = 0.941	dT =		3.00 min		σ'_c =	0.5 ksf	0.288	0.282	io= 8.2	-2%
initial	22.6	9/14/15	09	11	00	103.5	100.0	52.00	45.43	1.00	9.56E-06
final	22.6	9/14/15	09	13	30			48.37	46.60		8.93E-06
2	RT = 0.941	dT =		2.50 min		σ'_c =	0.5 ksf	0.270	0.271	io= 8.2	2%
initial	22.6	9/14/15	09	14	00	103.5	100.0	52.00	45.43	0.97	9.38E-06
final	22.6	9/14/15	09	17	30			47.85	46.80		8.77E-06
3	RT = 0.941	dT =		3.50 min		σ'_c =	0.5 ksf	0.309	0.317	io= 8.2	0%
initial	22.6	9/14/15	09	18	00	103.5	100.0	52.00	45.43	1.01	9.41E-06
final	22.6	9/14/15	09	20	00			48.80	46.45		8.80E-06
4	RT = 0.941	dT =		2.00 min		σ'_c =	0.5 ksf	0.238	0.236	io= 8.2	0%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc =	10.016	cm	ε_{axial} =	0.7%	
Ac =	41.250	cm^2			
Vc=	413.17	cm^3	ε_{vol} =	1.5%	
Sc =	0.243	cm^{-1}	Sc = Lc / Ac , final		

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	20.68	122.5	101.5	84.6
PreTest	23.55	127.3	103.0	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **8.76E-06** cm/sec

(i_o)ave = 8.2

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B011 | Test No.: P10569

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-9B | DEPTH (ft): 44.25

Specimen - Apparatus set-up - Test Information | Cell No. E | Apparatus No. 5 | Stage No.: 4

Preliminary Length/Area Calculations

Lo =	4.032	in	Lo=	10.242	cm
dLc=	0.070	in	Ao =	42.04	cm^2
Lc=	3.962	in	Vo =	430.59	cm^3
			Lc=	10.064	cm
dVc = 3 Vo * (dLc/Lo)			dVc=	22.43	cm^3
			Vc =	408.17	cm^3
Sc =	0.248	cm^{-1}	Ac=	40.557	cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or			
	x	with stones or		Stones with filter paper or			top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination			
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes	
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only	
5) Direction of permeant :	x	Up during or		Down during permeation			
6) Permeant: water used	x	Tap		Distilled			
or		Demineralized		0.005 N calcium sulfate (CaSO4)			

Equations Used

Kt = - 0.0000751 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3236

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Permeability Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.5	8/28/15	09	03	00	120.8	100.0	58.46	39.40	1.01	3.90E-08
final	22.5	8/28/15	10	39	00			55.84	40.24		3.59E-08
1	RT = 0.943	dT =		96.00 min		σ'_c =	3.0 ksf	0.197	0.195	io= 23.8	0%
initial	22.5	8/28/15	10	42	00	120.8	100.0	58.30	39.43	0.98	3.87E-08
final	23.0	8/28/15	12	14	00			55.82	40.25		3.54E-08
2	RT = 0.937	dT =		92.00 min		σ'_c =	3.0 ksf	0.186	0.190	io= 23.6	-1%
initial	23.0	8/28/15	12	16	00	120.8	100.0	58.00	39.57	1.02	4.01E-08
final	22.7	8/28/15	13	12	00			56.42	40.07		3.66E-08
3	RT = 0.935	dT =		56.00 min		σ'_c =	3.0 ksf	0.119	0.116	io= 23.0	2%
initial	22.7	8/28/15	13	14	00	120.8	100.0	58.07	39.55	0.98	3.91E-08
final	23.0	8/28/15	13	56	00			56.89	39.94		3.57E-08
4	RT = 0.935	dT =		42.00 min		σ'_c =	3.0 ksf	0.089	0.090	io= 23.1	-1%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc = 10.064 cm ε_{axial} = 1.7%

Ac = 41.537 cm^2

Vc= 418.02 cm^3 ε_{vol} = 2.9%

Sc = 0.242 cm^{-1} Sc = Lc / Ac , final

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	18.81	128.6	108.2	88.2
PreTest	19.65	133.4	111.5	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **3.59E-08** cm/sec

(i_o)ave = 23.4

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B012 | Test No.: P10577

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-3B | DEPTH (ft): 15.85

Specimen - Apparatus set-up - Test Information | Cell No. E | Apparatus No. 1 | Stage No.: 3

Preliminary Length/Area Calculations

Lo =	3.995	in	Lo=	10.147	cm
dLc=	0.028	in	Ao =	41.74	cm^2
Lc=	3.967	in	Vo =	423.50	cm^3
			Lc=	10.076	cm
dVc = 3 Vo * (dLc/Lo)			dVc=	8.91	cm^3
			Vc =	414.59	cm^3
Sc =	0.245	cm^{-1}	Ac=	41.148	cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or				
	x	with stones or		Stones with filter paper or		top + bottom		
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination				
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes		
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only		
5) Direction of permeant :	x	Up during or		Down during permeation				
6) Permeant: water used	x	Tap		Distilled				
or		Demineralized		0.005 N calcium sulfate (CaSO4)				Permeability

Equations Used

Kt = - 0.0000757 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3127

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.6	9/8/15	08	57	00	110.4	100.0	57.10	37.20	0.79	8.02E-08
final	23.1	9/8/15	11	00	00			50.84	39.67		7.41E-08
1	RT = 0.935	dT =	123.00 min			σ'_c =	1.5 ksf	0.469	0.592	io= 24.8	-1%
initial	23.1	9/8/15	11	01	00	110.4	100.0	54.20	38.67	1.01	8.30E-08
final	23.2	9/8/15	12	02	00			51.37	39.55		7.60E-08
2	RT = 0.927	dT =	61.00 min			σ'_c =	1.5 ksf	0.212	0.211	io= 19.4	2%
initial	23.2	9/8/15	12	03	00	110.4	100.0	54.50	38.50	0.98	8.22E-08
final	23.5	9/8/15	13	18	00			51.05	39.60		7.49E-08
3	RT = 0.922	dT =	75.00 min			σ'_c =	1.5 ksf	0.258	0.264	io= 20.0	0%
initial	23.5	9/8/15	13	21	00	110.4	100.0	54.20	38.62	1.01	8.22E-08
final	24.0	9/8/15	14	48	00			50.40	39.80		7.41E-08
4	RT = 0.913	dT =	87.00 min			σ'_c =	1.5 ksf	0.285	0.283	io= 19.4	-1%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc = 10.076 cm ε_{axial} = 0.7%

Ac = 41.665 cm^2

Vc= 419.81 cm^3 ε_{vol} = 0.9%

Sc = 0.242 cm^{-1} Sc = Lc / Ac , final

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	16.60	130.8	112.2	89.1
PreTest	18.14	133.7	113.2	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **7.48E-08** cm/sec

(i_o)ave = 20.9

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B014 | Test No.: P10567

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-3B | DEPTH (ft): 34.05

Specimen - Apparatus set-up - Test Information | Cell No. 6 | Apparatus No. 1 | Stage No.: 5

Preliminary Length/Area Calculations

Lo =	4.018	in	Lo=	10.205 cm
dLc=	0.066	in	Ao =	42.17 cm^2
Lc=	3.952	in	Vo =	430.33 cm^3
			Lc=	10.037 cm
dVc = 3 Vo * (dLc/Lo)			dVc=	21.21 cm^3
			Vc =	409.12 cm^3
Sc =	0.246	cm^{-1}	Ac=	40.761 cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or		
	x	with stones or		Stones with filter paper or		top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination		
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only
5) Direction of permeant :	x	Up during or		Down during permeation		
6) Permeant: water used	x	Tap		Distilled		
or		Demineralized		0.005 N calcium sulfate (CaSO4)		Permeability

Equations Used

Kt = - 0.0000757 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3127

Consol Stage-Trial No.	Temp. º C	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.3	8/27/15	09	02	00	131.7	90.0	55.90	38.04	1.00	1.99E-07
final	22.4	8/27/15	09	46	00			50.80	39.64		1.88E-07
1	RT = 0.947	dT =		44.00 min		σ'_c =	6.0 ksf	0.382	0.383	io= 22.4	0%
initial	22.4	8/27/15	09	46	00	131.7	90.0	55.23	38.24	0.97	2.01E-07
final	22.8	8/27/15	10	35	00			49.92	39.95		1.89E-07
2	RT = 0.941	dT =		49.00 min		σ'_c =	6.0 ksf	0.398	0.410	io= 21.3	0%
initial	22.8	8/27/15	10	36	00	131.7	90.0	55.30	38.23	0.98	2.01E-07
final	22.8	8/27/15	11	20	00			50.38	39.80		1.88E-07
3	RT = 0.936	dT =		44.00 min		σ'_c =	6.0 ksf	0.369	0.376	io= 21.4	0%
initial	22.8	8/27/15	11	21	00	131.7	90.0	55.60	38.15	1.00	2.03E-07
final	22.5	8/27/15	12	15	00			49.69	40.00		1.90E-07
4	RT = 0.940	dT =		54.00 min		σ'_c =	6.0 ksf	0.443	0.443	io= 21.9	1%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc =	10.037	cm	ε_{axial} =	1.6%	
Ac =	40.838	cm^2			
Vc=	409.89	cm^3	ε_{vol} =	4.7%	
Sc =	0.246	cm^{-1}	Sc = Lc / Ac , final		

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	14.94	130.4	113.4	78.9
PreTest	16.33	138.5	119.1	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **1.89E-07** cm/sec

(i_o)ave = 21.7

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B016 | Test No.: P10568

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-1B | DEPTH (ft): 4.35

Specimen - Apparatus set-up - Test Information | Cell No. P-1 | Apparatus No. 3 | Stage No.: 2

Preliminary Length/Area Calculations

Lo =	3.825	in	Lo=	9.715 cm
dLc=	0.019	in	Ao =	41.20 cm^2
Lc=	3.806	in	Vo =	400.26 cm^3
			Lc=	9.667 cm
dVc = 3 Vo * (dLc/Lo)			dVc=	5.97 cm^3
			Vc =	394.30 cm^3
Sc =	0.237	cm^{-1}	Ac=	40.789 cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or		
	x	with stones or		Stones with filter paper or		top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination		
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only
5) Direction of permeant :	x	Up during or		Down during permeation		
6) Permeant: water used	x	Tap		Distilled		
or		Demineralized		0.005 N calcium sulfate (CaSO4)		Permeability

Equations Used

Kt = - 0.0000755 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt TubeC= 1.3132

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.5	8/28/15	09	01	00	103.5	100.0	57.00	49.50	0.97	2.41E-06
final	22.5	8/28/15	09	06	00			54.20	50.40		2.25E-06
1	RT = 0.943	dT =		5.00 min		σ'_c =	0.5 ksf	0.209	0.215	io= 9.8	1%
initial	22.5	8/28/15	09	07	00	103.5	100.0	57.00	49.50	0.96	2.34E-06
final	22.5	8/28/15	09	11	00			54.67	50.26		2.19E-06
2	RT = 0.943	dT =		4.00 min		σ'_c =	0.5 ksf	0.174	0.181	io= 9.8	-2%
initial	22.5	8/28/15	09	12	00	103.5	100.0	57.00	49.50	0.99	2.40E-06
final	22.5	8/28/15	09	22	00			52.78	50.83		2.25E-06
3	RT = 0.943	dT =		10.00 min		σ'_c =	0.5 ksf	0.315	0.317	io= 9.8	1%
initial	22.5	8/28/15	09	23	00	103.5	100.0	57.00	49.50	0.95	2.39E-06
final	22.5	8/28/15	09	29	00			53.85	50.54		2.24E-06
4	RT = 0.943	dT =		6.00 min		σ'_c =	0.5 ksf	0.235	0.248	io= 9.8	0%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					

TEST SUMMARY

Final Specimen and Test Conditions

Lc =	9.667	cm	ε_{axial} =	0.5%	
Ac =	41.143	cm^2			
Vc=	397.72	cm^3	ε_{vol} =	0.6%	
Sc =	0.235	cm^{-1}	Sc = Lc / Ac , final		

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	25.80	124.2	98.8	96.1
PreTest	26.44	125.7	99.4	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4

ave K @ 20 ºC: **2.23E-06** cm/sec

(i_o)ave = 9.8

Tested By: BB Reviewed By: G. Thomas

PERMEABILITY TEST: FALLING HEAD - CONSTANT VOLUME U-TUBE

ASTM D 5084 - Method F

Project No.: T60428794 | BORING: JOP-B023 | Test No.: P10580

Project Name: Dynegy CCR - Joppa | SAMPLE: ST-1A | DEPTH (ft): 43.2

Specimen - Apparatus set-up - Test Information | Cell No. E | Apparatus No. 3 | Stage No.: 4

Preliminary Length/Area Calculations

Lo = 3.808 in | Lo= 9.673 cm

dLc= 0.253 in | Ao = 42.13 cm^2

Lc= 3.555 in | Vo = 407.47 cm^3

Lc= 9.030 cm

dVc = 3 Vo * (dLc/Lo) | dVc= 81.21 cm^3

Vc = 326.26 cm^3

Sc = 0.250 cm^{-1} | Ac= 36.130 cm^2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or		
	x	with stones or		Stones with filter paper or		top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination		
3) During saturation: Water flushed up sides of specimen to remove air			x	No		Yes
4) During consolidation:	x	Top and bottom drainage or		Top		Bottom only
5) Direction of permeant :	x	Up during or		Down during permeation		
6) Permeant: water used	x	Tap		Distilled		
or		Demineralized		0.005 N calcium sulfate (CaSO4)		Permeability

Equations Used

Kt = - 0.0000755 * Sc/dT(min) * ln (ho/hf)

RT = (-0.02452*(ave. temp in C) + 1.495)

K @ 20 ºC = RT * Kt | TubeC= 1.3132

TEST SUMMARY

Final Specimen and Test Conditions

Lc = 9.030 cm | ε_{axial} = 6.6%

Ac = 36.487 cm^2

Vc= 329.48 cm^3 | ε_{vol} = 19.1%

Sc = 0.247 cm^{-1} | Sc = Lc / Ac , final

	w (%)	γ_τ (pcf)	γ_d (pcf)	S (%)
Initial	57.52	104.2	66.2	98.1
PreTest	40.58	115.0	81.8	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

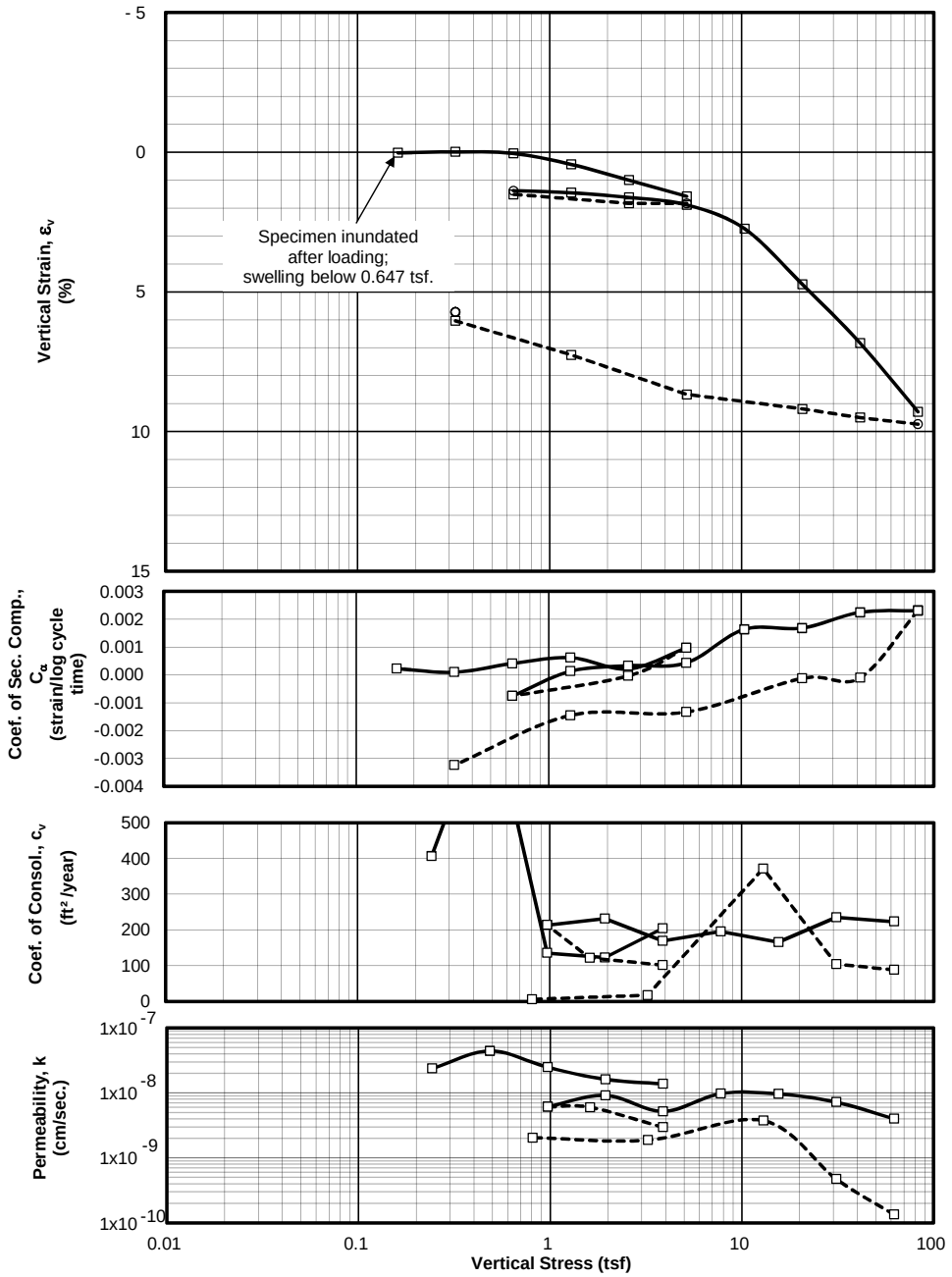
Averages for trials: 1-4

ave K @ 20 ºC: **2.17E-06** cm/sec

(i_o)ave = 10.4

Tested By: BB | Reviewed By: G. Thomas

Consol Stage-Trial No.	Temp. ºC	Date	Time hr	Time min	Time sec	Initial σ_c psi	Initial Ub psi	U-tube Reading Head (cm) (cc)	U-tube Reading Tail (cm) (cc)	Flow in/out gradient	Preliminary Final at 20ºC cm/sec Dev. from Ave.
initial	22.6	9/14/15	09	11	00	113.9	100.0	57.00	49.50	0.97	2.33E-06
final	22.6	9/14/15	09	16	00			54.37	50.35		2.17E-06
1	RT = 0.941	dT =		5.00 min		σ'_c =	2.0 ksf	0.197	0.203	io= 10.4	0%
initial	22.6	9/14/15	09	17	00	113.9	100.0	57.00	49.50	0.98	2.32E-06
final	22.6	9/14/15	09	24	00			53.70	50.56		2.16E-06
2	RT = 0.941	dT =		7.00 min		σ'_c =	2.0 ksf	0.247	0.253	io= 10.4	0%
initial	22.6	9/14/15	09	25	00	113.9	100.0	57.00	49.50	0.96	2.33E-06
final	22.6	9/14/15	09	35	30			52.85	50.85		2.17E-06
3	RT = 0.941	dT =		10.50 min		σ'_c =	2.0 ksf	0.310	0.322	io= 10.4	0%
initial	22.6	9/14/15	09	36	00	113.9	100.0	57.00	49.50	1.00	2.35E-06
final	22.6	9/14/15	09	44	00			53.40	50.63		2.19E-06
4	RT = 0.941	dT =		8.00 min		σ'_c =	2.0 ksf	0.269	0.270	io= 10.4	1%
initial											
final											
5		dT =				σ'_c =					
initial											
final											
6		dT =				σ'_c =					



SAMPLE INFORMATION

Boring:	JOP-B007
Sample:	ST-2C
Depth:	10.05 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL, orange brown lean clay with gravel

LL = 36, PL = 16, PI = 20

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.62	inch
Diameter:	2.50	inch

Initial water content:	18.6	%
Initial total unit weight:	127.9	pcf
Initial dry unit weight:	107.8	pcf
Initial void ratio:	0.520	
Initial degree of saturation:	94	%
Final water content:	20.0	%
Final total unit weight:	130.9	pcf
Final dry unit weight:	109.1	pcf
Final void ratio:	0.502	
Final degree of saturation:	105	%

(measured specific gravity = 2.63)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	11.5 (Range: 8.8 to 11.7)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.082
Compression Index (void ratio per log cycle stress):	0.125
Swell Ratio (strain per log cycle stress):	0.005
Swell Index (void ratio per log cycle stress):	0.008
Recompression Ratio (strain per log cycle stress):	0.004
Recompression Index (void ratio per log cycle stress):	0.006
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 9/11/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-B007 Depth: 10.05 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.617 inch	Final height:	0.610 inch	
BORING:	JOP-B007	Initial water content:	18.6 %	Final water content:	20.0 %	
SAMPLE:	ST-2C	Initial dry density:	107.8 pcf	Final dry density:	109.1 pcf	
TEST:	C15151	Initial total density:	127.9 pcf	Final total density:	130.9 pcf	
DEPTH, feet:	10.05	Initial saturation:	94 %	Final saturation:	105 %	
BY:	CMJ/YC	Initial void ratio:	0.520	Final void ratio:	0.502	
TEST DATE:	9/11/2015			Final strain:	1.2 %	

EQUIPMENT:

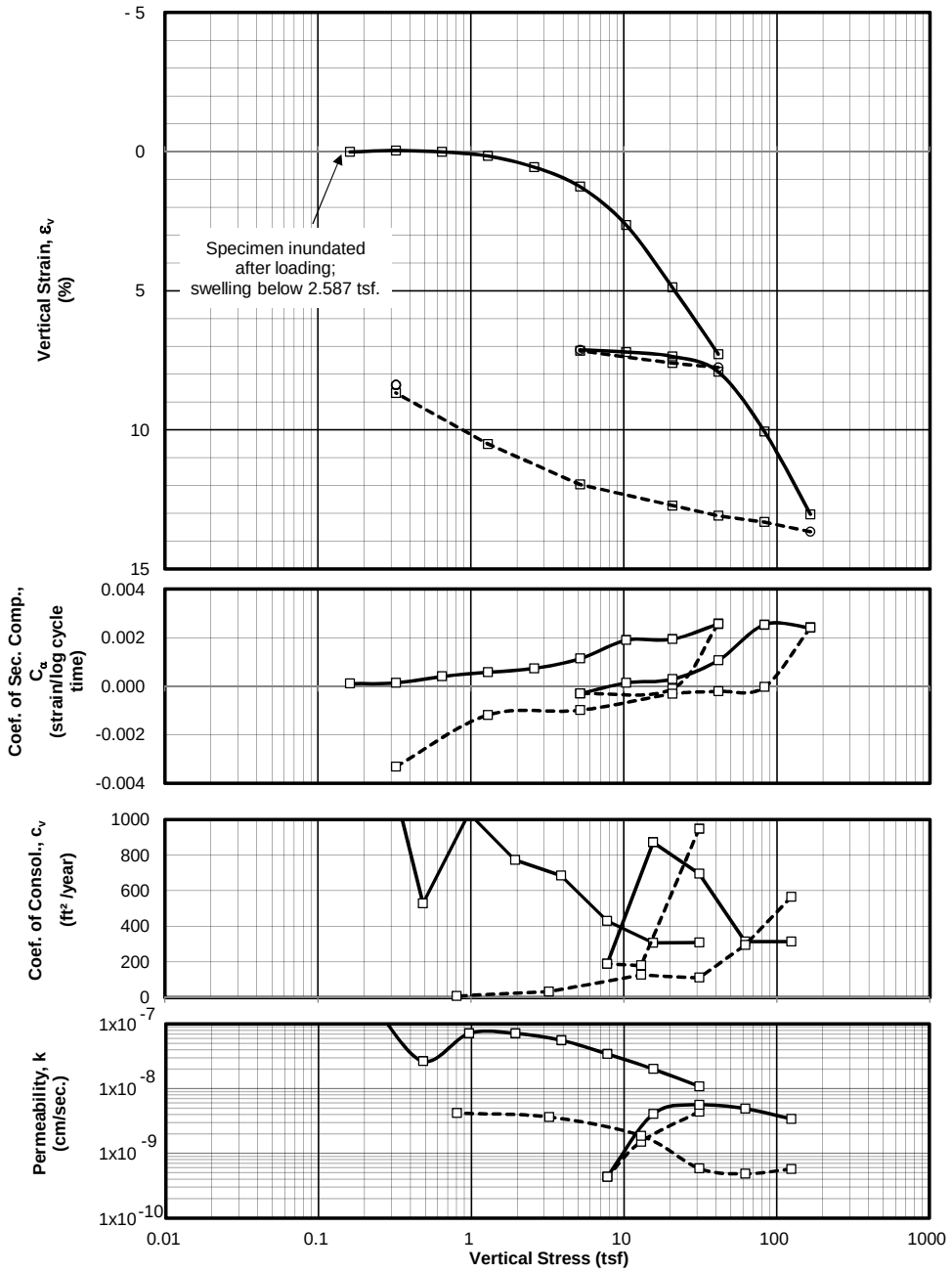
Load Frame No.: 5

Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: CL, orange brown lean clay with gravel

G	LL	PL	PI
2.626	36	16	20

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft^2/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.162	0.0001	0.022	0.520	0.025	0.520	219.60	0.0002	745.81	8.88E-09
2	0.323	-0.0001	-0.010	0.520	-0.010	0.520	406.64	0.0001	515.49	2.38E-08
3	0.647	0.0003	0.047	0.520	0.150	0.518	839.78	0.0004	572.11	4.43E-08
4	1.29	0.0027	0.440	0.514	0.531	0.512	135.34	0.0006	164.51	2.48E-08
5	2.59	0.0062	1.007	0.505	1.054	0.504	122.32	0.0002	228.08	1.62E-08
6	5.17	0.0098	1.584	0.496	1.832	0.492	204.41	0.0010	448.84	1.37E-08
7	2.59	0.0113	1.832	0.492	1.826	0.492	101.85	0.0000	1040.00	2.95E-09
8	0.647	0.0094	1.515	0.497	1.380	0.499	121.93	-0.0008	612.41	6.01E-09
9	1.29	0.0090	1.454	0.498	1.477	0.498	213.52	0.0001	1055.23	6.10E-09
10	2.59	0.0100	1.625	0.496	1.683	0.495	231.20	0.0003	760.02	9.18E-09
11	5.17	0.0116	1.888	0.492	1.956	0.491	169.17	0.0004	982.09	5.20E-09
12	10.4	0.0169	2.741	0.479	2.985	0.475	195.81	0.0016	606.52	9.74E-09
13	20.7	0.0292	4.734	0.448	5.106	0.443	165.98	0.0017	519.53	9.64E-09
14	41.4	0.0422	6.838	0.416	7.200	0.411	234.91	0.0022	983.35	7.21E-09
15	82.8	0.0573	9.293	0.379	9.735	0.372	223.27	0.0023	1685.58	4.00E-09
16	41.4	0.0586	9.502	0.376	9.494	0.376	88.12	-0.0001	19824.43	1.34E-10
17	20.7	0.0567	9.191	0.381	9.174	0.381	104.42	-0.0001	6656.80	4.73E-10
18	5.17	0.0535	8.671	0.388	8.314	0.394	371.01	-0.0013	2985.51	3.75E-09
19	1.29	0.0448	7.258	0.410	7.069	0.413	17.02	-0.0015	274.42	1.87E-09
20	0.323	0.0373	6.041	0.428	5.717	0.433	5.40	-0.0032	79.71	2.04E-09



SAMPLE INFORMATION

Boring:	JOP-B008
Sample:	ST-3C
Depth:	39.80 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL, yellowish brown clay

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.62	inch
Diameter:	2.50	inch

Initial water content:	20.6	%
Initial total unit weight:	125.3	pcf
Initial dry unit weight:	103.9	pcf
Initial void ratio:	0.604	
Initial degree of saturation:	91	%
Final water content:	21.7	%
Final total unit weight:	128.4	pcf
Final dry unit weight:	105.5	pcf
Final void ratio:	0.579	
Final degree of saturation:	100	% (assumed specific gravity = 2.67)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	10.9 (Range: 9.3 to 15.2)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.096
Compression Index (void ratio per log cycle stress):	0.154
Swell Ratio (strain per log cycle stress):	0.007
Swell Index (void ratio per log cycle stress):	0.011
Recompression Ratio (strain per log cycle stress):	0.008
Recompression Index (void ratio per log cycle stress):	0.013
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 9/18/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-B008 Depth: 39.80 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.621 inch	Final height:	0.611 inch	
BORING:	JOP-B008	Initial water content:	20.6 %	Final water content:	21.7 %	
SAMPLE:	ST-3C	Initial dry density:	103.9 pcf	Final dry density:	105.5 pcf	
TEST:	C15159	Initial total density:	125.3 pcf	Final total density:	128.4 pcf	
DEPTH, feet:	39.8	Initial saturation:	91 %	Final saturation:	100 %	
BY:	CMJ/YC	Initial void ratio:	0.604	Final void ratio:	0.579	
TEST DATE:	9/18/2015			Final strain:	1.6 %	

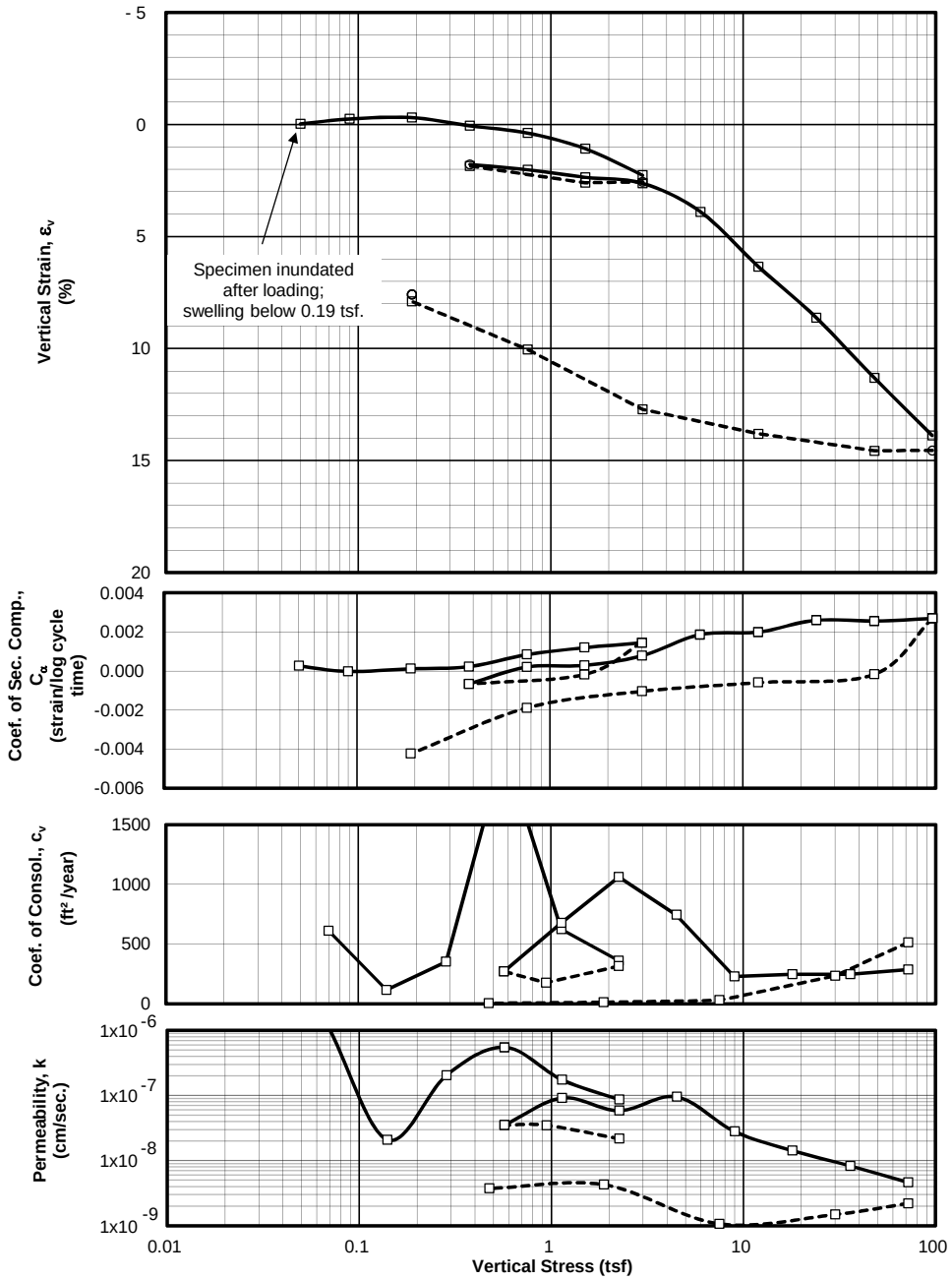
EQUIPMENT: SPECIMEN DESCRIPTION: CL, yellowish brown clay

Load Frame No.: 5

Ring Diameter: 2.5 inch

G	LL	PL	PI
2.67			

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft^2/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.162	0.0001	0.016	0.604	0.020	0.604	1918.89	0.0001	1028.38	5.63E-08
2	0.323	-0.0002	-0.037	0.605	-0.025	0.605	1579.43	0.0001	307.79	1.55E-07
3	0.647	0.0001	0.017	0.604	0.087	0.603	528.74	0.0004	602.68	2.65E-08
4	1.29	0.0010	0.165	0.602	0.372	0.598	1034.42	0.0006	437.42	7.13E-08
5	2.59	0.0035	0.561	0.595	0.794	0.592	772.83	0.0007	326.37	7.14E-08
6	5.17	0.0078	1.263	0.584	1.622	0.578	684.05	0.0011	368.66	5.60E-08
7	10.4	0.0164	2.640	0.562	2.996	0.556	429.18	0.0019	375.87	3.44E-08
8	20.7	0.0303	4.877	0.526	5.231	0.520	307.27	0.0019	462.77	2.00E-08
9	41.4	0.0452	7.280	0.488	7.759	0.480	309.03	0.0026	861.00	1.08E-08
10	20.7	0.0472	7.598	0.482	7.575	0.483	948.10	-0.0001	6507.93	4.40E-09
11	5.17	0.0445	7.164	0.489	7.121	0.490	179.36	-0.0003	3580.70	1.51E-09
12	10.4	0.0447	7.203	0.489	7.239	0.488	188.49	0.0001	13167.34	4.32E-10
13	20.7	0.0457	7.362	0.486	7.437	0.485	871.54	0.0003	6506.12	4.04E-09
14	41.4	0.0492	7.916	0.477	8.174	0.473	694.51	0.0011	3738.93	5.60E-09
15	82.8	0.0624	10.053	0.443	10.545	0.435	314.02	0.0025	1936.57	4.89E-09
16	165.6	0.0809	13.031	0.395	13.654	0.385	314.12	0.0024	2781.36	3.41E-09
17	82.8	0.0826	13.308	0.391	13.298	0.391	565.55	0.0000	29901.87	5.71E-10
18	41.4	0.0812	13.083	0.394	13.044	0.395	294.32	-0.0002	18388.36	4.83E-10
19	20.7	0.0790	12.720	0.400	12.674	0.401	110.81	-0.0003	5707.75	5.86E-10
20	5.17	0.0743	11.961	0.412	11.831	0.415	126.57	-0.0010	2046.02	1.87E-09
21	1.29	0.0652	10.503	0.436	10.323	0.439	32.09	-0.0012	266.07	3.64E-09



SAMPLE INFORMATION

Boring:	JOP-010
Sample:	ST-1C
Depth:	1.40 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL, light yellowish-gray lean clay

LL = 37, PL = 15, PI = 22

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.61	inch
Diameter:	2.50	inch

Initial water content:	20.2	%
Initial total unit weight:	122.5	pcf
Initial dry unit weight:	101.9	pcf
Initial void ratio:	0.606	
Initial degree of saturation:	87	%
Final water content:	23.4	%
Final total unit weight:	125.0	pcf
Final dry unit weight:	101.4	pcf
Final void ratio:	0.614	
Final degree of saturation:	100	%

(assumed specific gravity = 2.62)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	5.7 (Range: 3.8 to 5.9)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.085
Compression Index (void ratio per log cycle stress):	0.136
Swell Ratio (strain per log cycle stress):	0.012
Swell Index (void ratio per log cycle stress):	0.019
Recompression Ratio (strain per log cycle stress):	0.009
Recompression Index (void ratio per log cycle stress):	0.014
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 9/11/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-010 Depth: 1.40 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.607 inch	Final height:	0.610 inch	
BORING:	JOP-010	Initial water content:	20.2 %	Final water content:	23.4 %	
SAMPLE:	ST-1C	Initial dry density:	101.9 pcf	Final dry density:	101.4 pcf	
TEST:	C15152	Initial total density:	122.5 pcf	Final total density:	125.0 pcf	
DEPTH, feet:	1.4	Initial saturation:	87 %	Final saturation:	100 %	
BY:	CMJ/YC	Initial void ratio:	0.606	Final void ratio:	0.614	
TEST DATE:	9/11/2015			Final strain:	-0.5 %	

EQUIPMENT:

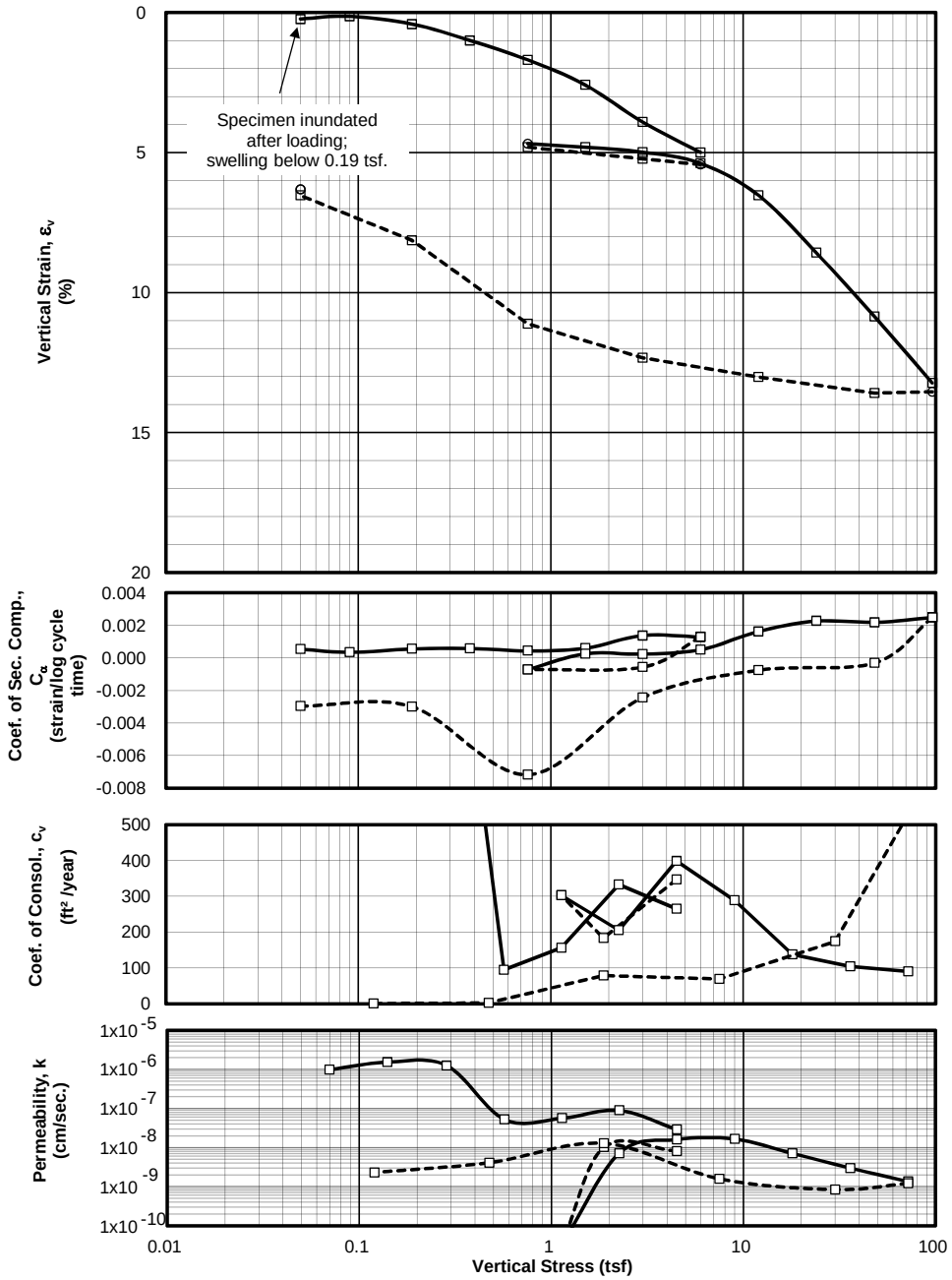
SPECIMEN DESCRIPTION: CL, light yellowish-gray lean clay

Load Frame No.: 2

Ring Diameter: 2.5 inch

G	LL	PL	PI
2.62	37	15	22

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft^2/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.050	-0.0001	-0.020	0.606	-0.022	0.606	1249.74	0.0003	256.11	1.47E-07
2	0.090	-0.0015	-0.245	0.610	-0.261	0.610	610.70	0.0000	17.74	1.04E-06
3	0.190	-0.0019	-0.305	0.611	-0.294	0.611	115.54	0.0001	167.30	2.08E-08
4	0.380	0.0004	0.063	0.605	0.123	0.604	350.74	0.0002	51.68	2.05E-07
5	0.760	0.0024	0.388	0.600	0.721	0.594	2133.68	0.0008	116.73	5.51E-07
6	1.51	0.0066	1.083	0.588	1.516	0.581	622.93	0.0012	107.97	1.74E-07
7	3.00	0.0138	2.267	0.569	2.556	0.565	360.56	0.0014	125.84	8.64E-08
8	1.51	0.0158	2.607	0.564	2.568	0.565	314.08	-0.0002	437.81	2.16E-08
9	0.380	0.0113	1.860	0.576	1.785	0.577	174.30	-0.0007	151.12	3.48E-08
10	0.760	0.0123	2.024	0.573	2.059	0.573	269.53	0.0002	231.65	3.51E-08
11	1.51	0.0143	2.358	0.568	2.423	0.567	677.08	0.0003	224.14	9.11E-08
12	3.00	0.0160	2.629	0.564	2.846	0.560	1061.35	0.0008	549.42	5.83E-08
13	6.00	0.0237	3.901	0.543	4.501	0.534	743.34	0.0019	236.01	9.50E-08
14	12.0	0.0385	6.345	0.504	6.695	0.498	227.59	0.0020	245.44	2.80E-08
15	24.0	0.0524	8.625	0.467	9.129	0.459	247.40	0.0026	526.33	1.42E-08
16	48.0	0.0687	11.307	0.424	11.814	0.416	245.60	0.0026	894.91	8.28E-09
17	96.0	0.0843	13.881	0.383	14.550	0.372	285.86	0.0027	1865.03	4.62E-09
18	48.0	0.0885	14.564	0.372	14.543	0.372	511.92	-0.0002	7025.16	2.20E-09
19	12.0	0.0839	13.805	0.384	13.687	0.386	233.77	-0.0006	4742.94	1.49E-09
20	3.00	0.0772	12.712	0.402	12.616	0.403	29.11	-0.0010	823.28	1.07E-09
21	0.760	0.0610	10.047	0.444	9.833	0.448	11.87	-0.0019	84.07	4.26E-09
22	0.190	0.0480	7.895	0.479	7.581	0.484	3.27	-0.0042	26.48	3.73E-09



SAMPLE INFORMATION

Boring:	JOP-010
Sample:	ST-3C
Depth:	34.80 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL, light brown sandy lean clay with gravel

LL = 27, PL = 11, PI = 16

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.62	inch
Diameter:	2.50	inch

Initial water content:	15.1	%
Initial total unit weight:	130.5	pcf
Initial dry unit weight:	113.3	pcf
Initial void ratio:	0.482	
Initial degree of saturation:	85	%

Final water content:	15.8	%
Final total unit weight:	136.4	pcf
Final dry unit weight:	117.7	pcf
Final void ratio:	0.426	
Final degree of saturation:	100	%

(assumed specific gravity = 2.69)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	8.1 (Range: 5.7 to 11.1)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.079
Compression Index (void ratio per log cycle stress):	0.117
Swell Ratio (strain per log cycle stress):	0.007
Swell Index (void ratio per log cycle stress):	0.010
Recompression Ratio (strain per log cycle stress):	0.006
Recompression Index (void ratio per log cycle stress):	0.009
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 9/14/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-010 Depth: 34.80 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.616 inch	Final height:	0.593 inch	
BORING:	JOP-010	Initial water content:	15.1 %	Final water content:	15.8 %	
SAMPLE:	ST-3C	Initial dry density:	113.3 pcf	Final dry density:	117.7 pcf	
TEST:	C15153	Initial total density:	130.5 pcf	Final total density:	136.4 pcf	
DEPTH, feet:	34.8	Initial saturation:	85 %	Final saturation:	100 %	
BY:	CMJ/YC	Initial void ratio:	0.482	Final void ratio:	0.426	
TEST DATE:	9/14/2015			Final strain:	3.7 %	

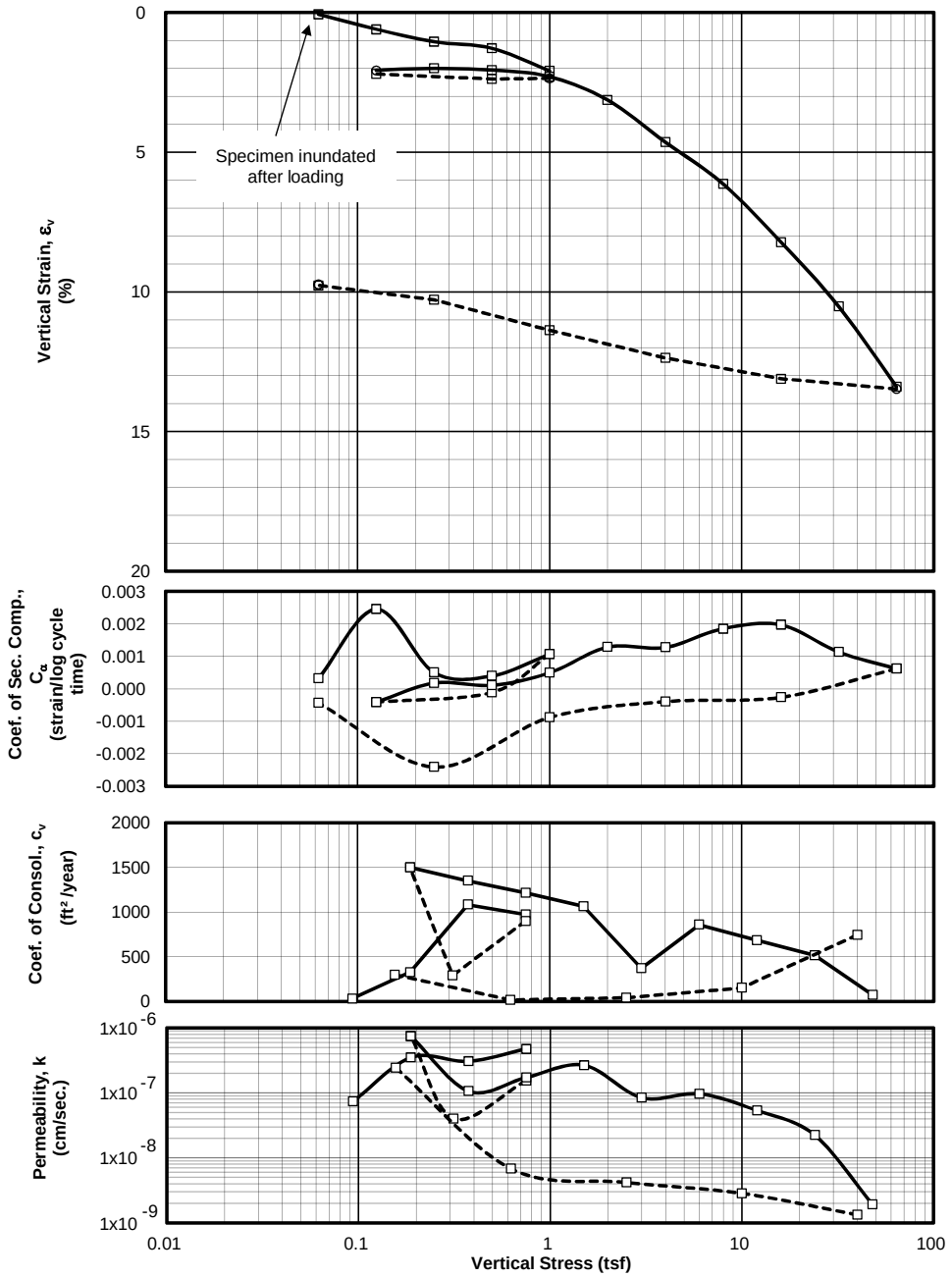
EQUIPMENT: SPECIMEN DESCRIPTION: CL, light brown sandy lean clay with gravel

Load Frame No.: 3

Ring Diameter: 2.5 inch

G	LL	PL	PI
2.69	27	11	16

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft^2/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.050	0.0014	0.235	0.478	0.225	0.478	1386.68	0.0005	21.32	1.96E-06
2	0.090	0.0009	0.141	0.480	0.254	0.478	1394.23	0.0003	42.56	9.88E-07
3	0.190	0.0026	0.416	0.476	0.561	0.474	1846.23	0.0006	36.32	1.53E-06
4	0.380	0.0062	1.001	0.467	1.193	0.464	1352.55	0.0006	32.45	1.26E-06
5	0.760	0.0105	1.698	0.457	1.736	0.456	94.50	0.0004	54.53	5.23E-08
6	1.51	0.0159	2.590	0.443	2.731	0.441	156.26	0.0006	84.08	5.61E-08
7	3.00	0.0241	3.914	0.424	4.167	0.420	332.41	0.0014	112.55	8.91E-08
8	6.00	0.0308	5.000	0.408	5.426	0.401	265.27	0.0013	276.33	2.90E-08
9	3.00	0.0322	5.233	0.404	5.162	0.405	346.40	-0.0006	1288.32	8.11E-09
10	0.760	0.0297	4.817	0.410	4.688	0.412	183.30	-0.0007	538.43	1.03E-08
11	1.51	0.0296	4.816	0.410	4.872	0.410	302.44	0.0003	282986.18	3.22E-11
12	3.00	0.0307	4.988	0.408	5.034	0.407	205.19	0.0002	868.28	7.13E-09
13	6.00	0.0332	5.389	0.402	5.506	0.400	398.24	0.0005	748.59	1.60E-08
14	12.0	0.0402	6.528	0.385	6.978	0.378	288.45	0.0016	526.77	1.65E-08
15	24.0	0.0528	8.581	0.355	8.932	0.349	137.36	0.0023	584.54	7.09E-09
16	48.0	0.0668	10.851	0.321	11.177	0.316	104.36	0.0022	1056.92	2.98E-09
17	96.0	0.0814	13.227	0.286	13.545	0.281	90.23	0.0025	2020.84	1.35E-09
18	48.0	0.0837	13.592	0.280	13.558	0.281	527.82	-0.0003	13144.13	1.21E-09
19	12.0	0.0801	13.015	0.289	12.908	0.291	174.07	-0.0008	6239.70	8.42E-10
20	3.00	0.0759	12.333	0.299	12.039	0.303	69.19	-0.0024	1320.71	1.58E-09
21	0.760	0.0684	11.119	0.317	10.257	0.330	78.32	-0.0072	184.48	1.28E-08
22	0.190	0.0501	8.135	0.361	7.954	0.364	2.59	-0.0030	19.10	4.09E-09
23	0.050	0.0402	6.533	0.385	6.315	0.388	0.66471	-0.0030	8.74	2.30E-09



SAMPLE INFORMATION

Boring:	JOP-B014
Sample:	ST-3A
Depth:	33.50 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	SC, light brown clayey sand

LL = 26, PL = 11, PI = 15

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.61	inch
Diameter:	2.50	inch

Initial water content:	13.8	%
Initial total unit weight:	126.7	pcf
Initial dry unit weight:	111.3	pcf
Initial void ratio:	0.498	
Initial degree of saturation:	74	%
Final water content:	16.3	%
Final total unit weight:	135.1	pcf
Final dry unit weight:	116.2	pcf
Final void ratio:	0.435	
Final degree of saturation:	100	% (assumed specific gravity = 2.67)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	5.6 (Range: 4.4 to 8.0)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.086
Compression Index (void ratio per log cycle stress):	0.129
Swell Ratio (strain per log cycle stress):	0.003
Swell Index (void ratio per log cycle stress):	0.004
Recompression Ratio (strain per log cycle stress):	0.001
Recompression Index (void ratio per log cycle stress):	0.001
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 8/25/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-B014 Depth: 33.50 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.615 inch	Final height:	0.589 inch	
BORING:	JOP-B014	Initial water content:	13.8 %	Final water content:	16.3 %	
SAMPLE:	ST-3A	Initial dry density:	111.3 pcf	Final dry density:	116.2 pcf	
TEST:	C15137	Initial total density:	126.7 pcf	Final total density:	135.1 pcf	
DEPTH, feet:	33.5	Initial saturation:	74 %	Final saturation:	100 %	
BY:	CMJ/YC	Initial void ratio:	0.498	Final void ratio:	0.435	
TEST DATE:	8/25/2015			Final strain:	4.2 %	

EQUIPMENT:

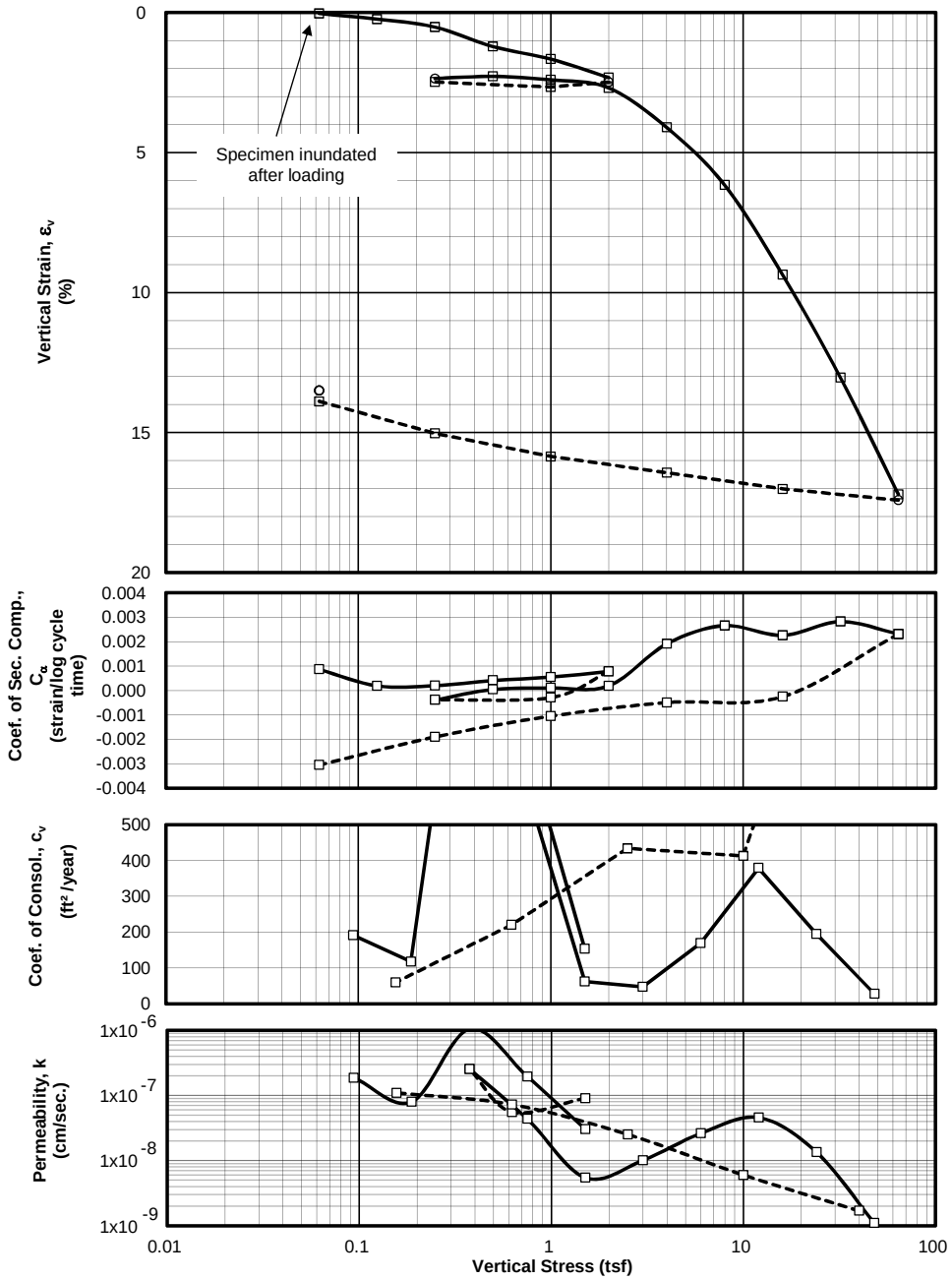
SPECIMEN DESCRIPTION: SC, light brown clayey sand

Load Frame No.: 2

Ring Diameter: 2.5 inch

G	LL	PL	PI
2.67	26	11	15

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft^2/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.063	0.0004	0.068	0.497	0.073	0.497	124.79	0.0003	91.36	4.12E-08
2	0.125	0.0037	0.605	0.489	0.785	0.486	28.63	0.0025	11.66	7.41E-08
3	0.250	0.0065	1.052	0.482	1.216	0.479	324.35	0.0005	27.95	3.50E-07
4	0.500	0.0079	1.286	0.478	1.404	0.477	1082.43	0.0004	106.73	3.06E-07
5	1.00	0.0129	2.097	0.466	2.360	0.462	970.90	0.0011	61.65	4.75E-07
6	0.500	0.0146	2.382	0.462	2.357	0.462	897.00	-0.0001	175.37	1.54E-07
7	0.125	0.0136	2.210	0.465	2.076	0.467	289.60	-0.0004	217.14	4.02E-08
8	0.250	0.0123	2.003	0.468	2.059	0.467	1499.21	0.0002	60.61	7.46E-07
9	0.500	0.0127	2.069	0.467	2.139	0.466	1349.53	0.0001	383.04	1.06E-07
10	1.00	0.0142	2.304	0.463	2.435	0.461	1213.52	0.0005	212.29	1.72E-07
11	2.00	0.0193	3.134	0.451	3.476	0.446	1064.37	0.0013	120.44	2.67E-07
12	4.00	0.0285	4.642	0.428	5.020	0.422	370.27	0.0013	132.66	8.42E-08
13	8.00	0.0377	6.139	0.406	6.601	0.399	857.99	0.0019	267.22	9.69E-08
14	16.0	0.0505	8.223	0.374	8.670	0.368	682.99	0.0020	383.83	5.37E-08
15	32.0	0.0647	10.522	0.340	10.727	0.337	516.58	0.0011	696.07	2.24E-08
16	64.0	0.0823	13.393	0.297	13.473	0.296	71.26	0.0006	1114.59	1.93E-09
17	16.0	0.0806	13.109	0.301	13.044	0.302	744.57	-0.0003	16919.51	1.33E-09
18	4.00	0.0760	12.363	0.312	12.276	0.314	151.52	-0.0004	1609.02	2.84E-09
19	1.00	0.0699	11.376	0.327	11.227	0.329	42.05	-0.0009	303.81	4.18E-09
20	0.250	0.0632	10.285	0.344	9.938	0.349	15.51	-0.0024	68.74	6.80E-09
21	0.063	0.0601	9.772	0.351	9.745	0.352	295.79	-0.0004	36.59	2.44E-07



SAMPLE INFORMATION

Boring:	JOP-B016
Sample:	ST-1B
Depth:	4.25 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL, light brown lean clay

LL = 33, PL = 21, PI = 12

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.61	inch
Diameter:	2.50	inch

Initial water content:	25.2	%
Initial total unit weight:	120.9	pcf
Initial dry unit weight:	96.5	pcf
Initial void ratio:	0.772	
Initial degree of saturation:	89	%

Final water content:	23.5	%
Final total unit weight:	128.5	pcf
Final dry unit weight:	104.0	pcf
Final void ratio:	0.645	
Final degree of saturation:	100	%

(assumed specific gravity = 2.74)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	5.9 (Range: 5.5 to 10.9)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.130
Compression Index (void ratio per log cycle stress):	0.230
Swell Ratio (strain per log cycle stress):	0.003
Swell Index (void ratio per log cycle stress):	0.005
Recompression Ratio (strain per log cycle stress):	0.002
Recompression Index (void ratio per log cycle stress):	0.004
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 8/27/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-B016 Depth: 4.25 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.611 inch	Final height:	0.567 inch	
BORING:	JOP-B016	Initial water content:	25.2 %	Final water content:	23.5 %	
SAMPLE:	ST-1B	Initial dry density:	96.5 pcf	Final dry density:	104.0 pcf	
TEST:	C15140	Initial total density:	120.9 pcf	Final total density:	128.5 pcf	
DEPTH, feet:	4.25	Initial saturation:	89 %	Final saturation:	100 %	
BY:	CMJ/YC	Initial void ratio:	0.772	Final void ratio:	0.645	
TEST DATE:	8/27/2015			Final strain:	7.2 %	

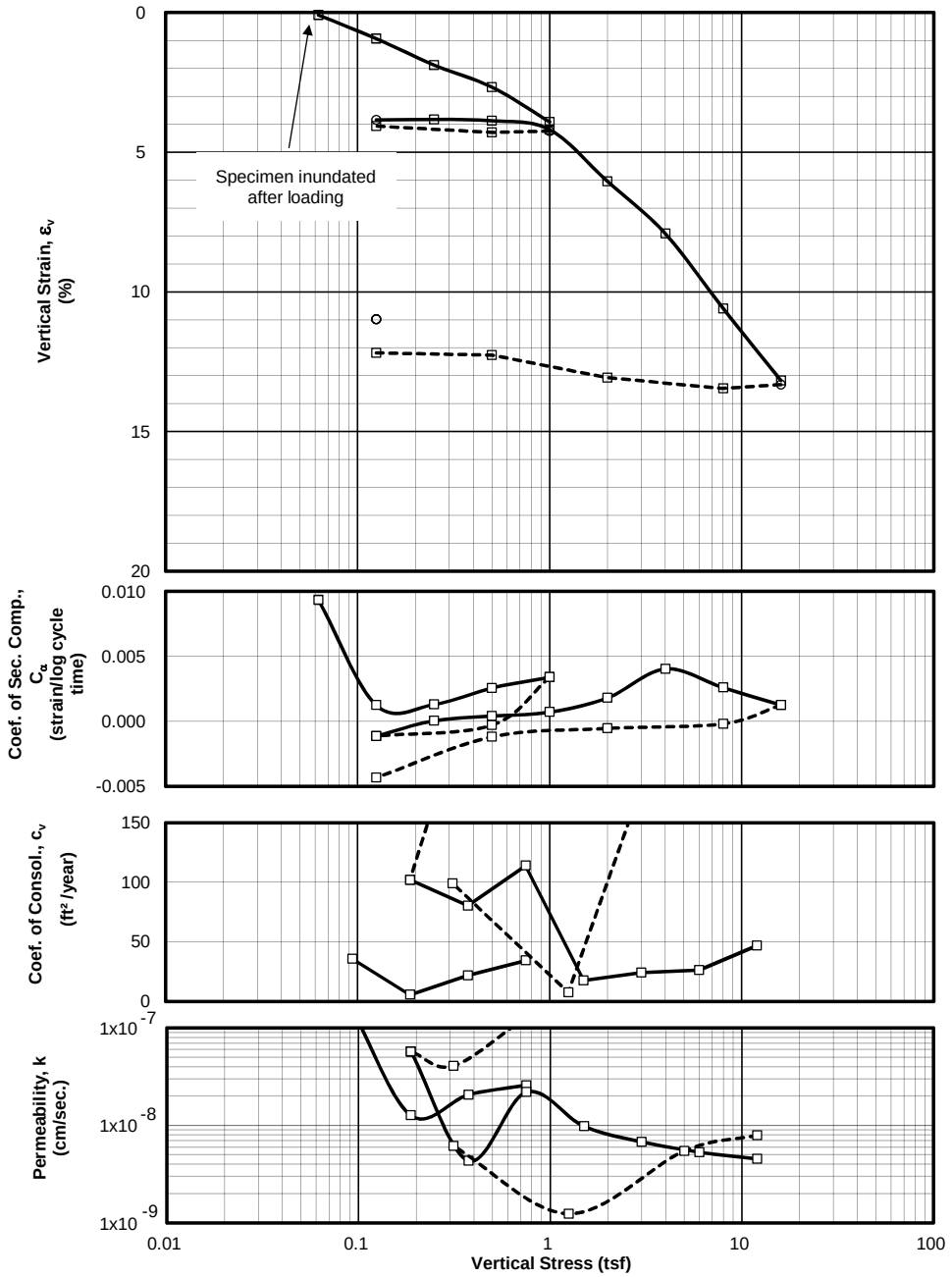
EQUIPMENT: SPECIMEN DESCRIPTION: CL, light brown lean clay

Load Frame No.: 6

Ring Diameter: 2.5 inch

G	LL	PL	PI
2.74	33	21	12

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft²/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.063	0.0002	0.040	0.771	0.089	0.770	327.32	0.0009	154.71	6.38E-08
2	0.125	0.0015	0.243	0.768	0.294	0.767	191.06	0.0002	30.77	1.87E-07
3	0.250	0.0032	0.525	0.763	0.572	0.762	117.55	0.0002	44.46	7.98E-08
4	0.500	0.0075	1.220	0.750	1.347	0.748	1251.85	0.0004	35.96	1.05E-06
5	1.00	0.0102	1.668	0.742	1.800	0.740	722.25	0.0005	111.46	1.95E-07
6	2.00	0.0142	2.328	0.731	2.490	0.728	152.92	0.0008	151.69	3.04E-08
7	1.00	0.0163	2.663	0.725	2.602	0.726	894.52	-0.0003	297.93	9.06E-08
8	0.250	0.0152	2.488	0.728	2.358	0.730	786.21	-0.0004	426.58	5.56E-08
9	0.500	0.0140	2.287	0.731	2.345	0.730	1048.78	0.0000	124.42	2.54E-07
10	1.00	0.0147	2.407	0.729	2.425	0.729	602.37	0.0001	416.86	4.36E-08
11	2.00	0.0165	2.698	0.724	2.744	0.723	62.04	0.0002	342.82	5.46E-09
12	4.00	0.0251	4.109	0.699	4.256	0.696	47.35	0.0019	141.80	1.01E-08
13	8.00	0.0377	6.164	0.663	6.701	0.653	168.81	0.0027	194.59	2.62E-08
14	16.0	0.0572	9.361	0.606	10.074	0.593	378.82	0.0023	250.26	4.57E-08
15	32.0	0.0796	13.036	0.541	13.607	0.531	194.87	0.0028	435.42	1.35E-08
16	64.0	0.1051	17.207	0.467	17.410	0.463	28.06	0.0023	767.09	1.10E-09
17	16.0	0.1039	17.007	0.471	16.931	0.472	1347.98	-0.0003	24029.27	1.69E-09
18	4.00	0.1004	16.429	0.481	16.236	0.484	412.82	-0.0005	2074.96	6.00E-09
19	1.00	0.0968	15.851	0.491	15.616	0.495	433.47	-0.0010	518.71	2.52E-08
20	0.250	0.0918	15.030	0.506	14.613	0.513	219.78	-0.0019	91.35	7.26E-08
21	0.063	0.0848	13.886	0.526	13.495	0.533	59.62	-0.0031	16.39	1.10E-07



SAMPLE INFORMATION

Boring:	JOP-B017
Sample:	ST-2A
Depth:	8.25 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL, brown sandy lean clay

LL = 33, PL = 17, PI = 16

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.61	inch
Diameter:	2.50	inch

Initial water content:	22.5	%
Initial total unit weight:	123.0	pcf
Initial dry unit weight:	100.4	pcf
Initial void ratio:	0.585	
Initial degree of saturation:	98	%
Final water content:	19.5	%
Final total unit weight:	127.1	pcf
Final dry unit weight:	106.4	pcf
Final void ratio:	0.496	
Final degree of saturation:	100	%

(assumed specific gravity = 2.55)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	1.7 (Range: 1.5 to 2.0)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.087
Compression Index (void ratio per log cycle stress):	0.138
Swell Ratio (strain per log cycle stress):	0.004
Swell Index (void ratio per log cycle stress):	0.006
Recompression Ratio (strain per log cycle stress):	0.006
Recompression Index (void ratio per log cycle stress):	0.010
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 8/24/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-B017 Depth: 8.25 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.610 inch	Final height:	0.576 inch	
BORING:	JOP-B017	Initial water content:	22.5 %	Final water content:	19.5 %	
SAMPLE:	ST-2A	Initial dry density:	100.4 pcf	Final dry density:	106.4 pcf	
TEST:	C15136	Initial total density:	123.0 pcf	Final total density:	127.1 pcf	
DEPTH, feet:	8.25	Initial saturation:	98 %	Final saturation:	100 %	
BY:	CMJ/YC	Initial void ratio:	0.585	Final void ratio:	0.496	
TEST DATE:	8/24/2015			Final strain:	5.6 %	

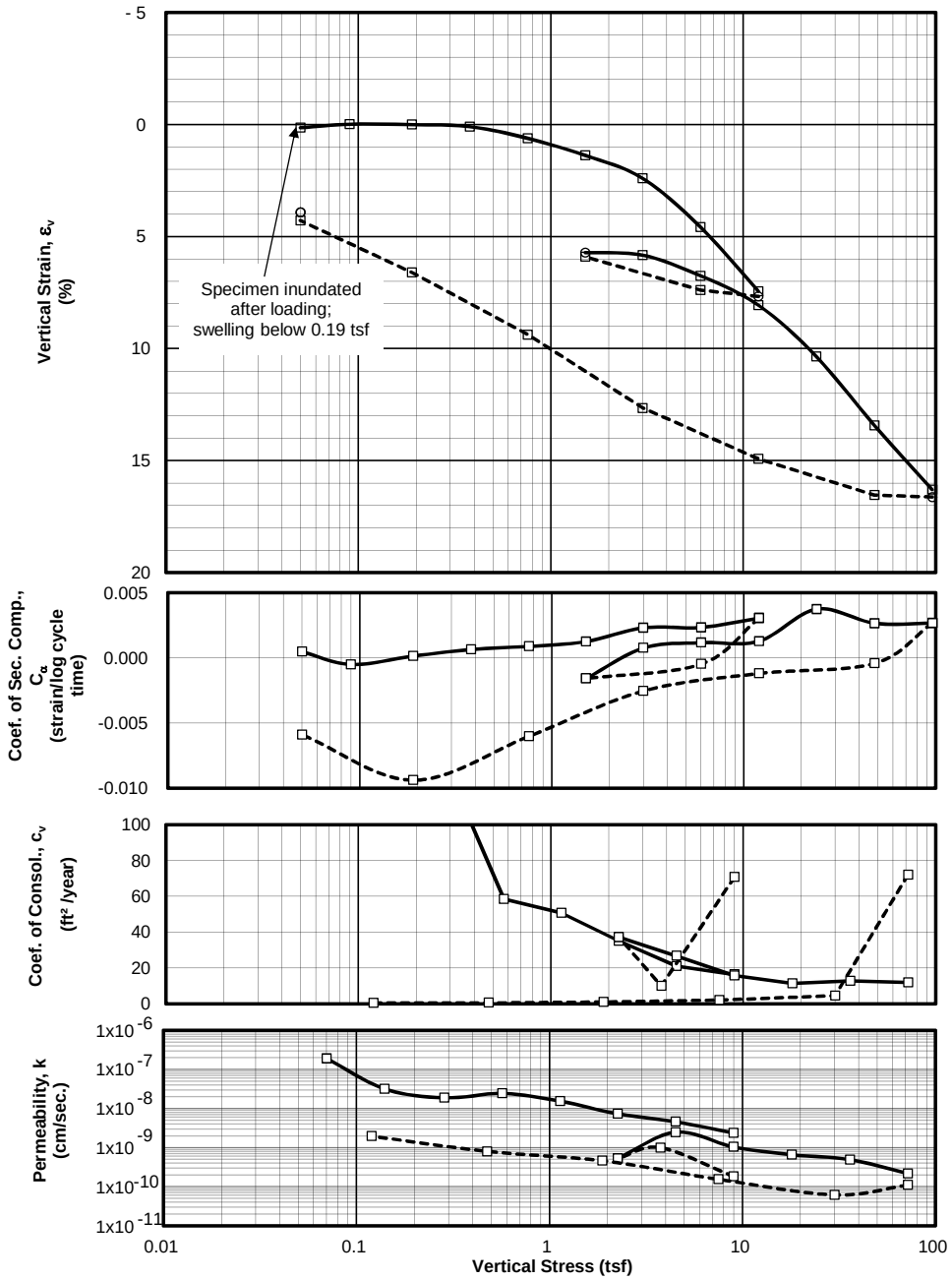
EQUIPMENT: SPECIMEN DESCRIPTION: CL, brown sandy lean clay

Load Frame No.: 1

Ring Diameter: 2.5 inch

G	LL	PL	PI
2.55	33	17	16

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft^2/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.063	0.0006	0.096	0.584	0.423	0.579	81.16	0.0094	64.92	3.77E-08
2	0.125	0.0057	0.941	0.570	1.081	0.568	35.77	0.0012	7.40	1.46E-07
3	0.250	0.0115	1.887	0.555	2.105	0.552	5.55	0.0013	13.20	1.27E-08
4	0.500	0.0163	2.675	0.543	3.117	0.536	21.73	0.0026	31.76	2.06E-08
5	1.00	0.0239	3.922	0.523	4.255	0.518	34.26	0.0034	40.10	2.58E-08
6	0.500	0.0262	4.299	0.517	4.242	0.518	568.46	-0.0003	132.40	1.30E-07
7	0.125	0.0248	4.066	0.521	3.846	0.524	216.86	-0.0011	160.62	4.07E-08
8	0.250	0.0234	3.832	0.525	3.835	0.525	101.91	0.0000	53.47	5.75E-08
9	0.500	0.0236	3.877	0.524	3.979	0.522	80.31	0.0004	559.61	4.33E-09
10	1.00	0.0256	4.197	0.519	4.292	0.517	113.91	0.0007	156.32	2.20E-08
11	2.00	0.0369	6.048	0.489	6.277	0.486	17.52	0.0018	54.02	9.79E-09
12	4.00	0.0483	7.917	0.460	8.280	0.454	24.04	0.0040	107.00	6.78E-09
13	8.00	0.0646	10.594	0.417	10.829	0.414	26.32	0.0026	149.44	5.31E-09
14	16.0	0.0804	13.174	0.376	13.316	0.374	46.70	0.0013	310.07	4.54E-09
15	8.00	0.0821	13.456	0.372	13.336	0.374	744.03	-0.0002	2839.35	7.91E-09
16	2.00	0.0797	13.069	0.378	12.903	0.381	280.74	-0.0005	1551.20	5.46E-09
17	0.500	0.0748	12.262	0.391	12.116	0.393	7.64	-0.0012	185.99	1.24E-09
18	0.125	0.0743	12.185	0.392	10.977	0.411	99.08	-0.0043	487.23	6.13E-09



SAMPLE INFORMATION

Boring:	JOP-B021
Sample:	ST-2B
Depth:	14.10 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL, greenish gray lean clay

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.61	inch
Diameter:	2.50	inch

Initial water content:	25.1	%
Initial total unit weight:	124.3	pcf
Initial dry unit weight:	99.4	pcf
Initial void ratio:	0.715	
Initial degree of saturation:	96	%
Final water content:	25.1	%
Final total unit weight:	126.5	pcf
Final dry unit weight:	101.1	pcf
Final void ratio:	0.685	
Final degree of saturation:	100	% (assumed specific gravity = 2.73)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	4.6 (Range: 4.2 to 5.0)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.102
Compression Index (void ratio per log cycle stress):	0.175
Swell Ratio (strain per log cycle stress):	0.025
Swell Index (void ratio per log cycle stress):	0.043
Recompression Ratio (strain per log cycle stress):	0.025
Recompression Index (void ratio per log cycle stress):	0.043
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 9/18/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-B021 Depth: 14.10 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.609 inch	Final height:	0.599 inch	
BORING:	JOP-B021	Initial water content:	25.1 %	Final water content:	25.1 %	
SAMPLE:	ST-2B	Initial dry density:	99.4 pcf	Final dry density:	101.1 pcf	
TEST:	C15160	Initial total density:	124.3 pcf	Final total density:	126.5 pcf	
DEPTH, feet:	14.1	Initial saturation:	96 %	Final saturation:	100 %	
BY:	CMJ/YC	Initial void ratio:	0.715	Final void ratio:	0.685	
TEST DATE:	9/18/2015			Final strain:	1.8 %	

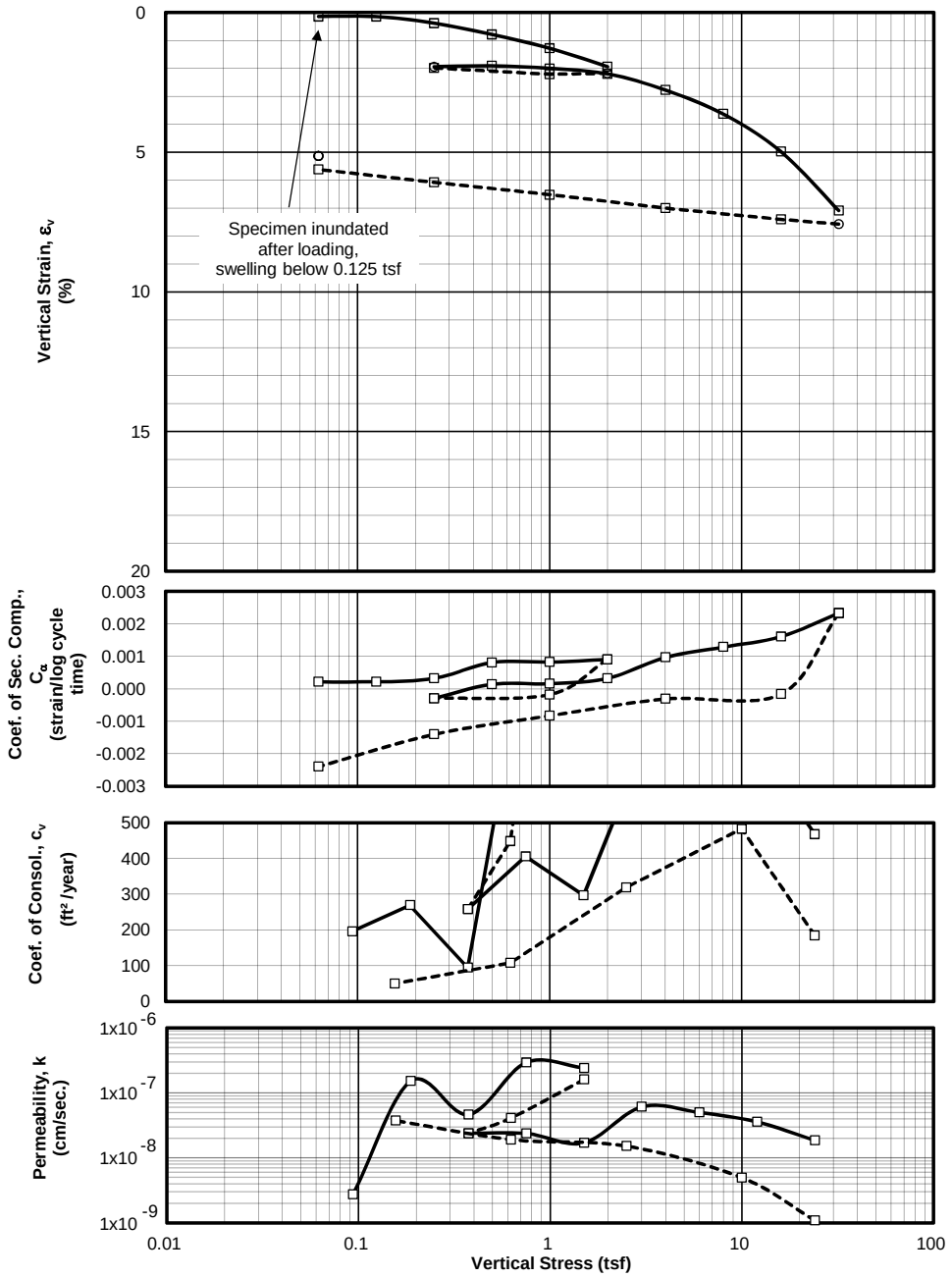
EQUIPMENT: SPECIMEN DESCRIPTION: CL, greenish gray lean clay

Load Frame No.: 2

Ring Diameter: 2.5 inch

G	LL	PL	PI
2.73			

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft²/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.050	0.0009	0.150	0.712	0.044	0.714	84.98	0.0005	33.42	7.67E-08
2	0.090	-0.0001	-0.012	0.715	-0.073	0.716	156.47	-0.0005	24.72	1.91E-07
3	0.190	0.0001	0.010	0.715	-0.014	0.715	479.55	0.0001	455.42	3.18E-08
4	0.380	0.0006	0.099	0.713	0.259	0.711	133.13	0.0007	214.04	1.88E-08
5	0.760	0.0038	0.623	0.704	0.750	0.702	58.40	0.0009	72.46	2.43E-08
6	1.51	0.0084	1.380	0.691	1.592	0.688	50.66	0.0013	99.03	1.54E-08
7	3.00	0.0147	2.407	0.674	2.675	0.669	35.13	0.0023	145.06	7.31E-09
8	6.00	0.0279	4.581	0.636	4.911	0.631	20.94	0.0023	137.99	4.58E-09
9	12.0	0.0454	7.447	0.587	7.675	0.583	16.36	0.0031	209.35	2.36E-09
10	6.00	0.0451	7.396	0.588	7.331	0.589	70.66	-0.0005	11663.71	1.83E-10
11	1.51	0.0360	5.902	0.614	5.722	0.617	9.88	-0.0016	300.57	9.92E-10
12	3.00	0.0355	5.832	0.615	5.912	0.614	37.13	0.0008	2123.99	5.27E-10
13	6.00	0.0411	6.752	0.599	6.876	0.597	26.73	0.0012	326.10	2.47E-09
14	12.0	0.0491	8.065	0.577	8.208	0.574	15.69	0.0013	456.82	1.04E-09
15	24.0	0.0631	10.357	0.537	10.731	0.531	11.33	0.0037	523.61	6.53E-10
16	48.0	0.0818	13.426	0.485	13.782	0.479	12.73	0.0027	782.08	4.91E-10
17	96.0	0.0993	16.297	0.436	16.625	0.430	11.95	0.0027	1672.10	2.16E-10
18	48.0	0.1008	16.540	0.431	16.437	0.433	71.98	-0.0004	19745.84	1.10E-10
19	12.0	0.0909	14.918	0.459	14.798	0.461	4.52	-0.0012	2220.46	6.14E-11
20	3.00	0.0771	12.655	0.498	12.463	0.501	2.03	-0.0025	397.61	1.54E-10
21	0.760	0.0572	9.382	0.554	9.030	0.560	1.05	-0.0060	68.43	4.61E-10
22	0.190	0.0403	6.610	0.602	6.222	0.608	0.54391	-0.0094	20.57	7.98E-10
23	0.050	0.0262	4.293	0.641	3.919	0.648	0.39179	-0.0059	6.04	1.96E-09



SAMPLE INFORMATION

Boring:	JOP-B022
Sample:	ST-2A
Depth:	8.30 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL, light brown lean clay; peat noted

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.62	inch
Diameter:	2.50	inch

Initial water content:	20.8	%
Initial total unit weight:	127.1	pcf
Initial dry unit weight:	105.2	pcf
Initial void ratio:	0.590	
Initial degree of saturation:	95	%
Final water content:	19.9	%
Final total unit weight:	130.8	pcf
Final dry unit weight:	109.1	pcf
Final void ratio:	0.533	
Final degree of saturation:	100	% (assumed specific gravity = 2.68)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	10.1 (Range: 6.8 to 12.3)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.070
Compression Index (void ratio per log cycle stress):	0.111
Swell Ratio (strain per log cycle stress):	0.004
Swell Index (void ratio per log cycle stress):	0.006
Recompression Ratio (strain per log cycle stress):	0.002
Recompression Index (void ratio per log cycle stress):	0.003
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - - Unloading

Test Date: 8/25/15 Tested By: CMJ/YC Checked By: GET

AECOM Project No. 60428794-107	Dynegy CCR - Joppa	ONE DIMENSIONAL CONSOLIDATION TEST Boring: JOP-B022 Depth: 8.30 feet
TerraSense, LLC	Project No. T60428794	November 2015

PROJECT:	Dynegy CCR - Joppa					
PROJECT NO.:	T60428794	Initial height:	0.617 inch	Final height:	0.594 inch	
BORING:	JOP-B022	Initial water content:	20.8 %	Final water content:	19.9 %	
SAMPLE:	ST-2A	Initial dry density:	105.2 pcf	Final dry density:	109.1 pcf	
TEST:	C15138	Initial total density:	127.1 pcf	Final total density:	130.8 pcf	
DEPTH, feet:	8.3	Initial saturation:	95 %	Final saturation:	100 %	
BY:	CMJ/YC	Initial void ratio:	0.590	Final void ratio:	0.533	
TEST DATE:	8/25/2015			Final strain:	3.6 %	

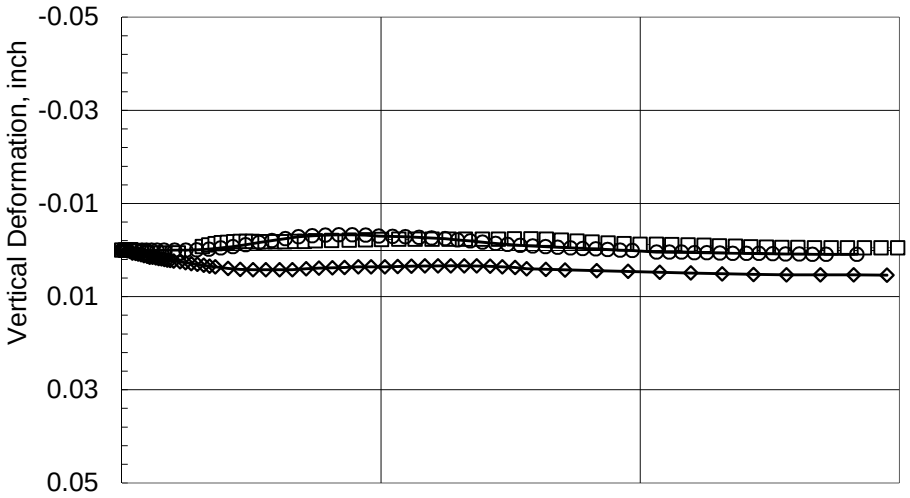
EQUIPMENT: SPECIMEN DESCRIPTION: CL, light brown lean clay; peat noted

Load Frame No.: 3

Ring Diameter: 2.5 inch

G	LL	PL	PI
2.68			

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft²/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.063	0.0009	0.148	0.588	0.138	0.588	195.27	0.0002	42.22	1.40E-07
2	0.125	0.0009	0.151	0.588	0.180	0.588	195.40	0.0002	2142.39	2.75E-09
3	0.250	0.0024	0.385	0.584	0.430	0.584	268.96	0.0003	53.33	1.52E-07
4	0.500	0.0049	0.793	0.578	0.925	0.576	94.15	0.0008	61.30	4.63E-08
5	1.00	0.0079	1.285	0.570	1.491	0.567	990.03	0.0008	101.67	2.94E-07
6	2.00	0.0120	1.941	0.560	2.183	0.556	1222.70	0.0009	152.41	2.42E-07
7	1.00	0.0137	2.216	0.555	2.107	0.557	1930.83	-0.0002	363.21	1.60E-07
8	0.250	0.0123	1.989	0.559	1.945	0.559	448.72	-0.0003	329.35	4.11E-08
9	0.500	0.0118	1.912	0.560	1.950	0.559	257.66	0.0001	325.53	2.39E-08
10	1.00	0.0124	2.009	0.558	2.045	0.558	405.82	0.0002	515.10	2.38E-08
11	2.00	0.0136	2.200	0.555	2.272	0.554	296.51	0.0003	523.36	1.71E-08
12	4.00	0.0171	2.780	0.546	3.068	0.542	696.91	0.0010	344.86	6.10E-08
13	8.00	0.0224	3.635	0.533	3.911	0.528	773.78	0.0013	467.63	4.99E-08
14	16.0	0.0307	4.983	0.511	5.354	0.505	702.91	0.0016	593.52	3.57E-08
15	32.0	0.0437	7.094	0.478	7.579	0.470	468.16	0.0023	758.05	1.86E-08
16	16.0	0.0457	7.408	0.473	7.416	0.472	184.14	-0.0002	5101.28	1.09E-09
17	4.00	0.0432	7.000	0.479	6.923	0.480	482.97	-0.0003	2941.21	4.95E-09
18	1.00	0.0402	6.526	0.487	6.331	0.490	318.23	-0.0008	632.82	1.52E-08
19	0.250	0.0375	6.085	0.494	5.762	0.499	107.69	-0.0014	170.14	1.91E-08
20	0.063	0.0346	5.617	0.501	5.133	0.509	49.72	-0.0024	40.12	3.74E-08



SAMPLE INFORMATION

Boring: JOP-010 Sample: ST-1 Depth: 0.5-2.5 feet
Type: Intact tube sample
Description: CL, brown lean clay

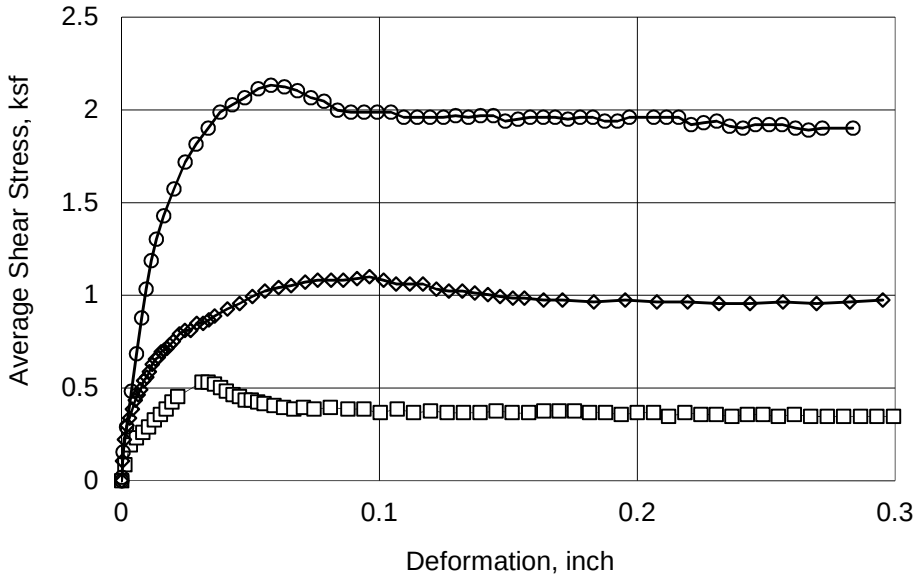
TEST INFORMATION

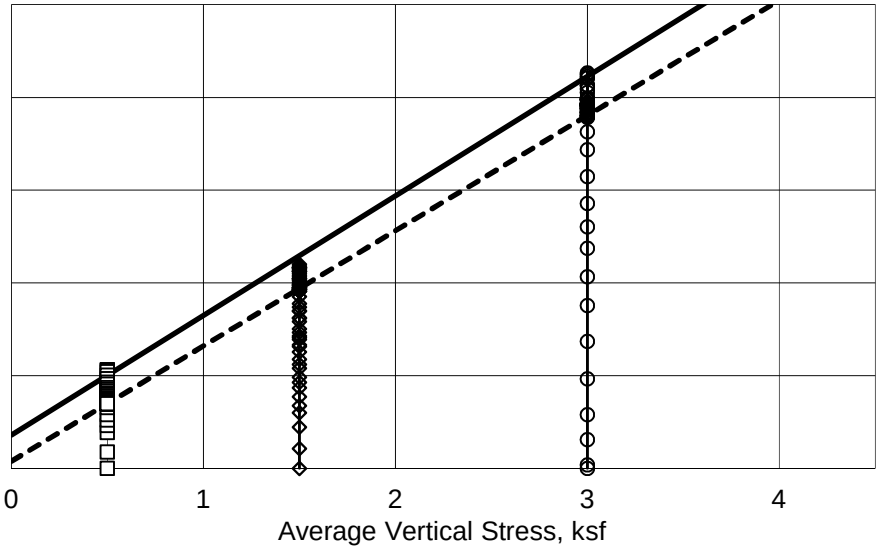
Symbol	Stage	Vertical Stress ksf	Deformation Rate inch/min.
□	6	0.5	0.0025
◊	6	1.5	0.0024
○	6	3.0	0.0020

TEST SUMMARY

Peak Effective Friction Angle: 32.8°, cohesion = 0.2ksf
Final Effective Friction Angle: 31.8°, cohesion = 0.0ksf

REMARKS:





AECOM #60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **SERIES SUMMARY** Boring: JOP-010 Sample: ST-1 Depth: 0.5-2.5	
TerraSense, LLC	T60428794		October 2015

Checked by: GET

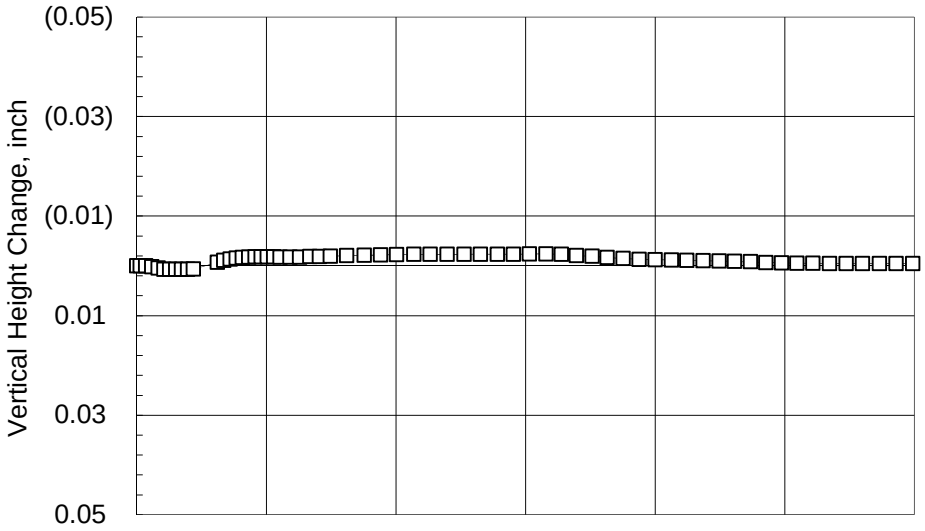
STAGED DRAINED DIRECT SHEAR TEST SERIES

Boring No	Stage No	w_o	γ_{to}	γ_{do}	$\sigma'_{v,c}$ (ksf)	Deformation rate (inch/min)	at Peak Shear Stress at High Deformation				Remarks
Sample/ Specimen		w_c (estimated) (%)	γ_{tc} (estimated) (pcf)	γ_{dc} (estimated) (pcf)	$\varepsilon_{v,c}$ (%)	t_c (days)	ΔL (inch)	τ_h (ksf)	ε_v (%)	Φ' for c'=0	
JOP-010	Stage 6	19.8	122.5	102.2	0.50	2.5E-3	0.03	0.53	-0.07	46.7	
ST-1		23.8	126.6	102.3	0.1	2.53	0.30	0.35	-0.05	34.8	
JOP-010	Stage 6	18.1	122.6	103.8	1.50	2.4E-3	0.10	1.10	0.35	36.3	
ST-1		21.2	129.5	106.9	2.9	0.15	0.30	0.97	0.52	33.0	
JOP-010	Stage 6	18.0	124.8	105.8	3.00	2.0E-3	0.06	2.13	-0.20	35.4	
ST-1		22.2	132.8	108.7	2.7	0.09	0.28	1.90	0.09	32.4	

Description of Material Tested and Remarks
CL, brown lean clay

Strength Envelope Summary			
Test Series	Failure Criterion	Φ' (degree)	c' (ksf)
1	1	32.8	0.2
	2	31.8	0.0
Failure Criterion		1. Peak shear stress 2. High deformation	

	AECOM #60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR SERIES SUMMARY**
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794	Boring: JOP-010 Sample: ST-1 Depth: 0.5-2.5 ft



SAMPLE INFORMATION

Boring: JOP-010 Sample: ST-1 Specimen: D Depth: 1.65 ft
Type: Intact tube sample

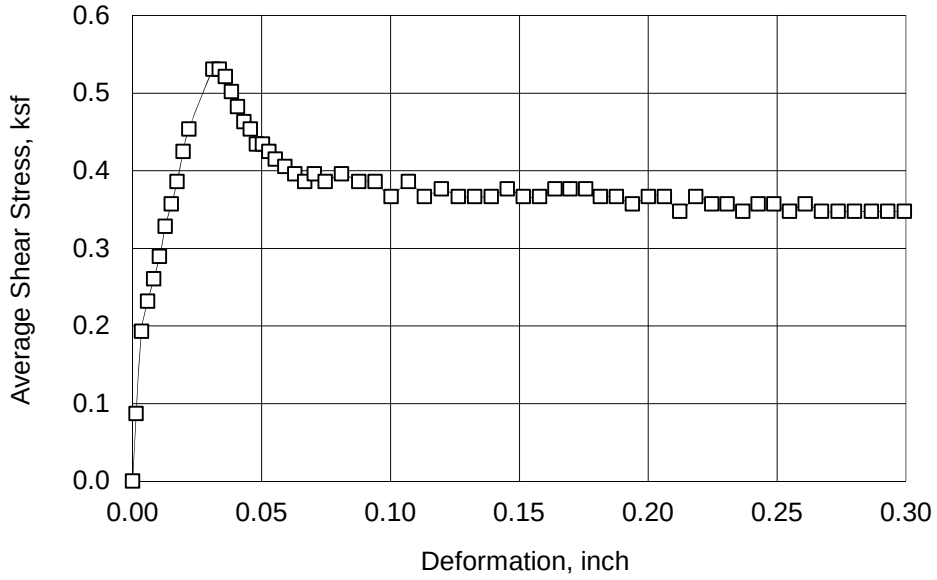
SPECIMEN INFORMATION (Initial)

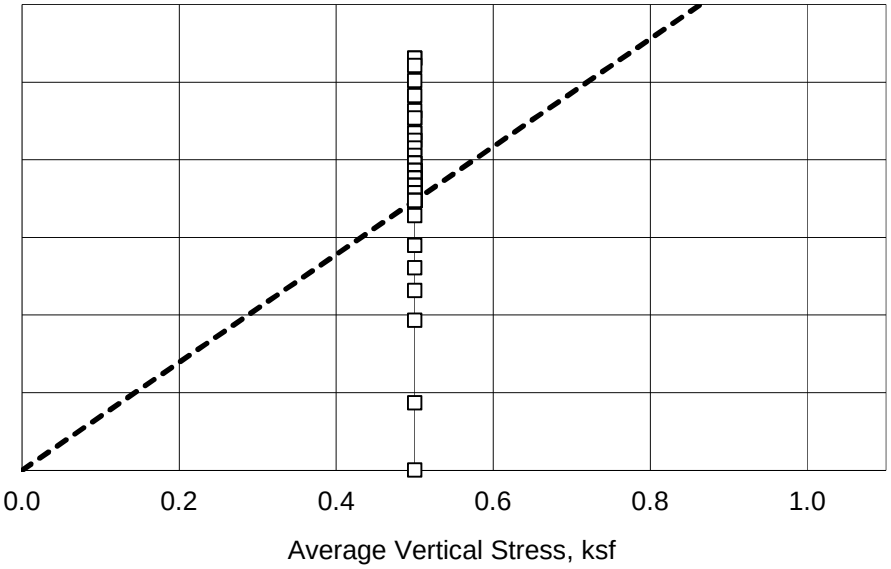
Description: CL, brown lean clay
Height: 1.01 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 19.8 % Dry Unit Weight: 102.2 pcf

TEST SUMMARY

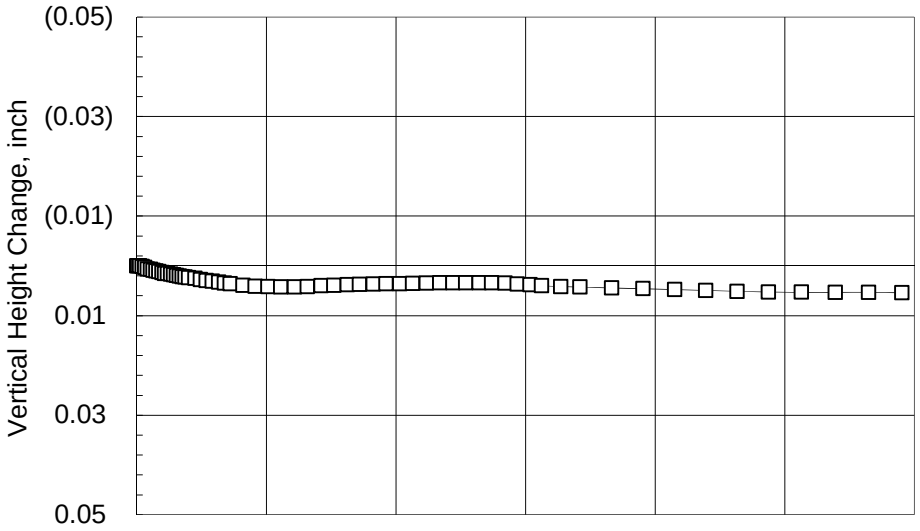
Vertical Consolidation Stress: 0.50 ksf
Water Content: 23.8 % Dry Unit Weight: 102.3 pcf
Deformation Rate: 0.00246 inch/min.
Peak Shear Strength: 0.53 ksf @ 0.03 inch deformation
Peak Effective Friction Angle: 46.7°, cohesion = 0.0ksf
Final Shear Strength: 0.35 ksf @ 0.30 inch deformation
Final Effective Friction Angle: 34.8° (Shown)

REMARKS:





	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY**	
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794	Boring: JOP-010 Sample: ST-1 Specimen: D Depth: 1.65 ft	October 15



SAMPLE INFORMATION

Boring: JOP-010 Sample: ST-1 Specimen: E Depth: 1.9 ft
Type: Intact tube sample

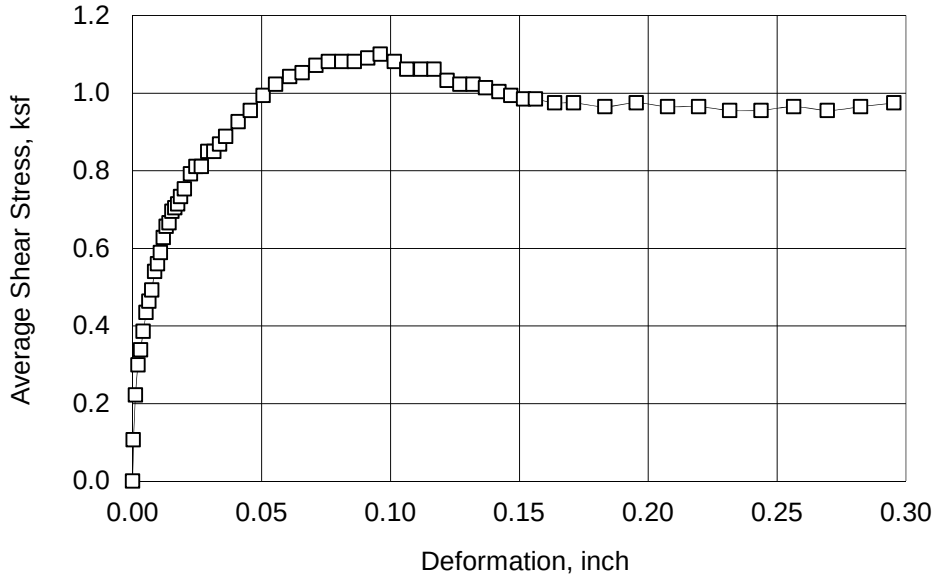
SPECIMEN INFORMATION (Initial)

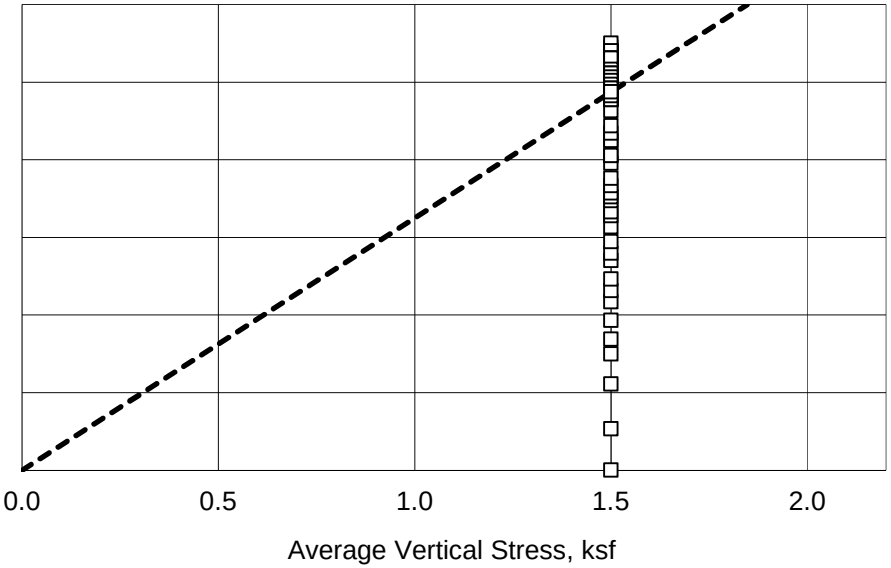
Description: CL, brown lean clay
Height: 1.03 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 18.1 % Dry Unit Weight: 103.8 pcf

TEST SUMMARY

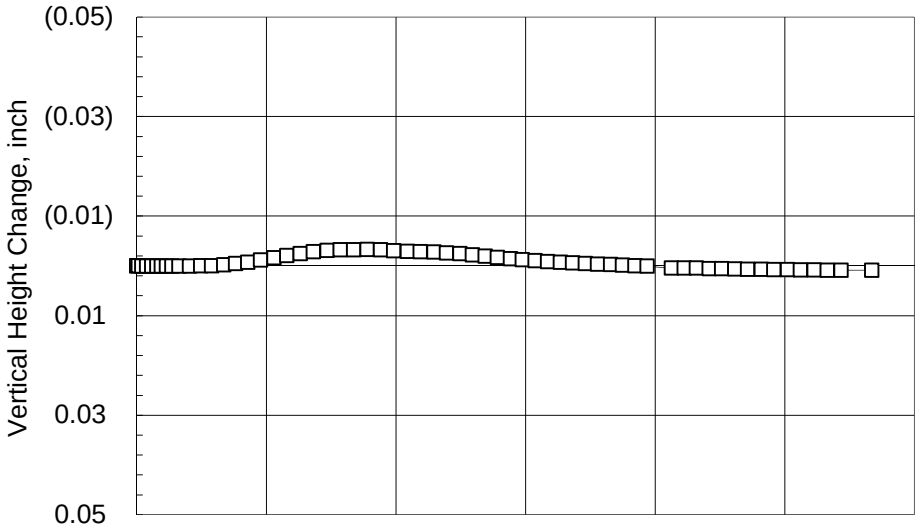
Vertical Consolidation Stress: 1.50 ksf
Water Content: 21.2 % Dry Unit Weight: 106.9 pcf
Deformation Rate: 0.00245 inch/min.
Peak Shear Strength: 1.10 ksf @ 0.10 inch deformation
Peak Effective Friction Angle: 36.3°, cohesion = 0.0ksf
Final Shear Strength: 0.97 ksf @ 0.30 inch deformation
Final Effective Friction Angle: 33.0° (Shown)

REMARKS:





	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY**	
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794	Boring: JOP-010 Sample: ST-1 Specimen: E Depth: 1.9 ft	October 15



SAMPLE INFORMATION

Boring: JOP-010 Sample: ST-1 Specimen: F Depth: 2.2 ft
Type: Intact tube sample

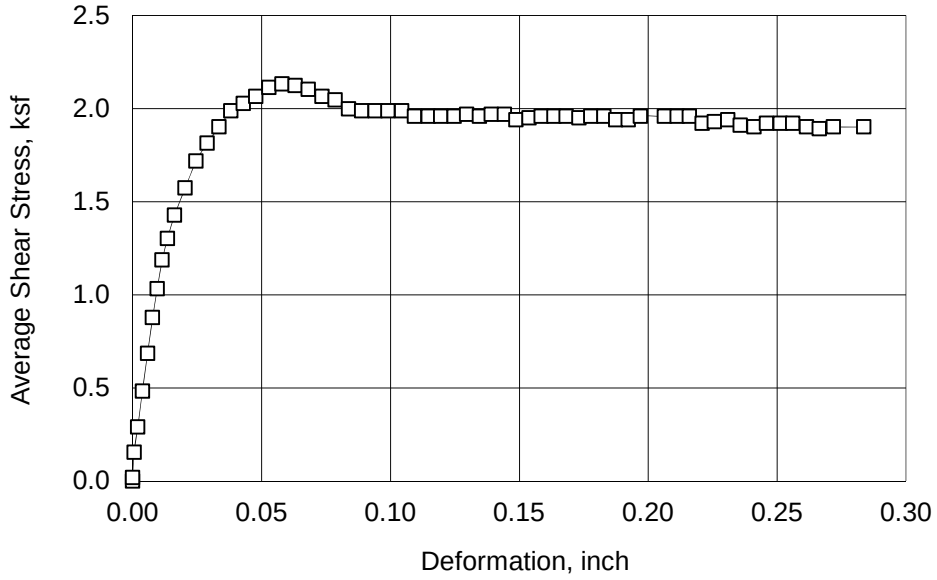
SPECIMEN INFORMATION (Initial)

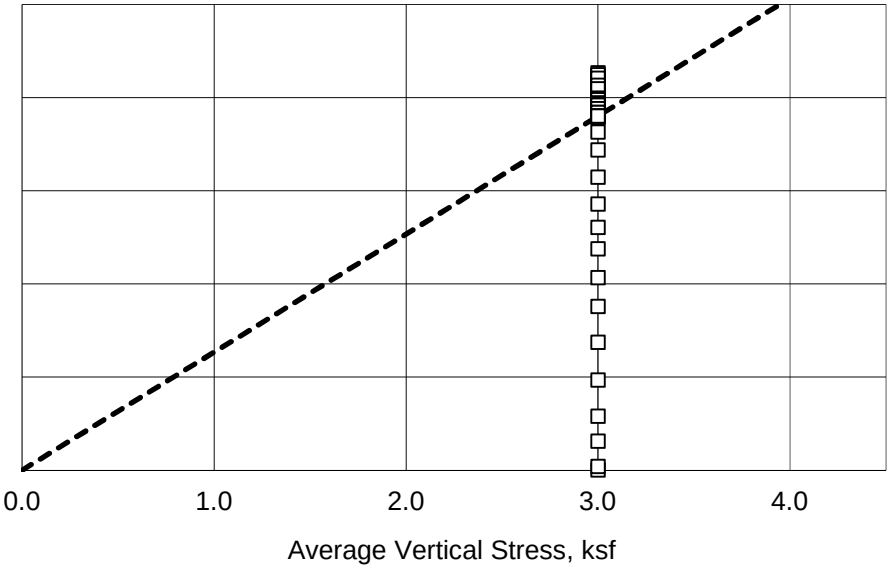
Description: CL, brown lean clay
Height: 1.03 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 18.0 % Dry Unit Weight: 105.8 pcf

TEST SUMMARY

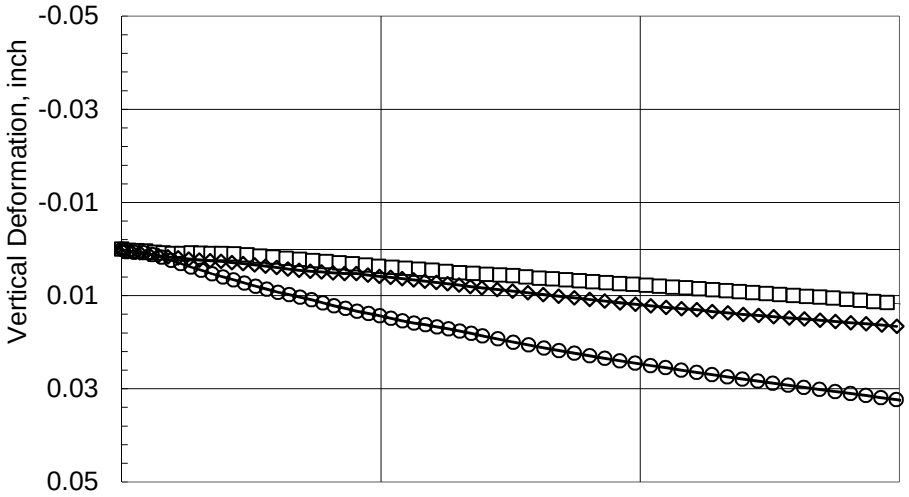
Vertical Consolidation Stress: 3.00 ksf
Water Content: 22.2 % Dry Unit Weight: 108.7 pcf
Deformation Rate: 0.00204 inch/min.
Peak Shear Strength: 2.13 ksf @ 0.06 inch deformation
Peak Effective Friction Angle: 35.4°, cohesion = 0.0ksf
Final Shear Strength: 1.90 ksf @ 0.28 inch deformation
Final Effective Friction Angle: 32.4° (Shown)

REMARKS:





	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY**	
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794	Boring: JOP-010 Sample: ST-1 Specimen: F Depth: 2.2 ft	October 15



SAMPLE INFORMATION

Boring: JOP-B016 Sample: ST-3 Depth: 23-25 feet
Type: Intact tube sample
Description: CL, Brown lean clay

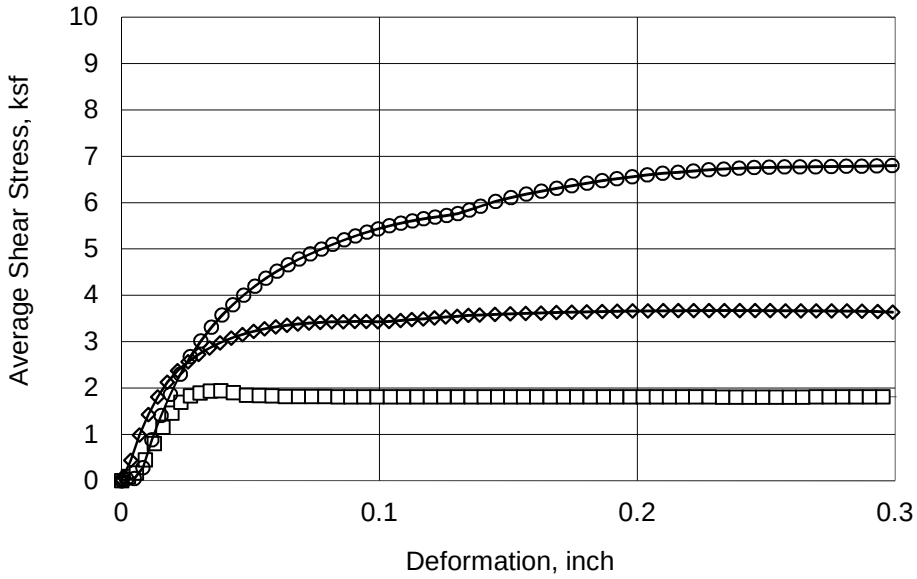
TEST INFORMATION

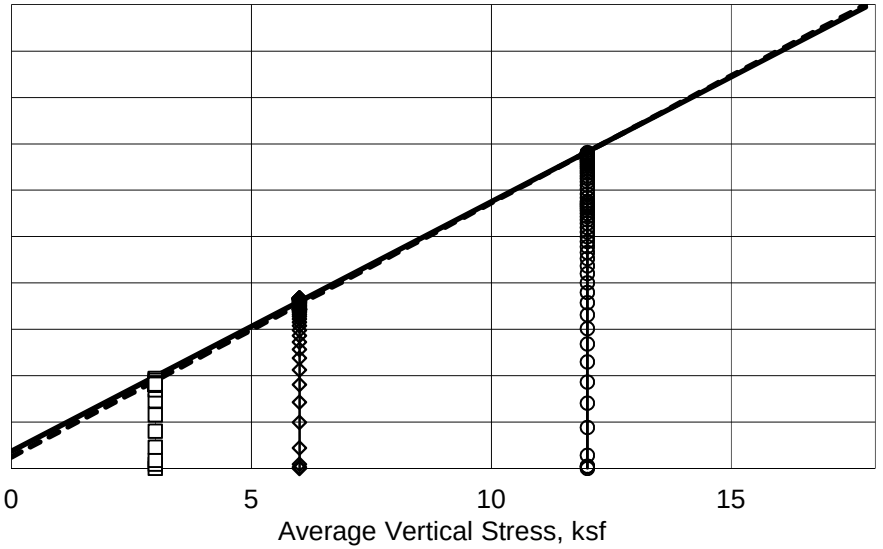
Symbol	Stage	Vertical Stress ksf	Deformation Rate inch/min.
□	6	3.0	0.0003
◊	6	6.0	0.0003
○	6	12.0	0.0003

TEST SUMMARY

Peak Effective Friction Angle: 28.3°, cohesion = 0.4ksf
Final Effective Friction Angle: 28.7°, cohesion = 0.2ksf

REMARKS:





Prepared by: MHC Checked by: GET	AECOM #60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **SERIES SUMMARY**	
	TerraSense, LLC	T60428794	Boring: JOP-B016 Sample: ST-3 Depth: 23-25	October 2015

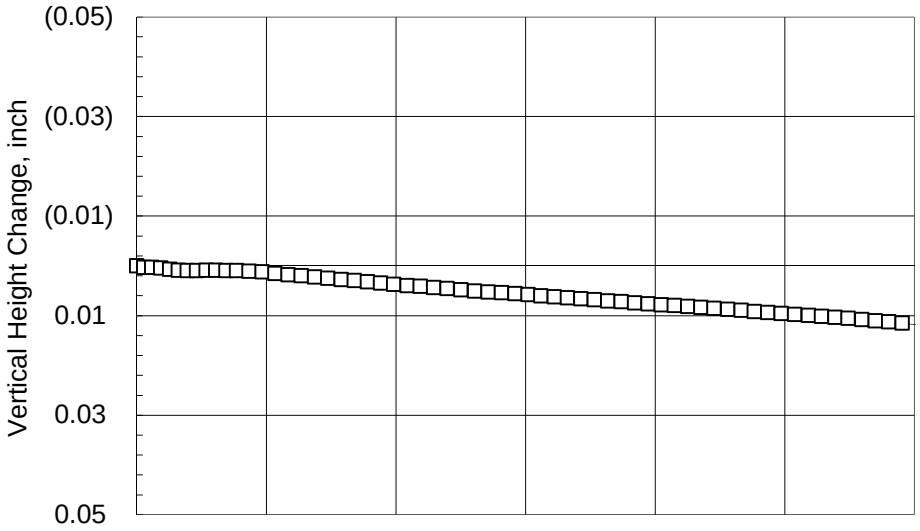
STAGED DRAINED DIRECT SHEAR TEST SERIES

Boring No / Sample / Specimen	Stage No	w_o / w_c (estimated) (%)	γ_{to} / γ_{tc} (estimated) (pcf)	γ_{do} / γ_{dc} (estimated) (pcf)	$\sigma'_{v,c}$ (ksf) / $\varepsilon_{v,c}$ (%)	Deformation rate (inch/min) / t_c (days)	at Peak Shear Stress at High Deformation: ΔL (inch)	τ_h (ksf)	ε_v (%)	Φ' for c'=0	Remarks
JOP-B016	Stage 6	19.1	129.1	108.4	3.00	2.8E-4	0.04	1.94	0.10	32.9	
ST-3					1.9	0.04	0.28	1.81	1.10	31.1	
JOP-B016	Stage 6	17.6	127.5	108.4	6.00	2.8E-4	0.22	3.67	1.29	31.5	
ST-3					3.3	0.05	0.28	3.66	1.57	31.4	
JOP-B016	Stage 6	18.2	129.2	109.3	12.00	2.9E-4	0.30	6.81	3.27	29.6	
ST-3					3.6	0.06	0.29	6.78	3.13	29.5	

Description of Material Tested and Remarks
CL, Brown lean clay

Strength Envelope Summary			
Test Series	Failure Criterion	Φ' (degree)	c' (ksf)
1	1	28.3	0.4
	2	28.7	0.2
Failure Criterion		1. Peak shear stress 2. High deformation	

	AECOM #60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR SERIES SUMMARY**
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794	Boring: JOP-B016 Sample: ST-3 Depth: 23-25 ft



SAMPLE INFORMATION

Boring: JOP-B016 Sample: ST-3 Specimen: C Depth: 24.15 ft
Type: Intact tube sample

SPECIMEN INFORMATION (Initial)

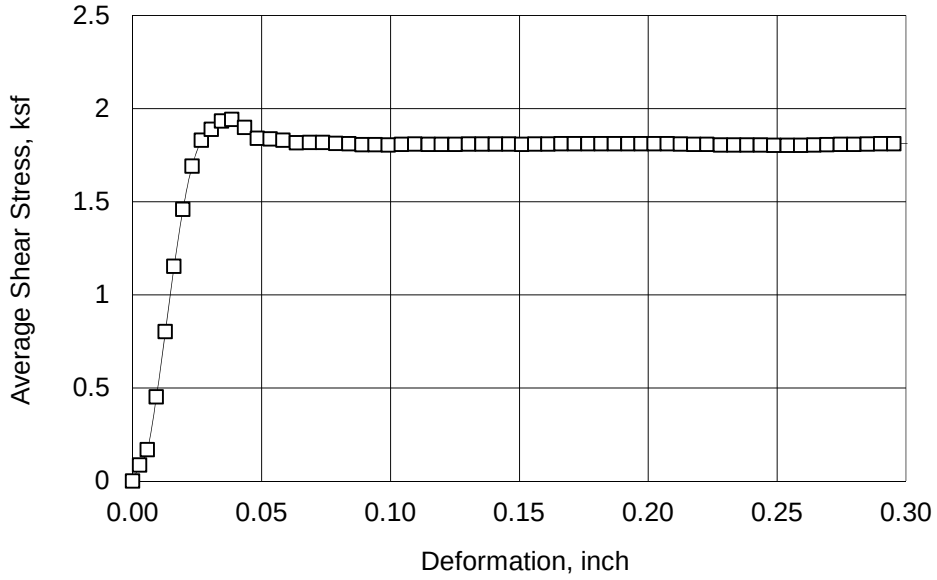
Description: CL, Brown lean clay
Height: 1.50 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 19.1 % Dry Unit Weight: 108.4 pcf

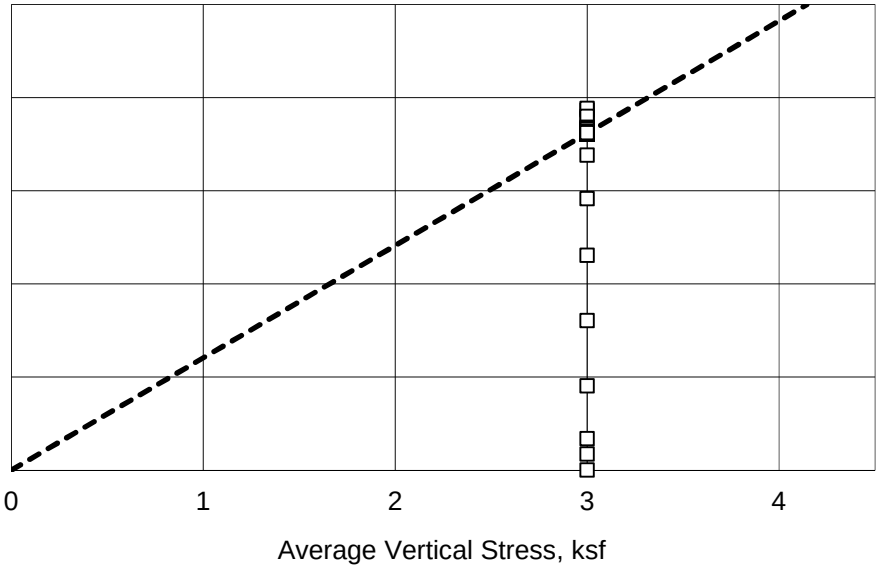
TEST SUMMARY

Vertical Consolidation Stress: 3.00 ksf

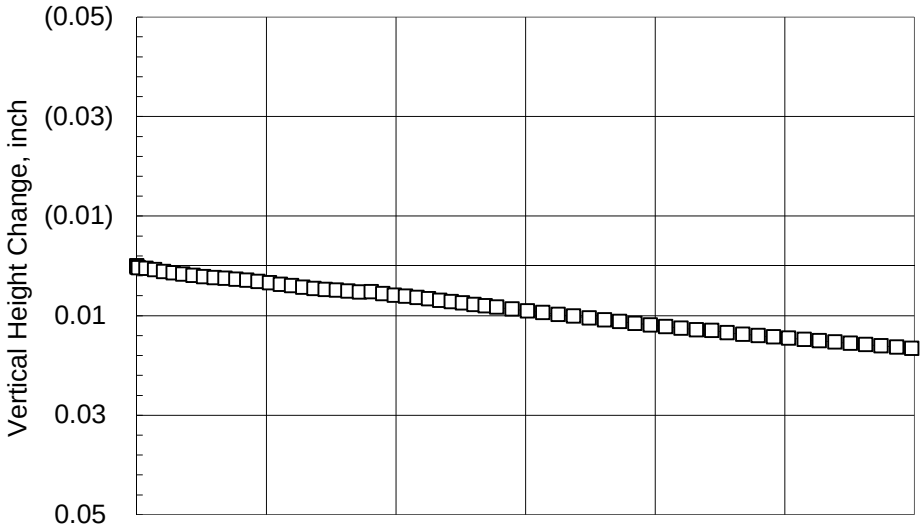
Deformation Rate: 0.00028 inch/min.
Peak Shear Strength: 1.94 ksf @ 0.04 inch deformation
Peak Effective Friction Angle: 32.9°, cohesion = 0.0 ksf
Final Shear Strength: 1.81 ksf @ 0.28 inch deformation
Final Effective Friction Angle: 31.1° (Shown)

REMARKS:





	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY**	
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794	Boring: JOP-B016 Sample: ST-3 Specimen: C Depth: 24.15 ft	October 15



SAMPLE INFORMATION

Boring: JOP-B016 Sample: ST-3 Specimen: E Depth: 24.5 ft
Type: Intact tube sample

SPECIMEN INFORMATION (Initial)

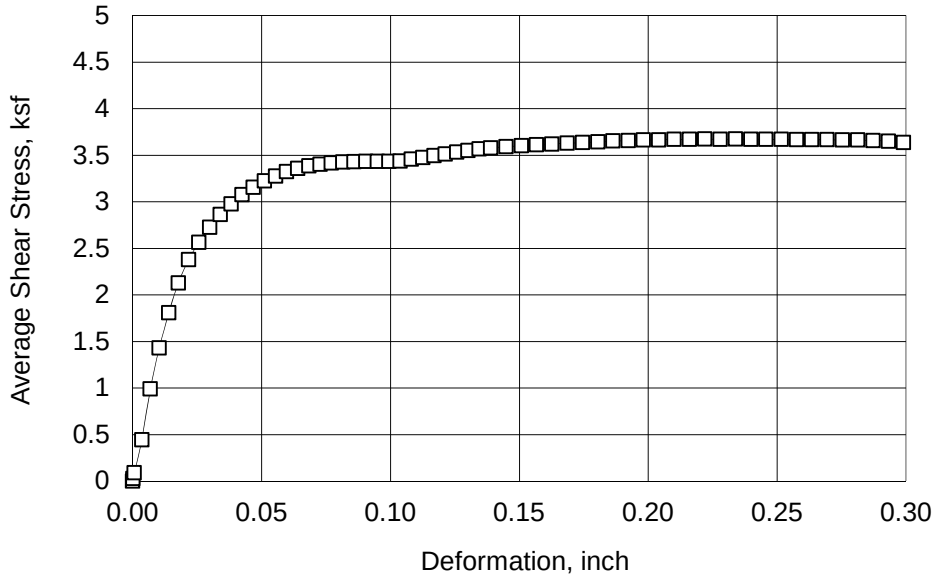
Description: CL, Brown lean clay
Height: 1.51 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 17.6 % Dry Unit Weight: 108.4 pcf

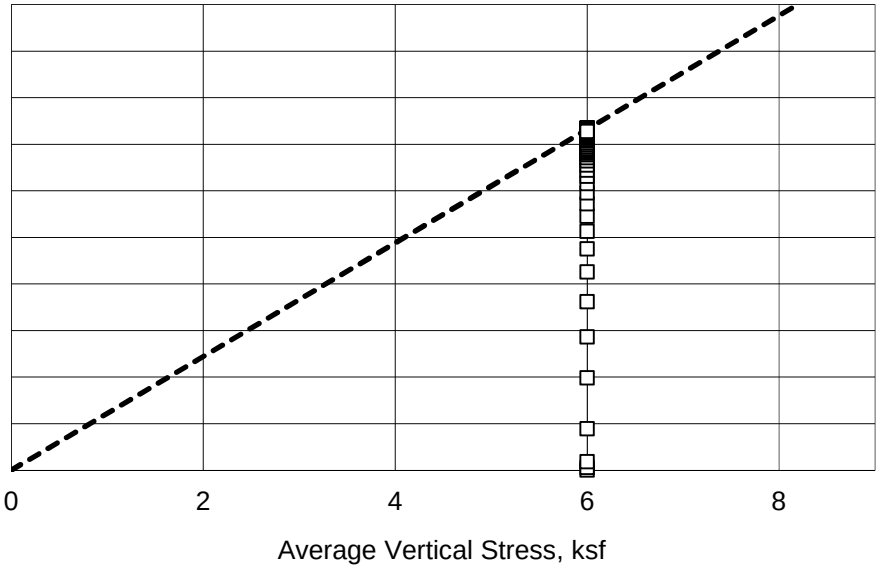
TEST SUMMARY

Vertical Consolidation Stress: 6.00 ksf

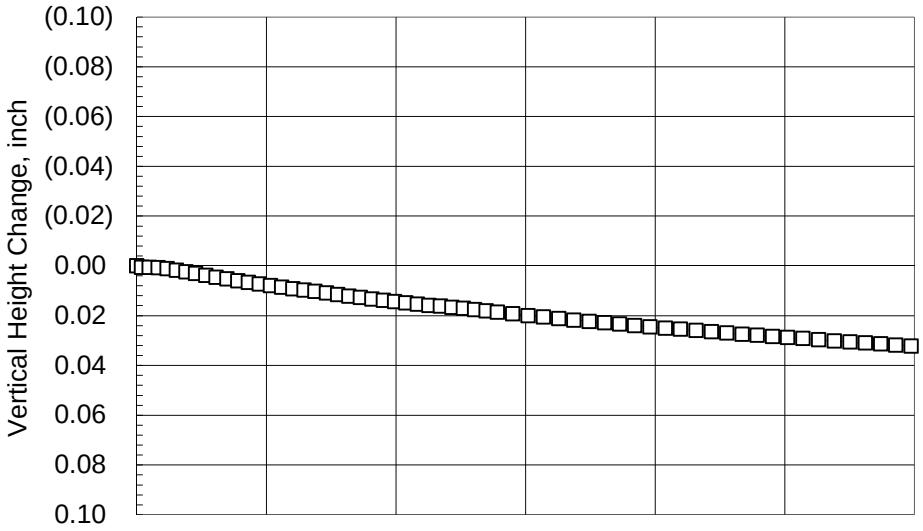
Deformation Rate: 0.00028 inch/min.
Peak Shear Strength: 3.67 ksf @ 0.22 inch deformation
Peak Effective Friction Angle: 31.5°, cohesion = 0.0 ksf
Final Shear Strength: 3.66 ksf @ 0.28 inch deformation
Final Effective Friction Angle: 31.4° (Shown)

REMARKS:





	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY**	
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794	Boring: JOP-B016 Sample: ST-3 Specimen: E Depth: 24.5 ft	October 15



SAMPLE INFORMATION

Boring: JOP-B016 Sample: ST-3 Specimen: E Depth: 24.8 ft
Type: Intact tube sample

SPECIMEN INFORMATION (Initial)

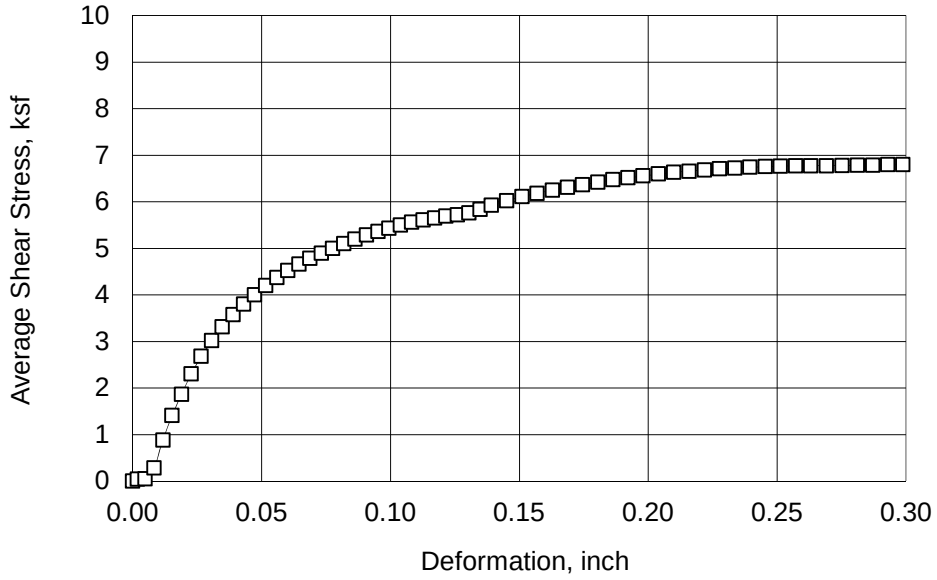
Description: CL, Brown lean clay
Height: 1.51 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 18.2 % Dry Unit Weight: 109.3 pcf

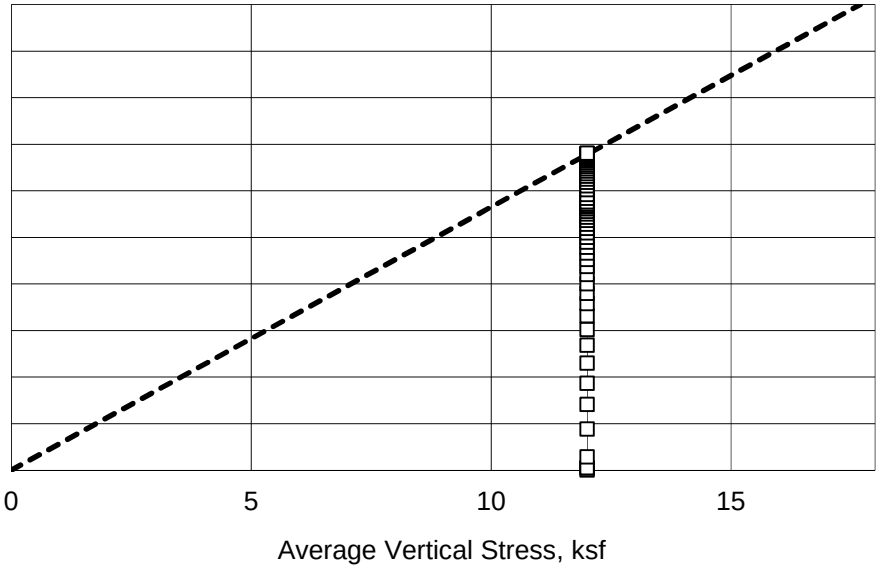
TEST SUMMARY

Vertical Consolidation Stress: 12.00 ksf

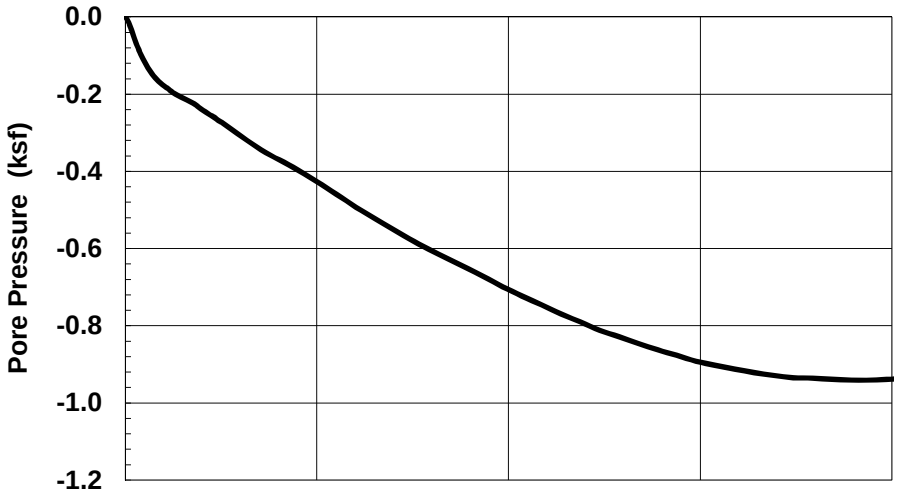
Deformation Rate: 0.00029 inch/min.
Peak Shear Strength: 6.81 ksf @ 0.30 inch deformation
Peak Effective Friction Angle: 29.6°, cohesion = 0.0 ksf
Final Shear Strength: 6.78 ksf @ 0.29 inch deformation
Final Effective Friction Angle: 29.5° (Shown)

REMARKS:





Prepared by: MHC Checked by: GET	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY**	
	TerraSense, LLC	T60428794	Boring: JOP-B016 Sample: ST-3 Specimen: E Depth: 24.8 ft	October 15



SAMPLE INFORMATION

Boring: JOP-B007 Sample: ST-2 Depth: 10.1 feet
Type: Intact tube sample
Description: CL, gray clay with brown sand textured mottles

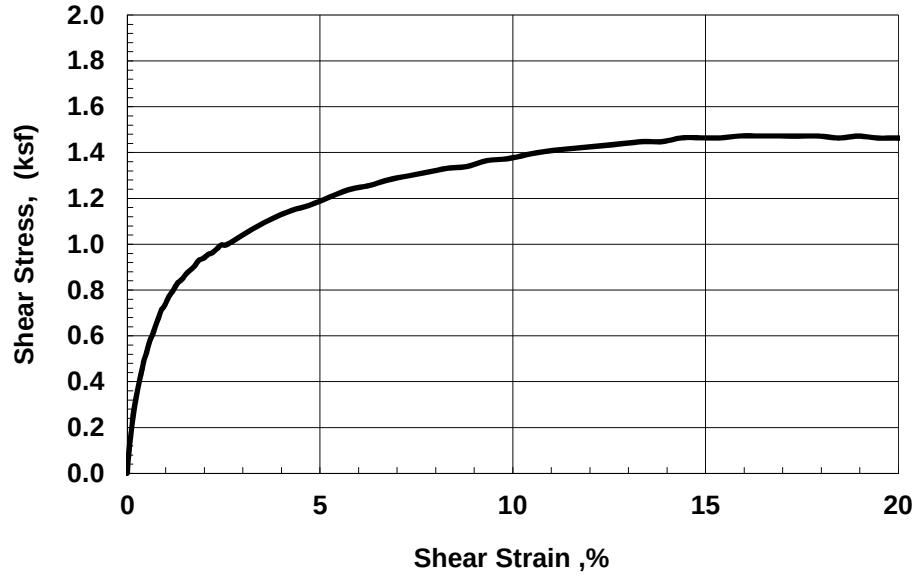
SPECIMEN INFORMATION (Initial)

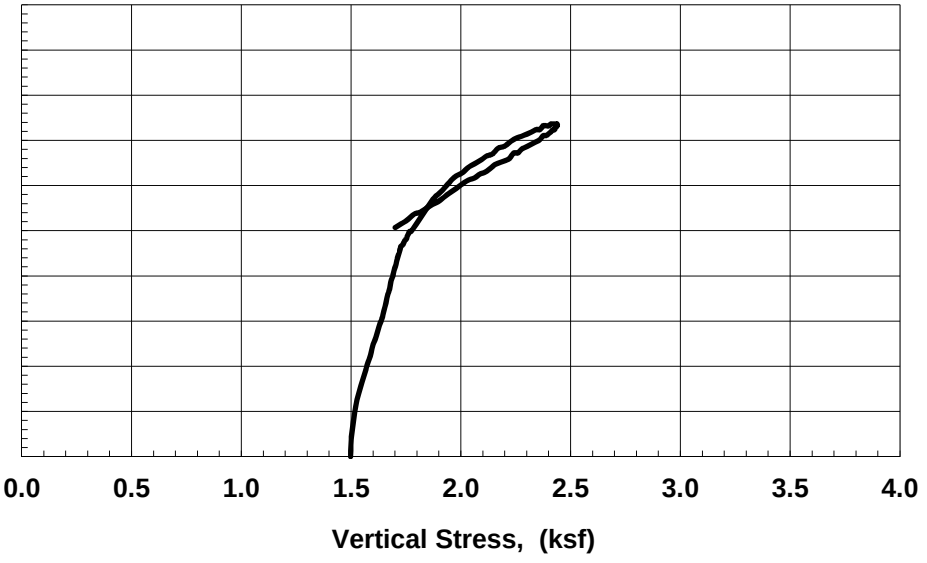
Height: 0.76 Diameter: 2.63 inch Area: 5.43 in²
Water Content: 20.6 % Total Unit Weight: 117.0 pcf

TEST SUMMARY

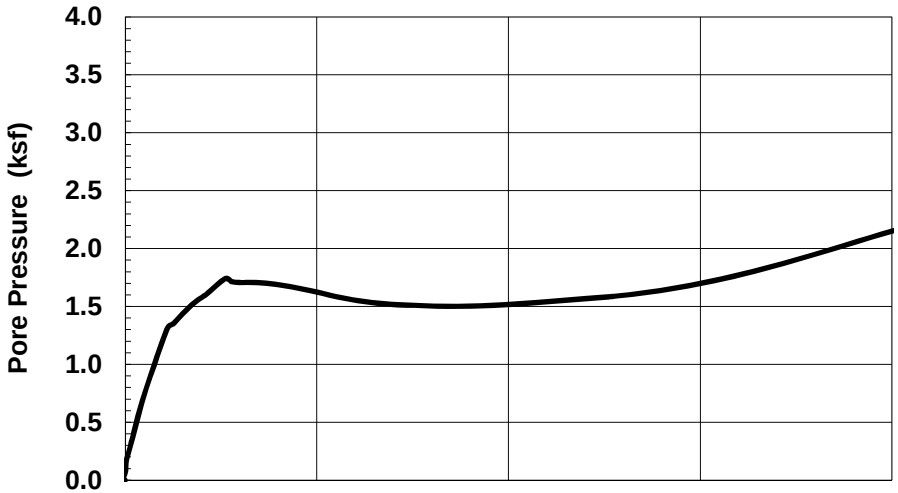
Vertical Consolidation Stress: 1.50 ksf OCR = 1.0
Water Content: 18.7 % Total Unit Weight: 120.6 pcf
Peak Shear Strength: 1.47 ksf @ 15.9 % Strain
Strain Rate: 0.063 %/min

REMARKS:





Test by: G. Thomas	Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa	CONSTANT VOLUME DIRECT SIMPLE SHEAR Boring: JOP-B007 Sample: ST-2 Depth: 10.1 feet	
Checked by: GET	**TerraSense, LLC**			October-15



SAMPLE INFORMATION

Boring: JOP-009 Sample: ST-11 Depth: 49.85 feet
Type: Intact tube sample
Description: CL, brown clay
LL = 37 PL = 15 PI = 22

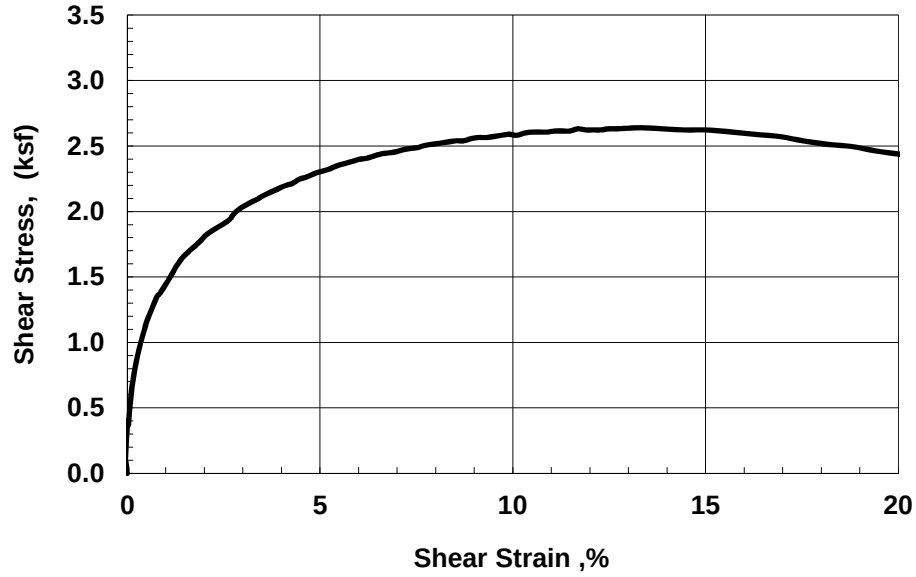
SPECIMEN INFORMATION (Initial)

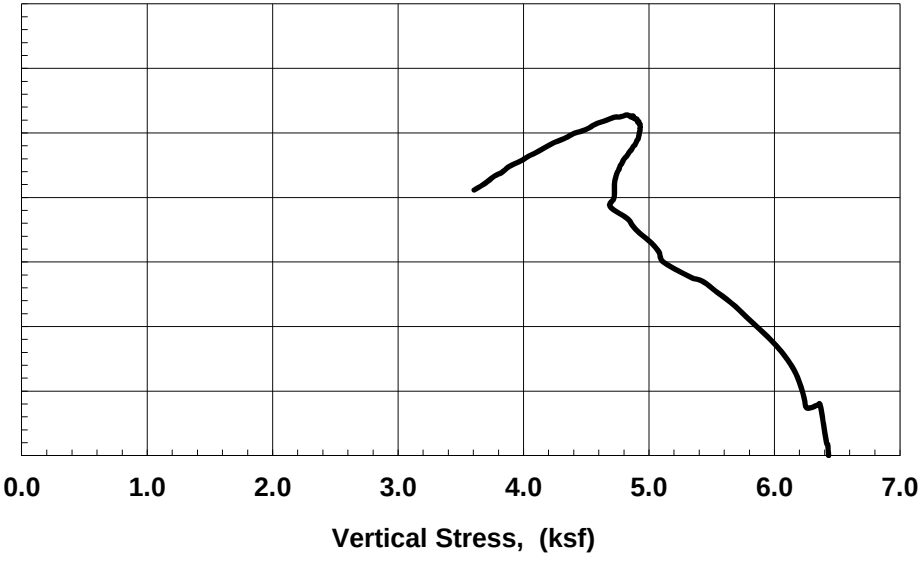
Height: 0.72 Diameter: 2.63 inch Area: 5.42 in²
Water Content: 20.1 % Total Unit Weight: 127.9 pcf

TEST SUMMARY

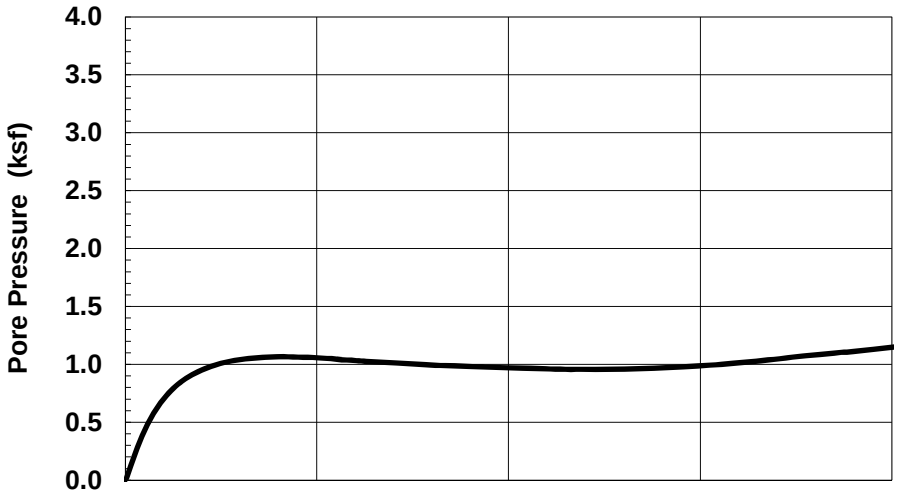
Vertical Consolidation Stress: 6.44 ksf OCR = 1.0
Water Content: 18.4 % Total Unit Weight: 131.2 pcf
Peak Shear Strength: 2.64 ksf @ 13.3 % Strain
Strain Rate: 0.051 %/min

REMARKS:





Test by: D. Tso	Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa	CONSTANT VOLUME DIRECT SIMPLE SHEAR Boring: JOP-009 Sample: ST-11 Depth: 49.85 feet	October-15
Checked by: GET	**TerraSense, LLC**			



SAMPLE INFORMATION

Boring: JOP-010 Sample: ST-3 Depth: 34.35 feet
Type: Intact tube sample
Description: CL, mottled gray and brown sandy clay

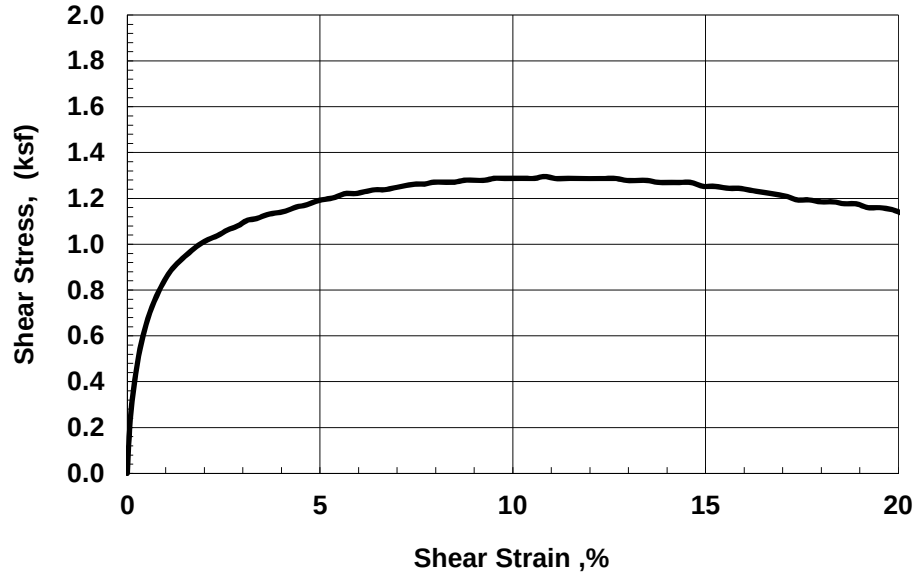
SPECIMEN INFORMATION (Initial)

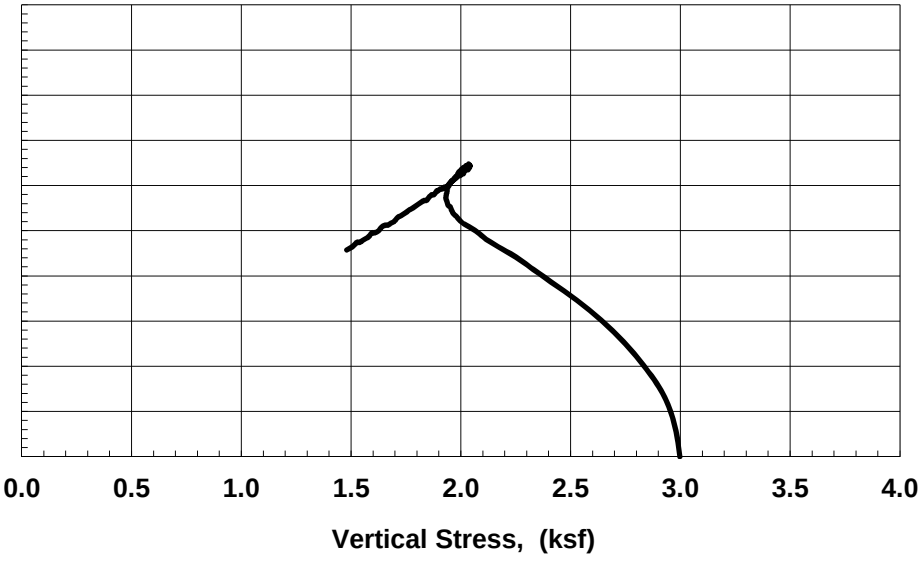
Height: 0.77 Diameter: 2.63 inch Area: 5.43 in²
Water Content: 15.8 % Total Unit Weight: 120.3 pcf

TEST SUMMARY

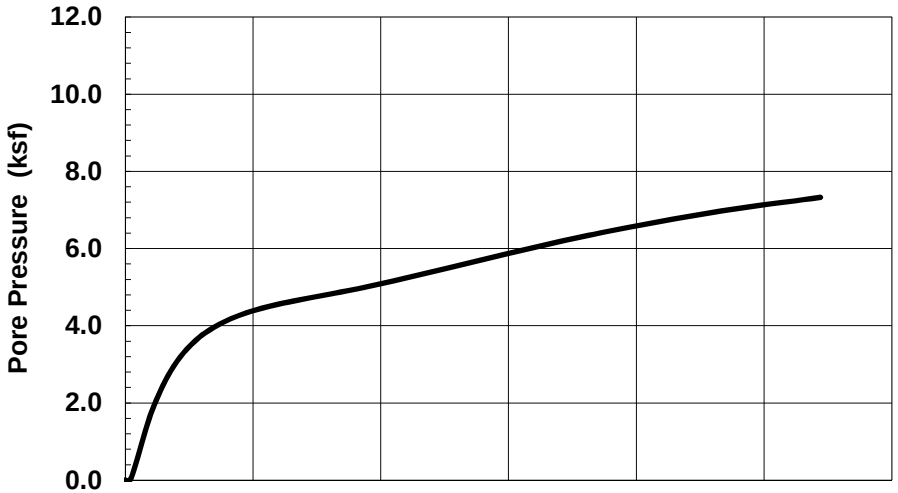
Vertical Consolidation Stress: 3.00 ksf OCR = 1.0
Water Content: 10.4 % Total Unit Weight: 126.3 pcf
Peak Shear Strength: 1.30 ksf @ 10.8 % Strain
Strain Rate: 0.066 %/min

REMARKS:





Test by: G. Thomas	Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa	CONSTANT VOLUME DIRECT SIMPLE SHEAR Boring: JOP-010 Sample: ST-3 Depth: 34.35 feet	October-15
Checked by: GET	**TerraSense, LLC**			



SAMPLE INFORMATION

Boring: JOP-011 Sample: ST-14 Depth: 69.8 feet
Type: Intact tube sample
Description: SC, beige clayey sand
LL = 34 PL = 11 PI = 23

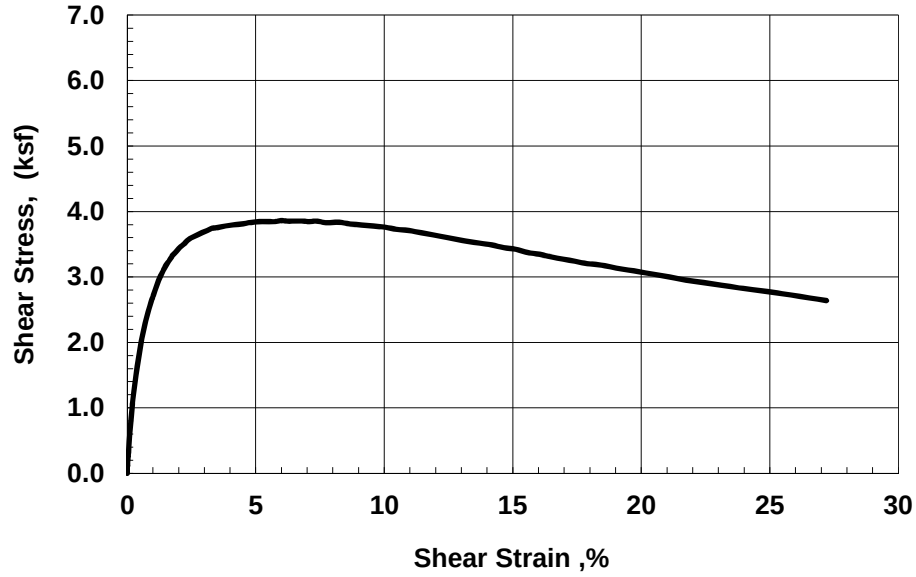
SPECIMEN INFORMATION (Initial)

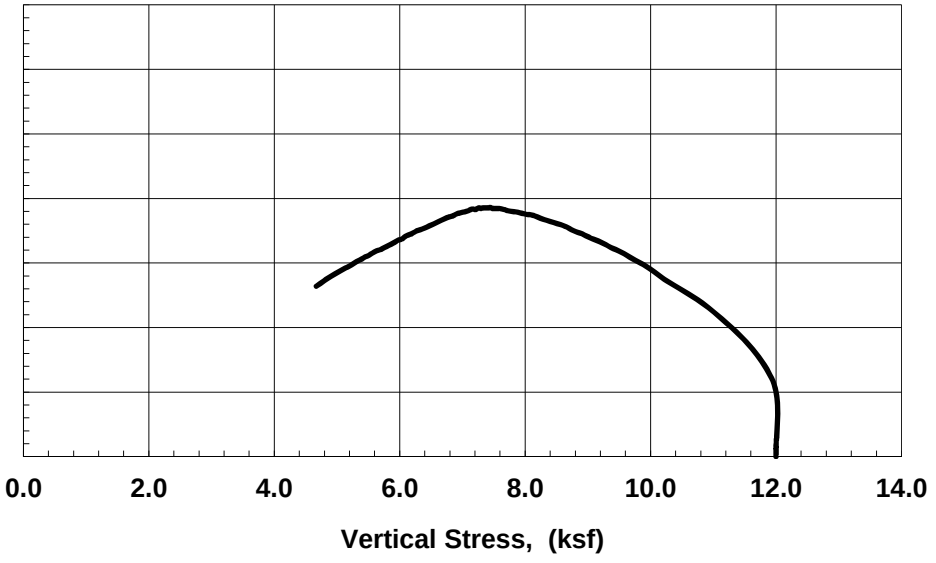
Height: 0.71 Diameter: 2.63 inch Area: 5.42 in²
Water Content: 16.4 % Total Unit Weight: 130.2 pcf

TEST SUMMARY

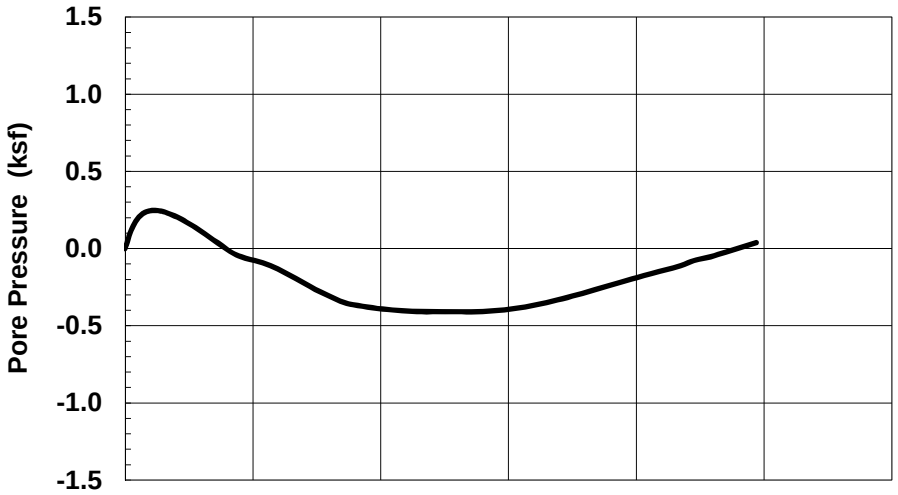
Vertical Consolidation Stress: 12.00 ksf OCR = 1.0
Water Content: 12.6 % Total Unit Weight: 141.3 pcf
Peak Shear Strength: 3.86 ksf @ 6.0 % Strain
Strain Rate: 0.066 %/min

REMARKS:





Test by: D. Tso	Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa	CONSTANT VOLUME DIRECT SIMPLE SHEAR Boring: JOP-011 Sample: ST-14 Depth: 69.8 feet	
Checked by: GET	**TerraSense, LLC**			October-15



SAMPLE INFORMATION

Boring: JOP-014 Sample: ST-2 Depth: 10.3 feet
Type: Intact tube sample
Description: CL, light brown clay
LL = 33 PL = 20 PI = 13

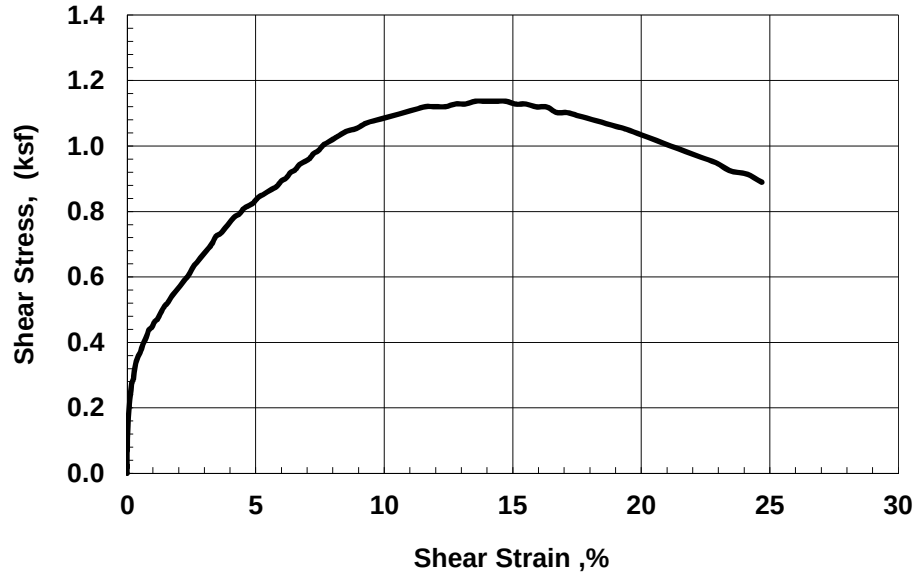
SPECIMEN INFORMATION (Initial)

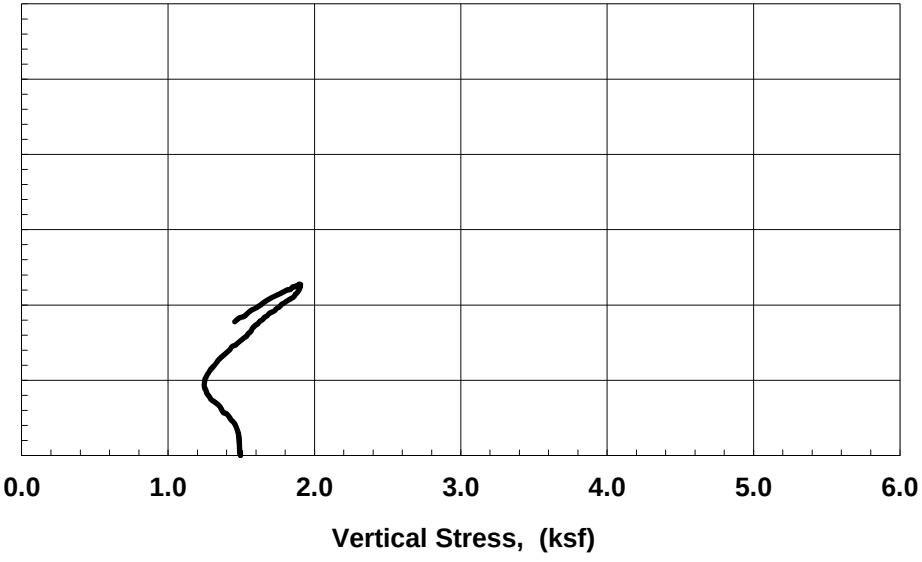
Height: 0.72 Diameter: 2.62 inch Area: 5.40 in²
Water Content: 21.5 % Total Unit Weight: 126.8 pcf

TEST SUMMARY

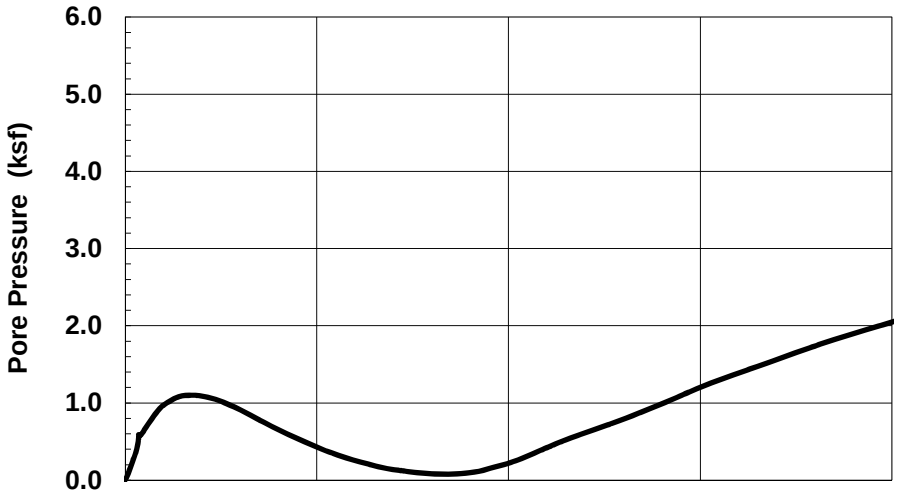
Vertical Consolidation Stress: 1.50 ksf OCR = 1.0
Water Content: 21.5 % Total Unit Weight: 127.5 pcf
Peak Shear Strength: 1.14 ksf @ 13.5 % Strain
Strain Rate: 0.062 %/min

REMARKS:





Test by: D. Tso	Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa	CONSTANT VOLUME DIRECT SIMPLE SHEAR Boring: JOP-014 Sample: ST-2 Depth: 10.3 feet
Checked by: GET	**TerraSense, LLC**		October-15



SAMPLE INFORMATION

Boring: JOP-016 Sample: ST-4 Depth: 44.6 feet
Type: Intact tube sample
Description: CL, pinkish clay with sand texture
LL = 27 PL = 17 PI = 10

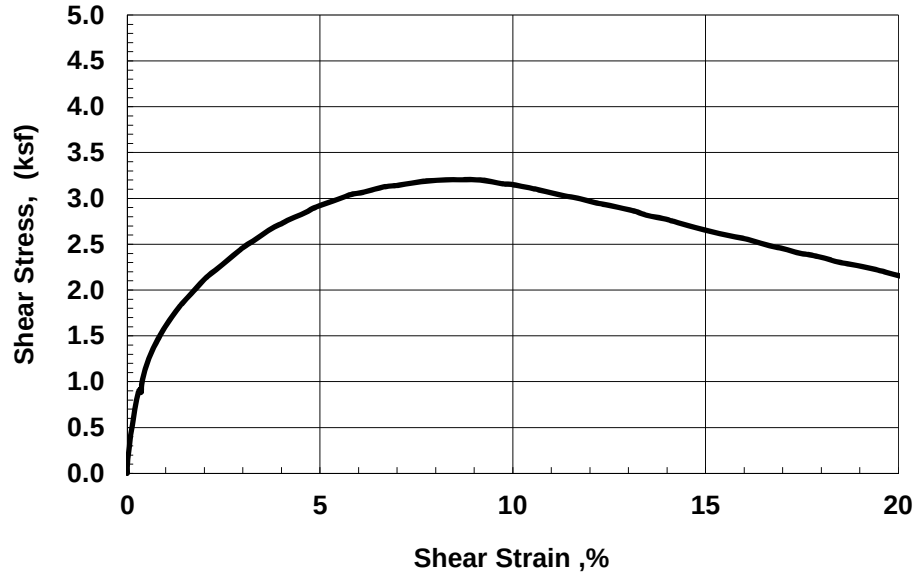
SPECIMEN INFORMATION (Initial)

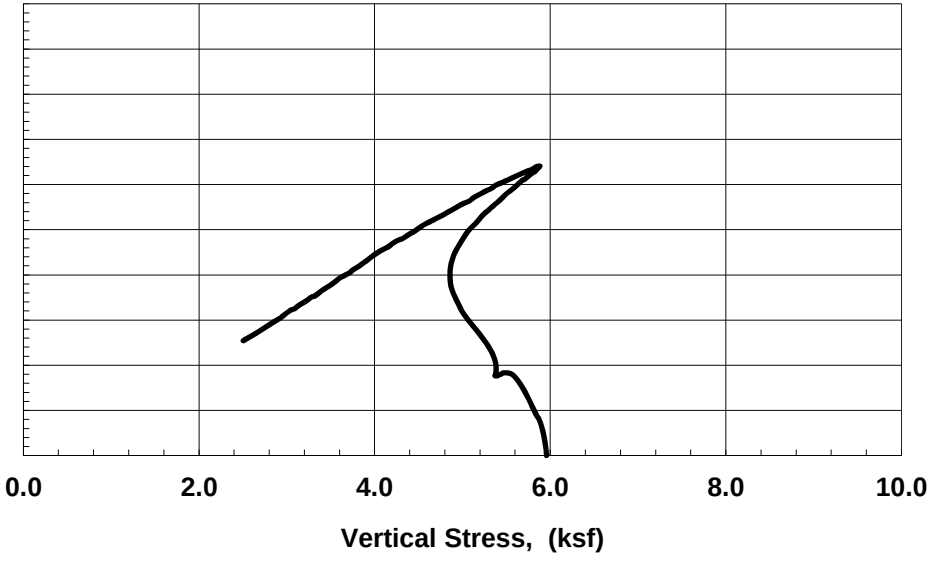
Height: 0.72 Diameter: 2.62 inch Area: 5.39 in²
Water Content: 18.1 % Total Unit Weight: 129.2 pcf

TEST SUMMARY

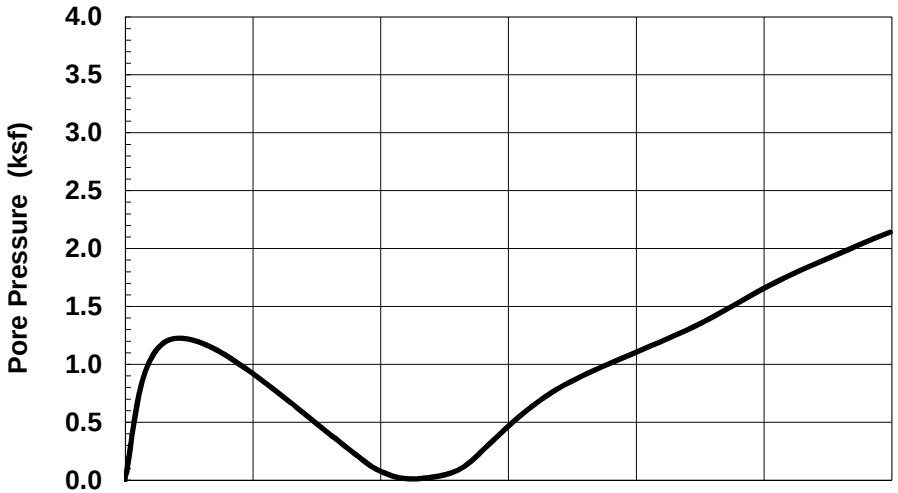
Vertical Consolidation Stress: 5.97 ksf OCR = 1.0
Water Content: 17.2 % Total Unit Weight: 130.7 pcf
Peak Shear Strength: 3.20 ksf @ 8.3 % Strain
Strain Rate: 0.063 %/min

REMARKS:





Test by: G. Thomas	Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa	CONSTANT VOLUME DIRECT SIMPLE SHEAR Boring: JOP-016 Sample: ST-4 Depth: 44.6 feet	
Checked by: GET	**TerraSense, LLC**			October-15



SAMPLE INFORMATION

Boring: JOP-019 Sample: ST-2 Depth: 43.25 feet
Type: Intact tube sample
Description: ML, gray silt with sand(flyash)

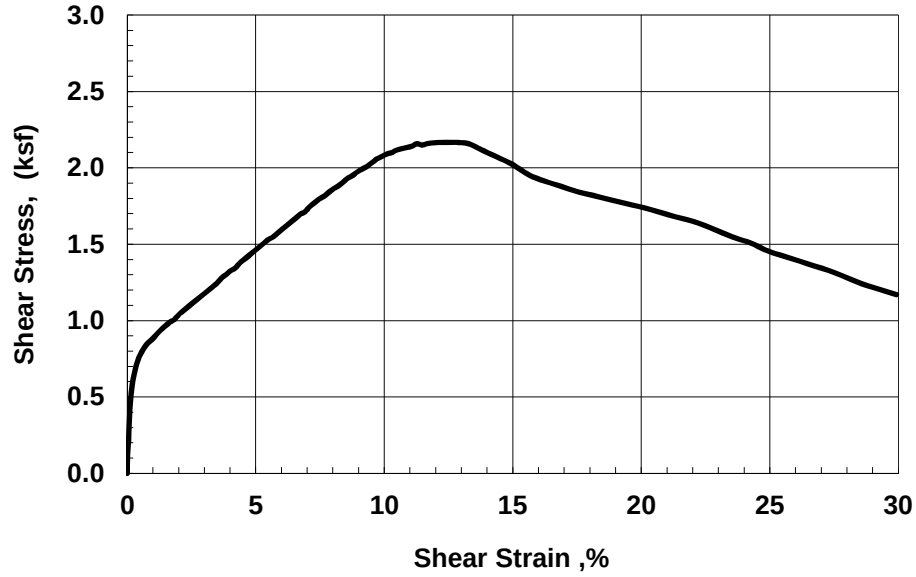
SPECIMEN INFORMATION (Initial)

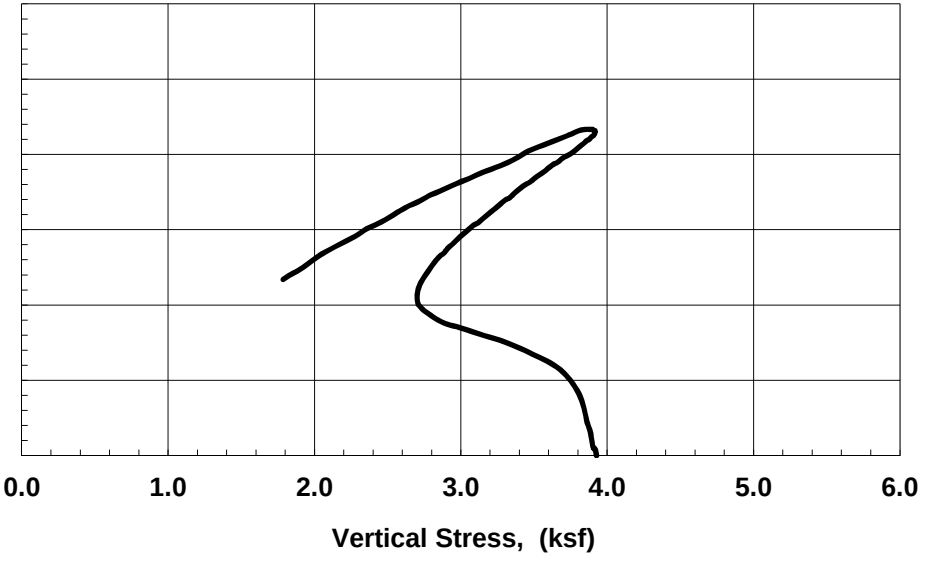
Height: 0.72 Diameter: 2.63 inch Area: 5.41 in²
Water Content: 41.8 % Total Unit Weight: 109.6 pcf

TEST SUMMARY

Vertical Consolidation Stress: 3.93 ksf OCR = 1.0
Water Content: 41.4 % Total Unit Weight: 112.6 pcf
Peak Shear Strength: 2.17 ksf @ 12.1 % Strain
Strain Rate: 0.065 %/min

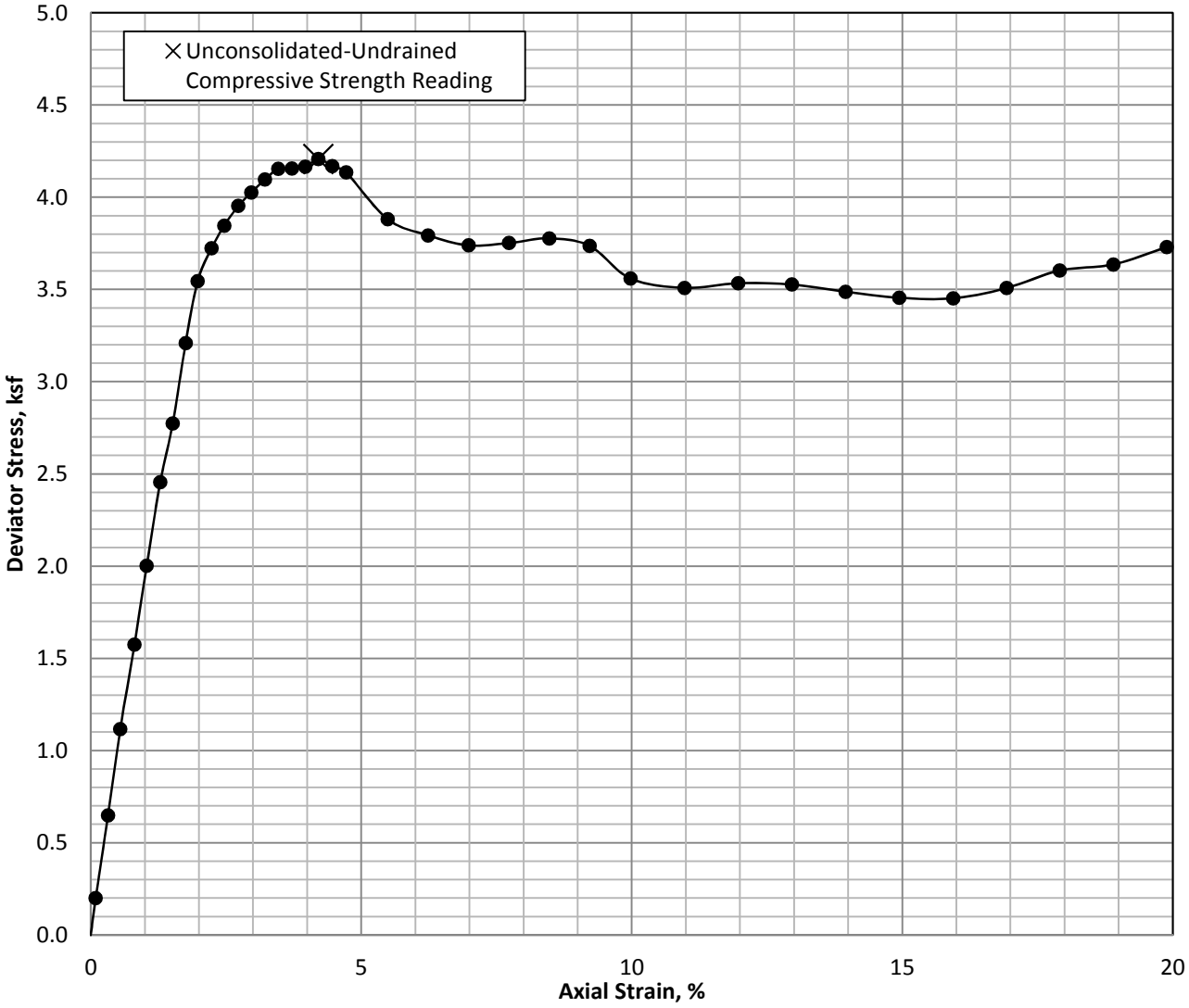
REMARKS:





Test by: D. Tso	Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa	CONSTANT VOLUME DIRECT SIMPLE SHEAR Boring: JOP-019 Sample: ST-2 Depth: 43.25 feet	
Checked by: GET	**TerraSense, LLC**			October-15

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

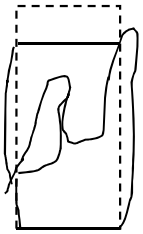
Sample Type: Intact tube sample

Description and/or Classification: CL, gray brown lean clay

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	21.1	123.6	102.1	0.59	92.9	6.003	2.872	2.1			2.60
0.5	21.1	123.7	102.1	0.59	93.0	6.002	2.871	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
4.21	2.105	4.2	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

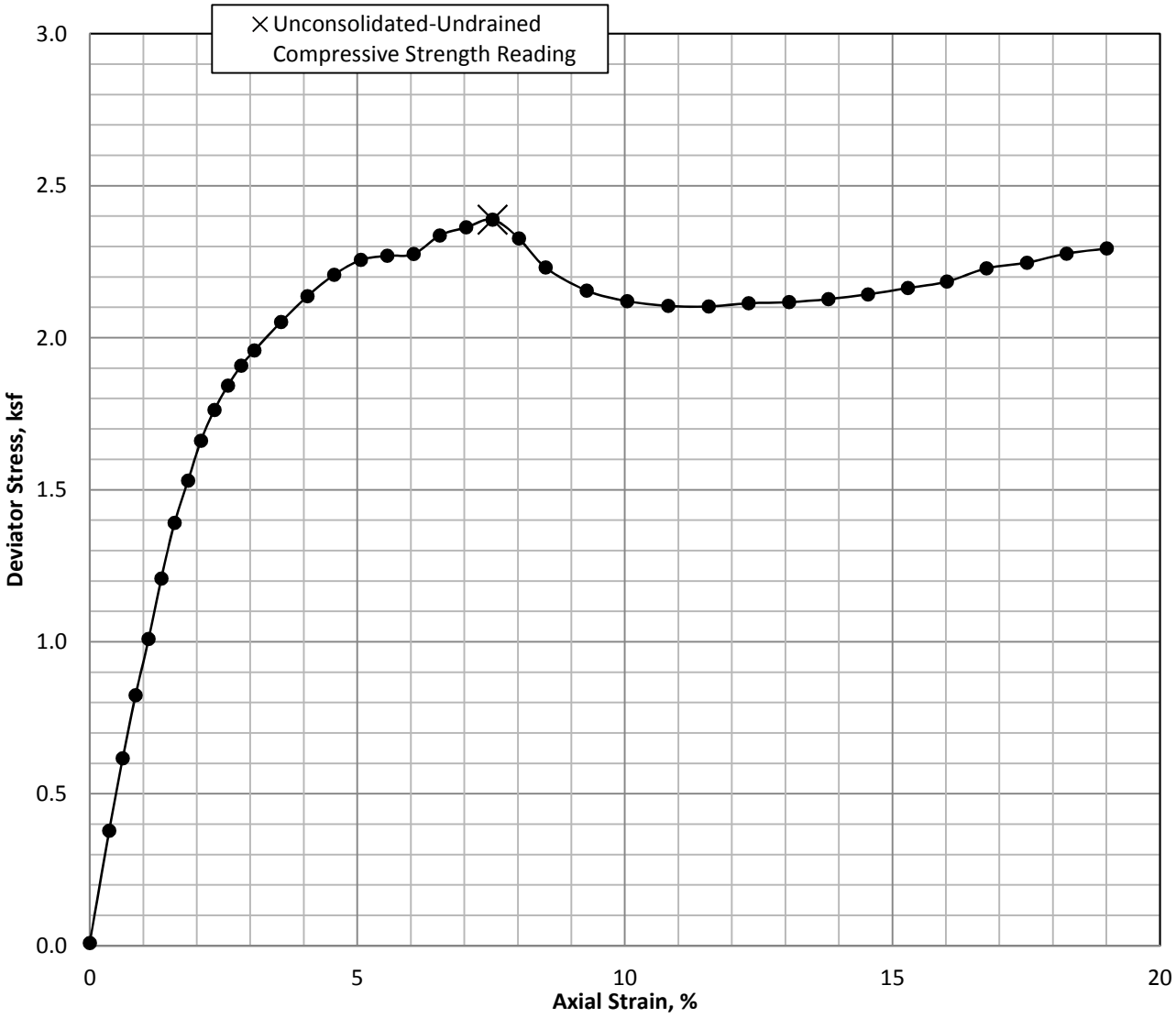
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/9/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B001 Sample: ST-1** **Section: C Depth: 5.00 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

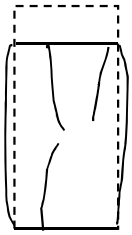
Sample Type: Intact tube sample

Description and/or Classification: CL, brown lean clay

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	24.3	123.0	98.9	0.65	98.1	5.968	2.846	2.1			2.61
3.0	24.3	123.6	99.4	0.64	99.5	5.957	2.841	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
2.39	1.195	7.5	0.75



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

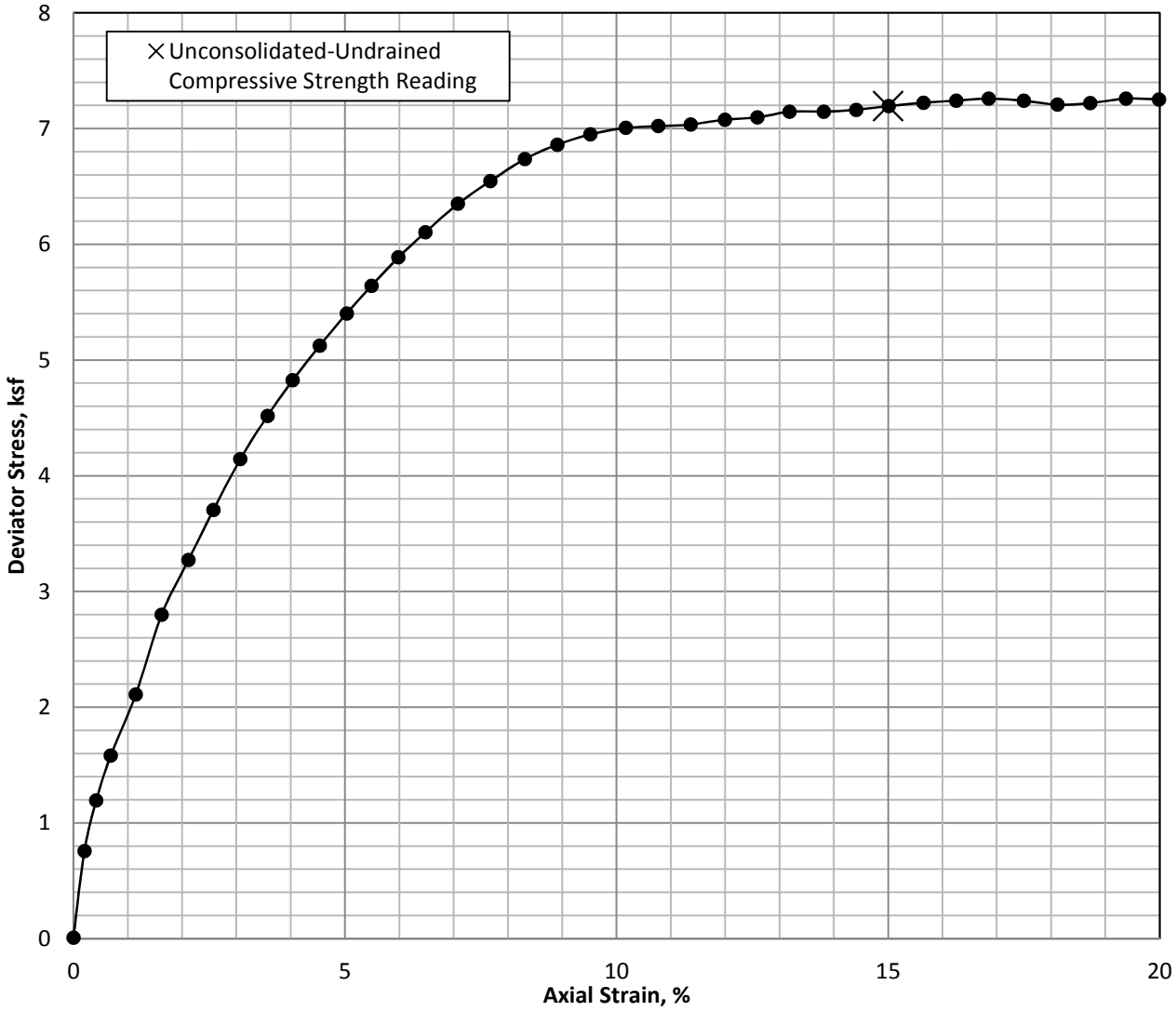
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 10/8/2015 Review Date: 10/12/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B002 Sample: ST-2** **Section: B Depth: 9.2 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

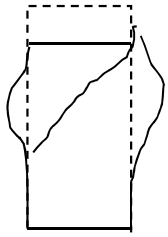
Sample Type: Intact tube sample

Description and/or Classification: CL, brown lean clay

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	15.7	134.8	116.6	0.42	98.1	6.050	2.865	2.1			2.66
1.5	15.7	135.5	117.1	0.42	99.8	6.040	2.860	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
7.19	3.595	15.0	0.73



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

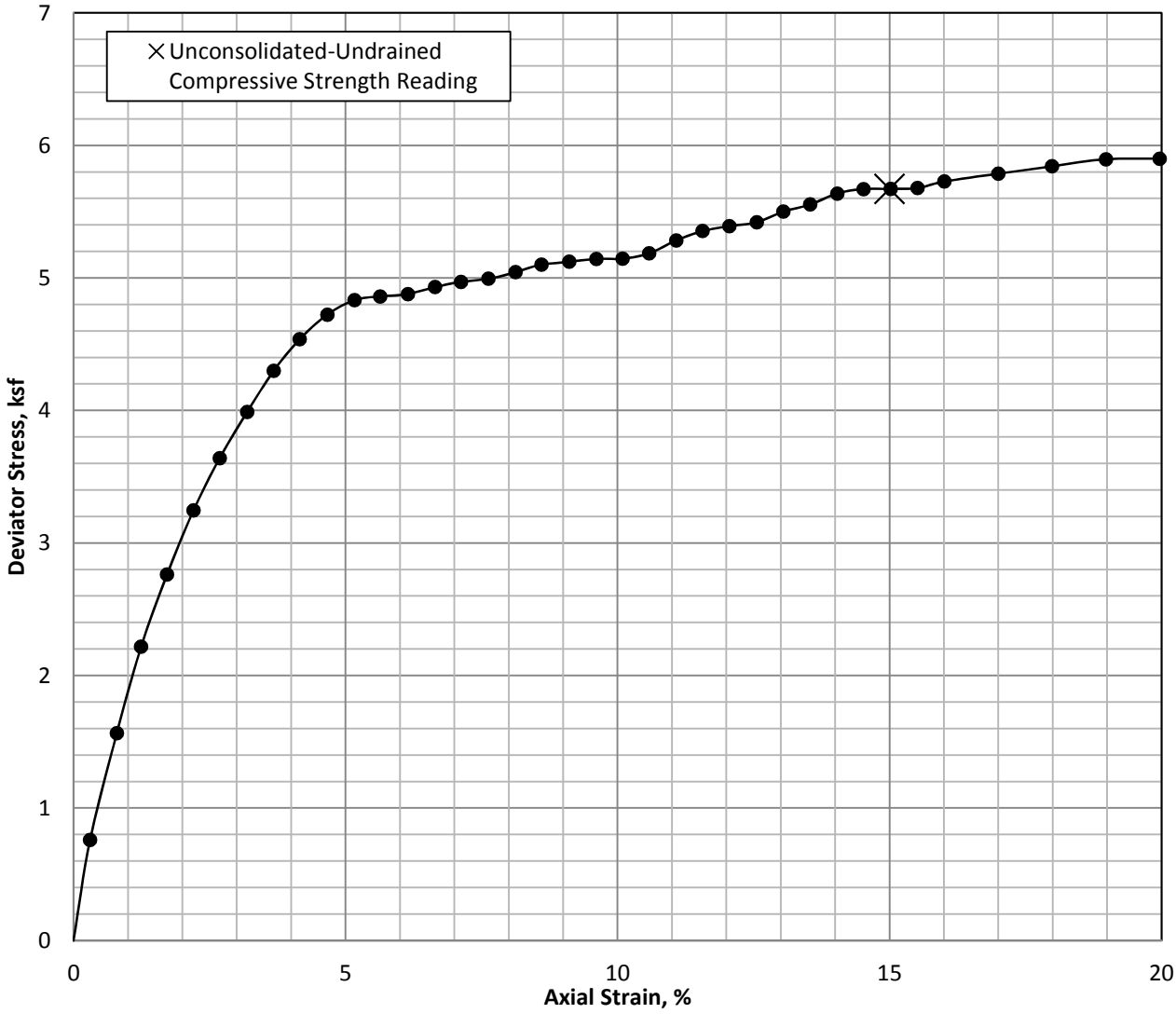
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 8/24/2015 Review Date: 9/2/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B004 Sample: ST-10 Section: B Depth: 49.15 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

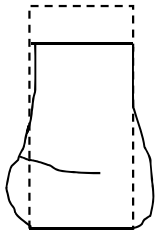
Sample Type: Intact tube sample

Description and/or Classification: CL, grayish brown lean clay with gravel

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	16.4	130.5	112.1	0.45	95.2	6.009	2.870	2.1			2.60
0.5	16.4	131.0	112.5	0.44	96.5	6.001	2.866	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
5.67	2.835	15.0	0.73



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

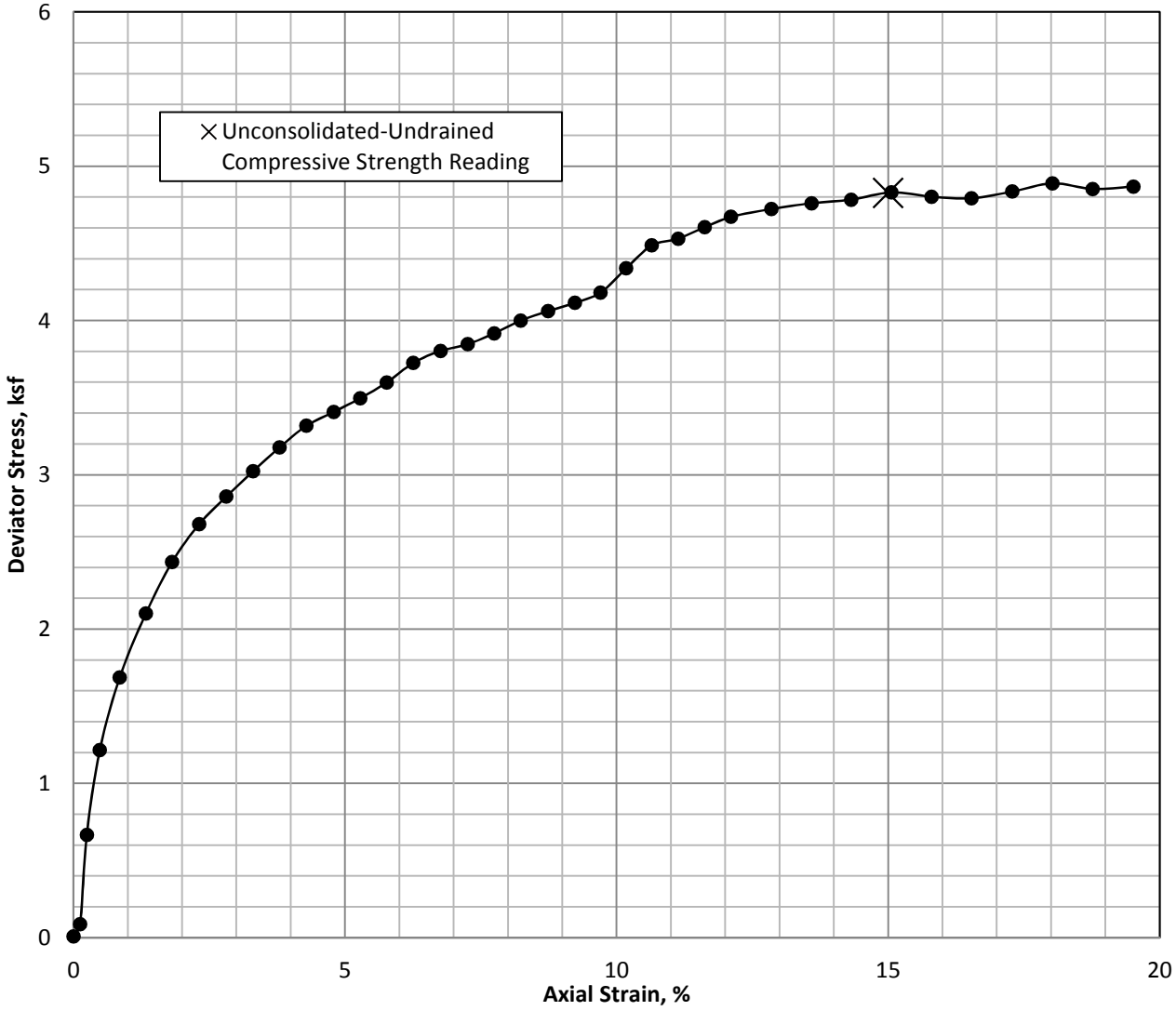
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/4/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B005 Sample: ST-2** **Section: A Depth: 8.30 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

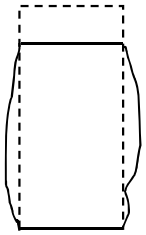
Sample Type: Intact tube sample

Description and/or Classification: CL, gray and brown lean clay

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	21.4	124.0	102.1	0.59	94.4	6.010	2.878	2.1			2.60
3.0	21.4	125.5	103.3	0.57	97.6	5.986	2.867	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
4.83	2.415	15.0	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

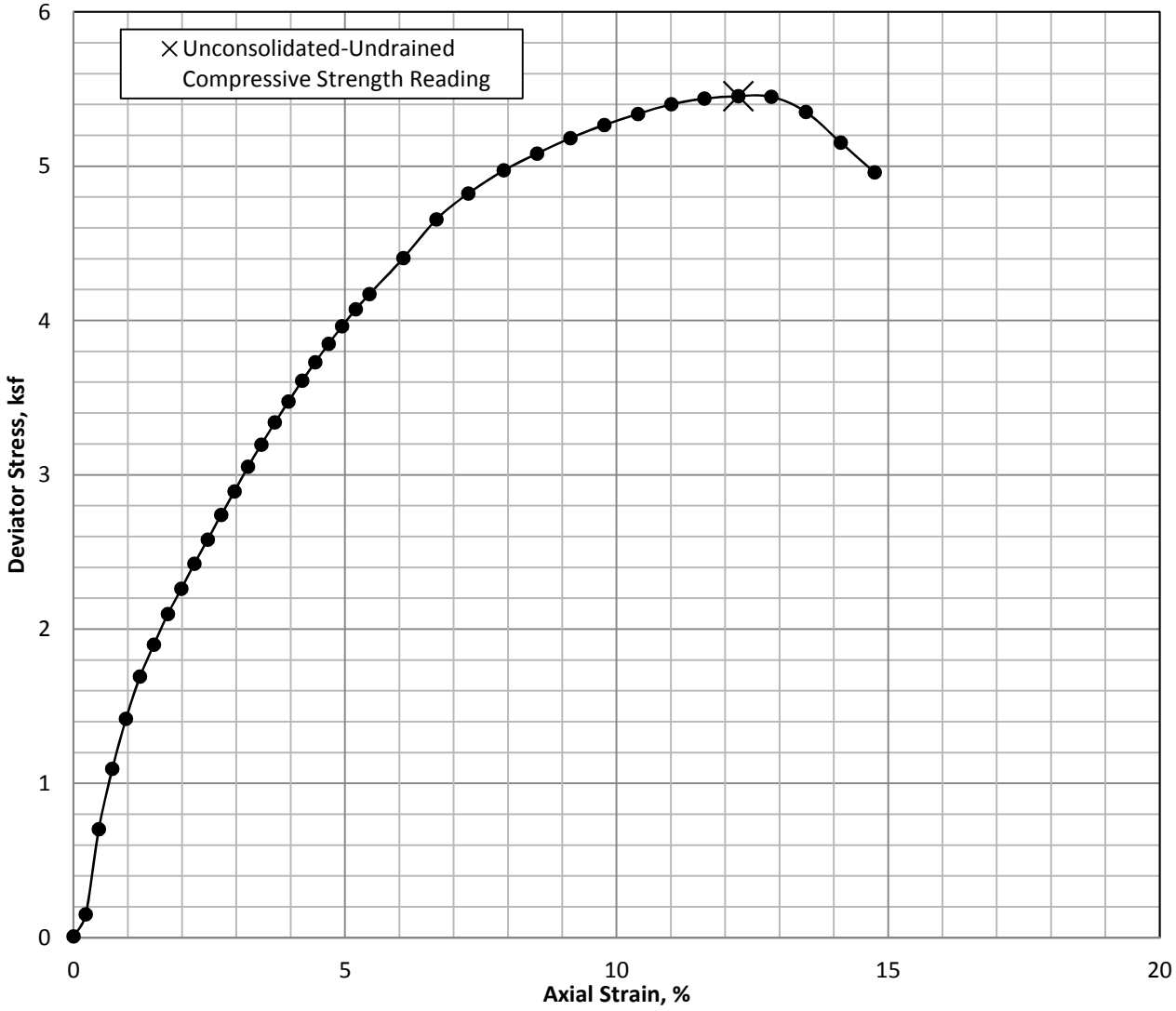
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/4/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B005 Sample: ST-7** **Section: A Depth: 33.30 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

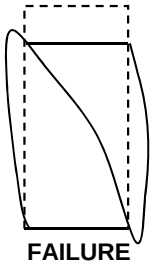
Sample Type: Intact tube sample

Description and/or Classification: CL, brown clay with sand and gravel

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	18.8	129.5	109.1	0.52	96.3	6.008	2.871	2.1			2.65
1.5	18.8	130.9	110.2	0.50	99.2	5.988	2.861	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
5.45	2.725	12.2	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

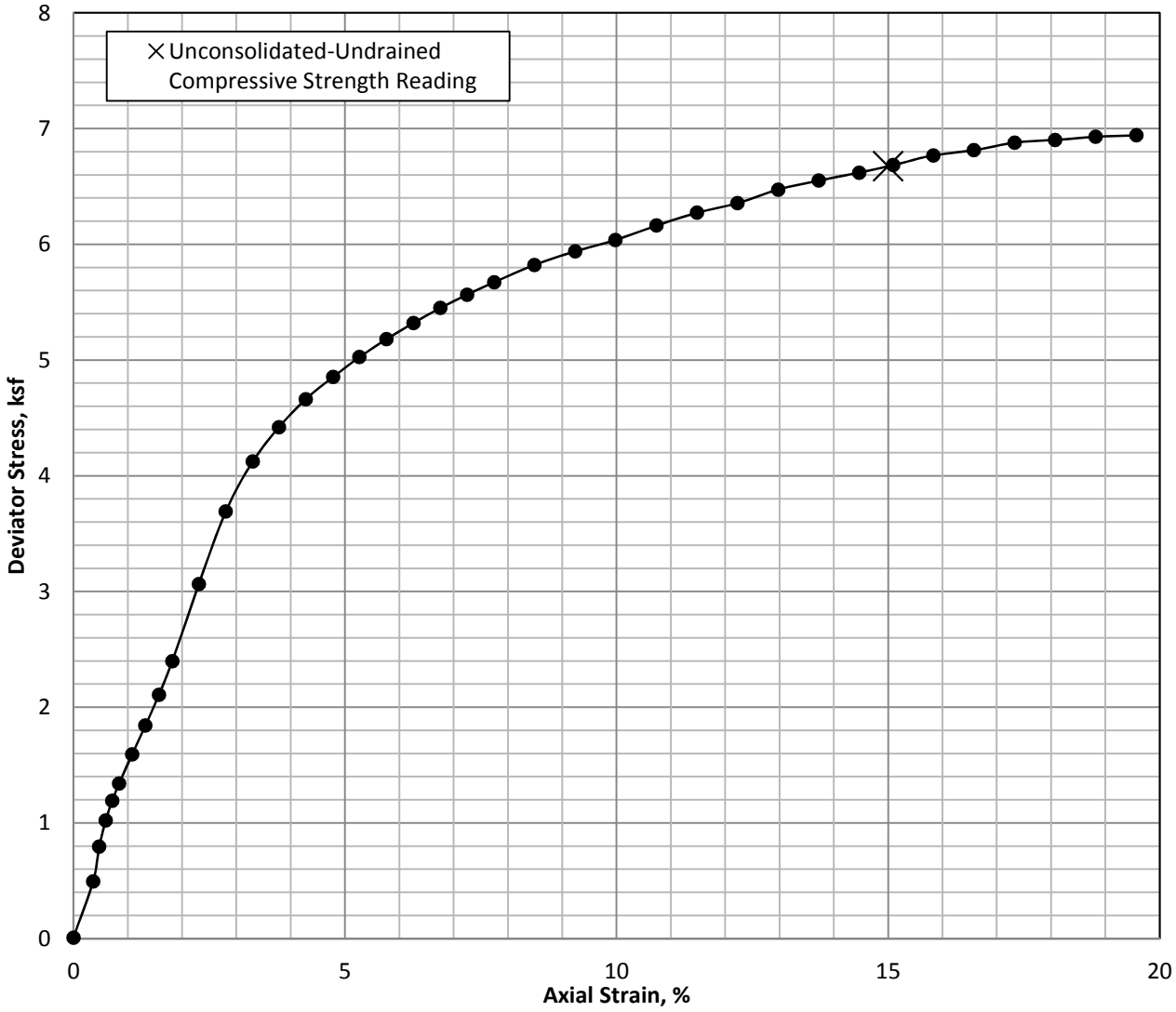
(2) Assumed specific gravity

Tested by: BB Reviewed by: GET

Test Date: 10/6/2015 Review Date: 10/12/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B008 Sample: ST-2 Section: B Depth: 26.70 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

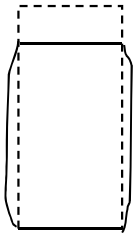
Sample Type: Intact tube sample

Description and/or Classification: CL, orangeish brown lean clay

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	21.3	127.3	104.9	0.60	95.4	6.011	2.881	2.1			2.69
4.5	21.3	129.5	106.8	0.57	100.0	5.976	2.864	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
6.67	3.335	15.0	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

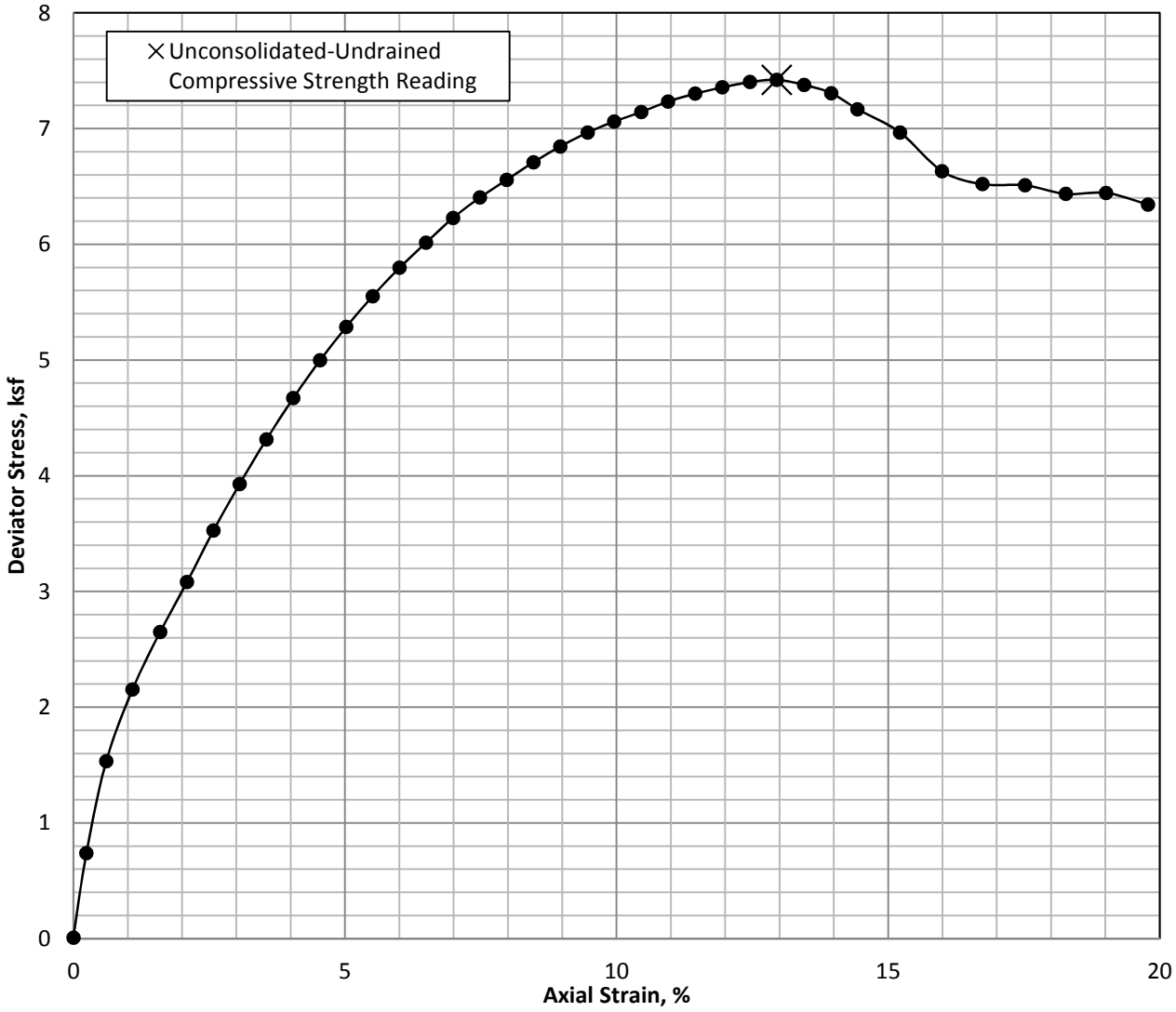
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/18/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B008 Sample: ST-3 Section: B Depth: 39.25 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

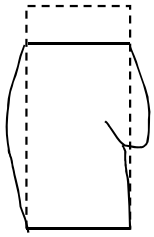
Sample Type: Intact tube sample

Description and/or Classification: CL, light brown lean clay

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	18.2	128.6	108.8	0.58	86.5	5.996	2.865	2.1			2.75
6.0	18.2	134.0	113.4	0.51	97.2	5.914	2.826	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
7.42	3.71	12.9	0.75



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

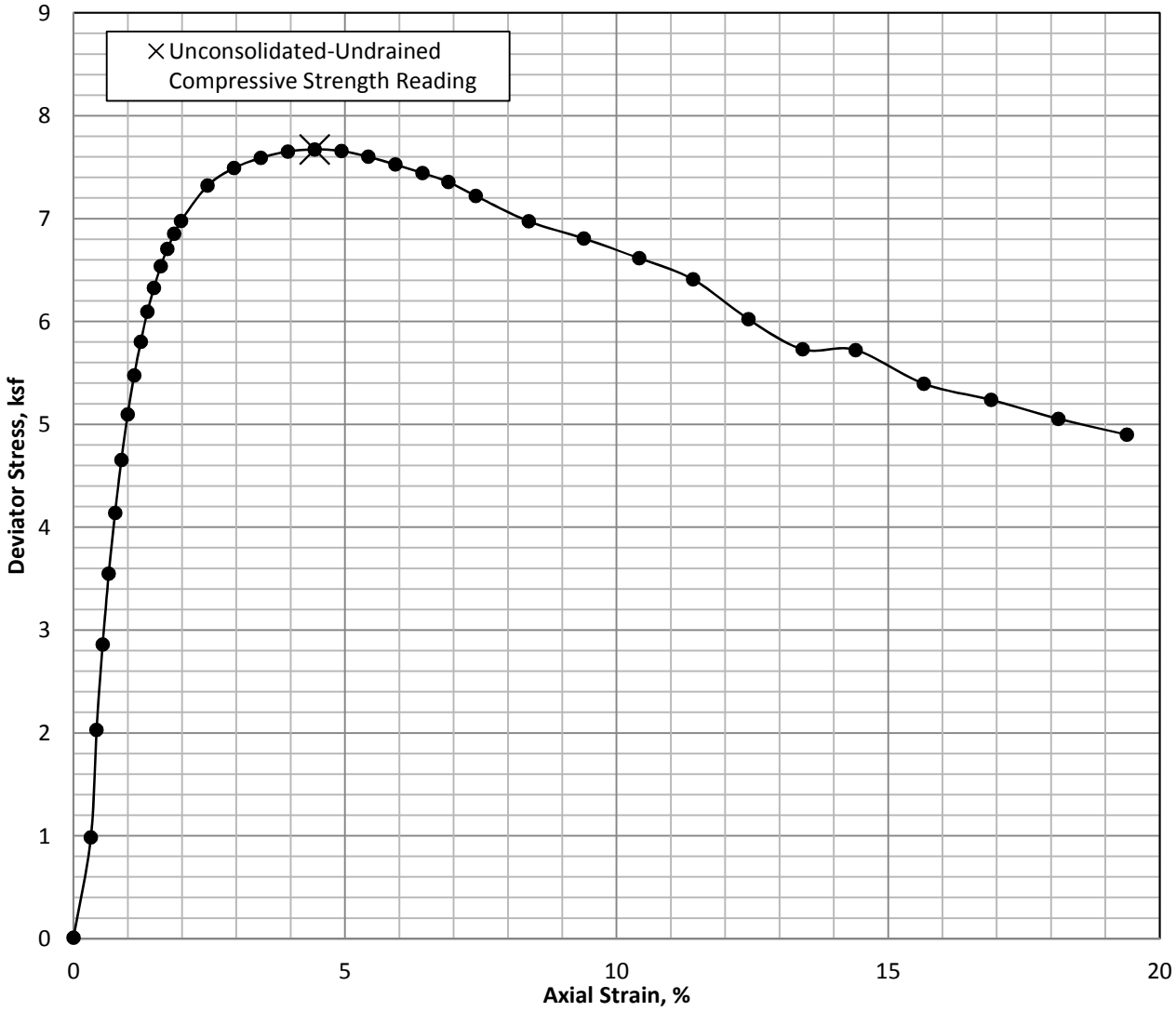
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/29/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B009 Sample: ST-11 Section: C Depth: 49.3 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

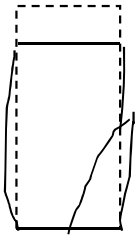
Sample Type: Intact tube sample

Description and/or Classification: CL, grayish brown lean clay

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	18.9	128.3	107.9	0.55	92.6	6.010	2.886	2.1			2.67
12.0	18.9	131.4	110.5	0.51	99.3	5.962	2.863	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
7.67	3.835	4.4	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

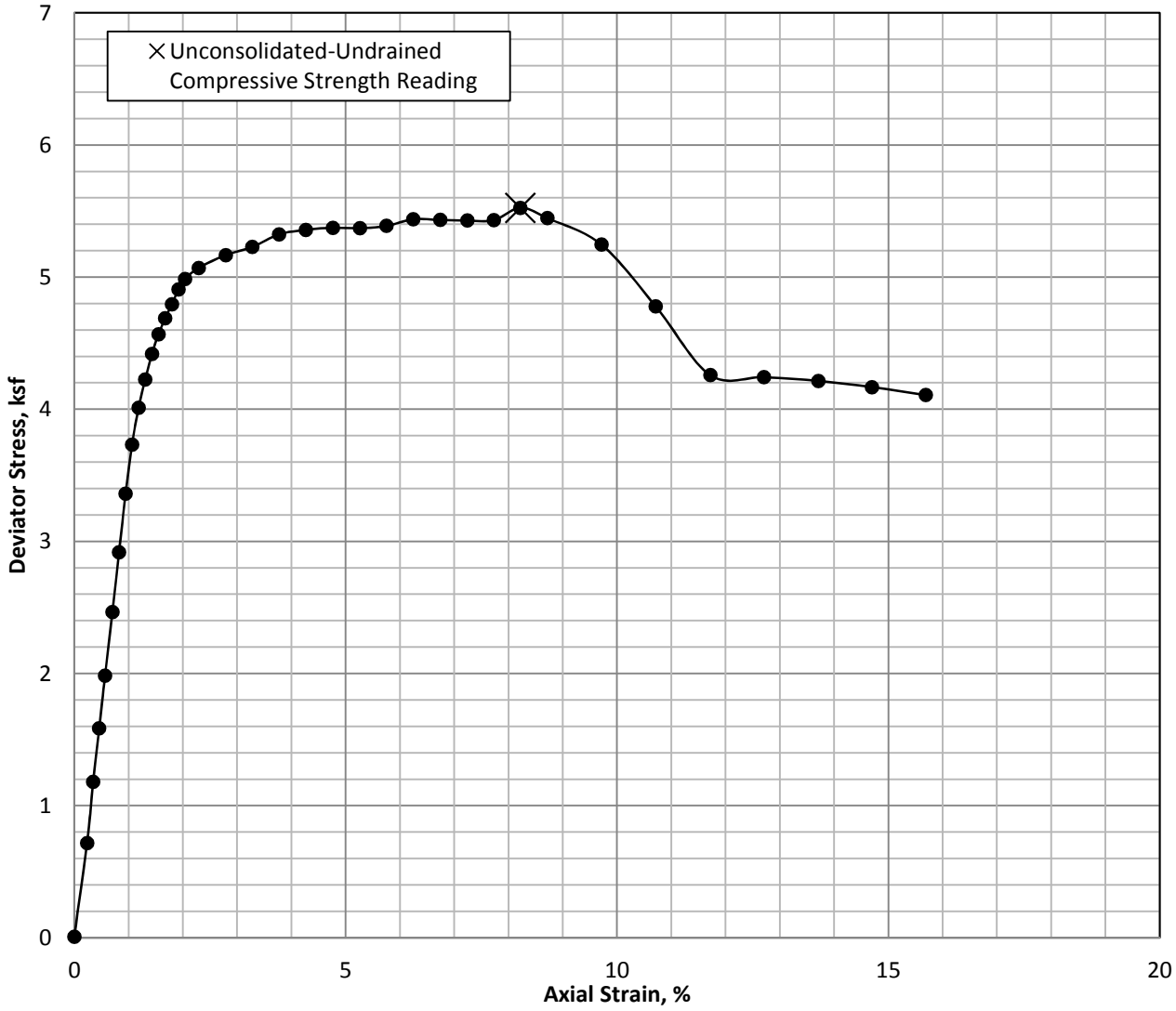
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/8/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B009 Sample: ST-14** **Section: B Depth: 64.20 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

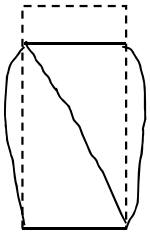
Sample Type: Intact tube sample

Description and/or Classification: CL, orangeish brown lean clay

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	17.8	126.1	107.0	0.52	89.5	5.998	2.874	2.1			2.60
1.5	17.8	126.7	107.6	0.51	91.0	5.987	2.868	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
5.52	2.76	8.2	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

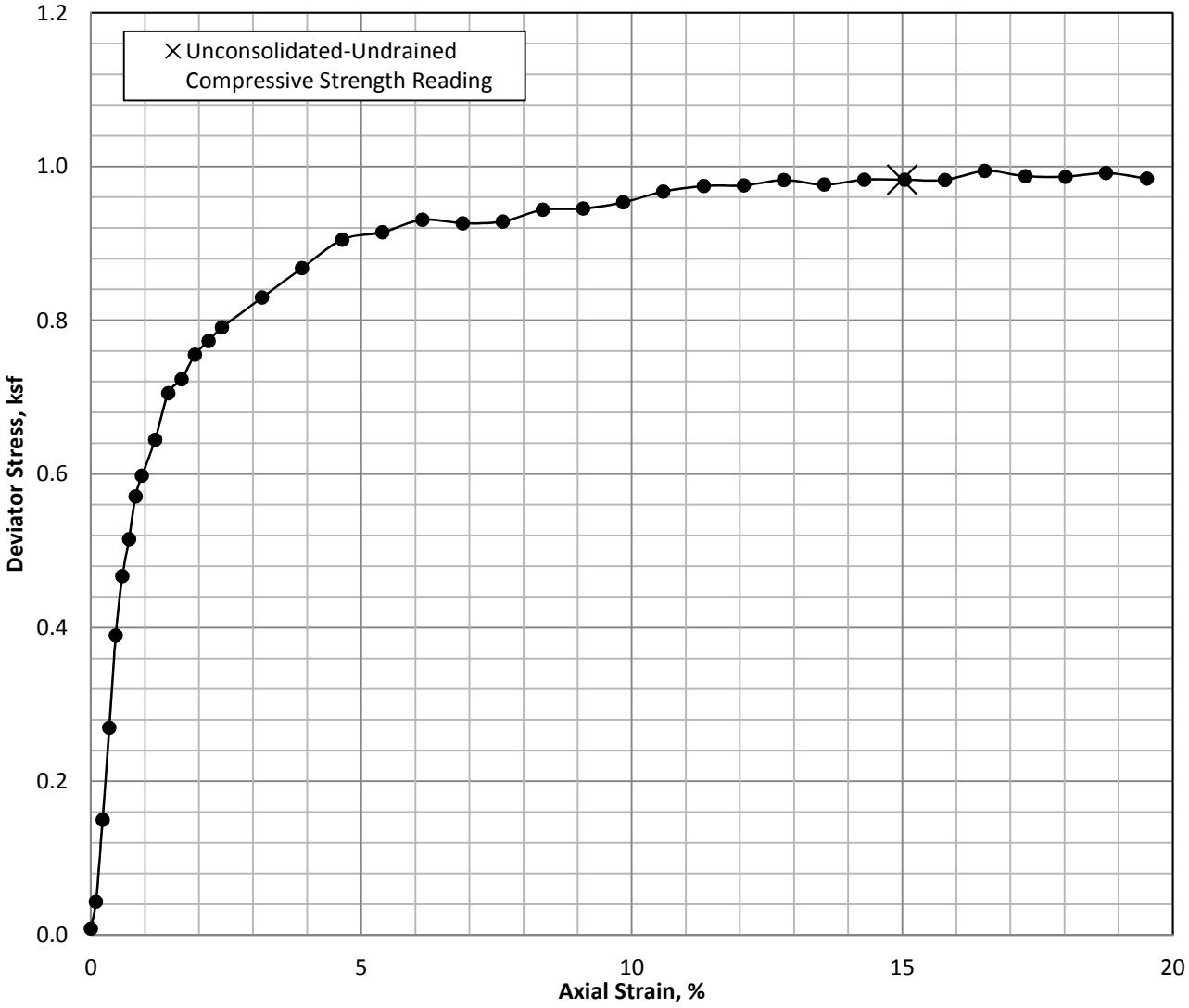
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/9/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B011 Sample: ST-5 Section: B Depth: 23.80 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

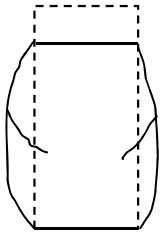
Sample Type: Intact tube sample

Description and/or Classification: CL, grayish brown lean clay

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	28.8	121.0	94.0	0.78	98.8	6.002	2.880	2.1			2.68
3.0	28.8	121.4	94.3	0.77	99.6	5.995	2.876	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
0.98	0.49	15.0	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

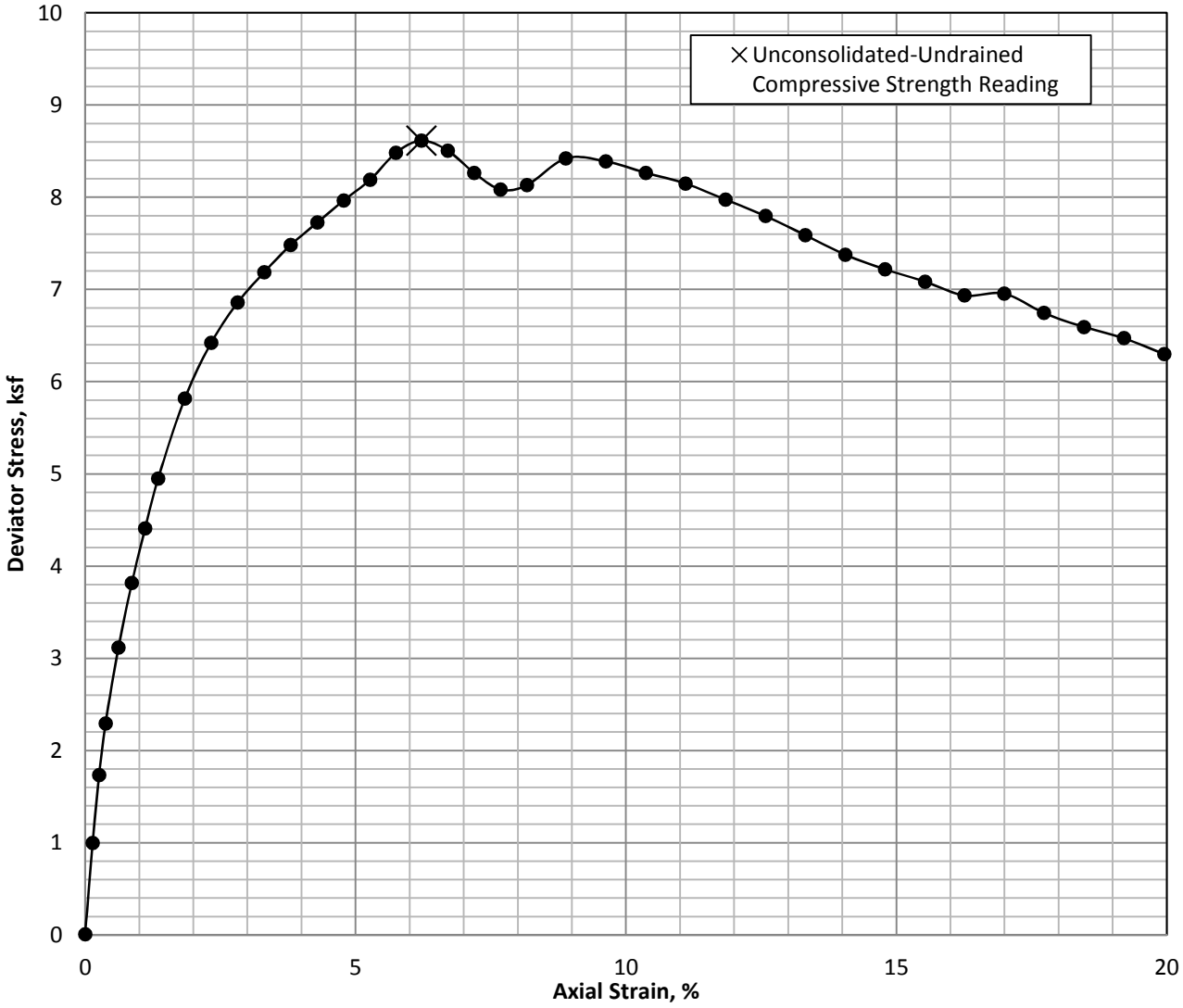
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/10/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B012 Sample: ST-8** **Section: B Depth: 33.05 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

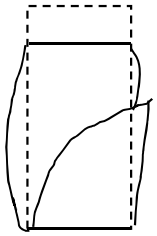
Sample Type: Intact tube sample

Description and/or Classification: CL, orangish brown lean clay with gravel

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	16.1	130.2	112.2	0.45	93.4	6.028	2.872	2.1			2.60
6.0	16.1	132.5	114.1	0.42	99.0	5.993	2.855	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
8.61	4.305	6.2	0.73



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

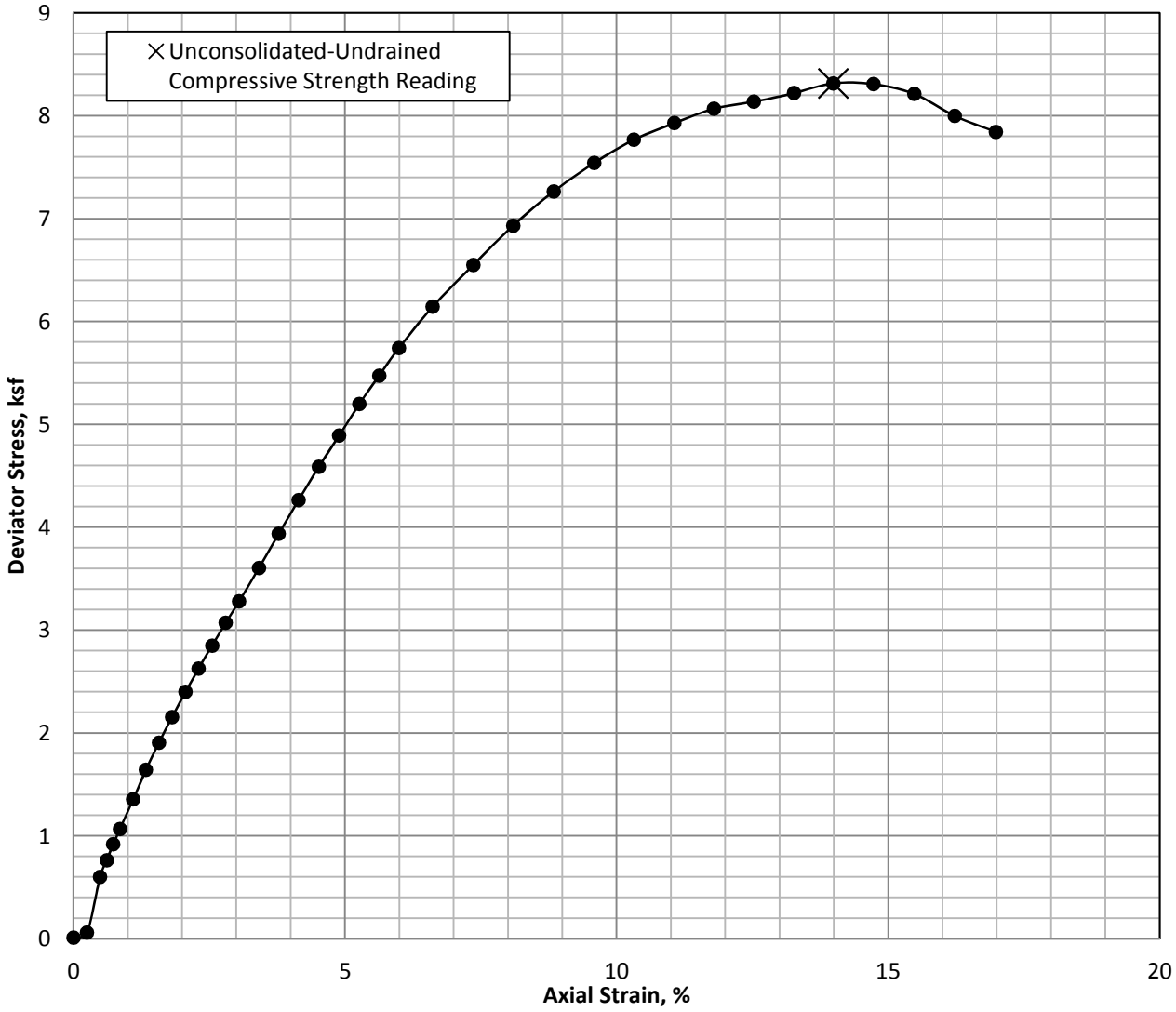
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 8/25/2015 Review Date: 9/2/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B014 Sample: ST-3 Section: C Depth: 34.65 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

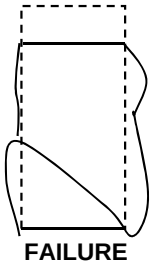
Sample Type: Intact tube sample

Description and/or Classification: CL, orange-brown clay

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	16.5	132.2	113.4	0.46	95.6	5.993	2.871	2.1			2.65
1.5	16.5	133.0	114.1	0.45	97.5	5.981	2.866	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
8.31	4.155	14.0	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

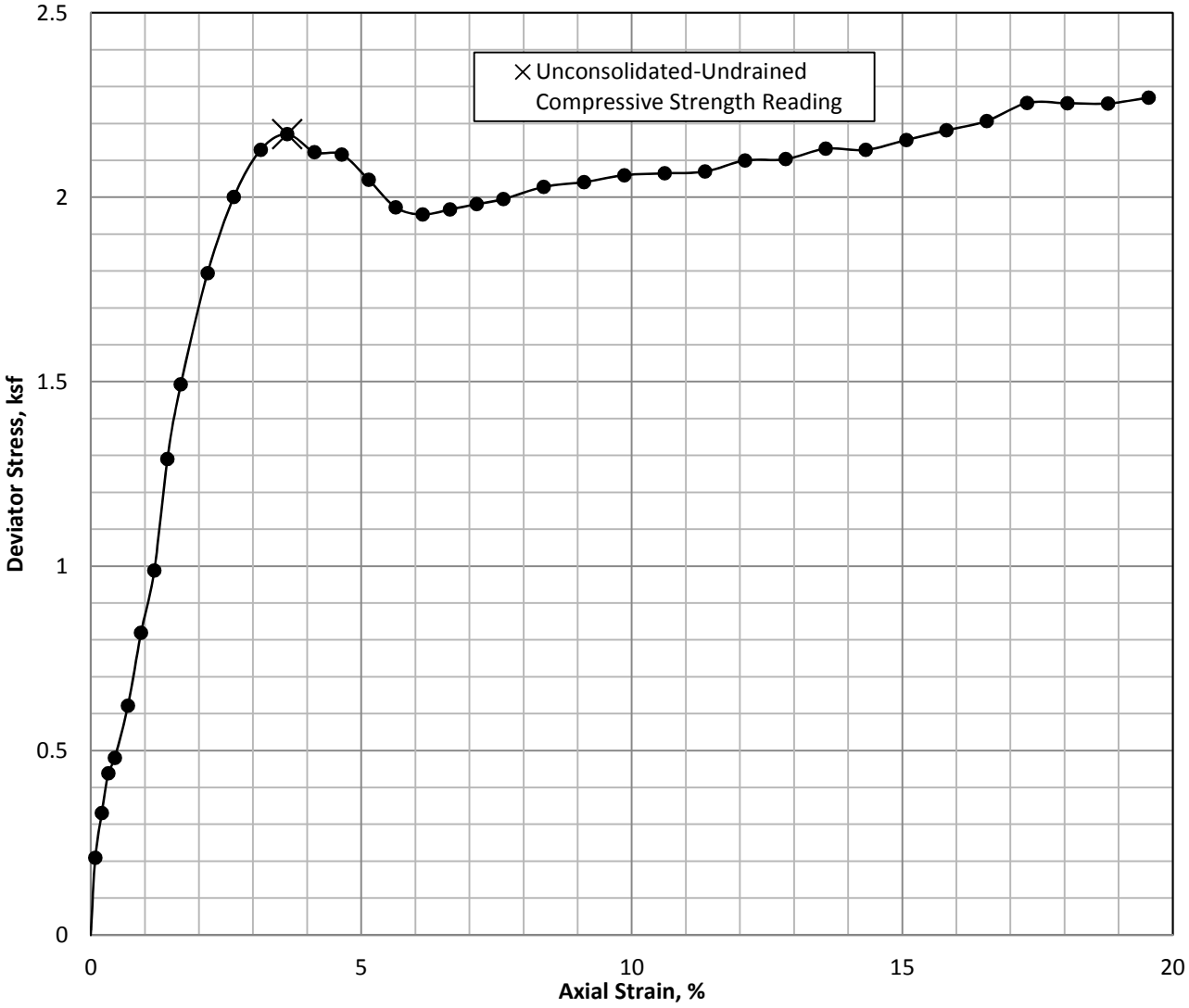
(2) Assumed specific gravity

Tested by: BB Reviewed by: GET

Test Date: 10/9/2015 Review Date: 10/12/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B015 Sample: ST-1 Section: B Depth: 18.80 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

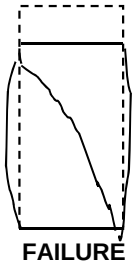
Sample Type: Intact tube sample

Description and/or Classification: CL, orangish brown lean clay

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	26.6	123.7	97.7	0.72	99.4	5.979	2.858	2.1			2.69
0.5	26.6	123.7	97.8	0.72	99.5	5.978	2.858	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
2.17	1.085	3.6	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

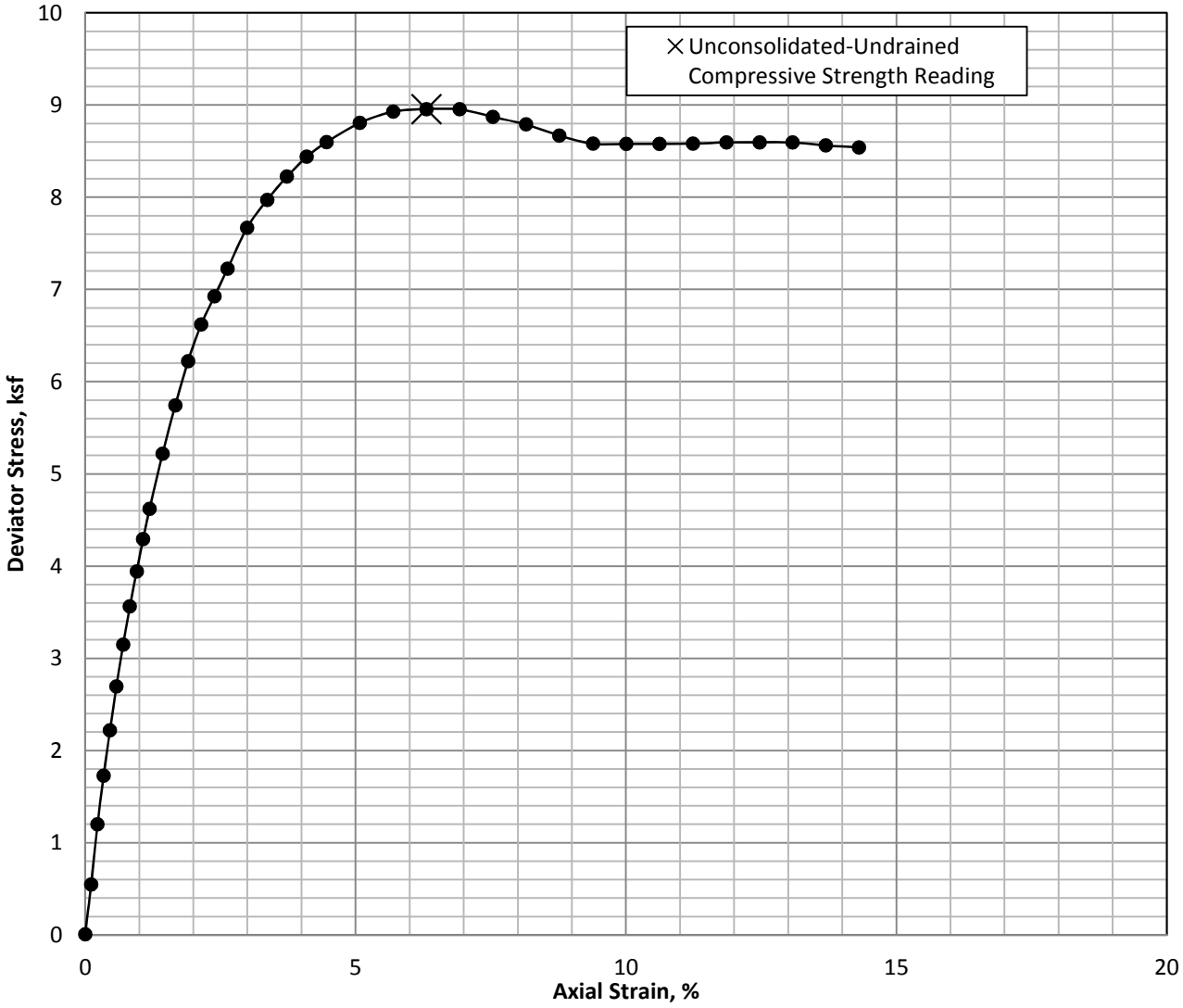
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 8/27/2015 Review Date: 9/2/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B016 Sample: ST-1** **Section: C Depth: 4.80 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

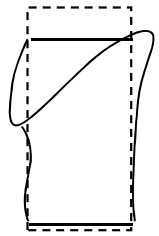
Sample Type: Intact tube sample

Description and/or Classification: CL, orange-brown clay, trace f. gravel, some c-f sand

Cell Pressure (ksf)	Water (1) Content (%)	Wet Unit Weight (pcf)	Dry Unit (1) Weight (pcf)	Void Ratio (-)	Saturation (2) (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific (2) Gravity (-)
0 (Initial)	15.6	133.9	115.9	0.43	96.3	6.006	2.876	2.1	38	24	2.65
3.0	15.6	135.4	117.1	0.41	100.0	5.984	2.866	2.1	14		

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
8.95	4.475	6.3	0.73



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

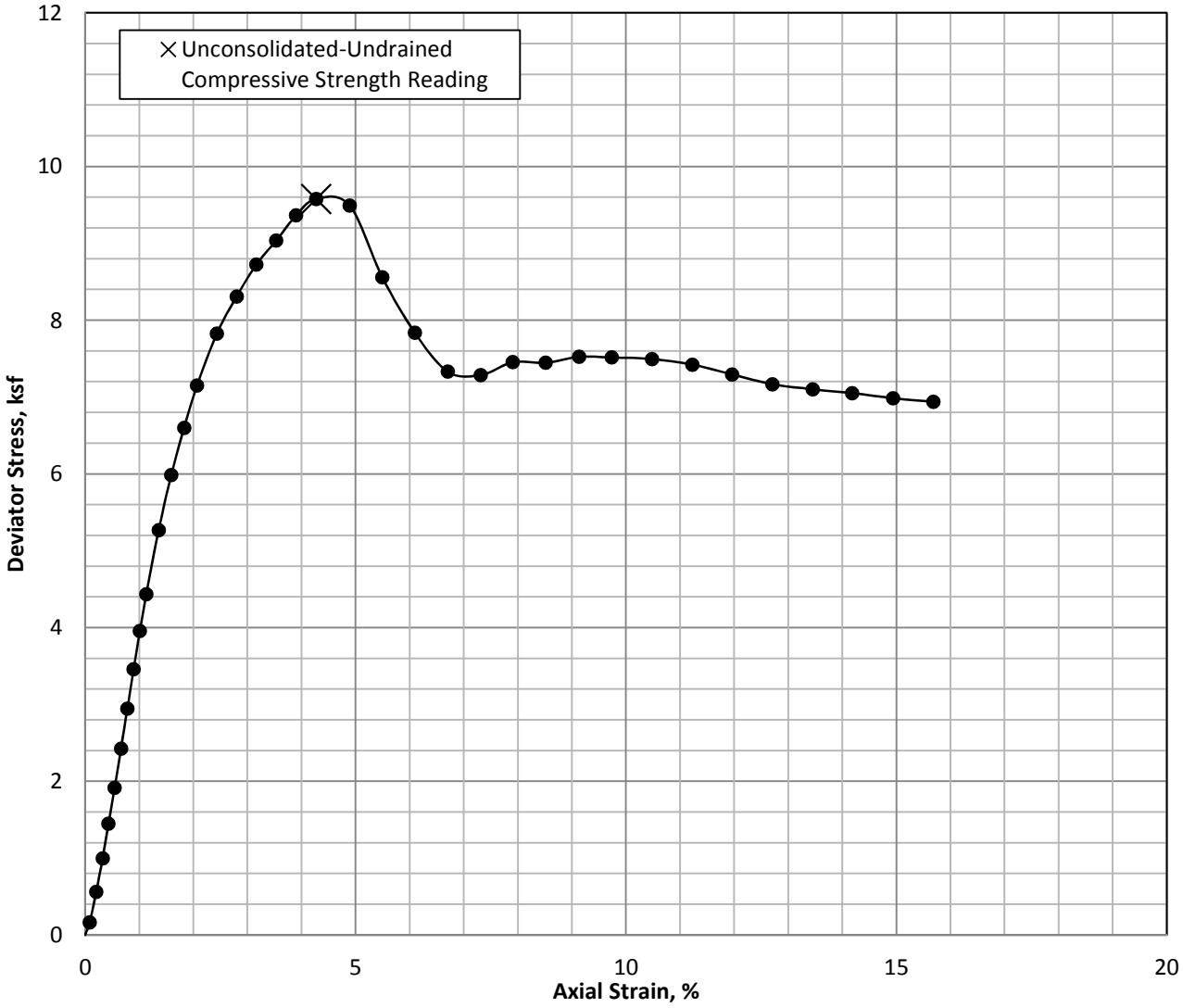
(2) Assumed specific gravity

Tested by: BB Reviewed by: GET

Test Date: 10/7/2015 Review Date: 10/12/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B018 Sample: ST-3** **Section: C Depth: 34.50 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

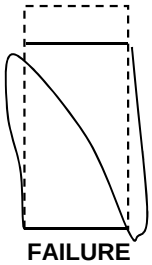
Sample Type: Intact tube sample

Description and/or Classification: CL, brown clay, trace f. sand

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	15.8	134.3	116.0	0.43	98.0	5.996	2.876	2.1	35	19	2.65
0.5	15.8	134.5	116.2	0.42	98.5	5.993	2.875	2.1	16		

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
9.58	4.79	4.3	0.73



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

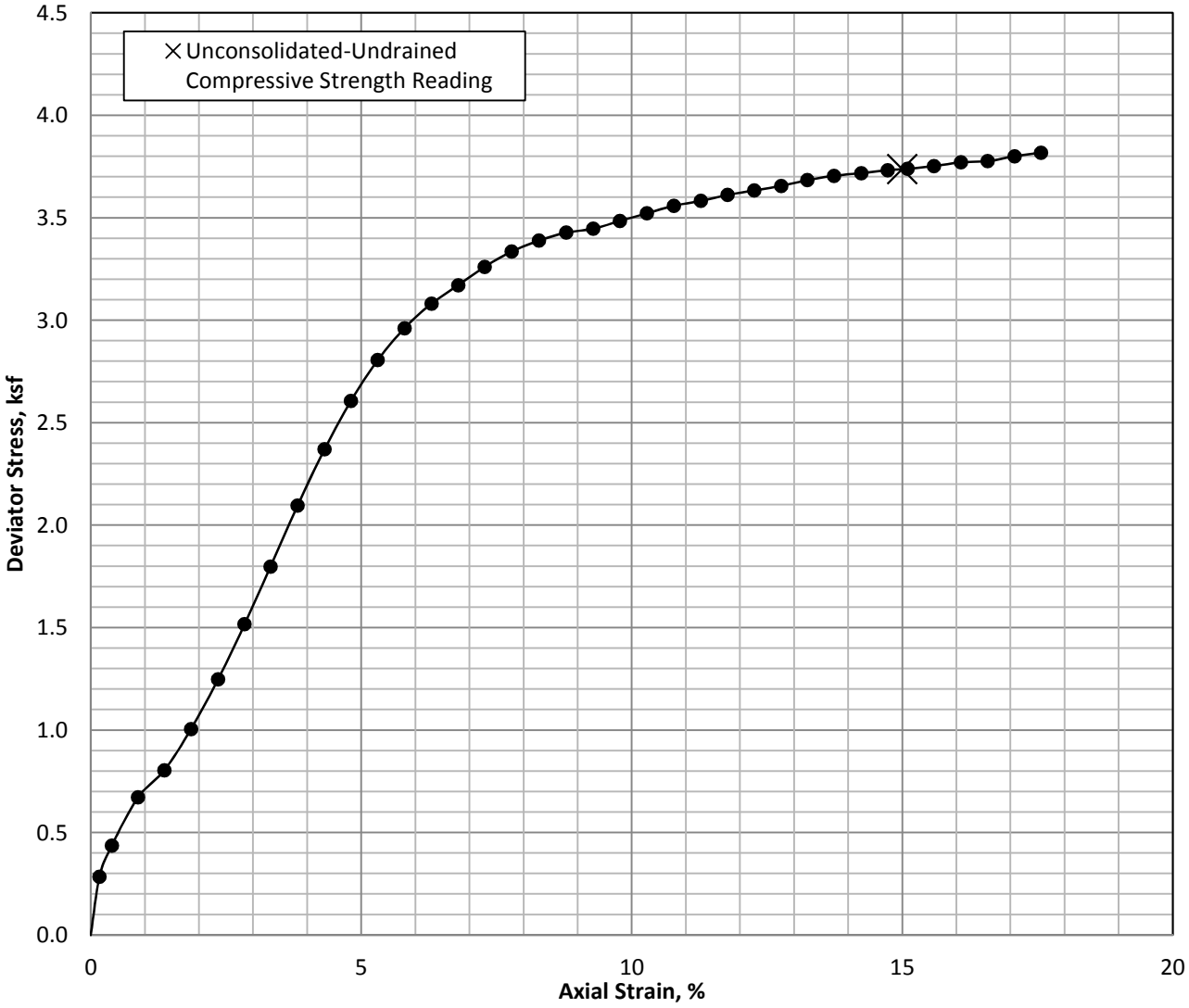
(2) Assumed specific gravity

Tested by: BB Reviewed by: GET

Test Date: 10/7/2015 Review Date: 10/12/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B020 Sample: ST-1** **Section: B Depth: 3.95 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

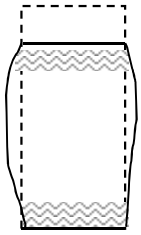
Sample Type: Intact tube sample

Description and/or Classification: CL, brown lean clay; CL-ML zones noted

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	16.6	129.6	111.1	0.46	93.7	5.986	2.842	2.1			2.60
0.5	16.6	129.9	111.4	0.46	94.4	5.981	2.839	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
3.74	1.87	15.0	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

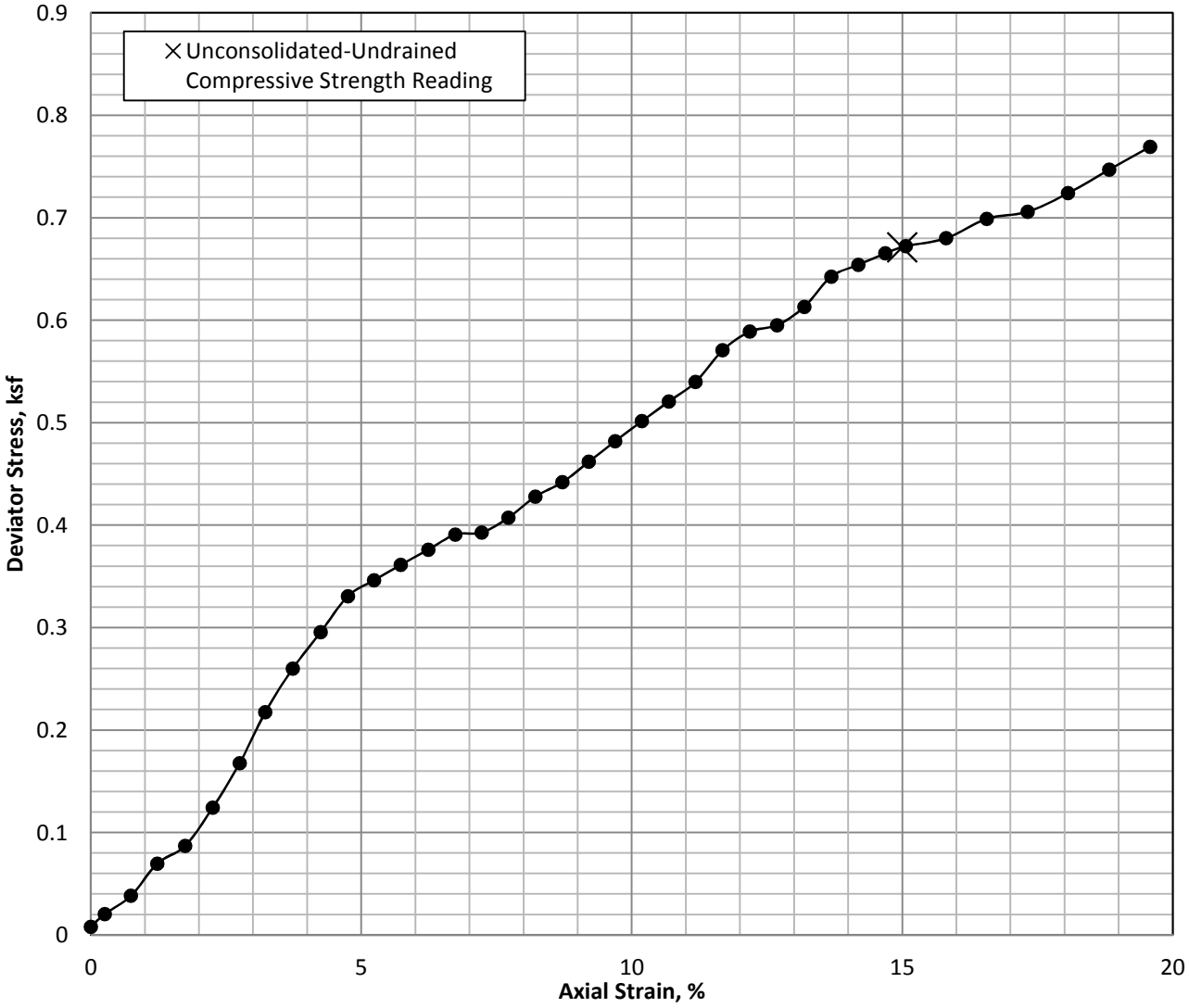
(2) Assumed specific gravity

Tested by: NB Reviewed by: CMJ

Test Date: 10/13/2015 Review Date: 10/15/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B021 Sample: ST-1** **Section: B Depth: 3.75 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

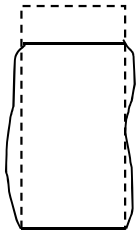
Sample Type: Intact tube sample

Description and/or Classification: CL, dark gray lean clay

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	44.8	106.9	73.8	1.20	97.2	5.929	2.942	2.0			2.60
0.5	44.8	107.2	74.0	1.19	97.6	5.924	2.939	2.0			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
0.67	0.335	15.0	0.75



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/18/2015 Review Date: 10/5/2015

AECOM
Project # 60428794-107

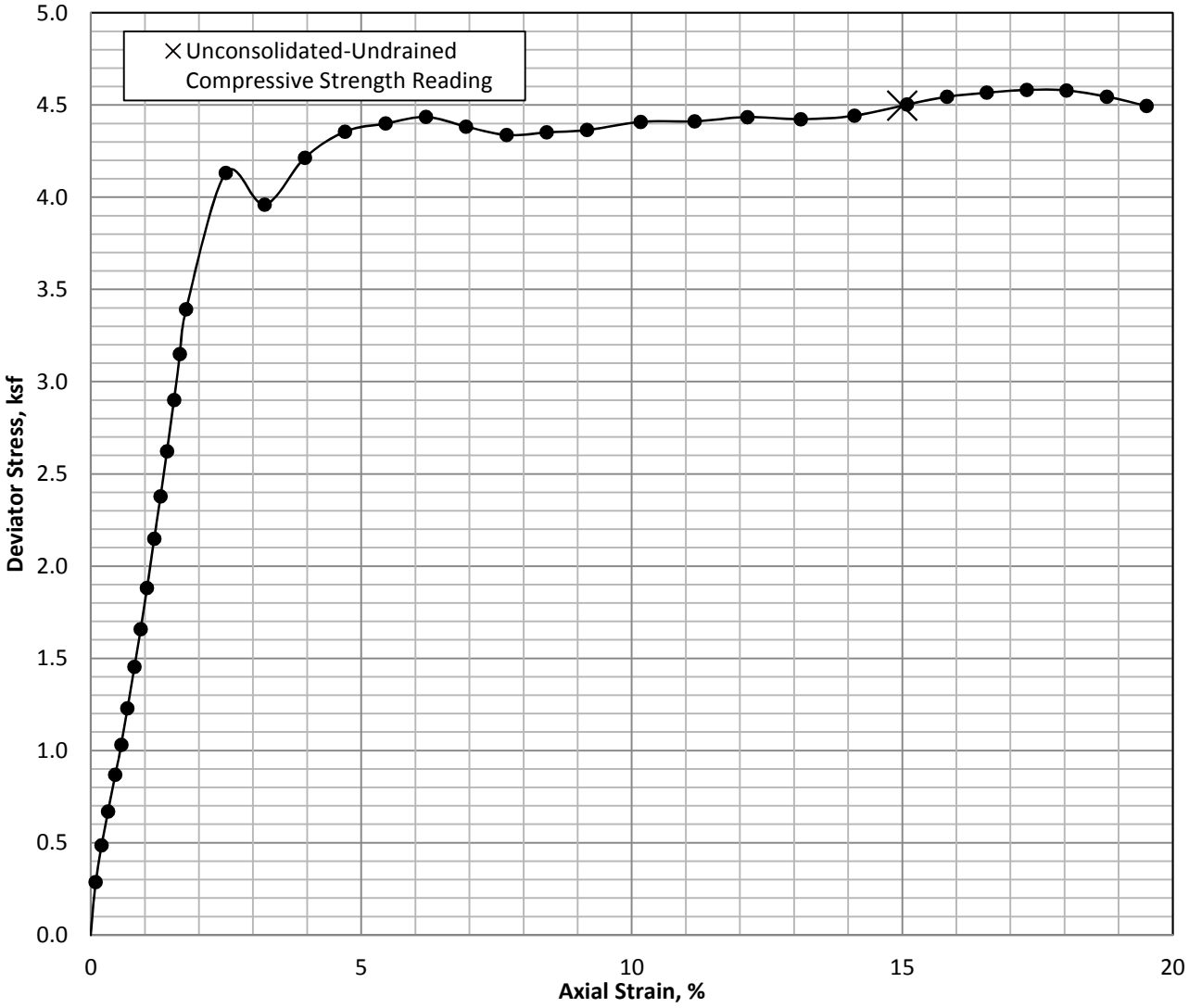
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

Boring: JOP-B021 Sample: ST-2
Section: A Depth: 13.55 ft.

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

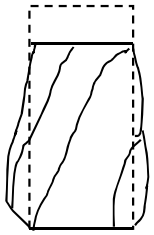
Sample Type: Intact tube sample

Description and/or Classification: CL, orangish brown lean clay with gravel

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	21.3	128.3	105.8	0.57	99.3	5.999	2.872	2.1			2.66
0.5	21.3	128.4	105.9	0.57	99.6	5.997	2.871	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
4.5	2.25	15.0	0.74



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

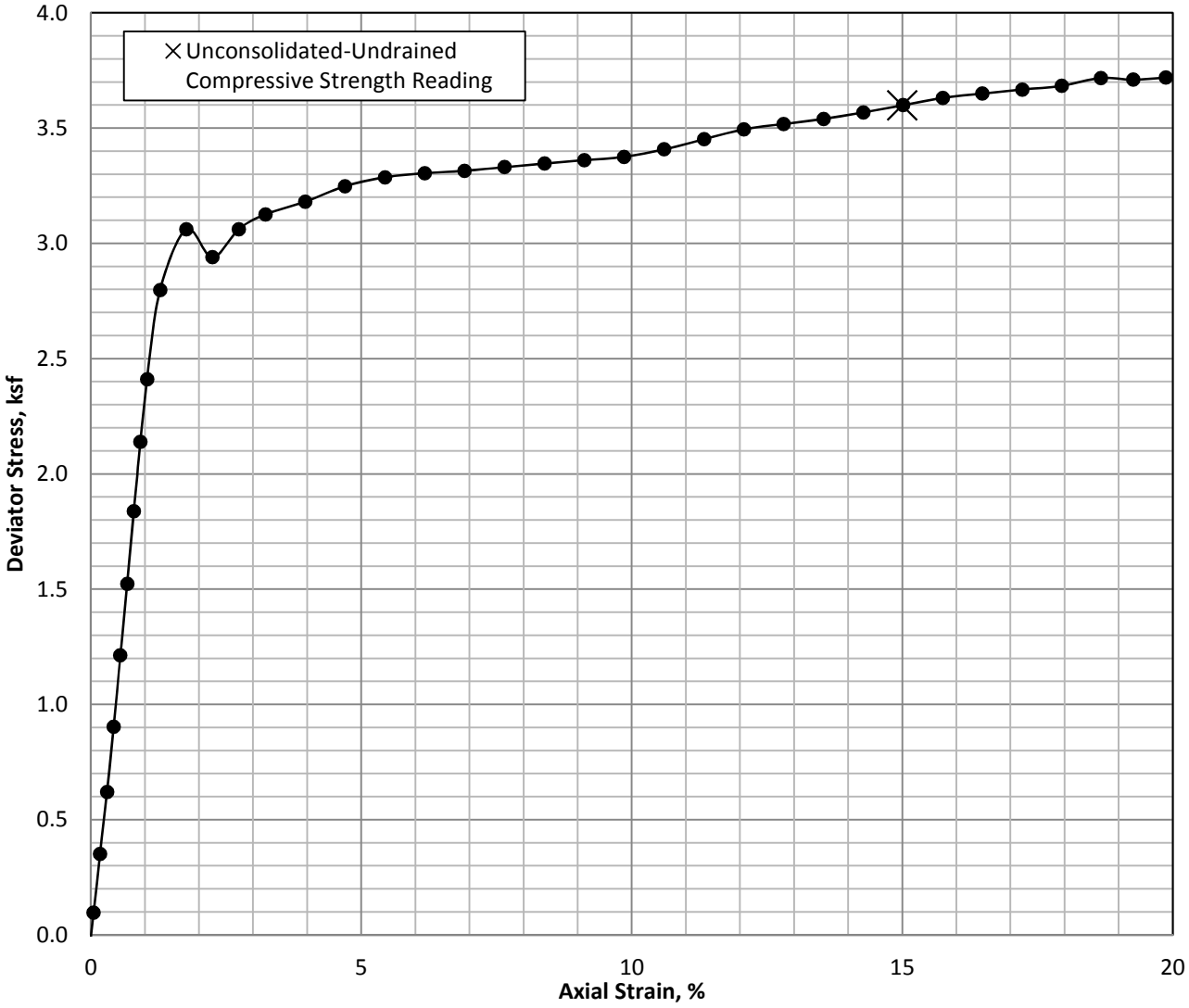
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 8/25/2015 Review Date: 9/2/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B022 Sample: ST-2** **Section: B Depth: 8.85 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

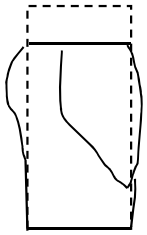
Sample Type: Intact tube sample

Description and/or Classification: CL, orangeish brown lean clay

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	19.3	129.1	108.2	0.51	99.5	6.034	2.880	2.1			2.61
1.5	19.3	129.1	108.2	0.51	99.7	6.033	2.879	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
3.6	1.8	15.0	0.73



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

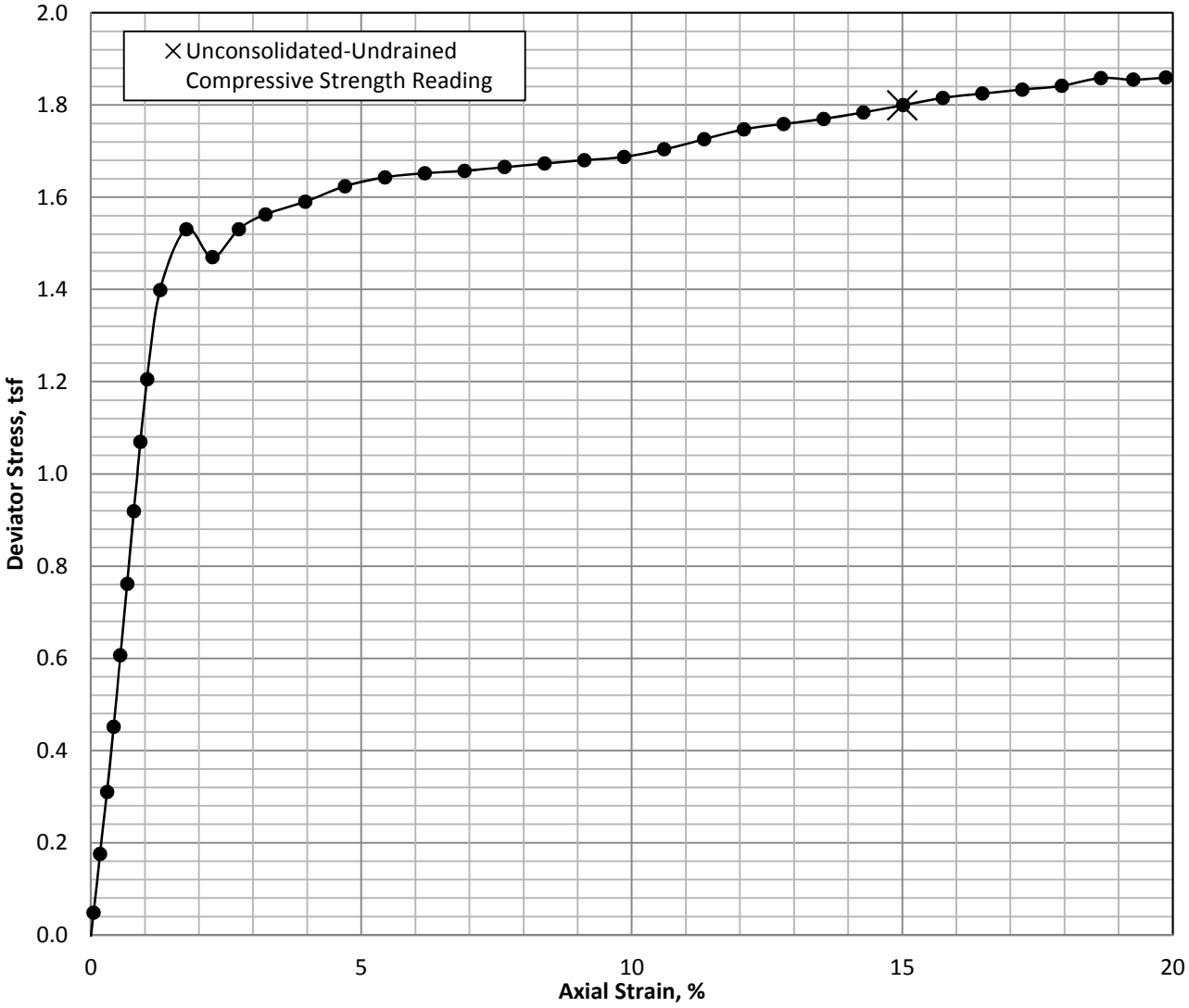
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/15/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B022 Sample: ST-3 Section: B Depth: 23.90 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

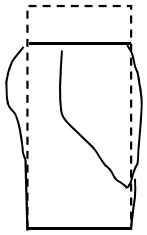
Sample Type: Intact tube sample

Description and/or Classification: CL, orangeish brown lean clay

Cell Pressure (tsf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	19.3	129.1	108.2	0.51	99.5	6.034	2.880	2.1			2.61
0.7	19.3	129.1	108.2	0.51	99.7	6.033	2.879	2.1			

Failure Summary

U-U Compressive Strength (tsf)	U-U Shear Strength, s_u (tsf)	Strain to to Peak (%)	Strain Rate (%/min)
1.8	0.9	15.0	0.73



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

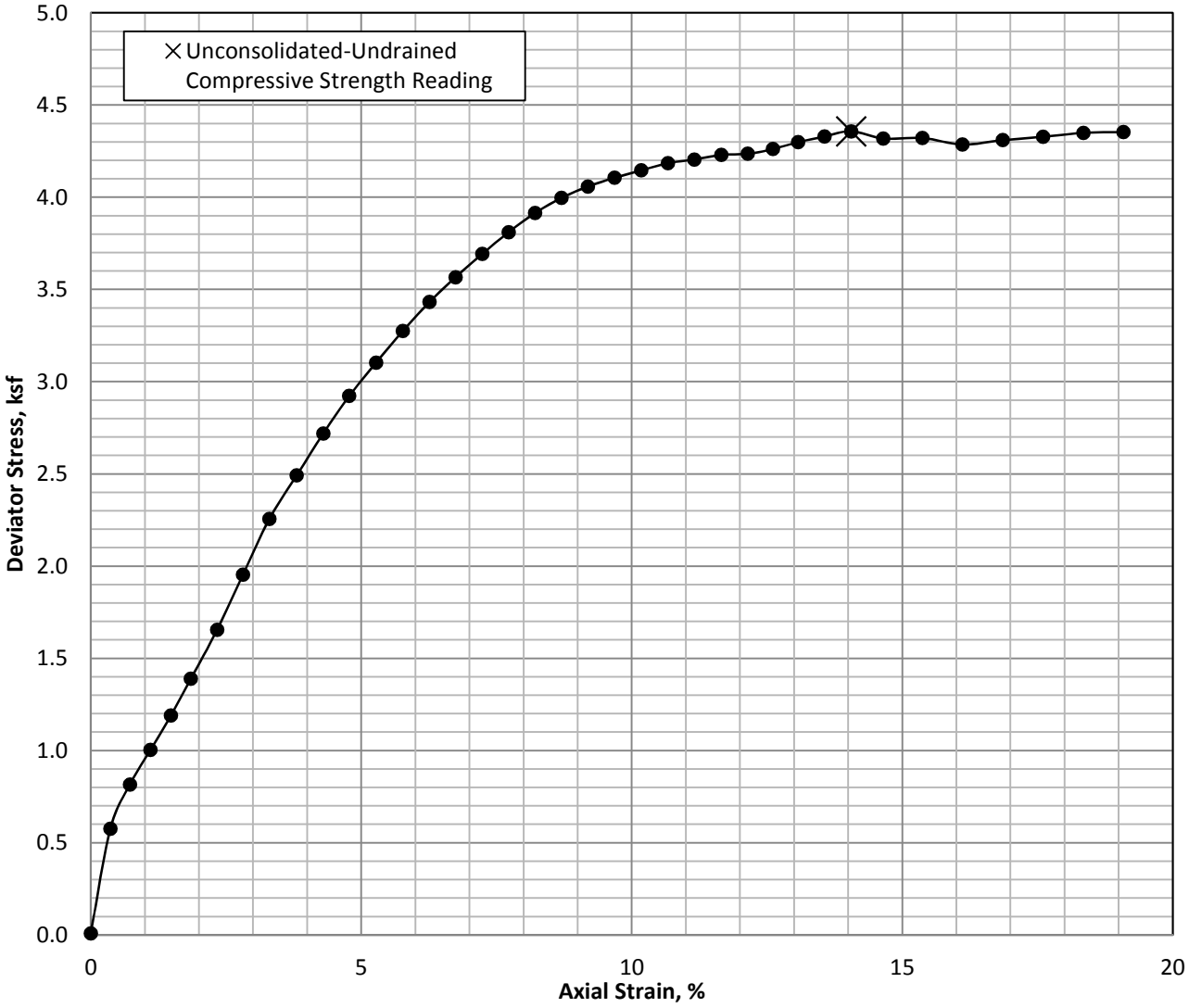
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/15/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B022 Sample: ST-3 Section: B Depth: 23.90 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

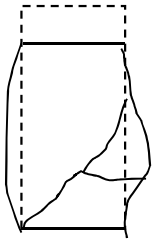
Sample Type: Intact tube sample

Description and/or Classification: CL, brown lean clay with sand

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	18.0	131.8	111.7	0.51	95.5	6.031	2.873	2.1	23	9	2.70
3.0	18.0	133.7	113.3	0.49	99.6	6.003	2.859	2.1	14		

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
4.36	2.18	14.1	0.73



FAILURE SKETCH

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

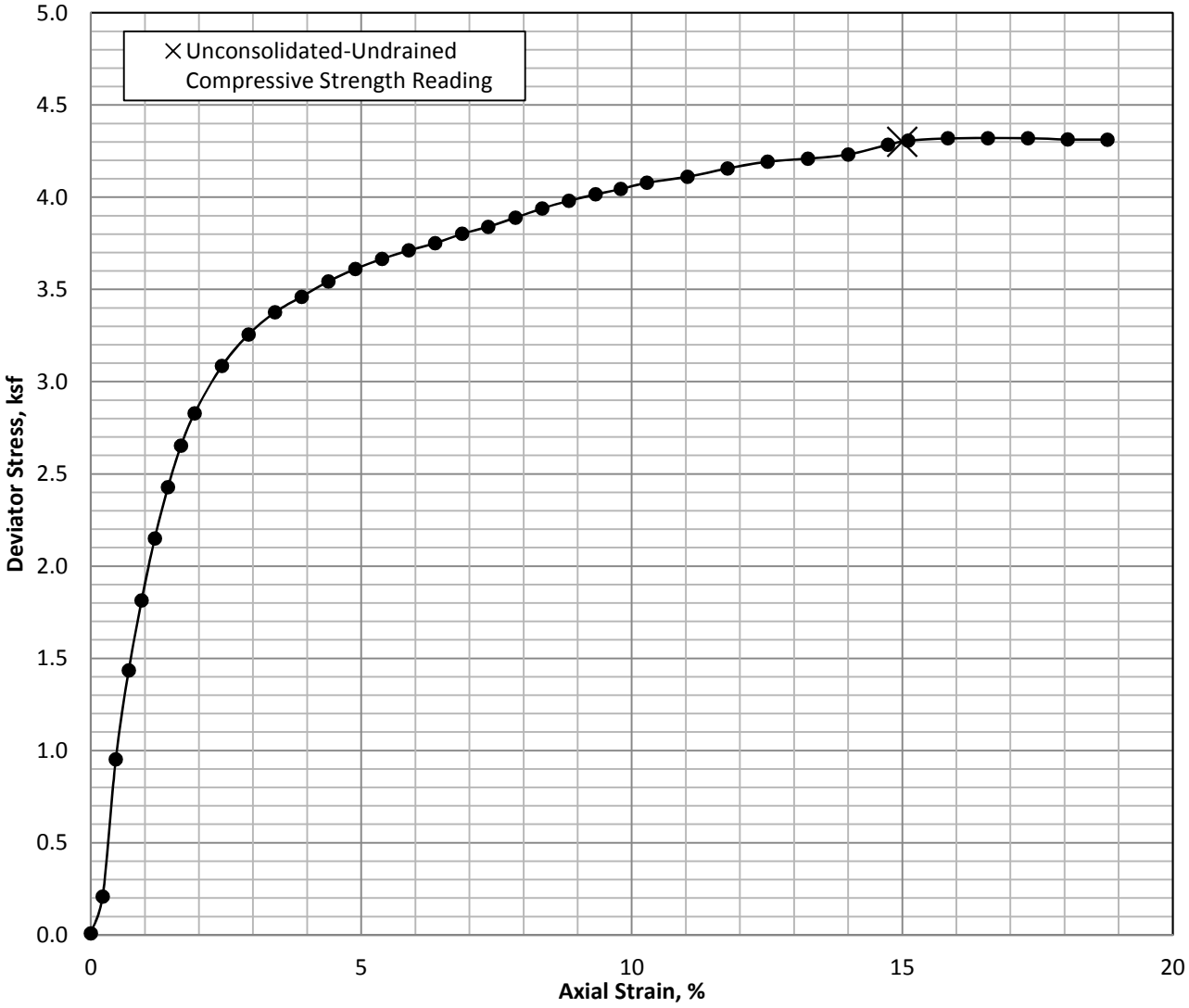
(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/15/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B022 Sample: ST-4** **Section: B Depth: 38.8 ft.**

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

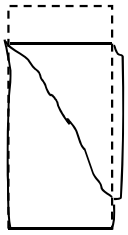
Sample Type: Intact tube sample

Description and/or Classification: CL, orangish brown lean clay

Cell Pressure (ksf)	Water [1] Content (%)	Wet Unit Weight (pcf)	Dry Unit [1] Weight (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [2] Gravity (-)
0 (Initial)	20.9	129.6	107.2	0.58	97.3	6.007	2.873	2.1			2.72
4.0	20.9	130.7	108.1	0.57	99.5	5.990	2.865	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to to Peak (%)	Strain Rate (%/min)
4.3	2.15	15.0	0.74



FAILURE SKETCH

Remarks and Notes:

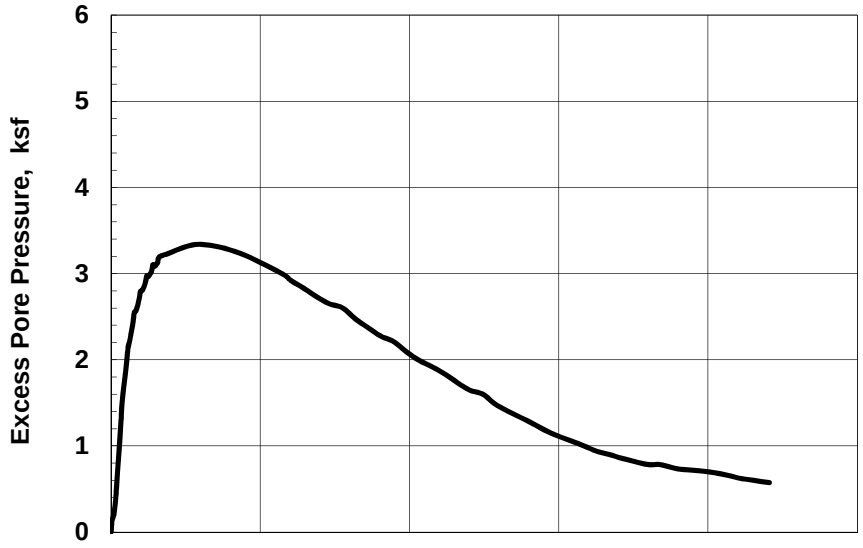
(1) Water Content determined after shear from partial specimen.

(2) Assumed specific gravity

Tested by: BB Reviewed by: CMJ

Test Date: 9/17/2015 Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST**
TerraSense, LLC **Project # T60428794**		**Boring: JOP-B023 Sample: ST-2 Section: A Depth: 48.45 ft.**

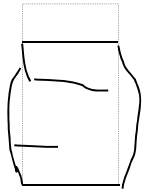


SAMPLE INFORMATION

Boring: JOP-B001 Sample: ST-4C Depth: 44.35 ft
Type: Intact tube sample
Description: SC, light gray clayey sand
LL = 29 PL = 12 PI = 17

SPECIMEN INFORMATION (Initial)

Height: 6.04 inch Diameter: 2.89 inch Area: 6.55 in²
Water Content: 14.5 % Total Unit Weight: 131.5 pcf

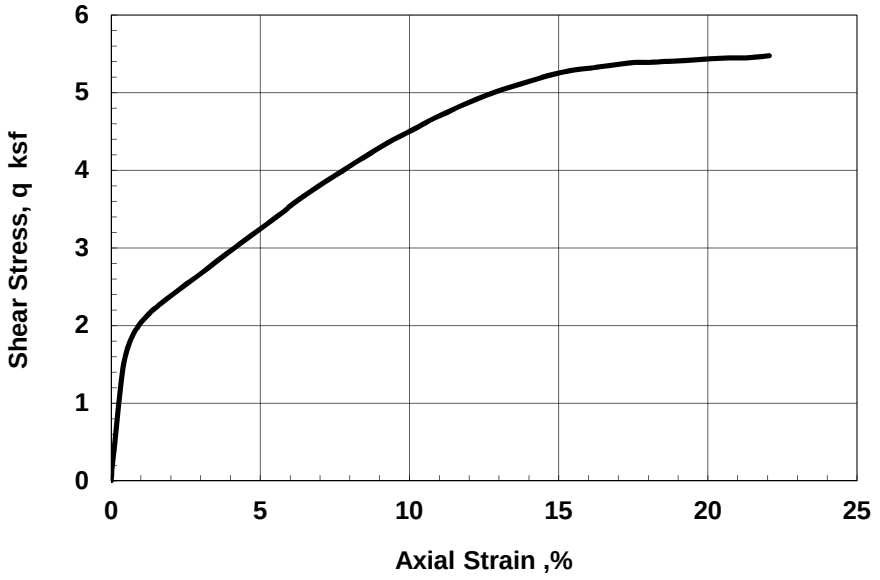


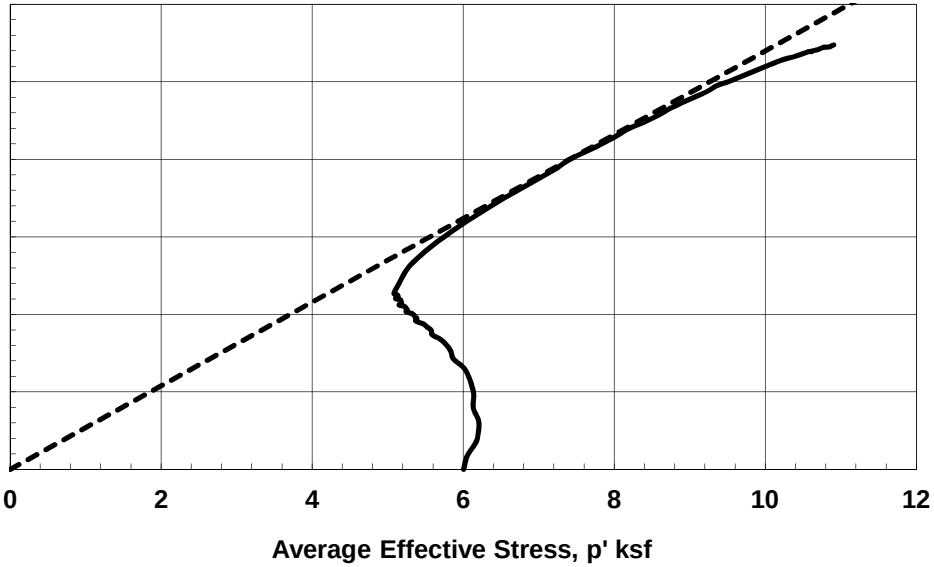
Failure Sketch

TEST SUMMARY

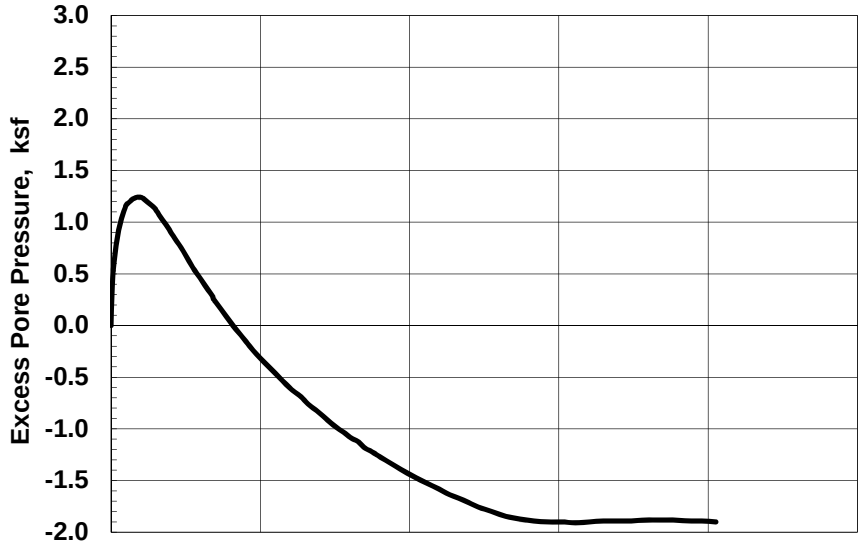
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 14.8 % Total Unit Weight: 136.1 pcf
B Coefficient: 98.67 Strain Rate: 0.021 %/min
Peak Shear Strength: 5.48 ksf @ 22.1 % Strain
Peak Effective Friction Angle: 32.7°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B001 Sample: ST-4C	November-15

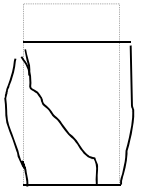


SAMPLE INFORMATION

Boring: JOP-B002 Sample: ST-3C Depth: 39.55 ft
Type: Intact tube sample
Description: CL, brown lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.00 inch Diameter: 2.88 inch Area: 6.49 in²
Water Content: 21.4 % Total Unit Weight: 127.9 pcf

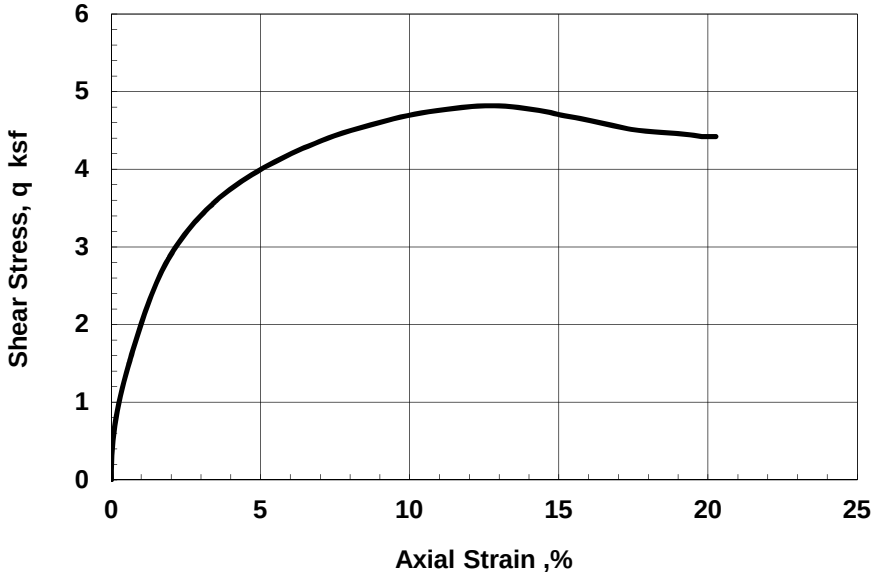


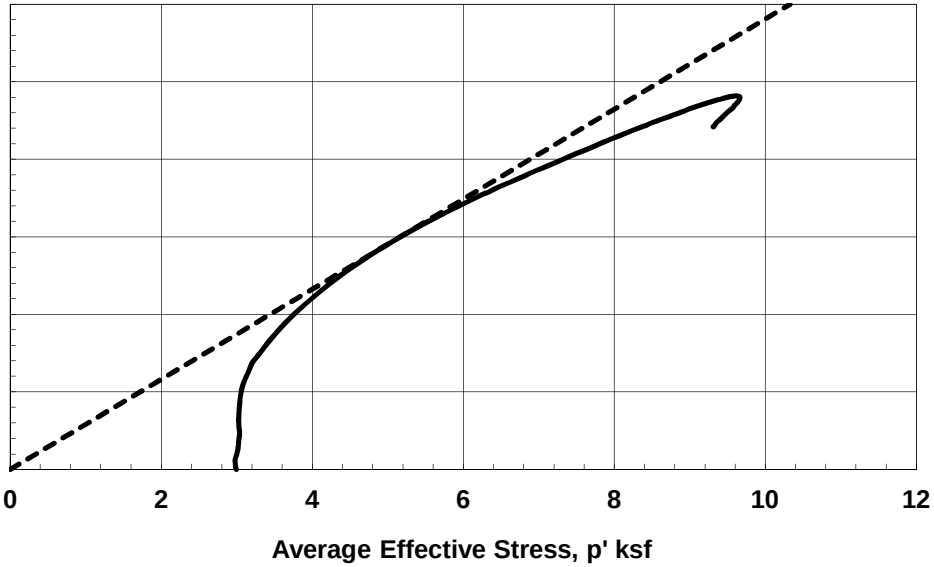
Failure Sketch

TEST SUMMARY

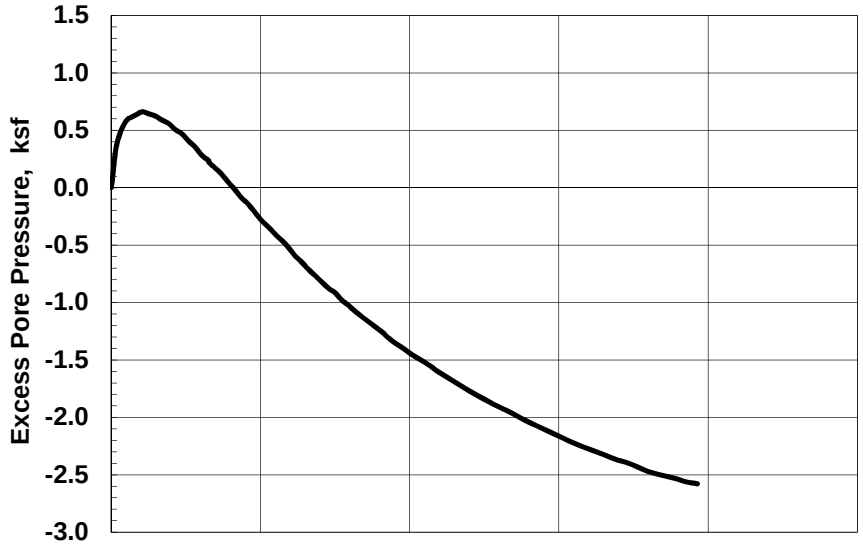
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 21.2 % Total Unit Weight: 128.4 pcf
B Coefficient: Strain Rate: 0.020 %/min
Peak Shear Strength: 4.82 ksf @ 12.8 % Strain
Peak Effective Friction Angle: 35.5°

REMARKS:





Test by: DT	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B002 Sample: ST-3C	October-15

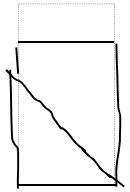


SAMPLE INFORMATION

Boring: JOP-B003 Sample: ST-2B Depth: 19.05 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 35 PL = 17 PI = 18

SPECIMEN INFORMATION (Initial)

Height: 6.19 inch Diameter: 2.86 inch Area: 6.45 in²
Water Content: 16.2 % Total Unit Weight: 126.5 pcf

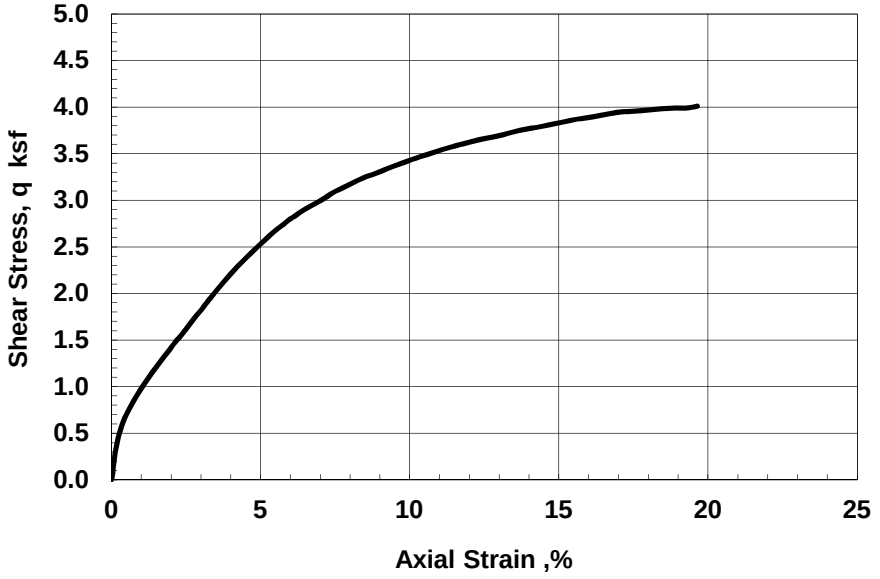


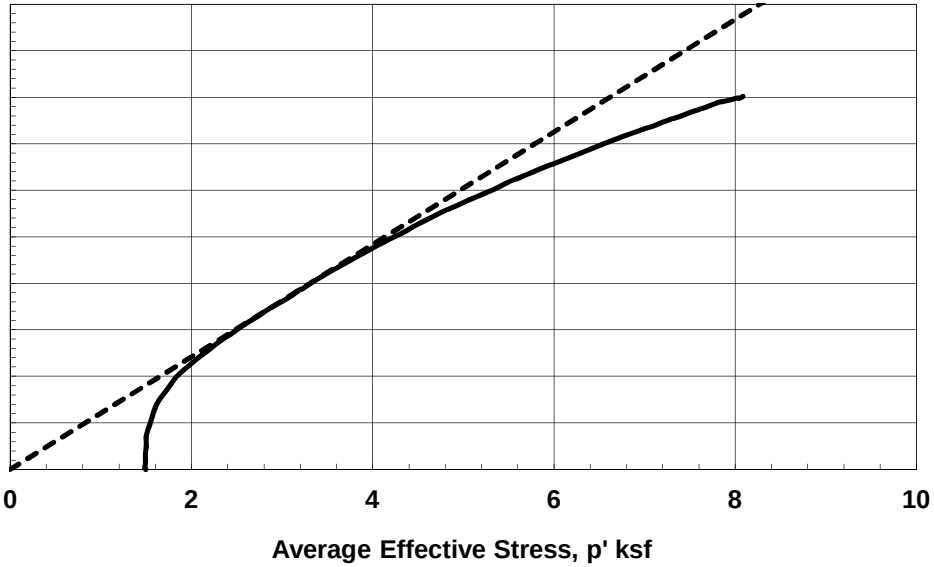
Failure Sketch

TEST SUMMARY

Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 17.2 % Total Unit Weight: 132.2 pcf
B Coefficient: Strain Rate: 0.019 %/min
Peak Shear Strength: 4.01 ksf @ 19.6 % Strain
Peak Effective Friction Angle: 37.2°

REMARKS:





Test by: DT	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B003 Sample: ST-2B	October-15

SAMPLE INFORMATION

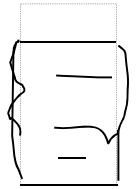
Boring: JOP-B004 Sample: ST-4C Depth: 19.6 ft
Type: Intact tube sample
Description: CL, grayish brown lean clay with fine sand
LL = 36 PL = 14 PI = 22

SPECIMEN INFORMATION (Initial)

Height: 6.01 inch Diameter: 2.88 inch Area: 6.50 in²
Water Content: 16.6 % Total Unit Weight: 133.3 pcf

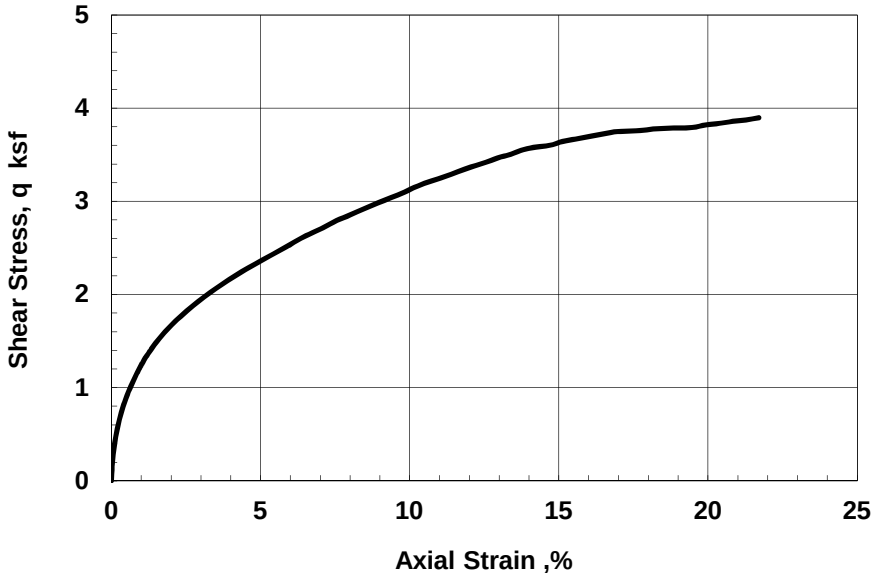
TEST SUMMARY

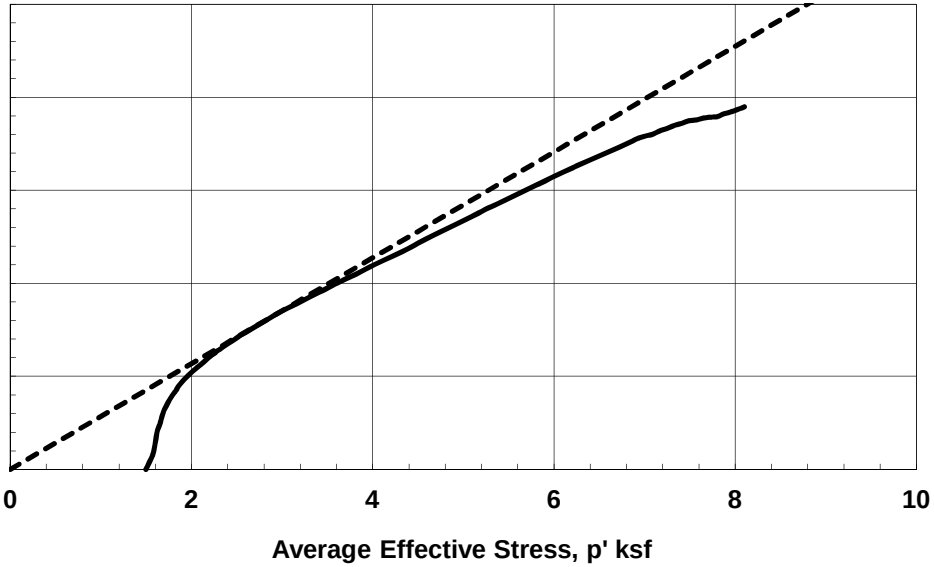
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 17.6 % Total Unit Weight: 135.8 pcf
B Coefficient: 98.98 Strain Rate: 0.022 %/min
Peak Shear Strength: 3.90 ksf @ 21.7 % Strain
Peak Effective Friction Angle: 34.6°



Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B004 Sample: ST-4C	September-15

SAMPLE INFORMATION

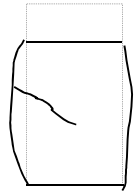
Boring: JOP-B004 Sample: ST-10C Depth: 49.7 ft
Type: Intact tube sample
Description: CL, gray / brown lean clay with fine sand
LL = 34 PL = 16 PI = 18

SPECIMEN INFORMATION (Initial)

Height: 6.04 inch Diameter: 2.87 inch Area: 6.47 in²
Water Content: 16.2 % Total Unit Weight: 133.4 pcf

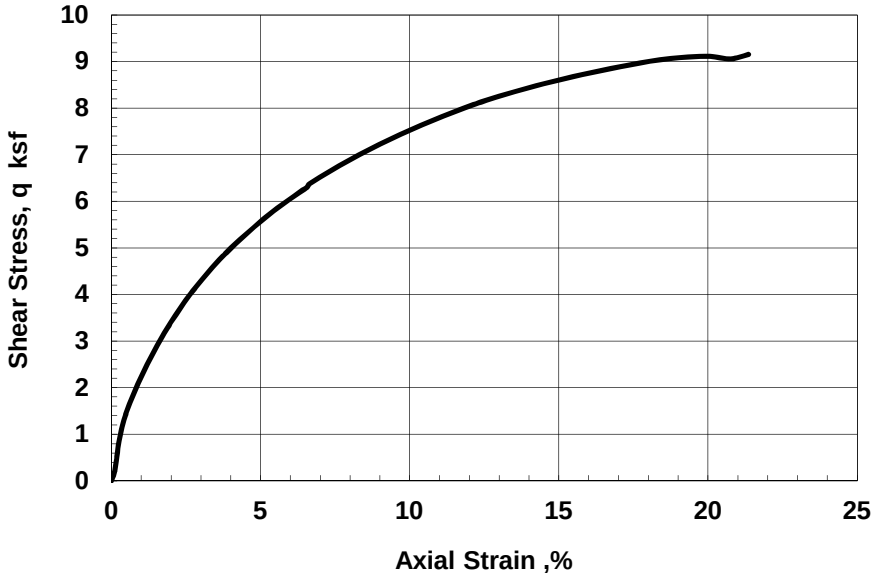
TEST SUMMARY

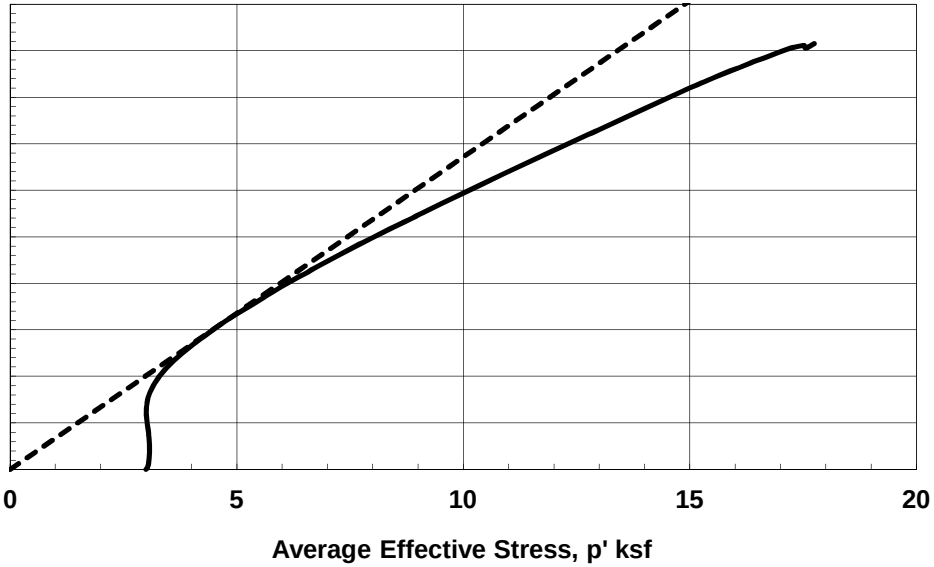
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 16.9 % Total Unit Weight: 135.7 pcf
B Coefficient: 98.68 Strain Rate: 0.021 %/min
Peak Shear Strength: 9.15 ksf @ 21.4 % Strain
Peak Effective Friction Angle: 42.2°



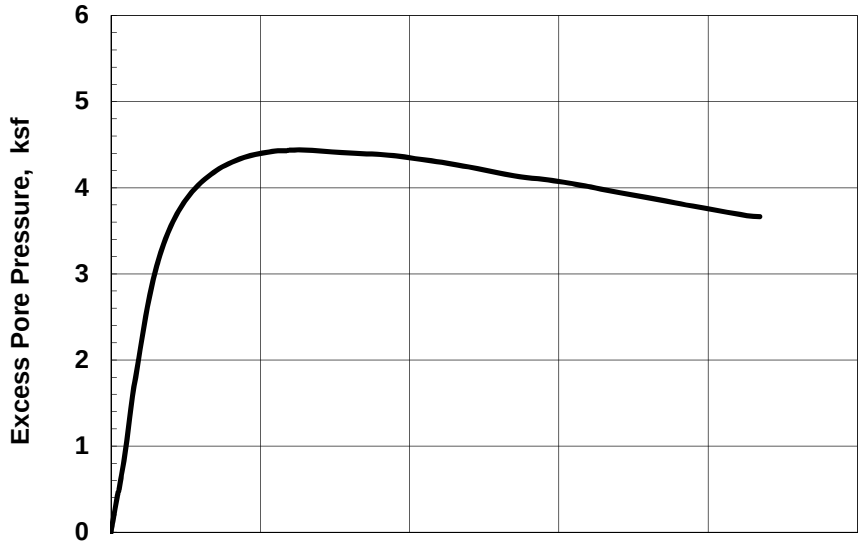
Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B004 Sample: ST-10C	September-15

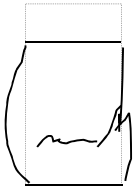


SAMPLE INFORMATION

Boring: JOP-B004 Sample: ST-12A Depth: 58.3 ft
Type: Intact tube sample
Description: CL, brown lean clay with fine sand
LL = 37 PL = 14 PI = 23

SPECIMEN INFORMATION (Initial)

Height: 6.02 inch Diameter: 2.87 inch Area: 6.46 in²
Water Content: 19.9 % Total Unit Weight: 134.6 pcf

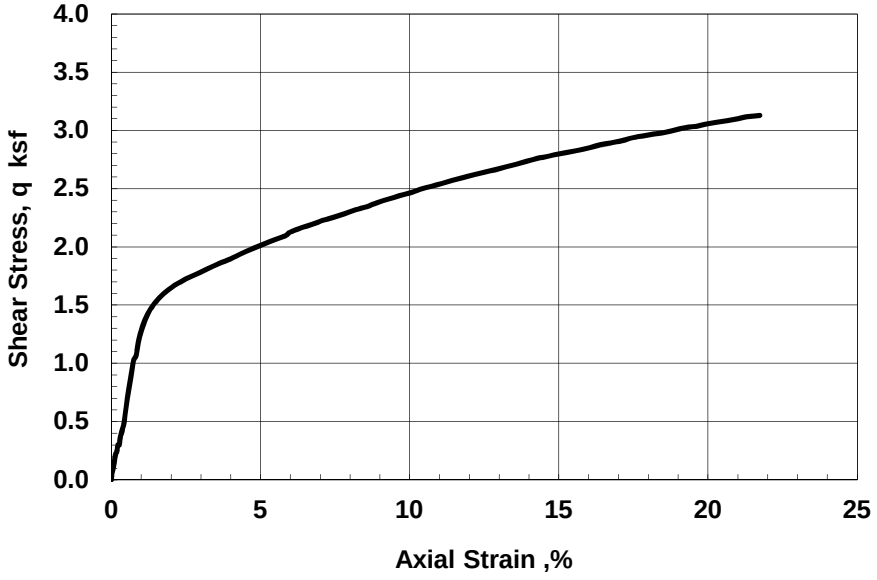


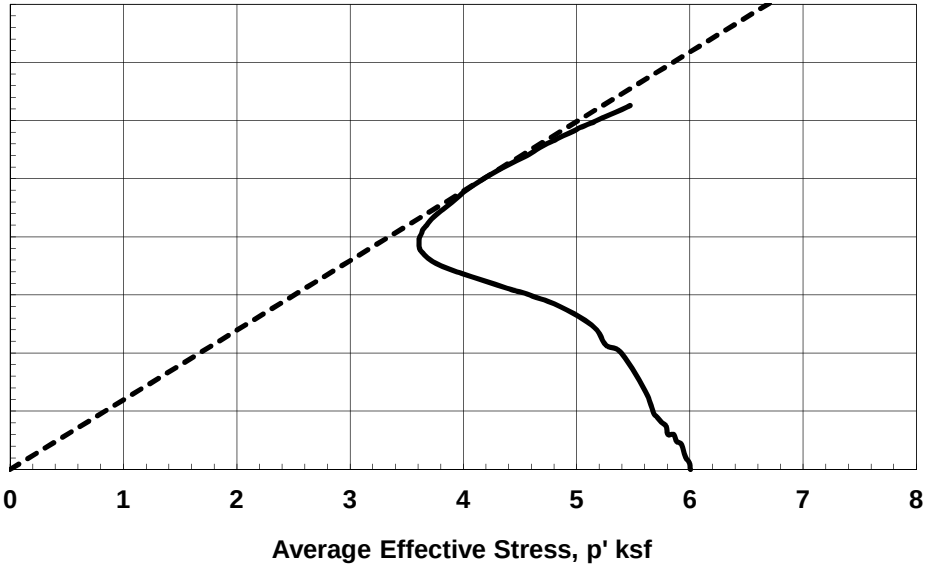
Failure Sketch

TEST SUMMARY

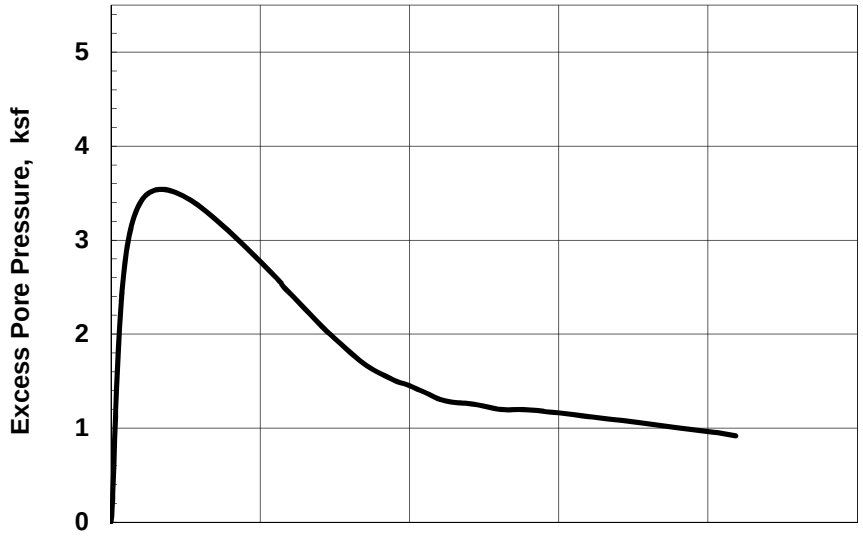
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 17.3 % Total Unit Weight: 138.2 pcf
B Coefficient: 99.65 Strain Rate: 0.023 %/min
Peak Shear Strength: 3.13 ksf @ 21.7 % Strain
Peak Effective Friction Angle: 36.7°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B004 Sample: ST-12A	September-15

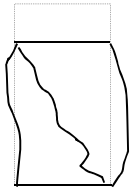


SAMPLE INFORMATION

Boring: JOP-B004 Sample: ST-14B Depth: 65.9 ft
Type: Intact tube sample
Description: CL-ML, black silty clay with sand, possible organics
LL = 25 PL = 19 PI = 6

SPECIMEN INFORMATION (Initial)

Height: 6.17 inch Diameter: 2.90 inch Area: 6.58 in²
Water Content: 22.7 % Total Unit Weight: 123.3 pcf

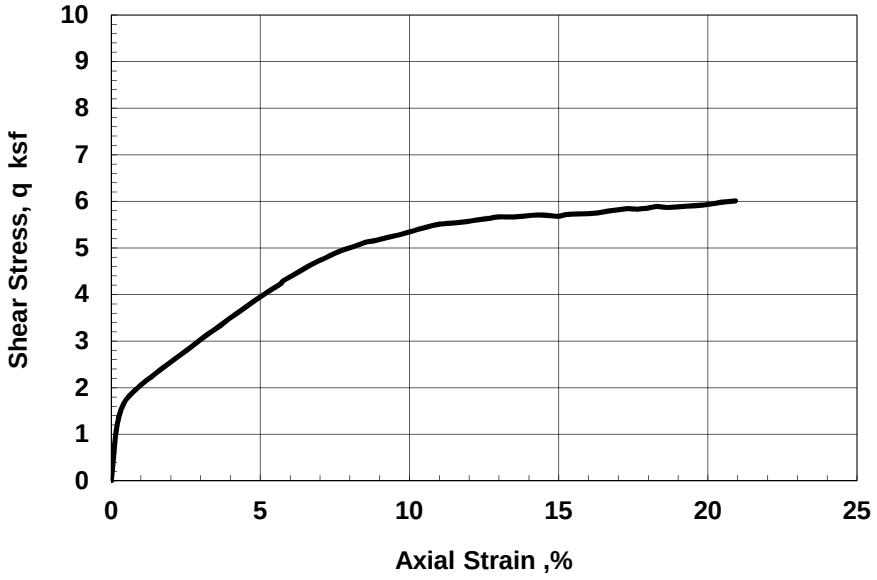


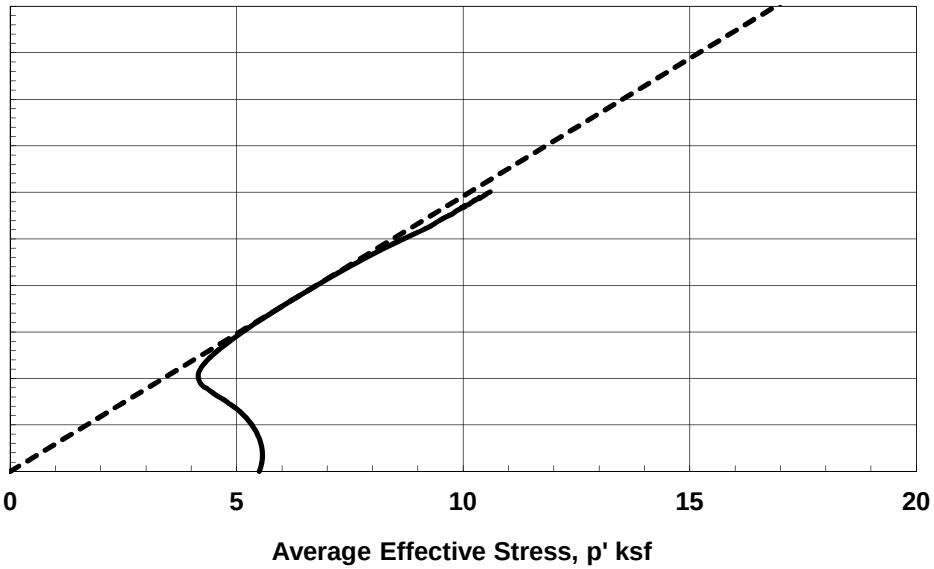
Failure Sketch

TEST SUMMARY

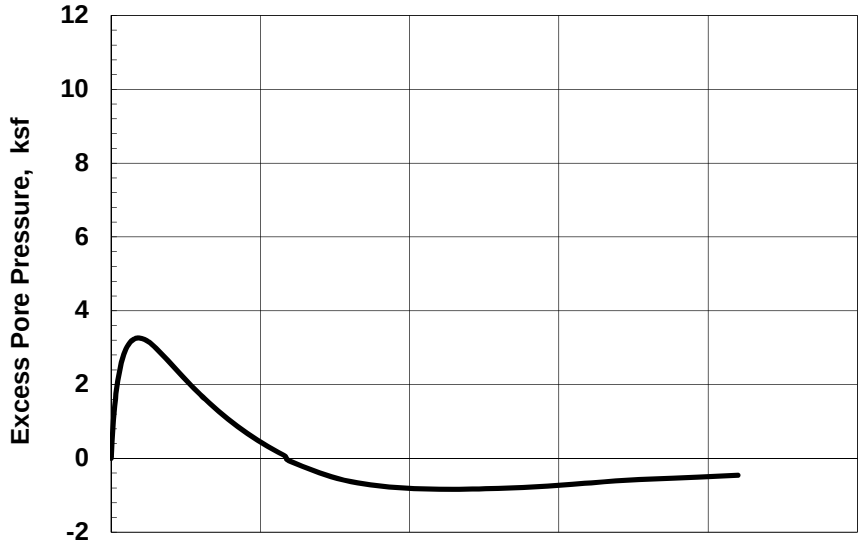
Consolidation Stresses: 5.50 ksf vertical, 5.50 ksf lateral
Water Content: 20.2 % Total Unit Weight: 127.0 pcf
B Coefficient: 99.82 Strain Rate: 0.021 %/min
Peak Shear Strength: 6.01 ksf @ 20.9 % Strain
Peak Effective Friction Angle: 36.3°

REMARKS:





Test by: NB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B004 Sample: ST-14B	December-15

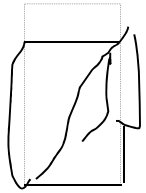


SAMPLE INFORMATION

Boring: JOP-B004 Sample: ST-16C Depth: 70.1 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 32 PL = 16 PI = 16

SPECIMEN INFORMATION (Initial)

Height: 5.99 inch Diameter: 2.86 inch Area: 6.44 in²
Water Content: 19.2 % Total Unit Weight: 131.1 pcf

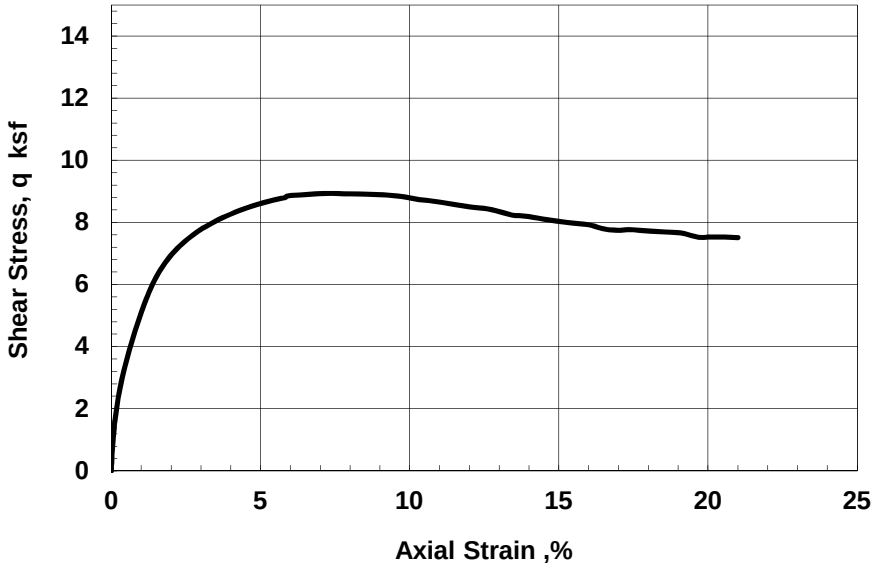


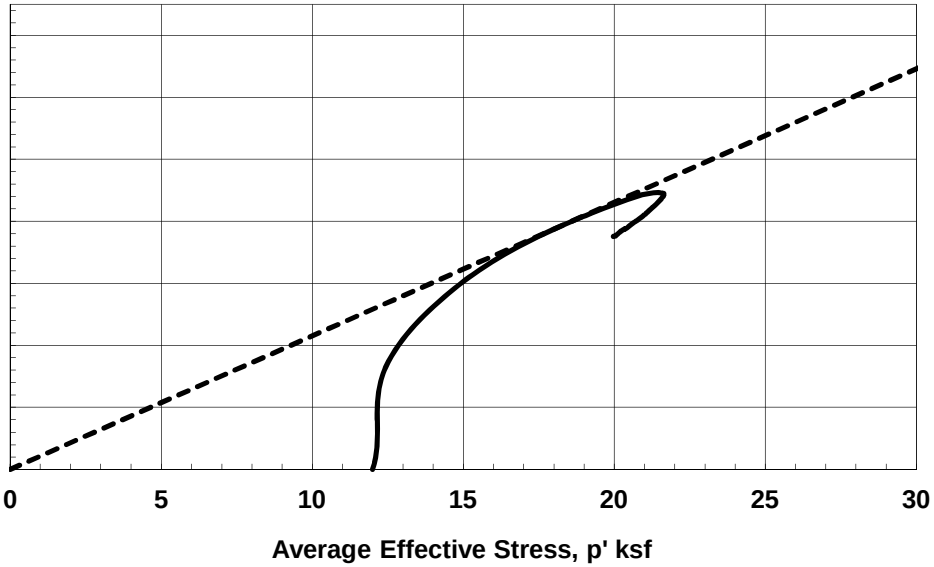
Failure Sketch

TEST SUMMARY

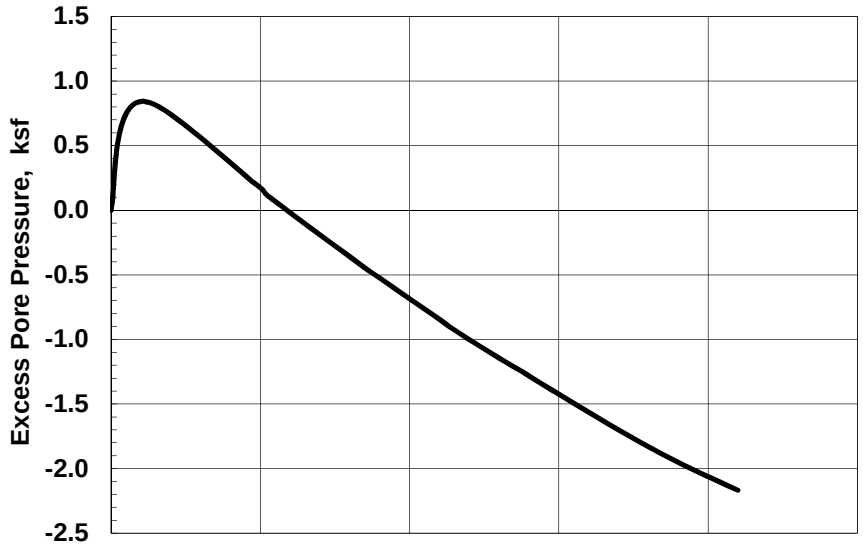
Consolidation Stresses: 12.00 ksf vertical, 12.00 ksf lateral
Water Content: 18.4 % Total Unit Weight: 134.7 pcf
B Coefficient: 99.12 Strain Rate: 0.022 %/min
Peak Shear Strength: 8.93 ksf @ 7.6 % Strain
Peak Effective Friction Angle: 25.5°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B004 Sample: ST-16C	September-15

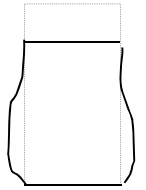


SAMPLE INFORMATION

Boring: JOP-B005 Sample: ST-2B Depth: 9 ft
Type: Intact tube sample
Description: CL, gray-brown lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.04 inch Diameter: 2.87 inch Area: 6.46 in²
Water Content: 17.7 % Total Unit Weight: 127.5 pcf

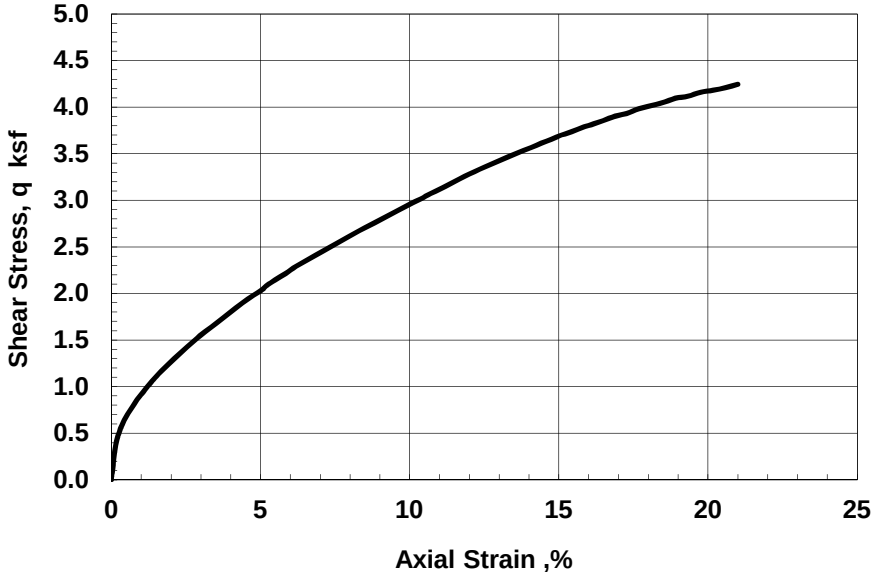


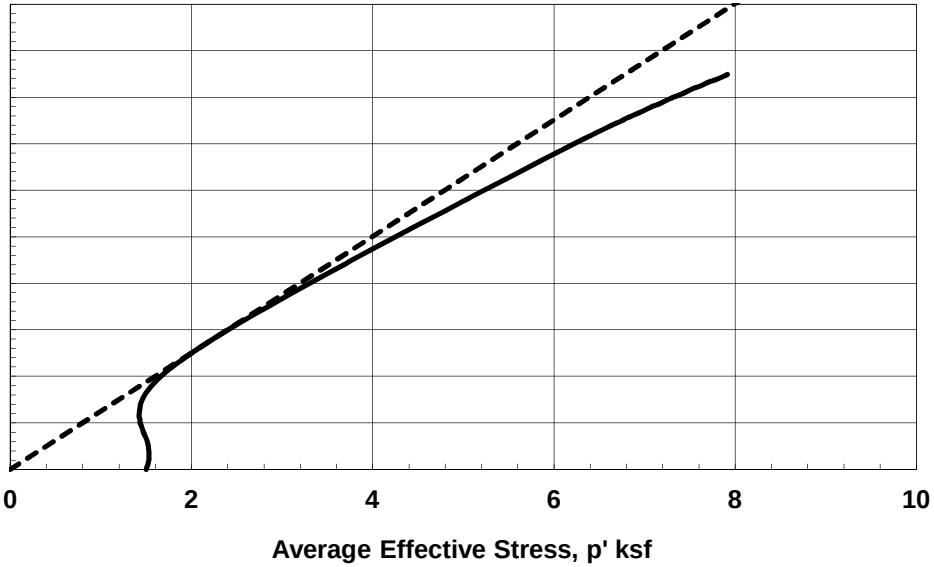
Failure Sketch

TEST SUMMARY

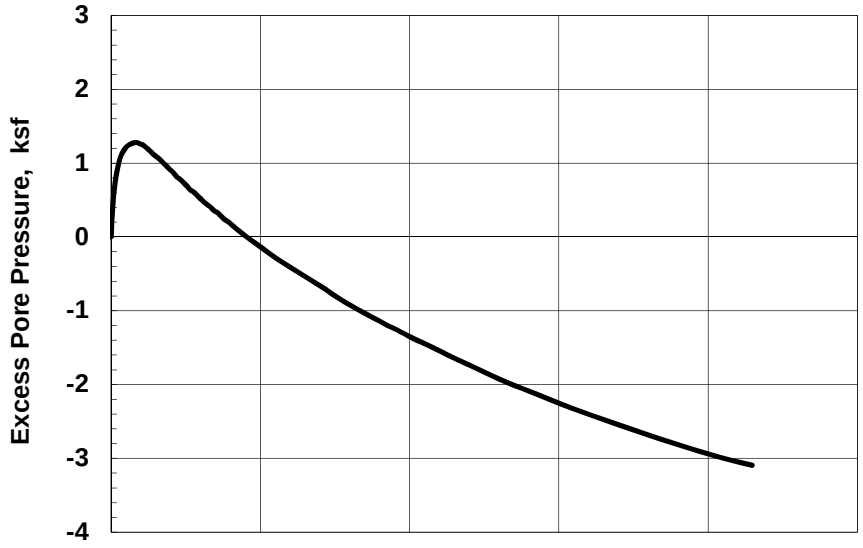
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 19.8 % Total Unit Weight: 131.3 pcf
B Coefficient: 96.42 Strain Rate: 0.021 %/min
Peak Shear Strength: 4.25 ksf @ 21.0 % Strain
Peak Effective Friction Angle: 38.8°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B005 Sample: ST-2B
			September-15

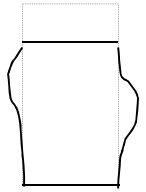


SAMPLE INFORMATION

Boring: JOP-B005 Sample: ST-4B Depth: 19.15 ft
Type: Intact tube sample
Description: CL, gray / brown lean clay
LL = 37 PL = 21 PI = 16

SPECIMEN INFORMATION (Initial)

Height: 6.03 inch Diameter: 2.86 inch Area: 6.44 in²
Water Content: 20.1 % Total Unit Weight: 129.1 pcf

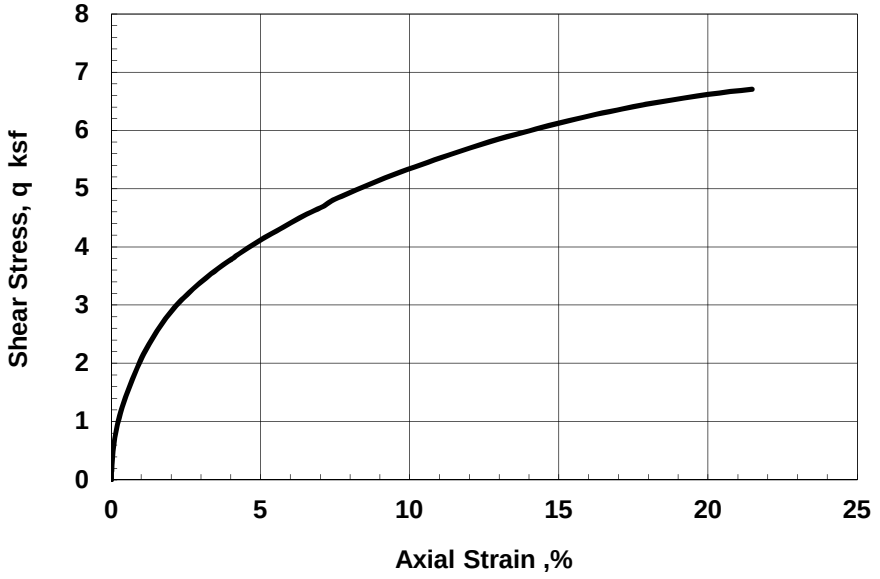


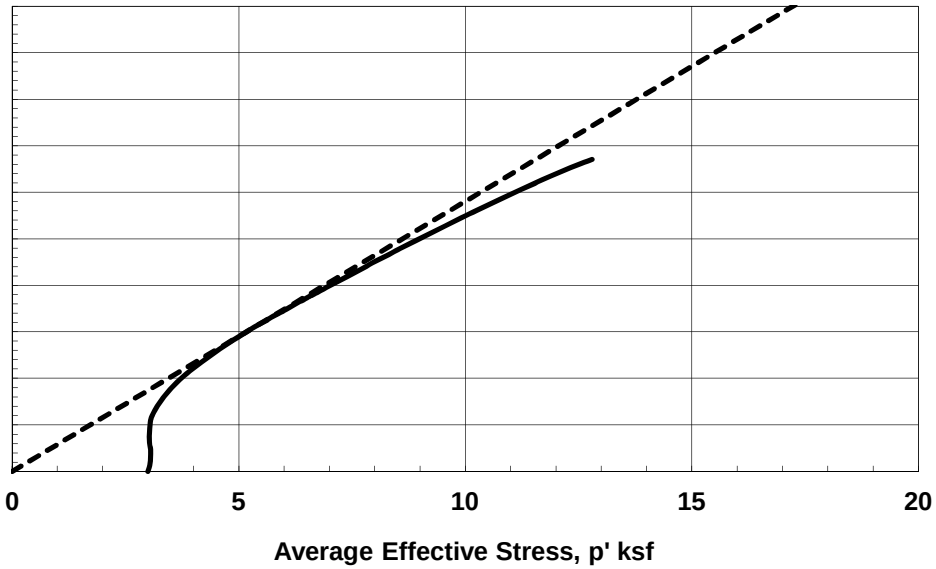
Failure Sketch

TEST SUMMARY

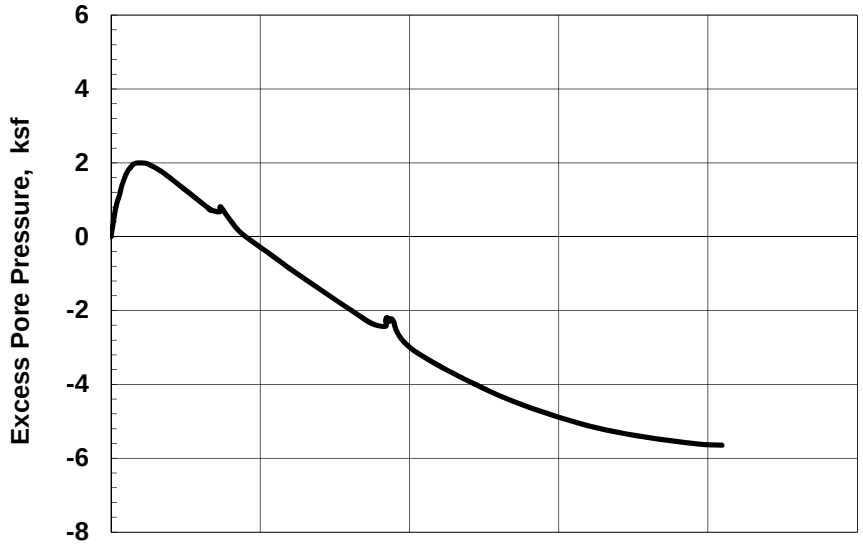
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 20.5 % Total Unit Weight: 131.4 pcf
B Coefficient: 97.22 Strain Rate: 0.023 %/min
Peak Shear Strength: 6.71 ksf @ 21.5 % Strain
Peak Effective Friction Angle: 35.5°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B005 Sample: ST-4B	September-15



SAMPLE INFORMATION

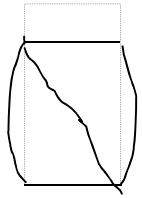
Boring: JOP-B005 Sample: ST-7B Depth: 33.9 ft
Type: Intact tube sample
Description: CL, gray and brown lean clay
LL = 38 PL = 19 PI = 19

SPECIMEN INFORMATION (Initial)

Height: 6.05 inch Diameter: 2.88 inch Area: 6.50 in²
Water Content: 18.7 % Total Unit Weight: 129.6 pcf

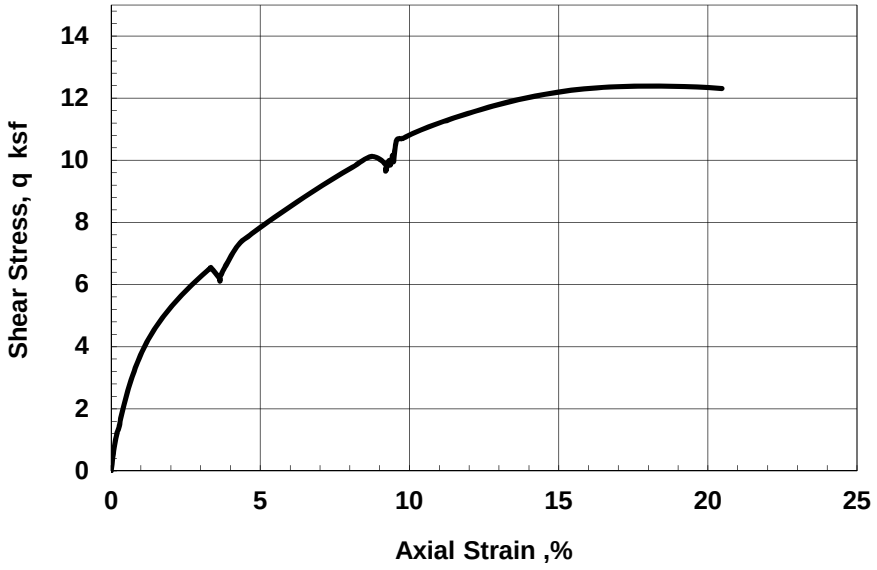
TEST SUMMARY

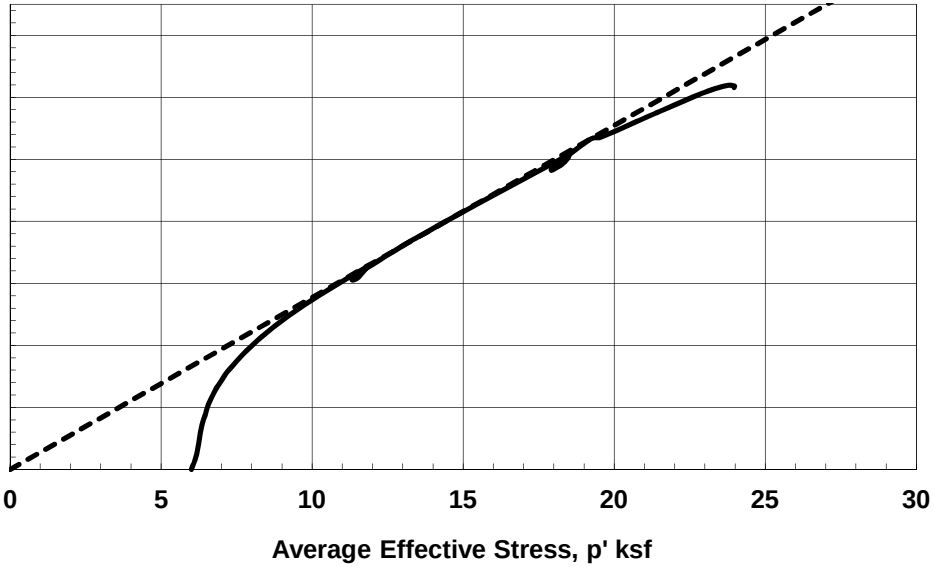
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 19.8 % Total Unit Weight: 134.1 pcf
B Coefficient: 97.32 Strain Rate: 0.010 %/min
Peak Shear Strength: 12.39 ksf @ 17.9 % Strain
Peak Effective Friction Angle: 33.7°



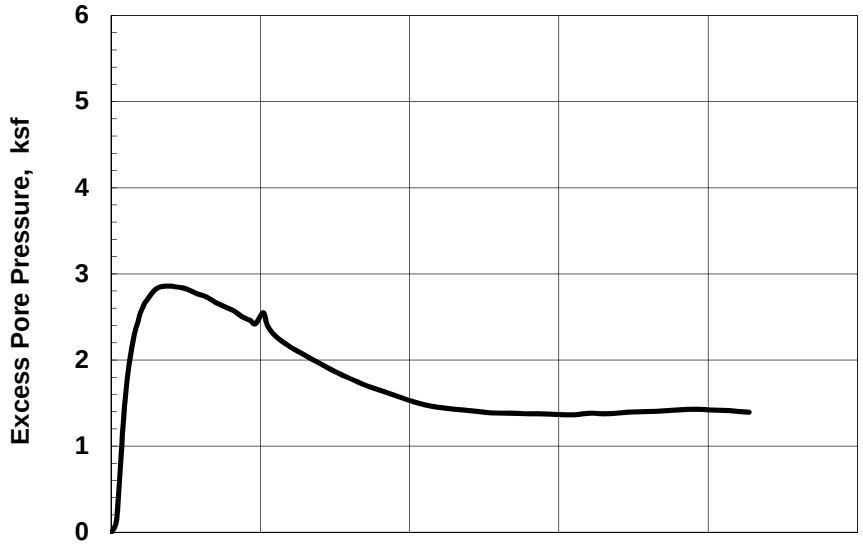
Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B005 Sample: ST-7B	November-15

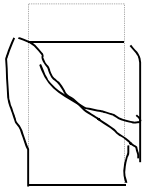


SAMPLE INFORMATION

Boring: JOP-B005 Sample: ST-10C Depth: 44.7 ft
Type: Intact tube sample
Description: CL, yellowish brown lean clay with fine sand
LL = 39 PL = 14 PI = 25

SPECIMEN INFORMATION (Initial)

Height: 6.00 inch Diameter: 2.85 inch Area: 6.40 in²
Water Content: 20.6 % Total Unit Weight: 129.4 pcf

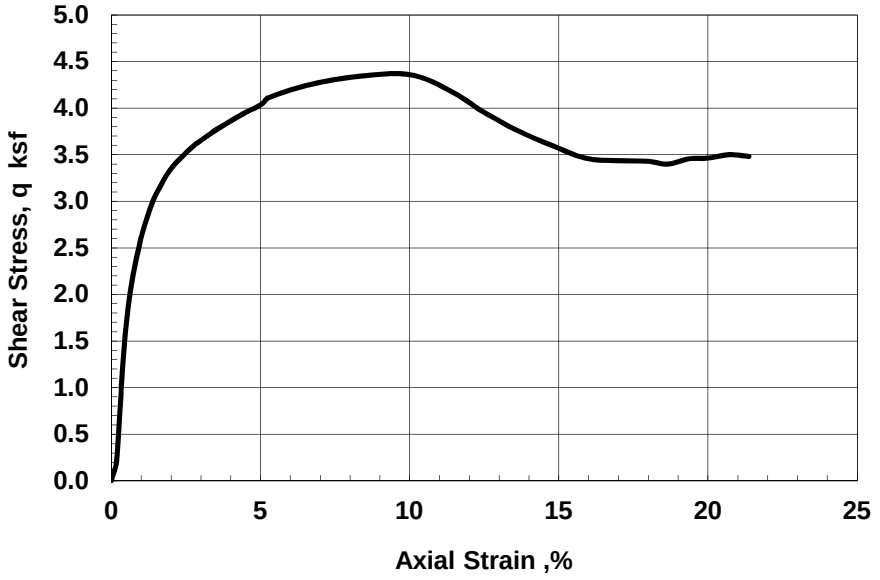


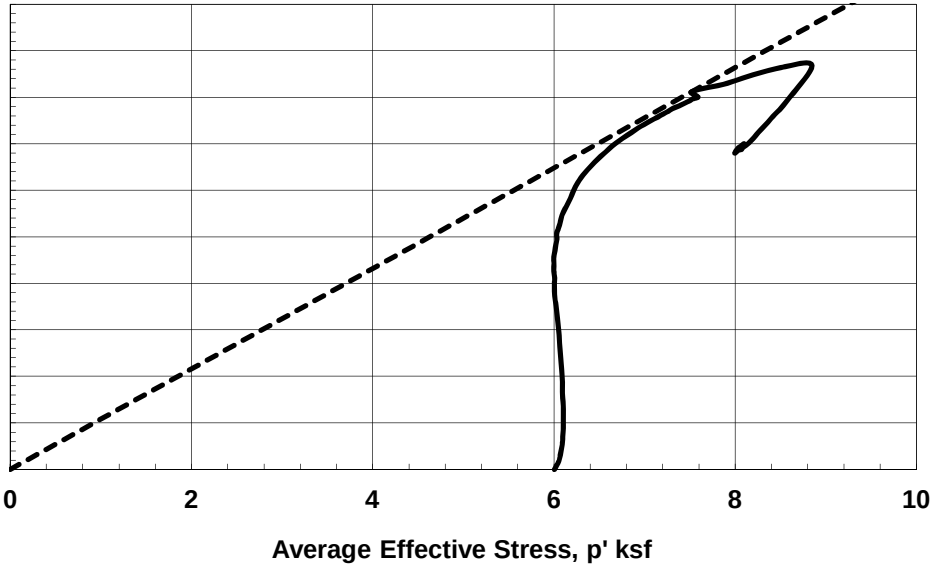
Failure Sketch

TEST SUMMARY

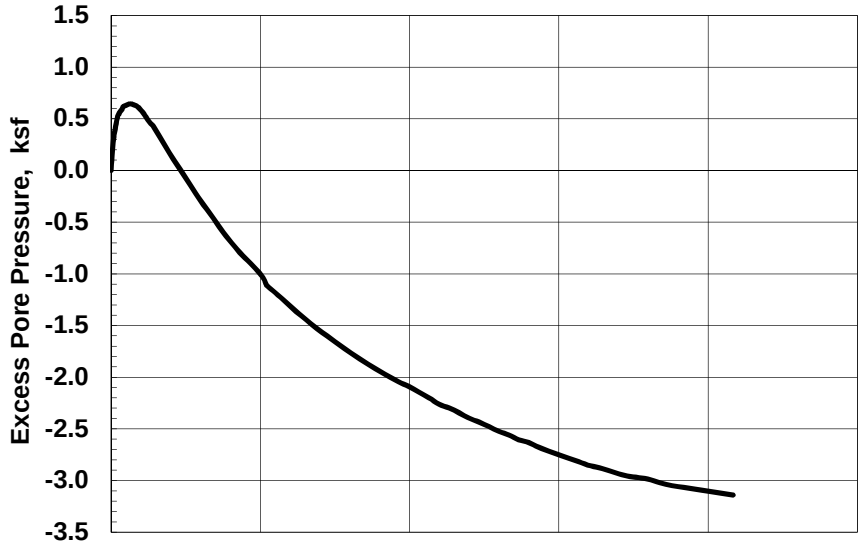
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 19.7 % Total Unit Weight: 134.8 pcf
B Coefficient: 98.69 Strain Rate: 0.008 %/min
Peak Shear Strength: 4.37 ksf @ 9.6 % Strain
Peak Effective Friction Angle: 32.7°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B005 Sample: ST-10C	September-15



SAMPLE INFORMATION

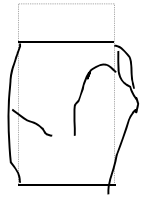
Boring: JOP-B007 Sample: ST-3C Depth: 29.6 ft
Type: Intact tube sample
Description: CL, light gray lean clay
LL = 37 PL = 15 PI = 22

SPECIMEN INFORMATION (Initial)

Height: 6.06 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 18.7 % Total Unit Weight: 129.8 pcf

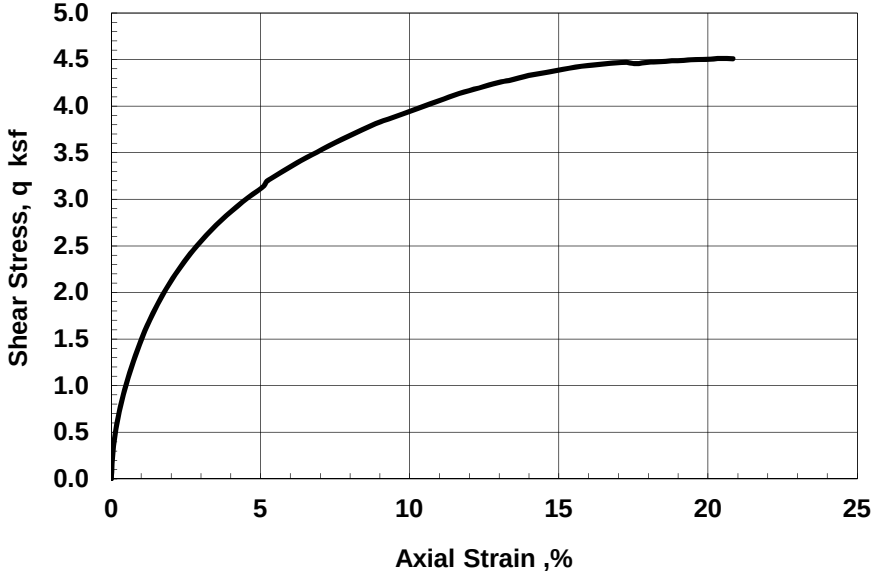
TEST SUMMARY

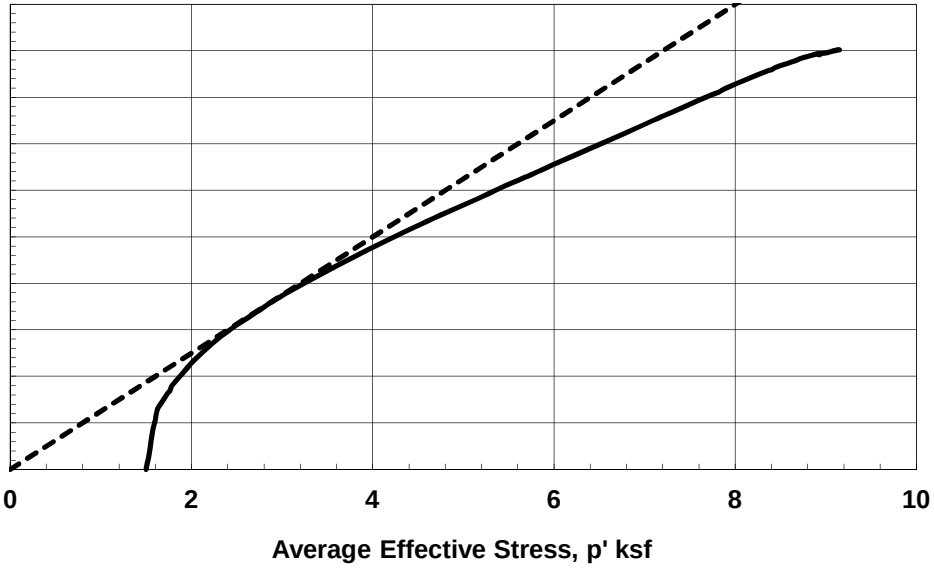
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 19.3 % Total Unit Weight: 132.5 pcf
B Coefficient: 99.68 Strain Rate: 0.021 %/min
Peak Shear Strength: 4.51 ksf @ 20.4 % Strain
Peak Effective Friction Angle: 38.7°



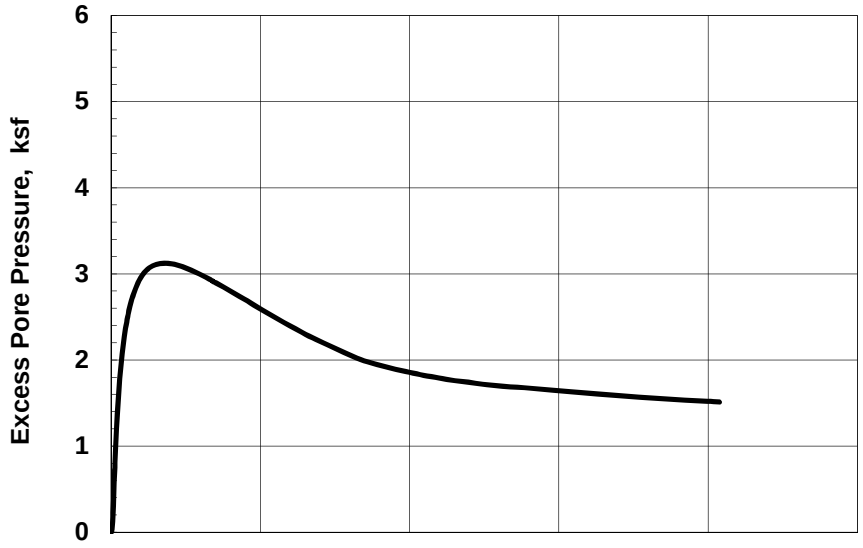
Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B007 Sample: ST-3C	September-15

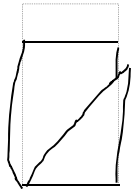


SAMPLE INFORMATION

Boring: JOP-B008 Sample: ST-5C Depth: 64.75 ft
Type: Intact tube sample
Description: CL, light brown lean clay

SPECIMEN INFORMATION (Initial)

Height: 5.99 inch Diameter: 2.86 inch Area: 6.43 in²
Water Content: 19.3 % Total Unit Weight: 130.1 pcf

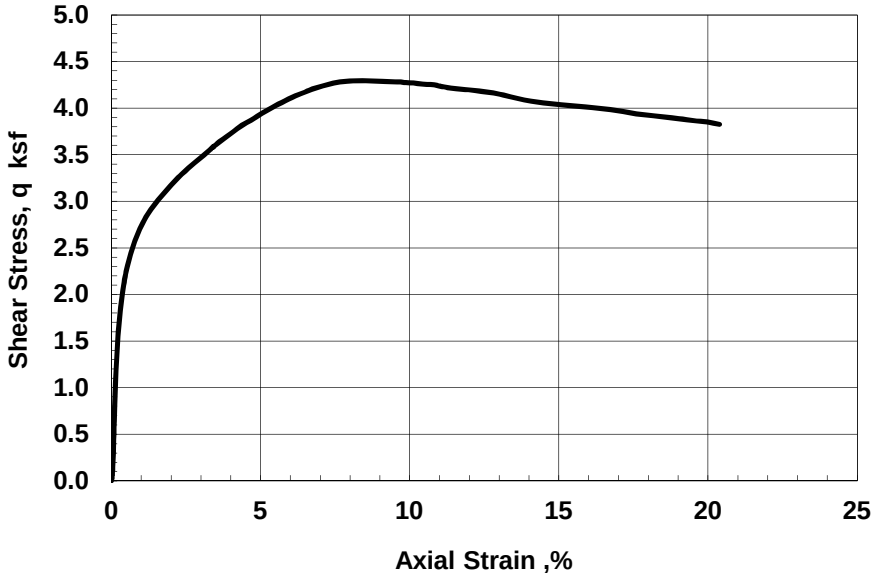


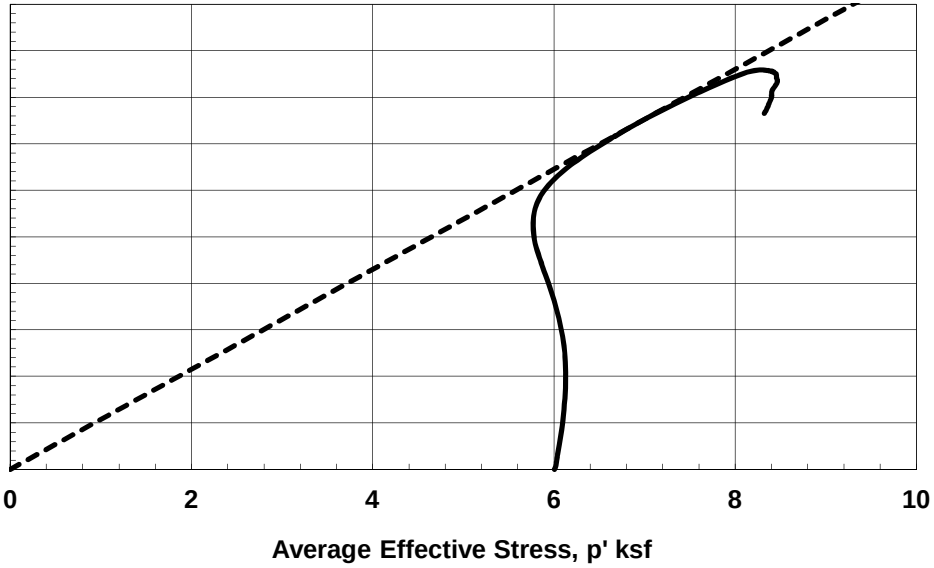
Failure Sketch

TEST SUMMARY

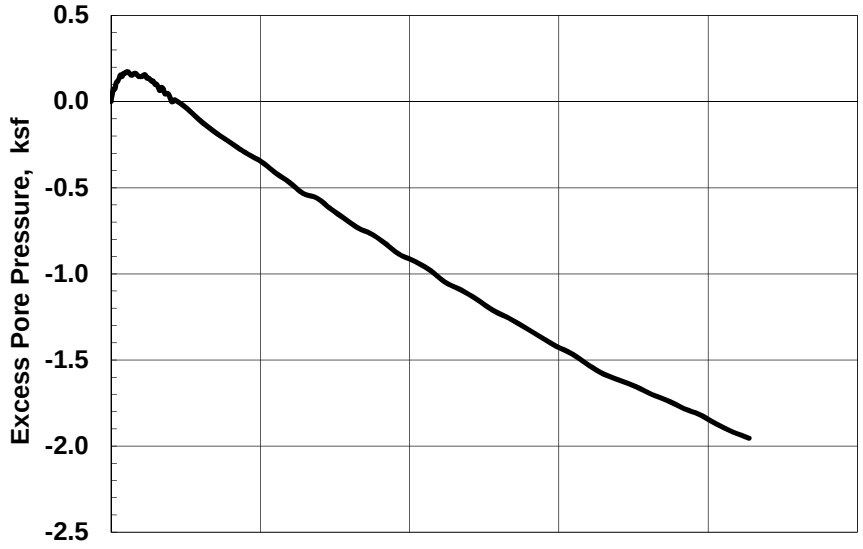
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 18.5 % Total Unit Weight: 132.6 pcf
B Coefficient: Strain Rate: 0.019 %/min
Peak Shear Strength: 4.30 ksf @ 8.2 % Strain
Peak Effective Friction Angle: 32.5°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B008 Sample: ST-5C	October-15

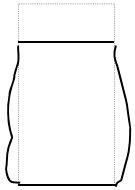


SAMPLE INFORMATION

Boring: JOP-B009 Sample: ST-3B Depth: 13.8 ft
Type: Intact tube sample
Description: CL, brown lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.01 inch Diameter: 2.88 inch Area: 6.53 in²
Water Content: 16.9 % Total Unit Weight: 134.2 pcf

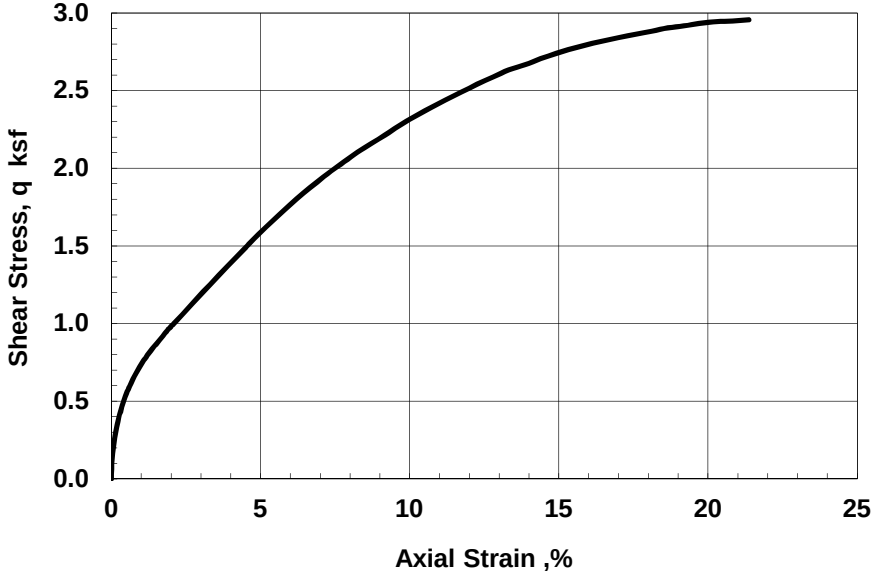


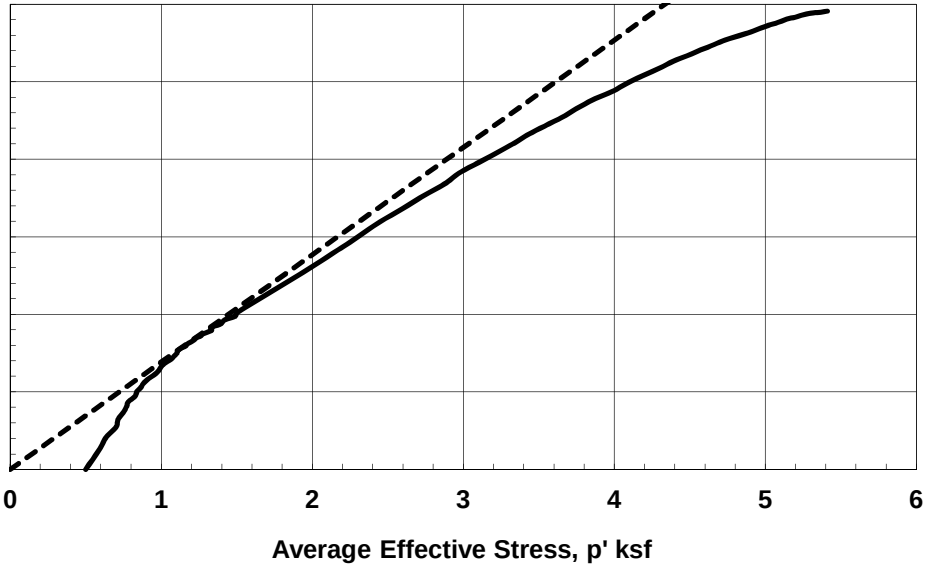
Failure Sketch

TEST SUMMARY

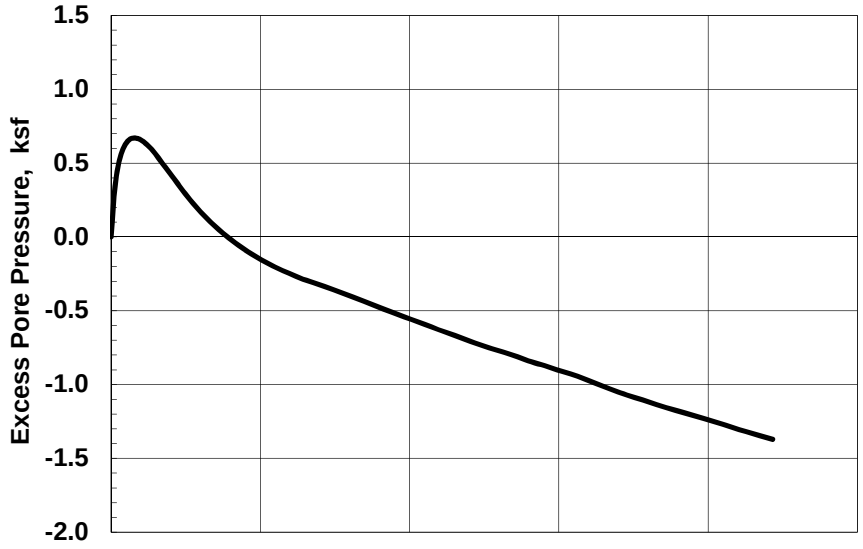
Consolidation Stresses: 0.50 ksf vertical, 0.50 ksf lateral
Water Content: 17.5 % Total Unit Weight: 135.5 pcf
B Coefficient: 99.87 Strain Rate: 0.023 %/min
Peak Shear Strength: 2.96 ksf @ 21.4 % Strain
Peak Effective Friction Angle: 43.8°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B009 Sample: ST-3B	September-15

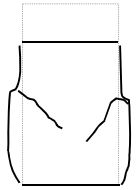


SAMPLE INFORMATION

Boring: JOP-B009 Sample: ST-3C Depth: 14.35 ft
Type: Intact tube sample
Description: CL, brown sandy lean clay
LL = 34 PL = 14 PI = 20

SPECIMEN INFORMATION (Initial)

Height: 6.02 inch Diameter: 2.87 inch Area: 6.46 in²
Water Content: 15.5 % Total Unit Weight: 134.9 pcf

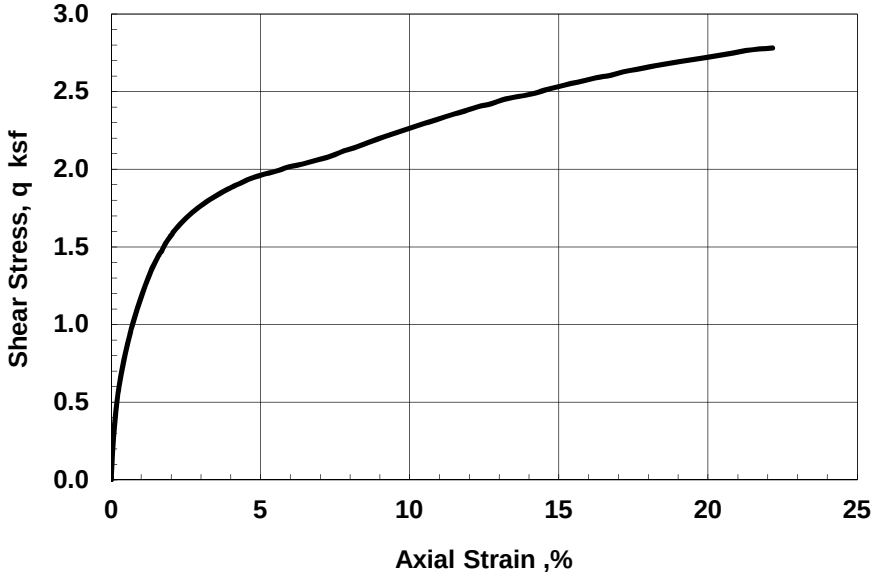


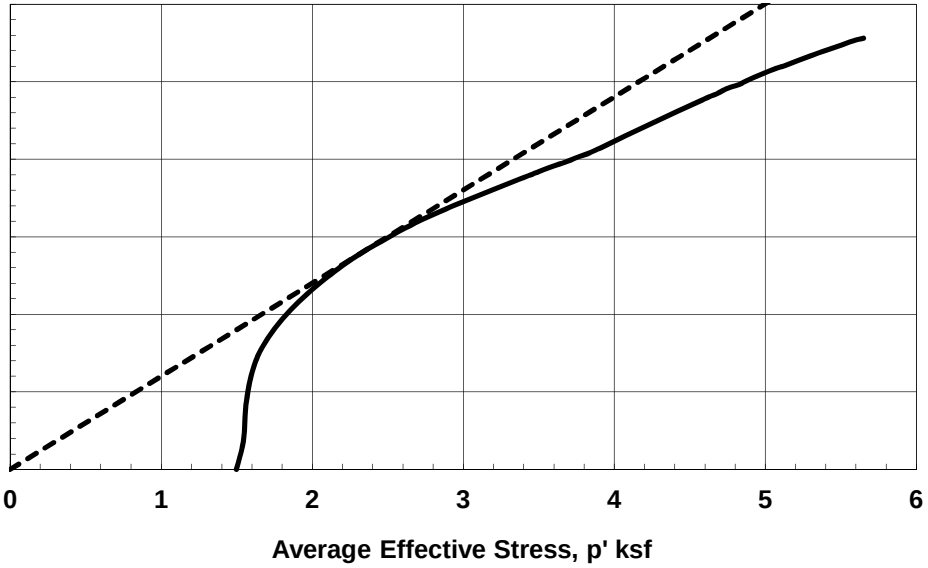
Failure Sketch

TEST SUMMARY

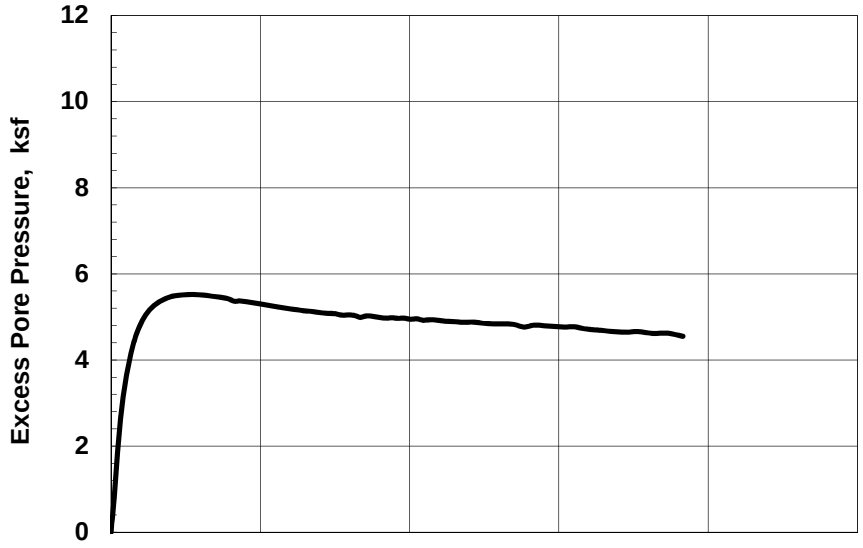
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 16.4 % Total Unit Weight: 137.4 pcf
B Coefficient: Strain Rate: 0.022 %/min
Peak Shear Strength: 2.78 ksf @ 22.2 % Strain
Peak Effective Friction Angle: 36.9°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B009 Sample: ST-3C	September-15

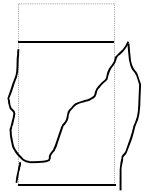


SAMPLE INFORMATION

Boring: JOP-B009 Sample: ST-14C Depth: 64.85 ft
Type: Intact tube sample
Description: CL, gray sandy lean clay
LL = 27 PL = 10 PI = 17

SPECIMEN INFORMATION (Initial)

Height: 6.04 inch Diameter: 2.88 inch Area: 6.50 in²
Water Content: 17.8 % Total Unit Weight: 130.6 pcf

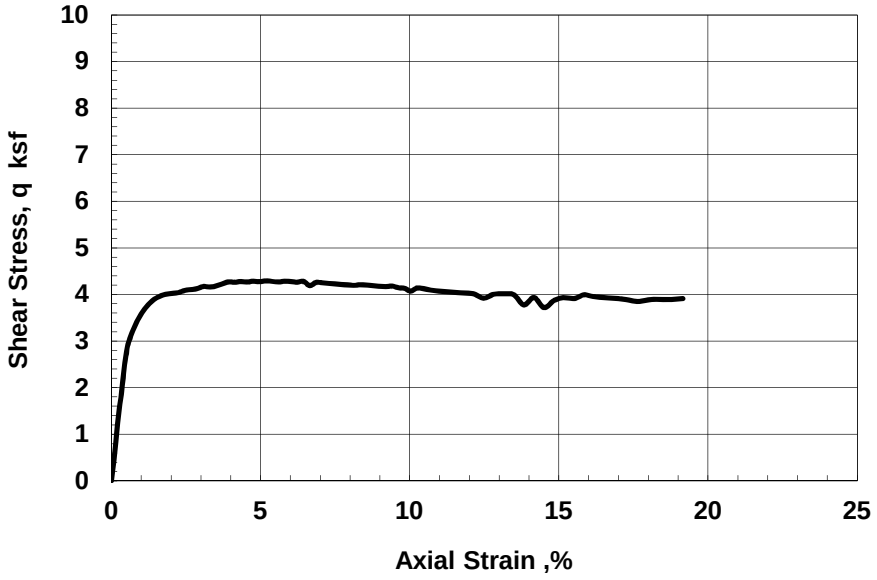


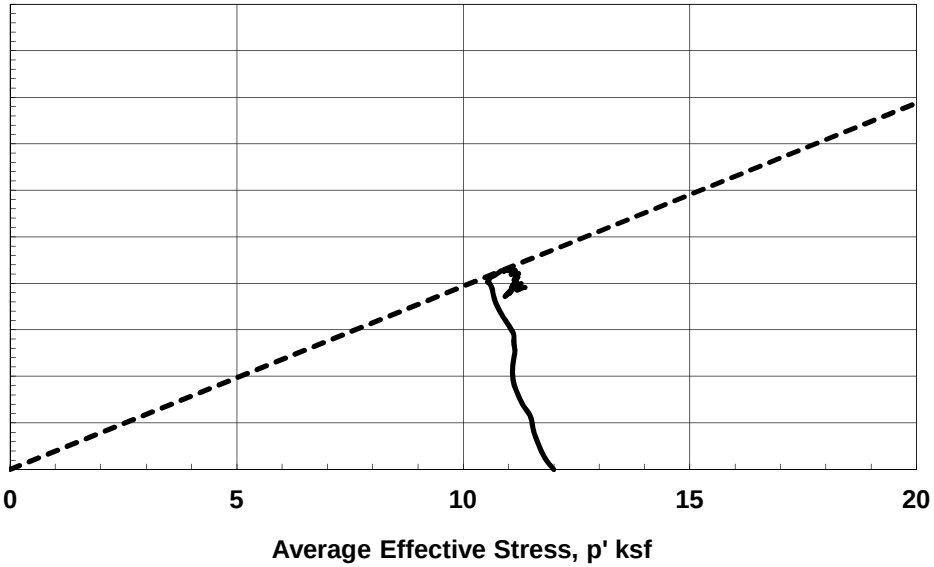
Failure Sketch

TEST SUMMARY

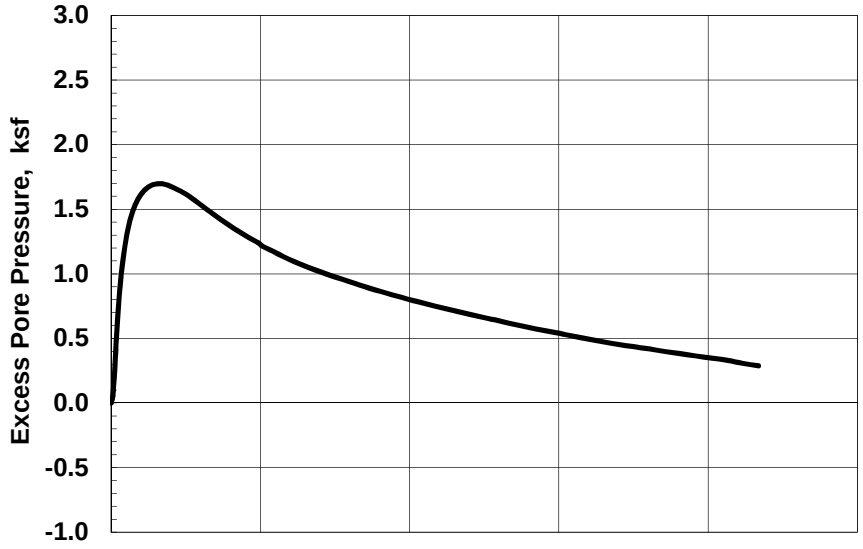
Consolidation Stresses: 12.00 ksf vertical, 12.00 ksf lateral
Water Content: 17.4 % Total Unit Weight: 134.2 pcf
B Coefficient: 97.68 Strain Rate: 0.021 %/min
Peak Shear Strength: 4.29 ksf @ 5.2 % Strain
Peak Effective Friction Angle: 23.2°

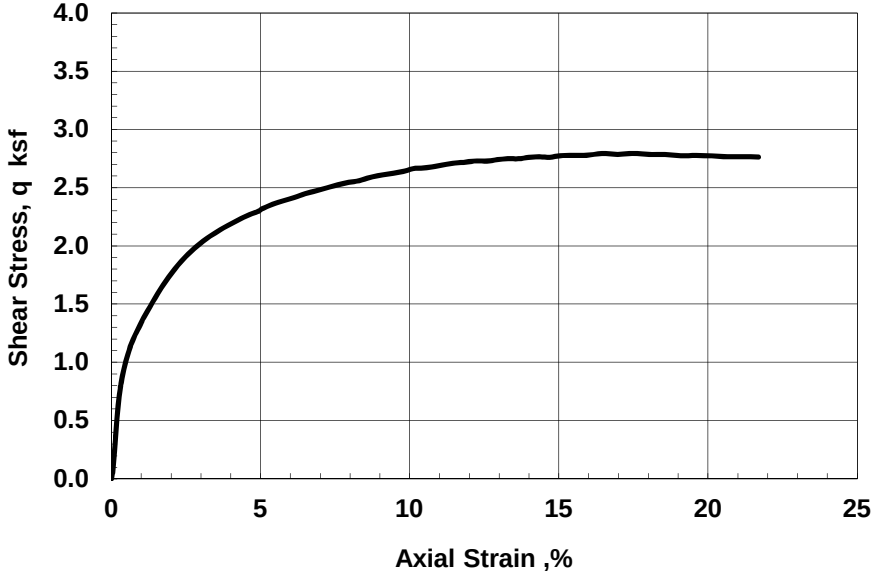
REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B009 Sample: ST-14C	September-15





SAMPLE INFORMATION

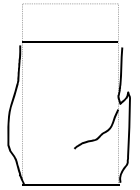
Boring: JOP-B010 Sample: ST-3D Depth: 35.35 ft
Type: Intact tube sample
Description: CL, brown sandy lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.04 inch Diameter: 2.88 inch Area: 6.51 in²
Water Content: 16.7 % Total Unit Weight: 132.9 pcf

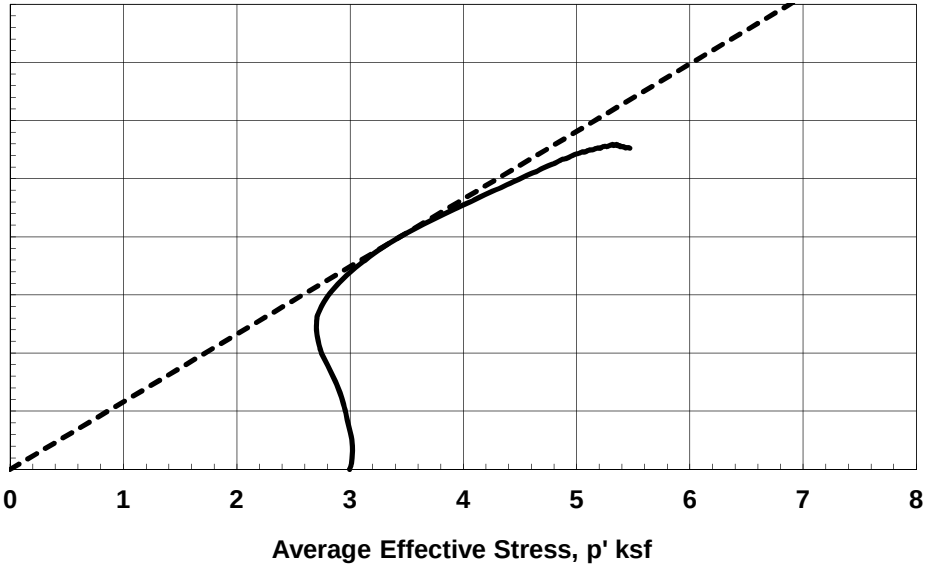
TEST SUMMARY

Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 16.6 % Total Unit Weight: 135.4 pcf
B Coefficient: 95.62 Strain Rate: 0.022 %/min
Peak Shear Strength: 2.79 ksf @ 17.5 % Strain
Peak Effective Friction Angle: 35.5°

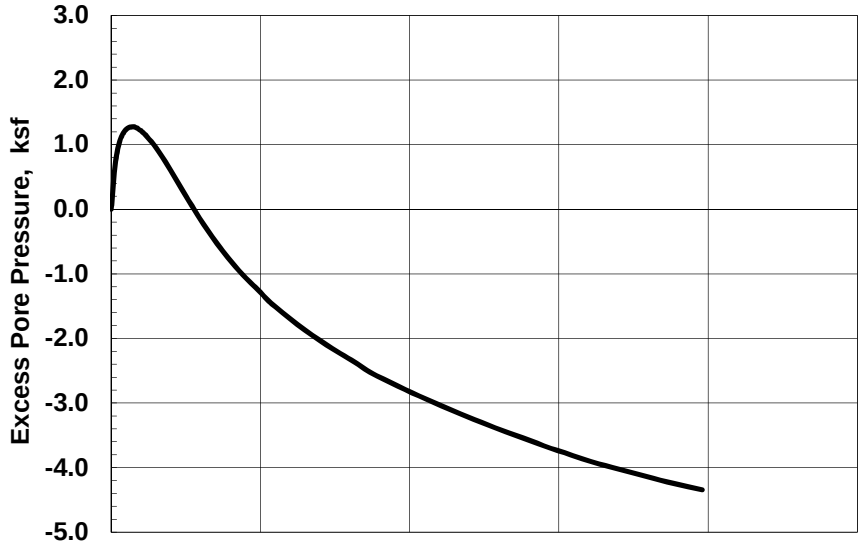


Failure Sketch

REMARKS:



Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B010 Sample: ST-3D — September-15

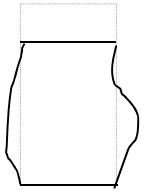


SAMPLE INFORMATION

Boring: JOP-B011 Sample: ST-5C Depth: 24.25 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 33 PL = 18 PI = 15

SPECIMEN INFORMATION (Initial)

Height: 6.03 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 18.0 % Total Unit Weight: 129.4 pcf

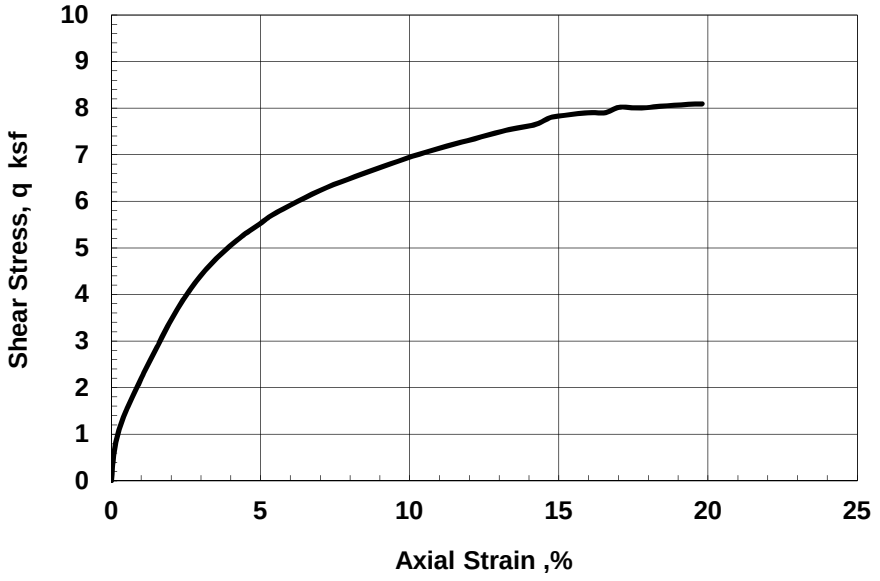


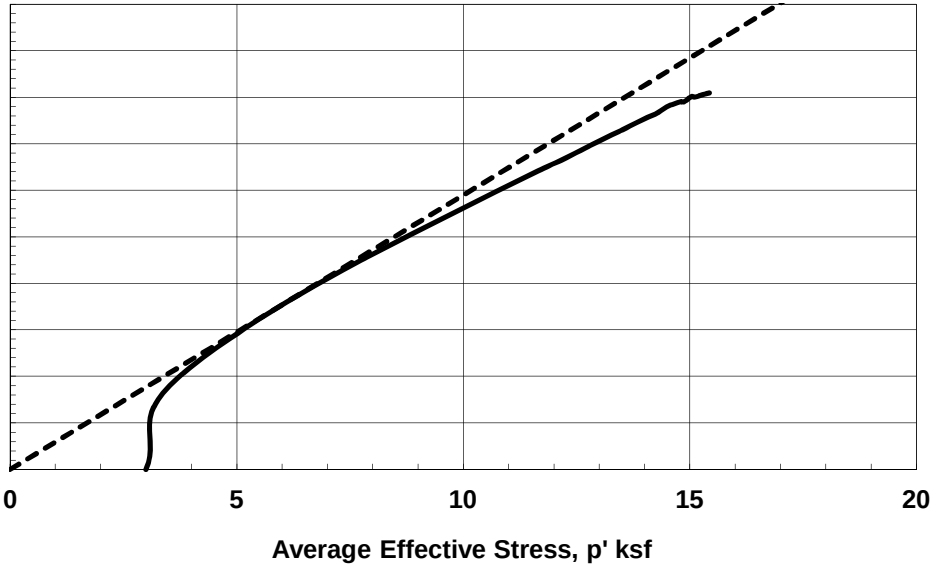
Failure Sketch

TEST SUMMARY

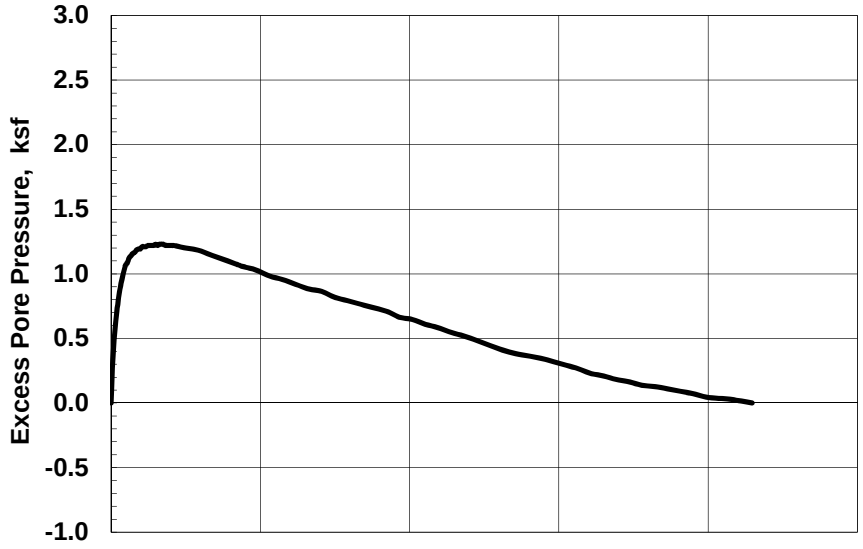
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 19.2 % Total Unit Weight: 133.3 pcf
B Coefficient: 99.72 Strain Rate: 0.020 %/min
Peak Shear Strength: 8.09 ksf @ 19.8 % Strain
Peak Effective Friction Angle: 36.1°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B011 Sample: ST-5C	September-15

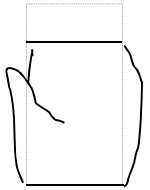


SAMPLE INFORMATION

Boring: JOP-B011 Sample: ST-9C Depth: 44.8 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 36 PL = 14 PI = 22

SPECIMEN INFORMATION (Initial)

Height: 6.03 inch Diameter: 2.87 inch Area: 6.47 in²
Water Content: 18.3 % Total Unit Weight: 128.9 pcf

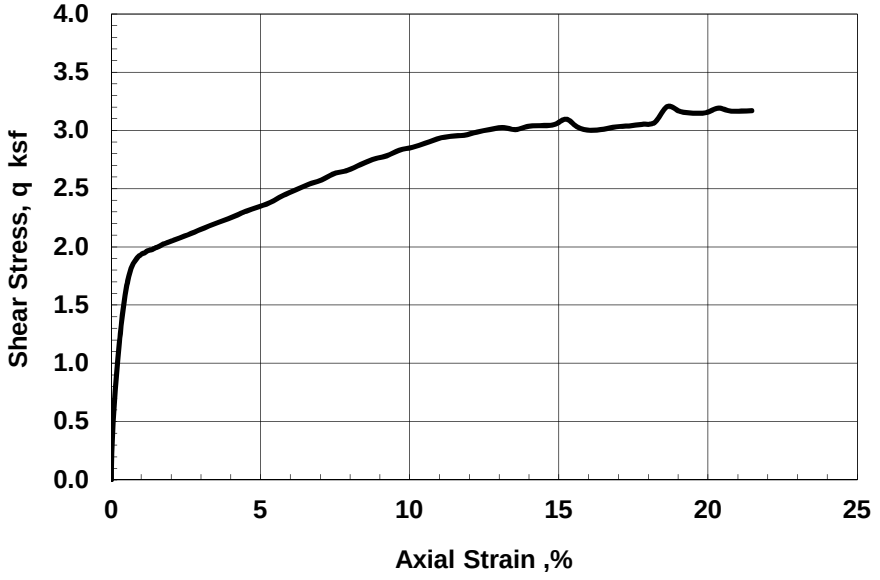


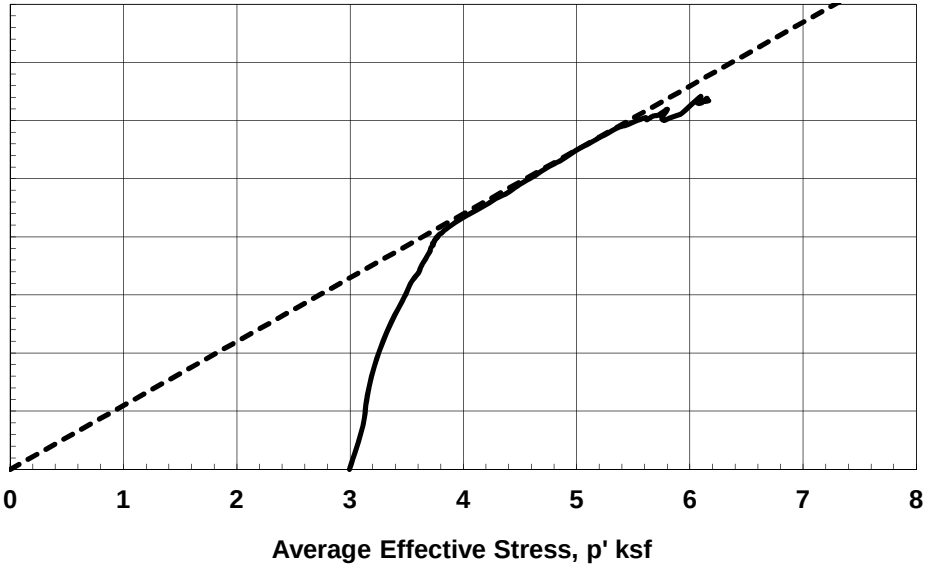
Failure Sketch

TEST SUMMARY

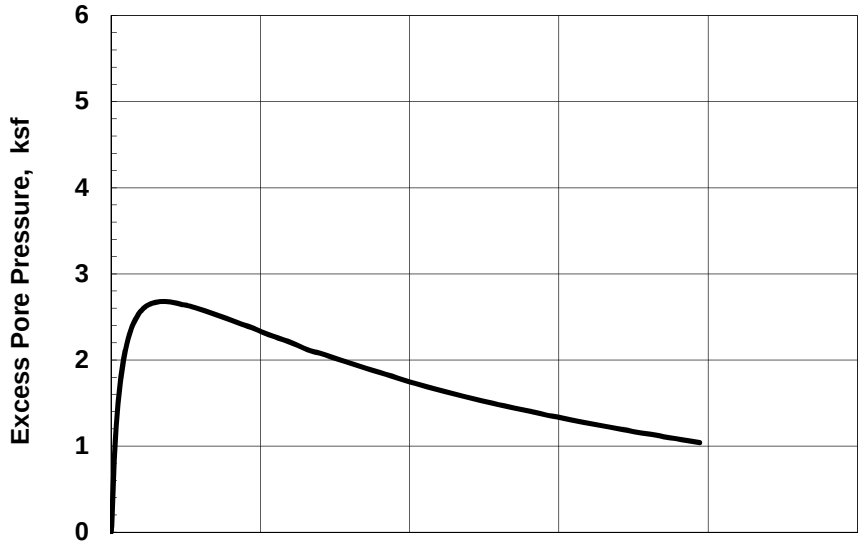
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 19.4 % Total Unit Weight: 133.7 pcf
B Coefficient: 99.25 Strain Rate: 0.022 %/min
Peak Shear Strength: 3.21 ksf @ 18.6 % Strain
Peak Effective Friction Angle: 33.3°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B011 Sample: ST-9C
			September-15

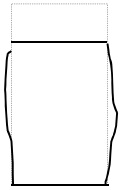


SAMPLE INFORMATION

Boring: JOP-B012 Sample: ST-3C Depth: 16.45 ft
Type: Intact tube sample
Description: CL, gray lean clay with fine sand
LL = 37 PL = 13 PI = 24

SPECIMEN INFORMATION (Initial)

Height: 6.03 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 17.4 % Total Unit Weight: 131.9 pcf

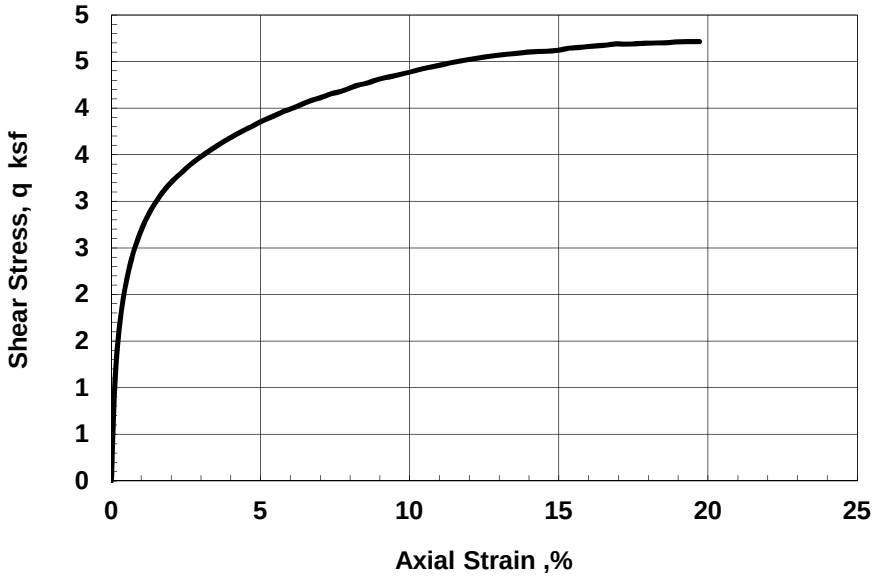


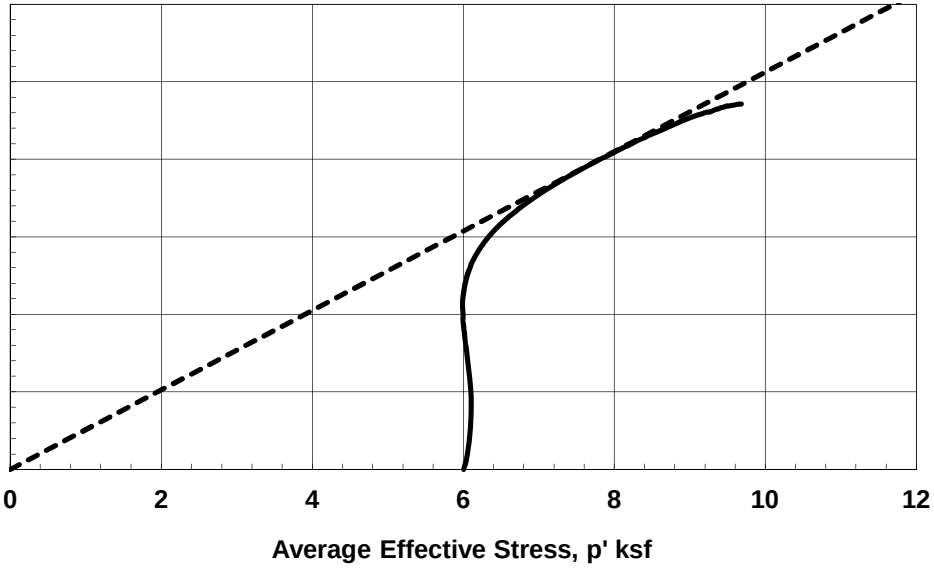
Failure Sketch

TEST SUMMARY

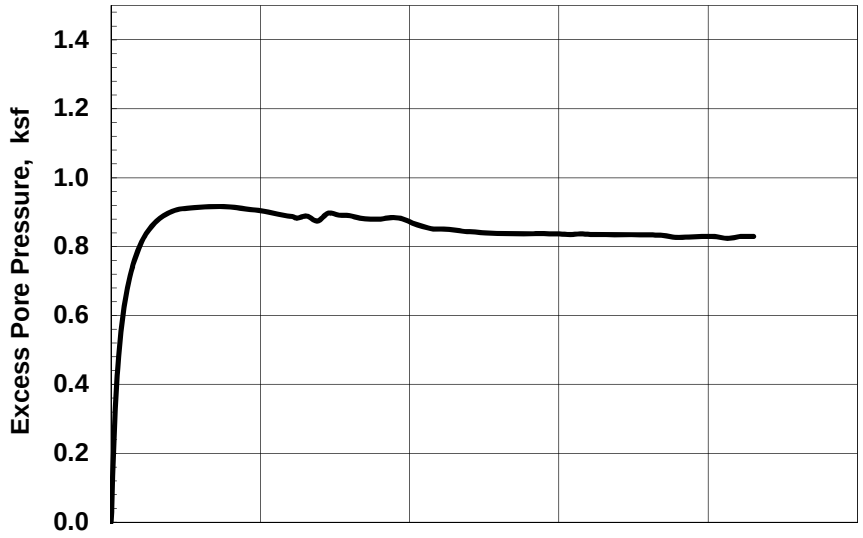
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 17.3 % Total Unit Weight: 137.1 pcf
B Coefficient: 98.64 Strain Rate: 0.020 %/min
Peak Shear Strength: 4.71 ksf @ 19.7 % Strain
Peak Effective Friction Angle: 30.8°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B012 Sample: ST-3C	September-15



SAMPLE INFORMATION

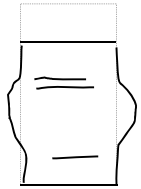
Boring: JOP-B012 Sample: ST-8C Depth: 33.6 ft
Type: Intact tube sample
Description: CL, brown-gray lean clay
LL = 40 PL = 19 PI = 21

SPECIMEN INFORMATION (Initial)

Height: 6.01 inch Diameter: 2.89 inch Area: 6.55 in²
Water Content: 29.1 % Total Unit Weight: 120.8 pcf

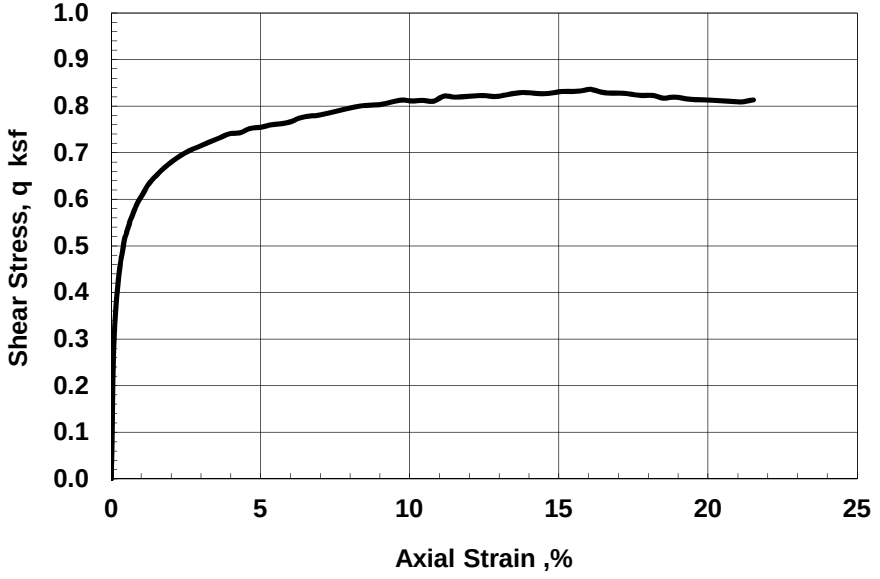
TEST SUMMARY

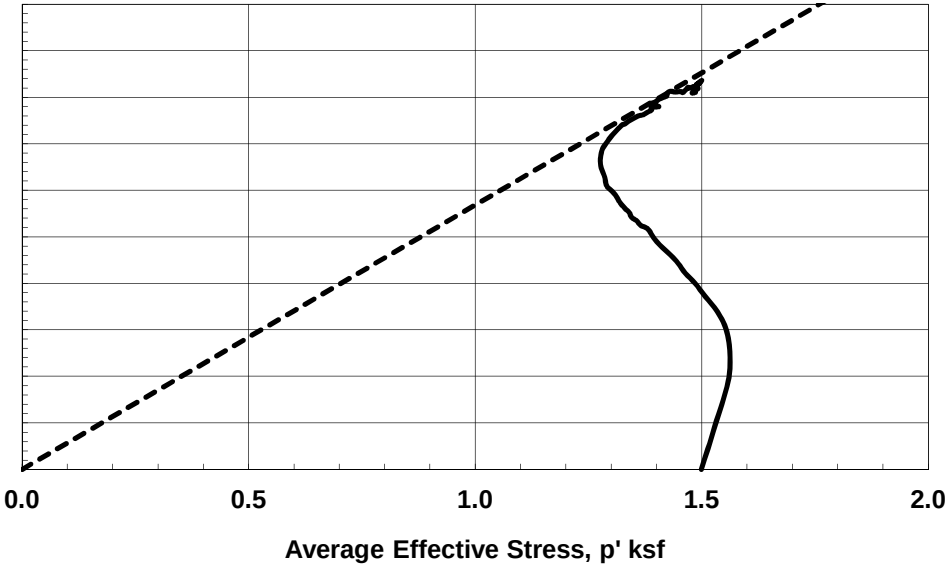
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 27.3 % Total Unit Weight: 123.0 pcf
B Coefficient: 99.78 Strain Rate: 0.022 %/min
Peak Shear Strength: 0.84 ksf @ 16.1 % Strain
Peak Effective Friction Angle: 34.6°



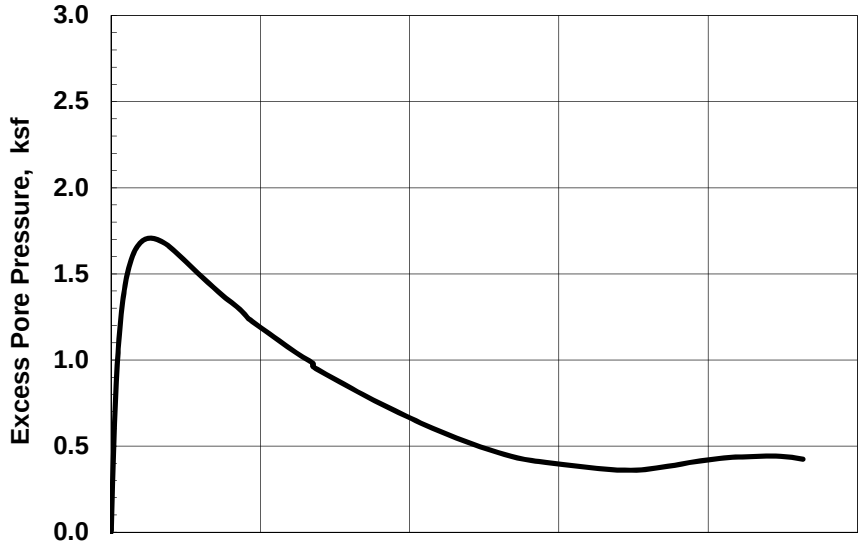
Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B012 Sample: ST-8C	September-15

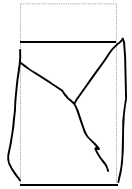


SAMPLE INFORMATION

Boring: JOP-B012 Sample: ST-13B Depth: 53.95 ft
Type: Intact tube sample
Description: CL, yellowish brown sandy lean clay
LL = 27 PL = 12 PI = 15

SPECIMEN INFORMATION (Initial)

Height: 6.02 inch Diameter: 2.88 inch Area: 6.52 in²
Water Content: 17.0 % Total Unit Weight: 132.3 pcf

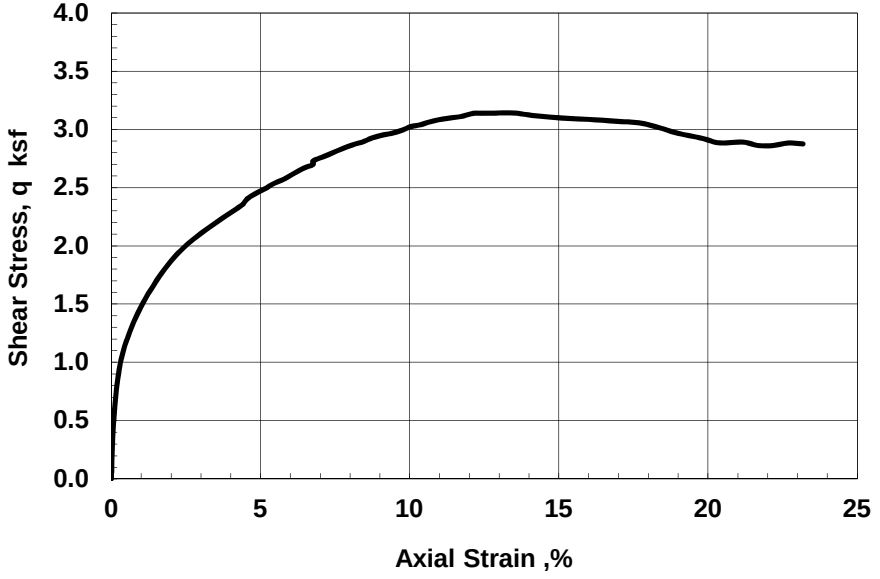


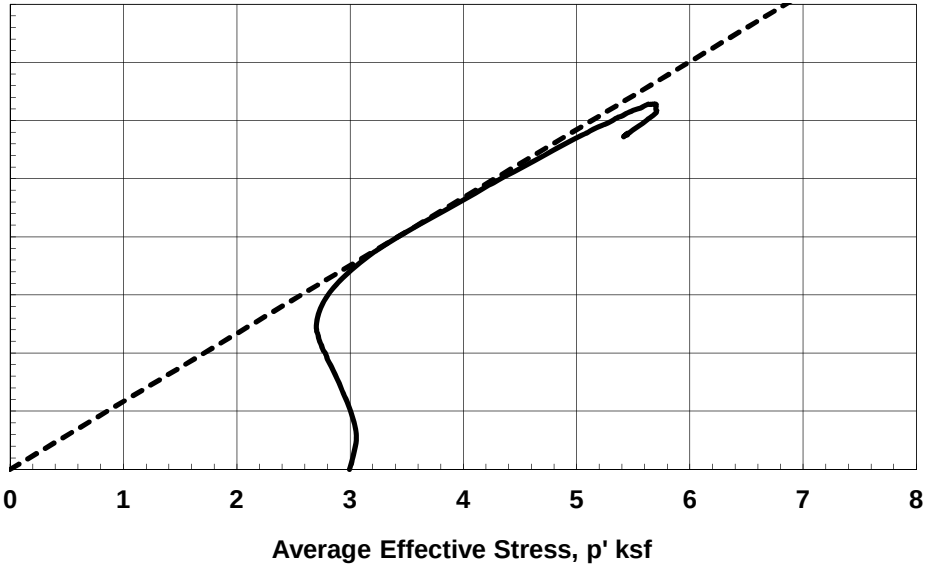
Failure Sketch

TEST SUMMARY

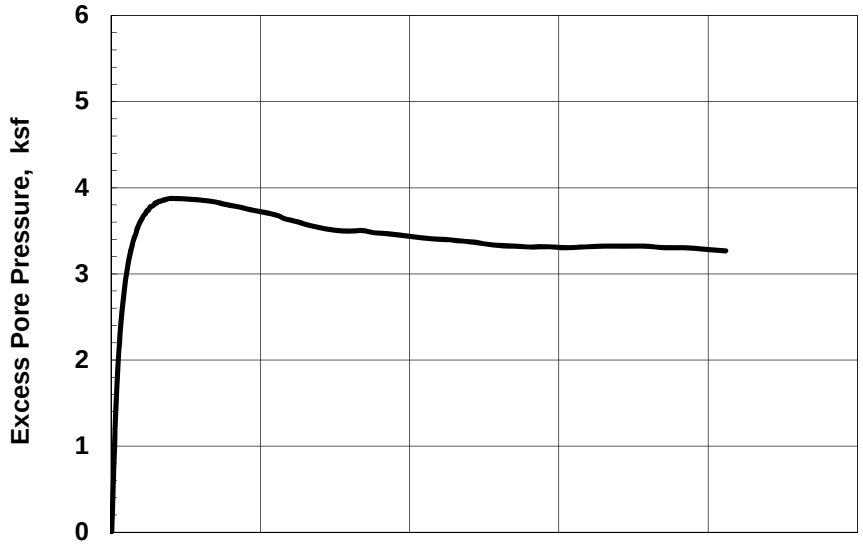
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 17.6 % Total Unit Weight: 136.1 pcf
B Coefficient: 99.42 Strain Rate: 0.020 %/min
Peak Shear Strength: 3.14 ksf @ 13.1 % Strain
Peak Effective Friction Angle: 35.8°

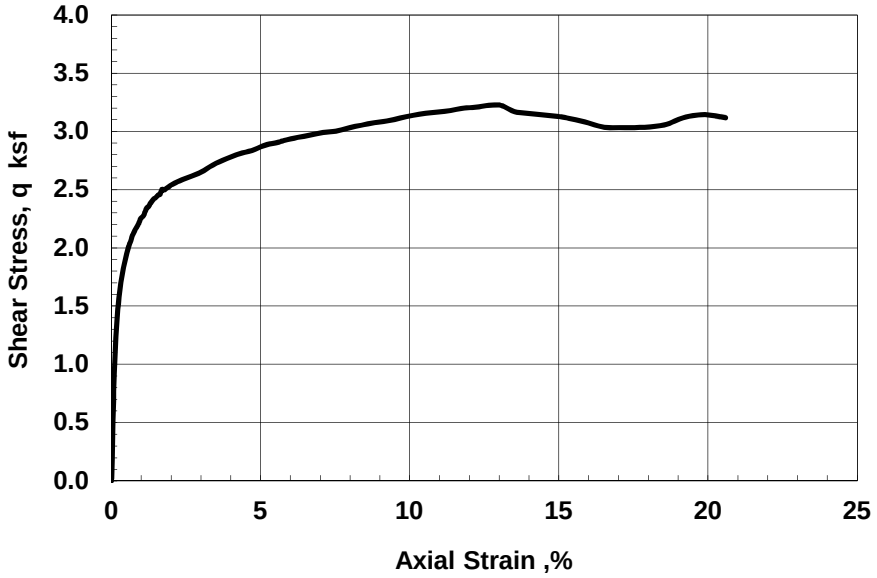
REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B012 Sample: ST-13B	September-15





SAMPLE INFORMATION

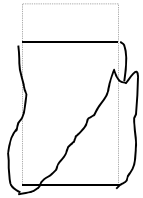
Boring: JOP-B012 Sample: ST-13C Depth: 54.55 ft
Type: Intact tube sample
Description: CL, yellowish brown sandy lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.03 inch Diameter: 2.88 inch Area: 6.52 in²
Water Content: 17.4 % Total Unit Weight: 132.0 pcf

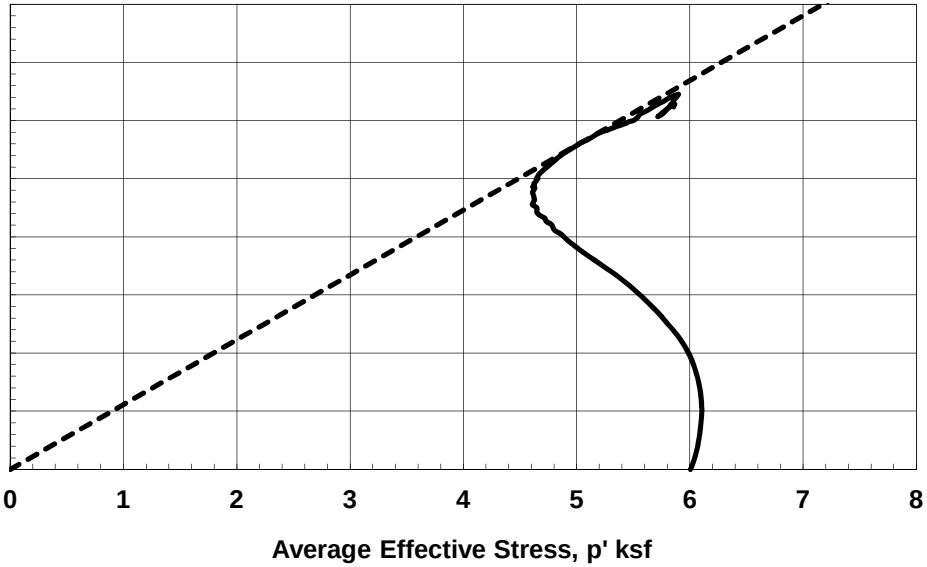
TEST SUMMARY

Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 17.3 % Total Unit Weight: 136.7 pcf
B Coefficient: 99.26 Strain Rate: 0.021 %/min
Peak Shear Strength: 3.22 ksf @ 13.1 % Strain
Peak Effective Friction Angle: 33.9°

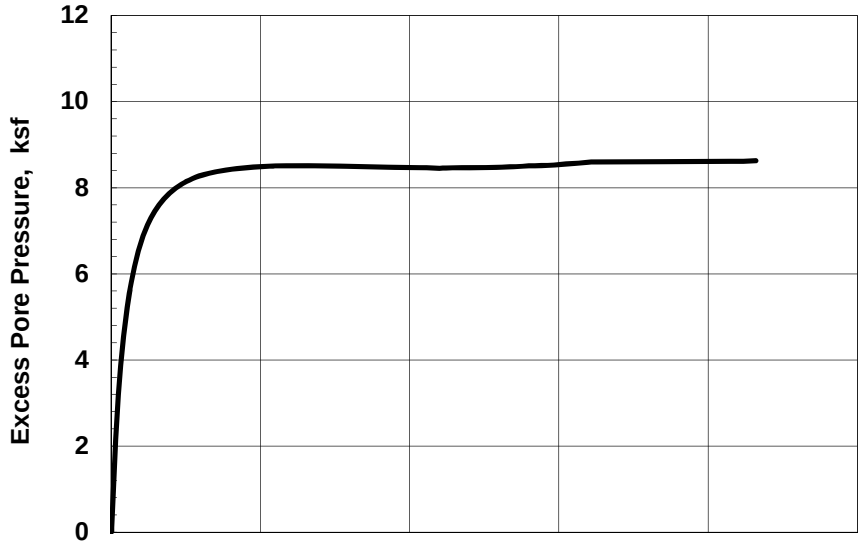


Failure Sketch

REMARKS:



Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B012 Sample: ST-13C	September-15



SAMPLE INFORMATION

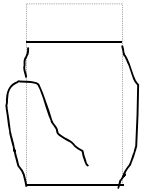
Boring: JOP-B012 Sample: ST-16C Depth: 66.6 ft
Type: Intact tube sample
Description: CL, gray brown sandy lean clay
LL = 33 PL = 13 PI = 20

SPECIMEN INFORMATION (Initial)

Height: 6.02 inch Diameter: 2.85 inch Area: 6.40 in²
Water Content: 20.0 % Total Unit Weight: 126.8 pcf

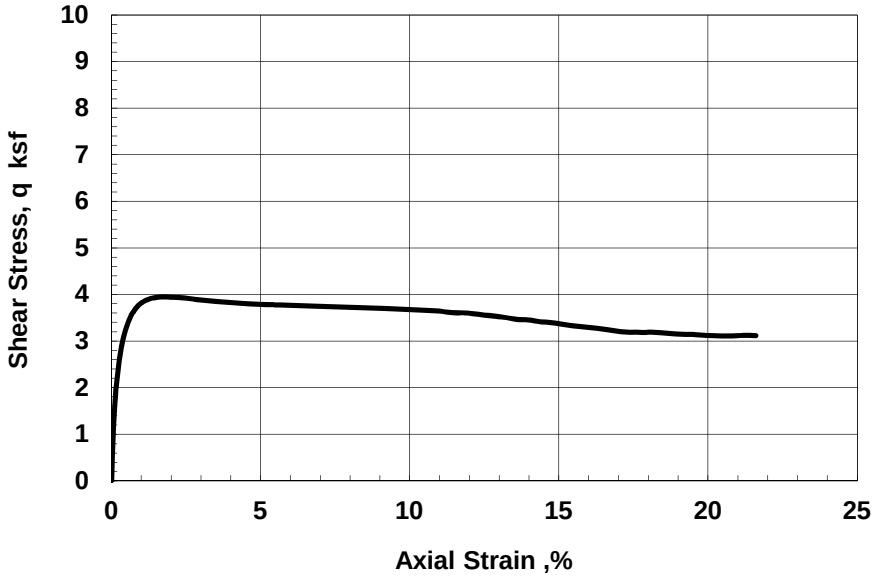
TEST SUMMARY

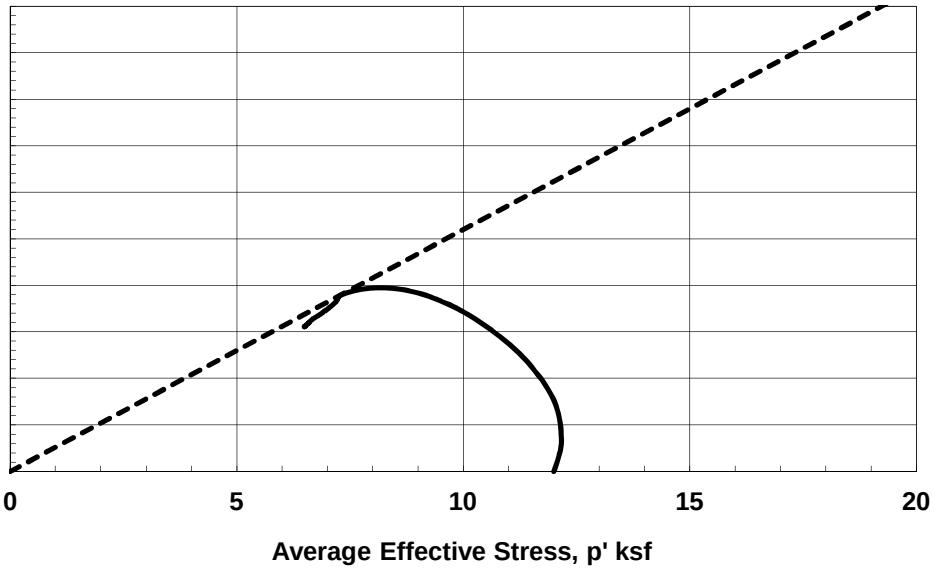
Consolidation Stresses: 12.00 ksf vertical, 12.00 ksf lateral
Water Content: 19.4 % Total Unit Weight: 135.2 pcf
B Coefficient: 98.12 Strain Rate: 0.022 %/min
Peak Shear Strength: 3.95 ksf @ 1.8 % Strain
Peak Effective Friction Angle: 31.3°



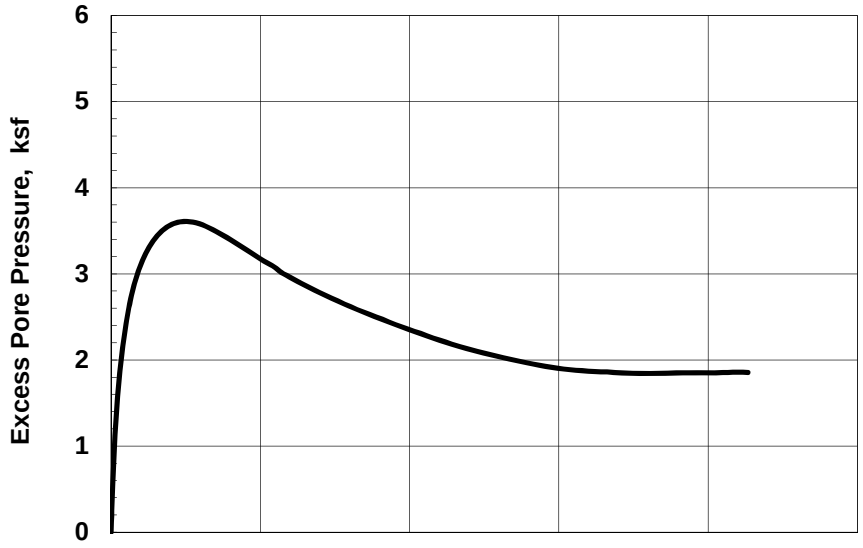
Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B012 Sample: ST-16C	September-15



SAMPLE INFORMATION

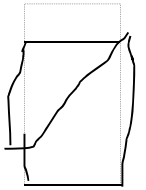
Boring: JOP-B014 Sample: ST-4C Depth: 44.6 ft
Type: Intact tube sample
Description: CL, gray brown sandy lean clay
LL = 33 PL = 12 PI = 21

SPECIMEN INFORMATION (Initial)

Height: 6.07 inch Diameter: 2.88 inch Area: 6.52 in²
Water Content: 16.7 % Total Unit Weight: 132.5 pcf

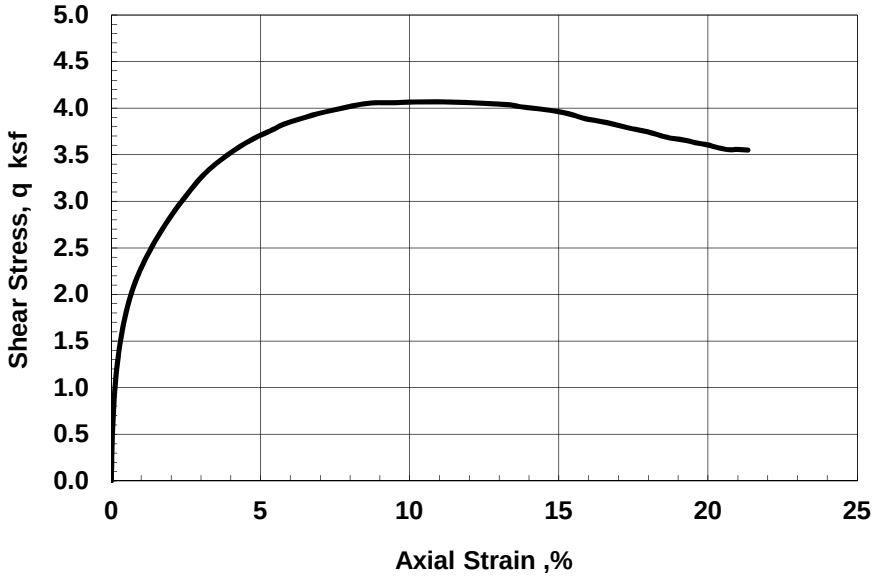
TEST SUMMARY

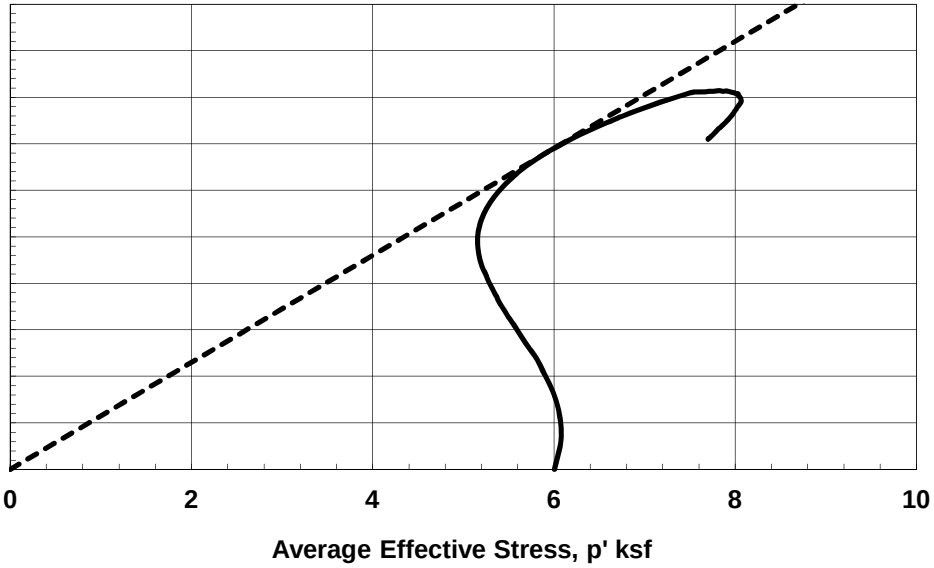
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 16.7 % Total Unit Weight: 138.7 pcf
B Coefficient: 98.66 Strain Rate: 0.021 %/min
Peak Shear Strength: 4.07 ksf @ 10.8 % Strain
Peak Effective Friction Angle: 35.1°



Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B014 Sample: ST-4C — September-15

SAMPLE INFORMATION

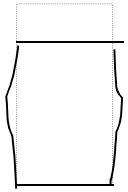
Boring: JOP-B015 Sample: ST-1C Depth: 19.35 ft
Type: Intact tube sample
Description: CH, brown fat clay
LL = 53 PL = 14 PI = 39

SPECIMEN INFORMATION (Initial)

Height: 6.00 inch Diameter: 2.86 inch Area: 6.43 in²
Water Content: 18.7 % Total Unit Weight: 128.4 pcf

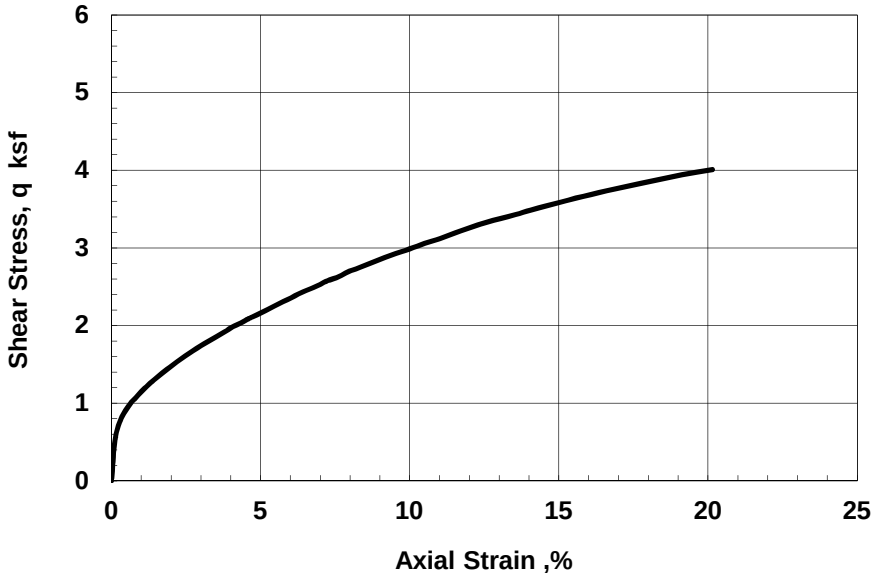
TEST SUMMARY

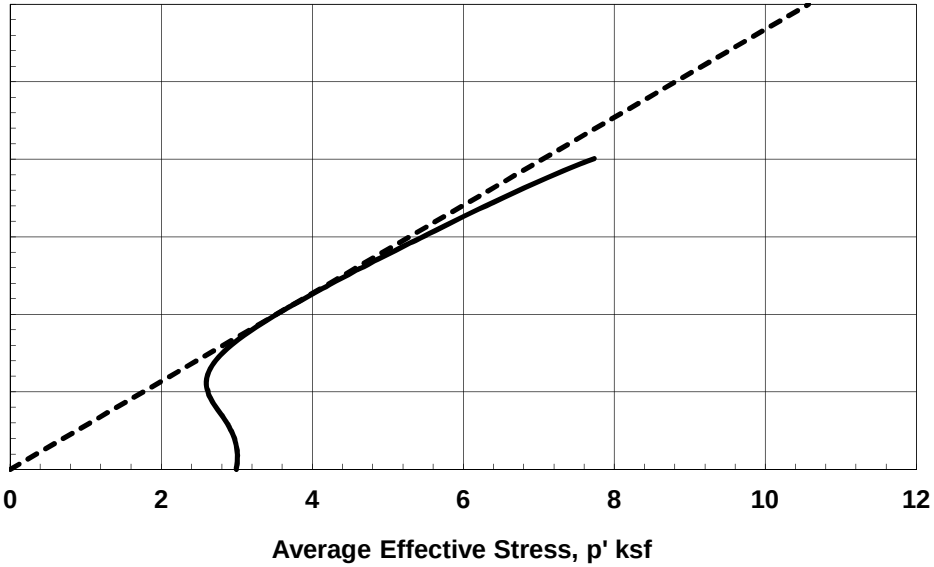
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 18.9 % Total Unit Weight: 133.4 pcf
B Coefficient: 96.4 Strain Rate: 0.021 %/min
Peak Shear Strength: 4.01 ksf @ 20.1 % Strain
Peak Effective Friction Angle: 34.6°



Failure Sketch

REMARKS:





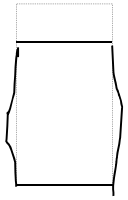
Test by: DT	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B015 Sample: ST-1C	October-15

SAMPLE INFORMATION

Boring: JOP-B015 Sample: ST-2B Depth: 41.7 ft
Type: Intact tube sample
Description: CL, gray brown lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.18 inch Diameter: 2.87 inch Area: 6.47 in²
Water Content: 23.3 % Total Unit Weight: 122.7 pcf

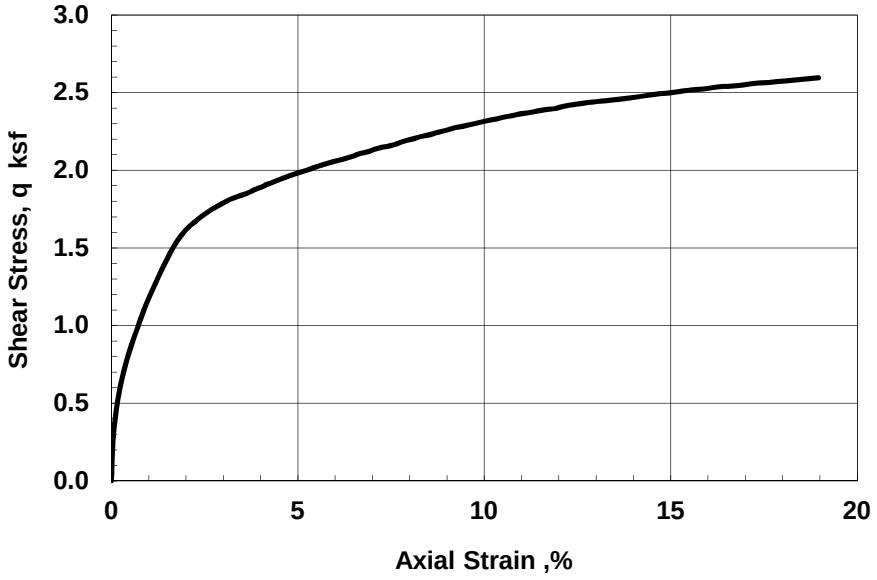


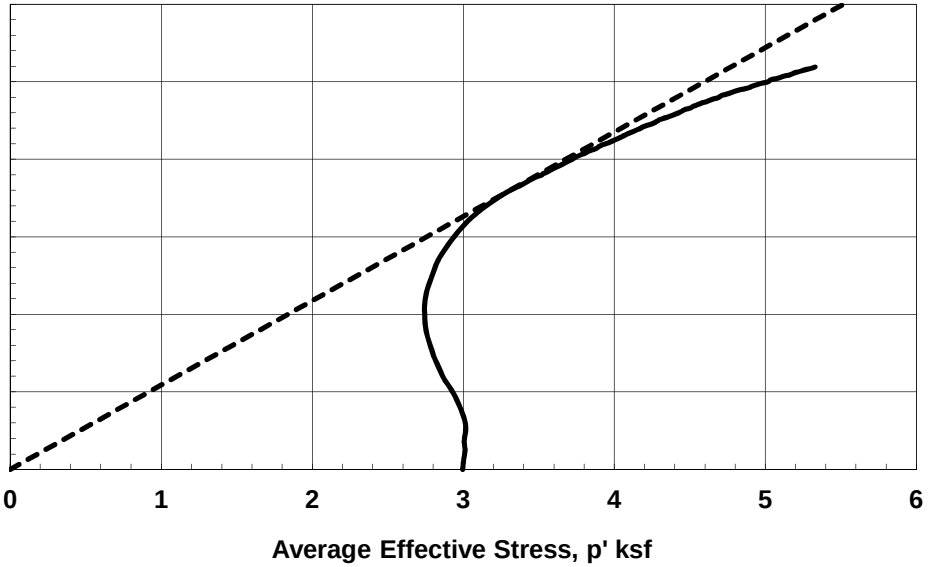
Failure Sketch

TEST SUMMARY

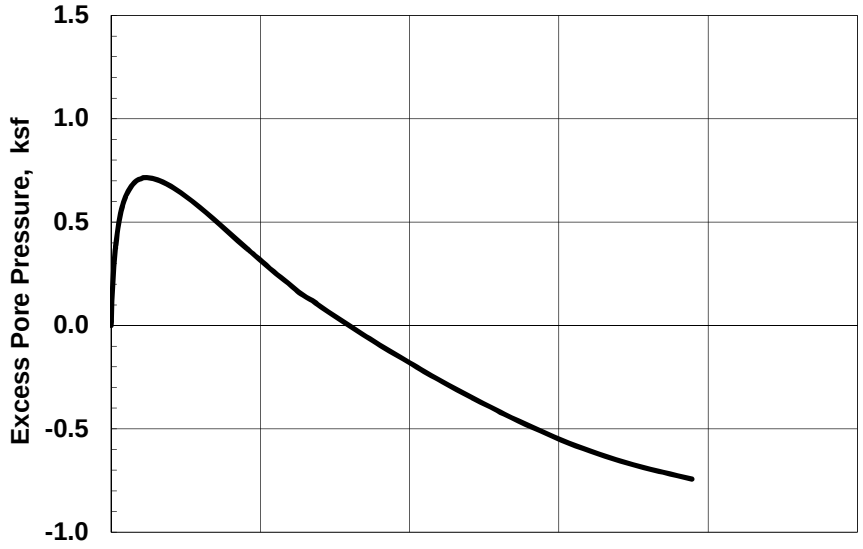
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 22.6 % Total Unit Weight: 126.9 pcf
B Coefficient: Strain Rate: 0.019 %/min
Peak Shear Strength: 2.60 ksf @ 19.0 % Strain
Peak Effective Friction Angle: 32.9°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B015 Sample: ST-2B	October-15



SAMPLE INFORMATION

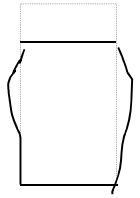
Boring: JOP-B015 Sample: ST-3C Depth: 47.3 ft
Type: Intact tube sample
Description: CL, gray brown lean clay
LL = 31 PL = 15 PI = 16

SPECIMEN INFORMATION (Initial)

Height: 6.22 inch Diameter: 2.84 inch Area: 6.33 in²
Water Content: 19.5 % Total Unit Weight: 128.0 pcf

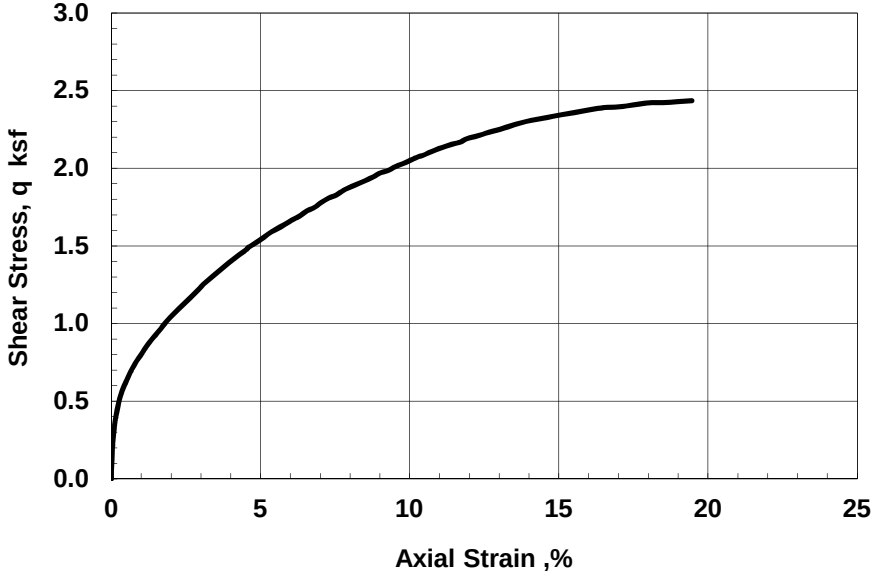
TEST SUMMARY

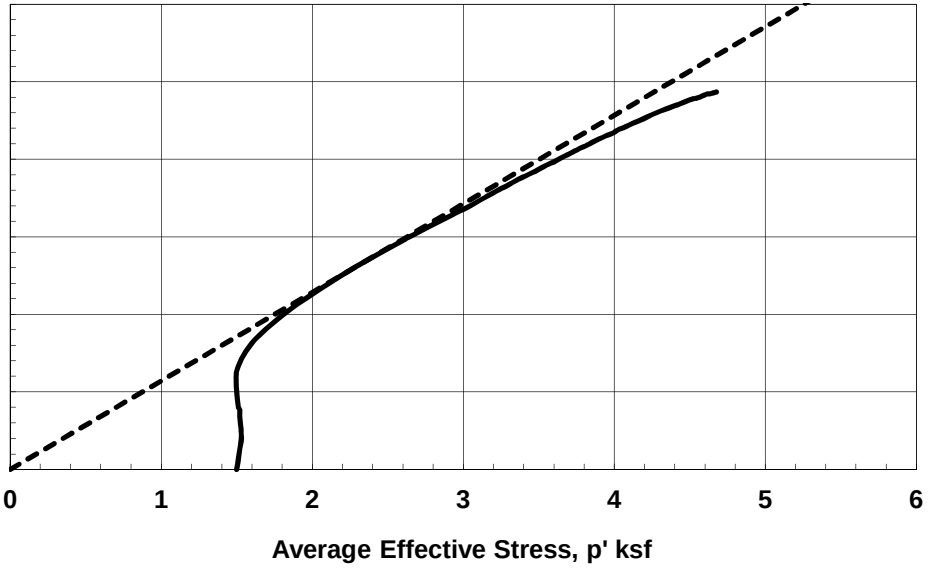
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 19.1 % Total Unit Weight: 131.1 pcf
B Coefficient: Strain Rate: 0.020 %/min
Peak Shear Strength: 2.43 ksf @ 19.5 % Strain
Peak Effective Friction Angle: 34.8°



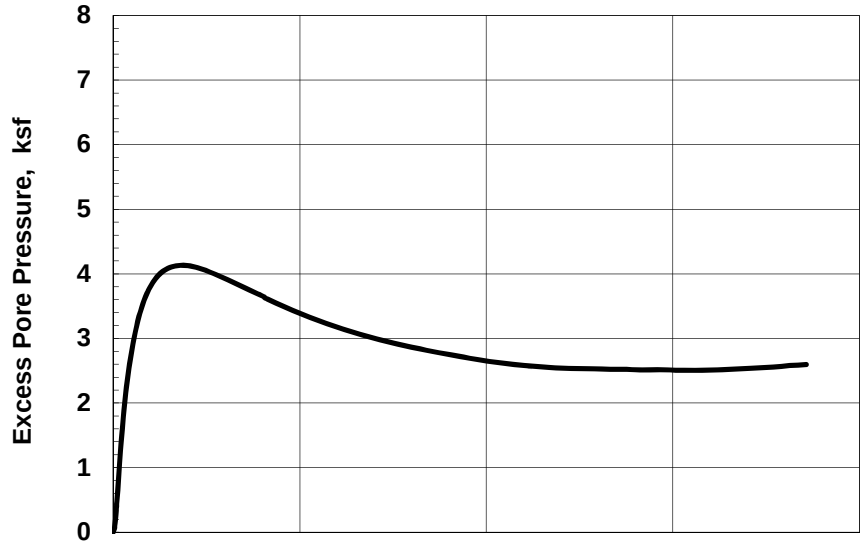
Failure Sketch

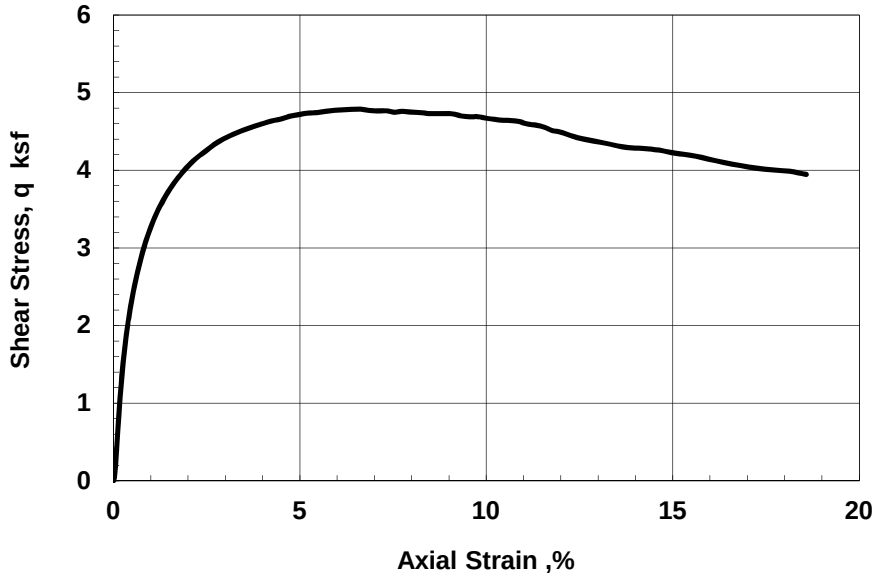
REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B015 Sample: ST-3C	October-15





SAMPLE INFORMATION

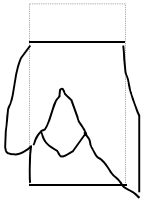
Boring: JOP-B015 Sample: ST-4B Depth: 69.25 ft
Type: Intact tube sample
Description: CL, light gray lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.23 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 21.4 % Total Unit Weight: 124.7 pcf

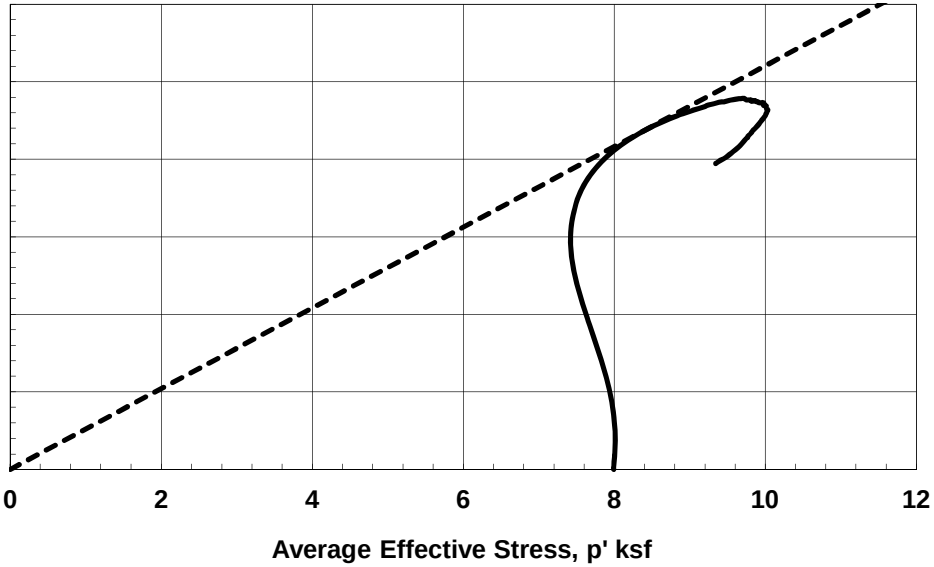
TEST SUMMARY

Consolidation Stresses: 7.99 ksf vertical, 7.99 ksf lateral
Water Content: 20.9 % Total Unit Weight: 127.8 pcf
B Coefficient: Strain Rate: 0.019 %/min
Peak Shear Strength: 4.79 ksf @ 6.6 % Strain
Peak Effective Friction Angle: 31.4°

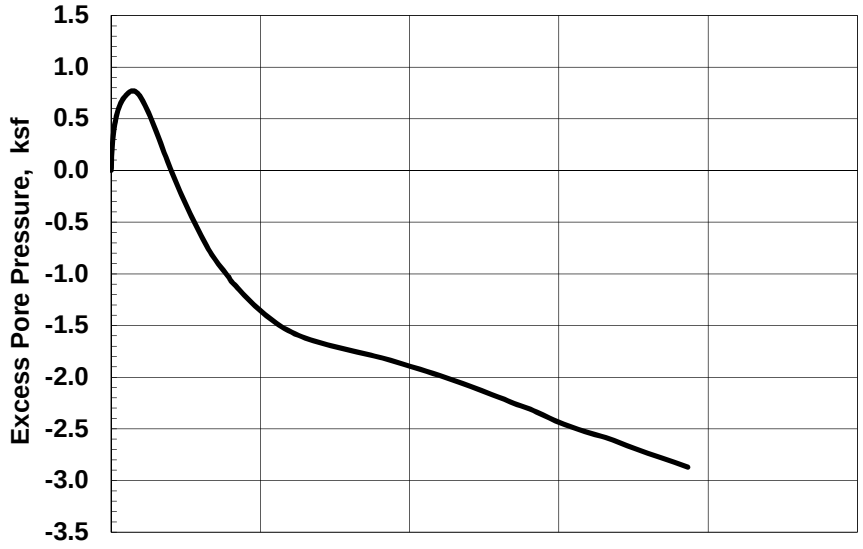


Failure Sketch

REMARKS:



Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B015 Sample: ST-4B	October-15



SAMPLE INFORMATION

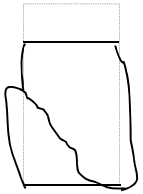
Boring: JOP-B016 Sample: ST-3B Depth: 23.7 ft
Type: Intact tube sample
Description: CL, lean clay
LL = 35 PL = 15 PI = 20

SPECIMEN INFORMATION (Initial)

Height: 6.21 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 19.5 % Total Unit Weight: 127.5 pcf

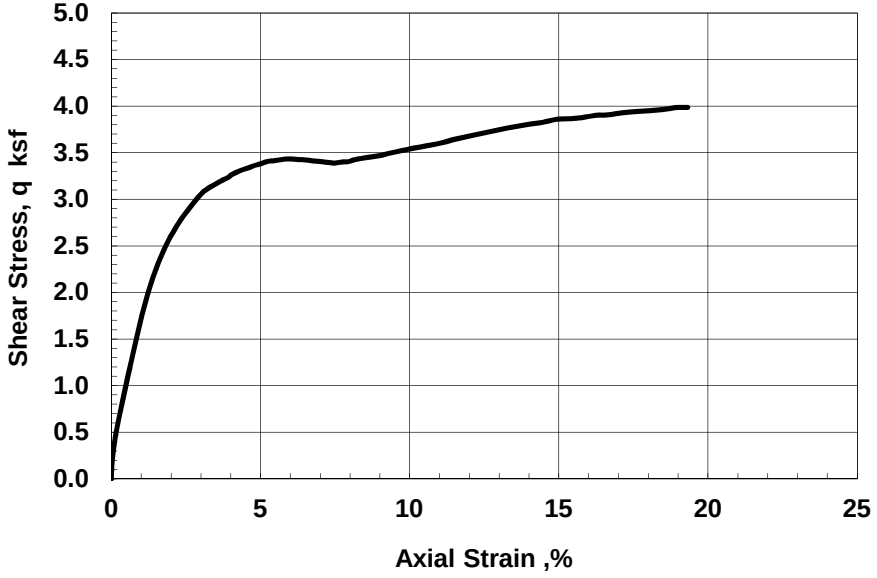
TEST SUMMARY

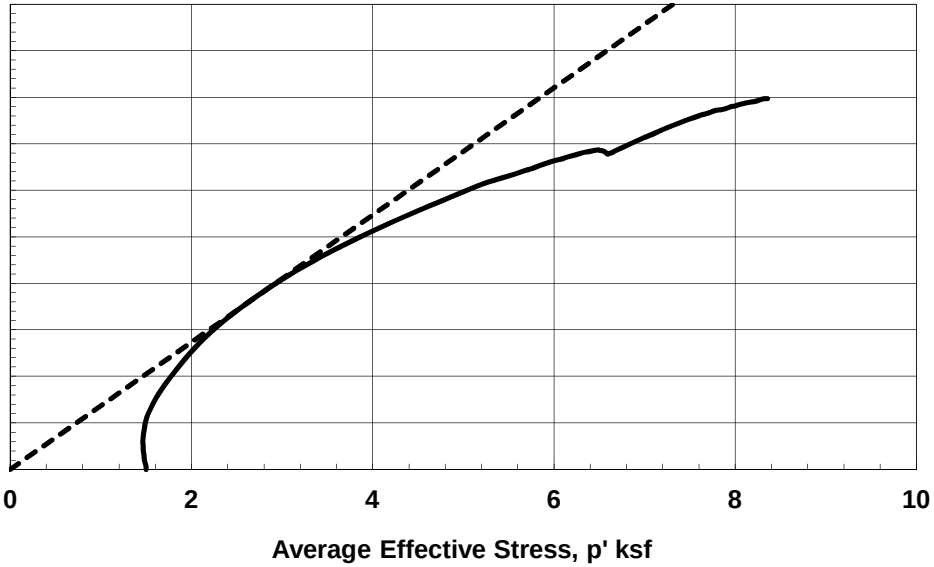
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 19.6 % Total Unit Weight: 129.6 pcf
B Coefficient: Strain Rate: 0.018 %/min
Peak Shear Strength: 3.99 ksf @ 19.3 % Strain
Peak Effective Friction Angle: 43.1°



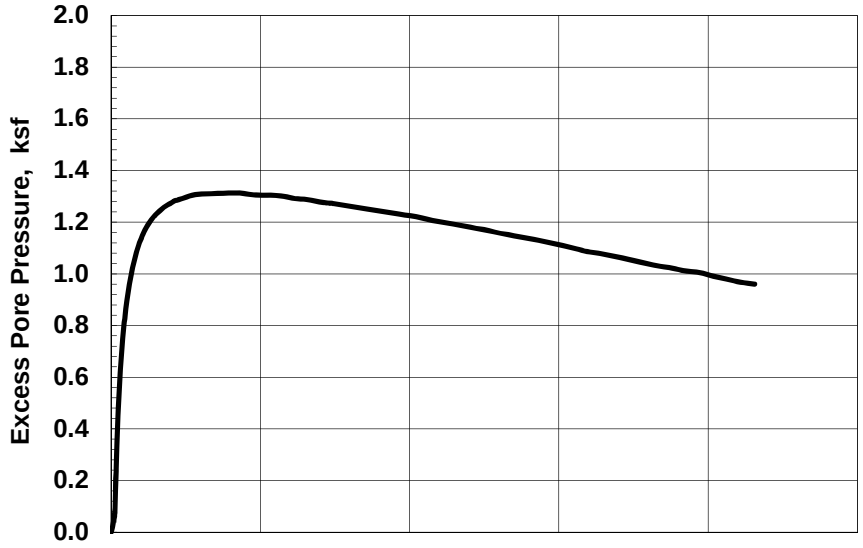
Failure Sketch

REMARKS:





Test by: DT	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B016 Sample: ST-3B	October-15

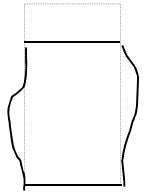


SAMPLE INFORMATION

Boring: JOP-B017 Sample: ST-2B Depth: 8.85 ft
Type: Intact tube sample
Description: CL, brown sandy lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.03 inch Diameter: 2.87 inch Area: 6.47 in²
Water Content: 17.1 % Total Unit Weight: 129.6 pcf

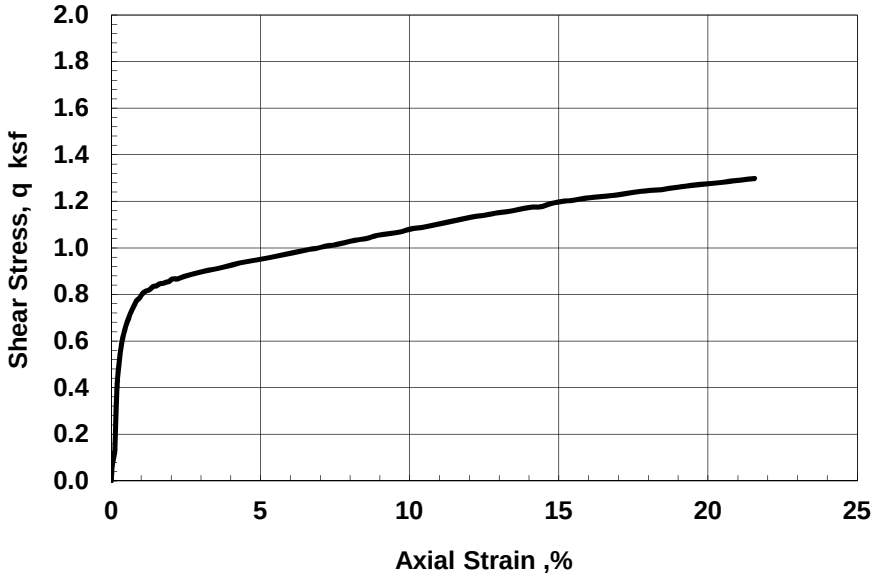


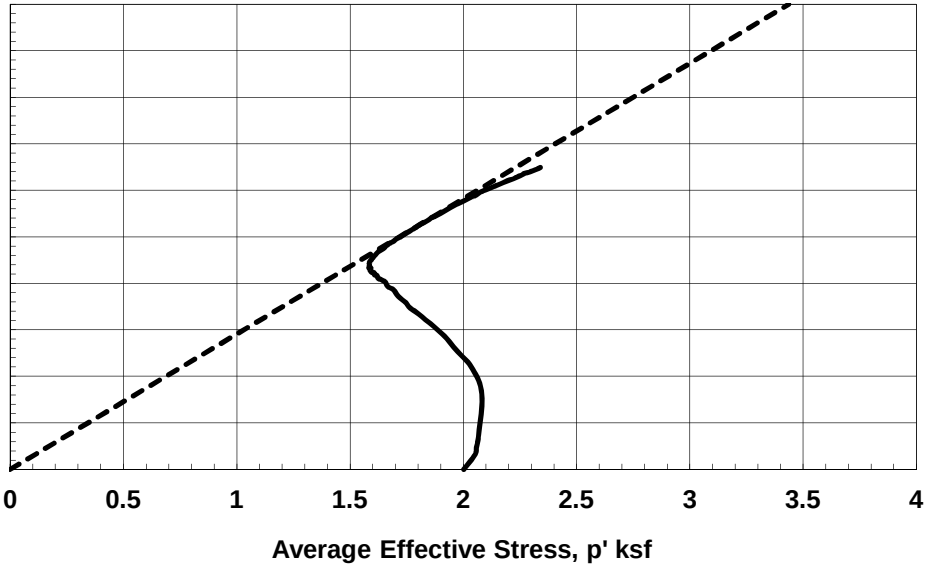
Failure Sketch

TEST SUMMARY

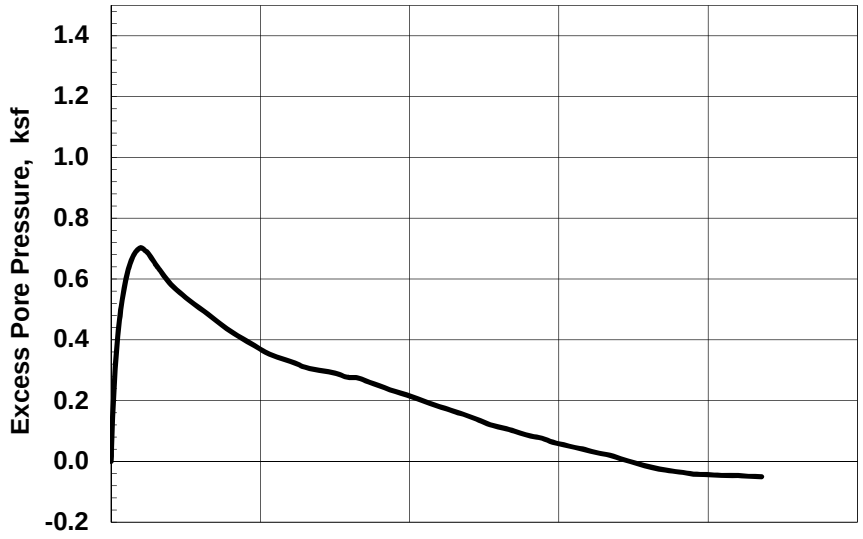
Consolidation Stresses: 2.00 ksf vertical, 2.00 ksf lateral
Water Content: 17.6 % Total Unit Weight: 133.6 pcf
B Coefficient: 98.42 Strain Rate: 0.023 %/min
Peak Shear Strength: 1.30 ksf @ 21.6 % Strain
Peak Effective Friction Angle: 35.6°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B017 Sample: ST-2B	September-15

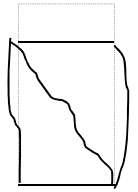


SAMPLE INFORMATION

Boring: JOP-B017 Sample: ST-3C Depth: 24.8 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 34 PL = 14 PI = 20

SPECIMEN INFORMATION (Initial)

Height: 6.01 inch Diameter: 2.87 inch Area: 6.46 in²
Water Content: 21.3 % Total Unit Weight: 127.2 pcf

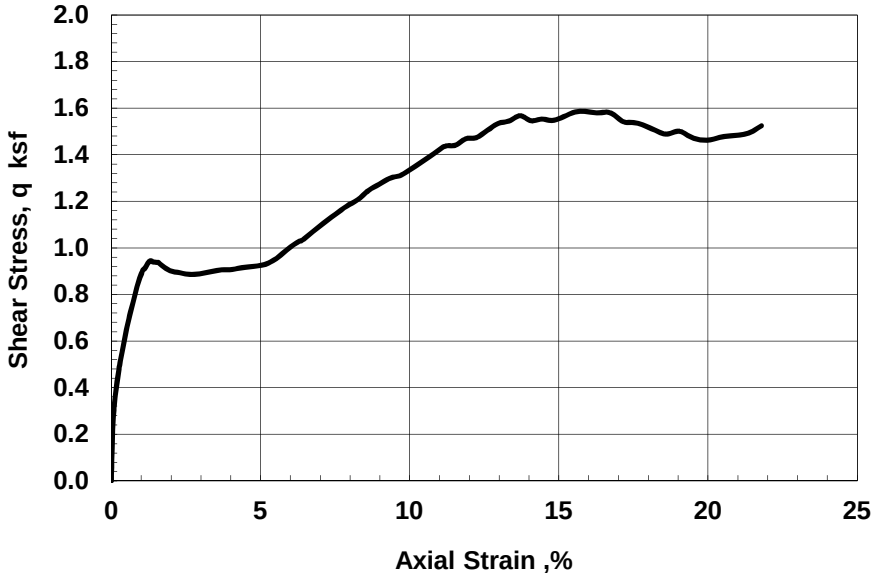


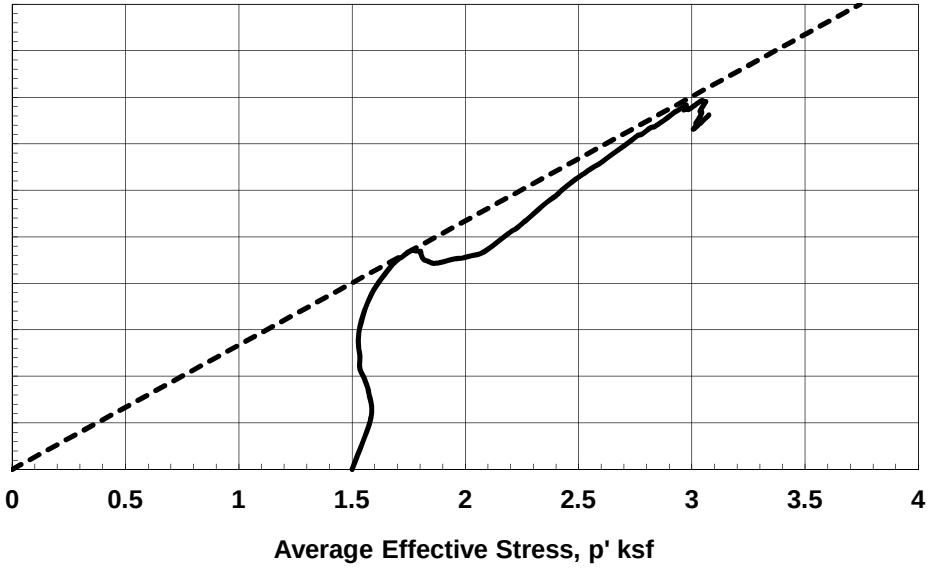
Failure Sketch

TEST SUMMARY

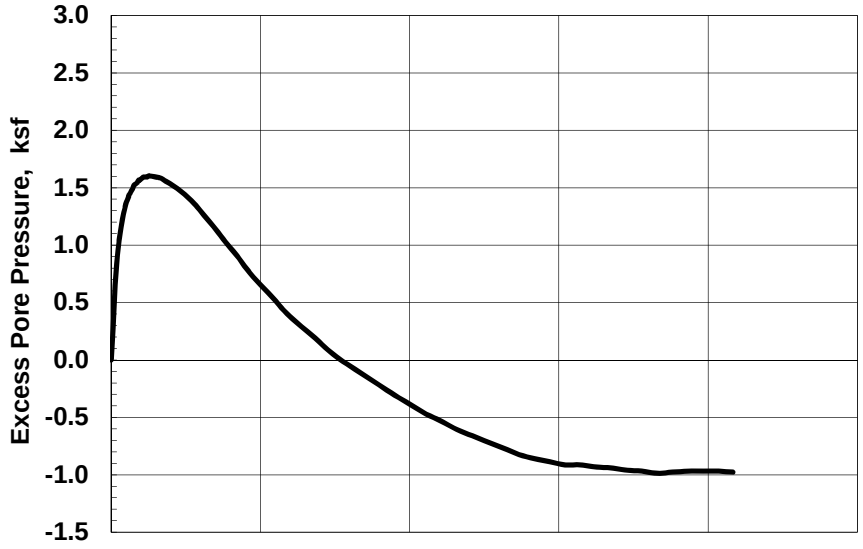
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 21.9 % Total Unit Weight: 130.9 pcf
B Coefficient: 96.82 Strain Rate: 0.023 %/min
Peak Shear Strength: 1.59 ksf @ 15.9 % Strain
Peak Effective Friction Angle: 32.3°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B017 Sample: ST-3C	September-15



SAMPLE INFORMATION

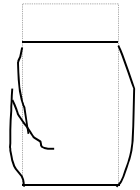
Boring: JOP-B017 Sample: ST-4D Depth: 34.85 ft
Type: Intact tube sample
Description: CL, brown gray lean clay with sand
LL = 35 PL = 14 PI = 21

SPECIMEN INFORMATION (Initial)

Height: 6.19 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 21.2 % Total Unit Weight: 128.1 pcf

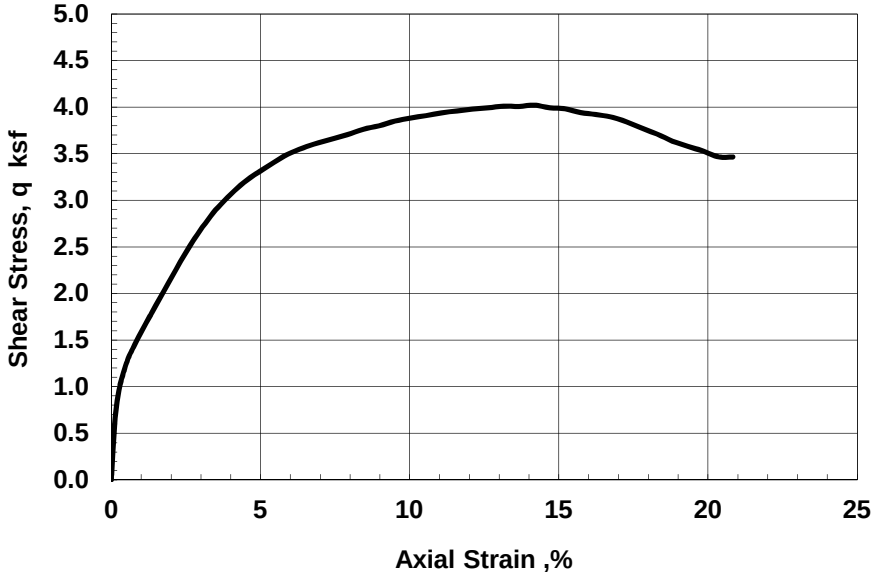
TEST SUMMARY

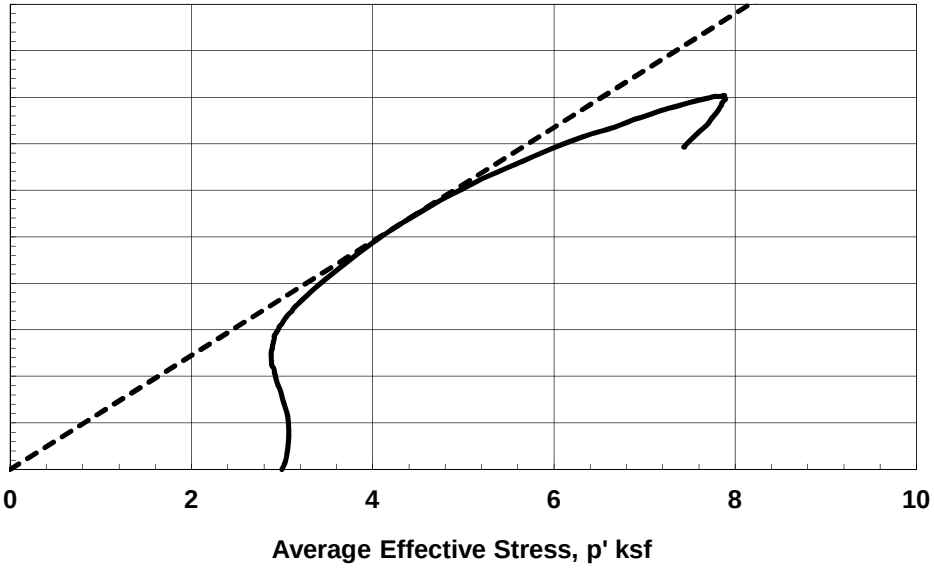
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 21.3 % Total Unit Weight: 130.1 pcf
B Coefficient: Strain Rate: 0.022 %/min
Peak Shear Strength: 4.02 ksf @ 14.2 % Strain
Peak Effective Friction Angle: 37.8°



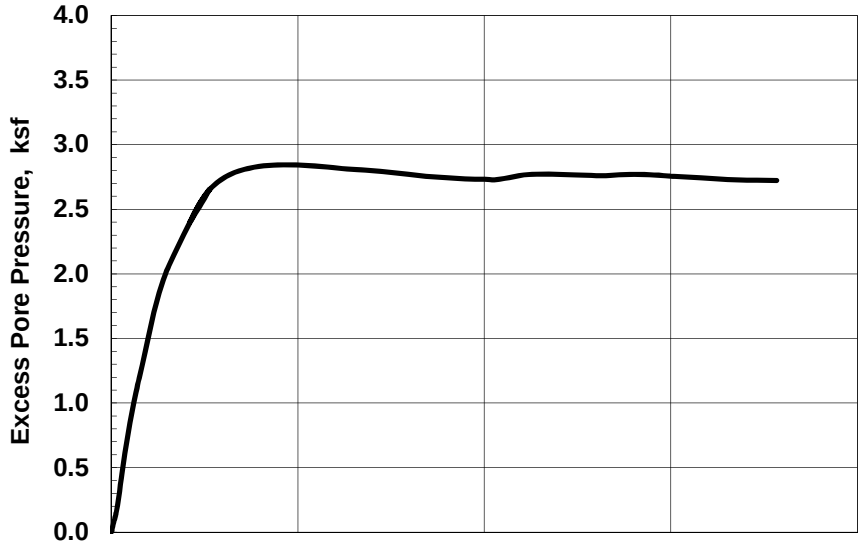
Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B017 Sample: ST-4D	October-15

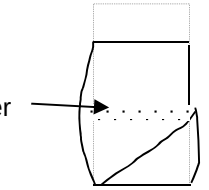


SAMPLE INFORMATION

Boring: JOP-B019 Sample: ST-2B Depth: 43.8 ft
Type: Intact tube sample
Description: ML, gray silt; flyash
LL = - PL = 35 PI = NP

SPECIMEN INFORMATION (Initial)

Height: 6.05 inch Diameter: 2.86 inch Area: 6.42 in²
Water Content: 54.5 % Total Unit Weight: 102.9 pcf

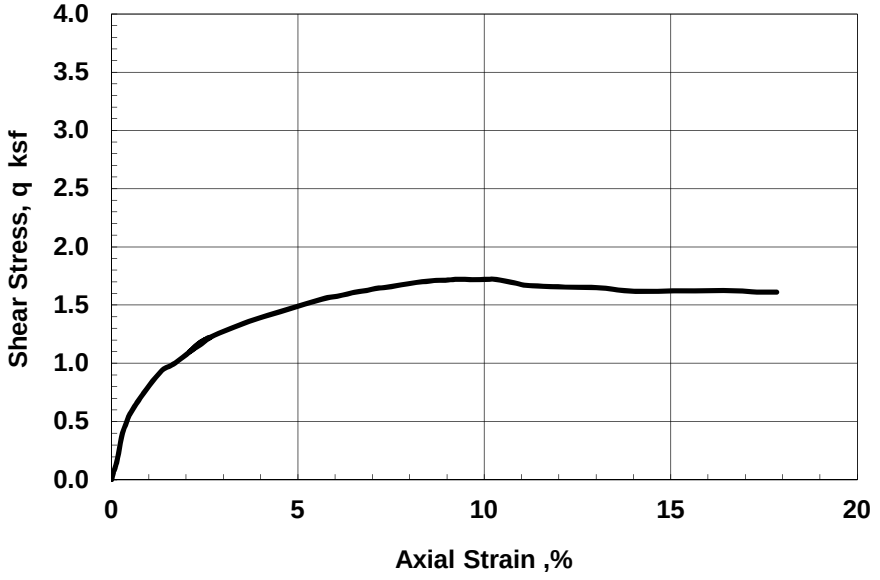


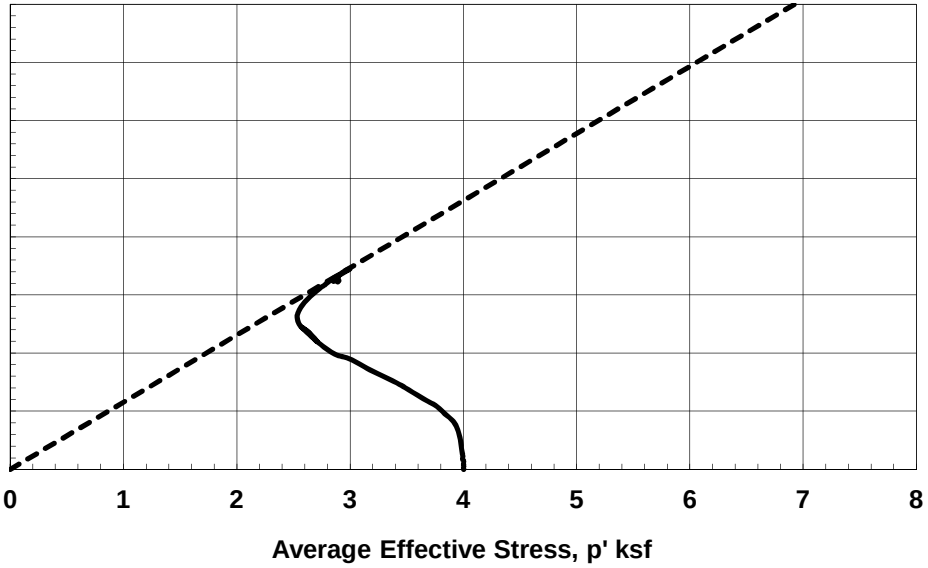
Failure Sketch

TEST SUMMARY

Consolidation Stresses: 4.00 ksf vertical, 4.00 ksf lateral
Water Content: 47.3 % Total Unit Weight: 109.9 pcf
B Coefficient: Strain Rate: 0.022 %/min
Peak Shear Strength: 1.72 ksf @ 10.3 % Strain
Peak Effective Friction Angle: 35.3°

REMARKS:





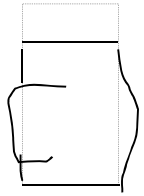
Test by: DT	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B019 Sample: ST-2B	October-15

SAMPLE INFORMATION

Boring: JOP-B020 Sample: ST-2B Depth: 19.25 ft
Type: Intact tube sample
Description: CL, gray brown lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.20 inch Diameter: 2.87 inch Area: 6.47 in²
Water Content: 15.3 % Total Unit Weight: 130.3 pcf

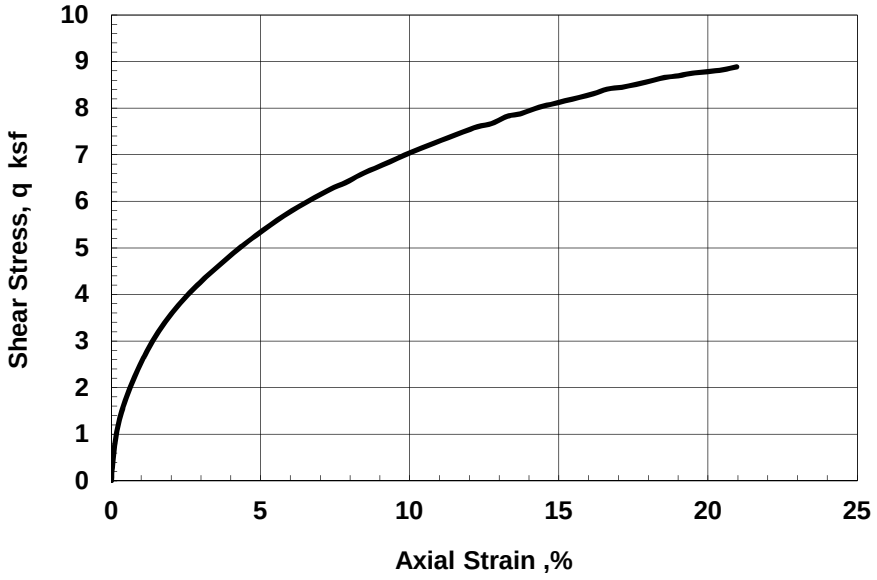


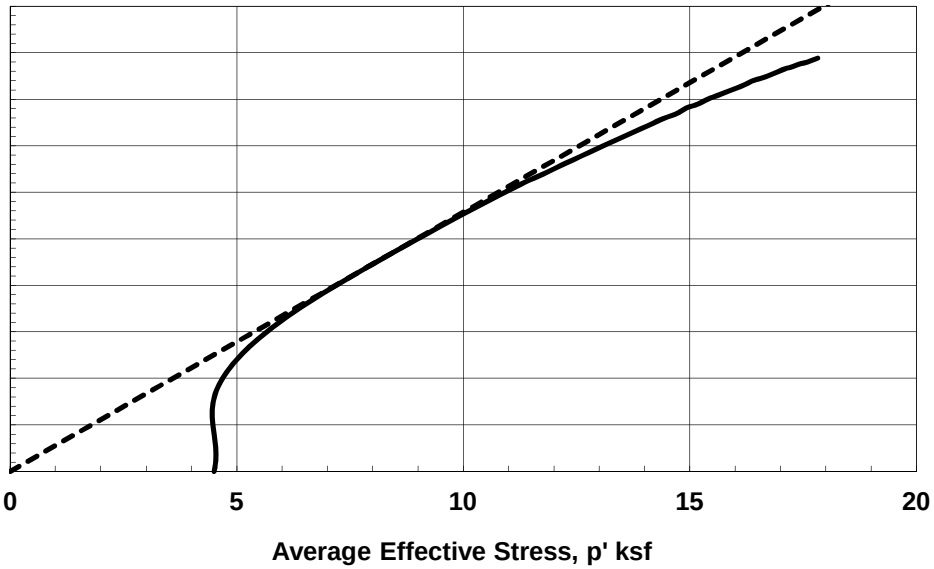
Failure Sketch

TEST SUMMARY

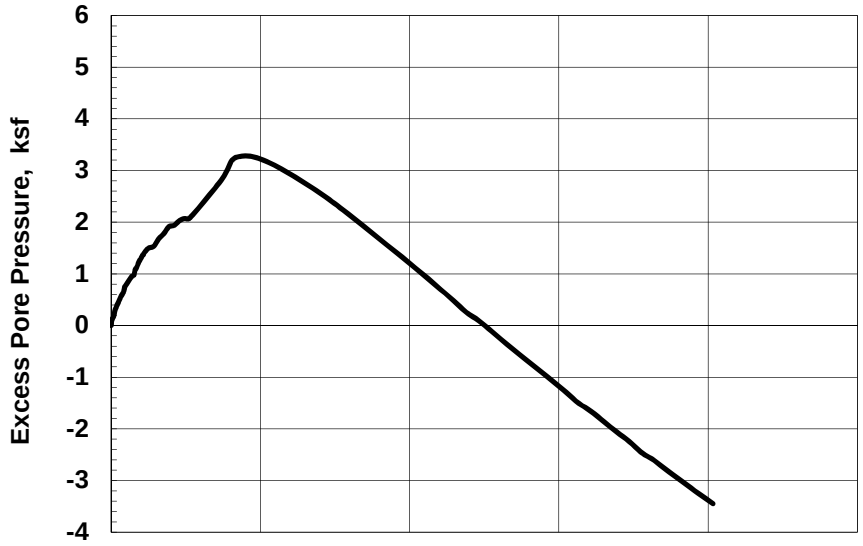
Consolidation Stresses: 4.50 ksf vertical, 4.50 ksf lateral
Water Content: 16.0 % Total Unit Weight: 134.4 pcf
B Coefficient: 99.12 Strain Rate: 0.020 %/min
Peak Shear Strength: 8.89 ksf @ 21.0 % Strain
Peak Effective Friction Angle: 33.9°

REMARKS:





Test by: NB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B020 Sample: ST-2B	October-15



SAMPLE INFORMATION

Boring: JOP-B020 Sample: ST-4C Depth: 49.75 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 31 PL = 14 PI = 17

SPECIMEN INFORMATION (Initial)

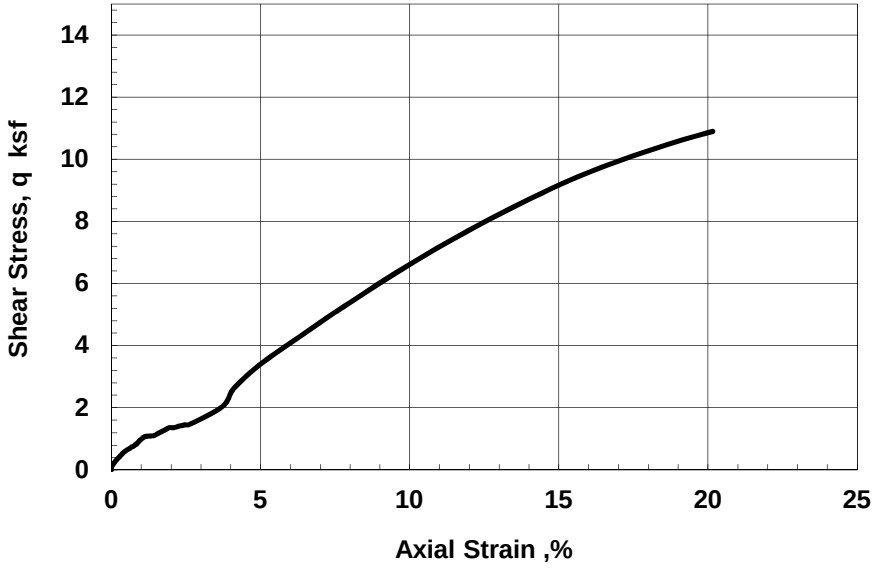
Height: 6.21 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 13.3 % Total Unit Weight: 134.0 pcf

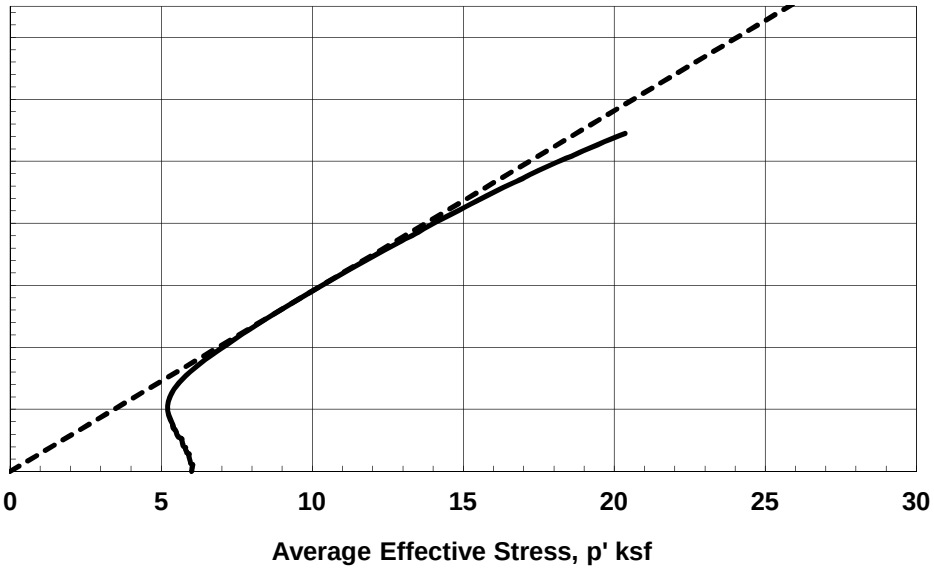
TEST SUMMARY

Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 13.5 % Total Unit Weight: 137.5 pcf
B Coefficient: 99.7 Strain Rate: 0.020 %/min
Peak Shear Strength: 10.90 ksf @ 20.2 % Strain
Peak Effective Friction Angle: 35.6°

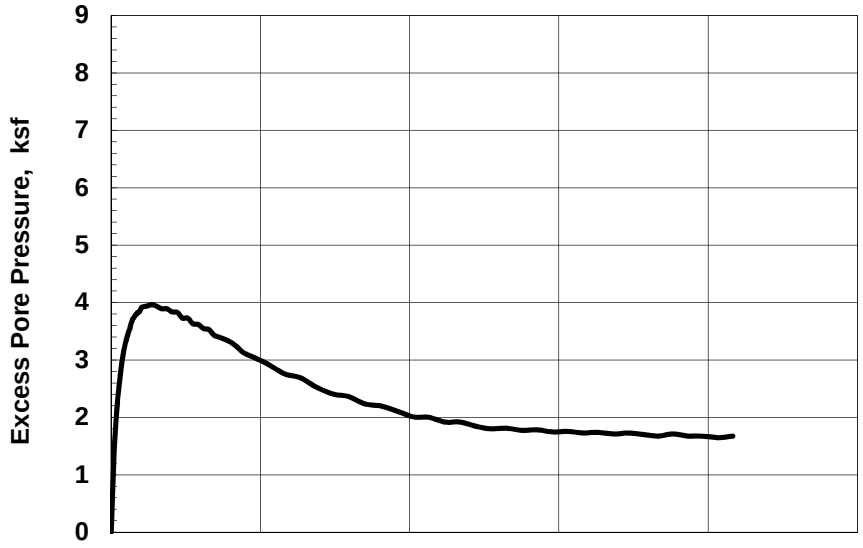
Failure Sketch

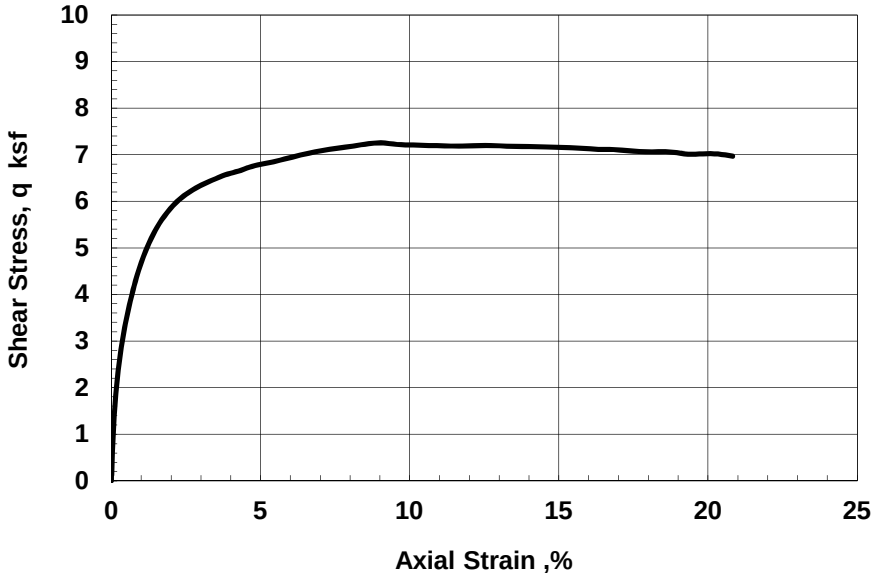
REMARKS:





Test by: DT	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B020 Sample: ST-4C	October-15





SAMPLE INFORMATION

Boring: JOP-B020 Sample: ST-5C Depth: 69.8 ft
Type: Intact tube sample
Description: CL, gray brown lean clay

SPECIMEN INFORMATION (Initial)

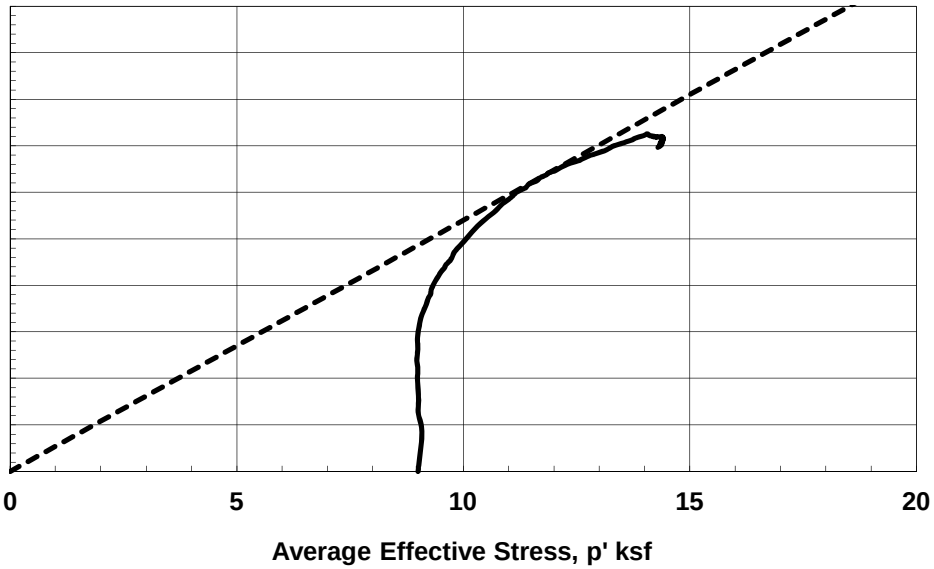
Height: 6.20 inch Diameter: 2.86 inch Area: 6.43 in²
Water Content: 18.2 % Total Unit Weight: 128.6 pcf

TEST SUMMARY

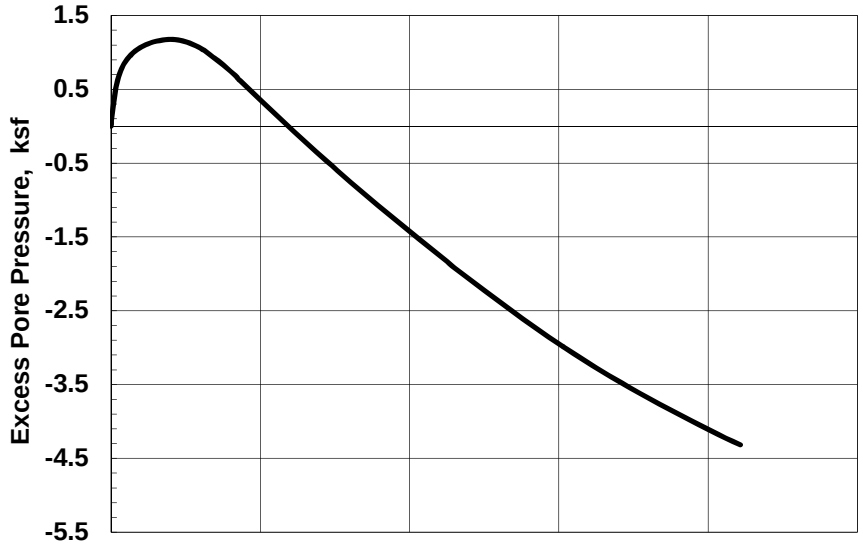
Consolidation Stresses: 9.00 ksf vertical, 9.00 ksf lateral
Water Content: 17.6 % Total Unit Weight: 132.7 pcf
B Coefficient: 98.36 Strain Rate: 0.022 %/min
Peak Shear Strength: 7.26 ksf @ 9.0 % Strain
Peak Effective Friction Angle: 32.7°

Failure Sketch

REMARKS:



Test by: DT	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B020 Sample: ST-5C	October-15



SAMPLE INFORMATION

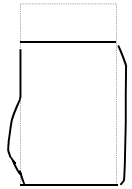
Boring: JOP-B021 Sample: ST-1C Depth: 4.25 ft
Type: Intact tube sample
Description: CL, gray brown lean clay
LL = 39 PL = 13 PI = 26

SPECIMEN INFORMATION (Initial)

Height: 6.18 inch Diameter: 2.86 inch Area: 6.40 in²
Water Content: 15.0 % Total Unit Weight: 131.5 pcf

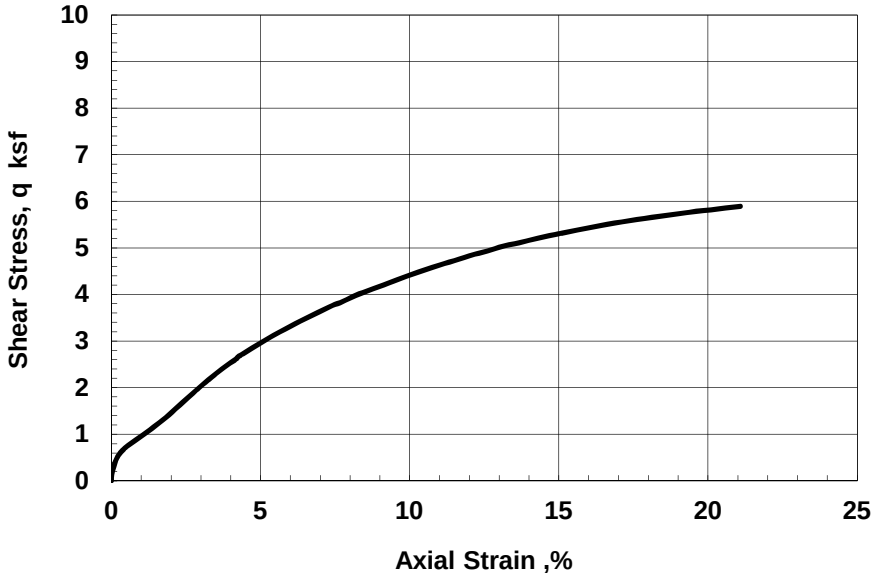
TEST SUMMARY

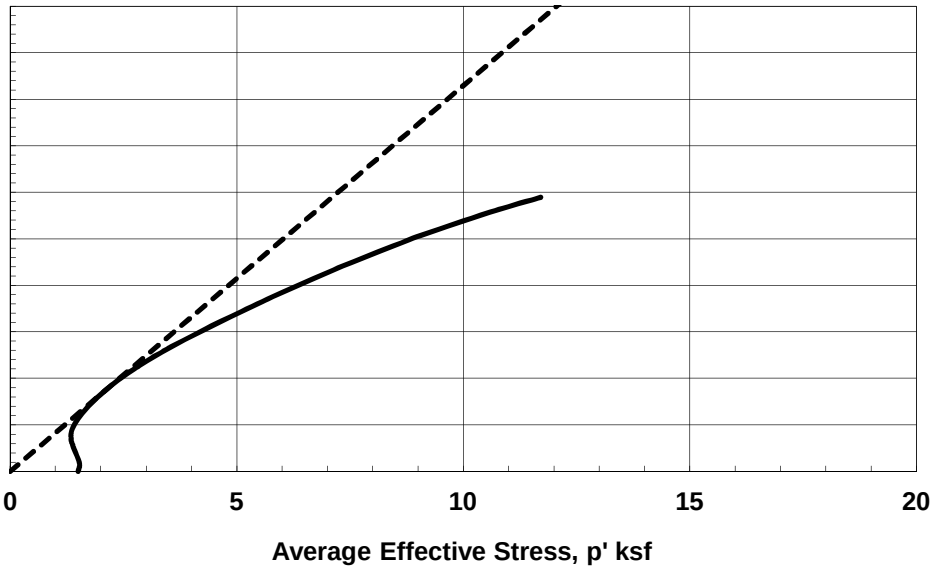
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 15.8 % Total Unit Weight: 135.0 pcf
B Coefficient: Strain Rate: 0.021 %/min
Peak Shear Strength: 5.89 ksf @ 21.1 % Strain
Peak Effective Friction Angle: 56.0°



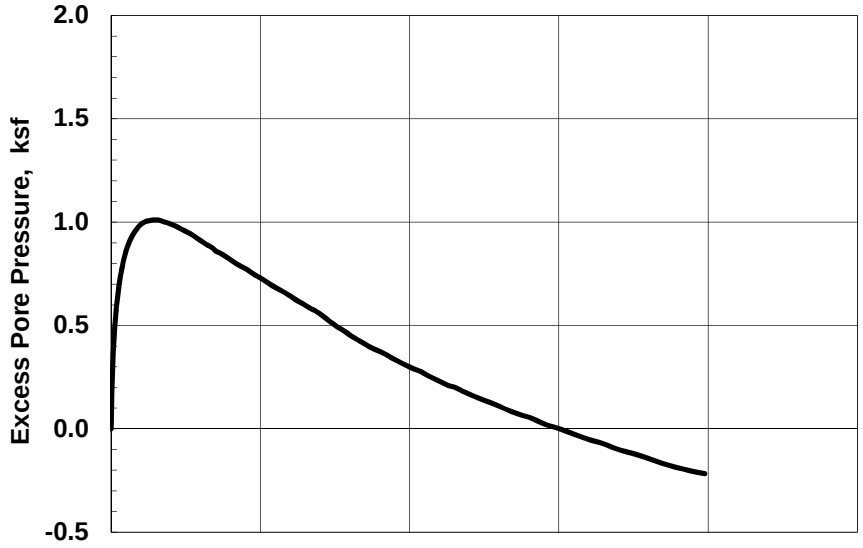
Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B021 Sample: ST-1C	October-15

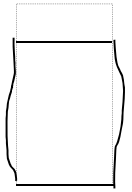


SAMPLE INFORMATION

Boring: JOP-B021 Sample: ST-2C Depth: 14.6 ft
Type: Intact tube sample
Description: CL, gray lean clay

SPECIMEN INFORMATION (Initial)

Height: 6.02 inch Diameter: 2.87 inch Area: 6.46 in²
Water Content: 23.1 % Total Unit Weight: 125.4 pcf

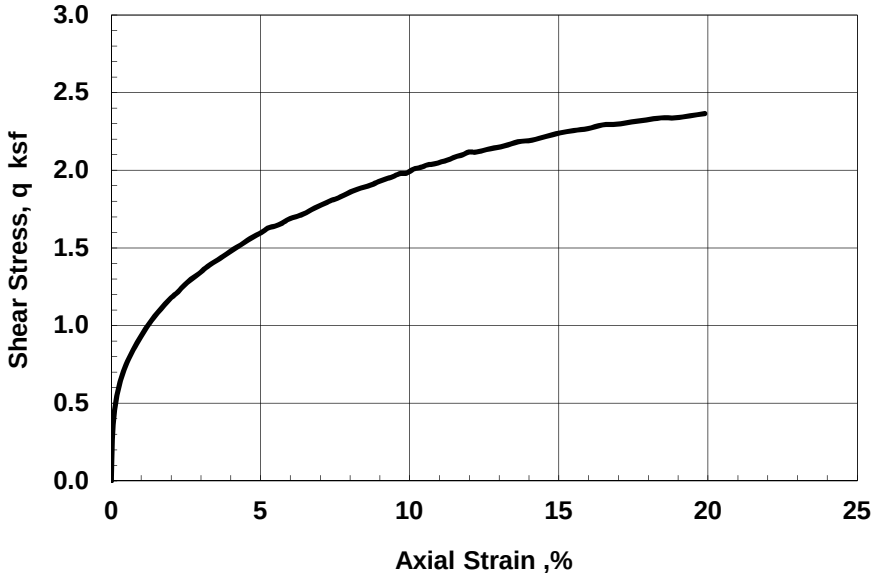


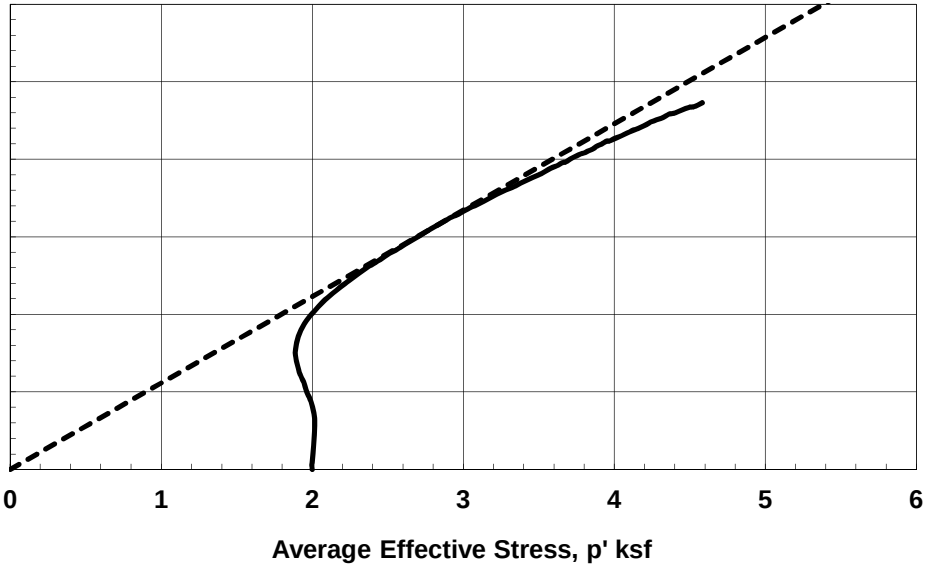
Failure Sketch

TEST SUMMARY

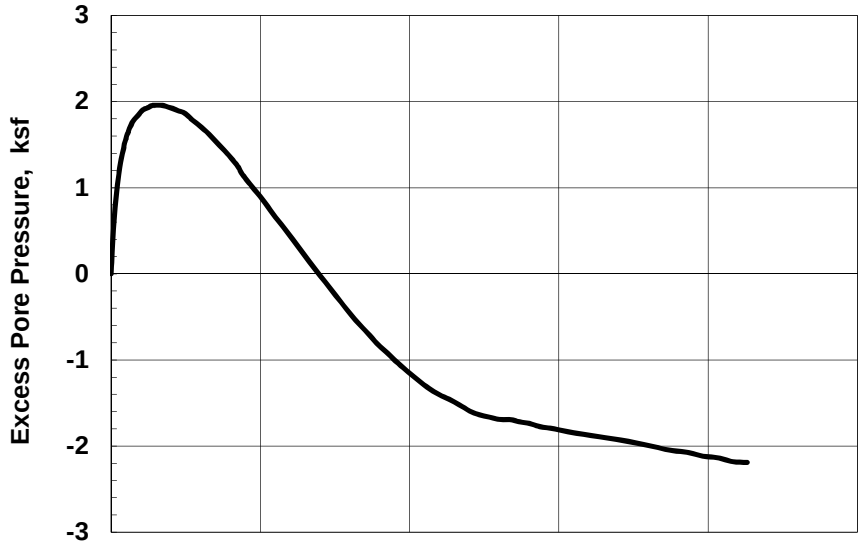
Consolidation Stresses: 2.00 ksf vertical, 2.00 ksf lateral
Water Content: 22.5 % Total Unit Weight: 127.5 pcf
B Coefficient: Strain Rate: 0.019 %/min
Peak Shear Strength: 2.37 ksf @ 19.9 % Strain
Peak Effective Friction Angle: 33.9°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B021 Sample: ST-2C	October-15

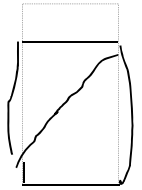


SAMPLE INFORMATION

Boring: JOP-B021 Sample: ST-3B Depth: 34.1 ft
Type: Intact tube sample
Description: CL, brown sandy clay
LL = 22 PL = 13 PI = 9

SPECIMEN INFORMATION (Initial)

Height: 6.19 inch Diameter: 2.86 inch Area: 6.41 in²
Water Content: 15.0 % Total Unit Weight: 127.6 pcf

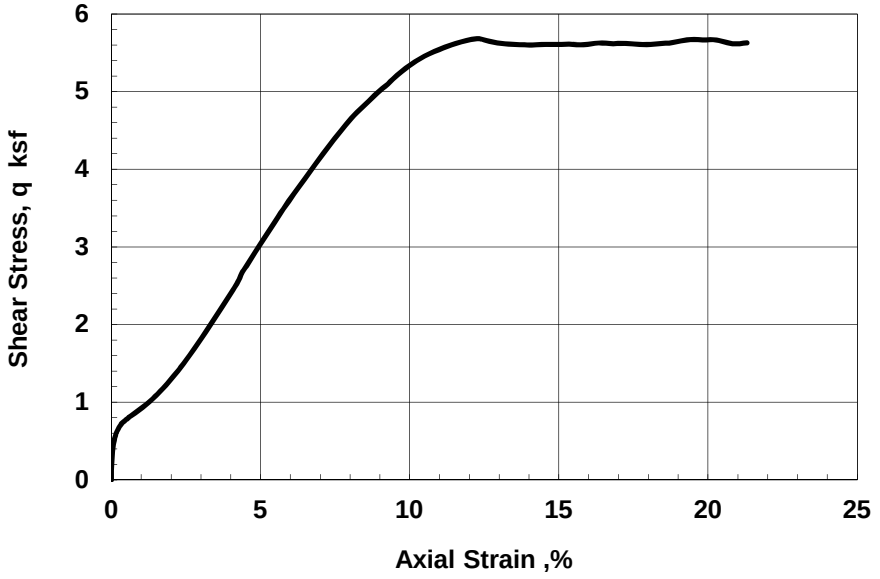


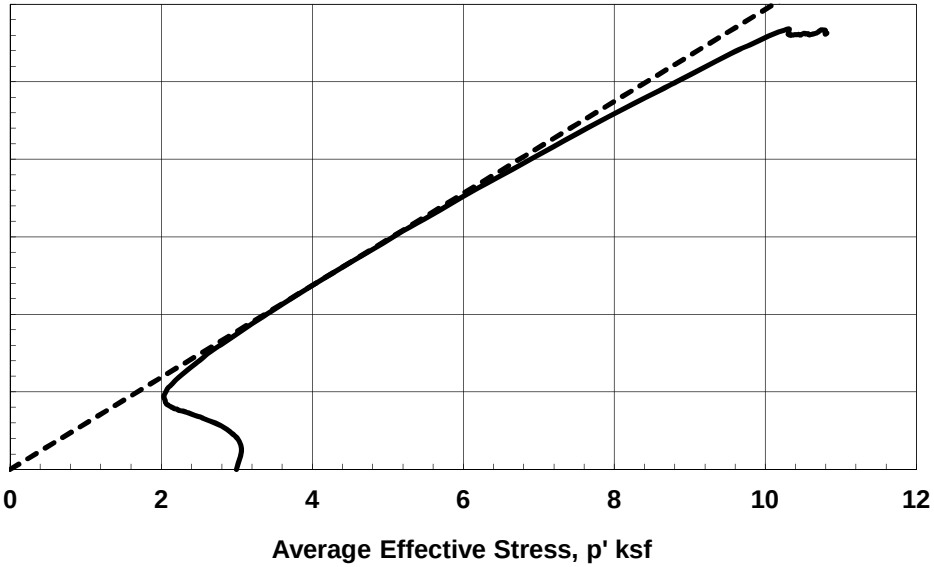
Failure Sketch

TEST SUMMARY

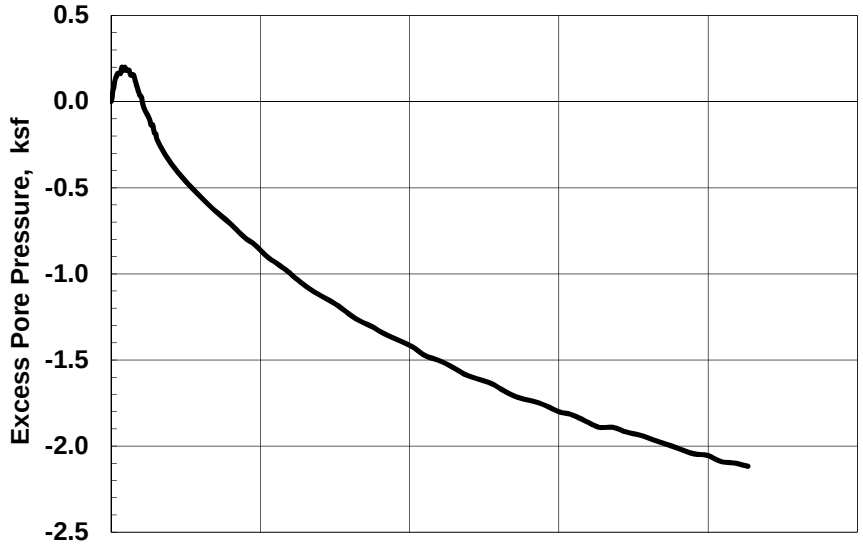
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 15.8 % Total Unit Weight: 134.7 pcf
B Coefficient: 98.78 Strain Rate: 0.021 %/min
Peak Shear Strength: 5.68 ksf @ 12.3 % Strain
Peak Effective Friction Angle: 36.4°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B021 Sample: ST-3B	October-15

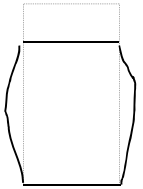


SAMPLE INFORMATION

Boring: JOP-B022 Sample: ST-2C Depth: 9.4 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 35 PL = 18 PI = 17

SPECIMEN INFORMATION (Initial)

Height: 6.01 inch Diameter: 2.87 inch Area: 6.46 in²
Water Content: 21.4 % Total Unit Weight: 128.2 pcf

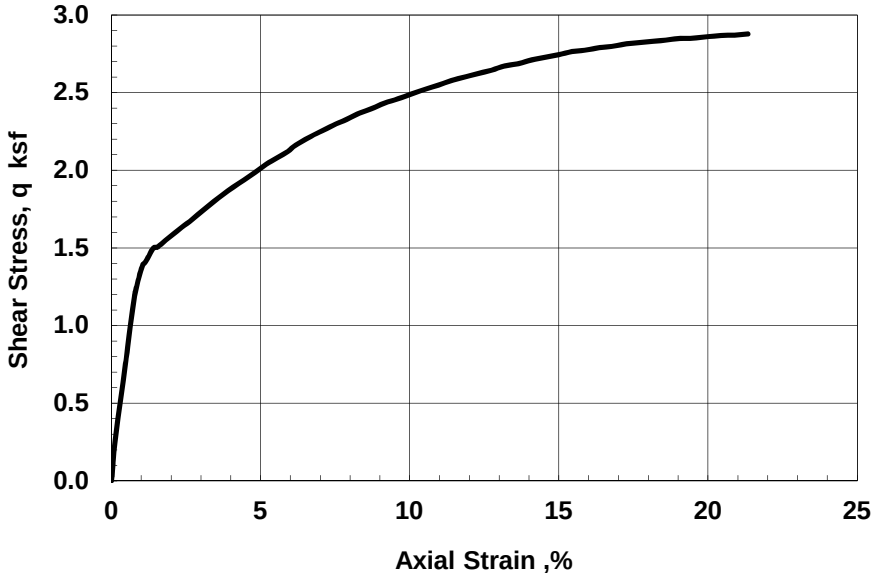


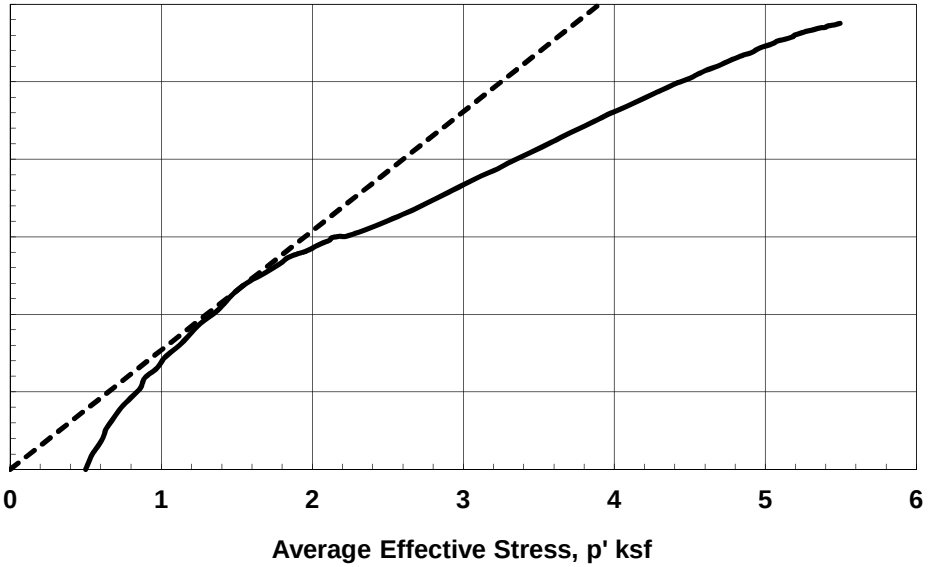
Failure Sketch

TEST SUMMARY

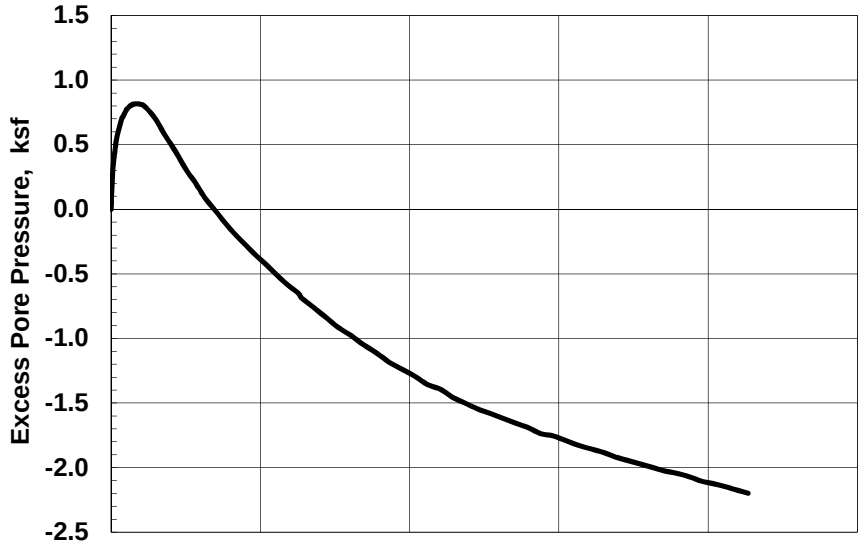
Consolidation Stresses: 0.50 ksf vertical, 0.50 ksf lateral
Water Content: 21.7 % Total Unit Weight: 129.7 pcf
B Coefficient: 99.87 Strain Rate: 0.022 %/min
Peak Shear Strength: 2.88 ksf @ 21.3 % Strain
Peak Effective Friction Angle: 50.3°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B022 Sample: ST-2C	September-15

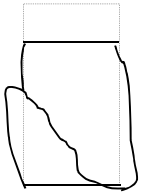


SAMPLE INFORMATION

Boring: JOP-B022 Sample: ST-3C Depth: 24.5 ft
Type: Intact tube sample
Description: CL, brown gray lean clay
LL = 38 PL = 14 PI = 24

SPECIMEN INFORMATION (Initial)

Height: 6.03 inch Diameter: 2.87 inch Area: 6.47 in²
Water Content: 19.5 % Total Unit Weight: 130.6 pcf

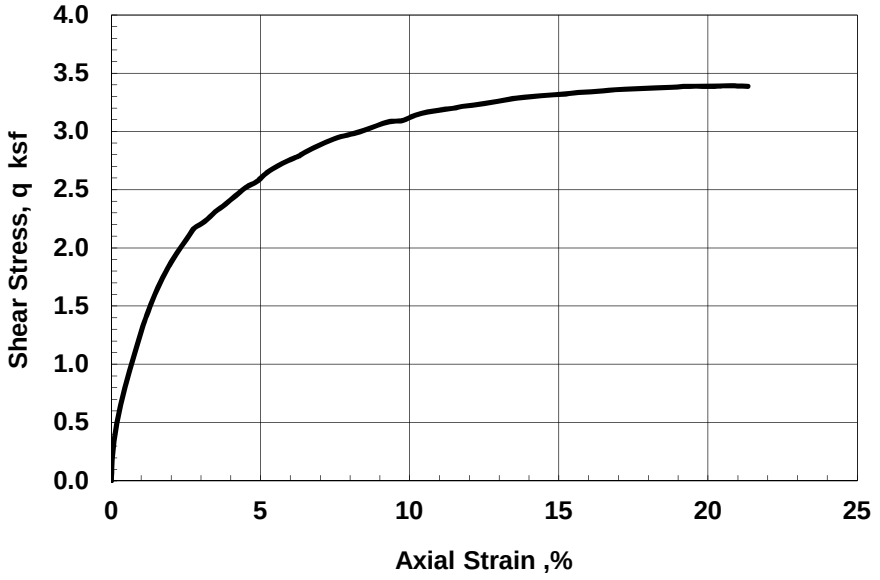


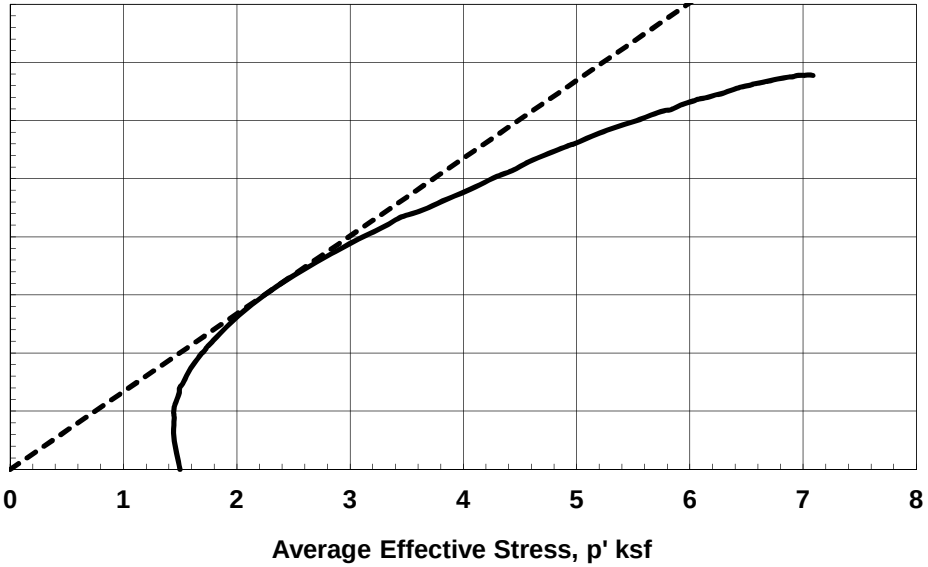
Failure Sketch

TEST SUMMARY

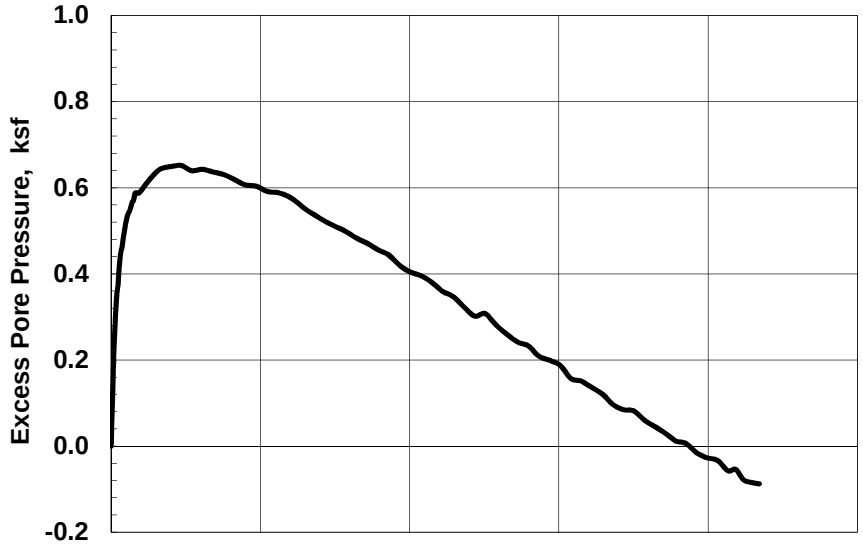
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 19.9 % Total Unit Weight: 132.7 pcf
B Coefficient: 96.76 Strain Rate: 0.021 %/min
Peak Shear Strength: 3.39 ksf @ 20.7 % Strain
Peak Effective Friction Angle: 42.0°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B022 Sample: ST-3C
			September-15

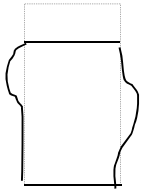


SAMPLE INFORMATION

Boring: JOP-B023 Sample: ST-1B Depth: 43.7 ft
Type: Intact tube sample
Description: CL, gray lean clay
LL = 32 PL = 22 PI = 10

SPECIMEN INFORMATION (Initial)

Height: 5.89 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 27.1 % Total Unit Weight: 123.2 pcf

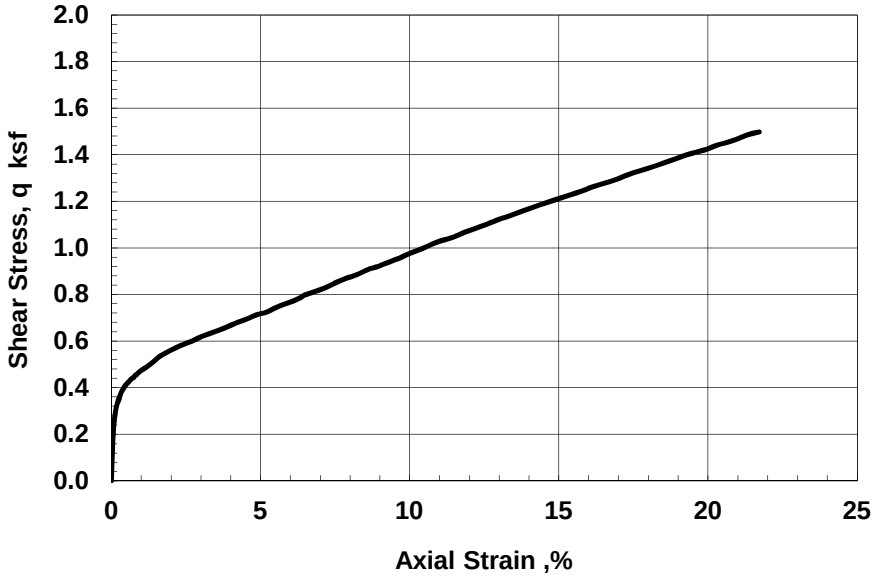


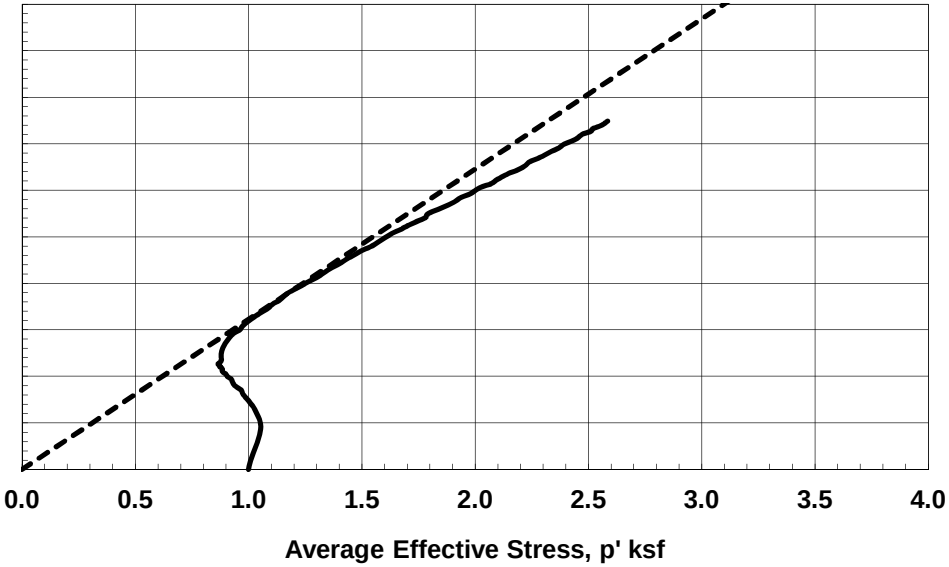
Failure Sketch

TEST SUMMARY

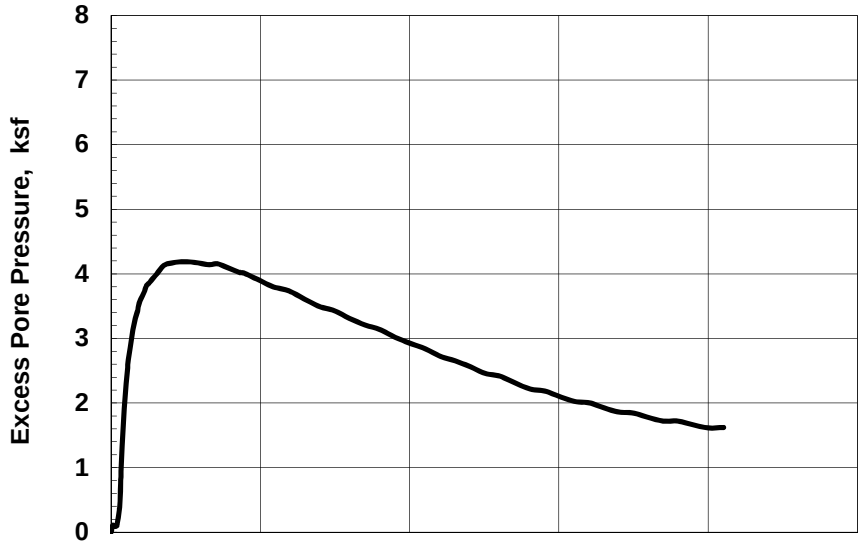
Consolidation Stresses: 1.00 ksf vertical, 1.00 ksf lateral
Water Content: 24.5 % Total Unit Weight: 127.2 pcf
B Coefficient: 96.32 Strain Rate: 0.022 %/min
Peak Shear Strength: 1.50 ksf @ 21.7 % Strain
Peak Effective Friction Angle: 40.2°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements
Checked by: GET	**TerraSense, LLC**		Boring: JOP-B023 Sample: ST-1B — September-15



SAMPLE INFORMATION

Boring: JOP-B023 Sample: ST-2B Depth: 49 ft
Type: Intact tube sample
Description: CL, brown-gray lean clay with sand
LL = 35 PL = 14 PI = 21

SPECIMEN INFORMATION (Initial)

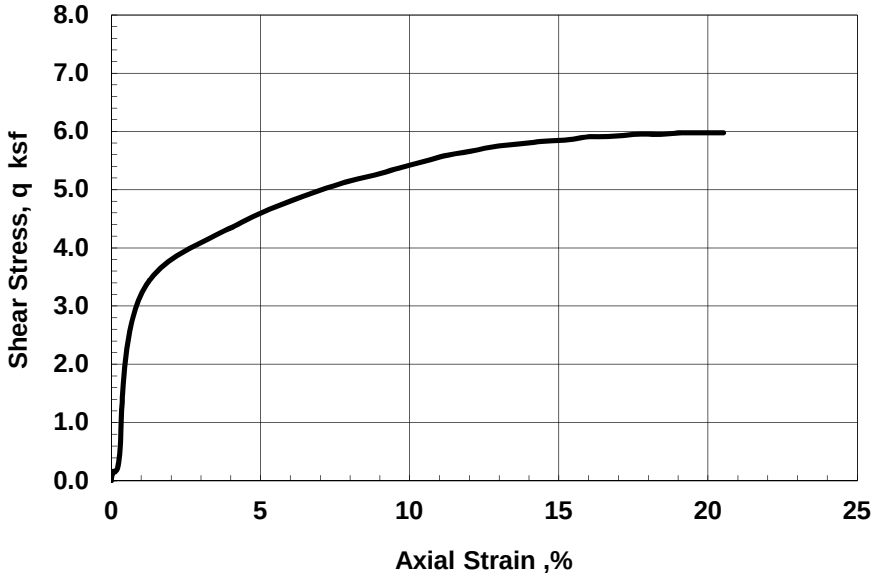
Height: 6.06 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 18.1 % Total Unit Weight: 132.1 pcf

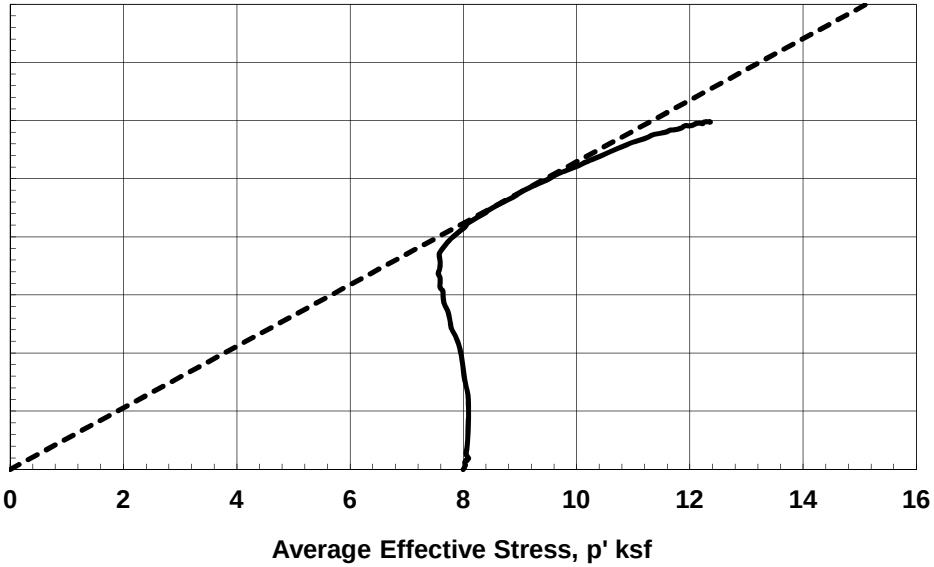
TEST SUMMARY

Consolidation Stresses: 8.00 ksf vertical, 8.00 ksf lateral
Water Content: 16.7 % Total Unit Weight: 135.9 pcf
B Coefficient: 95.89 Strain Rate: 0.021 %/min
Peak Shear Strength: 5.98 ksf @ 19.5 % Strain
Peak Effective Friction Angle: 32.0°

Failure Sketch

REMARKS:





Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements	
TerraSense, LLC		Boring: JOP-B023 Sample: ST-2B	October-15

DIRECT SHEAR TEST (ASTM D 3080): Setup / Take Down

Project Number: 04.11150035 | Apparatus No.: DS-S02 | File Name: JOP-B001_ST-2a
Task Number: | Assign. Units: [X] ksf; or Other: | Ring No.: FL1
Project Name: | Series $\sigma'_{v,c}$ or $\sigma'_{n,c}$: 3 , 5 | Area - Shear Box, A_{sb} (cm^2): 31.703
" 8 & | Height - Shear Box, H_{sb} (mm):
This Test $\sigma'_{v,c}$ or $\sigma'_{n,c}$: 3 ; 5 ; & 8 | Shear Box: [X] Circular [ ] Square
Induced OCR: NA ; Max. $\sigma'_{v,max}$: NA | Specific Gravity: 2.7 [X] Assumed; [ ] Measured
Multistage: [ ] No; [X] Yes | Residual/Multishearing: [X] No; [ ] Yes | Precut Failure Plane [X] No; [ ] Yes
Assign. Remarks:

[X] Tube [ ] Field Extruded [ ] Liner [ ]	[ ] Tampling	[ ] Constant Effort:	Blows/Tamps per Layer =
Boring No.: JOP-B001 [ ] Reconstituted	[ ] Kneading	Rammer Wgt.(lbf)=	Tamper: Force (lbf)=
Sample No.: ST-2 Compostite No.:	[ ] Inpact/Rammer	Drop(in.)=	Dia.(in.)=
Depth (ft): 10.00 Specimen No.: a	[ ] Pluviated:	[ ] Undercompaction: U_{ni} (%) =	Ref.Effort=
[ ] Spec. Selection by X - Ray; [ ] Geomarine Sample		No. Layers =	% Comp= ± Opt.=

Water Content (WC);	Initial - Trimming Location			Final, W_{at}
	Top (W1)	Bottom (W2)	Sides (W3)	(see below)
Container No.	4094	4153	6184	3
Mass Moist Soil + Container (g)	117.29	99.82	107.35	156.80
Mass Dry Soil + Container (g)	98.77	82.06	88.71	126.28
Mass Container (g)	30.56	30.28	29.95	16.29
WATER CONTENT (%)	27.15	34.30	31.72	27.75
Avg. Initial WC, W4 (%)	31.06	Final W_{at}: Soil with free water trimmed away		
[ ] See attached data sheet(s) for additional water contents				

Soil and Ring Masses (g)	Initial	Final
Mass Moist Soil+Trimming Ring	346.65	NA
Mass Trimming Ring, etc.	199.01	NA
Mass Moist Soil	147.64	NA
Excess Dry Soil (soil not included in final water content)		
Container No.		
Mass Dry Soil + Cont. (g)		
Mass Container (g)		
Mass Excess Dry Soil (g)	0.00	

Soil Height: Measurements(1)	
Initial (mm)	
with Spec., H_{soil}	without Spec., H_{app}
24.60	
24.68	
24.69	
24.71	
24.66	
Block Used (2): [ ] Yes ; [X] No	

(1) Measured in trimming ring, not shear box.

Soil Height/Volume: Calc., (mm)	Initial
Height of Gauge Block, H_{gb} (2)	NA
Reading on Gauge Block, R_{gb}	NA
Avg. Reading on Soil, H_{soil}	24.67
Avg. Reading on Apparatus without Specimen, H_{app}	0.00
Soil Height, $H = H_{soil} - H_{app} + H_{gb} - R_{gb}$	24.67
Initial Soil Volume, V_o (cm^3)	78.20

Estimated Initial Unit Weight			
Total, $\gamma_{t,o}$ (pcf)=	117.86	Dry, $\gamma_{d,o}$ (pcf)=	89.93

(2) Req. block ht. to set bench comparator so the initial soil ht. can be determined directly by the diff. between the reading with and without spec. Enter value for H_{gb} and d_{gb} only when these values have to be included in the determination of the soil height.
(3) Equals wgt. top cap, loading hanger and Bellofram piston (if used). (4) Reduced value if soil will dilate during shear.

Apparatus Information:	Wgt. of Top Shear Ring, M_{sb} (lbf) = 2.07 Dead Wgt. of Loading System(3) (lbf)= 4.81
	Top Shear Box Supported by Counter Force: [ ] Yes ; [X] No: Shear Box Free to Move Up & Down: [ ] Yes ; [X] No:
	Porous Inserts: [X] Stone; [ ] Metal; **Do not use filter paper over porours inserts.** Free to Rotate: [ ] Yes ; [X] No:
	Porous Inserts with Additional Shear Transfer Features: [ ] None; [ ] Pins; [ ] Grid Plate; [X] Waffle Stone; [ ] Other:
	Apparatus deformation under consolidation load determined: [ ] Yes ; [X] No

Sketch of Specimen

Photo taken of Sliced Test Specimen: [ ] Yes ; [X] No
Final Visual Description: Sandy Clay, brown and greenish gray, with ferrous stains and small gravel
Trimming/Etc. Remarks:

Method of trimming periphery: [X] "Casagrande" Lathe ; [ ] Cutting Shoe ; [ ] Wire Saw; [ ] Other
Method of trimming ends: [ ] Wire Saw & Sharp (knife) Straight Edge; [X] Wire Saw & Straight Edge; [ ] Wire Saw; [ ] Other
For soils containig sand, ~100 % passes sieve size: [ ] #4 (4.75 mm); [ ] #10 (2.0 mm); [ ] #20 (0.85 mm) or; [ ] #40 (0.425 mm)
Shear Box Gap Setting(2): Clays, 0.50 to 0.65 mm; Sands,1 mm to sieve size (mm) for 100 % passing

Trim./Recon. By: PL Set up By: JTG Prelim. Cal. By: JTG Taken Down By: PL
Date: 12/8/2015 Date: 12/8/2015 Final Cal. By: JTG Date: 12/14/2015
Reviewed By: JTG

DIRECT SHEAR TEST (ASTM D 3080): SPECIMEN CALCULATIONS & SUMMARY

Project Number: 04.11150035 Boring/Exploration No.: JOP-B001 Type Test: DS
Task Number: Sample No.: ST-2 Specific Gravitiy, G_s: 2.70
Project Name: Penetration/Depth (ft): 10.00
Calculations Corrected for Salt (dissolved soilids): [X] No or, [ ] Yes, with salinity, S_{ppt} _____ ppt

Water Content Copied/Derived From:	Water Content, $W_{o,n}$ (%)	Mass Dry Soil, $M_{do,n}$ (g)	Degree of Sat., $S_{o,n}$ (%)
Initial, Top, W1	27.15	116.11	89.9
" Bottom, W2	34.30	109.93	101.0
" Sides, W3	31.72	112.08	97.3
" Average, W4	31.06	112.65	96.3
" Assumed, W	31.06	112.65	96.3
Final (After Test/Shear)	27.75		

Back-calculated Data Item	Value	Input Data for Back Calculation $S_{o,n}$ (%)	
Initial Mass Dry Soil, $M_{d,c}$			G_s
Specific Gravity, G_s			$M_{d,o}$ (g)

Calculation Constant: = (unit conversion) / $G_s \times \rho_w \times A_{sb}$	
Estimated	0.11704
Final Selected	0.11704

Soil Height: Final by Dial Change During Test (mm)		For Multistage Testing	
	Initial Height, H_o	2nd Stage	3rd Stage
Change in Height During Consol.(not corrected for apparatus flexability)	0.78	0.18	0.17
Height after Consolidation, H_c	23.88	23.51	23.20
Change in Height During **Initial** Shear (+ compression, - dilation)	0.19	0.15	0.48
Change in Height During Repeated/Residual Shear	NA	NA	NA
Change in Height During Consol. to Max. Consol. Stress	NA	NA	NA
Final Soil Height (After Test/Shear), H_{at}	23.69	23.36	22.71

Summary of Specimen Physical Properties: Initial Conditions

Area, A_{sb}: 31.703 , cm^2
Specific Gravity, G_s: 2.700 [X] Assumed [ ] Measured
Mass Dry Soil, Md (g): 112.65 [X] Based on average water content [ ] Value based on one of the above values

	Water Content, w (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Void Ratio, e	Degree of Saturation, S (%)	Height, H (mm)	Volume, V (cm^3)	
Initial:	31.1	117.86	89.93	0.871	96.3	24.67	78.20	

Consolidation Summary: Stress Units = (ksf)	Stage:	1st	2nd	3rd		1st	2nd	3rd
	$\sigma'_{n,c}$ or $\sigma'_{v,c}$	3	5	8	$\varepsilon_{a,c}$ (%)	3.18	0.73	0.69
	$\sigma'_{v,max}$	NA	NA	NA	$\varepsilon_{a,max}$ (%)	NA	NA	NA
	OCR	NA	NA	NA	t_c (days)	0.67	0.69	0.74

Remarks:
NA - Not Applicable

Calculated by: JTG Reviewed by: JTG
Date: 12/14/2015

DRAINED DIRECT SHEAR TEST: Test Results

Project Number:	04.11150035	App. No.:	DS-S02	Boring No.:	JOP-B001
Task No.:		Consol. Stress, $\sigma'_{v,c}$:	3 (ksf)	Sample No.:	ST-2
Project Name:		Induced OCR:	NA	Specimen No.:	a
File Name:	JOP-B001_ST-2a	$\sigma'_{v,max}$:	NA (ksf)	Depth (ft):	10.00
Shear Box Dia./Width:	63.5 (mm)	Specimen Ht.:	23.88 (mm)		
Shear Box:	[X] Circular [ ] Square	Vert. Strain During Consol.:	3.18 (%)		

Part of Test Series: [X] No; [ ] Yes If yes, Test: NA of NA
Multistage: [ ] No; [X] Yes If yes, Test Stage No.: 1
Residual/Multishearing: [X] No; [ ] Yes Precut Failure Plane [X] No; [ ] Yes

Initial Test Conditions:				
Water Content, w (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Void Ratio, e	Degree of Saturation, S (%)
31.1	117.86	89.93	0.871	96.3

Shearing Data For:	[X]	Intact - Without Repeated Shearing (Peak Data)
	[ ]	Intact - Before Repeated Shearing (Peak Data)
	[ ]	After Rapid Repeated Shearing (Residual Data)
	[ ]	Continuous Shearing: Forwards & Backwards (Peak & Residual Data)

Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
0.00	0.0000	-0.02	0.00	0.00
10.00	-0.0002	0.27	0.00	0.01
20.00	-0.0003	0.37	0.00	0.01
33.00	-0.0004	0.49	0.00	0.01
48.00	0.0007	1.16	0.02	0.03
63.00	-0.0029	3.80	0.01	0.11
78.00	0.0321	11.07	0.04	0.32
93.00	0.0795	14.65	0.11	0.43
108.00	0.1136	17.10	0.15	0.50
123.00	0.1541	18.99	0.19	0.56
138.00	0.1885	20.86	0.26	0.61
153.00	0.2303	22.84	0.30	0.67
168.00	0.2725	24.80	0.34	0.73
185.00	0.3293	27.05	0.39	0.79
210.00	0.4217	30.77	0.48	0.90
235.00	0.5025	35.00	0.54	1.03
260.00	0.5736	37.49	0.59	1.10
285.00	0.6521	39.45	0.65	1.16
310.00	0.7235	40.87	0.68	1.20
335.00	0.8035	42.66	0.71	1.25
360.00	0.8955	44.39	0.75	1.30
385.00	0.9868	46.30	0.80	1.36
390.00	1.0036	46.59	0.80	1.37

Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

Def. Rate (mm/min): 0.00257

DRAINED DIRECT SHEAR TEST: Test Results

Project Number:	04.11150035	App. No.:	DS-S02	Boring No.:	JOP-B001
Task No.:		Consol. Stress, $\sigma'_{v,c}$:	5 (ksf)	Sample No.:	ST-2
Project Name:		Induced OCR:	NA	Specimen No.:	a
File Name:	JOP-B001_ST-2a	$\sigma'_{v,max}$:	NA (ksf)	Depth (ft):	10.00
Shear Box Dia./Width:	63.5 (mm)	Specimen Ht.:	23.51 (mm)		
Shear Box:	[X] Circular [ ] Square	Vert. Strain During Consol.:	0.73 (%)		

Part of Test Series: [X] No; [ ] Yes If yes, Test: NA of NA
Multistage: [ ] No; [X] Yes If yes, Test Stage No.: 2
Residual/Multishearing: [X] No; [ ] Yes Precut Failure Plane [X] No; [ ] Yes

Initial Test Conditions:				
Water Content, w (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Void Ratio, e	Degree of Saturation, S (%)
31.1	117.86	89.93	0.871	96.3

Shearing Data For:	[X]	Intact - Without Repeated Shearing (Peak Data)
	[ ]	Intact - Before Repeated Shearing (Peak Data)
	[ ]	After Rapid Repeated Shearing (Residual Data)
	[ ]	Continuous Shearing: Forwards & Backwards (Peak & Residual Data)

Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
0.00	0.0000	0.10	0.00	0.00
10.00	-0.0009	0.51	-0.01	0.01
20.00	0.0058	0.99	0.01	0.03
33.00	0.0036	3.58	0.00	0.10
48.00	0.0239	10.72	0.02	0.31
63.00	0.0667	15.21	0.06	0.45
78.00	0.1037	18.94	0.09	0.55
93.00	0.1377	22.52	0.13	0.66
108.00	0.1776	26.43	0.16	0.77
123.00	0.2205	30.24	0.20	0.89
138.00	0.2659	34.44	0.23	1.01
153.00	0.3148	38.78	0.26	1.14
168.00	0.3626	43.07	0.30	1.26
185.00	0.4133	46.87	0.33	1.37
210.00	0.4823	52.88	0.37	1.55
235.00	0.5463	58.49	0.40	1.71
260.00	0.6176	63.01	0.44	1.85
285.00	0.6988	66.30	0.48	1.94
310.00	0.7827	70.46	0.52	2.06
335.00	0.8651	74.21	0.57	2.17
360.00	0.9481	77.02	0.60	2.26
385.00	1.0106	78.81	0.63	2.31

Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

Def. Rate (mm/min): 0.00262

DRAINED DIRECT SHEAR TEST: Test Results

Project Number:	04.11150035	App. No.:	DS-S02	Boring No.:	JOP-B001
Task No.:		Consol. Stress, $\sigma'_{v,c}$:	8 (ksf)	Sample No.:	ST-2
Project Name:		Induced OCR:	NA	Specimen No.:	a
File Name:	JOP-B001_ST-2a	$\sigma'_{v,max}$:	NA (ksf)	Depth (ft):	10.00
Shear Box Dia./Width:	63.5 (mm)	Specimen Ht.:	23.20 (mm)		
Shear Box:	[X] Circular [ ] Square	Vert. Strain During Consol.:	0.69 (%)		

Part of Test Series: [X] No; [ ] Yes If yes, Test: NA of NA
Multistage: [ ] No; [X] Yes If yes, Test Stage No.: 3
Residual/Multishearing: [X] No; [ ] Yes Precut Failure Plane [X] No; [ ] Yes

Initial Test Conditions:				
Water Content, w (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Void Ratio, e	Degree of Saturation, S (%)
31.1	117.86	89.93	0.871	96.3

Shearing Data For:	[X]	Intact - Without Repeated Shearing (Peak Data)
	[ ]	Intact - Before Repeated Shearing (Peak Data)
	[ ]	After Rapid Repeated Shearing (Residual Data)
	[ ]	Continuous Shearing: Forwards & Backwards (Peak & Residual Data)

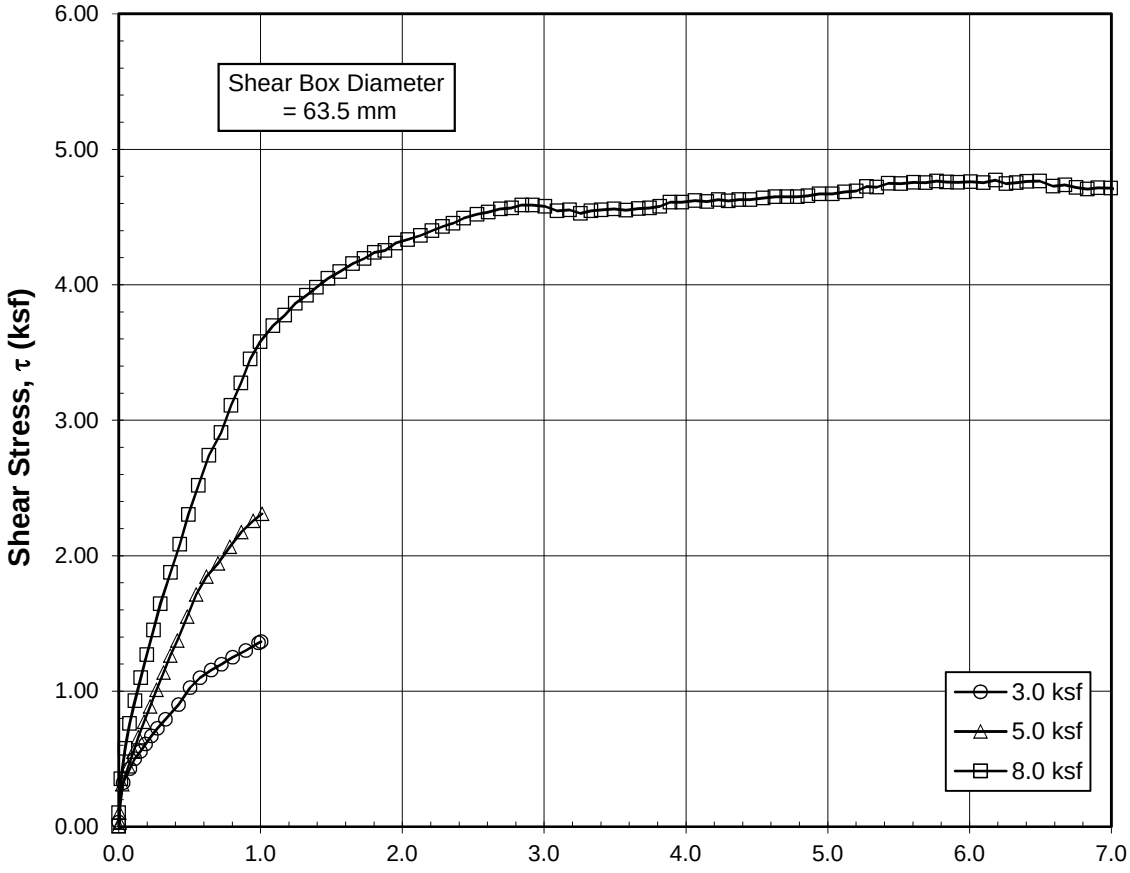
Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
0.00	0.0000	0.12	0.00	0.00
10.00	-0.0009	0.25	0.00	0.01
20.00	-0.0020	0.39	-0.01	0.01
33.00	-0.0022	0.70	-0.01	0.02
48.00	-0.0020	1.11	0.00	0.03
63.00	0.0002	3.55	0.00	0.10
78.00	0.0164	12.04	0.01	0.35
93.00	0.0454	19.72	0.03	0.58
108.00	0.0762	26.02	0.06	0.76
123.00	0.1143	31.74	0.10	0.93
138.00	0.1552	37.50	0.14	1.10
153.00	0.1993	43.30	0.17	1.27
168.00	0.2453	49.52	0.20	1.45
185.00	0.2944	56.13	0.24	1.64
210.00	0.3663	64.08	0.28	1.88
235.00	0.4300	71.11	0.31	2.08
260.00	0.4909	78.60	0.35	2.30
285.00	0.5613	85.94	0.38	2.52
310.00	0.6364	93.54	0.40	2.74
335.00	0.7229	99.26	0.47	2.91
360.00	0.7924	106.10	0.51	3.11
385.00	0.8618	111.78	0.55	3.28
410.00	0.9277	117.79	0.58	3.45
435.00	0.9969	122.11	0.59	3.58
460.00	1.0866	126.15	0.65	3.70
485.00	1.1705	128.86	0.68	3.78
510.00	1.2466	131.85	0.70	3.86
535.00	1.3254	133.84	0.76	3.92
560.00	1.3949	135.88	0.79	3.98
585.00	1.4748	138.12	0.82	4.05
610.00	1.5600	139.76	0.86	4.10
635.00	1.6501	141.80	0.88	4.16
660.00	1.7316	143.14	0.93	4.19
685.00	1.8030	144.66	0.96	4.24
710.00	1.8774	145.14	0.98	4.25
735.00	1.9525	146.98	1.02	4.31
760.00	2.0375	147.87	1.04	4.33

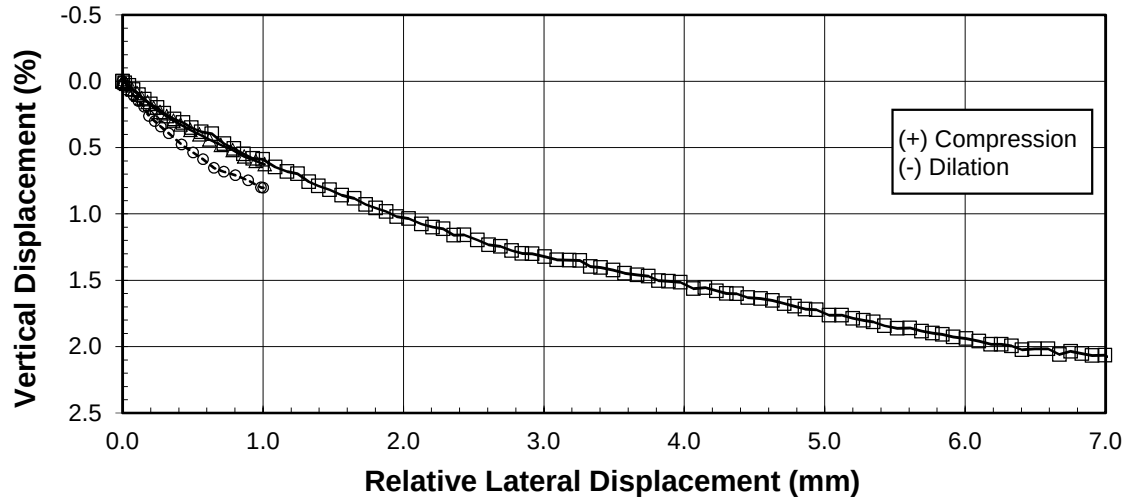
Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

Def. Rate (mm/min): 0.00306

Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
785.00	2.1287	148.94	1.08	4.36
810.00	2.2088	150.11	1.10	4.40
835.00	2.2835	151.21	1.11	4.43
860.00	2.3587	151.94	1.16	4.45
885.00	2.4318	153.23	1.16	4.49
910.00	2.5268	154.20	1.20	4.52
935.00	2.6073	154.83	1.23	4.54
960.00	2.6919	155.60	1.25	4.56
985.00	2.7713	155.81	1.28	4.57
1010.00	2.8433	156.53	1.30	4.59
1035.00	2.9177	156.56	1.30	4.59
1060.00	3.0064	156.24	1.32	4.58
1085.00	3.0922	155.15	1.35	4.55
1110.00	3.1799	155.35	1.35	4.55
1135.00	3.2561	154.50	1.35	4.53
1160.00	3.3315	155.13	1.40	4.55
1185.00	3.4036	155.38	1.40	4.55
1210.00	3.4926	155.63	1.42	4.56
1235.00	3.5763	155.30	1.45	4.55
1260.00	3.6637	155.71	1.46	4.56
1285.00	3.7434	155.83	1.47	4.57
1310.00	3.8161	156.24	1.50	4.58
1335.00	3.8880	157.33	1.51	4.61
1360.00	3.9721	157.31	1.51	4.61
1385.00	4.0645	157.68	1.56	4.62
1410.00	4.1465	157.42	1.56	4.61
1435.00	4.2288	157.90	1.58	4.63
1460.00	4.2997	157.63	1.60	4.62
1485.00	4.3737	157.92	1.60	4.63
1510.00	4.4532	157.94	1.63	4.63
1535.00	4.5443	158.34	1.64	4.64
1560.00	4.6278	158.68	1.65	4.65
1585.00	4.7120	158.67	1.68	4.65
1610.00	4.7860	158.66	1.70	4.65
1635.00	4.8605	158.89	1.72	4.66
1660.00	4.9398	159.38	1.72	4.67
1685.00	5.0320	159.36	1.76	4.67
1710.00	5.1190	159.89	1.76	4.69
1735.00	5.2005	160.08	1.79	4.69
1760.00	5.2745	161.23	1.80	4.72
1785.00	5.3468	161.05	1.81	4.72
1810.00	5.4262	162.05	1.84	4.75
1835.00	5.5155	161.97	1.86	4.75
1860.00	5.6054	162.32	1.86	4.76
1885.00	5.6899	162.23	1.88	4.75
1910.00	5.7669	162.58	1.90	4.76
1935.00	5.8376	162.34	1.91	4.76
1960.00	5.9164	162.29	1.93	4.76
1985.00	6.0068	162.49	1.94	4.76
2010.00	6.0975	162.23	1.96	4.75
2035.00	6.1822	162.84	1.98	4.77
2060.00	6.2577	162.00	1.98	4.75
2085.00	6.3304	162.18	1.99	4.75
2110.00	6.4052	162.53	2.02	4.76
2135.00	6.4941	162.59	2.02	4.76
2160.00	6.5897	161.32	2.02	4.73
2185.00	6.6729	161.64	2.06	4.74
2210.00	6.7525	161.00	2.03	4.72
2235.00	6.8303	160.58	2.05	4.71
2260.00	6.9043	160.91	2.07	4.72
2285.00	6.9948	160.82	2.07	4.71
2290.00	7.0115	160.65	2.08	4.71

Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

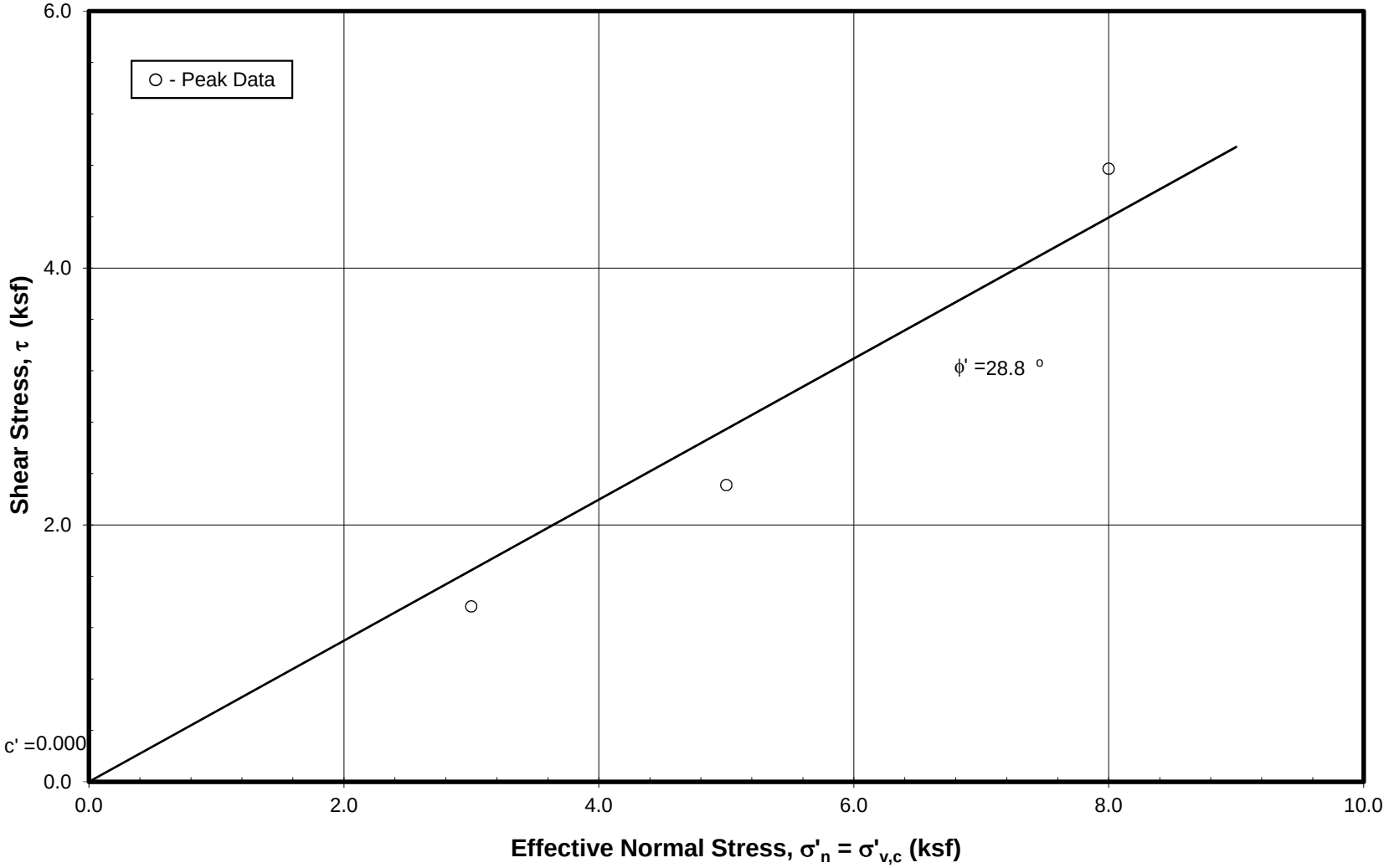




DRAINED DIRECT SHEAR TEST: All Tests in Test Series

Soil - Soil Interface $\sigma'_{v,c}$ = 3.0, 5.0, 8.0 ksf

Boring: JOP-B001 - Sample: ST-2a - Depth: 10.00 ft



DRAINED DIRECT SHEAR TEST: Test Series - (Peak Strength)

Soil - Soil Interface

Boring: JOP-B001 - Sample: ST-2a - Depth: 10.00 ft

CYCLIC DSS STRENGTH TEST (ASTM D 6528 & D 5311): Specimen Setup / Take Down

Project Number: 04.11150035 | Test Type: CyDSS ta=0 | Sta. No.: CSS-S04 | File Name: OP-B001_ST-2
Task No.: | Assign, $\sigma'_{v,c}$ = 1.00 ksf | Static DSS $c_u/\sigma'_{v,c}$ = 1.000
Project Name: | Induced OCR = 1.00 | Cyclic Ratios: τ_{cy} / c_u = 0.300 | τ_{avg} / c_u = NA
Sequence No.: of | Assig. Remarks: See Other Remarks | $\tau_{cy}/\sigma'_{v,c}$ = 0.300 | $\tau_{avg}/\sigma'_{v,c}$ =
Failure Criterion: [ ] Peak Obliquity, or [ ] Shear Strain (%) = | Specific Gravity: 2.700 [ ] Meas.; [X] Assumed

[X] Tube [ ] Field Extruded	[ ] Liner [ ] Remolded	[ ] Tamping	[ ] Constant Effort:	Blows/Tamps per Layer =	
Boring No.: JOP-B001	[ ] LPC Core	[ ] Impact/Rammer	Rammer Wgt.(lbf)=	No. Layers =	
Sample No.: ST-2	Compostite No.:	[ ] Pluviated:	Tamper Force (lbf)=	Drop (in.) =	
Depth (ft): 9.75	Specimen No.: b	[ ] Kneading	[ ] Undercompaction:	U_{ni} (%) =	Dia. (in.) =
[ ] Spec. Selection by X-ray;	[ ] Geomarine Sample		Ref. Effort=	% Comp. =	± Opt.=

Type of Consolidation:	[X] K_o at:	[X] Incremental	; [ ] Anisotropic at:	[ ] Inclined Stress Path, $K_{c,DSS}$	[X] Used automated system
		[ ] CRS		[ ] 90° Stress Path	Remarks:
Loading Conditions:	[ ] Static	[ ] Strain	[ ] Creep	[X] Const, Vol./Ht	[X] Without - Water	[X] Cyclic (Hz)	[ ] Strain	[X] Stress
	[ ] Dynamic	[ ] Stress	[ ] Post Cyclic	[ ] Drained	[ ] With - Bath	Rate: [ ] 0.1;	[X] 1;	Other:

Water Content (WC);	Initial - Trimming Location			Final, W_{at}
	Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	(see below)
Container No.	706	4056	6277	6593
Mass Moist Soil + Cont. (g)	112.74	73.01	74.87	59.95
Mass Dry Soil + Container (g)	92.10	61.78	64.06	52.94
Mass Container (g)	31.66	29.92	31.66	30.14
WATER CONTENT (%)	34.15	35.25	33.36	30.75
Avg. Initial WC, $W_{o,avg}$ (%)	34.25	Final W_{at}: [X] Slice ; [ ]		Whole Spec.
[ ] See attached data sheet(s) for additional water contents				

Soil and Ring Masses	Initial	Final
Mass Moist Soil + Tare (g)	298.37	128.10
Mass Tare (g)	179.93	13.53
Mass Moist Soil, $M_{t,o}$ $Mt_{,at}$ (g)	118.44	114.57
Excess Dry Soil (soil not included in final mass above)		
Container No.		
Mass Dry Soil + Container (g)		
Mass Container (g)		
Mass Excess Dry Soil (g)	0.00	

Specimen Trimming:

[ ] Trimming Ring for Fugro Apparatus	NL4	Large-ring ID #	
[X] Trimming Ring for NGI Apparatus		Small-ring ID #	
$H_{s,t}$ (mm):	18.32	$A_{s,t}$ (cm^2):	34.99
$D_{s,t}$ (mm) :	66.75	$V_{s,t}$ (cm^3):	64.10

Remarks:

[ ] Free Standing by Wire Saw Lathe (mm)

	Height (H_{tr})	Diameter (D_o)		Remarks:
1	18.310	1-T	NA	
2	18.320	2-M	NA	
3	18.300	3-B	NA	
4	18.330	1'-T	NA	For Free Standing
5	18.330	2'-M	NA	Trimmed Spec.:
Avg.		3'-B	NA	A_{tr} (cm^2): NA
=	18.318	Avg	NA	V_{tr} (cm^3): NA

Note: NA-Indicates not applicable. | Top Cap No. 16

F or G in the Sta. No. indicates Fugro or GEOTAC apparatus.

Estimated Initial Unit Weight

Total, $\gamma_{t,o}$ (lb/ft^3)= 115.36 | Dry, $\gamma_{d,o}$ (lb/ft^3)= 85.93

Specimen Lateral Confinement by:

[X] **Wire Reinforced, Model:** C=1.5 Thickness (mm) = 0.72

Stress Level	Dia. by PiTape (mm) Meas.	Corr.	Area, $A_{c,n}$ (cm^2)	(in^2)
0	68.05	66.61	34.85	5.401
$\sigma'_{v,c}$	68.18	66.74	34.98	5.422
$\sigma'_{v,max}$	68.18	66.74	34.98	5.422

[ ] **Regular Membrane with Ring Set No.** | ID, Rings (mm)

Thickness (mm): Top: , = | [ ] Single Bottom: , Corr. for mem. | [ ] Double Membr. Thick. = =

Area Ring with mem., A_o (cm^2) ; (in^2)=

Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf

Data corr. for M_{tc}: [X] Yes; [ ] No | Plattens with Pins: [ ] Yes; [X] No

Sketch of Specimen

Final Visual Description: Clay Sandy, Brown gray, with Silty Pockets

Other Remarks :

Trim./ Recon. By: HC | Date: 12/14/2015
Set Up By: HC | Date: 12/14/2015
Taken Down By: HC | Date: 12/14/2015
Prelim. Calc. By: HC
Final Calc. By: JJR
Reviewed By: HP

Specimen Take Down: [X] Spec. removed right after shearing
[ ] Spec. unloaded to zero stress with access to water
Remarks:

CYCLIC DSS STRENGTH TEST: Specimen Calculations & Summary

Project Number: 04.11150035 Station No.: CSS-S04 File Name: OP-B001_ST-2b

Task Number: Specific Gravity: 2.700 [ ] Measured; [X] Assumed

Type Test: CyDSS ta=0 Specimen: [X] "Intact"; [ ] Reconstituted; [ ] Remolded

Calculations Corr. for Salt (dissolved solids): [X] No or, [ ] Yes, with concentration = _____ ppm

Consolidation Stress Summary and Loading Summary

Test Stage:	Max. Stress	Pre-Cyclic	Post Cyclic
Nominal Vertical Stress, σ'_v (ksf)	NA	1	
Axial/Vertical Force, $P_{vr,n}$ (lbf)	NA	NA	
Horizontal Force, $P_{hr,n}$ (lbf)	NA	0	
Nominal OCR	NA	1	
t_c,(ON,days,hrs)	NA	0.11 days	

Static Strain Rate = NA (%/hr or)

[X] Cyclic Rate (Hz): [ ] 0.1; [X] 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
Post Cy.Displ. Reset to Null Position:	[X] Yes;	[ ] No

[ ] Undrained ambient stress applied: with Delta shear force (lbf) = NA & Duration (min) = NA & Delta disp., $\Delta d_{h,ua}$ (mm) = NA

Trimmed Specimen (TS) - Inital Water Contents over Saturation (%):

	Top, $W_{o,1}$	Botttom, $W_{o,2}$	Sides, $W_{o,3}$	Avg., $W_{o,avg}$	Selct., $W_{o,s}$	Back Cal.
W_o	34.15	35.25	33.36	34.25	34.25	35.16
S_o	96.4	97.8	95.3	96.5	96.5	97.7

Measured final mass of moist soil, $M_{t,at}$ (g) 114.57

Final mass of moist soil corrected for excess dry soil, $M_{tat,c}$ (g) 114.57

Calculated Mass of Dry Soil (g)

Initial Selected Water Content (%)	34.25
Initial , $M_{d,o}$	88.22
Final, $M_{d,at}$	87.63
Selected, M_d	87.93

Initial Back Cal. Specific Gravity (TS):

Selected S_o (%)	
Selected W_o (%)	
Specific Gravity, $G_{s,bc}$	

Height/Volume Change Summary

Variation in Height & Volume During Consol.	During Initial Consol. to $\sigma'_{v,c}$or $\sigma'_{vc,max}$=	During Rebound to $\sigma'_{v,c}$ =	Specimen Unloaded After Test To
Stress Units (ksf)	1.000	NA	NA
Sign Convention: (+) ΔV out & ΔH down; (-) ΔV in & ΔH up			
Delta Def. Read., $\Delta d_{ar,n}$ (mm)	0.323		
Total Equip. Comp., $\Sigma\Delta d_{afc}$ (mm)	0.000		
Corr. Total Def. $\Delta H_{c,n}$ (mm)	0.323		
ΔV_n using A_o - spec. (cm^3)	1.13		
ΔV_n using $A_{c,n}$ - app. (cm^3)	1.13		
ΔV_n using burette meas.(cm^3)	0.50		
Selected ΔV_n (cm^3)	1.13	NA	NA = ΔV_{uL}
After Test WC Corr. for ΔV during Shear & Unloading, $W_{at,c}$ (%)			NA

Lateral Confinement Area Cal. Approach (LCA); Method 1, 2, 3 or 4: 3

Calculation of ΔV_c by Different Procedures

By Selected Volumes		By Change in Mass	
ΔV_c (cm^3)	1.13	~($M_{t,o}$ - $M_{tat,c}$)/ρ_w + ΔV_L + ΔV_{uL}	
By Cal. Height & App. Area		ΔV_c (cm^3)	3.87
ΔV_c (cm^3)	1.13	**By Saturation = 100% and**	
By Cal. Ht. & Init. Spec. Area		**Spec. Unloaded to 0 Stress**	
ΔV_c (cm^3)	1.13	ΔV_c (cm^3)	NA

Back Cal. Water Content During Consol. - Based on the Consolidation Conclusions Given Below

Assumed Saturation (%)	100.00
Back Cal. WC before Loading, $W_{c,bc}$ (%)	34.43
Back Cal.WC at Max. Stress, $W_{cmax,bc}$ (%)	NA

Consolidation & Preshear Conclusions							
	ΔV_c (cm^3) =	1.14	ΔH_c (mm) =	0.323	$\varepsilon_{a,c}$ (%) =	1.76	$\Delta V_{c,max}$ (cm^3) = NA
	V_c (cm^3) =	62.95	H_c (mm) =	17.995	$\varepsilon_{v,c}$ (%) =	1.78	$\varepsilon_{ac,max}$ (%)= NA
	A_c (cm^2) =	34.98	$\Delta\gamma_c$ (mm) =	NA	γ_c (%) =	NA	Preshear: γ_{ua} (%)= NA

Summary of Specimen Physical Properties:

Specific Gravity: G_s = 2.700 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)		LL PL PI
Initial (as trimmed)	18.318	64.10	34.99	34.7	115.4	85.6	97.1		NA
After to $\sigma'_{v,c}$	17.995	62.95	34.98	34.4	117.2	87.2	100.0		NA
Consol.: to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA		

LCA-Method: 1- Initial measured value remains constant. 4 - Based on change in height & volume. Calculated By: JJR

& Note(s) 2 - Initial measured value corrected for applied stress. NA - Not Applicable Reviewed By: HP

3 - Uses measured value at appropriate stress level (NA for rings).

Remarks:

RESULTS OF CYCLIC DSS STRENGTH TEST

Project Number: 4.11150035 | Boring/Exploration No.: JOP-B001 | Test Type: CyDSS ta=0

Task Number | Sample No.: ST-2b | Test Sequence Number:

Project Name: | Specimen No: b | File Name: JOP-B001_ST-2b

Depth : 9.75 (ft)

Units:	US	key in US or SI
Stress Factor:	1.0000	(ksf->kPa)
Length Factor:	1.0000	(ft->m)
Unit Weight Factor:	1.0000	(pcf->kN/m^3)

Initial Height (mm): 18.318

Initial Diameter (mm): 66.747

Effective Vert. Stress at Consolidation, $\sigma'_{v,c}$: 1.0 (ksf)

Effective Vert. Stress Just Prior to Cyc. Loading, $\sigma'_{v,cy}$: 1.000 (ksf)

Induced OCR : 1.0

$K_{c,DSS}$: 1.000

$K_{u,DSS}$: 1.000

Axial/Vertical Strain During Consol., $\varepsilon_{c,max}$ (%) : 1.76

Shear Strain During Application of Undr. Bias Shear Stress, $\gamma_{u,b}$ (%): NA

Static DSS $c_u/\sigma'_{v,c}$: 1.000

τ_{avg}/c_u: 0.000

τ_{cy}/c_u : 0.223

Ψ_{DSS} : (degree)

$\gamma_{hf,max}$ (%) : 5.79

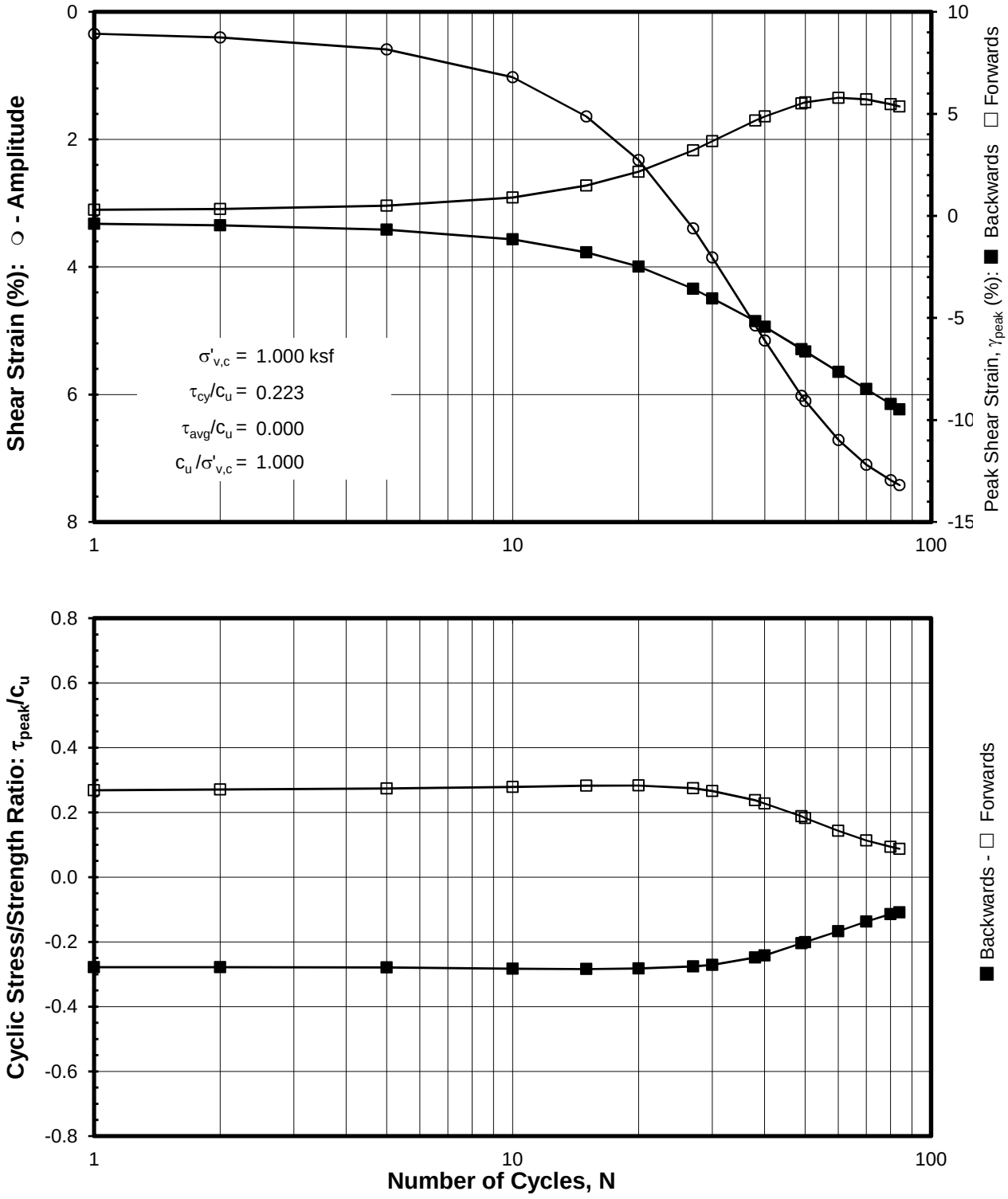
$\gamma_{hb,max}$ (%) : -9.48

Summary of Specimen Physical Properties:

Specific Gravity: G_s = 2.700 / **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)		LL / PL / PI
Initial (as trimmed)	18.318	64.10	34.99	34.7	115.4	85.6	97.1		NA
After to $\sigma'_{v,c}$	17.995	62.95	34.98	34.4	117.2	87.2	100.0		NA
Consol.: to $\sigma'_{vc,max}$	NA	NA	NA	NA			NA		

Notes: (1) A positive number indicates the value is in the forwards region. (2) Value should be close to zero if a bias shear stress is not applied. (3) Based on ASTM D 5311; Uses stress or strain, based on control type.

Cycle No.	Shear Stress: Forwards $\tau_{h,f}$ (ksf)	Shear Stress: Backwards (1) $\tau_{h,b}$ (ksf)	Cyclic Shear Stress Amp. τ_{cy} (ksf)	Avg. Cyclic or Bias Stress τ_{avg} (2) (ksf)	Cyclic Stress Ratio τ_{cy} / $\sigma'_{v,c}$	Average Cyclic Stress Ratio $(\tau_{cy}$ / $\sigma'_{v,c})_{avg}$	Max. Decr. in Vert. Stress $\Delta\sigma'_{v,max}$ (ksf)	Normalized Decr. in Vert. Stress $\Delta\sigma'_{v,max}$ / $\sigma'_{v,c}$	Shear Strain: Forwards γ_f (%)	Shear Strain: Backwards (1) γ_b (%)	Cyclic Shear Strain Amp. γ_{cy} (%)	Average Shear Strain γ_{avg} (%) (2)	Shear Modulus (τ_{cy} / γ_{cy}) G (ksf)	Loading Requirement P_{error} (3)
1	0.268	-0.278	0.273	-0.005	0.273	0.273	-0.040	-0.040	0.303	-0.387	0.345	-0.042	79.234	3.630
2	0.271	-0.278	0.274	-0.004	0.274	0.274	-0.023	-0.023	0.343	-0.464	0.403	-0.060	68.032	3.191
5	0.274	-0.279	0.277	-0.004	0.277	0.275	0.154	0.154	0.500	-0.679	0.590	-0.090	46.900	2.411
10	0.279	-0.282	0.280	-0.003	0.280	0.276	0.312	0.312	0.901	-1.149	1.025	-0.124	27.362	1.002
15	0.283	-0.284	0.283	-0.003	0.283	0.278	0.423	0.423	1.488	-1.791	1.639	-0.152	17.284	0.000
20	0.283	-0.282	0.283	-0.002	0.283	0.278	0.477	0.477	2.165	-2.480	2.323	-0.158	12.169	0.245
27	0.275	-0.276	0.275	-0.002	0.275	0.278	0.559	0.559	3.216	-3.576	3.396	-0.180	8.107	2.822
30	0.266	-0.271	0.268	-0.002	0.268	0.277	0.576	0.576	3.657	-4.048	3.853	-0.196	6.966	5.278
38	0.237	-0.248	0.243	-0.002	0.243	0.273	0.647	0.647	4.679	-5.159	4.919	-0.240	4.934	14.339
40	0.228	-0.242	0.235	-0.003	0.235	0.269	0.663	0.663	4.876	-5.432	5.154	-0.278	4.558	17.087
49	0.188	-0.204	0.196	-0.003	0.196	0.263	0.739	0.739	5.516	-6.532	6.024	-0.508	3.255	30.793
50	0.183	-0.201	0.192	-0.004	0.192	0.257	0.733	0.733	5.564	-6.639	6.102	-0.537	3.144	32.290
60	0.144	-0.167	0.155	-0.004	0.155	0.249	0.798	0.798	5.789	-7.640	6.715	-0.925	2.314	45.160
70	0.113	-0.137	0.125	-0.005	0.125	0.240	0.826	0.826	5.715	-8.484	7.100	-1.384	1.762	55.837
80	0.094	-0.114	0.104	-0.005	0.104	0.231	0.833	0.833	5.472	-9.218	7.345	-1.873	1.417	63.268
84	0.088	-0.109	0.098	-0.006	0.098	0.223	0.839	0.839	5.361	-9.483	7.422	-2.061	1.323	65.332

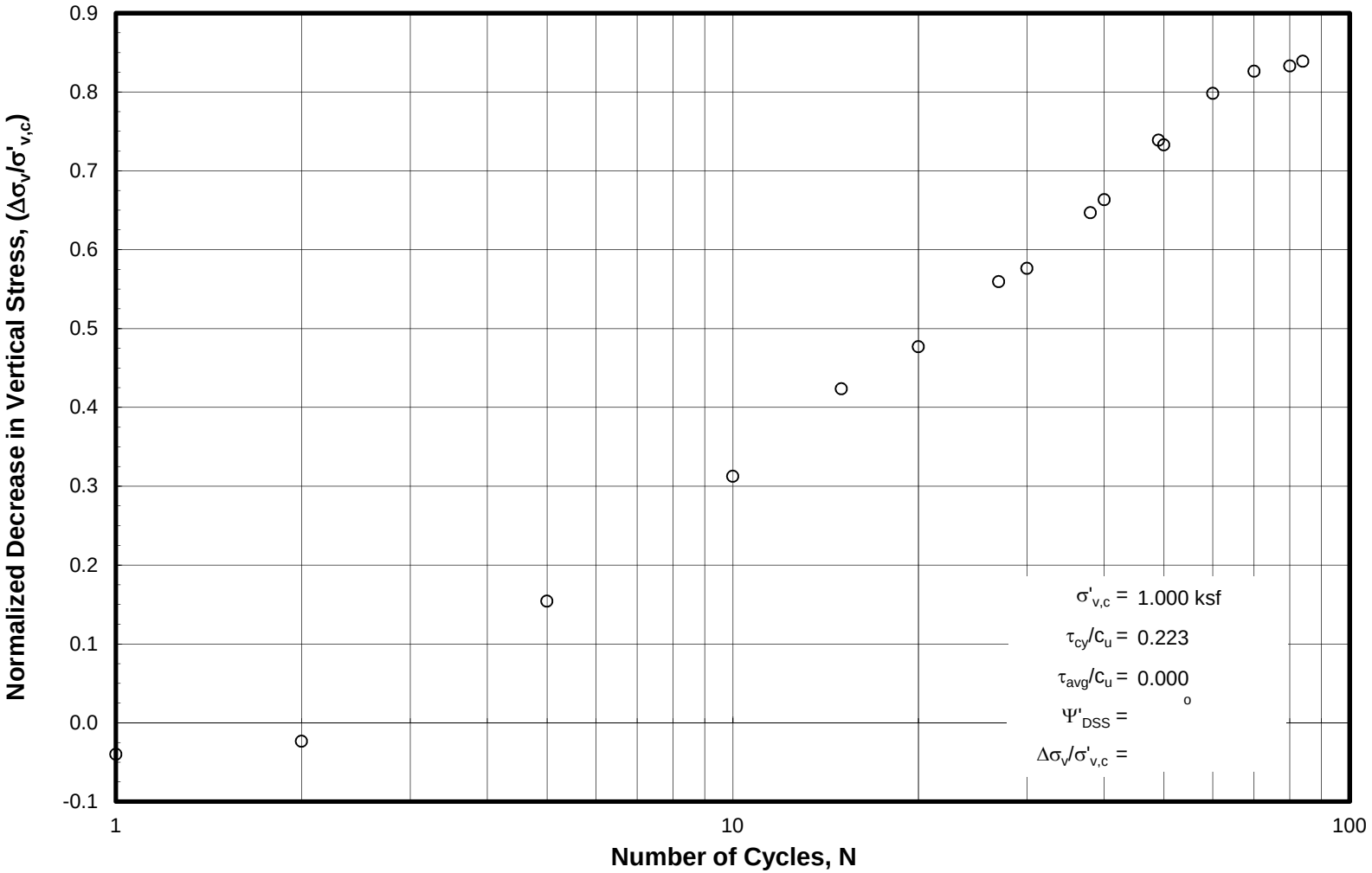


CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-2b - Depth: 9.75 ft

Boring JOP-B001

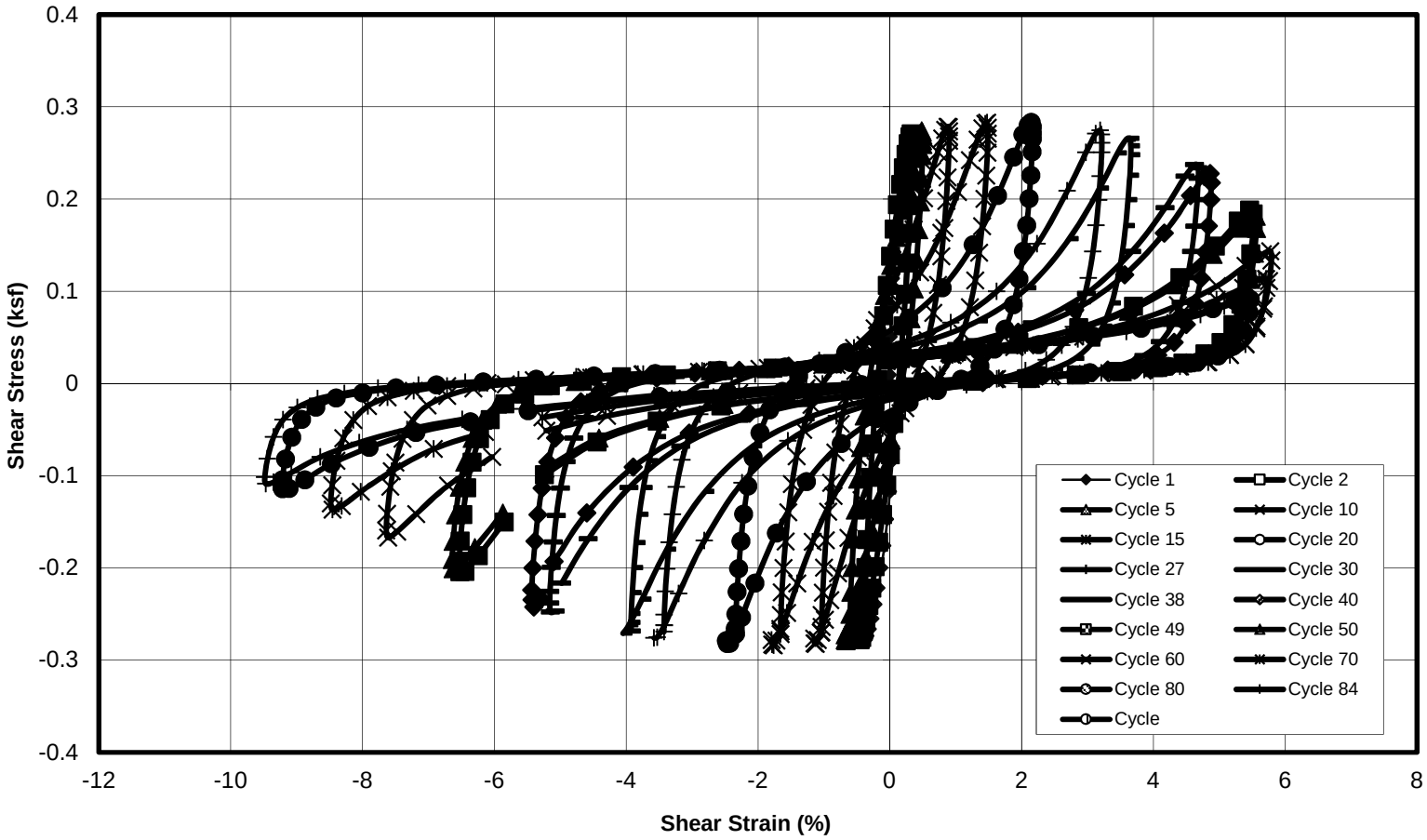


CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-2b - Depth: 9.75 ft

Boring JOP-B001



CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-2b - Depth: 9.75 ft

Boring JOP-B001

DIRECT SIMPLE SHEAR TEST (ASTM D 6528): Specimen Setup / Take Down

Project Number: 04.11150035 | Test Type: Post Cyclic DSS | Sta. No.: CSS-S04 | File Name: OP-B001_ST-2
Task No.: | Assign, $\sigma'_{v,c}$ = 1.00 ksf | Static DSS $c_u/\sigma'_{v,c}$ = 1.000
Project Name: | Induced OCR = 1.00 | Cyclic Ratios: τ_{cy} / c_u = 0.300 | τ_{avg} / c_u = NA
Sequence No.: of | Assig. Remarks: See Other Remarks | $\tau_{cy}/\sigma'_{v,c}$ = 0.300 | $\tau_{avg}/\sigma'_{v,c}$ =
Failure Criterion: [ ] Peak Obliquity, or [ ] Shear Strain (%) = | Specific Gravity: 2.700 [ ] Meas.; [X] Assumed

[X] Tube	[X] Field Extruded	[ ] Liner	[ ] Remolded	[ ] Tamping	[ ] Constant Effort:	Blows/Tamps per Layer =	
Boring No.: JOP-B001		[ ] LPC Core		[ ] Impact/Rammer	Rammer Wgt.(lbf)=	No. Layers =	
Sample No.: ST-2		Compostite No.:		[ ] Pluviated:	Tamper Force (lbf)=	Drop (in.) =	
Depth (ft): 9.75		Specimen No.: b		[ ] Kneading	[ ] Undercompaction:	U_{ni} (%) =	Dia. (in.) =
[ ] Spec. Selection by X-ray;		[ ] Geomarine Sample			Ref. Effort=	% Comp. =	± Opt.=

Type of Consolidation:	[ ] K_o at:	[ ] Incremental	; [ ] Anisotropic at:	[ ] Inclined Stress Path, $K_{c,DSS}$	[ ] Used automated system							
		[ ] CRS		[ ] 90° Stress Path	Remarks:							
Loading Conditions:	[ ] Static	[ ] Strain	[ ] Creep	[ ] Const, Vol./Ht	[ ] Without - Water	[ ] Cyclic (Hz)	[ ] Strain	[ ] Stress				
	[ ] Dynamic	[ ] Stress	[ ] Post Cyclic	[ ] Drained	[ ] With - Bath	Rate: [ ] 0.1;	[ ] 1;	Other:				

Water Content (WC);	Initial - Trimming Location			Final, W_{at}	**Soil and Ring Masses**	Initial	Final
	Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	(see below)	Mass Moist Soil + Tare (g)	298.37	128.10
Container No.	706	4056	6277	6593	Mass Tare (g)	179.93	13.53
Mass Moist Soil + Cont. (g)	112.74	73.01	74.87	59.95	Mass Moist Soil, $M_{t,o}$ $Mt_{,at}$ (g)	118.44	114.57
Mass Dry Soil + Container (g)	92.10	61.78	64.06	52.94	**Excess Dry Soil (soil not included in final mass above)**		
Mass Container (g)	31.66	29.92	31.66	30.14	Container No.		
WATER CONTENT (%)	34.15	35.25	33.36	30.75	Mass Dry Soil + Container (g)		
Avg. Initial WC, $W_{o,avg}$ (%)	34.25	Final W_{at}: [X] Slice ; [ ]		Whole Spec.	Mass Container (g)		
[ ] See attached data sheet(s) for additional water contents					Mass Excess Dry Soil (g)		0.00

Specimen Trimming:

[ ] Trimming Ring for Fugro Apparatus		NL4	Large-ring ID #
[X] Trimming Ring for NGI Apparatus			Small-ring ID #
$H_{s,t}$ (mm):	18.32	$A_{s,t}$ (cm^2):	34.99
$D_{s,t}$ (mm) :	66.75	$V_{s,t}$ (cm^3):	64.10

Remarks:
[ ] Free Standing by Wire Saw Lathe (mm)

	Height (H_{tr})	Diameter (D_o)		Remarks:
1	18.310	1-T	NA	
2	18.320	2-M	NA	
3	18.300	3-B	NA	
4	18.330	1'-T	NA	For Free Standing
5	18.330	2'-M	NA	Trimmed Spec.:
Avg.		3'-B	NA	A_{tr} (cm^2): NA
=	18.318	Avg	NA	V_{tr} (cm^3): NA

Note: NA-Indicates not applicable.
F or G in the Sta. No. indicates Fugro or GEOTAC apparatus.

Estimated Initial Unit Weight

Total, $\gamma_{t,o}$ (lb/ft^3)= 115.36 | Dry, $\gamma_{d,o}$ (lb/ft^3)= 85.93

Specimen Lateral Confinement by:

[X] **Wire Reinforced, Model:** C=1.5 Thickness (mm) = 0.72

Stress Level	Dia. by PiTape (mm) Meas.	Corr.	Area, $A_{c,n}$ (cm^2)	(in^2)
0	68.05	66.61	34.85	5.401
$\sigma'_{v,c}$	68.18	66.74	34.98	5.422
$\sigma'_{v,max}$	68.18	66.74	34.98	5.422

[ ] **Regular Membrane with Ring Set No.** | ID, Rings (mm)
Thickness (mm): Top: , =
[ ] Single Bottom: , Corr. for mem.
[ ] Double Membr. Thick. = =
Area Ring with mem., A_o (cm^2) ; (in^2)=
Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf
Data corr. for M_{tc}: [X] Yes; [ ] No | Plattens with Pins: [ ] Yes; [X] No

Top Cap No. 16

Sketch of Specimen

Final Visual Description: Clay Sandy, Brown gray, with Silty Pockets

Other Remarks :

Trim./ Recon. By: HC | Date: 12/14/2015
Set Up By: HC | Date: 12/14/2015
Taken Down By: HC | Date: 12/14/2015
Prelim. Calc. By: HC
Final Calc. By: JJR
Reviewed By: HP

Specimen Take Down: [X] Spec. removed right after shearing
[ ] Spec. unloaded to zero stress with access to water
Remarks:

DIRECT SIMPLE SHEAR TEST (ASTM D 6528): Specimen Calculations & Summary

Project Number: 04.11150035 | Test Station No.: CSS-S04 | File Name: OP-B001_ST-2b
Task Number: | Specific Gravity: 2.700 | [ ] Measured; [X] Assumed

Type Test: Post Cyclic DSS | Specimen: [X] "Undisturbed"; [ ] Reconstituted; [ ] Remolded
Calculations Corr. for Salt (dissolved solids): [X] No or, [ ] Yes, with concentration = _____ ppm

Consolidation Stress Summary and Loading Summary

Test Stage:	Max. Stress	Pre-Shear	Post Cyclic
Nominal Vertical Stress, σ'_v (ksf)	NA	1.00	
Axial/Vertical Force, $P_{vr,n}$ (lbf)	NA	NA	
Horizontal Force, $P_{hr,n}$ (lbf)	NA	0	
Nominal OCR	NA	1	
t_c,(ON,days,hrs)	NA	0.11 days	

0 Static Strain Rate = NA (%/hr or)
Cyclic Rate (Hz): [ ] 0.1; [ ] 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
Post Cy.Displ. Reset to Null Position:	[ ] Yes;	[ ] No

[ ] Undrained ambient stress applied: with Delta shear force (lbf) = NA & Duration (min) = NA & Delta disp., $\Delta d_{h,ua}$ (mm) = NA

Trimmed Specimen (TS) - Inital Water Contents over Saturation (%):

	Top, $W_{o,1}$	Botttom, $W_{o,2}$	Sides, $W_{o,3}$	Avg., $W_{o,avg}$	Selct., $W_{o,s}$	Back Cal.
W_o	34.15	35.25	33.36	34.25	34.25	35.16
S_o	96.4	97.8	95.3	96.5	96.5	97.7

Measured final mass of moist soil, $M_{t,at}$ (g) = 114.57
Final mass of moist soil corrected for excess dry soil, $M_{tat,c}$ (g) = 114.57

Calculated Mass of Dry Soil (g)

Initial Selected Water Content (%)	34.25
Initial , $M_{d,o}$	88.22
Final, $M_{d,at}$	87.63
Selected, M_d	87.92

Initial Back Cal. Specific Gravity (TS):

Selected S_o (%)	
Selected W_o (%)	
Specific Gravity, $G_{s,bc}$	

Height/Volume Change Summary

Variation in Height & Volume During Consol.	During Initial Consol. to $\sigma'_{v,c}$or $\sigma'_{vc,max}$=	During Rebound to $\sigma'_{v,c}$ =	Specimen Unloaded After Test To
Stress Units (ksf)	1.000	NA	NA
Sign Convention: (+) ΔV out & ΔH down; (-) ΔV in & ΔH up			
Delta Def. Read., $\Delta d_{ar,n}$ (mm)	0.323		
Total Equip. Comp., $\Sigma\Delta d_{afc}$ (mm)	0.000		
Corr. Total Def. $\Delta H_{c,n}$ (mm)	0.323		
ΔV_n using A_o - spec. (cm^3)	1.13		
ΔV_n using $A_{c,n}$ - app. (cm^3)	1.13		
ΔV_n using burette meas.(cm^3)	0.50		
Selected ΔV_n (cm^3)	1.13		NA = ΔV_{uL}
After Test WC Corr. for ΔV during Shear & Unloading, $W_{at,c}$ (%)			NA

Lateral Confinement Area Cal. Approach (LCA); Method 1, 2, 3 or 4: 3

Calculation of ΔV_c by Different Procedures

By Selected Volumes		By Change in Mass	
ΔV_c (cm^3)	#VALUE!	~ $M_{t,o}$ - ($M_{tat,c}$ + ΔV_L + ΔV_{uL})	
By Cal. Height & App. Area		ΔV_c (cm^3)	3.87
ΔV_c (cm^3)	1.13	**By Saturation = 100% and**	
By Cal. Ht. & Init. Spec. Area		**Spec. Unloaded to 0 Stress**	
ΔV_c (cm^3)	1.13	ΔV_c (cm^3)	NA

Back Cal. Water Content During Consol. - Based on the Consolidation Conclusions Given Below

Assumed Saturation (%)	100.00
Back Cal. WC before Loading, $W_{c,bc}$ (%)	34.43
Back Cal.WC at Max. Stress, $W_{cmax,bc}$ (%)	NA

Consolidation & Preshear Conclusions								
	ΔV_c (cm^3) =	1.14	ΔH_c (mm) =	0.323	$\varepsilon_{a,c}$ (%) =	1.76	$\Delta V_{c,max}$ (cm^3) =	NA
	V_c (cm^3) =	62.95	H_c (mm) =	17.995	$\varepsilon_{v,c}$ (%) =	1.78	$\varepsilon_{ac,max}$ (%)=	NA
	A_c (cm^2) =	34.98	$\Delta\gamma_c$ (mm) =	NA	γ_c (%) =	NA	Preshear: γ_{ua} (%)=	NA

Summary of Specimen Physical Properties:

Specific Gravity: G_s = 2.700 / **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)	
Initial (as trimmed)	18.318	64.10	34.99	34.7	115.4	85.6	97.1	
After to $\sigma'_{v,c}$	17.995	62.95	34.98	34.4	117.2	87.2	100.0	
Consol.: to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA	

LCA-Method: 1- Initial measured value remains constant. 4 - Based on change in height & volume. Calculated By: HP
& Note(s) 2 - Initial measured value corrected for applied stress. NA - Not Applicable Reviewed By: HP
3 - Uses measured value at appropriate stress level (NA for rings).

Remarks:

DIRECT SIMPLE SHEAR TEST

Project Number:	04.11150035	Task Number:		Boring No.:	JOP-B001
Project Name:		Test Type:	Post Cyclic DSS	Sample No.:	ST-2
Test Number:		Test Series No.:		Specimen No.:	b
				Depth (ft.):	9.75

Horiz. Load Factor (lbf/V/V):	29.983	Vert. Load Factor (lbf/V/V):	144.426
Horiz. Load, Test Floating Zero (V/V):	3.494E-03	Vert. Load, Test Floating Zero (V/V):	7.854E-03
Horiz. Deform. Factor (mm/V/V):	-0.394	Vert. Deform. Factor (mm/V/V):	0.491

	Max Stress	Pre-Shear	Post Cyclic
Vertical Load (V/V) or (lbf):		2.61E-01	
Calculated Vertical Stress (ksf):		1.000	
Horizontal Load (V/V) or (lbf):			
Calculated Horizontal Load (ksf):			

Elapsed Time (min)	Exitation (Volts)	Horizontal Load (Volts)	Horizontal Deformation (Volts)	Vertical Load (Volts)	Vertical Deformation (Volts)	Horizontal Load (grams)
0.0	1.000	5.553E-3	-0.144	3.250E-2	-3.046	0
4.2	1.000	1.311E-2	0.017	2.166E-2	-3.040	0
8.3	1.000	1.377E-2	0.175	3.448E-2	-3.069	0
12.5	1.000	1.607E-2	0.335	3.283E-2	-3.095	0
16.7	1.000	1.771E-2	0.494	3.711E-2	-3.050	0
20.8	1.000	2.330E-2	0.653	4.236E-2	-3.059	0
25.0	1.000	2.396E-2	0.812	3.612E-2	-3.091	0
29.2	1.000	2.462E-2	0.969	2.725E-2	-3.111	0
33.3	1.000	2.396E-2	1.126	2.100E-2	-3.071	0
37.5	1.000	2.790E-2	1.287	3.546E-2	-3.044	0
41.7	1.000	3.053E-2	1.449	3.218E-2	-3.073	0
45.8	1.000	3.152E-2	1.605	2.692E-2	-3.112	0
50.0	1.000	3.316E-2	1.764	2.757E-2	-3.054	0
54.2	1.000	3.546E-2	1.923	1.607E-2	-3.062	0
58.3	1.000	3.875E-2	2.081	2.527E-2	-3.050	0
62.5	1.000	4.072E-2	2.239	3.842E-2	-3.098	0
66.7	1.000	4.401E-2	2.398	3.711E-2	-3.105	0
70.8	1.000	4.795E-2	2.557	3.415E-2	-3.042	0
75.0	1.000	5.288E-2	2.716	3.185E-2	-3.108	0
79.2	1.000	5.781E-2	2.876	3.053E-2	-3.039	0
83.3	1.000	6.537E-2	3.034	2.626E-2	-3.053	0
87.5	1.000	7.359E-2	3.194	4.434E-2	-3.068	0
91.7	1.000	8.673E-2	3.352	4.762E-2	-3.097	0
95.8	1.000	9.791E-2	3.511	4.762E-2	-3.070	0
100.0	1.000	1.137E-1	3.671	5.222E-2	-3.083	0
104.2	1.000	1.295E-1	3.828	5.124E-2	-3.032	0
108.3	1.000	1.502E-1	3.985	6.011E-2	-3.031	0
112.5	1.000	1.702E-1	4.147	5.978E-2	-3.109	0
116.7	1.000	1.935E-1	4.305	6.504E-2	-3.049	0
120.8	1.000	2.169E-1	4.464	7.293E-2	-3.129	0
125.0	1.000	2.369E-1	4.623	8.345E-2	-3.071	0
129.2	1.000	2.593E-1	4.779	1.009E-1	-3.113	0
133.3	1.000	2.790E-1	4.938	1.028E-1	-3.113	0
137.5	1.000	3.010E-1	5.099	1.107E-1	-3.047	0
141.7	1.000	3.184E-1	5.258	1.078E-1	-3.046	0
145.8	1.000	3.391E-1	5.416	1.065E-1	-3.054	0
150.0	1.000	3.546E-1	5.576	1.275E-1	-3.101	0
154.2	1.000	3.710E-1	5.732	1.216E-1	-3.061	0
158.3	1.000	3.858E-1	5.893	1.278E-1	-3.040	0
162.5	1.000	3.990E-1	6.050	1.327E-1	-3.066	0
166.7	1.000	4.138E-1	6.211	1.308E-1	-3.129	0
170.8	1.000	4.266E-1	6.369	1.318E-1	-3.133	0

175.0	1.000	4.374E-1	6.527	1.295E-1	-3.061	0
179.2	1.000	4.489E-1	6.688	1.492E-1	-3.047	0
183.3	1.000	4.614E-1	6.846	1.581E-1	-3.124	0
187.5	1.000	4.742E-1	7.006	1.594E-1	-3.088	0
191.7	1.000	4.824E-1	7.163	1.571E-1	-3.088	0
195.8	1.000	4.870E-1	7.323	1.623E-1	-3.134	0
200.0	1.000	4.897E-1	7.481	1.623E-1	-3.125	0
204.2	1.000	4.893E-1	7.638	1.581E-1	-3.059	0
208.3	1.000	4.880E-1	7.797	1.640E-1	-3.043	0
212.5	1.000	4.870E-1	7.956	1.640E-1	-3.057	0
216.7	1.000	4.877E-1	8.115	1.640E-1	-3.050	0
220.8	1.000	4.893E-1	8.274	1.581E-1	-3.076	0
225.0	1.000	4.877E-1	8.432	1.581E-1	-3.076	0
229.2	1.000	4.821E-1	8.592	1.479E-1	-3.135	0
233.3	1.000	4.723E-1	8.752	1.567E-1	-3.043	0
237.5	1.000	4.644E-1	8.910	1.308E-1	-3.070	0
239.9	1.000	4.594E-1	9.006	1.567E-1	-3.095	0

Results of Direct Simple Shear Test

Project Number: 04.11150035 Test Type: Post Cyclic DSS Test Sta. No.: CSS-S04 File Name: OP-B001_ST-2
Project Name: Task No.: Test No.: Test Series for:

X Tube	X Field Extruded	Liner	Remolded	Tamping	Constant Effort: Blows/Tamps per Layer =
Boring No.: JOP-B001		LPC Core		Impact/Rammer	Rammer Wgt.(lbf)= No. Layers =
Sample No.: ST-2		Compostite No.:		Pluviated:	Tamper Force (lbf)= Drop (in.) =
Depth (ft): 9.75		Specimen No.: b		Kneading	Undercompaction: U_{ni} (%) = Dia. (in.) =
Spec. Selection by X-ray;		Geomarine Sample			Ref. Effort= % Comp. = ± Opt.=

Type Consolidation:	K_o at:	Incremental CRS	Anisotropic at:	Inclined Stress Path, $K_{c,DSS}$ 90° Stress Path	Used Automated System Remarks:
Loading Conditions:	0 Static Dynamic	Strain Stress	Creep Post Cyclic	Const, Vol./Ht Drained	Without - Water With - Bath; Cyclic (Hz) Rate: 0.1; Strain 1; Other: Stress

Summary of Specimen Physical Properties

Specific Gravity: G_s = 2.700 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Unit Weight Total (pcf)	Unit Weight Dry (pcf)	Saturation (%)	LL PL PI		
Initial	18.32	64.10	34.99	34.71	115.4	85.6	97.1			
After Consol.: to $\sigma'_{v,c}$	18.00	62.95	34.98	34.43	117.2	87.2	100.0			
to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA			

Consolidation Stress Summary and Loading Summary

Item	Unit	Max. Stress	Pre-Shear	Post Cyclic
Vert. Consol. Stress, $\sigma'_{v,c}$	(ksf)	NA	1.000	NA
Induced OCR	-	NA	1.00	NA
Axial Strain during Consol., $\varepsilon_{a,c}$	%	NA	1.76	NA
Horiz. Consol. Stress, $\tau_{h,c}$	(ksf)	NA	NA	NA
Consol. Stress Ratio, $\tau_{h,c}$ / $\sigma'_{v,c}$	-	NA	NA	NA
Shear Strain during Consol., $\varepsilon_{h,c}$	%	NA	NA	NA
Undr. Ambient Shear Stress, $\tau_{h,ua}$	(ksf)	NA	NA	NA
Undr. Ambient Shear Strain, ε_{ua}	%	NA	NA	NA

0 Static Strain Rate = 5.0 %/hr.
Cyclic Rate (Hz): 0.1; 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
Post Cy.Displ. Reset to Null Pos.:	Yes;	No

Number of Loading Cycles, N = NA
$\pm\tau_h$ = NA (ksf) $\pm\gamma$ = NA %
at end of cyclic loading, $\sigma'_{vcy,r}$ = NA (ksf)

Weight Top Cap, etc., M_{tc} (lbf): 1.09
Data corr. for M_{tc}: X Yes; No Plattens with Pins: Yes; X No
X Wire Reinforced Membrane, Model: C=1.5 Data corr. for Membr. strength
Regular Membrane with Rings Yes X No

Data Normalization: X Yes No Value: 1.000 (ksf)
Using Effective Vertical Stress:
X Pre-Shear Conditions Post-Cyclic Conditions
Maximum Stress during Consol.

Notes: See Fugro South, Inc. Notation Listing for definition of symbols and acronyms. F or G in the Test Sta. No. indicates Fugro or GEOTAC apparatus.
NA - Not Applicable

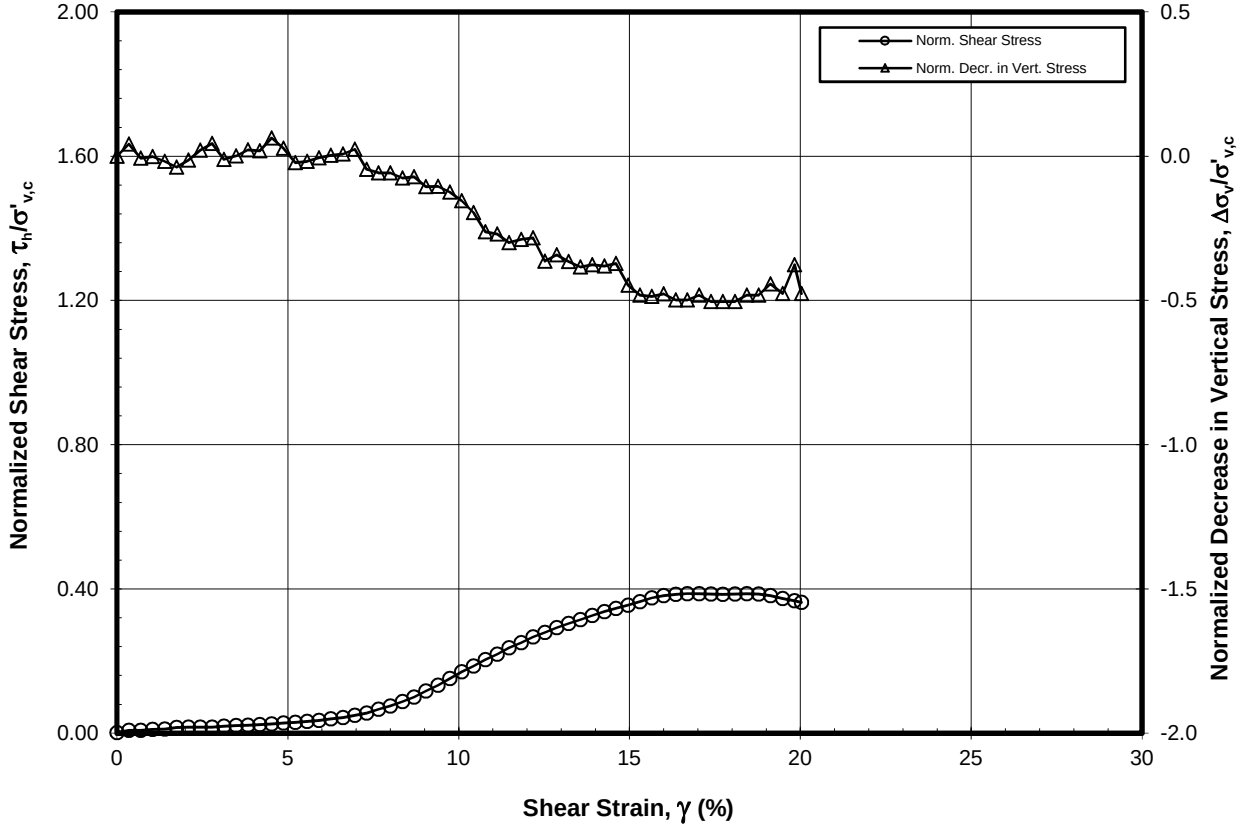
Final Visual Description and Remarks: Clay Sandy, Brown gray, with Silty Pockets

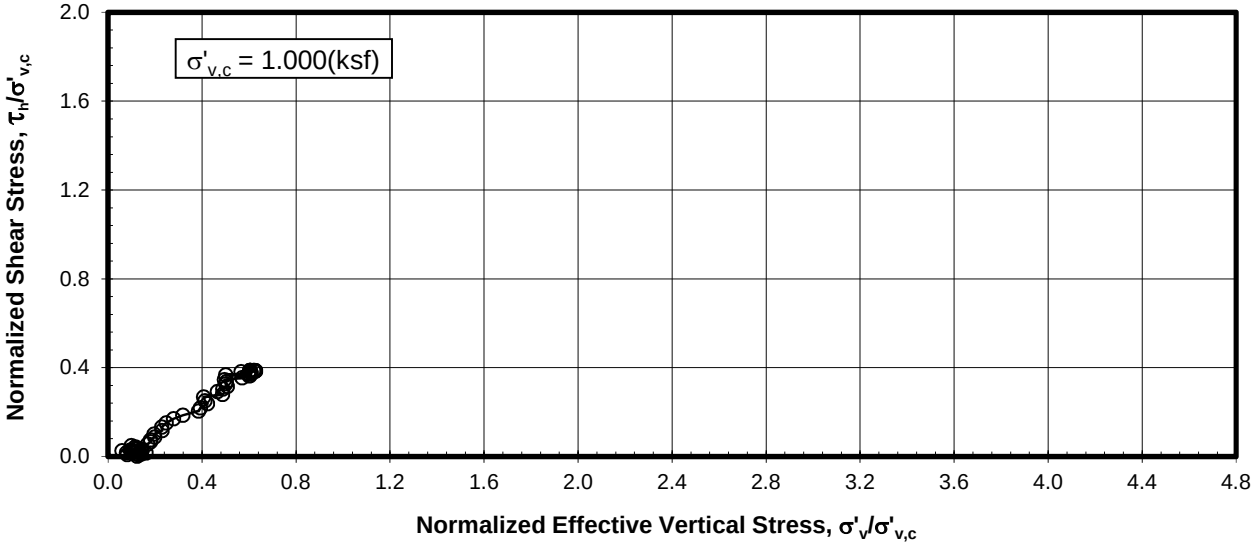
Loading Summary

	τ_h (ksf)	γ (%)	σ'_v (ksf)	τ_h/σ'_v -	$\Delta\sigma'_v/\sigma'_{v,c}$ -	$c_u/\sigma'_{v,c}$
at Peak Shear Stress	0.387	16.69	0.621	0.623	-0.498	0.387
at Maximum Strain	0.363	20.03	0.600	0.605	-0.476	

Results of Direct Simple Shear Test

Elapsed Time (min)	Shear Strain γ (%)	Shear Stress τ_h (ksf)	Effective Vertical Stress σ'_v (ksf)	Calulated Pore Press. Change $\Delta U = \Delta\sigma'_v$ (ksf)	Secant Shear Modulus G_s (ksf)	Tangent Modulus G_T (ksf)	Norm. Shear Stress $\tau_h/\sigma'_{v,c}$	Norm. Vert. Stress $\sigma'_v/\sigma'_{v,c}$	Norm. Decr. in V. Stress $\Delta\sigma'_v/\sigma'_{v,c}$	Stress Ratio Angle ϕ'_{DSS} (°)
0.0	0.00	0.002	0.123	0.000	-	-	0.002	0.123	0.000	0.76
4.2	0.35	0.008	0.082	0.042	1.711	0.931	0.008	0.082	0.042	5.35
8.3	0.70	0.008	0.131	-0.008	0.935	0.338	0.008	0.131	-0.008	3.58
12.5	1.05	0.010	0.125	-0.001	0.799	0.450	0.010	0.125	-0.001	4.59
16.7	1.40	0.011	0.141	-0.018	0.693	0.827	0.011	0.141	-0.018	4.59
20.8	1.74	0.016	0.161	-0.038	0.810	0.715	0.016	0.161	-0.038	5.59
25.0	2.09	0.016	0.137	-0.014	0.700	0.151	0.016	0.137	-0.014	6.77
29.2	2.44	0.017	0.103	0.020	0.623	0.000	0.017	0.103	0.020	9.25
33.3	2.78	0.016	0.079	0.044	0.527	0.370	0.016	0.079	0.044	11.62
37.5	3.13	0.019	0.135	-0.011	0.568	0.740	0.019	0.135	-0.011	8.21
41.7	3.49	0.022	0.122	0.001	0.570	0.410	0.022	0.122	0.001	10.00
45.8	3.83	0.022	0.102	0.021	0.540	0.304	0.022	0.102	0.021	12.35
50.0	4.18	0.024	0.104	0.019	0.526	0.451	0.024	0.104	0.019	12.74
54.2	4.53	0.025	0.060	0.063	0.526	0.640	0.025	0.060	0.063	22.87
58.3	4.87	0.028	0.096	0.028	0.542	0.605	0.028	0.096	0.028	16.36
62.5	5.22	0.030	0.146	-0.023	0.537	0.603	0.030	0.146	-0.023	11.47
66.7	5.57	0.032	0.141	-0.018	0.550	0.827	0.032	0.141	-0.018	12.88
70.8	5.91	0.035	0.130	-0.006	0.571	1.015	0.035	0.130	-0.006	15.27
75.0	6.26	0.039	0.121	0.003	0.602	1.124	0.039	0.121	0.003	18.02
79.2	6.61	0.043	0.116	0.008	0.629	1.430	0.043	0.116	0.008	20.48
83.3	6.96	0.049	0.099	0.024	0.685	1.801	0.049	0.099	0.024	26.36
87.5	7.31	0.056	0.169	-0.045	0.741	2.447	0.056	0.169	-0.045	18.30
91.7	7.65	0.066	0.181	-0.058	0.844	2.793	0.066	0.181	-0.058	20.07
95.8	8.00	0.075	0.181	-0.058	0.919	3.073	0.075	0.181	-0.058	22.51
100.0	8.35	0.088	0.199	-0.076	1.031	3.626	0.088	0.199	-0.076	23.79
104.2	8.70	0.100	0.195	-0.072	1.135	4.216	0.100	0.195	-0.072	27.19
108.3	9.04	0.117	0.229	-0.106	1.274	4.646	0.117	0.229	-0.106	26.99
112.5	9.39	0.133	0.228	-0.105	1.396	4.932	0.133	0.228	-0.105	30.21
116.7	9.74	0.151	0.248	-0.125	1.537	5.357	0.151	0.248	-0.125	31.37
120.8	10.09	0.170	0.278	-0.155	1.668	4.976	0.170	0.278	-0.155	31.39
125.0	10.44	0.186	0.319	-0.195	1.765	4.895	0.186	0.319	-0.195	30.25
129.2	10.78	0.204	0.386	-0.262	1.874	4.848	0.204	0.386	-0.262	27.84
133.3	11.13	0.219	0.393	-0.270	1.957	4.747	0.219	0.393	-0.270	29.16
137.5	11.48	0.237	0.423	-0.300	2.050	4.485	0.237	0.423	-0.300	29.23
141.7	11.83	0.251	0.412	-0.289	2.106	4.365	0.251	0.412	-0.289	31.32
145.8	12.17	0.267	0.407	-0.284	2.182	4.144	0.267	0.407	-0.284	33.29
150.0	12.52	0.280	0.488	-0.364	2.219	3.672	0.280	0.488	-0.364	29.82
154.2	12.87	0.293	0.465	-0.342	2.262	3.583	0.293	0.465	-0.342	32.18
158.3	13.22	0.304	0.489	-0.366	2.291	3.195	0.304	0.489	-0.366	31.91
162.5	13.56	0.315	0.508	-0.384	2.310	3.195	0.315	0.508	-0.384	31.80
166.7	13.91	0.327	0.500	-0.377	2.336	3.142	0.327	0.500	-0.377	33.14
170.8	14.26	0.337	0.504	-0.381	2.351	2.718	0.337	0.504	-0.381	33.75
175.0	14.61	0.346	0.495	-0.372	2.354	2.552	0.346	0.495	-0.372	34.90
179.2	14.96	0.355	0.571	-0.448	2.360	2.738	0.355	0.571	-0.448	31.85
183.3	15.30	0.365	0.605	-0.482	2.372	2.896	0.365	0.605	-0.482	31.08
187.5	15.65	0.375	0.610	-0.487	2.384	2.408	0.375	0.610	-0.487	31.57
191.7	16.00	0.381	0.601	-0.478	2.373	1.472	0.381	0.601	-0.478	32.39
195.8	16.35	0.385	0.621	-0.498	2.345	0.826	0.385	0.621	-0.498	31.79
200.0	16.69	0.387	0.621	-0.498	2.309	0.265	0.387	0.621	-0.498	31.93
204.2	17.04	0.387	0.605	-0.482	2.261	-0.188	0.387	0.605	-0.482	32.60
208.3	17.39	0.386	0.628	-0.504	2.209	-0.263	0.386	0.628	-0.504	31.58
212.5	17.73	0.385	0.628	-0.504	2.162	-0.038	0.385	0.628	-0.504	31.53
216.7	18.08	0.386	0.628	-0.504	2.123	0.263	0.386	0.628	-0.504	31.56
220.8	18.43	0.387	0.605	-0.482	2.090	0.000	0.387	0.605	-0.482	32.60
225.0	18.78	0.386	0.605	-0.482	2.044	-0.826	0.386	0.605	-0.482	32.51
229.2	19.13	0.381	0.566	-0.442	1.984	-1.755	0.381	0.566	-0.442	33.96
233.3	19.48	0.373	0.600	-0.476	1.908	-2.025	0.373	0.600	-0.476	31.89
237.5	19.82	0.367	0.500	-0.377	1.843	-1.848	0.367	0.500	-0.377	36.26
239.9	20.03	0.363	0.600	-0.476	1.804	-1.881	0.363	0.600	-0.476	31.18





POST CYCLIC STATIC DSS TEST

K_o Consolidation - OCR = 1 - Strain Rate = 5 %/hr

Sample: ST-2b - Depth: 9.75 ft.

Boring JOP-B001

DIRECT SHEAR TEST (ASTM D 3080): Setup / Take Down

Project Number: 04.11150035 | Apparatus No.: DS-S01 | File Name: JOP-B002_ST-1a
Task Number: | Assign. Units: [X] ksf; or Other: | Ring No.: FL1
Project Name: | Series $\sigma'_{v,c}$ or $\sigma'_{n,c}$: 2 , 4 | Area - Shear Box, A_{sb} (cm^2): 31.703
" 8 & | Height - Shear Box, H_{sb} (mm):
This Test $\sigma'_{v,c}$ or $\sigma'_{n,c}$: 2 ; 4 ; & 8 | Shear Box: [X] Circular [ ] Square
Induced OCR: NA ; Max. $\sigma'_{v,max}$: NA | Specific Gravity: 2.7 [X] Assumed; [ ] Measured
Multistage: [ ] No; [X] Yes | Residual/Multishearing: [X] No; [ ] Yes | Precut Failure Plane [X] No; [ ] Yes
Assign. Remarks:

[X] Tube [ ] Field Extruded [ ] Liner [ ]	[ ] Tampling	[ ] Constant Effort:	Blows/Tamps per Layer =
Boring No.: JOP-B002 [ ] Reconstituted	[ ] Kneading	Rammer:Wgt.(lbf)=	Tamper: Force (lbf)=
Sample No.: ST-1 Compostite No.:	[ ] Inpact/Rammer	Drop(in.)=	Dia.(in.)=
Depth (ft): 5.00 Specimen No.: a	[ ] Pluviated:	[ ] Undercompaction: U_{ni} (%) =	Ref.Effort=
[ ] Spec. Selection by X - Ray; [ ] Geomarine Sample		No. Layers =	% Comp= ± Opt.=

Water Content (WC);	Initial - Trimming Location			Final, W_{at}
	Top (W1)	Bottom (W2)	Sides (W3)	(see below)
Container No.	4105	4218	6305	31
Mass Moist Soil + Container (g)	84.51	115.91	106.05	169.91
Mass Dry Soil + Container (g)	74.77	100.60	92.86	144.81
Mass Container (g)	30.31	30.12	30.10	16.29
WATER CONTENT (%)	21.91	21.72	21.02	19.53
Avg. Initial WC, W4 (%)	21.55	Final W_{at}: Soil with free water trimmed away		
[ ] See attached data sheet(s) for additional water contents				

Soil and Ring Masses (g)	Initial	Final
Mass Moist Soil+Trimming Ring	359.44	NA
Mass Trimming Ring, etc.	199.01	NA
Mass Moist Soil	160.43	NA
Excess Dry Soil (soil not included in final water content)		
Container No.		
Mass Dry Soil + Cont. (g)		
Mass Container (g)		
Mass Excess Dry Soil (g)		0.00

Soil Height: Measurements(1)	
Initial (mm)	
with Spec., H_{soil}	without Spec., H_{app}
24.81	
24.89	
24.85	
24.86	
24.83	
Block Used (2): [ ] Yes ; [X] No	

(1) Measured in trimming ring, not shear box.

Soil Height/Volume: Calc., (mm)	Initial
Height of Gauge Block, H_{gb} (2)	NA
Reading on Gauge Block, R_{gb}	NA
Avg. Reading on Soil, H_{soil}	24.85
Avg. Reading on Apparatus without Specimen, H_{app}	0.00
Soil Height, $H = H_{soil} - H_{app} + H_{gb} - R_{gb}$	24.85
Initial Soil Volume, V_o (cm^3)	78.78

Estimated Initial Unit Weight			
Total, $\gamma_{t,o}$ (pcf)=	127.14	Dry, $\gamma_{d,o}$ (pcf)=	104.60

(2) Req. block ht. to set bench comparator so the initial soil ht. can be determined directly by the diff. between the reading with and without spec. Enter value for H_{gb} and d_{gb} only when these values have to be included in the determination of the soil height.
(3) Equals wgt. top cap, loading hanger and Bellofram piston (if used). (4) Reduced value if soil will dilate during shear.

Apparatus Information:

Wgt. of Top Shear Ring, M_{sb} (lbf) = 2.57 | Dead Wgt. of Loading System(3) (lbf)= 4.87
Top Shear Box Supported by Counter Force: [ ] Yes ; [X] No: | Shear Box Free to Move Up & Down: [ ] Yes ; [X] No:
Porous Inserts: [X] Stone; [ ] Metal; **Do not use filter paper over porours inserts.** | Free to Rotate: [ ] Yes ; [X] No:
Porous Inserts with Additional Shear Transfer Features: [ ] None; [ ] Pins; [ ] Grid Plate; [X] Waffle Stone; [ ] Other:
Apparatus deformation under consolidation load determined: [ ] Yes ; [X] No

Sketch of Specimen

Photo taken of Sliced Test Specimen: [ ] Yes ; [X] No
Final Visual Description: Sandy Clay, brown, with ferrous stains
Trimming/Etc. Remarks:

Method of trimming periphery: [X] "Casagrande" Lathe ; [ ] Cutting Shoe ; [ ] Wire Saw; [ ] Other
Method of trimming ends: [ ] Wire Saw & Sharp (knife) Straight Edge; [X] Wire Saw & Straight Edge; [ ] Wire Saw; [ ] Other
For soils containig sand, ~100 % passes sieve size: [ ] #4 (4.75 mm); [ ] #10 (2.0 mm); [ ] #20 (0.85 mm) or; [ ] #40 (0.425 mm)
Shear Box Gap Setting(2): Clays, 0.50 to 0.65 mm; Sands,1 mm to sieve size (mm) for 100 % passing

Trim./Recon. By: PL | Set up By: JTG | Prelim. Cal. By: JTG | Taken Down By: PL
Date: 12/8/2015 | Date: 12/8/2015 | Final Cal. By: JTG | Date: 12/14/2015
Reviewed By: JTG

DIRECT SHEAR TEST (ASTM D 3080): SPECIMEN CALCULATIONS & SUMMARY

Project Number: 04.11150035 Boring/Exploration No.: JOP-B002 Type Test: DS
Task Number: Sample No.: ST-1 Specific Gravitiy, G_s: 2.70
Project Name: Penetration/Depth (ft): 5.00
Calculations Corrected for Salt (dissolved soilids): [X] No or, [ ] Yes, with salinity, S_{ppt} _____ ppt

Water Content Copied/Derived From:	Water Content, $W_{o,n}$ (%)	Mass Dry Soil, $M_{do,n}$ (g)	Degree of Sat., $S_{o,n}$ (%)
Initial, Top, W1	21.91	131.60	96.4
" Bottom, W2	21.72	131.80	96.0
" Sides, W3	21.02	132.57	94.3
" Average, W4	21.55	131.99	95.6
" Assumed, W	21.55	131.99	95.6
Final (After Test/Shear)	19.53		

Back-calculated Data Item	Value	Input Data for Back Calculation $S_{o,n}$ (%)	
Initial Mass Dry Soil, $M_{d,c}$			G_s
Specific Gravity, G_s			$M_{d,o}$ (g)

Calculation Constant: = (unit conversion) / $G_s \times \rho_w \times A_{sb}$	
Estimated	0.11704
Final Selected	0.11704

Soil Height: Final by Dial Change During Test (mm)		For Multistage Testing	
	Initial Height, H_o 24.85	2nd Stage	3rd Stage
Change in Height During Consol.(not corrected for apparatus flexability)	0.90	0.23	0.24
Height after Consolidation, H_c	23.95	23.61	23.25
Change in Height During **Initial** Shear (+ compression, - dilation)	0.10	0.12	0.29
Change in Height During Repeated/Residual Shear	NA	NA	NA
Change in Height During Consol. to Max. Consol. Stress	NA	NA	NA
Final Soil Height (After Test/Shear), H_{at}	23.85	23.49	22.96

Summary of Specimen Physical Properties: Initial Conditions

Area, A_{sb}: 31.703 , cm^2
Specific Gravity, G_s: 2.700 — [X] Assumed [ ] Measured
Mass Dry Soil, Md (g): 131.99 — [X] Based on average water content [ ] Value based on one of the above values

	Water Content, w (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Void Ratio, e	Degree of Saturation, S (%)	Height, H (mm)	Volume, V (cm^3)	
Initial:	21.5	127.14	104.60	0.609	95.6	24.85	78.78	

Consolidation Summary: Stress Units = (ksf)	Stage:	1st	2nd	3rd		1st	2nd	3rd
	$\sigma'_{n,c}$ or $\sigma'_{v,c}$	2	4	8	$\varepsilon_{a,c}$ (%)	3.61	0.94	0.98
	$\sigma'_{v,max}$	NA	NA	NA	$\varepsilon_{a,max}$ (%)	NA	NA	NA
	OCR	NA	NA	NA	t_c (days)	0.76	0.72	0.75

Remarks:
NA - Not Applicable

Calculated by: JTG Reviewed by: JTG
Date: 12/14/2015

DRAINED DIRECT SHEAR TEST: Test Results

Project Number:	04.11150035	App. No.:	DS-S01	Boring No.:	JOP-B002
Task No.:		Consol. Stress, $\sigma'_{v,c}$:	2 (ksf)	Sample No.:	ST-1
Project Name:		Induced OCR:	NA	Specimen No.:	a
File Name:	JOP-B002_ST-1a	$\sigma'_{v,max}$:	NA (ksf)	Depth (ft):	5.00
Shear Box Dia./Width:	63.5 (mm)	Specimen Ht.:	23.95 (mm)		
Shear Box:	[X] Circular [ ] Square	Vert. Strain During Consol.:	3.61 (%)		

Part of Test Series: [X] No; [ ] Yes If yes, Test: NA of NA
Multistage: [ ] No; [X] Yes If yes, Test Stage No.: 1
Residual/Multishearing: [X] No; [ ] Yes Precut Failure Plane [X] No; [ ] Yes

Initial Test Conditions:				
Water Content, w (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Void Ratio, e	Degree of Saturation, S (%)
21.5	127.14	104.60	0.609	95.6

Shearing Data For:	[X]	Intact - Without Repeated Shearing (Peak Data)
	[ ]	Intact - Before Repeated Shearing (Peak Data)
	[ ]	After Rapid Repeated Shearing (Residual Data)
	[ ]	Continuous Shearing: Forwards & Backwards (Peak & Residual Data)

Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
0.00	0.0000	0.40	0.00	0.01
10.00	-0.0019	1.89	0.00	0.06
20.00	0.0059	7.32	0.00	0.21
33.00	0.0394	11.53	0.02	0.34
48.00	0.0815	13.71	0.06	0.40
63.00	0.1147	15.18	0.10	0.44
78.00	0.1601	16.96	0.13	0.50
93.00	0.1988	18.25	0.16	0.53
108.00	0.2388	19.71	0.18	0.58
123.00	0.2819	21.19	0.21	0.62
138.00	0.3279	22.45	0.28	0.66
153.00	0.3745	23.64	0.25	0.69
168.00	0.4207	24.74	0.28	0.72
185.00	0.4736	26.02	0.29	0.76
210.00	0.5595	28.27	0.33	0.83
235.00	0.6386	29.87	0.37	0.88
260.00	0.7173	31.30	0.36	0.92
285.00	0.7923	32.66	0.43	0.96
310.00	0.8712	33.92	0.39	0.99
335.00	0.9519	35.36	0.39	1.04
350.00	1.0022	35.47	0.44	1.04

Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

Def. Rate (mm/min): 0.00286

DRAINED DIRECT SHEAR TEST: Test Results

Project Number:	04.11150035	App. No.:	DS-S01	Boring No.:	JOP-B002
Task No.:		Consol. Stress, $\sigma'_{v,c}$:	4 (ksf)	Sample No.:	ST-1
Project Name:		Induced OCR:	NA	Specimen No.:	a
File Name:	JOP-B002_ST-1a	$\sigma'_{v,max}$:	NA (ksf)	Depth (ft):	5.00
Shear Box Dia./Width:	63.5 (mm)	Specimen Ht.:	23.61 (mm)		
Shear Box:	[X] Circular [ ] Square	Vert. Strain During Consol.:	0.94 (%)		

Part of Test Series: [X] No; [ ] Yes If yes, Test: NA of NA
Multistage: [ ] No; [X] Yes If yes, Test Stage No.: 2
Residual/Multishearing: [X] No; [ ] Yes Precut Failure Plane [X] No; [ ] Yes

Initial Test Conditions:				
Water Content, w (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Void Ratio, e	Degree of Saturation, S (%)
21.5	127.14	104.60	0.609	95.6

Shearing Data For:	[X]	Intact - Without Repeated Shearing (Peak Data)
	[ ]	Intact - Before Repeated Shearing (Peak Data)
	[ ]	After Rapid Repeated Shearing (Residual Data)
	[ ]	Continuous Shearing: Forwards & Backwards (Peak & Residual Data)

Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
0.00	0.0000	0.09	0.00	0.00
10.00	0.0006	3.54	0.00	0.10
20.00	0.0121	8.69	0.02	0.25
33.00	0.0417	14.62	0.03	0.43
48.00	0.0697	17.39	0.06	0.51
63.00	0.0789	17.42	0.09	0.51
78.00	0.1101	22.02	0.10	0.65
93.00	0.1518	25.63	0.14	0.75
108.00	0.1967	29.02	0.17	0.85
123.00	0.2426	32.65	0.20	0.96
138.00	0.2903	35.94	0.23	1.05
153.00	0.3377	39.14	0.26	1.15
168.00	0.3828	42.25	0.32	1.24
185.00	0.4341	45.26	0.33	1.33
210.00	0.5045	49.45	0.34	1.45
235.00	0.5777	52.90	0.37	1.55
260.00	0.6557	56.91	0.43	1.67
285.00	0.7364	60.45	0.45	1.77
310.00	0.8176	63.67	0.43	1.87
335.00	0.8958	65.99	0.49	1.93
350.00	0.9417	67.21	0.49	1.97

Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

Def. Rate (mm/min): 0.00269

DRAINED DIRECT SHEAR TEST: Test Results

Project Number:	04.11150035	App. No.:	DS-S01	Boring No.:	JOP-B002
Task No.:		Consol. Stress, $\sigma'_{v,c}$:	8 (ksf)	Sample No.:	ST-1
Project Name:		Induced OCR:	NA	Specimen No.:	a
File Name:	JOP-B002_ST-1a	$\sigma'_{v,max}$:	NA (ksf)	Depth (ft):	5.00
Shear Box Dia./Width:	63.5 (mm)	Specimen Ht.:	23.25 (mm)		
Shear Box:	[X] Circular [ ] Square	Vert. Strain During Consol.:	0.98 (%)		

Part of Test Series: [X] No; [ ] Yes If yes, Test: NA of NA
Multistage: [ ] No; [X] Yes If yes, Test Stage No.: 3
Residual/Multishearing: [X] No; [ ] Yes Precut Failure Plane [X] No; [ ] Yes

Initial Test Conditions:				
Water Content, w (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Void Ratio, e	Degree of Saturation, S (%)
21.5	127.14	104.60	0.609	95.6

Shearing Data For:	[X]	Intact - Without Repeated Shearing (Peak Data)
	[ ]	Intact - Before Repeated Shearing (Peak Data)
	[ ]	After Rapid Repeated Shearing (Residual Data)
	[ ]	Continuous Shearing: Forwards & Backwards (Peak & Residual Data)

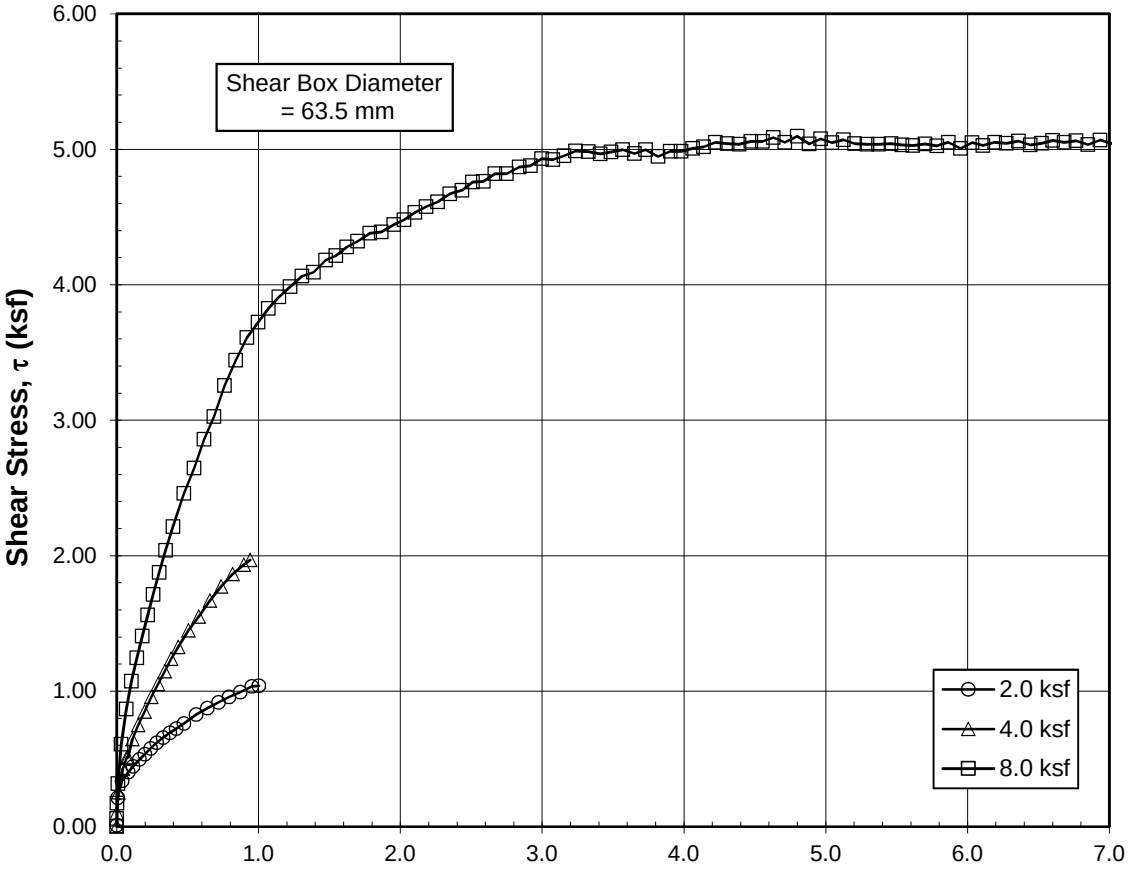
Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
0.00	0.0000	0.07	0.00	0.00
10.00	0.0001	2.04	0.00	0.06
20.00	0.0033	5.91	-0.01	0.17
33.00	0.0098	10.84	0.00	0.32
48.00	0.0325	20.76	0.01	0.61
63.00	0.0673	29.59	0.04	0.87
78.00	0.1040	36.66	0.07	1.07
93.00	0.1411	42.52	0.11	1.25
108.00	0.1798	47.97	0.13	1.41
123.00	0.2183	53.34	0.17	1.56
138.00	0.2583	58.52	0.20	1.71
153.00	0.3009	64.01	0.22	1.88
168.00	0.3449	69.64	0.25	2.04
185.00	0.3966	75.56	0.29	2.21
210.00	0.4734	83.94	0.33	2.46
235.00	0.5458	90.31	0.36	2.65
260.00	0.6159	97.61	0.40	2.86
285.00	0.6853	103.32	0.43	3.03
310.00	0.7610	111.09	0.45	3.26
335.00	0.8386	117.51	0.48	3.44
360.00	0.9194	123.20	0.51	3.61
385.00	0.9985	127.09	0.52	3.72
410.00	1.0690	130.56	0.55	3.83
435.00	1.1434	133.41	0.57	3.91
460.00	1.2231	136.05	0.59	3.99
485.00	1.3065	138.67	0.61	4.06
510.00	1.3888	139.66	0.64	4.09
535.00	1.4729	142.66	0.65	4.18
560.00	1.5448	143.83	0.68	4.21
585.00	1.6219	146.01	0.69	4.28
610.00	1.6991	147.48	0.72	4.32
635.00	1.7860	149.46	0.74	4.38
660.00	1.8673	149.80	0.75	4.39
685.00	1.9536	151.65	0.77	4.44
710.00	2.0270	152.83	0.78	4.48
735.00	2.1026	154.70	0.81	4.53
760.00	2.1826	156.17	0.82	4.58

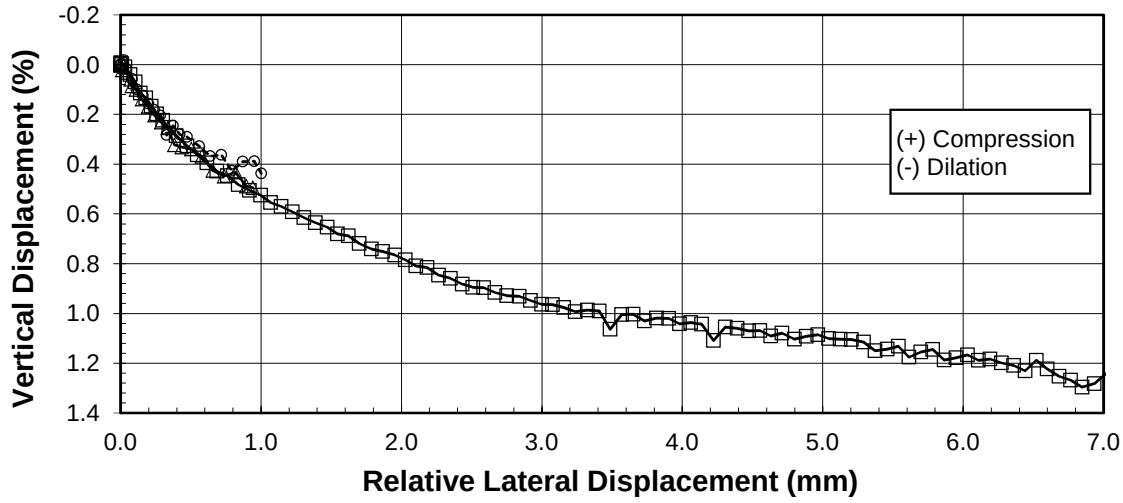
Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

Def. Rate (mm/min): 0.00314

Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
785.00	2.2644	157.41	0.85	4.61
810.00	2.3500	159.35	0.86	4.67
835.00	2.4345	160.28	0.88	4.70
860.00	2.5096	162.37	0.90	4.76
885.00	2.5858	162.56	0.90	4.76
910.00	2.6668	164.45	0.92	4.82
935.00	2.7495	164.43	0.93	4.82
960.00	2.8395	166.16	0.93	4.87
985.00	2.9180	166.46	0.95	4.88
1010.00	2.9978	168.27	0.96	4.93
1035.00	3.0768	168.05	0.96	4.92
1060.00	3.1550	168.95	0.98	4.95
1085.00	3.2369	170.19	0.99	4.99
1110.00	3.3252	170.05	0.99	4.98
1135.00	3.4094	169.48	0.99	4.97
1160.00	3.4874	169.96	1.06	4.98
1185.00	3.5672	170.53	1.00	5.00
1210.00	3.6513	169.51	1.00	4.97
1235.00	3.7305	170.52	1.03	5.00
1260.00	3.8171	168.84	1.02	4.95
1285.00	3.9037	170.08	1.02	4.98
1310.00	3.9812	170.11	1.04	4.99
1335.00	4.0609	170.85	1.04	5.01
1360.00	4.1391	171.26	1.04	5.02
1385.00	4.2222	172.34	1.11	5.05
1410.00	4.3061	172.02	1.05	5.04
1435.00	4.3901	171.84	1.06	5.04
1460.00	4.4731	172.61	1.07	5.06
1485.00	4.5530	172.57	1.07	5.06
1510.00	4.6311	173.56	1.09	5.09
1535.00	4.7111	172.38	1.08	5.05
1560.00	4.7987	173.92	1.10	5.10
1585.00	4.8830	171.94	1.09	5.04
1610.00	4.9644	173.29	1.08	5.08
1635.00	5.0437	172.32	1.10	5.05
1660.00	5.1242	173.01	1.10	5.07
1685.00	5.2036	172.06	1.10	5.04
1710.00	5.2918	171.86	1.11	5.04
1735.00	5.3730	171.87	1.15	5.04
1760.00	5.4604	172.02	1.14	5.04
1785.00	5.5384	171.71	1.13	5.03
1810.00	5.6138	171.55	1.18	5.03
1835.00	5.6991	171.99	1.16	5.04
1860.00	5.7842	171.49	1.14	5.03
1885.00	5.8647	172.33	1.19	5.05
1910.00	5.9505	170.85	1.18	5.01
1935.00	6.0313	172.28	1.17	5.05
1960.00	6.1079	171.57	1.19	5.03
1985.00	6.1912	172.37	1.18	5.05
2010.00	6.2729	172.13	1.20	5.04
2035.00	6.3596	172.72	1.21	5.06
2060.00	6.4416	171.76	1.23	5.03
2085.00	6.5206	172.10	1.19	5.04
2110.00	6.5997	172.87	1.22	5.07
2135.00	6.6821	172.36	1.25	5.05
2160.00	6.7649	172.74	1.27	5.06
2185.00	6.8481	171.78	1.30	5.03
2210.00	6.9337	172.90	1.28	5.07
2235.00	7.0159	172.05	1.24	5.04

Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

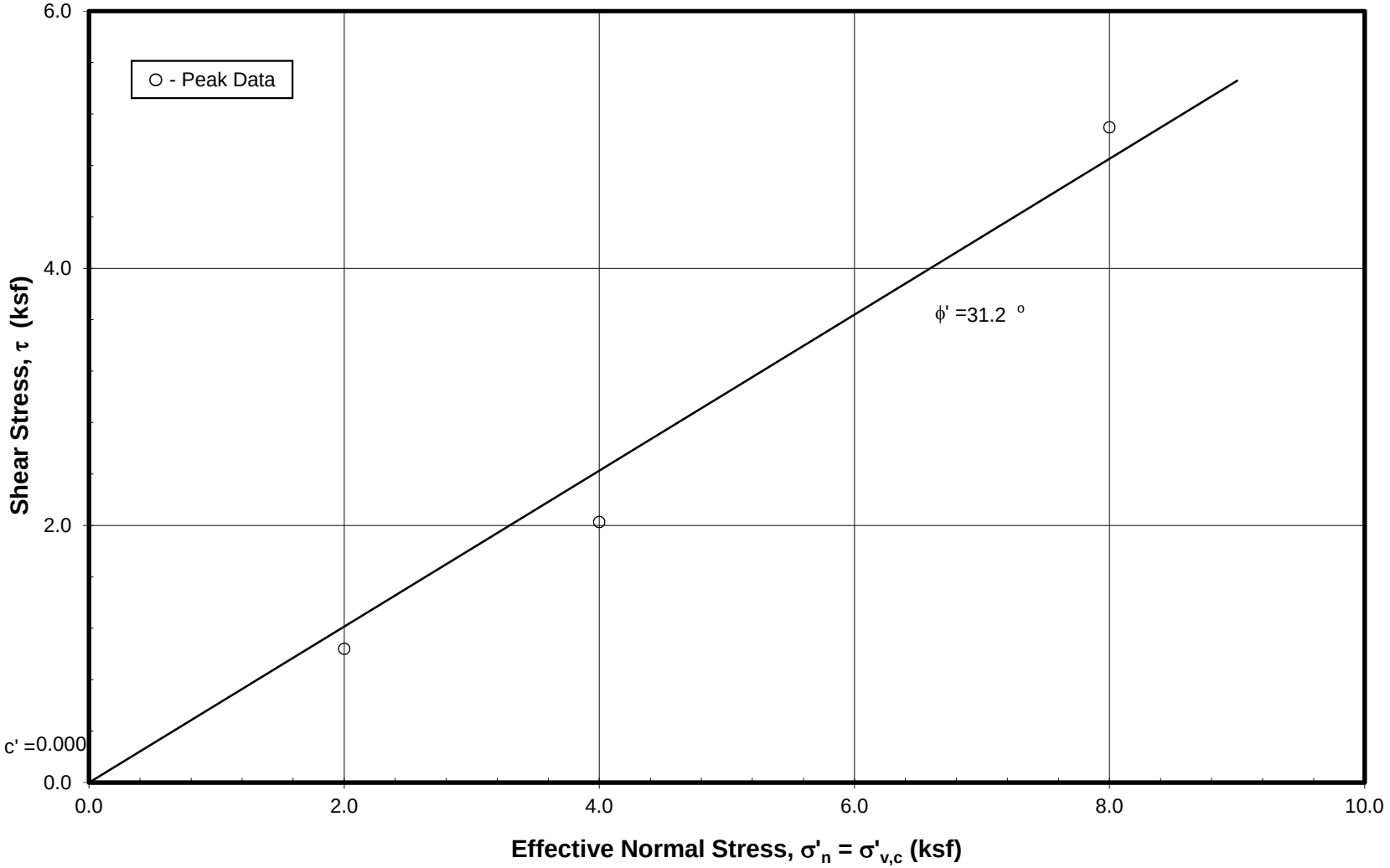




DRAINED DIRECT SHEAR TEST: All Tests in Test Series

Soil - Soil Interface $\sigma'_{v,c}$ = 2.0, 4.0, 8.0 ksf

Boring: JOP-B002 - Sample: ST-1a - Depth: 5.00 ft



DRAINED DIRECT SHEAR TEST: Test Series - (Peak Strength)

Soil - Soil Interface

Boring: JOP-B002 - Sample: ST-1a - Depth: 5.00 ft

CYCLIC DSS STRENGTH TEST (ASTM D 6528 & D 5311): Specimen Setup / Take Down

Project Number: 04.11150035 | Test Type: CyDSS ta=0 | Sta. No.: CSS-S04 | File Name: OP-B002_ST-1
Task No.: | Assign, $\sigma'_{v,c}$ = 0.50 ksf | Static DSS $c_u/\sigma'_{v,c}$ = 1.000
Project Name: | Induced OCR = 1.00 | Cyclic Ratios: τ_{cy} / c_u = 0.300 | τ_{avg} / c_u = NA
Sequence No.: of | Assig. Remarks: See Other Remarks | $\tau_{cy}/\sigma'_{v,c}$ = 0.300 | $\tau_{avg}/\sigma'_{v,c}$ =
Failure Criterion: [ ] Peak Obliquity, or [ ] Shear Strain (%) = | Specific Gravity: 2.720 [ ] Meas.; [X] Assumed

[X] Tube	[ ] Field Extruded	[ ] Liner	[ ] Remolded	[ ] Tamping	[ ] Constant Effort:	Blows/Tamps per Layer =	
Boring No.: JOP-B002		[ ] LPC Core		[ ] Impact/Rammer	Rammer Wgt.(lbf)=	No. Layers =	
Sample No.: ST-1	Compostite No.:			[ ] Pluviated:	Tamper Force (lbf)=	Drop (in.) =	
Depth (ft): 4.75	Specimen No.: b			[ ] Kneading	[ ] Undercompaction:	U_{ni} (%) =	Dia. (in.) =
[ ] Spec. Selection by X-ray;	[ ] Geomarine Sample				Ref. Effort=	% Comp. =	± Opt.=

Type of Consolidation:	[X] K_o at:	[X] Incremental	; [ ] Anisotropic at:		[ ] Inclined Stress Path, $K_{c,DSS}$	[X] Used automated system								
		[ ] CRS			[ ] 90° Stress Path	Remarks:								
Loading Conditions:	[ ] Static	[ ] Strain	[ ] Creep	[X] Const, Vol./Ht	[X] Without - Water	[X] Cyclic (Hz)		[ ] Strain	[X] Stress					
	[ ] Dynamic	[ ] Stress	[ ] Post Cyclic	[ ] Drained	[ ] With - Bath	Rate: [ ] 0.1;	[X] 1; Other:							

Water Content (WC);	Initial - Trimming Location			Final, W_{at}
	Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	(see below)
Container No.	610	4068	6585	
Mass Moist Soil + Cont. (g)	95.81	84.16	67.97	137.06
Mass Dry Soil + Container (g)	84.36	74.52	61.48	130.15
Mass Container (g)	32.01	30.01	30.12	100.76
WATER CONTENT (%)	21.87	21.66	20.70	23.51
Avg. Initial WC, $W_{o,avg}$ (%)	21.41	Final W_{at}: [X] Slice ; [ ]		Whole Spec.
[ ] See attached data sheet(s) for additional water contents				

Soil and Ring Masses	Initial	Final
Mass Moist Soil + Tare (g)	309.18	138.34
Mass Tare (g)	184.92	13.52
Mass Moist Soil, $M_{t,o}$ $Mt_{,at}$ (g)	124.26	124.82
Excess Dry Soil (soil not included in final mass above)		
Container No.		
Mass Dry Soil + Container (g)		
Mass Container (g)		
Mass Excess Dry Soil (g)		0.00

Specimen Trimming:

[ ] Trimming Ring for Fugro Apparatus		NL2	Large-ring ID #
[X] Trimming Ring for NGI Apparatus			Small-ring ID #
$H_{s,t}$ (mm):	17.91	$A_{s,t}$ (cm^2):	34.98
$D_{s,t}$ (mm) :	66.73	$V_{s,t}$ (cm^3):	62.66

Remarks:

[ ] Free Standing by Wire Saw Lathe (mm)

	Height (H_{tr})	Diameter (D_o)		Remarks:
1	17.940	1-T	NA	
2	17.910	2-M	NA	
3	17.900	3-B	NA	
4	17.910	1'-T	NA	For Free Standing
5	17.910	2'-M	NA	Trimmed Spec.:
Avg.		3'-B	NA	A_{tr} (cm^2): NA
=	17.914	Avg	NA	V_{tr} (cm^3): NA

Note: NA-Indicates not applicable. | Top Cap No. 16

F or G in the Sta. No. indicates Fugro or GEOTAC apparatus.

Estimated Initial Unit Weight

Total, $\gamma_{t,o}$ (lb/ft^3)= 123.80 | Dry, $\gamma_{d,o}$ (lb/ft^3)= 101.97

Specimen Lateral Confinement by:

[X] **Wire Reinforced, Model:** C=1.5 Thickness (mm) = 0.72

Stress Level	Dia. by PiTape (mm) Meas.	Corr.	Area, $A_{c,n}$ (cm^2)	(in^2)
0	68.03	66.59	34.83	5.398
$\sigma'_{v,c}$	68.14	66.70	34.94	5.416
$\sigma'_{v,max}$	68.14	66.70	34.94	5.416

[ ] **Regular Membrane with Ring Set No.** | ID, Rings (mm)

Thickness (mm): Top: , =

[ ] Single Bottom: , Corr. for mem.

[ ] Double Membr. Thick. = =

Area Ring with mem., A_o (cm^2) ; (in^2)=

Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf

Data corr. for M_{tc}: [X] Yes; [ ] No | Plattens with Pins: [ ] Yes; [X] No

Sketch of Specimen

Final Visual Description: Silty Clay, Tan & Gray, with Few Ferrous Stains

Other Remarks :

Trim./ Recon. By: HC | Date: 12/14/2015
Set Up By: HC | Date: 12/16/2015
Taken Down By: HC | Date: 12/17/2015
Prelim. Calc. By: HC
Final Calc. By: JJR
Reviewed By: HP

Specimen Take Down: [X] Spec. removed right after shearing
[ ] Spec. unloaded to zero stress with access to water
Remarks:

CYCLIC DSS STRENGTH TEST: Specimen Calculations & Summary

Project Number: 04.11150035 | Station No.: CSS-S04 | File Name: OP-B002_ST-1b

Task Number: | Specific Gravity: 2.720 | [ ] Measured; [X] Assumed

Type Test: CyDSS ta=0 | Specimen: [X] "Intact"; [ ] Reconstituted; [ ] Remolded

Calculations Corr. for Salt (dissolved solids): [X] No or, [ ] Yes, with concentration = _____ ppm

Consolidation Stress Summary and Loading Summary

Test Stage:	Max. Stress	Pre-Cyclic	Post Cyclic
Nominal Vertical Stress, σ'_v (ksf)	NA	0.5	
Axial/Vertical Force, $P_{vr,n}$ (lbf)	NA	NA	
Horizontal Force, $P_{hr,n}$ (lbf)	NA	0	
Nominal OCR	NA	1	
t_c,(ON,days,hrs)	NA	0.18 days	

Static Strain Rate = NA (%/hr or)

[X] Cyclic Rate (Hz): [ ] 0.1; [X] 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
Post Cy.Displ. Reset to Null Position:	[X] Yes;	[ ] No

[ ] Undrained ambient stress applied: with Delta shear force (lbf) = NA & Duration (min) = NA & Delta disp., $\Delta d_{h,ua}$ (mm) = NA

Trimmed Specimen (TS) - Inital Water Contents over Saturation (%):

	Top, $W_{o,1}$	Botttom, $W_{o,2}$	Sides, $W_{o,3}$	Avg., $W_{o,avg}$	Selct., $W_{o,s}$	Back Cal.
W_o	21.87	21.66	20.70	21.41	21.41	22.96
S_o	89.0	88.5	86.3	87.9	87.9	91.4

Measured final mass of moist soil, $M_{t,at}$ (g)	124.82
Final mass of moist soil corrected for excess dry soil, $M_{tat,c}$ (g)	124.82

Calculated Mass of Dry Soil (g)

Initial Selected Water Content (%)	21.41
Initial , $M_{d,o}$	102.35
Final, $M_{d,at}$	101.06
Selected, M_d	101.70

Initial Back Cal. Specific Gravity (TS):

Selected S_o (%)	
Selected W_o (%)	
Specific Gravity, $G_{s,bc}$	

Height/Volume Change Summary

Variation in Height & Volume During Consol.	During Initial Consol. to $\sigma'_{v,c}$or $\sigma'_{vc,max}$=	During Rebound to $\sigma'_{v,c}$ =	Specimen Unloaded After Test To
Stress Units (ksf)	0.500	NA	NA
Sign Convention: (+) ΔV out & ΔH down; (-) ΔV in & ΔH up			
Delta Def. Read., $\Delta d_{ar,n}$ (mm)	0.264		
Total Equip. Comp., $\Sigma\Delta d_{afc}$ (mm)	0.000		
Corr. Total Def. $\Delta H_{c,n}$ (mm)	0.264		
ΔV_n using A_o - spec. (cm^3)	0.92		
ΔV_n using $A_{c,n}$ - app. (cm^3)	0.92		
ΔV_n using burette meas.(cm^3)	1.00		
Selected ΔV_n (cm^3)	0.92	NA	NA = ΔV_{uL}
After Test WC Corr. for ΔV during Shear & Unloading, $W_{at,c}$ (%)			NA

Lateral Confinement Area Cal. Approach (LCA); Method 1, 2, 3 or 4: 3

Calculation of ΔV_c by Different Procedures

By Selected Volumes		By Change in Mass	
ΔV_c (cm^3)	0.92	~($M_{t,o}$ - $M_{tat,c}$)/ρ_w + ΔV_L + ΔV_{uL}	
By Cal. Height & App. Area		ΔV_c (cm^3)	-0.56
ΔV_c (cm^3)	0.92	**By Saturation = 100% and**	
By Cal. Ht. & Init. Spec. Area		**Spec. Unloaded to 0 Stress**	
ΔV_c (cm^3)	0.92	ΔV_c (cm^3)	NA

Back Cal. Water Content During Consol. - Based on the Consolidation Conclusions Given Below

Assumed Saturation (%)	100.00
Back Cal. WC before Loading, $W_{c,bc}$ (%)	23.77
Back Cal.WC at Max. Stress, $W_{cmax,bc}$ (%)	NA

Consolidation & Preshear Conclusions							
	ΔV_c (cm^3) =	0.99	ΔH_c (mm) =	0.264	$\varepsilon_{a,c}$ (%) =	1.47	$\Delta V_{c,max}$ (cm^3) = NA
	V_c (cm^3) =	61.67	H_c (mm) =	17.650	$\varepsilon_{v,c}$ (%) =	1.57	$\varepsilon_{ac,max}$ (%)= NA
	A_c (cm^2) =	34.94	$\Delta\gamma_c$ (mm) =	NA	γ_c (%) =	NA	Preshear: γ_{ua} (%)= NA

Summary of Specimen Physical Properties:

Specific Gravity: G_s = 2.720 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)		LL PL PI
Initial (as trimmed)	17.914	62.66	34.98	22.2	123.8	101.3	89.7		NA
After to $\sigma'_{v,c}$	17.650	61.67	34.94	23.8	127.4	103.0	100.0		NA
Consol.: to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA		

LCA-Method: 1- Initial measured value remains constant. 4 - Based on change in height & volume. Calculated By: JJR

& Note(s) 2 - Initial measured value corrected for applied stress. NA - Not Applicable Reviewed By: HP

3 - Uses measured value at appropriate stress level (NA for rings).

Remarks:

RESULTS OF CYCLIC DSS STRENGTH TEST

Project Number: 4.11150035 | Boring/Exploration No.: JOP-B002 | Test Type: CyDSS ta=0

Task Number | Sample No.: ST-1b | Test Sequence Number:

Project Name: | Specimen No: b | File Name: JOP-B002_ST-1b

Depth : 4.75 (ft)

	Units:	US	key in US or SI
	Stress Factor:	1.0000	(ksf->kPa)
	Length Factor:	1.0000	(ft->m)
	Unit Weight Factor:	1.0000	(pcf->kN/m^3)

Initial Height (mm): 17.914

Initial Diameter (mm): 66.734

Effective Vert. Stress at Consolidation, $\sigma'_{v,c}$: 0.5 (ksf)

Effective Vert. Stress Just Prior to Cyc. Loading, $\sigma'_{v,cy}$: 0.500 (ksf)

Induced OCR : 1.0

$K_{c,DSS}$: 1.000

$K_{u,DSS}$: 1.000

Axial/Vertical Strain During Consol., $\varepsilon_{c,max}$ (%) : 1.47

Shear Strain During Application of Undr. Bias Shear Stress, $\gamma_{u,b}$ (%): NA

Static DSS $c_u/\sigma'_{v,c}$: 1.000

τ_{avg}/c_u: 0.000

τ_{cy}/c_u : 0.264

Ψ_{DSS} : (degree)

$\gamma_{hf,max}$ (%) : 0.32

$\gamma_{hb,max}$ (%) : -0.38

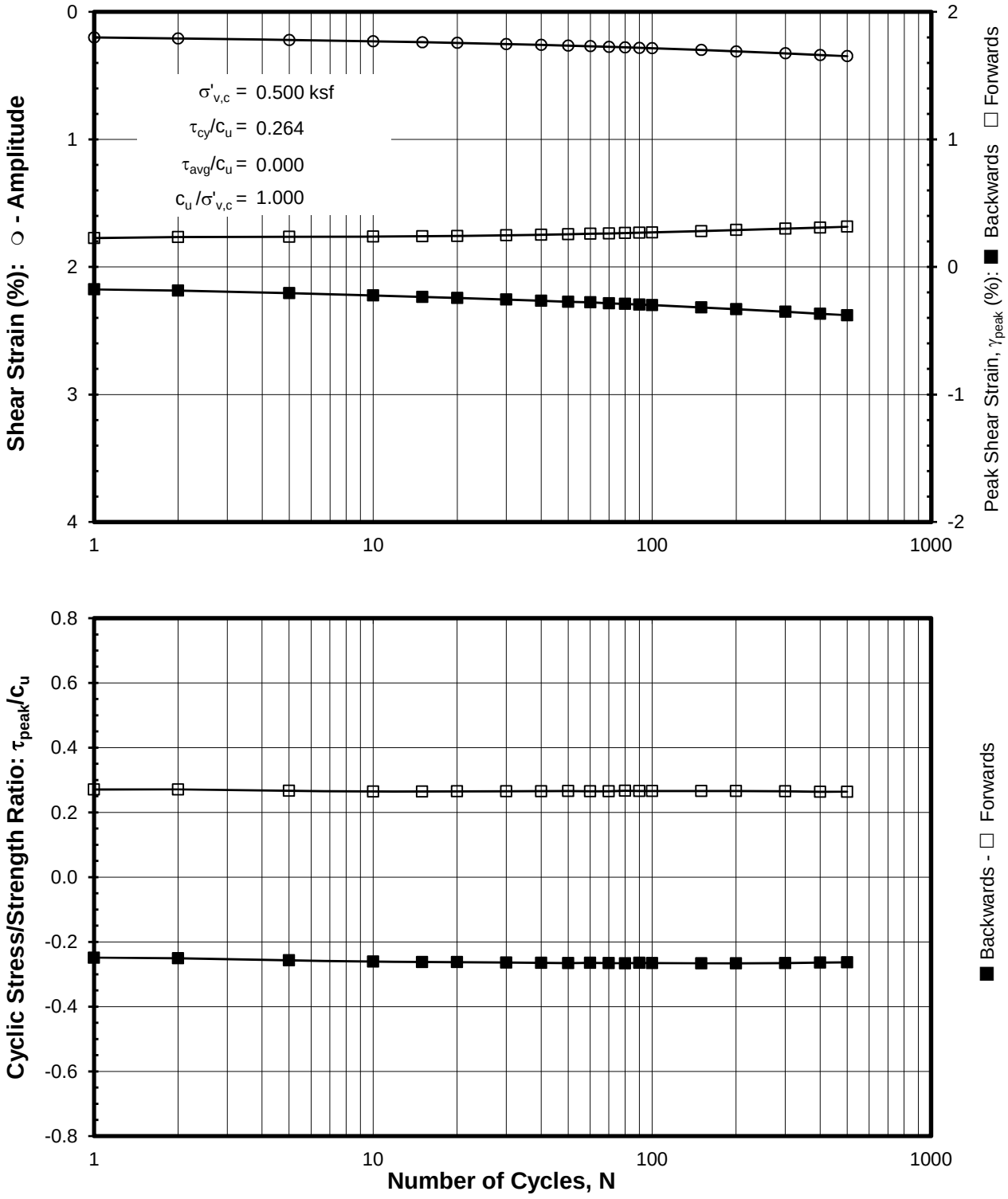
Summary of Specimen Physical Properties:

Specific Gravity: G_s = 2.720 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)		LL PL PI
Initial (as trimmed)	17.914	62.66	34.98	22.2	123.8	101.3	89.7		NA
After to $\sigma'_{v,c}$	17.650	61.67	34.94	23.8	127.4	103.0	100.0		NA
Consol.: to $\sigma'_{vc,max}$	NA	NA	NA	NA			NA		

Notes: (1) A positive number indicates the value is in the forwards region. (2) Value should be close to zero if a bias shear stress is not applied. (3) Based on ASTM D 5311; Uses stress or strain, based on control type.

Cycle No.	Shear Stress: Forwards $\tau_{h,f}$ (ksf)	Shear Stress: Backwards (1) $\tau_{h,b}$ (ksf)	Cyclic Shear Stress Amp. τ_{cy} (ksf)	Avg. Cyclic or Bias Stress τ_{avg} (2) (ksf)	Cyclic Stress Ratio τ_{cy} / $\sigma'_{v,c}$	Average Cyclic Stress Ratio $(\tau_{cy}$ / $\sigma'_{v,c})_{avg}$	Max. Decr. in Vert. Stress $\Delta\sigma'_{v,max}$ (ksf)	Normalized Decr. in Vert. Stress $\Delta\sigma'_{v,max}$ / $\sigma'_{v,c}$	Shear Strain: Forwards γ_f (%)	Shear Strain: Backwards (1) γ_b (%)	Cyclic Shear Strain Amp. γ_{cy} (%)	Average Shear Strain γ_{avg} (%) (2)	Shear Modulus (τ_{cy} / γ_{cy}) G (ksf)	Loading Requirement P_{error} (3)
1	0.135	-0.124	0.130	0.005	0.260	0.260	-0.056	-0.112	0.226	-0.176	0.201	0.025	64.613	2.479
2	0.136	-0.125	0.130	0.005	0.261	0.260	-0.059	-0.119	0.234	-0.185	0.210	0.025	62.254	2.027
5	0.133	-0.128	0.131	0.004	0.262	0.261	-0.060	-0.121	0.237	-0.206	0.221	0.015	59.084	1.741
10	0.132	-0.130	0.131	0.003	0.263	0.261	-0.053	-0.105	0.238	-0.224	0.231	0.007	56.909	1.299
15	0.132	-0.131	0.132	0.003	0.263	0.262	-0.046	-0.091	0.240	-0.235	0.238	0.003	55.395	1.102
20	0.132	-0.131	0.132	0.003	0.264	0.262	-0.036	-0.072	0.243	-0.243	0.243	0.000	54.242	1.023
30	0.133	-0.132	0.132	0.002	0.265	0.262	-0.026	-0.052	0.248	-0.256	0.252	-0.004	52.593	0.541
40	0.133	-0.132	0.132	0.002	0.265	0.263	-0.025	-0.050	0.253	-0.264	0.259	-0.006	51.223	0.521
50	0.133	-0.133	0.133	0.002	0.266	0.263	-0.012	-0.025	0.257	-0.273	0.265	-0.008	50.133	0.275
60	0.133	-0.132	0.132	0.002	0.265	0.263	-0.006	-0.012	0.260	-0.278	0.269	-0.009	49.212	0.521
70	0.133	-0.133	0.133	0.001	0.266	0.263	-0.008	-0.017	0.263	-0.285	0.274	-0.011	48.464	0.246
80	0.133	-0.133	0.133	0.001	0.266	0.264	-0.007	-0.014	0.267	-0.290	0.278	-0.012	47.828	0.000
90	0.133	-0.132	0.133	0.001	0.265	0.264	0.004	0.009	0.269	-0.295	0.282	-0.013	47.097	0.334
100	0.133	-0.133	0.133	0.001	0.266	0.264	0.006	0.013	0.270	-0.299	0.285	-0.014	46.671	0.207
150	0.133	-0.133	0.133	0.001	0.266	0.264	0.023	0.045	0.281	-0.318	0.299	-0.018	44.430	0.079
200	0.133	-0.133	0.133	0.001	0.266	0.264	0.029	0.058	0.290	-0.331	0.310	-0.021	42.851	0.148

Cycle No.	Shear Stress: Forwards $\tau_{h,f}$ (ksf)	Shear Stress: Backwards [1] $\tau_{h,b}$ (ksf)	Cyclic Shear Stress Amp. τ_{cy} (ksf)	Avg. Cyclic or Bias Stress τ_{avg} [2] (ksf)	Cyclic Stress Ratio $\tau_{cy} / \sigma'_{v,c}$	Average Cyclic Stress Ratio $(\tau_{cy} / \sigma'_{v,c})_{avg}$	Max. Decr. in Vert. Stress $\Delta\sigma'_{v,max}$ (ksf)	Normalized Decr. in Vert. Stress $\Delta\sigma'_{v,max} / \sigma'_{v,c}$	Shear Strain: Forwards γ_f (%)	Shear Strain: Backwards [1] γ_b (%)	Cyclic Shear Strain Amp. γ_{cy} (%)	Average Shear Strain γ_{avg} (%) [2]	Shear Modulus (τ_{cy} / γ_{cy}) G (ksf)	Loading Requirement P_{error} [3]
300	0.133	-0.133	0.133	0.001	0.265	0.264	0.041	0.083	0.300	-0.351	0.325	-0.025	40.788	0.325
400	0.132	-0.132	0.132	0.001	0.264	0.264	0.047	0.095	0.308	-0.367	0.338	-0.029	39.056	0.954
500	0.132	-0.132	0.132	0.001	0.263	0.264	0.062	0.124	0.315	-0.379	0.347	-0.032	37.958	1.072

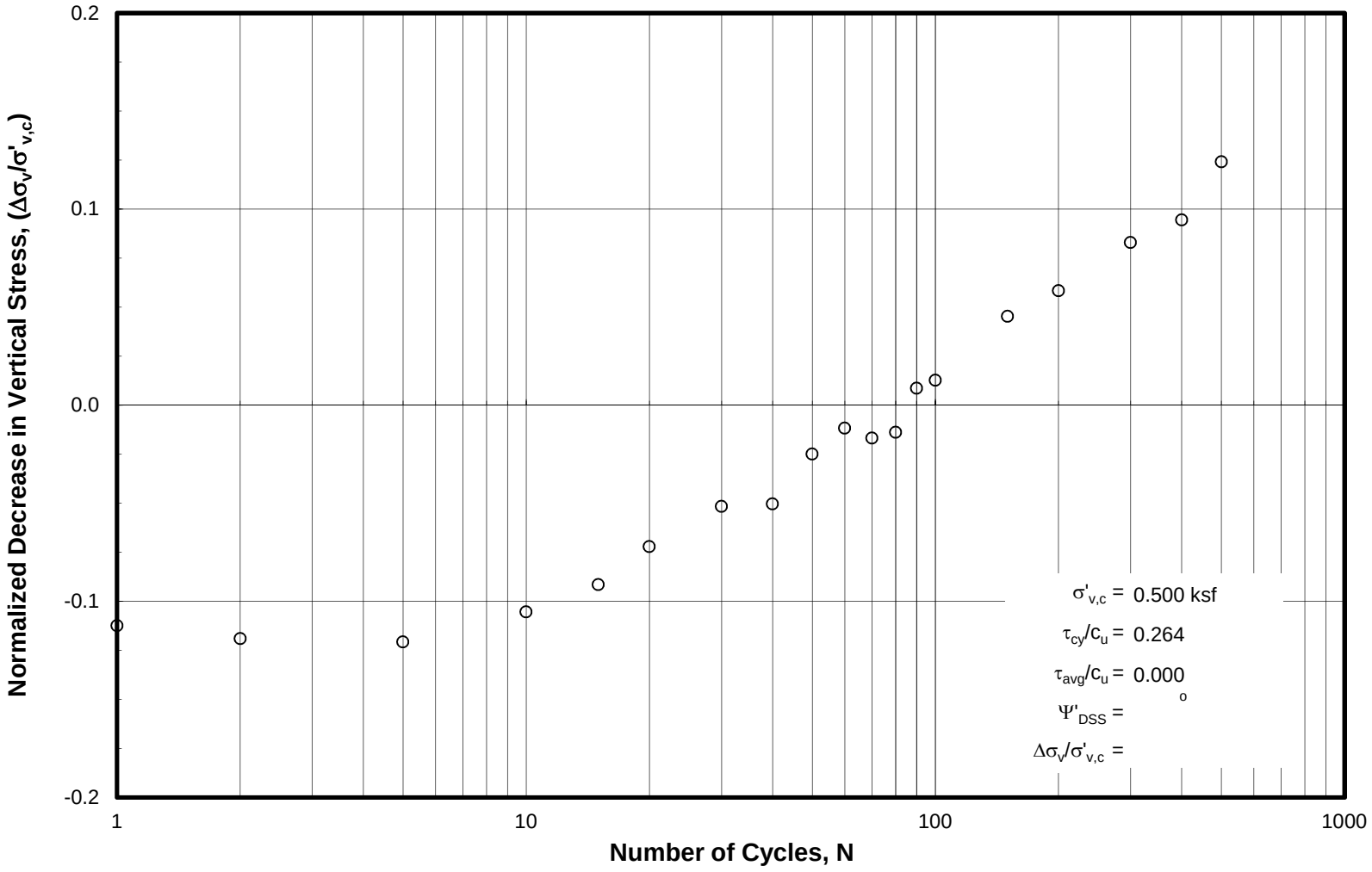


CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-1b - Depth: 4.75 ft

Boring JOP-B002

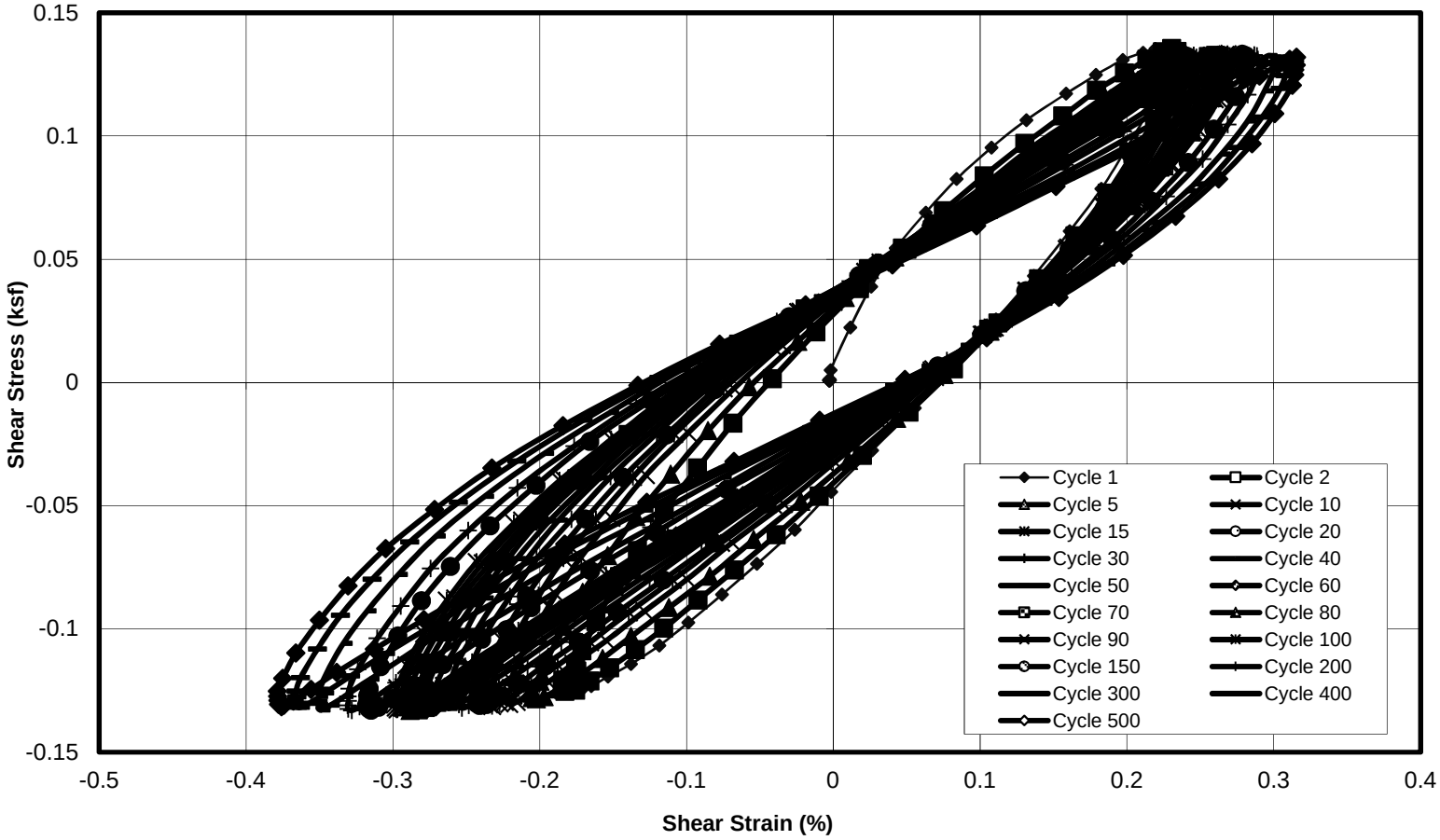


CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-1b - Depth: 4.75 ft

Boring JOP-B002



CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-1b - Depth: 4.75 ft

Boring JOP-B002

DIRECT SIMPLE SHEAR TEST (ASTM D 6528): Specimen Setup / Take Down

Project Number: 04.11150035 | Test Type: Post Cyclic DSS | Sta. No.: CSS-S04 | File Name: OP-B002_ST-1
Task No.: | Assign, $\sigma'_{v,c}$ = 0.50 ksf | Static DSS $c_u/\sigma'_{v,c}$ = 1.000
Project Name: | Induced OCR = 1.00 | Cyclic Ratios: τ_{cy}/c_u = 0.500 | τ_{avg}/c_u = NA
Sequence No.: of | Assig. Remarks: See Other Remarks | $\tau_{cy}/\sigma'_{v,c}$ = 0.500 | $\tau_{avg}/\sigma'_{v,c}$ =
Failure Criterion: [ ] Peak Obliquity, or [ ] Shear Strain (%) = | Specific Gravity: 2.720 [ ] Meas.; [X] Assumed

[X] Tube [X] Field Extruded	[ ] Liner [ ] Remolded	[ ] Tamping	[ ] Constant Effort:	Blows/Tamps per Layer =	
Boring No.: JOP-B002	[ ] LPC Core	[ ] Impact/Rammer	Rammer Wgt.(lbf)=	No. Layers =	
Sample No.: ST-1	Compostite No.:	[ ] Pluviated:	Tamper Force (lbf)=	Drop (in.) =	
Depth (ft): 4.75	Specimen No.: b	[ ] Kneading	[ ] Undercompaction:	U_{ni} (%) =	Dia. (in.) =
[ ] Spec. Selection by X-ray;	[ ] Geomarine Sample		Ref. Effort=	% Comp. =	± Opt.=

Type of Consolidation:	[ ] K_o at:	[ ] Incremental CRS	;	[ ] Anisotropic at:	[ ] Inclined Stress Path, $K_{c,DSS}$	[ ] 90° Stress Path	[ ] Used automated system	Remarks:						
Loading Conditions:	[ ] Static	[ ] Dynamic	[ ] Strain	[ ] Stress	[ ] Creep	[X] Post Cyclic	[ ] Const, Vol./Ht	[ ] Drained	[ ] Without - With -	Water Bath	[ ] Cyclic (Hz) Rate:	[ ] 0.1;	[ ] Strain	[ ] Stress [ ] 1; Other:

Water Content (WC);	Initial - Trimming Location			Final, W_{at}	**Soil and Ring Masses**	Initial	Final
	Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	(see below)	Mass Moist Soil + Tare (g)	309.18	138.34
Container No.	610	4068	6585		Mass Tare (g)	184.92	13.52
Mass Moist Soil + Cont. (g)	95.81	84.16	67.97	137.06	Mass Moist Soil, $M_{t,o}$ $Mt_{,at}$ (g)	124.26	124.82
Mass Dry Soil + Container (g)	84.36	74.52	61.48	130.15	**Excess Dry Soil (soil not included in final mass above)**		
Mass Container (g)	32.01	30.01	30.12	100.76	Container No.		
WATER CONTENT (%)	21.87	21.66	20.70	23.51	Mass Dry Soil + Container (g)		
Avg. Initial WC, $W_{o,avg}$ (%)	21.41	Final W_{at}: [X] Slice ; [ ] Whole Spec.			Mass Container (g)		
[ ] See attached data sheet(s) for additional water contents					Mass Excess Dry Soil (g)	0.00	

Specimen Trimming:

[ ] Trimming Ring for Fugro Apparatus | NL2 | Large-ring ID #
[X] Trimming Ring for NGI Apparatus | | Small-ring ID #

$H_{s,t}$ (mm):	17.91	$A_{s,t}$ (cm^2):	34.98
$D_{s,t}$ (mm) :	66.73	$V_{s,t}$ (cm^3):	62.66

Remarks:

[ ] Free Standing by Wire Saw Lathe (mm)

	Height (H_{tr})	Diameter (D_o)		Remarks:
1	17.940	1-T	NA	
2	17.910	2-M	NA	
3	17.900	3-B	NA	
4	17.910	1'-T	NA	For Free Standing
5	17.910	2'-M	NA	Trimmed Spec.:
Avg.		3'-B	NA	A_{tr} (cm^2): NA
=	17.914	Avg	NA	V_{tr} (cm^3): NA

Note: NA-Indicates not applicable. | Top Cap No. 16
F or G in the Sta. No. indicates Fugro or GEOTAC apparatus.

Estimated Initial Unit Weight

Total, $\gamma_{t,o}$ (lb/ft^3)= 123.80 | Dry, $\gamma_{d,o}$ (lb/ft^3)= 101.97

Specimen Lateral Confinement by:

[X] **Wire Reinforced, Model:** C=1.5 Thickness (mm) = 0.72

Stress Level	Dia. by PiTape (mm) Meas.	Corr.	Area, $A_{c,n}$ (cm^2)	(in^2)
0	68.03	66.59	34.83	5.398
$\sigma'_{v,c}$	68.14	66.70	34.94	5.416
$\sigma'_{v,max}$	68.14	66.70	34.94	5.416

[ ] **Regular Membrane with Ring Set No.** | ID, Rings (mm)
Thickness (mm): Top: , =
[ ] Single Bottom: , Corr. for mem.
[ ] Double Membr. Thick. = =
Area Ring with mem., A_o (cm^2) ; (in^2)=
Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf
Data corr. for M_{tc}: [X] Yes; [ ] No | Plattens with Pins: [ ] Yes; [X] No

Sketch of Specimen

Final Visual Description: Silty Clay, Tan & Gray, with Few Ferrous Stains

Other Remarks :

Trim./ Recon. By: HC | Date: 12/14/2015
Set Up By: HC | Date: 12/16/2015
Taken Down By: HC | Date: 12/17/2015
Prelim. Calc. By: HC
Final Calc. By: JJR
Reviewed By: HP

Specimen Take Down: [X] Spec. removed right after shearing
[ ] Spec. unloaded to zero stress with access to water
Remarks:

DIRECT SIMPLE SHEAR TEST (ASTM D 6528): Specimen Calculations & Summary

Project Number: 04.11150035 | Test Station No.: CSS-S04 | File Name: OP-B002_ST-1b
Task Number: | Specific Gravity: 2.720 | [ ] Measured; [X] Assumed

Type Test: Post Cyclic DSS | Specimen: [X] "Undisturbed"; [ ] Reconstituted; [ ] Remolded
Calculations Corr. for Salt (dissolved solids): [X] No or, [ ] Yes, with concentration = _____ ppm

Consolidation Stress Summary and Loading Summary

Test Stage:	Max. Stress	Pre-Shear	Post Cyclic
Nominal Vertical Stress, σ'_v (ksf)	NA	0.50	
Axial/Vertical Force, $P_{vr,n}$ (lbf)	NA	NA	
Horizontal Force, $P_{hr,n}$ (lbf)	NA	0	
Nominal OCR	NA	1	
t_c,(ON,days,hrs)	NA	0.18 days	

0 Static Strain Rate = Value ? (%/hr or)
[ ] Cyclic Rate (Hz): [ ] 0.1; [ ] 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	Value ?	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	Value ?	NA
Post Cy.Displ. Reset to Null Position:	[ ] Yes;	[ ] No

[ ] Undrained ambient stress applied: with Delta shear force (lbf) = NA & Duration (min) = NA & Delta disp., $\Delta d_{h,ua}$ (mm) = NA

Trimmed Specimen (TS) - Inital Water Contents over Saturation (%):

	Top, $W_{o,1}$	Botttom, $W_{o,2}$	Sides, $W_{o,3}$	Avg., $W_{o,avg}$	Selct., $W_{o,s}$	Back Cal.
W_o	21.87	21.66	20.70	21.41	21.41	22.96
S_o	89.0	88.5	86.3	87.9	87.9	91.4

Measured final mass of moist soil, $M_{t,at}$ (g): 124.82
Final mass of moist soil corrected for excess dry soil, $M_{tat,c}$ (g): 124.82

Calculated Mass of Dry Soil (g)

Initial Selected Water Content (%)	21.41
Initial , $M_{d,o}$	102.35
Final, $M_{d,at}$	101.06
Selected, M_d	101.70

Initial Back Cal. Specific Gravity (TS):

Selected S_o (%)	
Selected W_o (%)	
Specific Gravity, $G_{s,bc}$	

Height/Volume Change Summary

Variation in Height & Volume During Consol.	During Initial Consol. to $\sigma'_{v,c}$or $\sigma'_{vc,max}$=	During Rebound to $\sigma'_{v,c}$ =	Specimen Unloaded After Test To
Stress Units (ksf)	0.500	NA	NA
Sign Convention: (+) ΔV out & ΔH down; (-) ΔV in & ΔH up			
Delta Def. Read., $\Delta d_{ar,n}$ (mm)	0.264		
Total Equip. Comp., $\Sigma\Delta d_{afc}$ (mm)	0.000		
Corr. Total Def. $\Delta H_{c,n}$ (mm)	0.264		
ΔV_n using A_o - spec. (cm^3)	0.92		
ΔV_n using $A_{c,n}$ - app. (cm^3)	0.92		
ΔV_n using burette meas.(cm^3)	1.00		
Selected ΔV_n (cm^3)	0.92		NA = ΔV_{uL}
After Test WC Corr. for ΔV during Shear & Unloading, $W_{at,c}$ (%)			NA

Lateral Confinement Area Cal. Approach (LCA); Method 1, 2, 3 or 4: 3

Calculation of ΔV_c by Different Procedures

By Selected Volumes		By Change in Mass	
ΔV_c (cm^3)	#VALUE!	~ $M_{t,o}$ - ($M_{tat,c}$ + ΔV_L + ΔV_{uL})	
By Cal. Height & App. Area		ΔV_c (cm^3)	-0.56
ΔV_c (cm^3)	0.92	**By Saturation = 100% and**	
By Cal. Ht. & Init. Spec. Area		**Spec. Unloaded to 0 Stress**	
ΔV_c (cm^3)	0.92	ΔV_c (cm^3)	NA

Back Cal. Water Content During Consol. - Based on the Consolidation Conclusions Given Below

Assumed Saturation (%)	100.00
Back Cal. WC before Loading, $W_{c,bc}$ (%)	23.76
Back Cal.WC at Max. Stress, $W_{cmax,bc}$ (%)	NA

Consolidation & Preshear Conclusions							
	ΔV_c (cm^3) =	0.99	ΔH_c (mm) =	0.264	$\varepsilon_{a,c}$ (%) =	1.47	$\Delta V_{c,max}$ (cm^3) = NA
	V_c (cm^3) =	61.67	H_c (mm) =	17.650	$\varepsilon_{v,c}$ (%) =	1.57	$\varepsilon_{ac,max}$ (%)= NA
	A_c (cm^2) =	34.94	$\Delta\gamma_c$ (mm) =	NA	γ_c (%) =	NA	Preshear: γ_{ua} (%)= NA

Summary of Specimen Physical Properties:

Specific Gravity: G_s = 2.720 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)	
Initial (as trimmed)	17.914	62.66	34.98	22.2	123.8	101.3	89.7	
After to $\sigma'_{v,c}$	17.650	61.67	34.94	23.8	127.4	103.0	100.0	
Consol.: to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA	

LCA-Method: 1- Initial measured value remains constant. 4 - Based on change in height & volume.
& Note(s) 2 - Initial measured value corrected for applied stress. NA - Not Applicable
3 - Uses measured value at appropriate stress level (NA for rings).

Calculated By: HP
Reviewed By: HP

Remarks:

DIRECT SIMPLE SHEAR TEST

Project Number:	04.11150035	Task Number:		Boring No.:	JOP-B002
Project Name:		Test Type:	Post Cyclic DSS	Sample No.:	ST-1
Test Number:		Test Series No.:		Specimen No.:	b
				Depth (ft.):	4.75

Horiz. Load Factor (lbf/V/V):	29.983	Vert. Load Factor (lbf/V/V):	144.426
Horiz. Load, Test Floating Zero (V/V):	3.494E-03	Vert. Load, Test Floating Zero (V/V):	1.443E-02
Horiz. Deform. Factor (mm/V/V):	-0.394	Vert. Deform. Factor (mm/V/V):	0.491

	Max Stress	Pre-Shear	Post Cyclic
Vertical Load (V/V) or (lbf):		1.37E-01	
Calculated Vertical Stress (ksf):		0.500	
Horizontal Load (V/V) or (lbf):			
Calculated Horizontal Load (ksf):			

Elapsed Time (min)	Exitation (Volts)	Horizontal Load (Volts)	Horizontal Deformation (Volts)	Vertical Load (Volts)	Vertical Deformation (Volts)	Horizontal Load (grams)
0.0	1.000	5.225E-3	-0.008	1.331E-1	-2.576	0
4.2	1.000	1.406E-1	0.150	1.291E-1	-2.649	0
8.3	1.000	2.458E-1	0.302	1.400E-1	-2.636	0
12.5	1.000	2.958E-1	0.455	1.590E-1	-2.566	0
16.7	1.000	3.253E-1	0.610	1.590E-1	-2.653	0
20.8	1.000	3.451E-1	0.762	1.613E-1	-2.647	0
25.0	1.000	3.582E-1	0.915	1.541E-1	-2.657	0
29.2	1.000	3.631E-1	1.069	1.498E-1	-2.604	0
33.3	1.000	3.671E-1	1.223	1.475E-1	-2.592	0
37.5	1.000	3.668E-1	1.376	1.498E-1	-2.655	0
41.7	1.000	3.648E-1	1.528	1.525E-1	-2.592	0
45.8	1.000	3.605E-1	1.682	1.449E-1	-2.653	0
50.0	1.000	3.546E-1	1.836	1.354E-1	-2.650	0
54.2	1.000	3.487E-1	1.990	1.370E-1	-2.616	0
58.3	1.000	3.444E-1	2.144	1.492E-1	-2.639	0
62.5	1.000	3.378E-1	2.297	1.344E-1	-2.580	0
66.7	1.000	3.349E-1	2.449	1.212E-1	-2.589	0
70.8	1.000	3.290E-1	2.601	1.278E-1	-2.590	0
75.0	1.000	3.273E-1	2.756	1.232E-1	-2.577	0
79.2	1.000	3.250E-1	2.909	1.245E-1	-2.654	0
83.3	1.000	3.221E-1	3.063	1.196E-1	-2.572	0
87.5	1.000	3.221E-1	3.216	1.281E-1	-2.628	0
91.7	1.000	3.184E-1	3.370	1.212E-1	-2.578	0
95.8	1.000	3.214E-1	3.523	1.068E-1	-2.661	0
100.0	1.000	3.211E-1	3.678	1.160E-1	-2.638	0
104.2	1.000	3.227E-1	3.831	1.170E-1	-2.638	0
108.3	1.000	3.234E-1	3.986	1.166E-1	-2.619	0
112.5	1.000	3.240E-1	4.137	1.065E-1	-2.660	0
116.7	1.000	3.286E-1	4.289	1.091E-1	-2.595	0
120.8	1.000	3.299E-1	4.443	1.160E-1	-2.641	0
125.0	1.000	3.303E-1	4.596	1.068E-1	-2.610	0
129.2	1.000	3.336E-1	4.750	9.889E-2	-2.603	0
133.3	1.000	3.378E-1	4.902	1.206E-1	-2.596	0
137.5	1.000	3.391E-1	5.060	1.074E-1	-2.594	0
141.7	1.000	3.431E-1	5.209	1.028E-1	-2.613	0
145.8	1.000	3.457E-1	5.363	1.025E-1	-2.588	0
150.0	1.000	3.507E-1	5.518	1.180E-1	-2.644	0
154.2	1.000	3.536E-1	5.671	1.150E-1	-2.661	0
158.3	1.000	3.582E-1	5.825	1.206E-1	-2.585	0
162.5	1.000	3.608E-1	5.975	1.235E-1	-2.597	0
166.7	1.000	3.654E-1	6.130	1.153E-1	-2.595	0
170.8	1.000	3.710E-1	6.285	1.209E-1	-2.664	0

175.0	1.000	3.743E-1	6.438	1.226E-1	-2.622	0
179.2	1.000	3.799E-1	6.592	1.209E-1	-2.664	0
183.3	1.000	3.825E-1	6.743	1.265E-1	-2.587	0
187.5	1.000	3.858E-1	6.900	1.272E-1	-2.633	0
191.7	1.000	3.884E-1	7.051	1.262E-1	-2.650	0
195.8	1.000	3.927E-1	7.203	1.265E-1	-2.625	0
200.0	1.000	3.970E-1	7.358	1.301E-1	-2.607	0
204.2	1.000	4.016E-1	7.511	1.327E-1	-2.641	0
208.3	1.000	4.036E-1	7.662	1.337E-1	-2.623	0
212.5	1.000	4.059E-1	7.818	1.370E-1	-2.604	0
216.7	1.000	4.092E-1	7.971	1.275E-1	-2.610	0
220.8	1.000	4.131E-1	8.122	1.387E-1	-2.605	0
225.0	1.000	4.177E-1	8.278	1.347E-1	-2.619	0
229.2	1.000	4.210E-1	8.432	1.304E-1	-2.616	0
233.3	1.000	4.249E-1	8.584	1.396E-1	-2.631	0
237.5	1.000	4.302E-1	8.738	1.436E-1	-2.638	0
239.9	1.000	4.318E-1	8.830	1.521E-1	-2.659	0

Results of Direct Simple Shear Test

Project Number: 04.11150035 Test Type: Post Cyclic DSS Test Sta. No.: CSS-S04 File Name: OP-B002_ST-1
Project Name: Task No.: Test No.: Test Series for:

[X] Tube	[X] Field Extruded	[ ] Liner	[ ] Remolded	[ ] Tamping	[ ] Constant Effort:		Blows/Tamps per Layer =	
Boring No.:	JOP-B002	[ ] LPC Core		[ ] Impact/Rammer	Rammer Wgt.(lbf)=		No. Layers =	
Sample No.:	ST-1	Compostite No.:		[ ] Pluviated:	Tamper Force (lbf)=		Drop (in.) =	
Depth (ft):	4.75	Specimen No.:	b	[ ] Kneading	[ ] Undercompaction:	U_{ni} (%) =	Dia. (in.) =	
[ ] Spec. Selection by X-ray;		[ ] Geomarine Sample			Ref. Effort=	% Comp. =	± Opt.=	

Type Consolidation:	[ ]	K_o at:	[ ]	Incremental CRS	[ ]	Anisotropic at:	[ ]	Inclined Stress Path, $K_{c,DSS}$ 90° Stress Path	[ ]	Used Automated System Remarks:						
Loading Conditions:	0	Static	[ ]	Strain	[ ]	Creep	[ ]	Const, Vol./Ht	[ ]	Without - Water	[ ]	Cyclic (Hz)	[ ]	Strain	[ ]	Stress
	[ ]	Dynamic	[ ]	Stress	X	Post Cyclic	[ ]	Drained	[ ]	With - Bath	Rate:	[ ] 0.1;	[ ]	1; Other:		

Summary of Specimen Physical Properties

Specific Gravity: G_s = 2.720					Unit Weight					
Condition:	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total (pcf)	Dry (pcf)	Saturation (%)	LL PL PI		
Initial	17.91	62.66	34.98	22.18	123.8	101.3	89.7			
After to $\sigma'_{v,c}$	17.65	61.67	34.94	23.76	127.4	103.0	100.0			
Consol.: to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA			

Consolidation Stress Summary and Loading Summary

Item	Unit	Max. Stress	Pre-Shear	Post Cyclic
Vert. Consol. Stress, $\sigma'_{v,c}$	(ksf)	NA	0.500	NA
Induced OCR	-	NA	1.00	NA
Axial Strain during Consol., $\varepsilon_{a,c}$	%	NA	1.47	NA
Horiz. Consol. Stress, $\tau_{h,c}$	(ksf)	NA	NA	NA
Consol. Stress Ratio, $\tau_{h,c}$ / $\sigma'_{v,c}$	-	NA	NA	NA
Shear Strain during Consol., $\varepsilon_{h,c}$	%	NA	NA	NA
Undr. Ambient Shear Stress, $\tau_{h,ua}$	(ksf)	NA	NA	NA
Undr. Ambient Shear Strain, ε_{ua}	%	NA	NA	NA

0 Static Strain Rate = 4.9 %/hr.
Cyclic Rate (Hz): [ ] 0.1; [ ] 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	Value ?	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	Value ?	NA
Post Cy.Displ. Reset to Null Pos.:	[ ] Yes;	[ ] No

Number of Loading Cycles, N = NA
$\pm\tau_h$ = NA (ksf) $\pm\gamma$ = NA %
at end of cyclic loading, $\sigma'_{vcy,r}$ = NA (ksf)

Weight Top Cap, etc., M_{tc} (lbf): 1.09																
Data corr. for M_{tc}:	[X]	Yes;	[ ]	No	Plattens with Pins:	[ ]	Yes;	[X]	No							
[X]	Wire Reinforced Membrane,	Model:	C=1.5		Data corr. for Membr. strength	[ ]	Yes	[X]	No							
[ ]	Regular Membrane with Rings															

Data Normalization: [X] Yes [ ] No Value: 0.500 (ksf)
Using Effective Vertical Stress:
[X] Pre-Shear Conditions [ ] Post-Cyclic Conditions
[ ] Maximum Stress during Consol.

Notes: See Fugro South, Inc. Notation Listing for definition of symbols and acronyms. F or G in the Test Sta. No. indicates Fugro or GEOTAC apparatus.
NA - Not Applicable

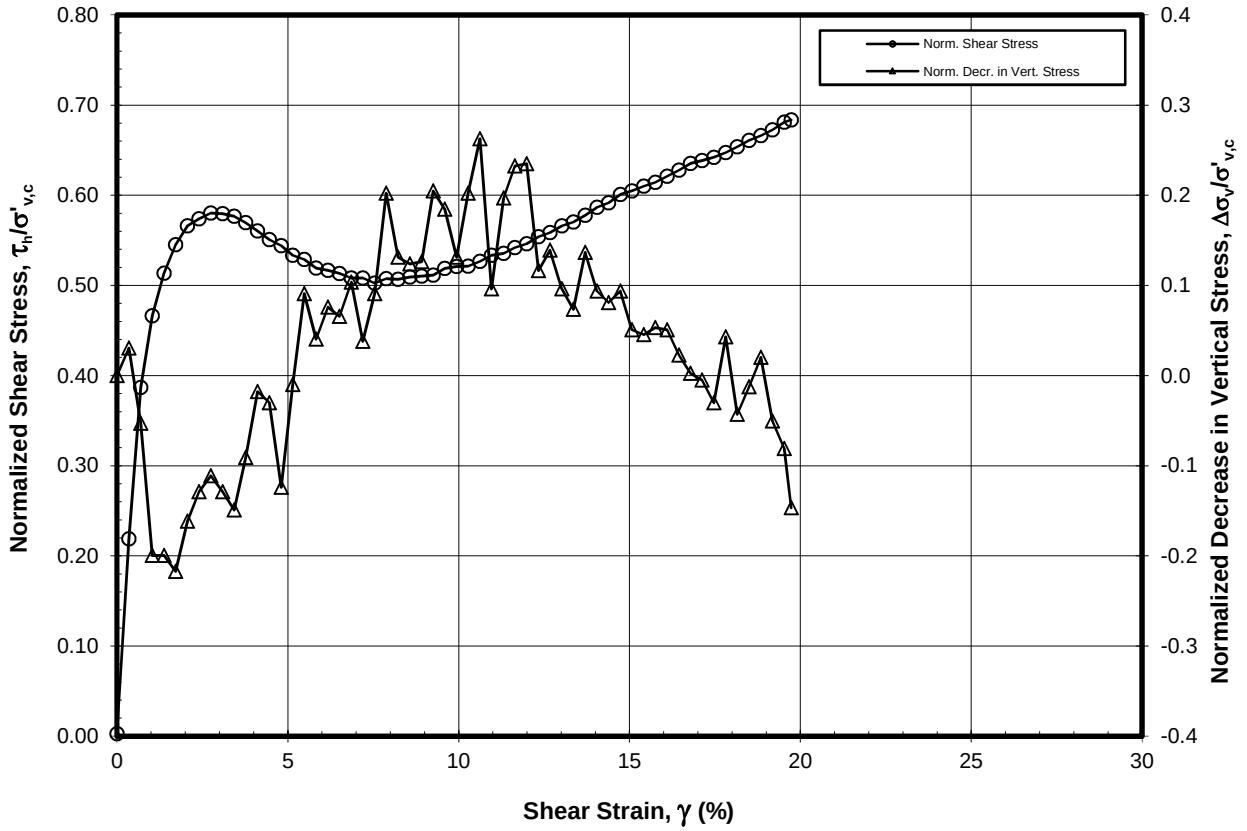
Final Visual Description and Remarks: Silty Clay, Tan & Gray, with Few Ferrous Stains

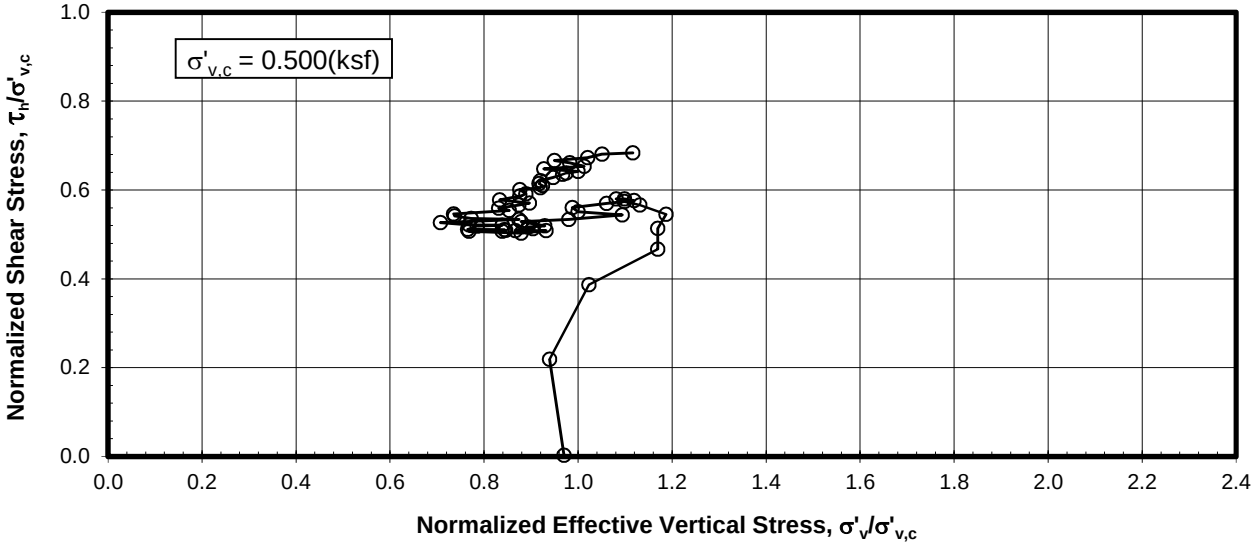
Loading Summary

	τ_h (ksf)	γ (%)	σ'_v (ksf)	τ_h/σ'_v -	$\Delta\sigma'_v/\sigma'_{v,c}$ -	$c_u/\sigma'_{v,c}$
at Peak Shear Stress	0.341	19.73	0.558	0.612	-0.147	0.684
at Maximum Strain	0.341	19.73	0.558	0.612	-0.147	

Results of Direct Simple Shear Test

Elapsed Time (min)	Shear Strain γ (%)	Shear Stress τ_h (ksf)	Effective Vertical Stress σ'_v (ksf)	Calulated Pore Press. Change $\Delta U = \Delta\sigma'_v$ (ksf)	Secant Shear Modulus G_s (ksf)	Tangent Modulus G_T (ksf)	Norm. Shear Stress $\tau_h/\sigma'_{v,c}$	Norm. Vert. Stress $\sigma'_v/\sigma'_{v,c}$	Norm. Decr. in V. Stress $\Delta\sigma'_v/\sigma'_{v,c}$	Stress Ratio Angle ϕ'_{DSS} (°)
0.0	0.00	0.001	0.484	0.000	-	-	0.003	0.970	0.000	0.16
4.2	0.35	0.109	0.469	0.015	30.653	27.641	0.219	0.940	0.030	13.11
8.3	0.69	0.193	0.511	-0.027	27.692	18.126	0.387	1.023	-0.053	20.71
12.5	1.04	0.233	0.584	-0.100	22.374	9.238	0.466	1.169	-0.200	21.74
16.7	1.38	0.257	0.584	-0.100	18.502	5.741	0.514	1.169	-0.200	23.71
20.8	1.72	0.272	0.593	-0.109	15.760	3.847	0.545	1.187	-0.217	24.66
25.0	2.06	0.283	0.565	-0.081	13.654	2.105	0.566	1.132	-0.162	26.58
29.2	2.40	0.287	0.549	-0.064	11.868	1.030	0.574	1.099	-0.129	27.58
33.3	2.75	0.290	0.540	-0.056	10.499	0.420	0.580	1.081	-0.111	28.22
37.5	3.09	0.290	0.549	-0.064	9.324	-0.270	0.580	1.099	-0.129	27.82
41.7	3.43	0.288	0.559	-0.074	8.357	-0.729	0.577	1.119	-0.149	27.26
45.8	3.77	0.285	0.530	-0.045	7.508	-1.184	0.570	1.061	-0.091	28.24
50.0	4.12	0.280	0.493	-0.009	6.767	-1.369	0.560	0.988	-0.018	29.57
54.2	4.46	0.275	0.500	-0.015	6.137	-1.178	0.551	1.000	-0.030	28.84
58.3	4.80	0.272	0.546	-0.062	5.628	-1.262	0.544	1.094	-0.124	26.45
62.5	5.15	0.267	0.490	-0.005	5.152	-1.114	0.534	0.980	-0.010	28.57
66.7	5.49	0.264	0.439	0.045	4.791	-1.042	0.529	0.879	0.091	31.04
70.8	5.83	0.259	0.464	0.020	4.430	-0.884	0.519	0.929	0.040	29.20
75.0	6.17	0.258	0.447	0.038	4.161	-0.458	0.517	0.894	0.076	30.03
79.2	6.51	0.256	0.452	0.033	3.914	-0.611	0.513	0.904	0.066	29.57
83.3	6.86	0.254	0.433	0.052	3.684	-0.343	0.508	0.866	0.104	30.41
87.5	7.20	0.254	0.466	0.019	3.509	-0.420	0.508	0.932	0.038	28.61
91.7	7.54	0.251	0.439	0.045	3.311	-0.076	0.503	0.879	0.091	29.76
95.8	7.88	0.253	0.384	0.101	3.197	0.306	0.507	0.768	0.202	33.46
100.0	8.23	0.253	0.419	0.066	3.060	0.153	0.507	0.838	0.131	31.15
104.2	8.57	0.254	0.423	0.062	2.953	0.267	0.509	0.846	0.124	31.05
108.3	8.92	0.255	0.421	0.063	2.845	0.154	0.510	0.844	0.126	31.18
112.5	9.25	0.256	0.382	0.102	2.747	0.616	0.512	0.765	0.205	33.76
116.7	9.59	0.259	0.392	0.092	2.687	0.692	0.519	0.785	0.184	33.45
120.8	9.94	0.260	0.419	0.066	2.605	0.192	0.521	0.838	0.131	31.85
125.0	10.28	0.261	0.384	0.101	2.521	0.419	0.521	0.768	0.202	34.19
129.2	10.62	0.263	0.353	0.131	2.464	0.881	0.527	0.707	0.263	36.68
133.3	10.96	0.267	0.437	0.048	2.419	0.649	0.534	0.874	0.096	31.41
137.5	11.31	0.268	0.386	0.098	2.353	0.621	0.536	0.773	0.197	34.73
141.7	11.65	0.271	0.368	0.116	2.313	0.777	0.542	0.737	0.232	36.31
145.8	11.99	0.273	0.367	0.117	2.264	0.876	0.546	0.735	0.235	36.62
150.0	12.34	0.277	0.426	0.058	2.232	0.916	0.554	0.854	0.116	32.98
154.2	12.68	0.279	0.415	0.069	2.191	0.877	0.559	0.831	0.139	33.92
158.3	13.02	0.283	0.437	0.048	2.161	0.846	0.566	0.874	0.096	32.93
162.5	13.36	0.285	0.448	0.037	2.123	0.844	0.570	0.897	0.073	32.46
166.7	13.70	0.289	0.416	0.068	2.096	1.174	0.578	0.833	0.136	34.72
170.8	14.05	0.293	0.438	0.047	2.076	1.026	0.587	0.876	0.093	33.79
175.0	14.39	0.296	0.444	0.040	2.045	1.033	0.592	0.889	0.081	33.65
179.2	14.73	0.300	0.438	0.047	2.027	0.961	0.601	0.876	0.093	34.43
183.3	15.07	0.302	0.459	0.025	1.996	0.684	0.605	0.919	0.051	33.34
187.5	15.42	0.305	0.462	0.023	1.967	0.686	0.610	0.924	0.045	33.43
191.7	15.76	0.307	0.458	0.027	1.939	0.814	0.614	0.917	0.053	33.82
195.8	16.10	0.310	0.459	0.025	1.919	0.994	0.621	0.919	0.051	34.04
200.0	16.44	0.314	0.473	0.011	1.899	1.029	0.628	0.947	0.023	33.55
204.2	16.78	0.317	0.483	0.001	1.883	0.770	0.635	0.967	0.003	33.30
208.3	17.12	0.319	0.487	-0.003	1.855	0.497	0.638	0.975	-0.005	33.22
212.5	17.47	0.321	0.500	-0.015	1.828	0.647	0.642	1.000	-0.030	32.70
216.7	17.81	0.323	0.463	0.021	1.808	0.848	0.647	0.927	0.043	34.93
220.8	18.15	0.327	0.506	-0.021	1.792	0.992	0.654	1.013	-0.043	32.84
225.0	18.50	0.330	0.491	-0.006	1.778	0.909	0.661	0.982	-0.013	33.93
229.2	18.84	0.333	0.474	0.010	1.759	0.846	0.666	0.950	0.020	35.05
233.3	19.18	0.336	0.510	-0.025	1.744	1.070	0.673	1.020	-0.051	33.39
237.5	19.53	0.340	0.525	-0.040	1.735	0.925	0.681	1.051	-0.081	32.95
239.9	19.73	0.341	0.558	-0.073	1.724	0.638	0.684	1.116	-0.147	31.48





POST CYCLIC STATIC DSS TEST

K_o Consolidation - OCR = 1 - Strain Rate = 5 %/hr

Sample: ST-1b - Depth: 4.75 ft.

Boring JOP-B002

ATTACHMENT F

MATERIAL CHARACTERIZATION CALCULATIONS

AECOM

QMS Form 3-3 (MM)

Date: September 2014

Dynegy CCR Program Quality Management

Calculation Check and Review Record

Project Name	Dynegy – Joppa DMM Design	**Client Name**	Dynegy
Project Location	Joppa, Illinois	**PM Name**	Vic Modeer
Project Number / Office Code	60440155	**PIC Name**	Vic Modeer

This form may be used instead of Form 3-4 – Check and Review Record for Detail Checks of calculations. If the calculation is a standalone deliverable, an Independent Technical Review (ITR) may be required, and this form can be used for that purpose as well.

Type	☐ Calculation Detail Check	☐ Calculation ITR

IDENTIFYING INFORMATION

(This section is to be completed by the PM, PM's Designee, or Originator.)

Calculation Medium: *(Select as appropriate)*

☒ Electronic — File Name: JOP_Material_Characterization_20160427v0.pdf

☐ Hard-copy — Unique Identification:

Number of pages *(including cover sheet)*:

Discipline:	Geotechnical
Title of Calculation:	Soil Characterization
Calculation Originator Name:	Tom Grummon
Calculation Contributor Names:	Robert Snow, Lucas Carr, Tom Cooling
Calculation Checker Names:	Danny Pond
Calculation Reviewer Names:	Doug Cauble

DESCRIPTION & PURPOSE

Develop design shear strength values for the Dynegy Joppa East Ash Pond

BASIS / REFERENCE / ASSUMPTIONS

2015 and 2016 AECOM data and historic data provided by Dynegy

ISSUE / REVISION RECORD

For comments, select N (None), HC (Hard Copy), EF (Electronic File), or Form 3-5 from drop-down. For a given Revision, indicate P (Preliminary), S (Superseded) or F (Final). If there are no revisions to the Initial Issue, check F (Final).

Rev. No.	Description	Comments	P	S	F	Originator Initials	Date	Checker Initials	Date	Reviewer Initials	Date
0	Initial Issue	N	☐	☐	☐	TG	4/22/16	DP	4/22/16		
1	Rev per ITR comments	N	☐	☒	☐	MJN	5/23/16	LPC	5/23/16		
2	Rev drained strength	N	☐	☒	☐	ZJF	8/24/16	LPC	8-25-16		
3		N	☐	☐	☐						

APPROVAL and DISTRIBUTION

☒ The below individuals confirm that the Calculation Check and Review process has been followed.

Tom Grummon — 22-Apr-16

Originator Signature — **Date**

Daniel Pond — 22-Apr-16

Checker Signature — **Date**

Douglas F. Cauble — 5-23-16

Reviewer Signature — **Date**

Victor Modeer — 5-23-2016

Project Manager (or Designee) Signature — **Date**

DISTRIBUTION	Project Central File – Quality File Folder Other – Specify:

AECOM	Calculation No. 01
CALCULATION SHEET	Project No. 60440155
Project Title: Dynegy CCR - Joppa Subject/Feature: Soil Characterization	Sheet No. 1 of 5 Rev: 3

1.0 INTRODUCTION

The Joppa Power Plant is located near the Illinois-Kentucky state line adjacent to the Ohio River and approximately 8 miles northwest of Metropolis, Illinois. The coal-fired plant began commercial operation in 1953 and has a total net generating capacity of approximately 802 Megawatts. The East Ash Pond, which comprises the North Pond and South Pond, is located approximately 2,000 feet north-northeast of the Ohio river (immediately north-northeast of the generating facility) and covers an area of roughly 110 acres with a large portion of the pond filled with ash.

AECOM performed field investigations at the Joppa Power Plant in August 2015 to obtain soil samples and information to characterize subsurface conditions in the vicinity of the East Ash Pond. A supplementary investigation to better characterize lithology and problematic ash zones was completed in 2016; however, additional lab testing on soils from this investigation has not been performed. This data was used to characterize soil strength and develop soil shear strength parameters for use by AECOM-STL (AECOM St. Louis) in static, seismic, and post-earthquake case slope stability models, as necessary, at critical sections of the earthen embankment. AECOM-SLC (AECOM Salt Lake City) was responsible for data processing.

2.0 OBJECTIVE

The objective of this soil strength characterization was to develop a basis for slope stability models performed to assess the stability of the containment dike surrounding the East Ash Pond for drained steady-state, pseudo-static (seismic), and post-earthquake loading conditions.

3.0 SOIL CHARACTERIZATION

In addition to any site-specific data obtained in August 2015, the following documents and resources were used in developing slope geometries and geologic interpretations for each of the critical sections:

- Illinois Height Modernization Program, Illinois State Geological Survey, and Illinois Department of Transportation, 2002–2013, Illinois LiDAR county database: Illinois State Geological Survey, http://www.isgs.uiuc.edu/nsdihome/webdocs/ilhmp/data.html (accessed July 15, 2015). [website address has changed: http://clearinghouse.isgs.illinois.edu/data/elevation/illinois-height-modernization-ilhmp-lidar-data]
- Joppa Existing Topography (2015), Weaver Consultants Group, Collinsville, Illinois [Drawing 4153-300-11-01, Sheets 1-5]
- East Ash Pond Cone Penetrometer Test (CPT) and Boring Location Survey (2015), surveyor unknown, survey performed 10/26/2015, data received from Dynegy on 10/28/2015.
- East Ash Pond Plan, Sections and Details (1973), Wapora Inc., Washington, D.C. 20015 [Drawing C-106, Rev. 3, 4229-8218]
- East Ash Pond Plan and Sections (1982), Electric Energy Inc., Joppa, Illinois [Drawing AP-109, Rev. 4, 4229-8211]
- Topographic Survey of the Ash Pond (2013), Shawnee Survey & Consulting, Inc., Joppa, Illinois [Final Drawing]

- Willman, H.B. et al, Handbook of Illinois Stratigraphy, Illinois State Geologic Survey, Bulletin 95, Urbana, Illinois, 1975, page 204.

3.1. Subsurface Materials

Subsurface materials at the East Ash Pond generally consist of clayey surficial soils, which were also used to construct the embankment. A brief summary of materials encountered at the site is provided in this section.

3.1.1. Embankment Clay Subsurface Conditions

The embankment fill materials at the East Ash Pond generally consist of over-consolidated, dilative lean clay (CL) and sandy clay (SC). Some isolated soft clay (dark brown in color) layers were encountered. Samples obtained from the field investigation showed samples to be generally stiff and moist with the following index soil characteristics:

- Uncorrected N-value of 8 to 12
- Natural Moisture Content of 16 to 18%
- Liquid Limit of 34 to 38
- Plasticity Index of 18 to 24
- Generally 70 percent or more fine (silt- and clay-sized) particles
- Total Unit Weight of 131 pcf

3.1.2. Foundation Clay Subsurface Conditions

The Foundation Clay native materials at the East Ash Pond generally consist of lean clay (CL) and sandy clay (SC). Some samples exhibited dilative behavior while limited samples exhibited contractive behavior. The soils were highly interbedded; however, the contractive clay was generally identified in deeper stratum and was less prevalent in surficial and shallow foundation clays. At several boring and CPT sounding locations, soft to very soft dark brown to brown clay with some organics was encountered immediately below the embankment. These areas were generally isolated and were generally located in areas of historic drainages. Samples obtained from the field investigation showed samples to be generally stiff and moist with the following index soil characteristics:

- Uncorrected N-value of 6 to 15, depending on sand content
- Natural Moisture Content of 16 to 20%
- Liquid Limit of 23 to 40
- Plasticity Index of 16 to 25, with low of 9
- Generally 50 percent or more fine (silt- and clay-sized) particles
- Total Unit Weight of 128 pcf

3.1.3. Foundation Sand Subsurface Conditions

The Foundation Sand native materials at the East Ash Pond generally consist of dense silty sand (SM) and poorly graded sand (SP) with varying gravel content. Some isolated zones of soft silt to medium stiff silty sand or poorly graded sand were encountered beneath the foundation clay and immediately above the dense sand and gravel layers, and very limited zones of loose sand were encountered. These zones were generally only a

couple feet thick, and are note expected to form a laterally or vertically continuous zone. The medium dense zones are generally located along the south and southeastern edges of the ash pond. Foundations sands, including the less dense SM and SP zones are in the Cretaceous Age, McNairy Formation based on the Illinois State Geologic Survey. As discussed in the *Joppa DMM Limits (Sta. 83+00 to 91+50)* calculation package, this Cretaceous-age formation is not expected to be susceptible to liquefaction.

The transition into the dense to very dense silty sand to poorly graded sand with gravel from the foundation clay is much more rapid around the large majority of the ash pond. Undisturbed samples were not obtained during the field investigation for this stratum; however, index testing was performed on disturbed samples. Samples obtained from the field investigation showed samples to be dense to very dense with the following index soil characteristics, on average:

- Uncorrected N-value of 25 to 50
- Natural Moisture Content: no lab data available
- Liquid Limit: does not apply
- Plasticity Index of 5 or less, most were NP
- Generally 25 percent or less fine (silt- and clay-sized) particles
- Total Unit Weight: no lab data available

3.1.4. Bottom Ash and Fly Ash (Ash) Subsurface Conditions

The Bottom Ash and Fly Ash (ash) ash materials at the East Ash Pond generally consist of non-plastic silt (ML) and fine to medium sand (SP). Ash was encountered within the ash pond and under the southeast corner of the South Ash Pond embankment. Samples were generally moist or saturated and field investigations showed that ash deposits were soft to very soft with the following index soil characteristics, on average:

- Uncorrected N-value of 0 to 3
- Insitu. Moisture Content of 25 to 50%
- Liquid Limit: not applicable
- Plasticity Index of 6 or less, most were NP
- Generally 60 to 80 percent or more fine (silt-sized) particles
- Total Unit Weight of 106 pcf

3.2. Soil Strength

In addition to any site-specific data obtained in August 2015, the following documents and resources were used in developing soil strength parameters for use in slope stability modeling:

- Global Stability Evaluation (2010), Geotechnology, Inc., St. Louis, Missouri, prepared for Electric Energy, Inc., Joppa, Illinois

For the East Ash Pond analysis, a series of direct shear, direct simple shear, unconsolidated-undrained triaxial, consolidated-undrained triaxial, and post-cyclic shear tests, were performed as part of this study using samples obtained in August 2015. Direct simple shear strength tests were performed with indirect pore pressure measurement recordings, allowing for the evaluation of both drained and undrained shear strength.

Table 1. Shear Strength Parameters

Material Description	Unit Weight	Drained Strength		Peak Undrained Strength	Post-Earthquake Strength
		Cohesion	Friction Angle[1]	S_u	S_u[2]
	(pcf)	(psf)	(deg)	(psf)	(psf)
Embankment Clay [Fill]	131	Non-linear strength envelope. See Figure 3.		σ'_{fc} < 0.5 ksf: S_u = 600 psf σ'_{fc} ≥ 0.5 ksf: S_u/σ'_{fc} = 0.65 and c_o = 274 psf	Peak undrained strength. Cyclic softening is not expected due to stiff nature of soil.
Foundation Clay	128	0	α > -5°: 33 deg -5° ≤ α ≤ 5°: 29 deg α < -5°: 33 deg	S_u/σ'_{fc} = 0.41 c_o = 700 psf	
Foundation Sand	130	0	35	DRAINED	DRAINED
Ash	106	0	α > -5°: 33 deg -5° ≤ α ≤ 5°: 29 deg α < -5°: 33 deg	S_u/σ'_{fc} = 0.44	S_u/σ'_{vc} = 0.07[3]
Soft Clay (Miscellaneous Fill)[4]	125	0	24	S_u/σ'_{fc} = 0.25, min Su = 500 psf	S_u/σ'_{fc} = 0.18, min Su = 400 psf

1. Where applicable, α represents the failure plane angle measured from horizontal.

2. Where applicable, post-earthquake analyses used drained strengths, 80% of the static undrained strengths, post-earthquake (liquefied) strengths.

3. Where applicable, post-earthquake (liquefied) strengths were calculated using the methodology proposed in Idriss and Boulanger (2008).

4. Soft clay (miscellaneous fill) I was encountered during the field exploration as low-blowcount soft clay. Shear strength for this material was assigned based on engineering judgement, and corresponds to a normally-consolidated clay. A 20% strength reduction was applied for post-earthquake shear strengths.

For the drained strength, the point of failure was defined as the point of peak obliquity for the isotropically consolidated undrained compression tests (CIU). For the direct simple shear (DSS) and direct shear (DS), however, the point of peak obliquity occurred at significantly higher strains than for the triaxial compression tests, which generally failed between 5-10 percent strains for peak obliquity. Consequently, the selected undrained shear strengths for these tests were based on 15-percent strain, following USACE EM 1110-2-1902 Slope Stability Manual guidance, while the drained strengths used peak obliquity in the CIU tests and 10% strain in DSS and DS tests.

AECOM plotted undrained shear strength versus effective overburden stress for each of the following laboratory tests:

- CIU – isotropically consolidated undrained triaxial compression
- UU – unconsolidated undrained triaxial compression
- DSS – direct simple shear
- LV – lab vane shear

For the CIU, UU, and DSS tests, AECOM plotted both peak shear strength and the shear stress at 15% strain. For the LV tests, only peak shear stress was plotted, as strain is not measured. For the CIU tests, the data was separated into those tests that were consolidated to within 500 psf of the effective overburden stress and

those tests that were consolidated to stresses beyond the effective overburden stress ±500 psf. The rationale for separating the CIU tests in this fashion was to control for the effect of overconsolidation and allow for an evaluation of undrained shear strength based on each of the four types of tests. The peak drained shear strength for the embankment clay was characterized with a nonlinear strength envelope to assign the shear strength as a function of the effective normal stress on the failure plane. The nonlinear strength envelope is curved below an effective normal stress of 2,000 psf and linear above 2,000 psf, as shown in Figure 3. A curved envelope was fit to the data at lower stresses since the compacted embankment material is more overconsolidated within the lower stress range. The linear portion of the envelope is defined by an effective stress friction angle (Φ') of 35 degrees and zero effective cohesion (c'). The tabulated envelope is listed in Table 2.

Table 2. Embankment Fill Nonlinear Drained Failure Envelope

Normal Effective Stress on Failure Plane (s'_{ff}), psf	Shear Strength (t_{ff}), psf
0	0
585.2	561
1308.6	1050.4
1497.4	1124.6
2000	1400.4
10000	7002.1

The shear strengths for the foundation sand and miscellaneous fills were either correlated or estimated based on available field data and soil descriptions.

Figures 1 through 6 show drained and undrained shear strength for ash, embankment clay, and foundation clay.

The post-earthquake, liquefied strength, of the ash was determined using the Idriss and Boulanger (2008) methodology for estimating residual strength. This was compared with results of the cyclic and post-cyclic shear tests and an estimate of residual strength from the sleeve friction obtained from the cone (See Figure 7and Attachment A).

3.3. Soil Weight

Total units weights were also developed for use in the slope stability models based on the available measured weights from lab tests. Although the unit weights used for each of the materials may vary by stratum, material type, and depth, the models are relatively unaffected by small changes in unit weight. This is largely because the slope stability models consider driving forces, which are largely based on soil weight, and shear resistance, which is largely a function of soil weight as well. Consequently, slope stability models are relatively insensitive to minor changes in soil unit weight. The soil unit weights were developed based on lab test data for Foundation Clay, Embankment Clay, and Ash, but were only estimated for the Foundation Sand and Miscellaneous Fill. Figure 8 shows histograms and scatter plots (versus elevation) of measured total unit weights for the three lab-tested soils. Table 1 shows the selected model unit weights for each of the soil types.

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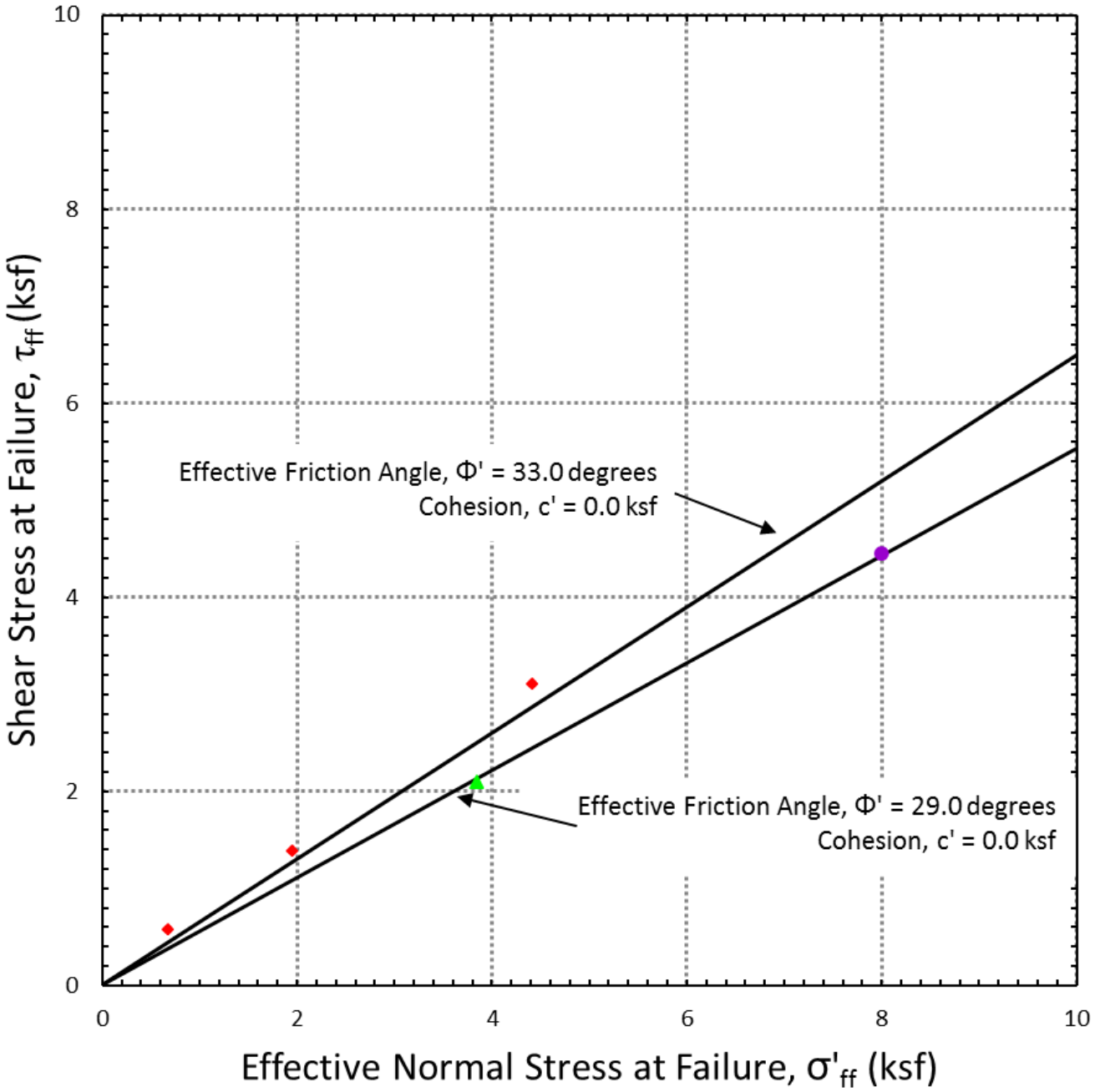


Notes:

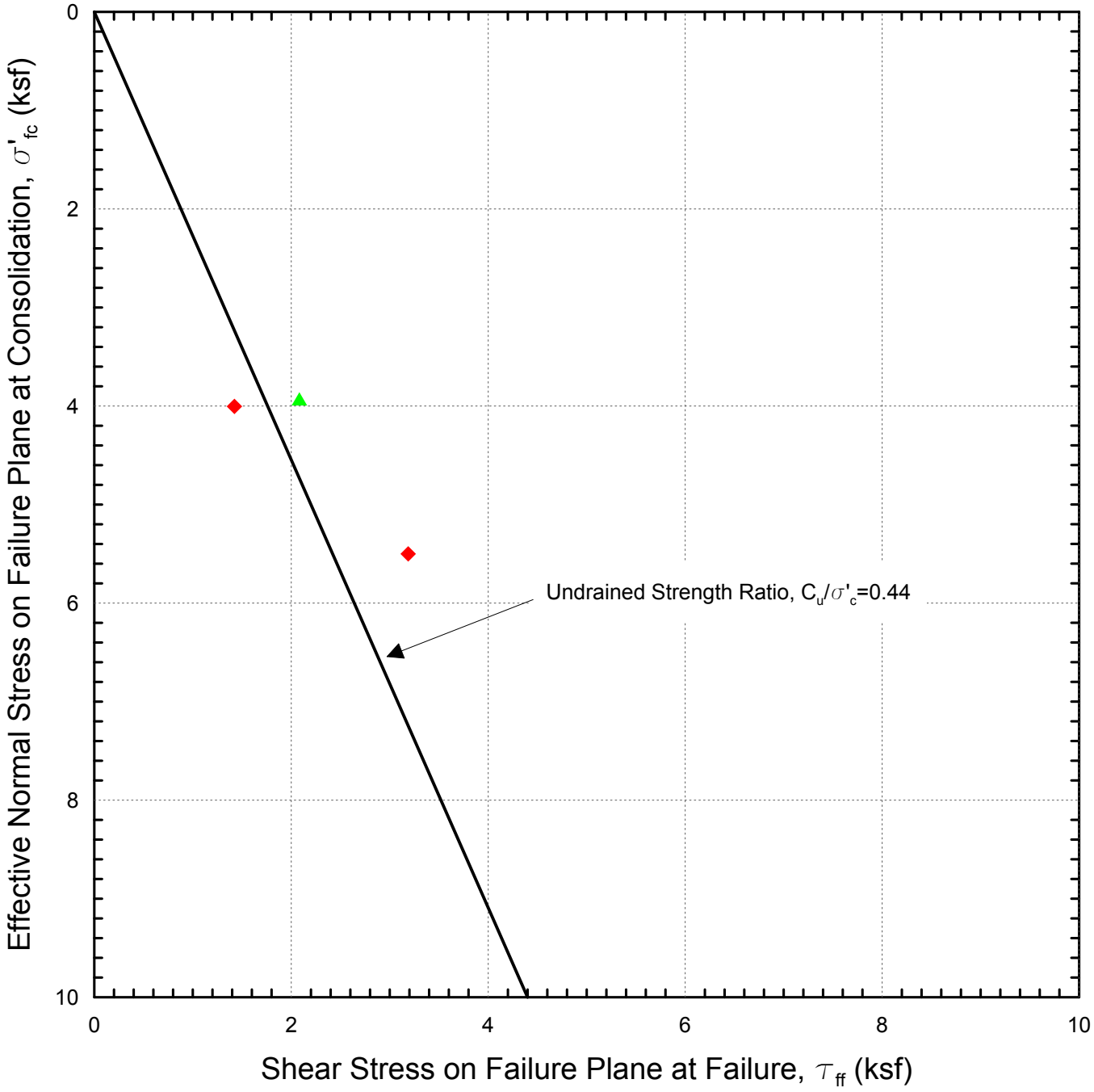
1. Failure defined at peak obliquity (i.e., maximum principle stress ratio) for undisturbed isotropically consolidated undrained compression tests (CIU)

2. Failure defined at 10% shear strain for undisturbed consolidated undrained direct simple shear tests (DSS)

3. Failure defined at 10% shear strain for undisturbed consolidated drained direct shear tests (DS)

2015 AECOM (CIU)
2015 AECOM (DSS)
2015 AECOM (DS)

PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND DRAINED SHEAR STRENGTH ASH	FIGURE 1
AECOM	JOPPA, ILLINOIS		



Notes:

1. Failure defined at peak obliquity (i.e., maximum principle stress ratio) for undisturbed isotropically consolidated undrained compression tests (CIU)

2. Failure defined at 10% shear strain for undisturbed consolidated undrained direct simple shear tests (DSS)

PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND UNDRAINED SHEAR STRENGTH ASH	FIGURE 2
AECOM	JOPPA, ILLINOIS		

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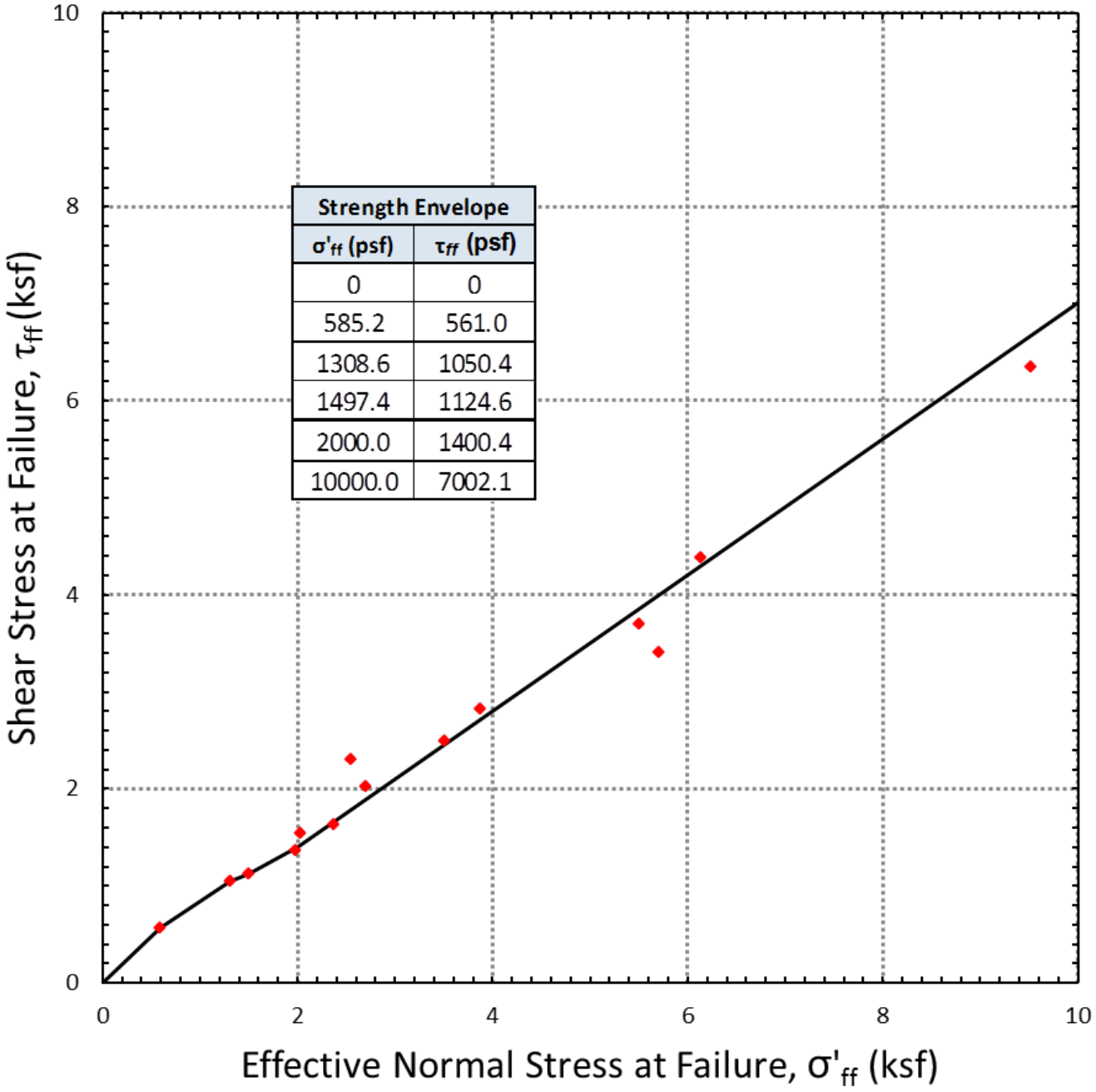

Strength Envelope	
σ'_{ff} (psf)	τ_{ff} (psf)
0	0
585.2	561.0
1308.6	1050.4
1497.4	1124.6
2000.0	1400.4
10000.0	7002.1

Notes:

1. Failure defined at peak obliquity (i.e., maximum principle stress ratio) for undisturbed isotropically consolidated undrained compression tests (CIU)

PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND DRAINED SHEAR STRENGTH EMBANKMENT CLAY	FIGURE 3
AECOM	JOPPA, ILLINOIS		

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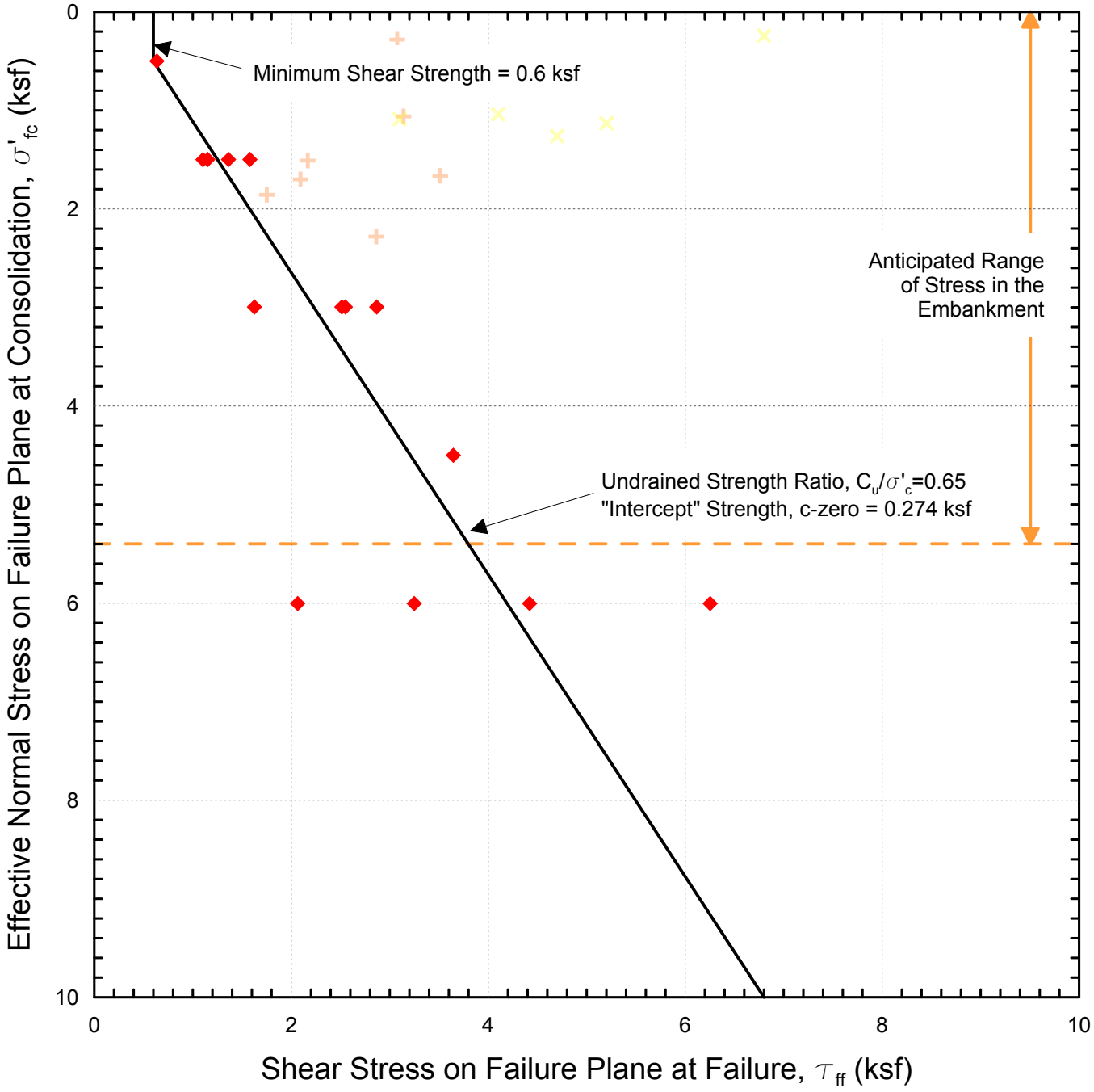

Notes:

1. Failure defined at peak obliquity (i.e., maximum principle stress ratio) for undisturbed isotropically consolidated undrained compression tests (CIU)

2. Failure defined at 10% axial strain for undisturbed unconsolidated undrained compression tests (UU)

3. Failure defined at peak shear resistance for lab vane shear tests (LV)

PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND UNDRAINED SHEAR STRENGTH EMBANKMENT CLAY	FIGURE 4
AECOM	JOPPA, ILLINOIS		

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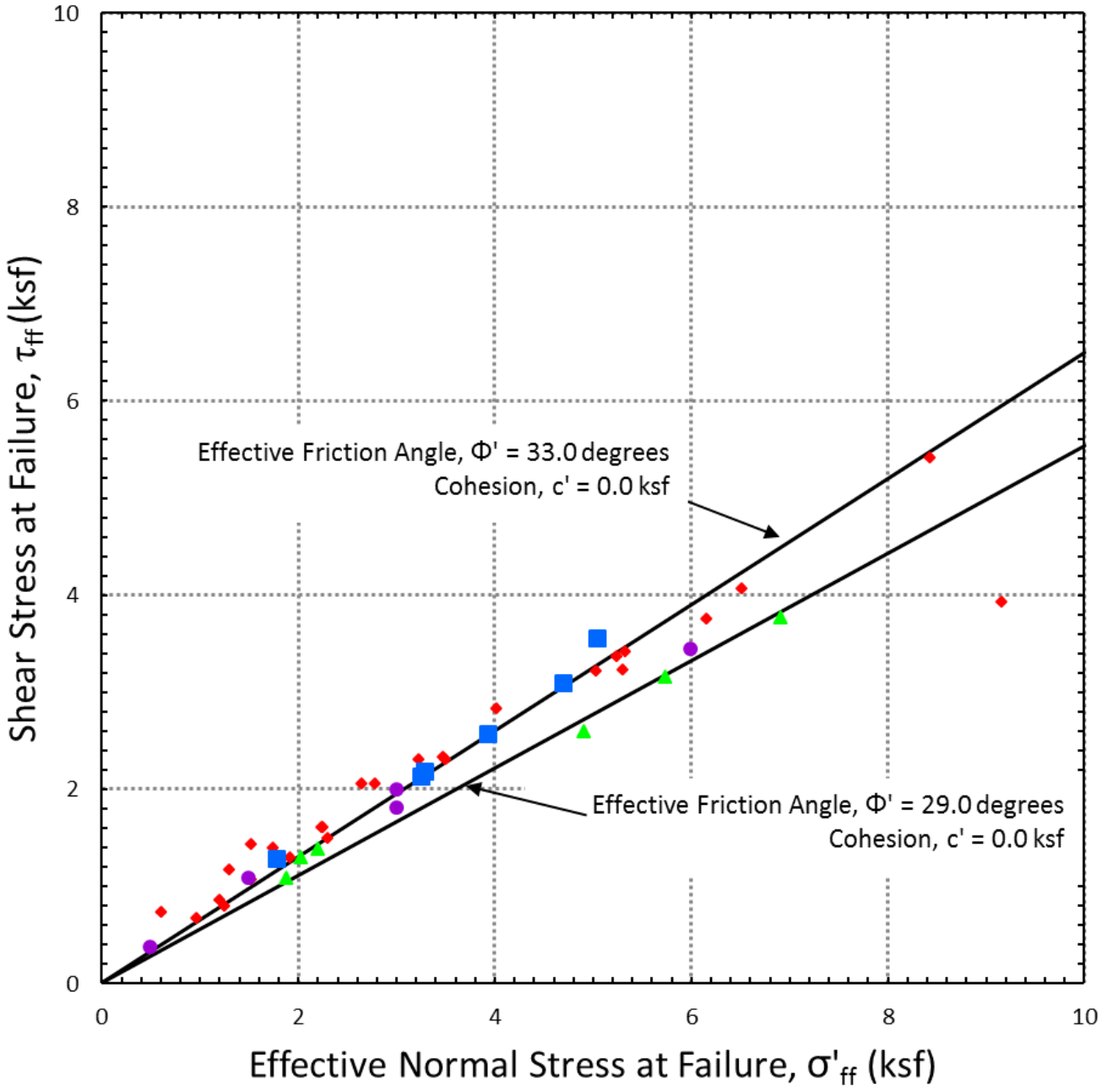


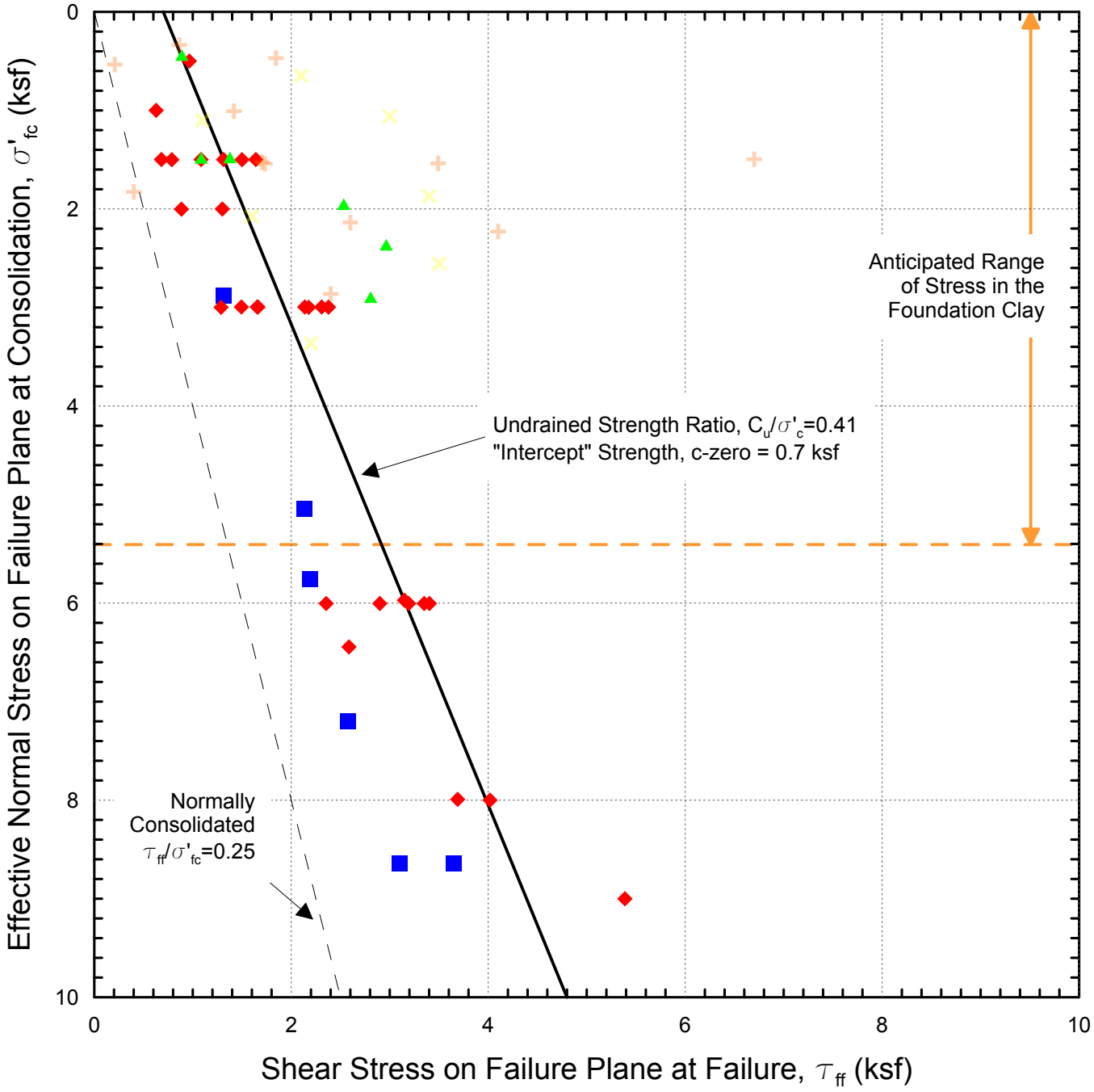
Notes:

1. Failure defined at peak obliquity (i.e., maximum principle stress ratio) for undisturbed isotropically consolidated undrained compression tests (CIU)

2. Failure defined at 10% shear strain for undisturbed consolidated undrained direct simple shear tests (DSS)

3. Failure defined at 10% shear strain for undisturbed consolidated drained direct shear tests (DS)

PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND DRAINED SHEAR STRENGTH FOUNDATION CLAY	FIGURE 5
AECOM	JOPPA, ILLINOIS		



Notes:

1. Failure defined at peak obliquity (i.e., maximum principle stress ratio) for undisturbed isotropically consolidated undrained compression tests (CIU)

2. Failure defined at 10% shear strain for undisturbed consolidated undrained direct simple shear tests (DSS)

3. Failure defined at 10% axial strain for undisturbed unconsolidated undrained compression tests (UU)

4. Failure defined at peak shear resistance for lab vane shear tests (LV)

- 2010 Geotechnology (CIU)
- 2015 AECOM (CIU)
- 2015 AECOM (DSS)
- 2015 AECOM (UU)
- 2015 AECOM (LV)

PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND UNDRAINED SHEAR STRENGTH FOUNDATION CLAY	FIGURE 6
AECOM	JOPPA, ILLINOIS		

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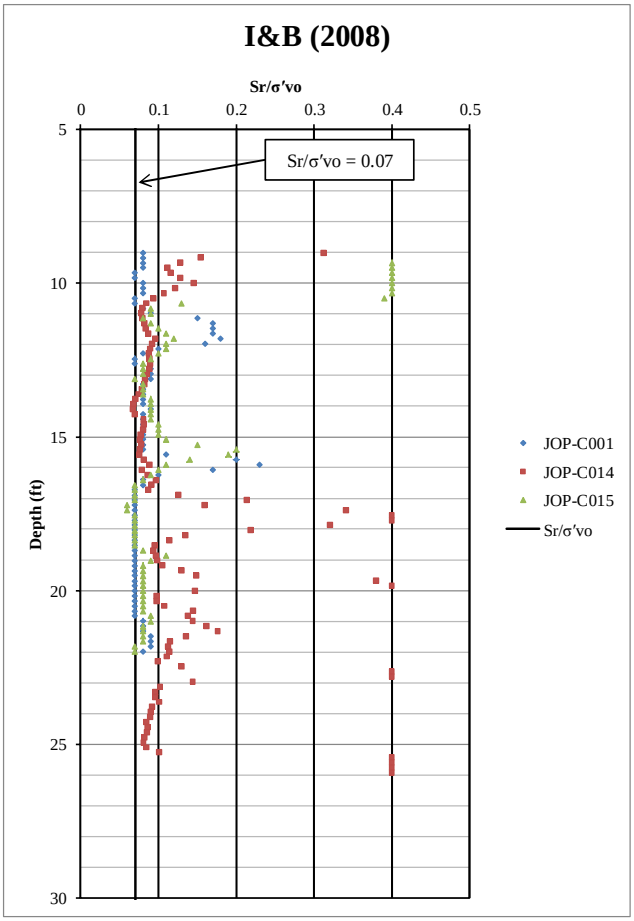
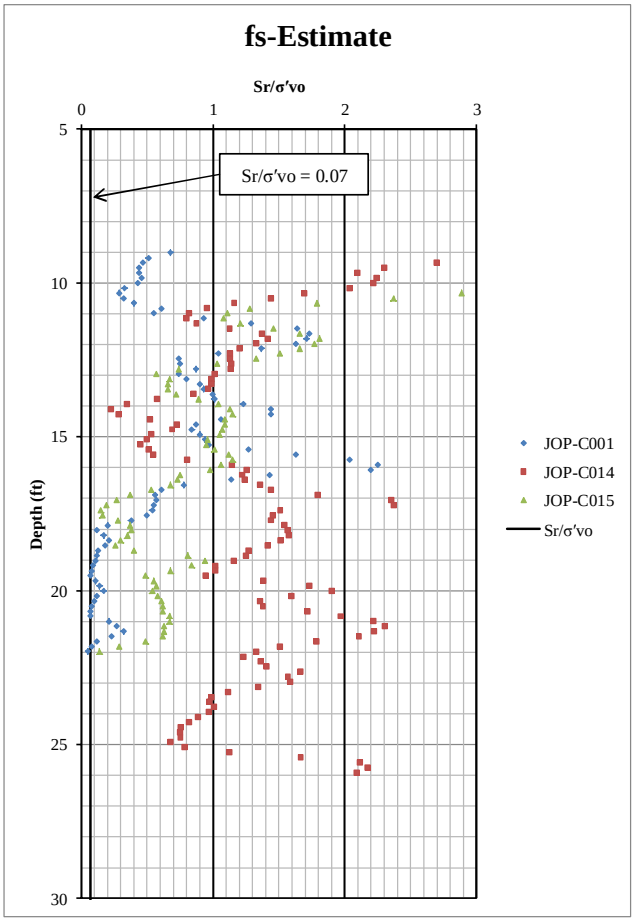
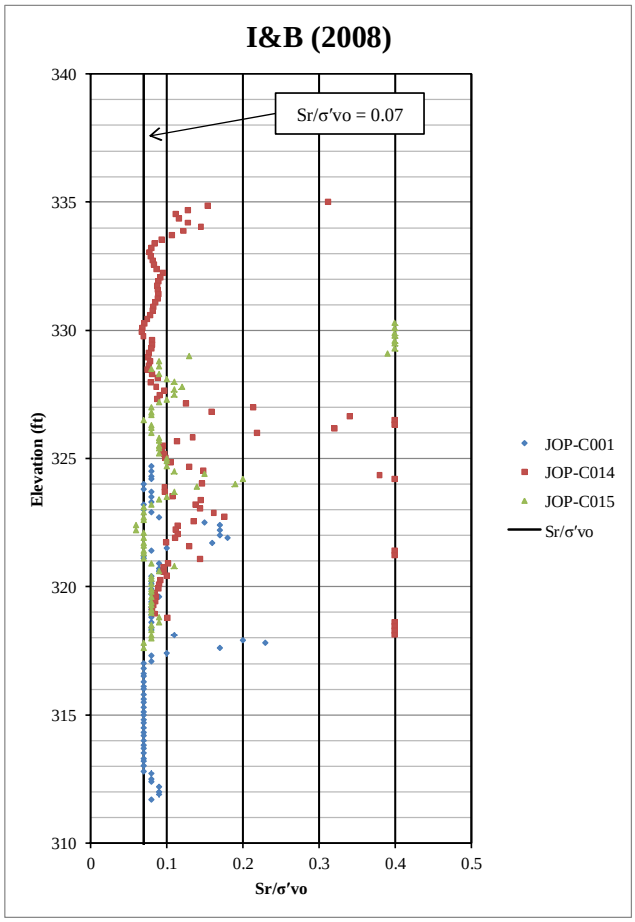






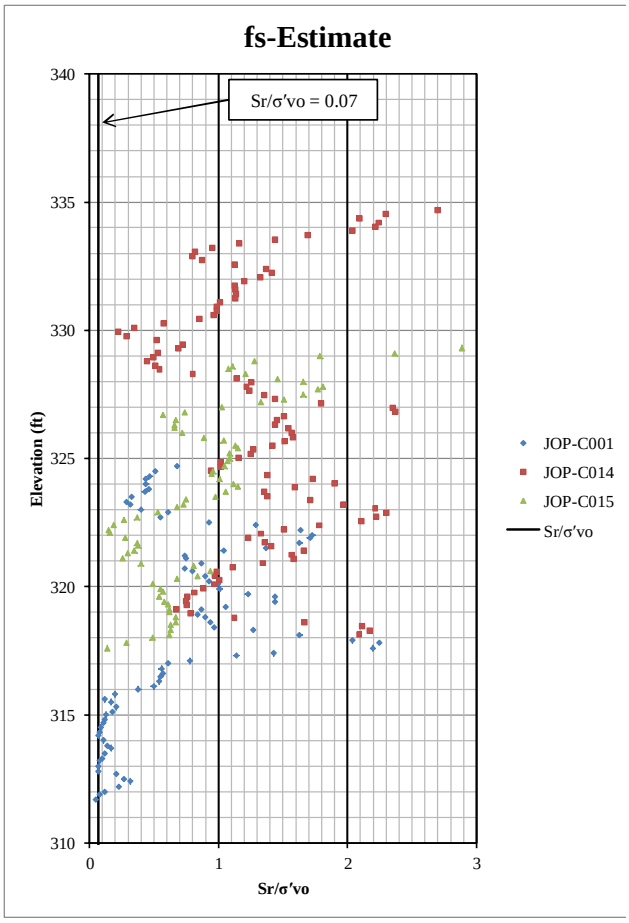
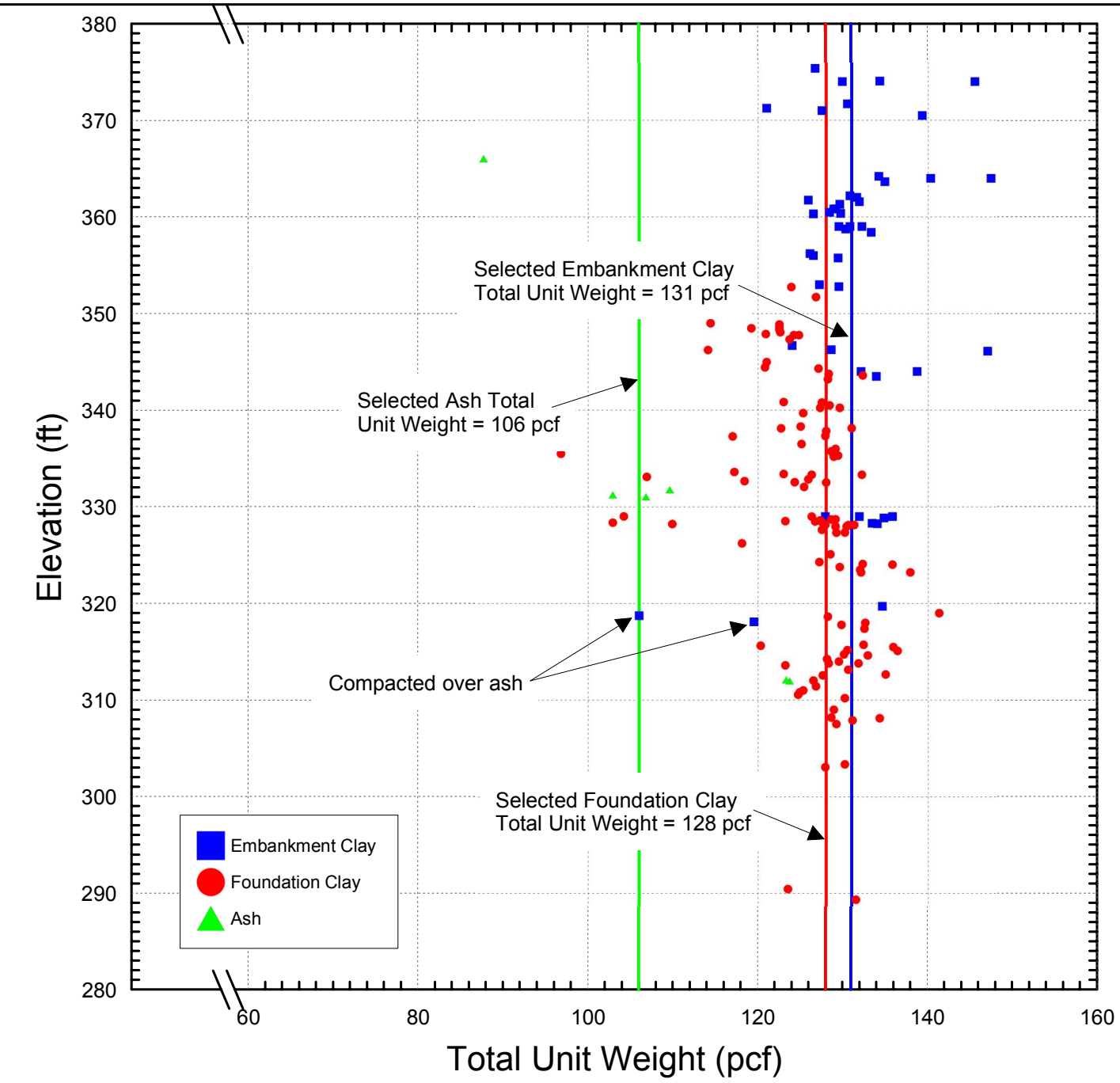
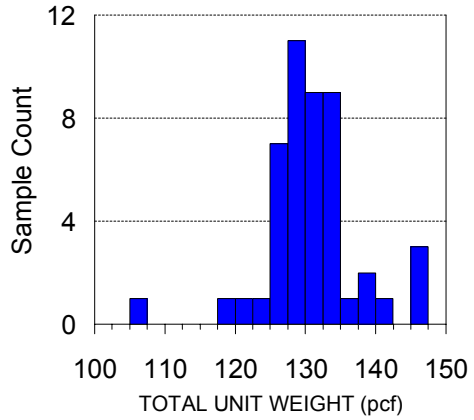
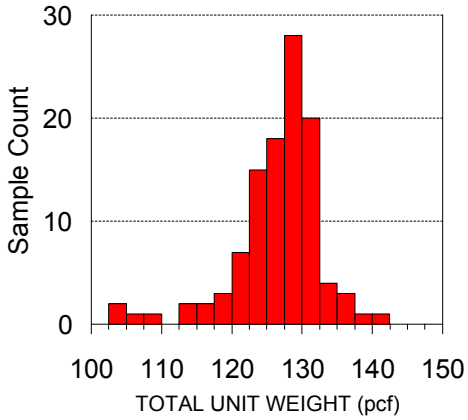
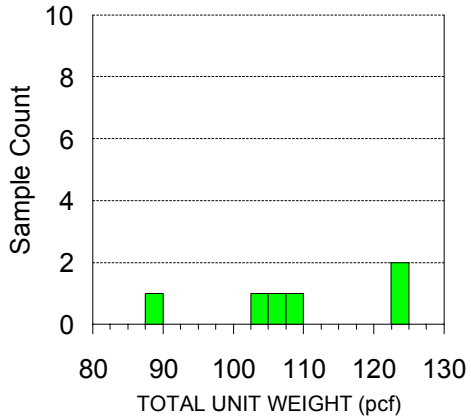


Figure 7 - Evaluation of Post-Liquefaction Shear Strength of Ash









PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND	FIGURE 8
AECOM	JOPPA, ILLINOIS	TOTAL UNIT WEIGHT	

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ATTACHMENT A

CYCLIC DSS STRENGTH TEST (ASTM D 6528 & D 5311): Specimen Setup / Take Down

Project Number: 04.11150035 | Test Type: CyDSS ta=0 | Sta. No.: CSS-S04 | File Name: OP-B001_ST-2
Task No.: | Assign, $\sigma'_{v,c}$ = 1.00 ksf | Static DSS $c_u/\sigma'_{v,c}$ = 1.000
Project Name: | Induced OCR = 1.00 | Cyclic Ratios: τ_{cy} / c_u = 0.300 | τ_{avg} / c_u = NA
Sequence No.: of | Assig. Remarks: See Other Remarks | $\tau_{cy}/\sigma'_{v,c}$ = 0.300 | $\tau_{avg}/\sigma'_{v,c}$ =
Failure Criterion: [ ] Peak Obliquity, or [ ] Shear Strain (%) = | Specific Gravity: 2.700 [ ] Meas.; [X] Assumed

[X] Tube [ ] Field Extruded	[ ] Liner [ ] Remolded	[ ] Tamping	[ ] Constant Effort:	Blows/Tamps per Layer =	
Boring No.: JOP-B001	[ ] LPC Core	[ ] Impact/Rammer	Rammer Wgt.(lbf)=	No. Layers =	
Sample No.: ST-2	Compostite No.:	[ ] Pluviated:	Tamper Force (lbf)=	Drop (in.) =	
Depth (ft): 9.75	Specimen No.: b	[ ] Kneading	[ ] Undercompaction:	U_{ni} (%) =	Dia. (in.) =
[ ] Spec. Selection by X-ray;	[ ] Geomarine Sample		Ref. Effort=	% Comp. =	± Opt.=

Type of Consolidation:	[X] K_o at:	[X] Incremental CRS	; [ ] Anisotropic at:	[ ] Inclined Stress Path, $K_{c,DSS}$ [ ] 90° Stress Path	[X] Used automated system Remarks:										
Loading Conditions:	[ ] Static [ ] Dynamic	[ ] Strain [ ] Stress	[ ] Creep [ ] Post Cyclic	[X] Const, Vol./Ht [ ] Drained	[X] Without - Water [ ] With - Bath	[X] Cyclic (Hz)	[ ] Strain [X] Stress	Rate: [ ] 0.1;	[X] 1; Other:

Water Content (WC);	Initial - Trimming Location			Final, W_{at}
	Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	(see below)
Container No.	706	4056	6277	6593
Mass Moist Soil + Cont. (g)	112.74	73.01	74.87	59.95
Mass Dry Soil + Container (g)	92.10	61.78	64.06	52.94
Mass Container (g)	31.66	29.92	31.66	30.14
WATER CONTENT (%)	34.15	35.25	33.36	30.75
Avg. Initial WC, $W_{o,avg}$ (%)	34.25	Final W_{at}: [X] Slice ; [ ] Whole Spec.		
[ ] See attached data sheet(s) for additional water contents				

Soil and Ring Masses	Initial	Final
Mass Moist Soil + Tare (g)	298.37	128.10
Mass Tare (g)	179.93	13.53
Mass Moist Soil, $M_{t,o}$ $Mt_{,at}$ (g)	118.44	114.57
Excess Dry Soil (soil not included in final mass above)		
Container No.		
Mass Dry Soil + Container (g)		
Mass Container (g)		
Mass Excess Dry Soil (g)	0.00	

Specimen Trimming:

[ ] Trimming Ring for Fugro Apparatus | NL4 | Large-ring ID #
[X] Trimming Ring for NGI Apparatus | | Small-ring ID #

$H_{s,t}$ (mm): 18.32 | $A_{s,t}$ (cm^2): 34.99
$D_{s,t}$ (mm) : 66.75 | $V_{s,t}$ (cm^3): 64.10

Remarks:

[ ] Free Standing by Wire Saw Lathe (mm)

	Height (H_{tr})	Diameter (D_o)		Remarks:
1	18.310	1-T	NA	
2	18.320	2-M	NA	
3	18.300	3-B	NA	
4	18.330	1'-T	NA	For Free Standing
5	18.330	2'-M	NA	Trimmed Spec.:
Avg.		3'-B	NA	A_{tr} (cm^2): NA
=	18.318	Avg	NA	V_{tr} (cm^3): NA

Note: NA-Indicates not applicable. | Top Cap No. 16

F or G in the Sta. No. indicates Fugro or GEOTAC apparatus.

Estimated Initial Unit Weight

Total, $\gamma_{t,o}$ (lb/ft^3)= 115.36 | Dry, $\gamma_{d,o}$ (lb/ft^3)= 85.93

Specimen Lateral Confinement by:

[X] **Wire Reinforced, Model:** C=1.5 Thickness (mm) = 0.72

Stress Level	Dia. by PiTape (mm) Meas.	Corr.	Area, $A_{c,n}$ (cm^2)	(in^2)
0	68.05	66.61	34.85	5.401
$\sigma'_{v,c}$	68.18	66.74	34.98	5.422
$\sigma'_{v,max}$	68.18	66.74	34.98	5.422

[ ] **Regular Membrane with Ring Set No.** | ID, Rings (mm)
Thickness (mm): Top: , =
[ ] Single Bottom: , Corr. for mem.
[ ] Double Membr. Thick. = =
Area Ring with mem., A_o (cm^2) ; (in^2)=

Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf
Data corr. for M_{tc}: [X] Yes; [ ] No | Plattens with Pins: [ ] Yes; [X] No

Sketch of Specimen

Final Visual Description: Clay Sandy, Brown gray, with Silty Pockets

Other Remarks :

Trim./ Recon. By: HC | Set Up By: HC | Taken Down By: HC
Date: 12/14/2015 | Date: 12/14/2015 | Date: 12/14/2015
Prelim. Calc. By: HC | Final Calc. By: JJR | Reviewed By: HP

Specimen Take Down: [X] Spec. removed right after shearing | Remarks:
[ ] Spec. unloaded to zero stress with access to water

ATTACHMENT A

CYCLIC DSS STRENGTH TEST: Specimen Calculations & Summary

Project Number: 04.11150035 Station No.: CSS-S04 File Name: OP-B001_ST-2b
Task Number: Specific Gravity: 2.700 [ ] Measured; [X] Assumed
Type Test: CyDSS ta=0 Specimen: [X] "Intact"; [ ] Reconstituted; [ ] Remolded
Calculations Corr. for Salt (dissolved solids): [X] No or, [ ] Yes, with concentration = _____ ppm

Consolidation Stress Summary and Loading Summary

Test Stage:	Max. Stress	Pre-Cyclic	Post Cyclic
Nominal Vertical Stress, σ'_v (ksf)	NA	1	
Axial/Vertical Force, $P_{vr,n}$ (lbf)	NA	NA	
Horizontal Force, $P_{hr,n}$ (lbf)	NA	0	
Nominal OCR	NA	1	
t_c,(ON,days,hrs)	NA	0.11 days	

Static Strain Rate = NA (%/hr or)
[X] Cyclic Rate (Hz): [ ] 0.1; [X] 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
Post Cy.Displ. Reset to Null Position: [X] Yes; [ ] No		

[ ] Undrained ambient stress applied: with Delta shear force (lbf) = NA & Duration (min) = NA & Delta disp., $\Delta d_{h,ua}$ (mm) = NA

Trimmed Specimen (TS) - Inital Water Contents over Saturation (%):

	Top, $W_{o,1}$	Botttom, $W_{o,2}$	Sides, $W_{o,3}$	Avg., $W_{o,avg}$	Selct., $W_{o,s}$	Back Cal.
W_o	34.15	35.25	33.36	34.25	34.25	35.16
S_o	96.4	97.8	95.3	96.5	96.5	97.7
Measured final mass of moist soil, $M_{t,at}$ (g)						114.57
Final mass of moist soil corrected for excess dry soil, $M_{tat,c}$ (g)						114.57

Calculated Mass of Dry Soil (g)

Initial Selected Water Content (%)	34.25
Initial , $M_{d,o}$	88.22
Final, $M_{d,at}$	87.63
Selected, M_d	87.93

Initial Back Cal. Specific Gravity (TS):

Selected S_o (%)	
Selected W_o (%)	
Specific Gravity, $G_{s,bc}$	

Height/Volume Change Summary

Variation in Height & Volume During Consol.	During Initial Consol. to $\sigma'_{v,c}$or $\sigma'_{vc,max}$=	During Rebound to $\sigma'_{v,c}$ =	Specimen Unloaded After Test To
Stress Units (ksf)	1.000	NA	NA
Sign Convention: (+) ΔV out & ΔH down; (-) ΔV in & ΔH up			
Delta Def. Read., $\Delta d_{ar,n}$ (mm)	0.323		
Total Equip. Comp., $\Sigma\Delta d_{afc}$ (mm)	0.000		
Corr. Total Def. $\Delta H_{c,n}$ (mm)	0.323		
ΔV_n using A_o - spec. (cm^3)	1.13		
ΔV_n using $A_{c,n}$ - app. (cm^3)	1.13		
ΔV_n using burette meas.(cm^3)	0.50		
Selected ΔV_n (cm^3)	1.13	NA	NA = ΔV_{uL}
After Test WC Corr. for ΔV during Shear & Unloading, $W_{at,c}$ (%)			NA

Lateral Confinement Area Cal. Approach (LCA); Method 1, 2, 3 or 4: 3

Calculation of ΔV_c by Different Procedures

By Selected Volumes		By Change in Mass	
ΔV_c (cm^3)	1.13	~($M_{t,o}$ - $M_{tat,c}$)/ρ_w + ΔV_L + ΔV_{uL}	
By Cal. Height & App. Area		ΔV_c (cm^3)	3.87
ΔV_c (cm^3)	1.13	**By Saturation = 100% and**	
By Cal. Ht. & Init. Spec. Area		**Spec. Unloaded to 0 Stress**	
ΔV_c (cm^3)	1.13	ΔV_c (cm^3)	NA

Back Cal. Water Content During Consol. - Based on the Consolidation Conclusions Given Below

Assumed Saturation (%)	100.00
Back Cal. WC before Loading, $W_{c,bc}$ (%)	34.43
Back Cal.WC at Max. Stress, $W_{cmax,bc}$ (%)	NA

Consolidation & Preshear Conclusions							
	ΔV_c (cm^3) =	1.14	ΔH_c (mm) =	0.323	$\varepsilon_{a,c}$ (%) =	1.76	$\Delta V_{c,max}$ (cm^3) = NA
	V_c (cm^3) =	62.95	H_c (mm) =	17.995	$\varepsilon_{v,c}$ (%) =	1.78	$\varepsilon_{ac,max}$ (%)= NA
	A_c (cm^2) =	34.98	$\Delta\gamma_c$ (mm) =	NA	γ_c (%) =	NA	Preshear: γ_{ua} (%)= NA

Summary of Specimen Physical Properties:

Specific Gravity: G_s = 2.700 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)		LL PL PI
Initial (as trimmed)	18.318	64.10	34.99	34.7	115.4	85.6	97.1		NA
After to $\sigma'_{v,c}$	17.995	62.95	34.98	34.4	117.2	87.2	100.0		NA
Consol.: to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA		

LCA-Method: 1- Initial measured value remains constant. 4 - Based on change in height & volume. Calculated By: JJR
& Note(s) 2 - Initial measured value corrected for applied stress. NA - Not Applicable Reviewed By: HP
3 - Uses measured value at appropriate stress level (NA for rings).

Remarks:

RESULTS OF CYCLIC DSS STRENGTH TEST

Project Number: 4.11150035 | Boring/Exploration No.: JOP-B001 | Test Type: CyDSS ta=0 | Units: US | key in US or SI

Task Number | Sample No.: ST-2b | Test Sequence Number: | Stress Factor: 1.0000 (ksf->kPa)

Project Name: | Specimen No: b | File Name: JOP-B001_ST-2b | Length Factor: 1.0000 (ft->m)

Depth : 9.75 (ft) | Unit Weight Factor: 1.0000 (pcf->kN/m^3)

Initial Height (mm): 18.318

Initial Diameter (mm): 66.747

Effective Vert. Stress at Consolidation, $\sigma'_{v,c}$: 1.0 (ksf)

Effective Vert. Stress Just Prior to Cyc. Loading, $\sigma'_{v,cy}$: 1.000 (ksf)

Induced OCR : 1.0

$K_{c,DSS}$: 1.000

$K_{u,DSS}$: 1.000

Axial/Vertical Strain During Consol., $\varepsilon_{c,max}$ (%) : 1.76

Shear Strain During Application of Undr. Bias Shear Stress, $\gamma_{u,b}$ (%): NA

Static DSS $c_u/\sigma'_{v,c}$: 1.000

τ_{avg}/c_u: 0.000

τ_{cy}/c_u : 0.223

Ψ_{DSS} : (degree)

$\gamma_{hf,max}$ (%) : 5.79

$\gamma_{hb,max}$ (%) : -9.48

Summary of Specimen Physical Properties:

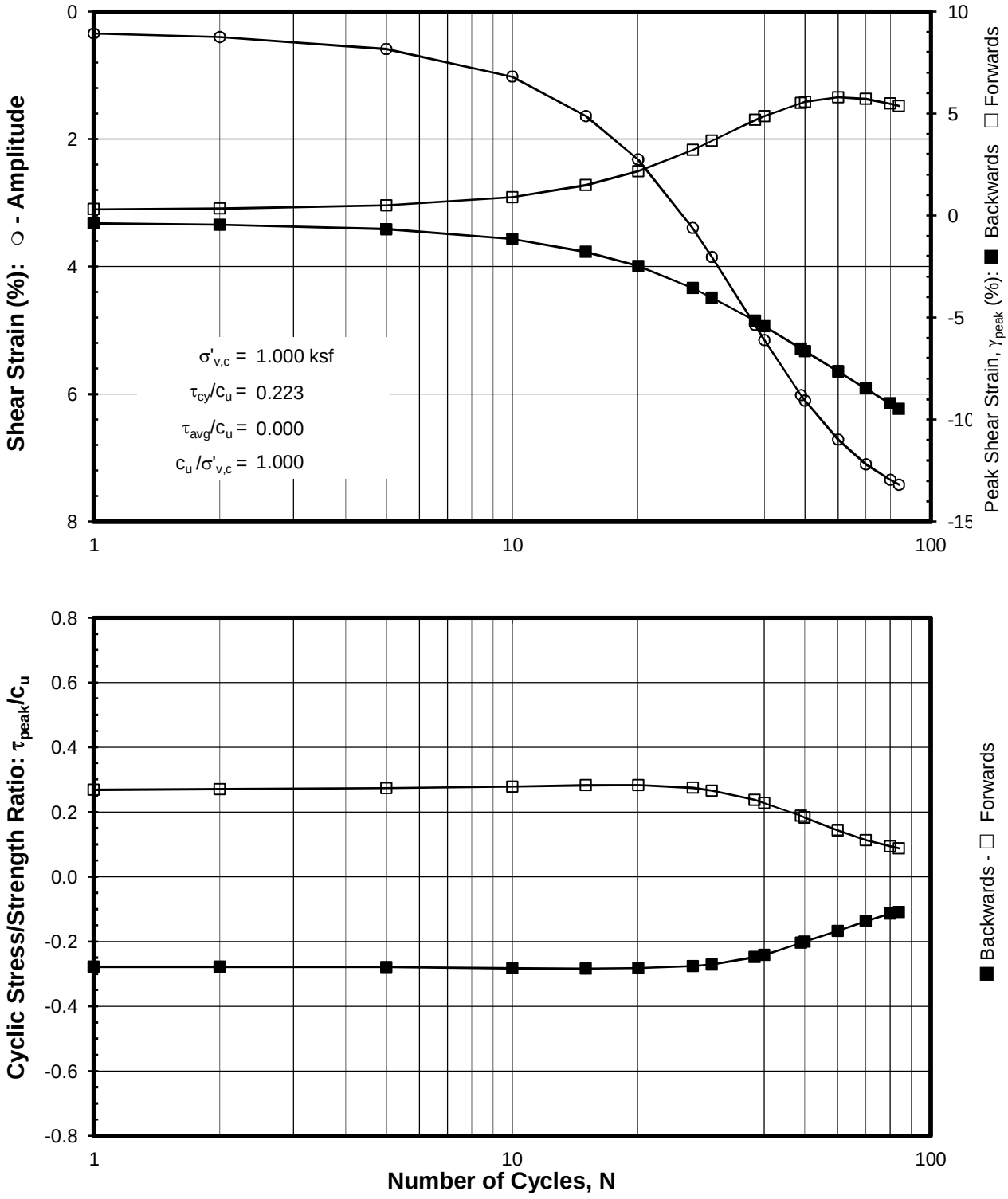
Specific Gravity: G_s = 2.700 / **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)		LL / PL / PI
Initial (as trimmed)	18.318	64.10	34.99	34.7	115.4	85.6	97.1		NA
After Consol.: to $\sigma'_{v,c}$	17.995	62.95	34.98	34.4	117.2	87.2	100.0		NA
to $\sigma'_{vc,max}$	NA	NA	NA	NA			NA		

Notes: (1) A positive number indicates the value is in the forwards region. (2) Value should be close to zero if a bias shear stress is not applied. (3) Based on ASTM D 5311; Uses stress or strain, based on control type.

Cycle No.	Shear Stress: Forwards $\tau_{h,f}$ (ksf)	Shear Stress: Backwards (1) $\tau_{h,b}$ (ksf)	Cyclic Shear Stress Amp. τ_{cy} (ksf)	Avg. Cyclic or Bias Stress τ_{avg} (2) (ksf)	Cyclic Stress Ratio $\tau_{cy}/\sigma'_{v,c}$	Average Cyclic Stress Ratio $(\tau_{cy}/\sigma'_{v,c})_{avg}$	Max. Decr. in Vert. Stress $\Delta\sigma'_{v,max}$ (ksf)	Normalized Decr. in Vert. Stress $\Delta\sigma'_{v,max}/\sigma'_{v,c}$	Shear Strain: Forwards γ_f (%)	Shear Strain: Backwards (1) γ_b (%)	Cyclic Shear Strain Amp. γ_{cy} (%)	Average Shear Strain γ_{avg} (%) (2)	Shear Modulus (τ_{cy}/γ_{cy}) G (ksf)	Loading Requirement P_{error} (3)
1	0.268	-0.278	0.273	-0.005	0.273	0.273	-0.040	-0.040	0.303	-0.387	0.345	-0.042	79.234	3.630
2	0.271	-0.278	0.274	-0.004	0.274	0.274	-0.023	-0.023	0.343	-0.464	0.403	-0.060	68.032	3.191
5	0.274	-0.279	0.277	-0.004	0.277	0.275	0.154	0.154	0.500	-0.679	0.590	-0.090	46.900	2.411
10	0.279	-0.282	0.280	-0.003	0.280	0.276	0.312	0.312	0.901	-1.149	1.025	-0.124	27.362	1.002
15	0.283	-0.284	0.283	-0.003	0.283	0.278	0.423	0.423	1.488	-1.791	1.639	-0.152	17.284	0.000
20	0.283	-0.282	0.283	-0.002	0.283	0.278	0.477	0.477	2.165	-2.480	2.323	-0.158	12.169	0.245
27	0.275	-0.276	0.275	-0.002	0.275	0.278	0.559	0.559	3.216	-3.576	3.396	-0.180	8.107	2.822
30	0.266	-0.271	0.268	-0.002	0.268	0.277	0.576	0.576	3.657	-4.048	3.853	-0.196	6.966	5.278
38	0.237	-0.248	0.243	-0.002	0.243	0.273	0.647	0.647	4.679	-5.159	4.919	-0.240	4.934	14.339
40	0.228	-0.242	0.235	-0.003	0.235	0.269	0.663	0.663	4.876	-5.432	5.154	-0.278	4.558	17.087
49	0.188	-0.204	0.196	-0.003	0.196	0.263	0.739	0.739	5.516	-6.532	6.024	-0.508	3.255	30.793
50	0.183	-0.201	0.192	-0.004	0.192	0.257	0.733	0.733	5.564	-6.639	6.102	-0.537	3.144	32.290
60	0.144	-0.167	0.155	-0.004	0.155	0.249	0.798	0.798	5.789	-7.640	6.715	-0.925	2.314	45.160
70	0.113	-0.137	0.125	-0.005	0.125	0.240	0.826	0.826	5.715	-8.484	7.100	-1.384	1.762	55.837
80	0.094	-0.114	0.104	-0.005	0.104	0.231	0.833	0.833	5.472	-9.218	7.345	-1.873	1.417	63.268
84	0.088	-0.109	0.098	-0.006	0.098	0.223	0.839	0.839	5.361	-9.483	7.422	-2.061	1.323	65.332

ATTACHMENT A

ATTACHMENT A



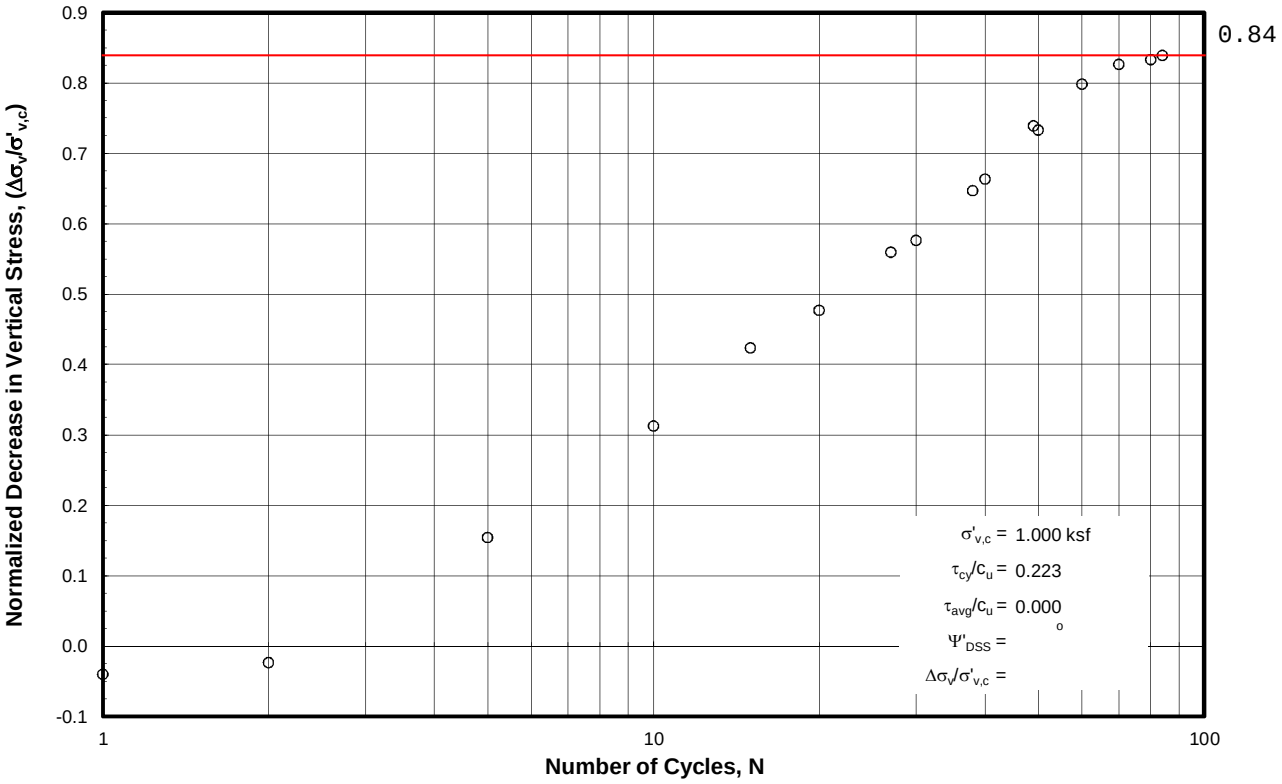
CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-2b - Depth: 9.75 ft

Boring JOP-B001

Undrained Ratio * 0.16 = 0.44 * 0.16 = 0.07



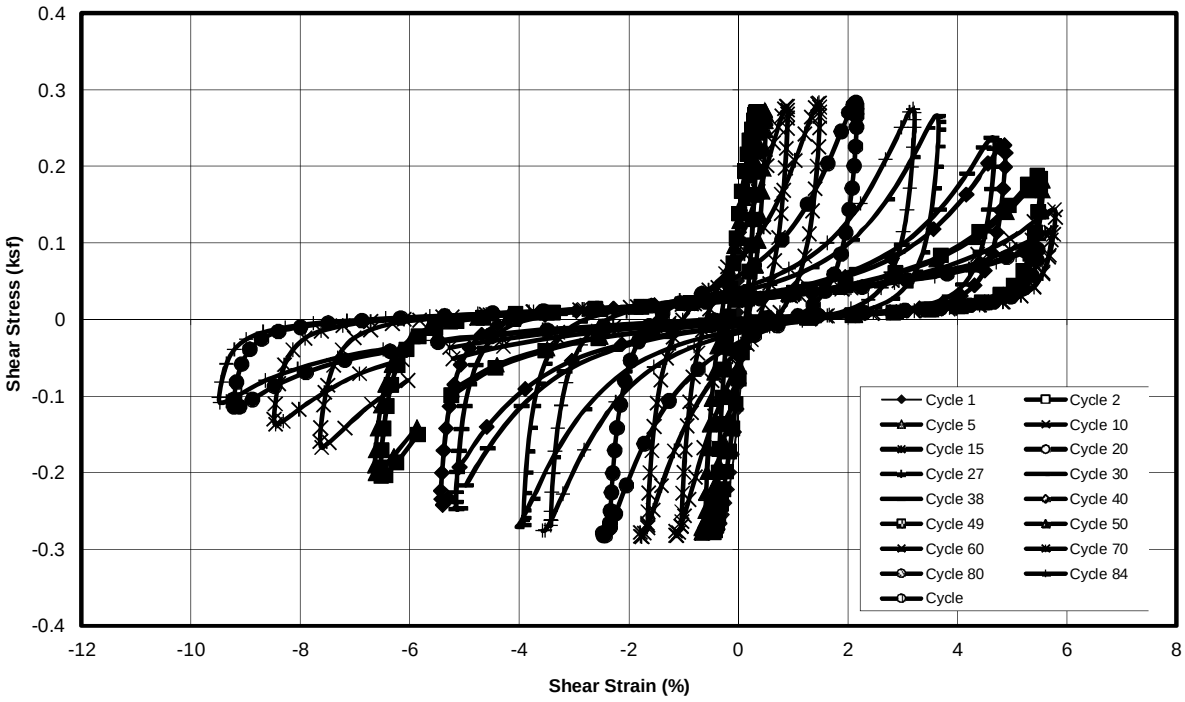
CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-2b - Depth: 9.75 ft

Boring JOP-B001

ATTACHMENT A



CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-2b - Depth: 9.75 ft

Boring JOP-B001

ATTACHMENT A

ATTACHMENT A

DIRECT SIMPLE SHEAR TEST (ASTM D 6528): Specimen Setup / Take Down

Project Number: 04.11150035 | Test Type: Post Cyclic DSS | Sta. No.: CSS-S04 | File Name: OP-B001_ST-2
Task No.: | Assign, $\sigma'_{v,c}$ = 1.00 ksf | Static DSS $c_u/\sigma'_{v,c}$ = 1.000
Project Name: | Induced OCR = 1.00 | Cyclic Ratios: τ_{cy}/c_u = 0.300 | τ_{avg}/c_u = NA
Sequence No.: of | Assig. Remarks: See Other Remarks | $\tau_{cy}/\sigma'_{v,c}$ = 0.300 | $\tau_{avg}/\sigma'_{v,c}$ =
Failure Criterion: [ ] Peak Obliquity, or [ ] Shear Strain (%) = | Specific Gravity: 2.700 [ ] Meas.; [X] Assumed

[X] Tube [X] Field Extruded	[ ] Liner [ ] Remolded	[ ] Tamping	[ ] Constant Effort:	Blows/Tamps per Layer =	
Boring No.: JOP-B001	[ ] LPC Core	[ ] Impact/Rammer	Rammer Wgt.(lbf)=	No. Layers =	
Sample No.: ST-2	Compostite No.:	[ ] Pluviated:	Tamper Force (lbf)=	Drop (in.) =	
Depth (ft): 9.75	Specimen No.: b	[ ] Kneading	[ ] Undercompaction:	U_{ni} (%) =	Dia. (in.) =
[ ] Spec. Selection by X-ray;	[ ] Geomarine Sample		Ref. Effort=	% Comp. =	± Opt.=

Type of Consolidation:	[ ] K_o at:	[ ] Incremental	; [ ] Anisotropic at:	[ ] Inclined Stress Path, $K_{c,DSS}$	[ ] Used automated system		
		[ ] CRS		[ ] 90° Stress Path	Remarks:		
Loading Conditions:	[ ] Static	[ ] Strain	[ ] Creep	[ ] Const, Vol./Ht	[ ] Without - Water	[ ] Cyclic (Hz)	[ ] Strain [ ] Stress
	[ ] Dynamic	[ ] Stress	[ ] Post Cyclic	[ ] Drained	[ ] With - Bath	Rate: [ ] 0.1;	[ ] 1; Other:

Water Content (WC);	Initial - Trimming Location			Final, W_{at}	Soil and Ring Masses	Initial	Final
	Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	(see below)	Mass Moist Soil + Tare (g)	298.37	128.10
Container No.	706	4056	6277	6593	Mass Tare (g)	179.93	13.53
Mass Moist Soil + Cont. (g)	112.74	73.01	74.87	59.95	Mass Moist Soil, $M_{t,o}$ $Mt_{,at}$ (g)	118.44	114.57
Mass Dry Soil + Container (g)	92.10	61.78	64.06	52.94	**Excess Dry Soil (soil not included in final mass above)**		
Mass Container (g)	31.66	29.92	31.66	30.14	Container No.		
WATER CONTENT (%)	34.15	35.25	33.36	30.75	Mass Dry Soil + Container (g)		
Avg. Initial WC, $W_{o,avg}$ (%)	34.25	Final W_{at}: [X] Slice ; [ ] Whole Spec.			Mass Container (g)		
[ ] See attached data sheet(s) for additional water contents					Mass Excess Dry Soil (g)	0.00	

Specimen Trimming:

[ ] Trimming Ring for Fugro Apparatus		NL4	Large-ring ID #
[X] Trimming Ring for NGI Apparatus			Small-ring ID #
$H_{s,t}$ (mm):	18.32	$A_{s,t}$ (cm^2):	34.99
$D_{s,t}$ (mm) :	66.75	$V_{s,t}$ (cm^3):	64.10

Remarks:

[ ] Free Standing by Wire Saw Lathe (mm)

	Height (H_{tr})	Diameter (D_o)		Remarks:
1	18.310	1-T	NA	
2	18.320	2-M	NA	
3	18.300	3-B	NA	
4	18.330	1'-T	NA	For Free Standing
5	18.330	2'-M	NA	Trimmed Spec.:
Avg.		3'-B	NA	A_{tr} (cm^2): NA
=	18.318	Avg	NA	V_{tr} (cm^3): NA

Note: NA-Indicates not applicable.
F or G in the Sta. No. indicates Fugro or GEOTAC apparatus.

Estimated Initial Unit Weight

Total, $\gamma_{t,o}$ (lb/ft^3)= 115.36 | Dry, $\gamma_{d,o}$ (lb/ft^3)= 85.93

Specimen Lateral Confinement by:

[X] **Wire Reinforced, Model:** C=1.5 Thickness (mm) = 0.72

Stress Level	Dia. by PiTape (mm) Meas.	Corr.	Area, $A_{c,n}$ (cm^2)	(in^2)
0	68.05	66.61	34.85	5.401
$\sigma'_{v,c}$	68.18	66.74	34.98	5.422
$\sigma'_{v,max}$	68.18	66.74	34.98	5.422

[ ] **Regular Membrane with Ring Set No.** | ID, Rings (mm)
Thickness (mm): Top: , =
[ ] Single Bottom: , Corr. for mem.
[ ] Double Membr. Thick. = =
Area Ring with mem., A_o (cm^2) ; (in^2)=
Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf
Top Cap No. 16
Data corr. for M_{tc}: [X] Yes; [ ] No Plattens with Pins: [ ] Yes; [X] No

Sketch of Specimen

Final Visual Description: Clay Sandy, Brown gray, with Silty Pockets

Other Remarks :

Trim./ Recon. By: HC | Date: 12/14/2015
Set Up By: HC | Date: 12/14/2015
Taken Down By: HC | Date: 12/14/2015
Prelim. Calc. By: HC
Final Calc. By: JJR
Reviewed By: HP

Specimen Take Down: [X] Spec. removed right after shearing
[ ] Spec. unloaded to zero stress with access to water
Remarks:

ATTACHMENT A

DIRECT SIMPLE SHEAR TEST (ASTM D 6528): Specimen Calculations & Summary

Project Number: 04.11150035 | Test Station No.: CSS-S04 | File Name: OP-B001_ST-2b
Task Number: | Specific Gravity: 2.700 | [ ] Measured; [X] Assumed

Type Test: Post Cyclic DSS | Specimen: [X] "Undisturbed"; [ ] Reconstituted; [ ] Remolded
Calculations Corr. for Salt (dissolved solids): [X] No or, [ ] Yes, with concentration = _____ ppm

Consolidation Stress Summary and Loading Summary

Test Stage:	Max. Stress	Pre-Shear	Post Cyclic
Nominal Vertical Stress, σ'_v (ksf)	NA	1.00	
Axial/Vertical Force, $P_{vr,n}$ (lbf)	NA	NA	
Horizontal Force, $P_{hr,n}$ (lbf)	NA	0	
Nominal OCR	NA	1	
t_c,(ON,days,hrs)	NA	0.11 days	

0 Static Strain Rate = NA (%/hr or)
Cyclic Rate (Hz): [ ] 0.1; [ ] 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
Post Cy.Displ. Reset to Null Position:	[ ] Yes;	[ ] No

[ ] Undrained ambient stress applied: with Delta shear force (lbf) = NA & Duration (min) = NA & Delta disp., $\Delta d_{h,ua}$ (mm) = NA

Trimmed Specimen (TS) - Inital Water Contents over Saturation (%):

	Top, $W_{o,1}$	Botttom, $W_{o,2}$	Sides, $W_{o,3}$	Avg., $W_{o,avg}$	Selct., $W_{o,s}$	Back Cal.
W_o	34.15	35.25	33.36	34.25	34.25	35.16
S_o	96.4	97.8	95.3	96.5	96.5	97.7

Measured final mass of moist soil, $M_{t,at}$ (g) = 114.57
Final mass of moist soil corrected for excess dry soil, $M_{tat,c}$ (g) = 114.57

Calculated Mass of Dry Soil (g)

Initial Selected Water Content (%)	34.25
Initial , $M_{d,o}$	88.22
Final, $M_{d,at}$	87.63
Selected, M_d	87.92

Initial Back Cal. Specific Gravity (TS):

Selected S_o (%)	
Selected W_o (%)	
Specific Gravity, $G_{s,bc}$	

Height/Volume Change Summary

Variation in Height & Volume During Consol.	During Initial Consol. to $\sigma'_{v,c}$or $\sigma'_{vc,max}$=	During Rebound to $\sigma'_{v,c}$ =	Specimen Unloaded After Test To
Stress Units (ksf)	1.000	NA	NA
Sign Convention: (+) ΔV out & ΔH down; (-) ΔV in & ΔH up			
Delta Def. Read., $\Delta d_{ar,n}$ (mm)	0.323		
Total Equip. Comp., $\Sigma\Delta d_{afc}$ (mm)	0.000		
Corr. Total Def. $\Delta H_{c,n}$ (mm)	0.323		
ΔV_n using A_o - spec. (cm^3)	1.13		
ΔV_n using $A_{c,n}$ - app. (cm^3)	1.13		
ΔV_n using burette meas.(cm^3)	0.50		
Selected ΔV_n (cm^3)	1.13		NA = ΔV_{uL}
After Test WC Corr. for ΔV during Shear & Unloading, $W_{at,c}$ (%)			NA

Lateral Confinement Area Cal. Approach (LCA); Method 1, 2, 3 or 4: 3

Calculation of ΔV_c by Different Procedures

By Selected Volumes		By Change in Mass	
ΔV_c (cm^3)	#VALUE!	~ $M_{t,o}$ - ($M_{tat,c}$ + ΔV_L + ΔV_{uL})	
By Cal. Height & App. Area		ΔV_c (cm^3)	3.87
ΔV_c (cm^3)	1.13	**By Saturation = 100% and**	
By Cal. Ht. & Init. Spec. Area		**Spec. Unloaded to 0 Stress**	
ΔV_c (cm^3)	1.13	ΔV_c (cm^3)	NA

Back Cal. Water Content During Consol. - Based on the Consolidation Conclusions Given Below

Assumed Saturation (%)	100.00
Back Cal. WC before Loading, $W_{c,bc}$ (%)	34.43
Back Cal.WC at Max. Stress, $W_{cmax,bc}$ (%)	NA

Consolidation & Preshear Conclusions								
	ΔV_c (cm^3) =	1.14	ΔH_c (mm) =	0.323	$\varepsilon_{a,c}$ (%) =	1.76	$\Delta V_{c,max}$ (cm^3) =	NA
	V_c (cm^3) =	62.95	H_c (mm) =	17.995	$\varepsilon_{v,c}$ (%) =	1.78	$\varepsilon_{ac,max}$ (%)=	NA
	A_c (cm^2) =	34.98	$\Delta\gamma_c$ (mm) =	NA	γ_c (%) =	NA	Preshear: γ_{ua} (%)=	NA

Summary of Specimen Physical Properties:

Specific Gravity: G_s = 2.700 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Saturation (%)	
Initial (as trimmed)	18.318	64.10	34.99	34.7	115.4	85.6	97.1	
After Consol.: to $\sigma'_{v,c}$	17.995	62.95	34.98	34.4	117.2	87.2	100.0	
to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA	

LCA-Method & Note(s): 1- Initial measured value remains constant. 2 - Initial measured value corrected for applied stress. 3 - Uses measured value at appropriate stress level (NA for rings). 4 - Based on change in height & volume. NA - Not Applicable

Calculated By: HP
Reviewed By: HP

Remarks:

ATTACHMENT A

DIRECT SIMPLE SHEAR TEST

Project Number:	04.11150035	Task Number:		Boring No.:	JOP-B001
Project Name:		Test Type:	Post Cyclic DSS	Sample No.:	ST-2
Test Number:		Test Series No.:		Specimen No.:	b
				Depth (ft.):	9.75

Horiz. Load Factor (lbf/V/V):	29.983	Vert. Load Factor (lbf/V/V):	144.426
Horiz. Load, Test Floating Zero (V/V):	3.494E-03	Vert. Load, Test Floating Zero (V/V):	7.854E-03
Horiz. Deform. Factor (mm/V/V):	-0.394	Vert. Deform. Factor (mm/V/V):	0.491

	Max Stress	Pre-Shear	Post Cyclic
Vertical Load (V/V) or (lbf):		2.61E-01	
Calculated Vertical Stress (ksf):		1.000	
Horizontal Load (V/V) or (lbf):			
Calculated Horizontal Load (ksf):			

Elapsed Time (min)	Exitation (Volts)	Horizontal Load (Volts)	Horizontal Deformation (Volts)	Vertical Load (Volts)	Vertical Deformation (Volts)	Horizontal Load (grams)
0.0	1.000	5.553E-3	-0.144	3.250E-2	-3.046	0
4.2	1.000	1.311E-2	0.017	2.166E-2	-3.040	0
8.3	1.000	1.377E-2	0.175	3.448E-2	-3.069	0
12.5	1.000	1.607E-2	0.335	3.283E-2	-3.095	0
16.7	1.000	1.771E-2	0.494	3.711E-2	-3.050	0
20.8	1.000	2.330E-2	0.653	4.236E-2	-3.059	0
25.0	1.000	2.396E-2	0.812	3.612E-2	-3.091	0
29.2	1.000	2.462E-2	0.969	2.725E-2	-3.111	0
33.3	1.000	2.396E-2	1.126	2.100E-2	-3.071	0
37.5	1.000	2.790E-2	1.287	3.546E-2	-3.044	0
41.7	1.000	3.053E-2	1.449	3.218E-2	-3.073	0
45.8	1.000	3.152E-2	1.605	2.692E-2	-3.112	0
50.0	1.000	3.316E-2	1.764	2.757E-2	-3.054	0
54.2	1.000	3.546E-2	1.923	1.607E-2	-3.062	0
58.3	1.000	3.875E-2	2.081	2.527E-2	-3.050	0
62.5	1.000	4.072E-2	2.239	3.842E-2	-3.098	0
66.7	1.000	4.401E-2	2.398	3.711E-2	-3.105	0
70.8	1.000	4.795E-2	2.557	3.415E-2	-3.042	0
75.0	1.000	5.288E-2	2.716	3.185E-2	-3.108	0
79.2	1.000	5.781E-2	2.876	3.053E-2	-3.039	0
83.3	1.000	6.537E-2	3.034	2.626E-2	-3.053	0
87.5	1.000	7.359E-2	3.194	4.434E-2	-3.068	0
91.7	1.000	8.673E-2	3.352	4.762E-2	-3.097	0
95.8	1.000	9.791E-2	3.511	4.762E-2	-3.070	0
100.0	1.000	1.137E-1	3.671	5.222E-2	-3.083	0
104.2	1.000	1.295E-1	3.828	5.124E-2	-3.032	0
108.3	1.000	1.502E-1	3.985	6.011E-2	-3.031	0
112.5	1.000	1.702E-1	4.147	5.978E-2	-3.109	0
116.7	1.000	1.935E-1	4.305	6.504E-2	-3.049	0
120.8	1.000	2.169E-1	4.464	7.293E-2	-3.129	0
125.0	1.000	2.369E-1	4.623	8.345E-2	-3.071	0
129.2	1.000	2.593E-1	4.779	1.009E-1	-3.113	0
133.3	1.000	2.790E-1	4.938	1.028E-1	-3.113	0
137.5	1.000	3.010E-1	5.099	1.107E-1	-3.047	0
141.7	1.000	3.184E-1	5.258	1.078E-1	-3.046	0
145.8	1.000	3.391E-1	5.416	1.065E-1	-3.054	0
150.0	1.000	3.546E-1	5.576	1.275E-1	-3.101	0
154.2	1.000	3.710E-1	5.732	1.216E-1	-3.061	0
158.3	1.000	3.858E-1	5.893	1.278E-1	-3.040	0
162.5	1.000	3.990E-1	6.050	1.327E-1	-3.066	0
166.7	1.000	4.138E-1	6.211	1.308E-1	-3.129	0
170.8	1.000	4.266E-1	6.369	1.318E-1	-3.133	0

175.0	1.000	4.374E-1	6.527	1.295E-1	-3.061	0
179.2	1.000	4.489E-1	6.688	1.492E-1	-3.047	0
183.3	1.000	4.614E-1	6.846	1.581E-1	-3.124	0
187.5	1.000	4.742E-1	7.006	1.594E-1	-3.088	0
191.7	1.000	4.824E-1	7.163	1.571E-1	-3.088	0
195.8	1.000	4.870E-1	7.323	1.623E-1	-3.134	0
200.0	1.000	4.897E-1	7.481	1.623E-1	-3.125	0
204.2	1.000	4.893E-1	7.638	1.581E-1	-3.059	0
208.3	1.000	4.880E-1	7.797	1.640E-1	-3.043	0
212.5	1.000	4.870E-1	7.956	1.640E-1	-3.057	0
216.7	1.000	4.877E-1	8.115	1.640E-1	-3.050	0
220.8	1.000	4.893E-1	8.274	1.581E-1	-3.076	0
225.0	1.000	4.877E-1	8.432	1.581E-1	-3.076	0
229.2	1.000	4.821E-1	8.592	1.479E-1	-3.135	0
233.3	1.000	4.723E-1	8.752	1.567E-1	-3.043	0
237.5	1.000	4.644E-1	8.910	1.308E-1	-3.070	0
239.9	1.000	4.594E-1	9.006	1.567E-1	-3.095	0

ATTACHMENT A

Results of Direct Simple Shear Test

Project Number: 04.11150035 Test Type: Post Cyclic DSS Test Sta. No.: CSS-S04 File Name: OP-B001_ST-2
Project Name: Task No.: Test No.: Test Series for:

X Tube	X Field Extruded	Liner	Remolded	Tamping	Constant Effort: Blows/Tamps per Layer =
Boring No.: JOP-B001		LPC Core		Impact/Rammer	Rammer Wgt.(lbf)= No. Layers =
Sample No.: ST-2		Compostite No.:		Pluviated:	Tamper Force (lbf)= Drop (in.) =
Depth (ft): 9.75		Specimen No.: b		Kneading	Undercompaction: U_{ni} (%) = Dia. (in.) =
Spec. Selection by X-ray;		Geomarine Sample			Ref. Effort= % Comp. = ± Opt.=

Type Consolidation:	K_o at:	Incremental CRS	Anisotropic at:	Inclined Stress Path, $K_{c,DSS}$ 90° Stress Path	Used Automated System Remarks:
Loading Conditions:	0 Static Dynamic	Strain Stress	Creep Post Cyclic	Const, Vol./Ht Drained	Without - Water With - Bath; Cyclic (Hz) Rate: 0.1; Strain 1; Stress Other:

Summary of Specimen Physical Properties

Specific Gravity: G_s = 2.700 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Unit Weight Total (pcf)	Unit Weight Dry (pcf)	Saturation (%)	LL PL PI		
Initial	18.32	64.10	34.99	34.71	115.4	85.6	97.1			
After Consol.: to $\sigma'_{v,c}$	18.00	62.95	34.98	34.43	117.2	87.2	100.0			
to $\sigma'_{vc,max}$	NA	NA	NA	NA	NA	NA	NA			

Consolidation Stress Summary and Loading Summary

Item	Unit	Max. Stress	Pre-Shear	Post Cyclic
Vert. Consol. Stress, $\sigma'_{v,c}$	(ksf)	NA	1.000	NA
Induced OCR	-	NA	1.00	NA
Axial Strain during Consol., $\varepsilon_{a,c}$	%	NA	1.76	NA
Horiz. Consol. Stress, $\tau_{h,c}$	(ksf)	NA	NA	NA
Consol. Stress Ratio, $\tau_{h,c} / \sigma'_{v,c}$	-	NA	NA	NA
Shear Strain during Consol., $\varepsilon_{h,c}$	%	NA	NA	NA
Undr. Ambient Shear Stress, $\tau_{h,ua}$	(ksf)	NA	NA	NA
Undr. Ambient Shear Strain, ε_{ua}	%	NA	NA	NA

0 Static Strain Rate = 5.0 %/hr.
Cyclic Rate (Hz): 0.1; 1; Other =

During/End of Loading	Static	Cyclic
Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
Post Cy.Displ. Reset to Null Pos.:	Yes;	No

Number of Loading Cycles, N = NA
$\pm\tau_h$ = NA (ksf) $\pm\gamma$ = NA %
at end of cyclic loading, $\sigma'_{vcy,r}$ = NA (ksf)

Weight Top Cap, etc., M_{tc} (lbf): 1.09
Data corr. for M_{tc}: X Yes; No Plattens with Pins: Yes; X No
X Wire Reinforced Membrane, Model: C=1.5 Data corr. for Membr. strength
Regular Membrane with Rings Yes X No

Data Normalization: X Yes No Value: 1.000 (ksf)
Using Effective Vertical Stress:
X Pre-Shear Conditions Post-Cyclic Conditions
Maximum Stress during Consol.

Notes: See Fugro South, Inc. Notation Listing for definition of symbols and acronyms. F or G in the Test Sta. No. indicates Fugro or GEOTAC apparatus.
NA - Not Applicable

Final Visual Description and Remarks: Clay Sandy, Brown gray, with Silty Pockets

Loading Summary

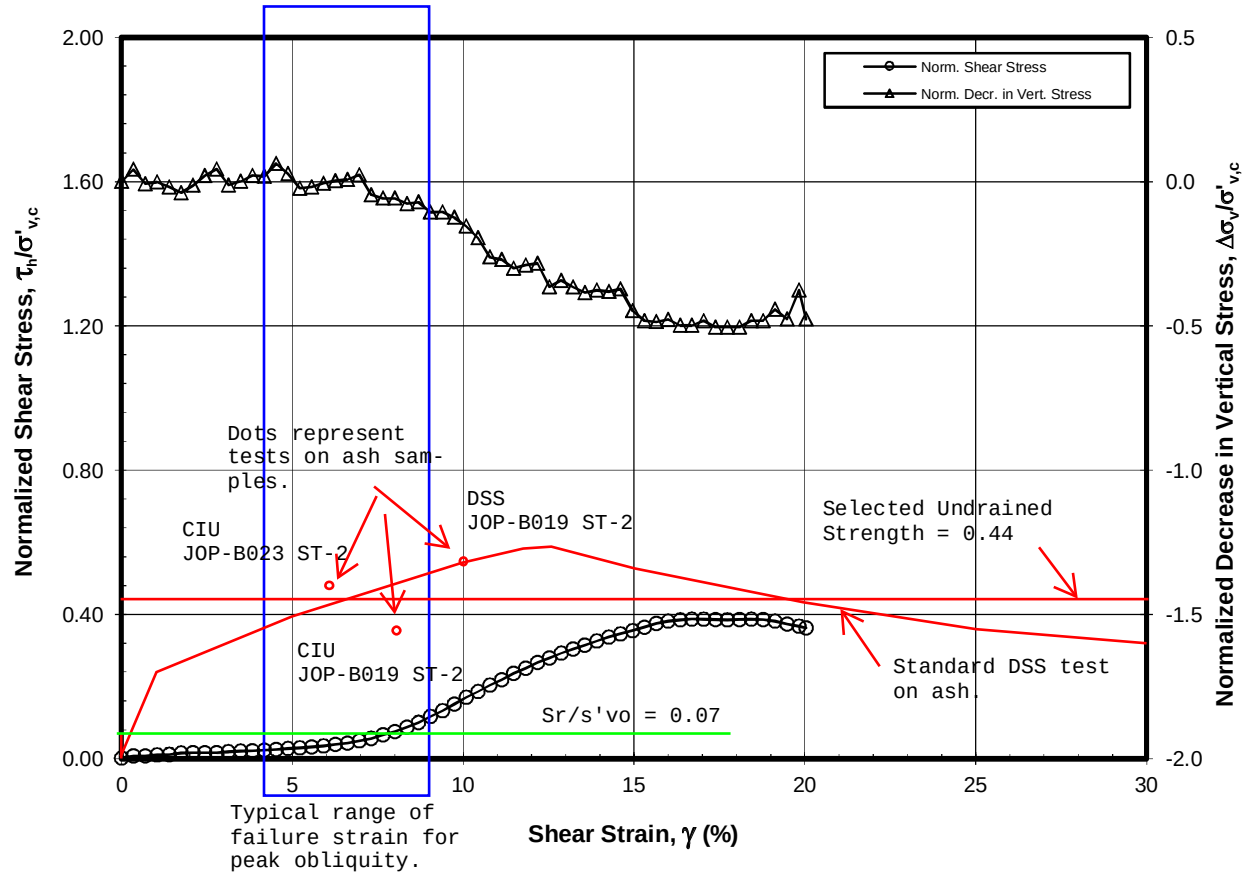
	τ_h (ksf)	γ (%)	σ'_v (ksf)	τ_h/σ'_v -	$\Delta\sigma'_v/\sigma'_{v,c}$ -	$c_u/\sigma'_{v,c}$
at Peak Shear Stress	0.387	16.69	0.621	0.623	-0.498	0.387
at Maximum Strain	0.363	20.03	0.600	0.605	-0.476	

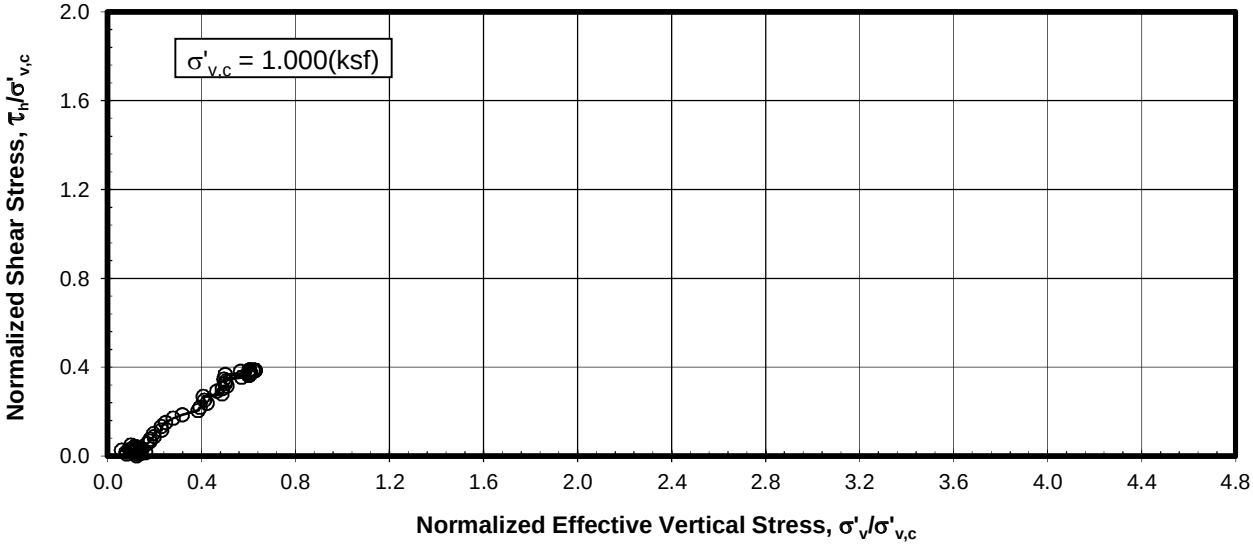
ATTACHMENT A

Results of Direct Simple Shear Test

Elapsed Time (min)	Shear Strain γ (%)	Shear Stress τ_h (ksf)	Effective Vertical Stress σ'_v (ksf)	Calulated Pore Press. Change $\Delta U = \Delta\sigma'_v$ (ksf)	Secant Shear Modulus G_s (ksf)	Tangent Modulus G_T (ksf)	Norm. Shear Stress $\tau_h/\sigma'_{v,c}$	Norm. Vert. Stress $\sigma'_v/\sigma'_{v,c}$	Norm. Decr. in V. Stress $\Delta\sigma'_v/\sigma'_{v,c}$	Stress Ratio Angle ϕ'_{DSS} (°)
0.0	0.00	0.002	0.123	0.000	-	-	0.002	0.123	0.000	0.76
4.2	0.35	0.008	0.082	0.042	1.711	0.931	0.008	0.082	0.042	5.35
8.3	0.70	0.008	0.131	-0.008	0.935	0.338	0.008	0.131	-0.008	3.58
12.5	1.05	0.010	0.125	-0.001	0.799	0.450	0.010	0.125	-0.001	4.59
16.7	1.40	0.011	0.141	-0.018	0.693	0.827	0.011	0.141	-0.018	4.59
20.8	1.74	0.016	0.161	-0.038	0.810	0.715	0.016	0.161	-0.038	5.59
25.0	2.09	0.016	0.137	-0.014	0.700	0.151	0.016	0.137	-0.014	6.77
29.2	2.44	0.017	0.103	0.020	0.623	0.000	0.017	0.103	0.020	9.25
33.3	2.78	0.016	0.079	0.044	0.527	0.370	0.016	0.079	0.044	11.62
37.5	3.13	0.019	0.135	-0.011	0.568	0.740	0.019	0.135	-0.011	8.21
41.7	3.49	0.022	0.122	0.001	0.570	0.410	0.022	0.122	0.001	10.00
45.8	3.83	0.022	0.102	0.021	0.540	0.304	0.022	0.102	0.021	12.35
50.0	4.18	0.024	0.104	0.019	0.526	0.451	0.024	0.104	0.019	12.74
54.2	4.53	0.025	0.060	0.063	0.526	0.640	0.025	0.060	0.063	22.87
58.3	4.87	0.028	0.096	0.028	0.542	0.605	0.028	0.096	0.028	16.36
62.5	5.22	0.030	0.146	-0.023	0.537	0.603	0.030	0.146	-0.023	11.47
66.7	5.57	0.032	0.141	-0.018	0.550	0.827	0.032	0.141	-0.018	12.88
70.8	5.91	0.035	0.130	-0.006	0.571	1.015	0.035	0.130	-0.006	15.27
75.0	6.26	0.039	0.121	0.003	0.602	1.124	0.039	0.121	0.003	18.02
79.2	6.61	0.043	0.116	0.008	0.629	1.430	0.043	0.116	0.008	20.48
83.3	6.96	0.049	0.099	0.024	0.685	1.801	0.049	0.099	0.024	26.36
87.5	7.31	0.056	0.169	-0.045	0.741	2.447	0.056	0.169	-0.045	18.30
91.7	7.65	0.066	0.181	-0.058	0.844	2.793	0.066	0.181	-0.058	20.07
95.8	8.00	0.075	0.181	-0.058	0.919	3.073	0.075	0.181	-0.058	22.51
100.0	8.35	0.088	0.199	-0.076	1.031	3.626	0.088	0.199	-0.076	23.79
104.2	8.70	0.100	0.195	-0.072	1.135	4.216	0.100	0.195	-0.072	27.19
108.3	9.04	0.117	0.229	-0.106	1.274	4.646	0.117	0.229	-0.106	26.99
112.5	9.39	0.133	0.228	-0.105	1.396	4.932	0.133	0.228	-0.105	30.21
116.7	9.74	0.151	0.248	-0.125	1.537	5.357	0.151	0.248	-0.125	31.37
120.8	10.09	0.170	0.278	-0.155	1.668	4.976	0.170	0.278	-0.155	31.39
125.0	10.44	0.186	0.319	-0.195	1.765	4.895	0.186	0.319	-0.195	30.25
129.2	10.78	0.204	0.386	-0.262	1.874	4.848	0.204	0.386	-0.262	27.84
133.3	11.13	0.219	0.393	-0.270	1.957	4.747	0.219	0.393	-0.270	29.16
137.5	11.48	0.237	0.423	-0.300	2.050	4.485	0.237	0.423	-0.300	29.23
141.7	11.83	0.251	0.412	-0.289	2.106	4.365	0.251	0.412	-0.289	31.32
145.8	12.17	0.267	0.407	-0.284	2.182	4.144	0.267	0.407	-0.284	33.29
150.0	12.52	0.280	0.488	-0.364	2.219	3.672	0.280	0.488	-0.364	29.82
154.2	12.87	0.293	0.465	-0.342	2.262	3.583	0.293	0.465	-0.342	32.18
158.3	13.22	0.304	0.489	-0.366	2.291	3.195	0.304	0.489	-0.366	31.91
162.5	13.56	0.315	0.508	-0.384	2.310	3.195	0.315	0.508	-0.384	31.80
166.7	13.91	0.327	0.500	-0.377	2.336	3.142	0.327	0.500	-0.377	33.14
170.8	14.26	0.337	0.504	-0.381	2.351	2.718	0.337	0.504	-0.381	33.75
175.0	14.61	0.346	0.495	-0.372	2.354	2.552	0.346	0.495	-0.372	34.90
179.2	14.96	0.355	0.571	-0.448	2.360	2.738	0.355	0.571	-0.448	31.85
183.3	15.30	0.365	0.605	-0.482	2.372	2.896	0.365	0.605	-0.482	31.08
187.5	15.65	0.375	0.610	-0.487	2.384	2.408	0.375	0.610	-0.487	31.57
191.7	16.00	0.381	0.601	-0.478	2.373	1.472	0.381	0.601	-0.478	32.39
195.8	16.35	0.385	0.621	-0.498	2.345	0.826	0.385	0.621	-0.498	31.79
200.0	16.69	0.387	0.621	-0.498	2.309	0.265	0.387	0.621	-0.498	31.93
204.2	17.04	0.387	0.605	-0.482	2.261	-0.188	0.387	0.605	-0.482	32.60
208.3	17.39	0.386	0.628	-0.504	2.209	-0.263	0.386	0.628	-0.504	31.58
212.5	17.73	0.385	0.628	-0.504	2.162	-0.038	0.385	0.628	-0.504	31.53
216.7	18.08	0.386	0.628	-0.504	2.123	0.263	0.386	0.628	-0.504	31.56
220.8	18.43	0.387	0.605	-0.482	2.090	0.000	0.387	0.605	-0.482	32.60
225.0	18.78	0.386	0.605	-0.482	2.044	-0.826	0.386	0.605	-0.482	32.51
229.2	19.13	0.381	0.566	-0.442	1.984	-1.755	0.381	0.566	-0.442	33.96
233.3	19.48	0.373	0.600	-0.476	1.908	-2.025	0.373	0.600	-0.476	31.89
237.5	19.82	0.367	0.500	-0.377	1.843	-1.848	0.367	0.500	-0.377	36.26
239.9	20.03	0.363	0.600	-0.476	1.804	-1.881	0.363	0.600	-0.476	31.18

ATTACHMENT A





POST CYCLIC STATIC DSS TEST

K_o Consolidation - OCR = 1 - Strain Rate = 5 %/hr

Sample: ST-2b - Depth: 9.75 ft.

Boring JOP-B001

ATTACHMENT G

SLOPE STABILITY ANALYSIS

AECOM

QMS Form 3-3 (MM)
Date: September 2014

Dynegy CCR Program Quality Management

Calculation Check and Review Record

Project Name	Joppa DMM Design	**Client Name**	Electric Energy, Incorporated
Project Location	Joppa, Illinois	**PM Name**	Vic Modeer
Project Number / Office Code		**PIC Name**	Vic Modeer

This form may be used instead of Form 3-4 – Check and Review Record for Detail Checks of calculations. If the calculation is a standalone deliverable, an Independent Technical Review (ITR) may be required, and this form can be used for that purpose as well.

Type	☐ Calculation Detail Check	☐ Calculation ITR

IDENTIFYING INFORMATION

(This section is to be completed by the PM, PM's Designee, or Originator.)

Calculation Medium: *(Select as appropriate)*
☒ Electronic — File Name: JOP_DMM_Global_Stability_20160419v0.pdf
☐ Hard-copy — Unique Identification:
Number of pages *(including cover sheet)*:

Discipline:	Geotechnical
Title of Calculation:	Joppa DMM Global Stability (Sta. 83+00 to 91+50)
Calculation Originator Name:	Lucas P. Carr
Calculation Contributor Names:	Tom Cooling
Calculation Checker Names:	Andrew J. Wilding
Calculation Reviewer Names:	Doug Cauble

DESCRIPTION & PURPOSE

Design a DMM zone for stability remediation at the Joppa East Ash Pond SE corner.

BASIS / REFERENCE / ASSUMPTIONS

USEPA CCR Rule, 2015 and 2016 explorations performed by AECOM, various historic data

ISSUE / REVISION RECORD

For comments, select N (None), HC (Hard Copy), EF (Electronic File), or Form 3-5 from drop-down. For a given Revision, indicate P (Preliminary), S (Superseded) or F (Final). If there are no revisions to the Initial Issue, check F (Final).

Rev. No.	Description	Comments	P	S	F	Originator Initials	Date	Checker Initials	Date	Reviewer Initials	Date
0	Initial Issue	N	☒	☐	☐	LPC	4/19/16	AW	4/20/16	DFC	4/23/16
1	Rev per checker & ITR cmts	N	☐	☒	☐	LPC	4/26/16	AW	4/26/16	DFC	4/27/16
2		N	☐	☐	☐						
3		N	☐	☐	☐						

APPROVAL and DISTRIBUTION

☒ The below individuals confirm that the Calculation Check and Review process has been followed.

Originator Signature	4-19-2016 Date
Checker Signature	4/26/16 Date
Reviewer Signature	4-27-2016 Date
Project Manager (or Designee) Signature	4/27/16 Date

DISTRIBUTION	Project Central File – Quality File Folder Other – Specify:

Calculation Notes AECOM

Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50) Project Name: Dynegy CCR

By: Lucas Carr Date: 4/14/2016 Project No: 60440155

Checked By: Andy Wilding Date: 4/26/2016 Task No.: 01

Objective

The design dimensions of a soil improvement zone, constructed using the deep mixing method (DMM), have been determined for the Southeast Corner of the Dynegy-Joppa Ash Pond. Per the ***DMM Zone Extents*** calculation package, the zone will extend from Sta. 83+00 to 91+50. Slope stability analyses were used to design the DMM zone at four cross-sections (sections) within this zone, including H, K, K–88+30, and A. The zone was sized to meet the safety factor criteria in the USEPA CCR Rule, with the post-earthquake stability being the controlling design case. Slope stability for pseudostatic seismic deformations was also evaluated, along with maximum storage pool and maximum surcharge pool static conditions.

Information on the slope stability analyses is discussed in the following sections.

Development of Sections for Analysis

Slope stability analyses were performed at the cross-sections listed in Table 1, including information describing each cross-section.

Table 1 – DMM Cross Sections for Analysis

Cross-Section	Approx. Station	Description
H	84+40	Cross-section near the western extents of the DMM zone. Note that borings drilled adjacent to Section H did not identify the potential for ash underneath the centerline of the embankment. However, nearby borings (B-025 and B-026) did identify the potential for ash underneath the embankment, so a continuous 4' thick zone of ash was included to account for potential uncertainties.
K	87+50	Cross-section near the corner of the embankment, where the toe elevation is slightly lower than Section H. Some ash is located beneath the embankment, and CPT C016, advanced at Section K, identified a potential zone of poor compaction at the bottom of the embankment. However, nearby borings identified the potential for ash underneath the crest of the embankment, so the zone of poor compaction was conservatively assumed to consist of ash.
K - 88+30	88+30	Alternate version of Section K, including the subsurface stratigraphy from K, with the ground surface geometry from the topo at Sta. 88+30, centerline ash thickness from B028, and toe stratigraphy taken from boring D009. Boring D009 was drilled at Sta. 88+30 and includes a thinner thickness of ash than was found at Section K, from borings C014 and B-021. Boring B028, however, shows a thicker ash zone below the center of the embankment than Boring B004 at section A. Also, this section was selected to evaluate the transition from the eastern end of the DMM zone (relatively high toe elevation and no slope benches) to the western end (much lower toe elevation and a slope bench at around El 350 ft).
A	90+50	Critical cross-section for the DMM zone, due to being located at the area of maximum embankment height, and the close proximity of the stream at the toe of the embankment, as well as the thickness of ash underlying the embankment.

Cross-sections were drawn in AutoCAD using survey data from the site, historic design drawings, and AECOM subsurface explorations from 2015 and 2014. These cross-sections, including a plan view of the area and a profile along the embankment centerline and toe, are included as **Attachment 1.**

Pore water pressures for each section were taken from a piezometric line. The location of the piezometric line was taken from explorations advanced by AECOM in 2015 and 2016. Beneath the crest of the embankment, CPTs advanced by AECOM showed that pore water was first encountered around 25 to 30 ft below the crest of the embankment, so the piezometric line was assumed to linearly decrease from the normal pool elevation (376 ft) to an elevation 25 ft below the crest of the embankment. The piezometric surface was clearly identified in the CPTs as pore pressure measurements during advancement showed negative or slightly positive pore pressures above 25 ft. Below 25 ft, pore pressures became positive and generally followed a trend indicative of saturated conditions (increases in pore pressures to hydrostatic or above hydrostatic conditions). This can be seen in CPT soundings SC002, C016, and C035. Additionally, vibrating wire piezometers installed by AECOM in the southeast corner show piezometric elevations of approximately EL. 340 to 350 ft, which is 30 to 40 ft below the crest elevation of the embankment (EL. 380 ft)

Beyond the crest, the piezometric line was assumed to gradually decrease to the elevation of the ditch at the toe of the embankment. Recent borings advanced by AECOM did not identify free pore water within the foundation ash/clay in this area, but CPTs did identify pore water pressures about 10 to 20 ft below the toe of the embankment in this zone, so the selected piezometric line is somewhat conservative.

Analysis Methodology

Loading Conditions

The slope stability analysis evaluated the following loading conditions, as required by the USEPA CCR Rule (except as noted):

- Long-Term, Maximum Storage Pool Loading Condition (Static Drained), Min FoS (minimum factor of safety) = 1.50: This case models the static stability of the embankment under long-term conditions, using drained soil strengths. A normal operating pool elevation of 376.0 ft was assumed and pore pressures for analysis are taken from a piezometric line based on AECOM's interpretation of groundwater levels from piezometer, CPT, and boring data. The DMM zone was not included in this analysis (see *Material Properties* section of the report).

- Maximum Surcharge Pool Loading Condition (Surcharge), Min FoS = 1.40: This case models the static stability of the embankment under short-term flood loading conditions. The flood pool

elevation was assumed to be equal to the crest of the embankment for this analysis case. The piezometric surface within the embankment was assumed to increase by 1 ft under the crest an d 0.5 ft under the toe. Due to the short-term nature of the loading, and the low permeability of the embankment and foundation soils, this is is a conservative assumption. The DMM zone not included in this analysis (see *Material Properties* section of the report).

- Seismic Condition (Pseudostatic), Min FoS = 1.00: This case models the stability of the embankment under earthquake loading. Normal pool conditions (El. 376.0 ft) and groundwater conditions are assumed. The pseudostatic seismic coefficient (k_h) was iterated to find a factor of safety of 1.00. The resulting k_h was used to perform a seismic deformation analysis using the Bray and Travasarou (2007) approach, to estimate horizontal and vertical deformations of the embankment during the design seismic event, which corresponds to the pseudostatic factor of safety of 1.00. The calculated deformations were small and considered tolerable. Peak undrained soil strengths were used for this analysis, due to the short duration of the loading and the fine-grained, slow-draining nature of the embankment and foundation soils. The DMM zone is included in this analysis.

  For practical purposes this case is not relevant because the ash in the foundation is liquefiable during shaking and therefore the post-earthquake case noted below is the more realistic case. The pseudo-static case was analyzed, however, due to regulatory requirements.

- Liquefaction Condition (Post-Earthquake), Min FoS = 1.20: This case models the stability of the embankment immediately following earthquake loading. Normal pool conditions (El. 376.0 ft) and groundwater conditions are assumed. Post-earthquake residual (liquefied) undrained strengths are assumed in the ash underlying and retained by the embankment. Peak undrained strengths were used for the embankment and foundation clays, as they are stiff materials and are unlikely to be susceptible to cyclic softening and strength losses. Where soft clay material was identified at and beyond the toe of the dike, cyclically softened shear strengths, corresponding to a 20% reduction in shear strength from the peak undrained strengths, were used. Drained material strengths were used in the foundation sand and crushed stone. The DMM zone is included in this analysis.

- Temporary Construction Stability (Not Required by CCR Rule), Min FoS = 1.30: This case models stability of the work pad and temporary cut slope during installation of the DMM zone. Undrained soil strengths are used for analysis due to the short-term nature of the loading condition (i.e. less than 6 months). The analysis was performed with and without a 500 psf construction surcharge load applied to the temporary construction bench, and modeled both

localized slip surfaces of the construction bench and a global slip surface encompassing them embankment. The DMM zone is not included in this analysis, as it corresponds to conditions during and immediately prior to construction. This analysis is conservative as it did not consider the limited width of the heavy equipment (3- dimensional effects) in the construction zone, and assumed a uniform surcharge over the entire area.

The minimum factor of safety for this case is not presented or required in the CCR Rule. However, USACE EM-1110-2-1902 (2003) lists a minimum factor of safety of 1.30 for temporary loading conditions for earthen embankments, so this criteria was used for design.

- Local Slope Stability of Work Pad (Not Required by CCR Rule), Min FoS = N/A: This case models the localized, surficial stability of the work pad under long-term conditions using drained soil strengths, and is intended to evaluate the potential for shallow sloughs of the relatively steep work pad. This case is not required by the CCR Rule but was evaluated by AECOM for the purposes of designing the work pad, as the work pad will permanently remain installed on the embankment and will not be removed. Regulatory or standard of engineering practice factors of safety are not available for local slope stability, so it is typically evaluated on a case-by-case basis. As seepage is not expected through the work pad, and any instability of the work pad will not affect the global stability of the overall embankment, a factor of safety of 1.30 was designated as the minimum factor of safety for this loading condition. The DMM zone not included in this analysis (see *Material Properties* section of the report).

Stability Analysis Approach

The slope stability analysis was conducted using SLOPE/W within the GeoStudio 2012 software package (Version 8.15.1.11236). The following approach was used to conduct the analysis:

- Analysis Method: Spencer
- Global Slip Surface Definition: Entry and exit. Slip surfaces were allowed to enter the ground surface upstream of the middle of the embankment crest and downstream of the embankment toe for global stability. Slip surface entry ranges were restricted to 150 ft upstream of the embankment crest for post-earthquake and pseudostatic analyses. This is because larger failure surfaces are not reasonable, and observed seismic failures of embankments are typically confined to the foundation and embankment itself, rather than a large zone of material behind the embankment.
- Local and Temporary Slip Surface Definition: Grid and radius, concentrated around the work pad at the toe of the embankment.

- Minimum Slip Surface Depth: 5 to 10 ft, depending on section and observed slip surface geometry
- Optimization: Critical slip surfaces were optimized. This allowed the critical slip surface to pass through the ash material in a nearly horizontal manner for many of the analysis cases.
- Tension Cracks: Added if necessary to reduce interslice tensile forces for all loading cases except pseudostatic stability. For pseudostatic stability, the short-duration nature of the loading was assumed to prevent a tension crack from opening. Where included, the tension crack was assumed to be full of water.
- Pore Pressures: From piezometric line

Material Properties –Soils (does not include DMM Zone)

Material properties for analysis were taken from the *Joppa Material Characterization* calculation package. The material properties are summarized in Tables 2, 3, and 4.

Table 2 – Joppa Soil Material Properties

Material	Unit Weight (pcf)	Peak Drained Shear Strength		Peak Undrained Shear Strength	Post-Earthquake Shear Strength
		Friction Angle (phi'), degrees	Cohesion (c'), psf		
Embankment Fill (Compacted Clay)	131	35	0	Shear/Normal Function[1]	Peak Undrained
Foundation Clay	128	33 (vertical) 29 (horizontal)	0	Shear/Normal Function[2]	Peak Undrained
Ash	106	33 (vertical) 29 (horizontal)	0	Su/p' = 0.44	Su/p' = 0.07
Foundation Sand	128	35	0	Peak Drained	Peak Drained
Soft Clay[3]	125	25	0	Su/p' = 0.23 Min Su = 500 psf	Su/p' = 0.18 Min Su = 400 psf
Working Pad[4]	125	30	0	1,500 psf	Peak Undrained
Crushed Stone[5]	130	40	0	Peak Drained	Peak Drained

Notes:

[1,2]Shear normal function is based on a Su/p' characterization. See Table 3 for Embankment Fill and table 4 for Foundation clay

[3]Strength testing was not performed on the soft clay. The design shear strengths are based on AECOM's experience with lower-bound drained and undrained shear strengths of normally consolidated soft clays in the region.

[4]The working pad is expected to be comprised of locally-sourced compacted clay fill. The design shear strengths are conservative values based on AECOM's analysis of compacted clay fill at the site comprising the embankment.

[5]Crushed stone shear strengths are based on AECOM's experience. The unit weight of 130 pcf is intended to correspond to a well-graded material with a relatively low void ratio.

Table 3 – Embankment Fill Shear/Normal Function

Effective Stress (psf)	Shear Strength (psf)
0	600
500	600
10,000	6,800

Table 4 – Foundation Clay Shear/Normal Function

Effective Stress (psf)	Shear Strength (psf)
0	700
10,000	4,800

As discussed in the *Joppa Material Characterization* calculation package, separate drained shear strengths, based on the orientation of the slip surface, were developed for the ash and foundation clay. Shear strengths in the vertical orientation were taken from CIU' triaxial tests and shear strength in the horizontal direction were taken from undrained direct simple shear (DSS) tests with pore pressure measurements, and drained direct shear (DS) tests. These strengths were modeled using anisotropic material models in SLOPE/W, where the horizontal and vertical friction angles were entered in the analysis separately. For the embankment fill, the various shear strength testing did not identify differing drained friction angles based on type of test, so a uniform friction angle of 35 degrees was used.

Material Properties –DMM Zone

Material properties for the DMM zone were estimated for undrained conditions only. This is because information on the drained composite strength of soil-DMM zones is limited in engineering literature, the drained friction angles of the insitu soils and ash are relatively high, and the drained strength of the soil-DMM zone will be at least as high, if not higher than the insitu soil, due to addition of the cement-based DMM columns, which likely add a considerable amount of cohesion to the composite DMM zone shear strength. Therefore, only undrained strengths were developed for the DMM zone, and the drained strength of the zone was assumed to be the same as the soil without any type of improvement.

Undrained soil strengths were developed by taking a weighted average of the undrained shear strength of the DMM columns and the undrained shear strength of the surrounding soil, based on the replacement ratio (i.e. for a 37% replacement ratio, the undrained strength of the DMM composite zone is 0.37 x DMM strength + 0.63 x soil strength). The DMM shear strength was developed using guidance presented in Filz and Templeton (2009), which states that the total stress cohesion intercept of the DMM zone should be one-half of the specified unconfined compressive strength of the DMM columns, multiplied by 0.8 to account for the reduction from peak unconfined strength to residual confined strength. Curing factors and variability factors recommended by Filz and Templeton were not included, as the Joppa DMM will include a performance-based specification based on testing of the 28-day

unconfined compressive strength of the DMM columns, and will require additional columns to be added if the variability and/or minimum strength criteria of the DMM columns is not met.

The Joppa DMM zone specifications will stipulate a design unconfined compressive strength of 150 psi Using these values and the Filz and Templeton equation, the undrained shear strength of the DMM zone will be 8,640 psf. This strength is assumed to be applicable for all of the soils which the DMM is installed in, and is not assumed to vary with depth, as it is a design value (and thereby may be exceeded in some areas of the columns).

The design DMM strength was then used to determine a composite DMM-soil strength for each of the soil materials present at the site. Because the undrained strength of the soil is dependent on the vertical effective stress, which varies with depth, this was done using an Excel spreadsheet to calculate the undrained shear strength of the soil under the crest centerline and toe of the embankment with depth, based on the shear strengths listed in Tables 2, 3, and 4. Weighted strengths, based on the DMM zone design shear strength, were then developed vs. depth for each soil at each location. The resulting data was then used to developed spatial shear strength functions in SLOPE/W, where the shear strength of the DMM zone was assumed to vary between the crest and toe, and remain constant upstream of the embankment crest and downstream of the toe. Variations between the crest and toe were modeled with either a linear interpretation or a Kriged surface, based on which method produced the more reasonable interpretation (this varied for each section and material type). These spreadsheets are attached to the calculation package.

Peak undrained strengths were used for the composite strength development for all materials. For the ash, which is susceptible to liquefaction, both peak undrained and post-liquefaction residual strengths were used to develop two separate strengths functions. Peak undrained strengths were used for the pseudostatic stability analysis and post-earthquake residual (liquefied) strengths were used for the post-earthquake analysis.

Geosynthetic Reinforcement Design

Section A requires a geosynthetic at the interface between the work pad and the existing grade, in order to maintain acceptable stability for the relatively steep slope of the work pad, due to encroachment of a creek channel into the toe of the work pad. Geotextiles and geogrids produced by Tencate Mirafi were evaluated for long-term allowable design strength (Tal) and pullout resistance following the criteria presented in FHWA NIH-10-024. (November 2009). The FHWA criterion reduces the ultimate strength of the geosynthetic using reduction factors for installation damage, creep, and durability. The reduction factors were picked from tables provided by FHWA and correspond to expected values based on the environment and expected installation procedures during construction. The resulting total reduction

factor is 4.6, meaning the ultimate tensile strength of the geosynthetic is reduced by a factor of 4.6 to determine the long-term allowable tensile strength.

Evaluated geosynthetics include the Mirafi PET70/70 through PET1000/100 geotextiles and the Mirafi 2XT to 24XT geogrids. A geosynthetic was selected for design as it also provides separation between the crushed stone and the clay subgrade, which is useful to prevent the migration of subgrade soil particles into the crushed stone.

Slope stability analyses were performed using the PET200 geotextile, which has a long-term allowable tensile strength of 3,000 lbs/ft. The geotextile was entered into the slope stability model at the proposed location. This was found to be effective for increasing the local slope stability factor of safety to at least 1.30 at Section A for both long-term drained conditions and temporary undrained conditions during construction. The pullout resistance of the geotextile was evaluated by calculating the length of geotextile behind the critical slip surface and estimating the pullout resistance following the FHWA criteria. The analysis found that the pullout resistance is higher than the strength of the fabric, which means that pullout is not the critical failure mode.

Geosynthetic calculations are attached to this document.

Seismic Deformation Analysis

Seismic deformations were evaluated using the Bray and Travasarou (2007) approach, within a spreadsheet developed by the authors. The approach uses the yield coefficient (k_y) estimated for the pseudostatic slope stability analysis (FoS = 1.00). The initial fundamental period of the embankment is then estimated based on the shear wave velocity of the embankment and the 2D relationship provided in the spreadsheet (Ts = 2.6H/Vs). Based on seismic CPT SC002, which was advanced at Section A, the approximate shear wave velocity of the embankment is about 600 ft/sec.

Additional input data includes the moment magnitude and spectral acceleration at the degraded period of the embankment (assumed to be 1.5 times Ts). For design, the moment magnitude was assumed to be equal to the greatest contributors to seismic hazards at Joppa, as found from a Probabilistic Seismic Hazard Assessment (PSHA) performed for Joppa by AECOM. Per the PSHA, the modal magnitude for Joppa is 7.6, which corresponds to an earthquake in the nearby New Madrid Seismic Zone. The spectral acceleration was taken from the Uniform Hazard Spectrum (UHS) presented in the PSHA for the ground surface, which was based on a one-dimensional site response analysis of the soils at the site which overly bedrock. This corresponds to the expected acceleration at the site's ground surface, or the interface between the embankment and foundation. The UHS is shown in Figure 1.

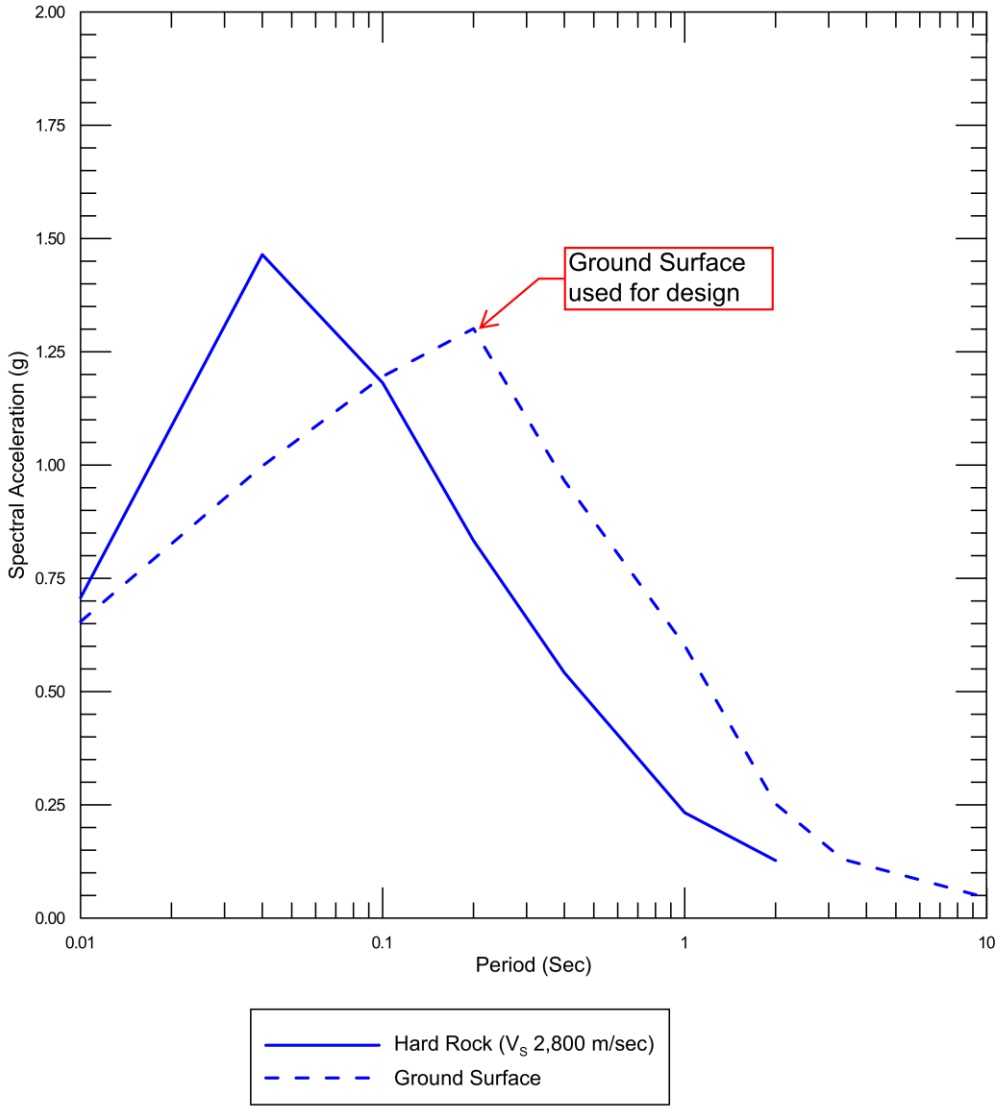


Figure 1: Joppa Uniform Hazard Spectrum (UHS)

The final inputs required for the spreadsheet are probability of exceedance values for deformations and a displacement threshold. The *displacement threshold* is termed as the maximum allowable deformations for the embankment. As the embankment typically has around 3 ft of freeboard, but does not contain critical buried components such as a drainage system or spillway pipe, a maximum vertical deformation of 3 ft was assumed, to correspond to a zero-freeboard condition. Probability of exceedance values were selected to correspond to mean minus one standard deviation, mean, and

mean plus one standard deviation levels, which correspond to lower-bound, mean, and upper bound deformations. The resulting upper-bound deformation (mean minus one standard deviation probability of exceedance value) is then selected for reporting.

Results

The DMM dimensions and notes are listed in Table 5. Resulting factors of safety are listed in Table 6 and upper bound seismic deformations are listed in Table 7. The DMM dimensions were sized to achieve the minimum factors of safety required by the USEPA CCR Rule criteria for all required loading conditions. For temporary construction conditions, the proposed work pad satisfies USACE stability criteria. Maximum estimated seismic deformations are on the order of 1.5 ft (both in the horizontal and vertical directions), which means that the embankment would still maintain about 1.5 feet of freeboard. Therefore, the deformations are expected to be tolerable, and correspond to a pseudostatic seismic factor of safety of 1.00.

Table 5 – Design DMM Dimensions and Notes

Section	DMM Width (ft)	DMM Estimated Height (ft)	DMM Min Bottom Elevation (ft)	DMM Top Elevation (ft)	DMM Est. Area (sf/ft)	Notes
H	30	28.1	321.2	349.3	715	Includes 5’ key into foundation clay.
K	30	38.3	311.0	349.3	1107	
K – 88+30	30	34.1	315.2	349.3	865	Based on available data, the foundation clay at this section is higher in elevation than at Section K. Includes 5’ key into foundation clay.
A	55	45.3	304.0	349.3	2370	Includes 5’ key into foundation clay. Also includes Mirafi PET200 geotextile between crushed stone and existing ground surface for temporary slope stability.

Table 6 – Slope Stability Analysis Factor of Safety

Section	Post-EQ Min FS = 1.20	Pseudostatic Min FS = 1.00	Max Storage Min FS = 1.50	Max Surcharge Min FS = 1.40	Temp Const. with Rig Min FS = 1.30[1]	Temp Const. w/o Rig Min FS = 1.30[1]	Local Work Pad Long-Term Min FS = 1.30[1]
H	1.27	1.00	1.60	1.58	1.58	1.54	1.49
K	1.22	1.00	1.53	1.53	1.36	1.42	1.35
K – 88+30	1.25	1.00	1.58	1.56	1.65	1.66	1.44
A	1.20	1.00	1.80	1.76	1.30[2] / 1.57[3]	1.30[2] / 1.63[3]	1.31[2] / 1.52[3]

[1]Loading condition and minimum factor of safety not required by USEPA CCR Rule.

[2]Refers to factors of safety when creek channel is adjacent to toe and the work pad toe is constructed out of riprap, with a 1.5H:1V slope to existing grade and a Mirafi PET200 geotextile on top of the existing grade. See text below for more information.

[3]Refers to factor of safety when creek channel is not adjacent to toe and the work pad is constructed out of compacted clay. See text below for more information.

Table 7 – Estimated Upper-Bound Seismic Deformations

Section	Yield Coefficient (k_y), g	Upper Bound* Seismic Deformations (cm)	Upper Bound* Seismic Deformations (inches)	Upper Bound* Seismic Deformations (feet)
H	0.242	46.0	18.1	1.5
K	0.245	41.2	16.2	1.4
K – 88+30	0.266	35.5	14.0	1.2
A	0.224	43.2	17.0	1.4

*Corresponds to mean minus one standard deviations probability of exceedance

At Section A, a stream encroaches near the toe of the proposed work pad for a distance of about 100 ft, before turning away from the work pad. This essentially means that the work pad is 5 to 10 ft higher at this location. As a result, the long-term local stability of the work pad is insufficient when it is constructed out of compacted clay. If crushed stone is used to construct the toe of the work pad, and the slope of the work pad is steepened to 1.5H:1V and a Mirafi PET200 geotextile is added between the existing grade and the crushed stone, the local stability factor of safety is 1.31, which is acceptable. For this configuration, a vertical interface between the compacted clay work pad and crushed stone toe would be present 1.5 feet downslope of the proposed DMM zone to allow mixing through the clay work pad. In areas where the ditch is not present, a supplemental stability analysis was performed assuming the ditch is filled in. The factor of safety for this condition, assuming the work pad is constructed fully

out of compacted clay with a 2H:1V slope and no geotextile, is 1.5. So the crushed stone and geotextile is only required where the creek encroaches into the slope of the work pad.

In adjacent areas near Section A, a supplemental analysis was done where the ditch was not included in the model and the work pad was assumed to be constructed out of compacted clay (not riprap). The factor of safety for local stability was 1.56, which is acceptable. Therefore, the crushed stone construction of the toe will only be required between approximate stations 90+00 and 90+80, where the stream is adjacent to the toe of the work pad.

Attachments

1. Engineering Analysis Output
    a. Section H
    b. Section K
    c. Section K – 88+30
    d. Section A
2. Geosynthetic Calculations
3. Section and Profile Drawings

Calculation Notes AECOM

Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50) Project Name: Dynegy CCR

By: Lucas Carr Date: 4/14/2016 Project No: 60440155

Checked By: Andy Wilding Date: 4/26/2016 Task No.: 01

Attachment 1

Engineering Analysis Output

Calculation Notes

Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50) Project Name: Dynegy CCR

By: Lucas Carr Date: 4/14/2016 Project No: 60440155

Checked By: Andy Wilding Date: 4/26/2016 Task No.: 01

1.A – Section H

Section H - Peak Undrained DMM Design Shear Strengths

Replacement Ratio: 0.37

Composite DMM Strengths at Embankment Centerline (x=300 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	378.1	0	0	0	0	600	8640	3197	3575
	131	355.0	0	3026	3026	3026	2300	8640	3197	4646
	131	322.5	2028	4258	7284	5256	3700	8640	3197	5528
Ash	106	322.5	2028	0	7284	5256	2312	8640	3197	4654
	106	318.6	2271	413	7697	5426	2387	8640	3197	4701
Fdxn Clay	128	318.6	2271	0	7697	5426	3000	8640	3197	5087
	128	300.7	3388	2291	9988	6600	3400	8640	3197	5339
Sand	128	300.7	3388	0	9988	6600	4621	8640	3197	6108
	128	200.0	9672	12890	22878	13206	9247	8640	3197	9022

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
300.0	378.1	3575
300.0	355.0	4646
300.0	322.5	5528
300.0	322.5	4654
300.0	318.6	4701
300.0	318.6	5087
300.0	300.7	5339
300.0	300.7	6108
300.0	200.0	9022

299.0	378.1	3575
299.0	355.0	4646
299.0	322.5	5528
299.0	322.5	4654
299.0	318.6	4701
299.0	318.6	5087
299.0	300.7	5339
299.0	300.7	6108
299.0	200.0	9022

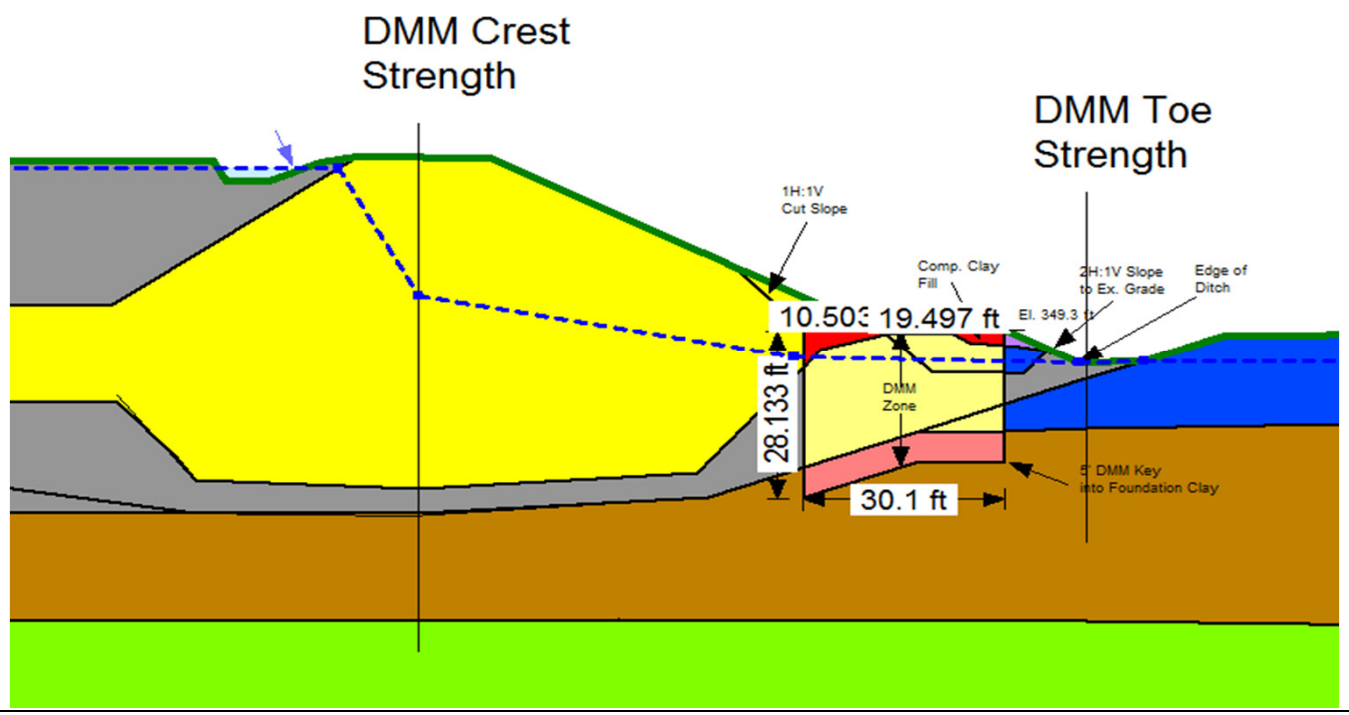
Composite DMM Strengths at Embankment Toe (x=400 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill			-	-	-	-	600	8640	3197	3575
			-	-	-	-	600	8640	3197	3575
Ash	106	344	0	0	0	0	0	8640	3197	3197
	106	333	705	1198	1198	493	217	8640	3197	3333
Fdxn Clay	128	333	705	0	1198	493	950	8640	3197	3795
	128	301	2702	4096	5294	2592	1800	8640	3197	4331
Sand	128	301	2702	0	5294	2592	1815	8640	3197	4340
	128	200	8973	12864	18158	9185	6431	8640	3197	7248

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
376.9	348.4	3575
376.9	342.0	3575
400.0	343.8	3197
400.0	332.5	3333
400.0	332.5	3795
400.0	300.5	4331
400.0	300.5	4340
400.0	200.0	7248

377.9	348.4	3575
377.9	342.0	3575
401.0	343.8	3197
401.0	332.5	3333
401.0	332.5	3795
401.0	300.5	4331
401.0	300.5	4340
401.0	200.0	7248



Section H - Post-EQ DMM Design Shear Strengths

Replacement Ratio: 0.37

Composite DMM Strengths at Embankment Centerline (x=300 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	378.1	0	0	0	0	600	8640	3197	3575
	131	355.0	0	3026	3026	3026	2300	8640	3197	4646
	131	322.5	2028	4258	7284	5256	3700	8640	3197	5528
Ash	106	322.5	2028	0	7284	5256	368	8640	3197	3429
	106	318.6	2271	413	7697	5426	380	8640	3197	3436
Fdxn Clay	128	318.6	2271	0	7697	5426	3000	8640	3197	5087
	128	300.7	3388	2291	9988	6600	3400	8640	3197	5339
Sand	128	300.7	3388	0	9988	6600	4621	8640	3197	6108
	128	200.0	9672	12890	22878	13206	9247	8640	3197	9022

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
300.0	378.1	3575
300.0	355.0	4646
300.0	322.5	5528
300.0	322.5	3429
300.0	318.6	3436
300.0	318.6	5087
300.0	300.7	5339
300.0	300.7	6108
300.0	200.0	9022

299.0	378.1	3575
299.0	355.0	4646
299.0	322.5	5528
299.0	322.5	3429
299.0	318.6	3436
299.0	318.6	5087
299.0	300.7	5339
299.0	300.7	6108
299.0	200.0	9022

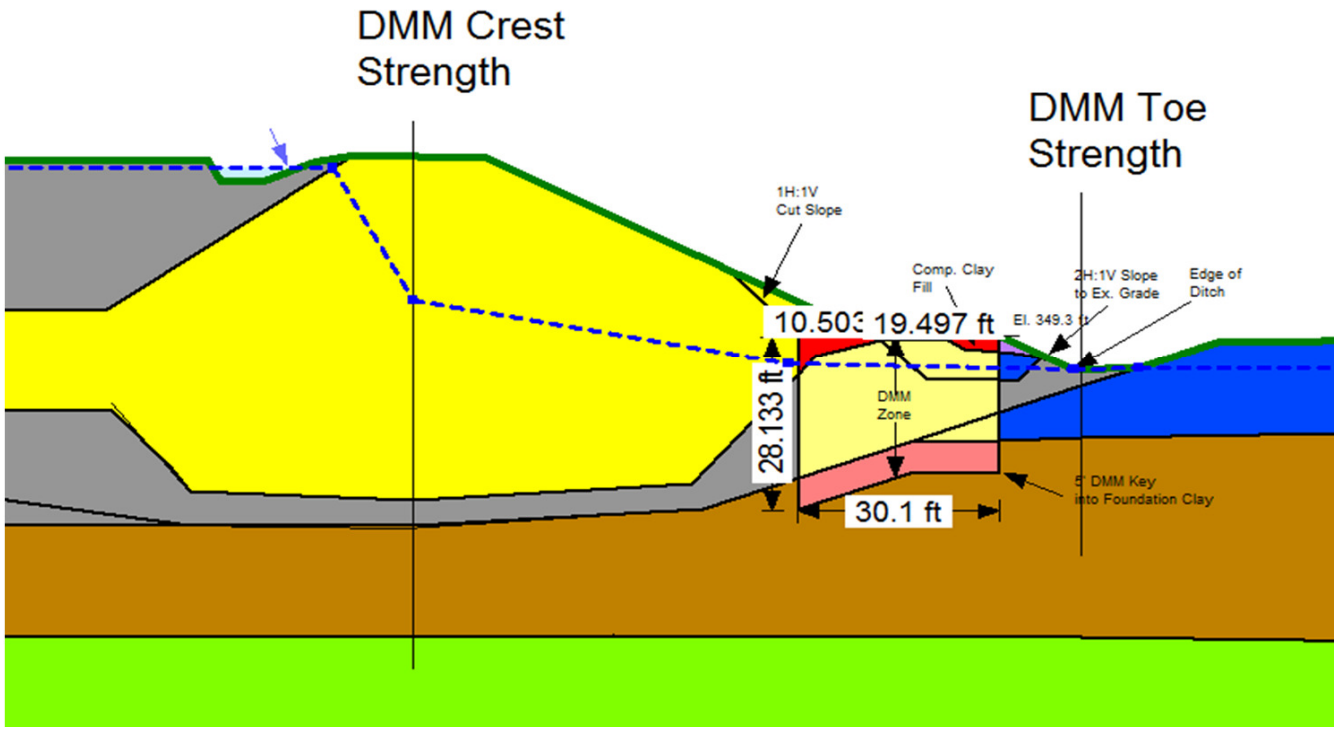
Composite DMM Strengths at Embankment Toe (x=400 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	-	-	-	-	-	-	600	8640	3197	3575
	-	-	-	-	-	-	600	8640	3197	3575
Ash	106	344	0	0	0	0	0	8640	3197	3197
	106	333	705	1198	1198	493	34	8640	3197	3219
Fdxn Clay	128	333	705	0	1198	493	950	8640	3197	3795
	128	301	2702	4096	5294	2592	1800	8640	3197	4331
Sand	128	301	2702	0	5294	2592	1815	8640	3197	4340
	128	200	8973	12864	18158	9185	6431	8640	3197	7248

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
376.9	348.4	3575
376.9	342.0	3575
400.0	343.8	3197
400.0	332.5	3219
400.0	332.5	3795
400.0	300.5	4331
400.0	300.5	4340
400.0	200.0	7248

377.9	348.4	3575
377.9	342.0	3575
401.0	343.8	3197
401.0	332.5	3219
401.0	332.5	3795
401.0	300.5	4331
401.0	300.5	4340
401.0	200.0	7248



Joppa Section H DMM Design

Computed By: LPC
Date: 4/19/2016

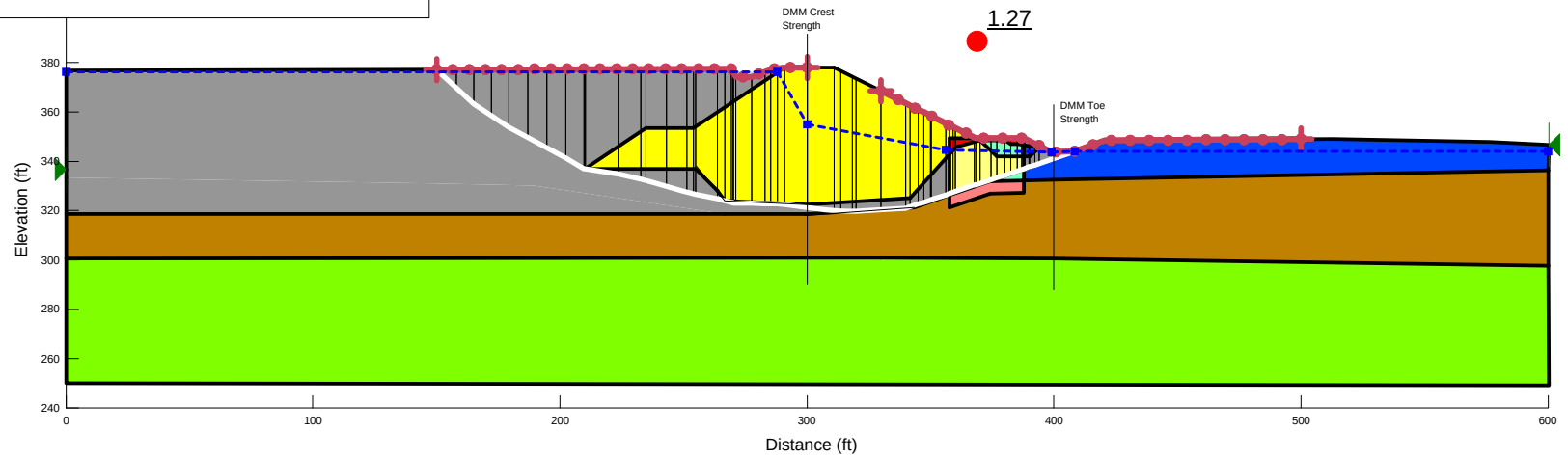
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Fly Ash (Post-Liquefaction) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.07 Minimum Strength: 0 psf Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: DMM - Embankment Unit Weight: 131 pcf Cohesion Spatial Fn: Embankment Fill DMM Phi': 0 ° Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: DMM - Foundation Unit Weight: 128 pcf Cohesion Spatial Fn: Foundation DMM Phi': 0 ° Piezometric Line: 1
Name: DMM - Ash (Post-EQ) Unit Weight: 106 pcf Cohesion Spatial Fn: Ash DMM - Post EQ Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay - Softened Unit Weight: 125 pcf Tau/Sigma Ratio: 0.184 Minimum Strength: 400 psf Piezometric Line: 1
Name: DMM - Soft Clay Unit Weight: 125 pcf Cohesion': 3,448 psf Phi': 0 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Fly Ash (Post-Liquefaction)
- Foundation Sand (Peak Drained)
- DMM - Embankment
- Toe Buttress (Peak Undrained)
- DMM - Foundation
- DMM - Ash (Post-EQ)
- Soft NC Clay - Softened
- DMM - Soft Clay

Section H Post-EQ

Kind: SLOPE/W
Method: Spencer
F of S: 1.27



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Joppa Section H DMM Design

Computed By: LPC
Date: 4/19/2016

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Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: DMM - Embankment Unit Weight: 131 pcf Cohesion Spatial Fn: Embankment Fill DMM Phi': 0 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: DMM - Ash Unit Weight: 106 pcf Cohesion Spatial Fn: Ash DMM Phi': 0 ° Piezometric Line: 1
Name: DMM - Foundation Unit Weight: 128 pcf Cohesion Spatial Fn: Foundation DMM Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Tau/Sigma Ratio: 0.23 Minimum Strength: 500 psf Piezometric Line: 1
Name: DMM - Soft Clay Unit Weight: 125 pcf Cohesion': 3,448 psf Phi': 0 ° Piezometric Line: 1

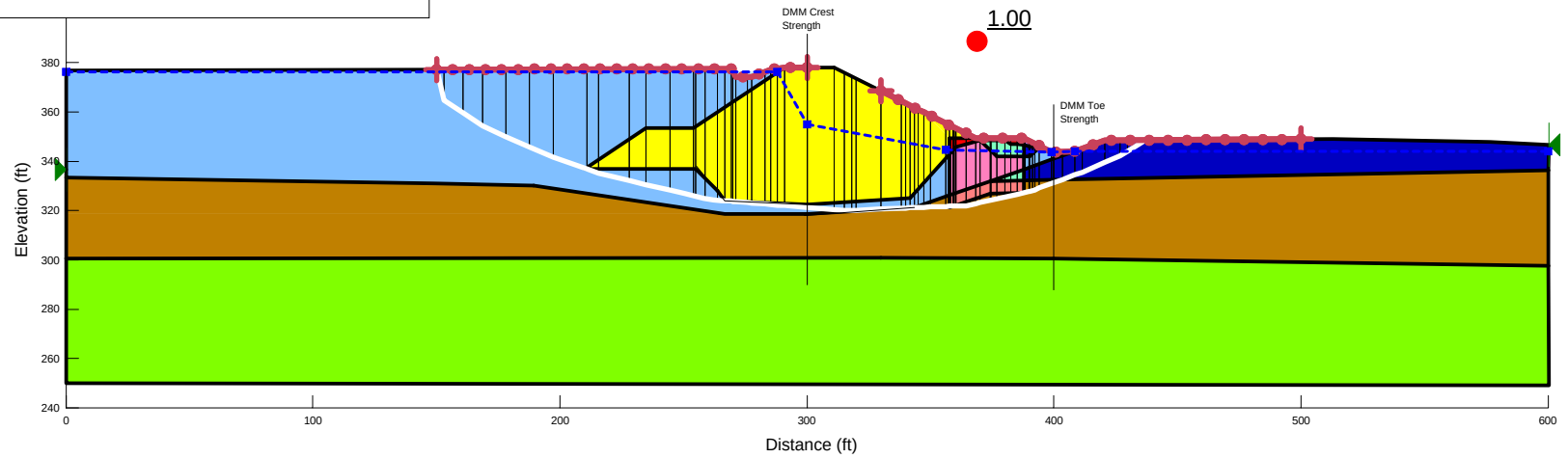
Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- DMM - Embankment
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- DMM - Ash
- DMM - Foundation
- Soft NC Clay
- DMM - Soft Clay

Section H Pseudostatic

Kind: SLOPE/W
Method: Spencer
F of S: 1.00

Pseudostatic Seismic Yield
ky = 0.242 g



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Joppa Section H DMM Design

Computed By: LPC
Date: 4/19/2016

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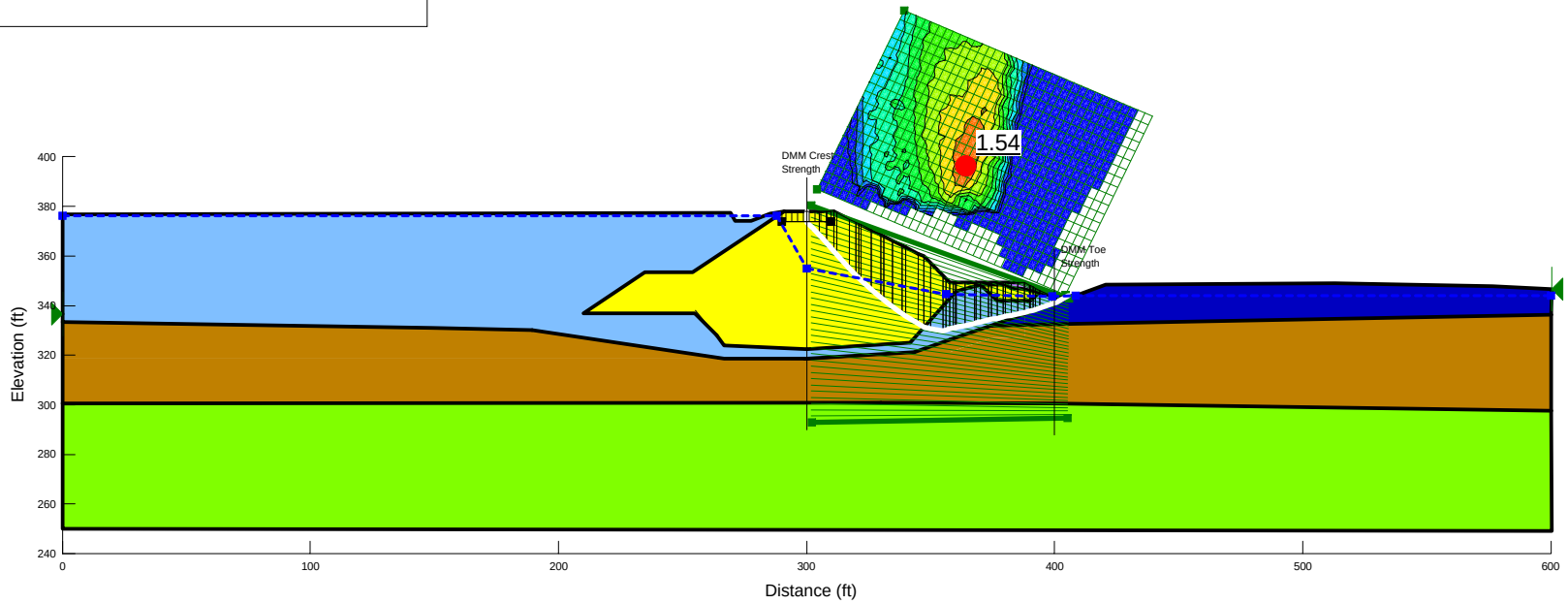
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Tau/Sigma Ratio: 0.23 Minimum Strength: 500 psf Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- Soft NC Clay

Section H Temp Construction

Kind: SLOPE/W
Method: Spencer
F of S: 1.54



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Joppa Section H DMM Design

Computed By: LPC
Date: 4/19/2016

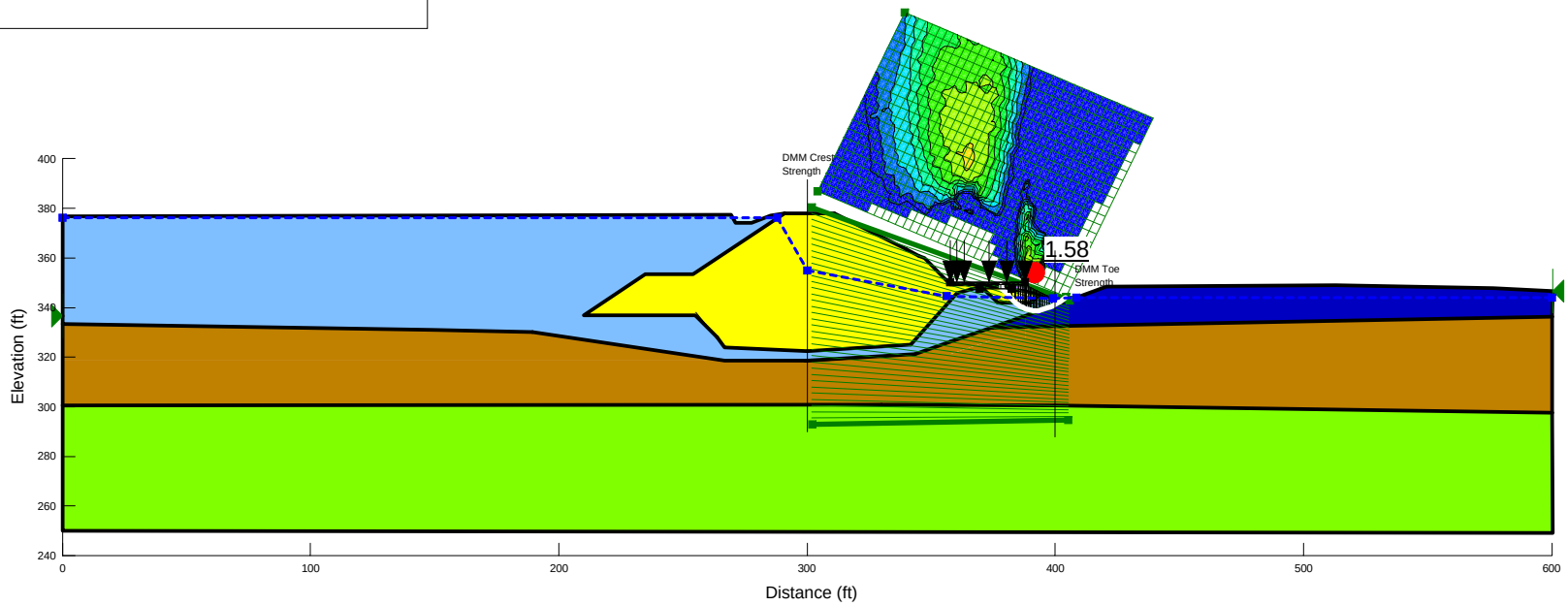
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Tau/Sigma Ratio: 0.23 Minimum Strength: 500 psf Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- Soft NC Clay

Section H Temp Construction - Rig Load

Kind: SLOPE/W
Method: Spencer
F of S: 1.58



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Joppa Section H DMM Design
Long-Term Drained Analysis

Computed By: LPC
Date: 4/19/2016

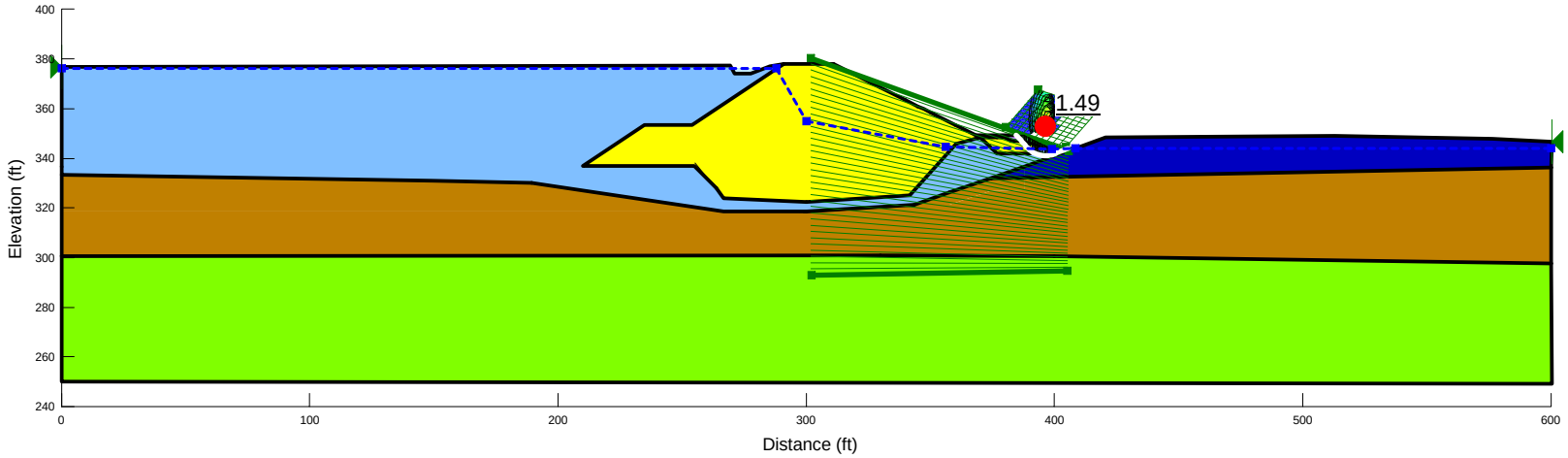
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Cohesion': 0 psf Phi': 25 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)
- Soft NC Clay

Name: Section H Local Stability

Kind: SLOPE/W
Method: Spencer
F of S: 1.49



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Joppa Section H DMM Design
Long-Term Drained Analysis

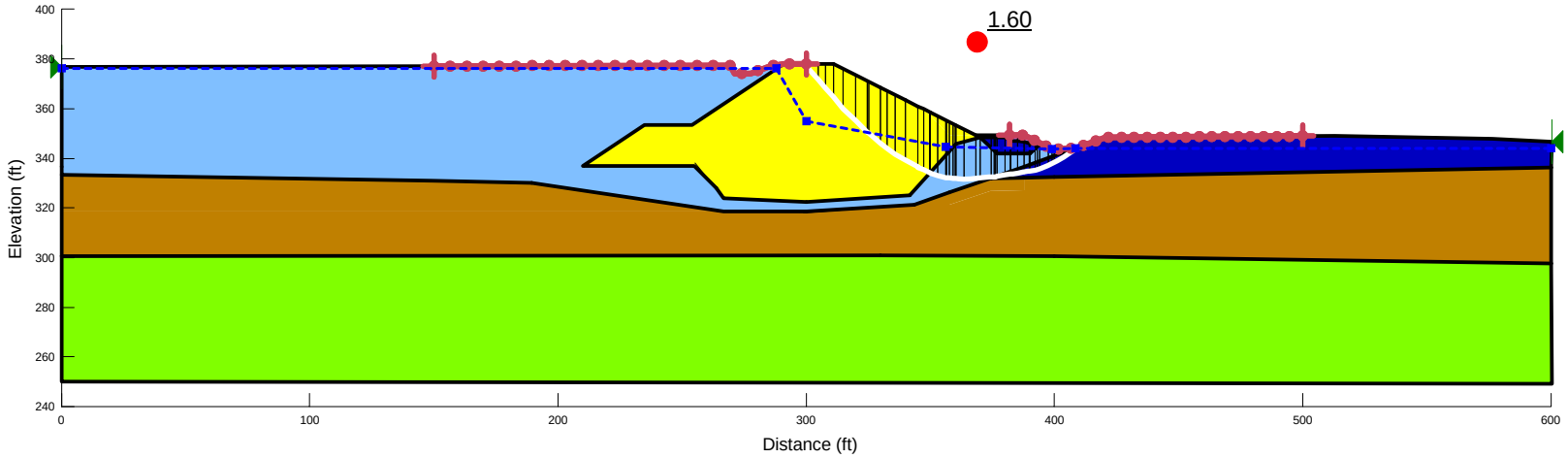
Computed By: LPC
Date: 4/19/2016

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Cohesion': 0 psf Phi': 25 ° Piezometric Line: 1

Materials
- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)
- Soft NC Clay

Name: Section H Max Storage Pool

Kind: SLOPE/W
Method: Spencer
F of S: 1.60



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Joppa Section H DMM Design
Long-Term Drained Analysis

Computed By: LPC
Date: 4/26/2016

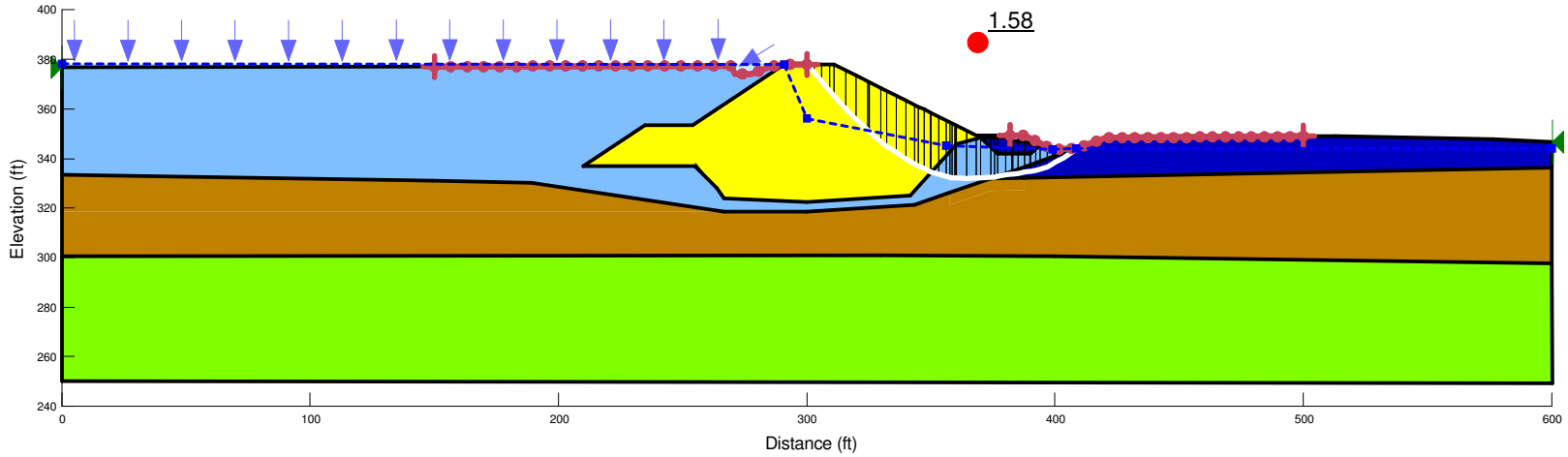
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Cohesion': 0 psf Phi': 25 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)
- Soft NC Clay

Name: Section H Max Surcharge Pool

Kind: SLOPE/W
Method: Spencer
F of S: 1.58



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Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.242		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.126533	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.19	seconds	
Moment Magnitude (Mw)	7.6		
Spectral Acceleration (Sa(1.5Ts))	1.3	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	91.44	cm

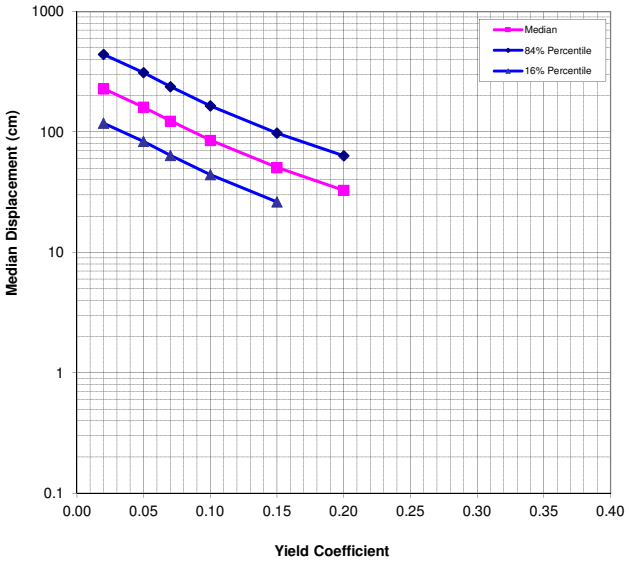
Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	23.85	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results			
Probability of Negligible Displ. (P(D=0))	0.00		eq. (3)
D1	12.4	cm	calc. using eq. (7)
D2	23.8	cm	calc. using eq. (7)
D3	46.0	cm	calc. using eq. (7)
P(D>d_threshold)	0.02		eq. (7)

Notes
1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
(e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s, i.e. Ts = 0.0. If Ts is just less than 0.05 s, set Ts = 0.050 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

Dependence on ky

ky	P(D="0")	D (cm)	Dmedian (cm)	D-84% (cm)	D-16% (cm)
0.020	0.00	228.4	228.4	440.4	118.5
0.05	0.00	161.1	161.1	310.5	83.6
0.07	0.00	123.1	123.1	237.4	63.9
0.1	0.00	85.3	85.3	164.4	44.3
0.15	0.00	50.7	50.7	97.7	26.3
0.2	0.00	32.8	32.8	63.2	17.0
0.3	0.00	16.2	16.2	31.2	8.4
0.4	0.01	9.2	9.0	17.5	4.6



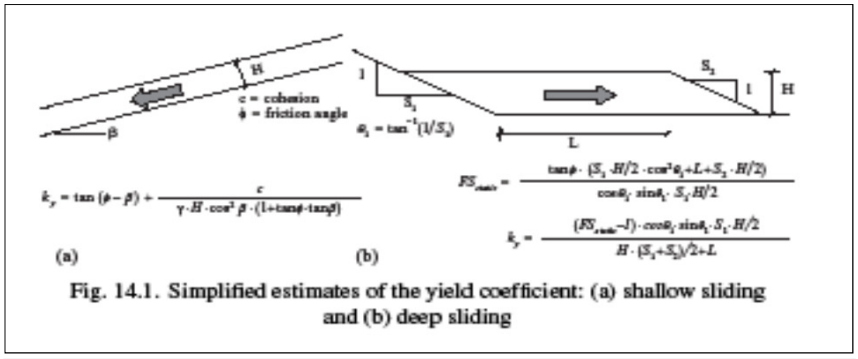


Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

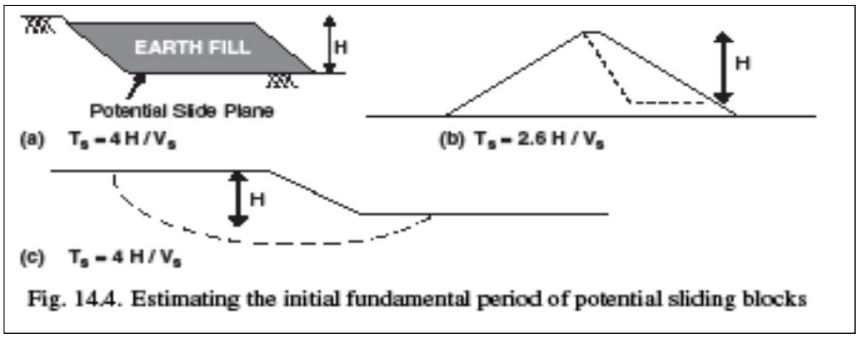


Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

Figures from Bray, J.D. (2007) "Chapter 14: Simplified Seismic Slope Displacement Procedures," Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

Calculation Notes

Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50) Project Name: Dynegy CCR

By: Lucas Carr Date: 4/14/2016 Project No: 60440155

Checked By: Andy Wilding Date: 4/26/2016 Task No.: 01

1.B – Section K

Section K - Peak Undrained DMM Design Shear Strengths

Replacement Ratio: 0.37

Composite DMM Strengths at Embankment Centerline (x=338 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	380.1	0	0	0	0	600	8640	3197	3575
	131	355.0	0	3288	3288	3288	2500	8640	3197	4772
	131	322.7	2016	4231	7519	5504	3900	8640	3197	5654
Ash	106	322.7	2016	0	7519	5504	2422	8640	3197	4722
	106	313.4	2596	986	8505	5909	2600	8640	3197	4835
Fdxn Clay	128	313.4	2596	0	8505	5909	3100	8640	3197	5150
	128	304.6	3145	1126	9632	6487	3300	8640	3197	5276
Sand	128	304.6	3145	0	9632	6487	4542	8640	3197	6058
	128	200.0	9672	13389	23020	13348	9347	8640	3197	9085

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
338.0	380.1	3575
338.0	355.0	4772
338.0	322.7	5654
338.0	322.7	4722
338.0	313.4	4835
338.0	313.4	5150
338.0	304.6	5276
338.0	304.6	6058
338.0	200.0	9085

337.0	380.1	3575
337.0	355.0	4772
337.0	322.7	5654
337.0	322.7	4722
337.0	313.4	4835
337.0	313.4	5150
337.0	304.6	5276
337.0	304.6	6058
337.0	200.0	9085

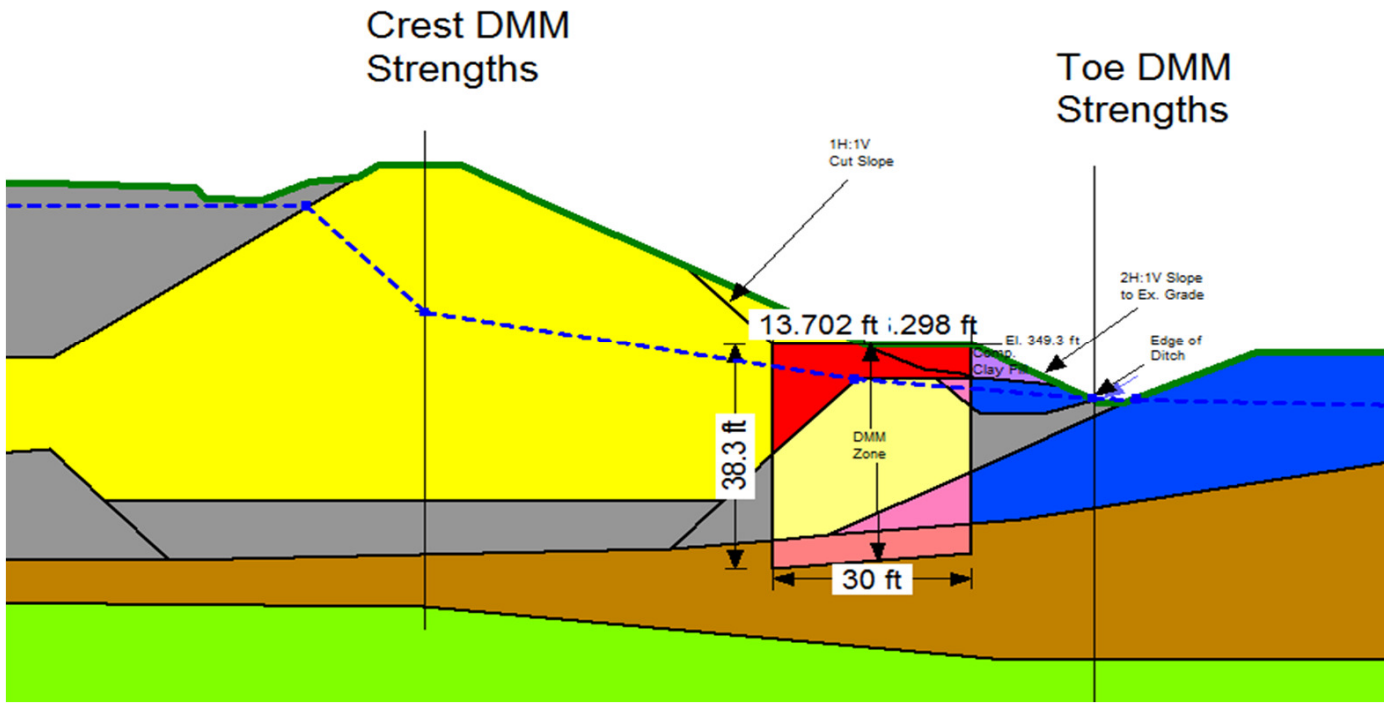
Composite DMM Strengths at Embankment Toe (x=400 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	-	-	-	-	-	-	600	8640	3197	3575
	-	-	-	-	-	-	600	8640	3197	3575
Ash	106	339.8	0	0	0	0	0	8640	3197	3197
	106	321.5	1142	1940	1940	798	351	8640	3197	3418
Fdxn Clay	128	321.5	1142	0	1940	798	1050	8640	3197	3858
	128	295.6	2758	3315	5255	2497	1700	8640	3197	4268
Sand	128	295.6	2758	0	5255	2497	1748	8640	3197	4298
	128	200.0	8724	12237	17492	8768	6140	8640	3197	7065

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
413.9	345	3575
413.9	343.3	3575
440.0	339.8	3197
440.0	321.5	3418
440.0	321.5	3858
440.0	295.6	4268
440.0	295.6	4298
440.0	200.0	7065

414.9	345.0	3575
414.9	343.3	3575
441.0	339.8	3197
441.0	321.5	3418
441.0	321.5	3858
441.0	295.6	4268
441.0	295.6	4298
441.0	200.0	7065



Section K - Post-EQ DMM Design Shear Strengths

Replacement Ratio: 0.37

Composite DMM Strengths at Embankment Centerline (x=338 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	380.1	0	0	0	0	600	8640	3197	3575
	131	355.0	0	3288	3288	3288	2500	8640	3197	4772
	131	322.7	2016	4231	7519	5504	3900	8640	3197	5654
Ash	106	322.7	2016	0	7519	5504	385	8640	3197	3440
	106	313.4	2596	986	8505	5909	414	8640	3197	3457
Fdxn Clay	128	313.4	2596	0	8505	5909	3100	8640	3197	5150
	128	304.6	3145	1126	9632	6487	3300	8640	3197	5276
Sand	128	304.6	3145	0	9632	6487	4542	8640	3197	6058
	128	200.0	9672	13389	23020	13348	9347	8640	3197	9085

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
338.0	380.1	3575
338.0	355.0	4772
338.0	322.7	5654
338.0	322.7	3440
338.0	313.4	3457
338.0	313.4	5150
338.0	304.6	5276
338.0	304.6	6058
338.0	200.0	9085

337.0	380.1	3575
337.0	355.0	4772
337.0	322.7	5654
337.0	322.7	3440
337.0	313.4	3457
337.0	313.4	5150
337.0	304.6	5276
337.0	304.6	6058
337.0	200.0	9085

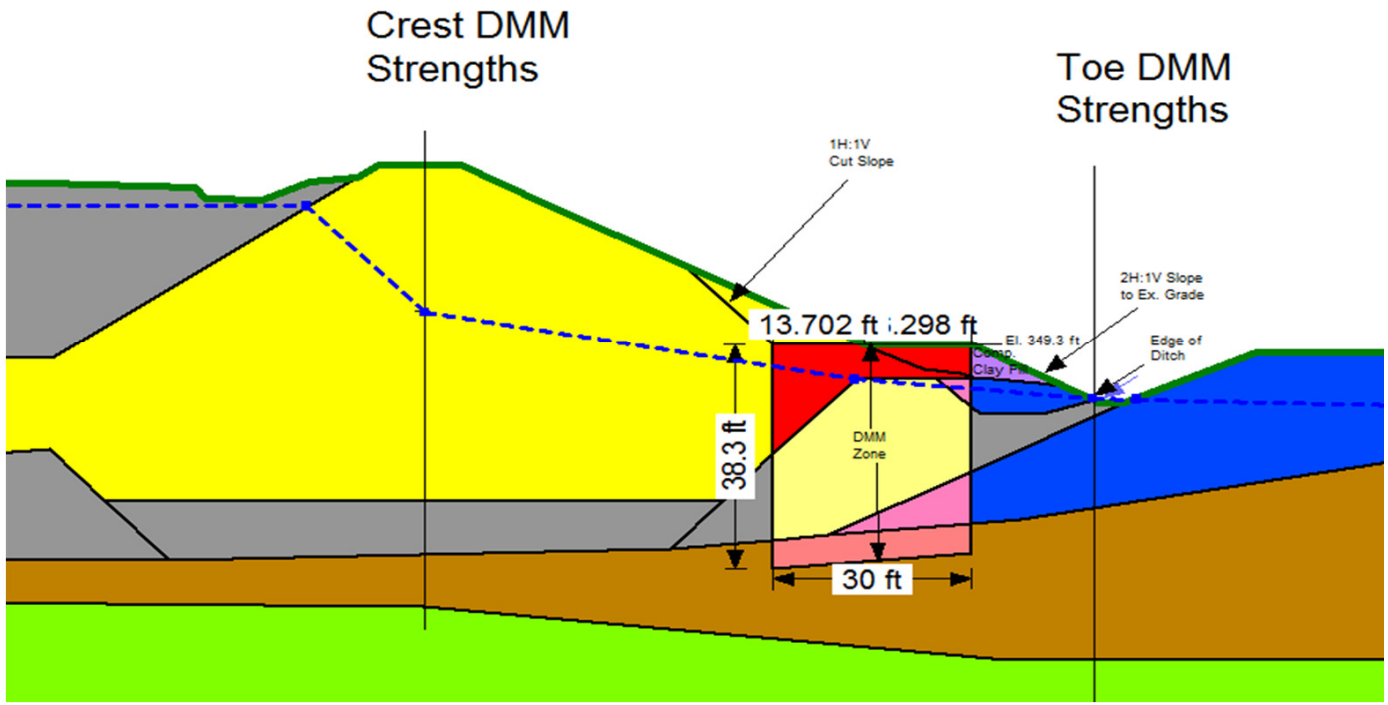
Composite DMM Strengths at Embankment Toe (x=400 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	-	-	-	-	-	-	600	8640	3197	3575
	-	-	-	-	-	-	600	8640	3197	3575
Ash	106	339.8	0	0	0	0	0	8640	3197	3197
	106	321.5	1142	1940	1940	798	56	8640	3197	3232
Fdxn Clay	128	321.5	1142	0	1940	798	1050	8640	3197	3858
	128	295.6	2758	3315	5255	2497	1700	8640	3197	4268
Sand	128	295.6	2758	0	5255	2497	1748	8640	3197	4298
	128	200.0	8724	12237	17492	8768	6140	8640	3197	7065

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
413.9	345	3575
413.9	343.3	3575
440.0	339.8	3197
440.0	321.5	3232
440.0	321.5	3858
440.0	295.6	4268
440.0	295.6	4298
440.0	200.0	7065

414.9	345.0	3575
414.9	343.3	3575
441.0	339.8	3197
441.0	321.5	3232
441.0	321.5	3858
441.0	295.6	4268
441.0	295.6	4298
441.0	200.0	7065



Joppa Section K DMM Design

Computed By: LPC
Date: 4/19/2016

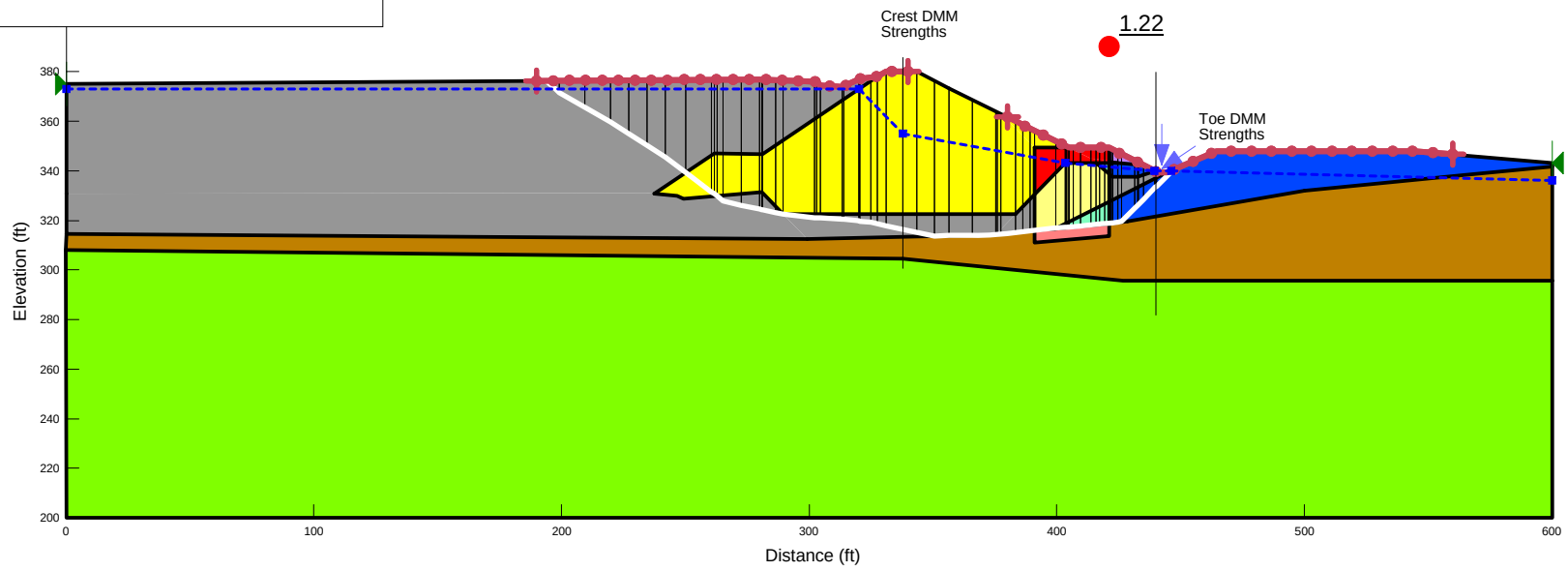
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Fly Ash (Post-Liquefaction) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.07 Minimum Strength: 0 psf Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: DMM - Embankment Unit Weight: 131 pcf Cohesion Spatial Fn: Embankment Fill DMM Phi': 0 ° Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: DMM - Foundation Unit Weight: 128 pcf Cohesion Spatial Fn: Foundation DMM Phi': 0 ° Piezometric Line: 1
Name: DMM - Ash (Post-EQ) Unit Weight: 106 pcf Cohesion Spatial Fn: Ash DMM - Post-EQ Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay - Softened Unit Weight: 125 pcf Tau/Sigma Ratio: 0.184 Minimum Strength: 400 psf Piezometric Line: 1
Name: DMM - Soft Clay Unit Weight: 125 pcf Cohesion': 3,448 psf Phi': 0 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Fly Ash (Post-Liquefaction)
- Foundation Sand (Peak Drained)
- DMM - Embankment
- Toe Buttress (Peak Undrained)
- DMM - Foundation
- DMM - Ash (Post-EQ)
- Soft NC Clay - Softened
- DMM - Soft Clay

Section K Post-EQ

Kind: SLOPE/W
Method: Spencer
F of S: 1.22



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Joppa Section K DMM Design

Computed By: LPC
Date: 4/19/2016

Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: DMM - Embankment Unit Weight: 131 pcf Cohesion Spatial Fn: Embankment Fill DMM Phi': 0 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: DMM - Ash Unit Weight: 106 pcf Cohesion Spatial Fn: Ash DMM Phi': 0 ° Piezometric Line: 1
Name: DMM - Foundation Unit Weight: 128 pcf Cohesion Spatial Fn: Foundation DMM Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Tau/Sigma Ratio: 0.23 Minimum Strength: 500 psf Piezometric Line: 1
Name: DMM - Soft Clay Unit Weight: 125 pcf Cohesion': 3,448 psf Phi': 0 ° Piezometric Line: 1

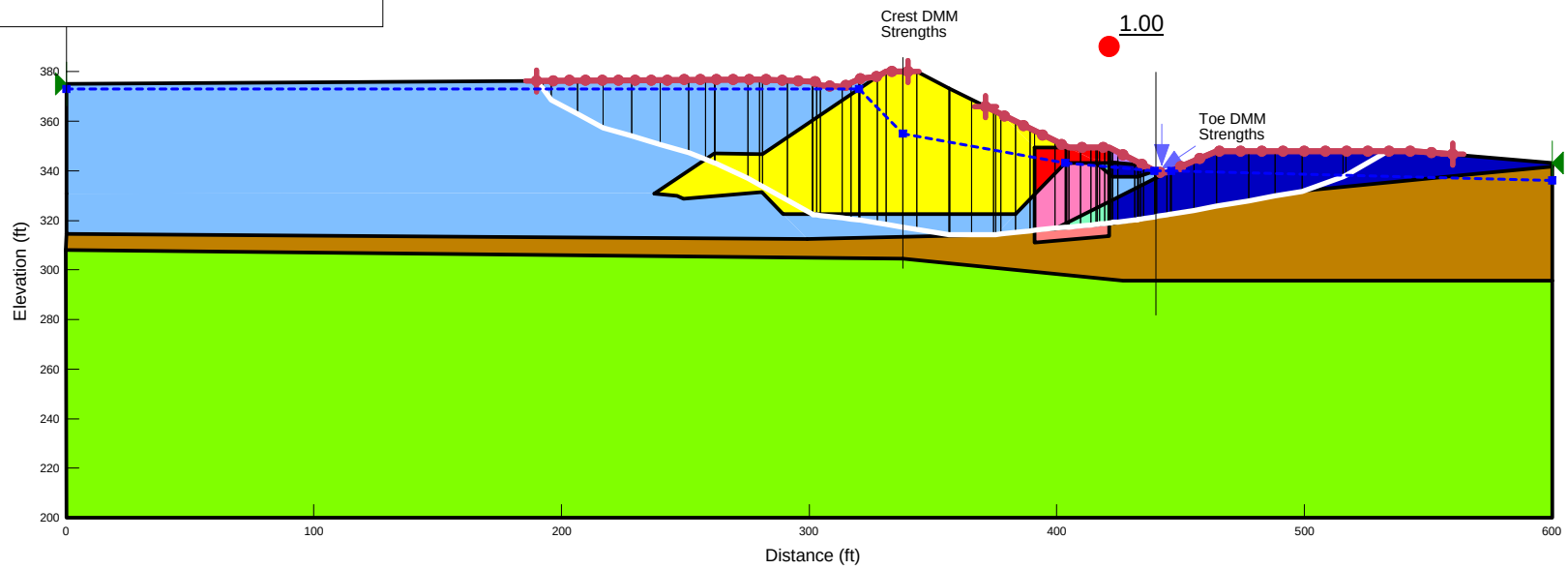
Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- DMM - Embankment
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- DMM - Ash
- DMM - Foundation
- Soft NC Clay
- DMM - Soft Clay

Section K Pseudostatic

Kind: SLOPE/W
Method: Spencer
F of S: 1.00

Pseudostatic Seismic Yield
ky = 0.245 g



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Joppa Section K DMM Design

Computed By: LPC
Date: 4/19/2016

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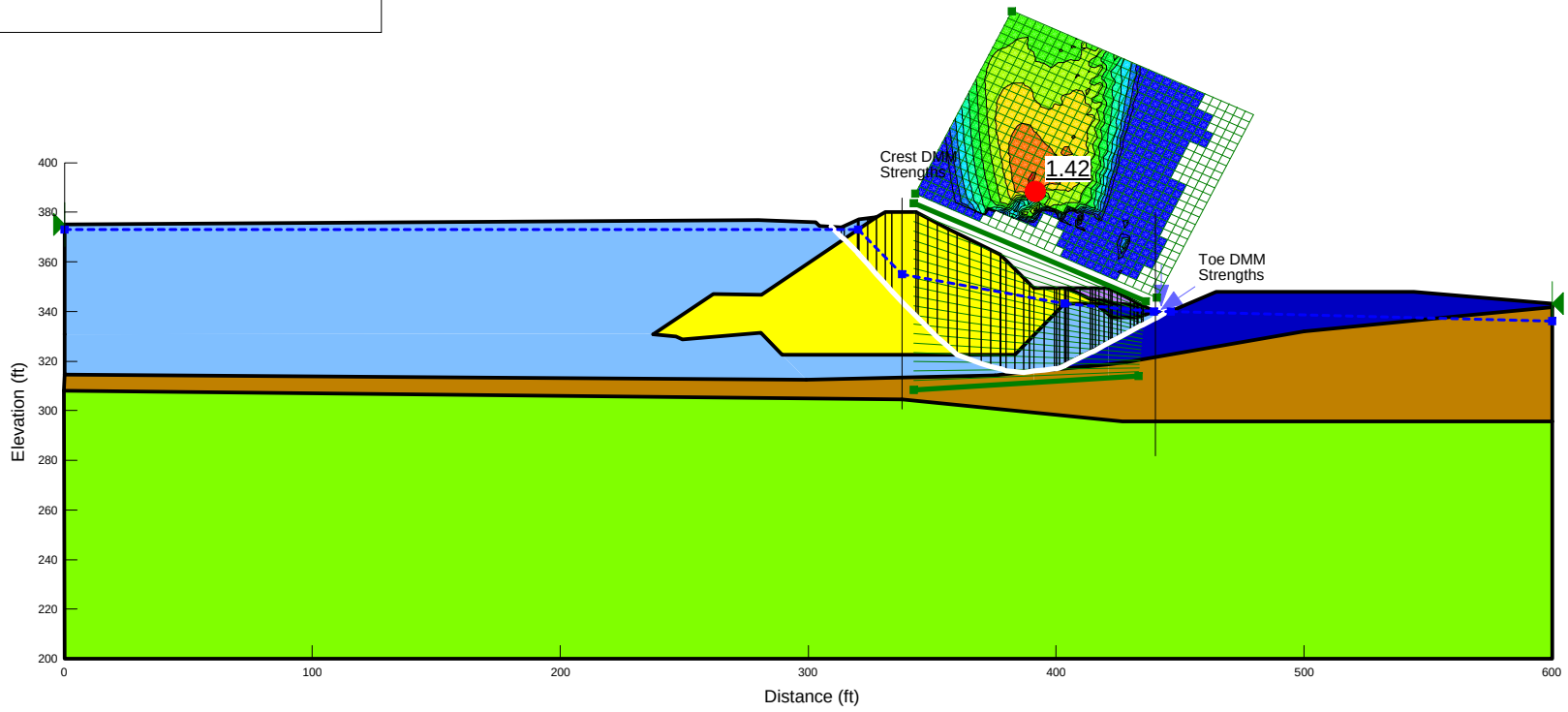
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Tau/Sigma Ratio: 0.23 Minimum Strength: 500 psf Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- Soft NC Clay

Section K Temp Construction

Kind: SLOPE/W
Method: Spencer
F of S: 1.42



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Joppa Section K DMM Design

Computed By: LPC
Date: 4/19/2016

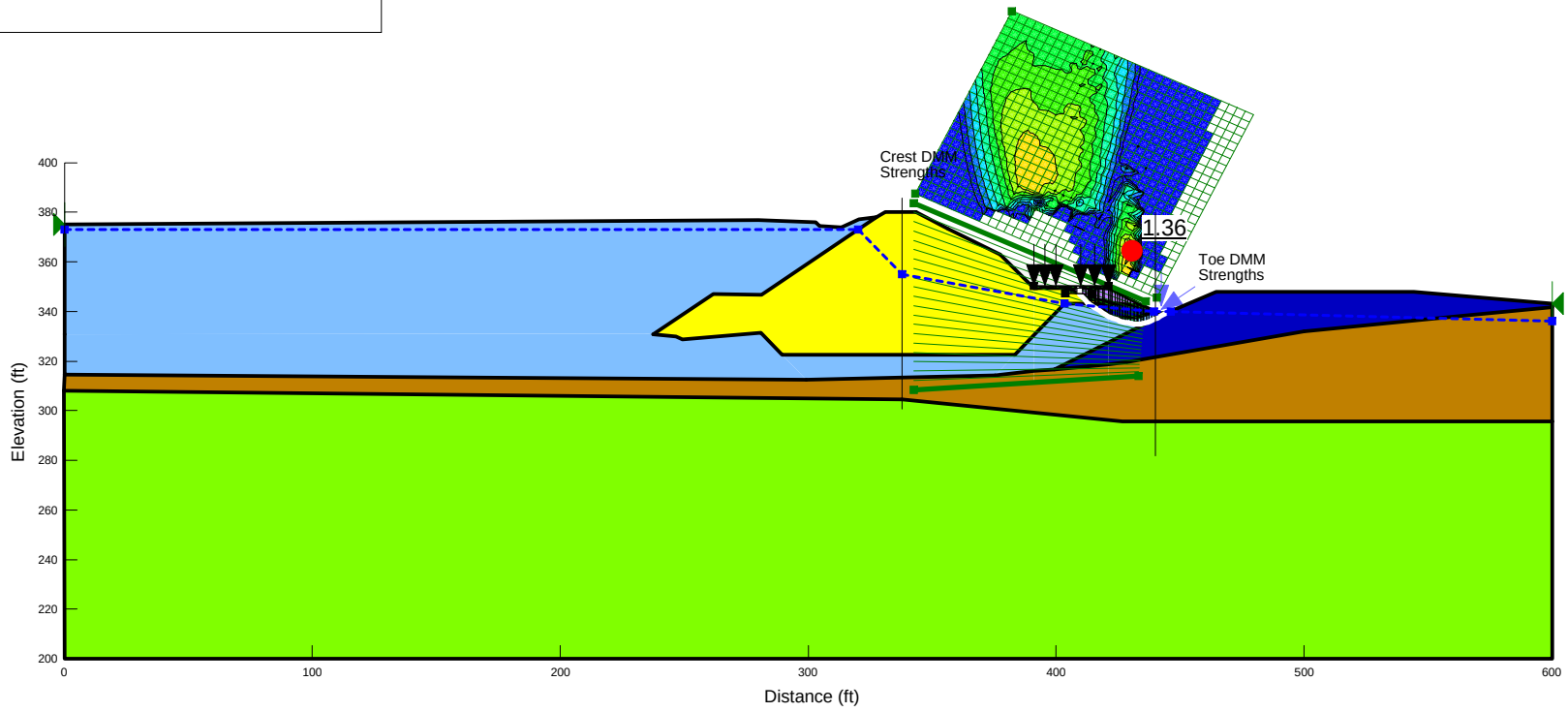
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Tau/Sigma Ratio: 0.23 Minimum Strength: 500 psf Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- Soft NC Clay

Section K Temp Construction - Rig Load

Kind: SLOPE/W
Method: Spencer
F of S: 1.36



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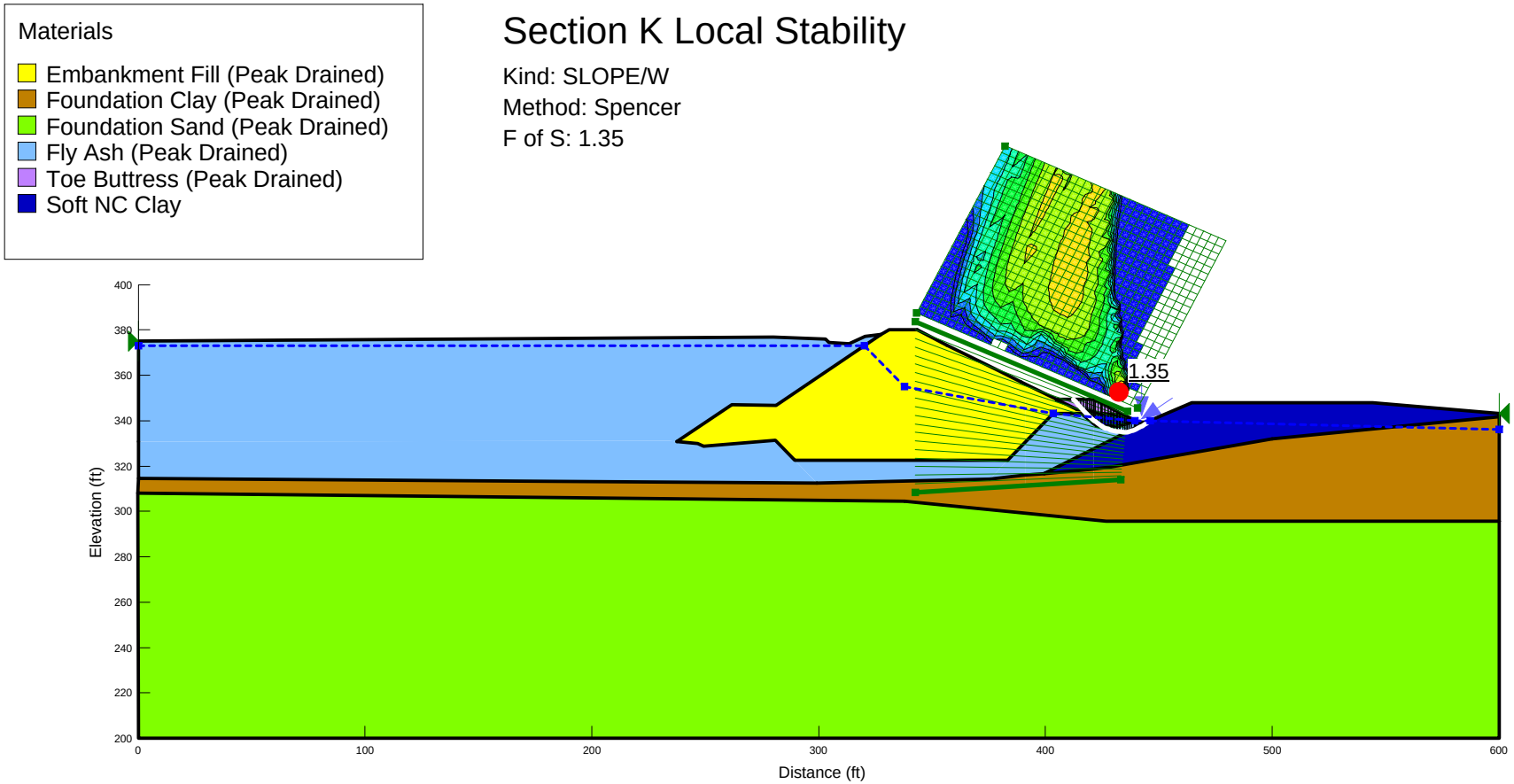
Joppa Section K DMM Design
Long-Termed Drained Stability

Computed By: LPC
Date: 4/13/2016

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Cohesion': 0 psf Phi': 25 ° Piezometric Line: 1



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Joppa Section K DMM Design
Long-Termed Drained Stability

Computed By: LPC
Date: 4/13/2016

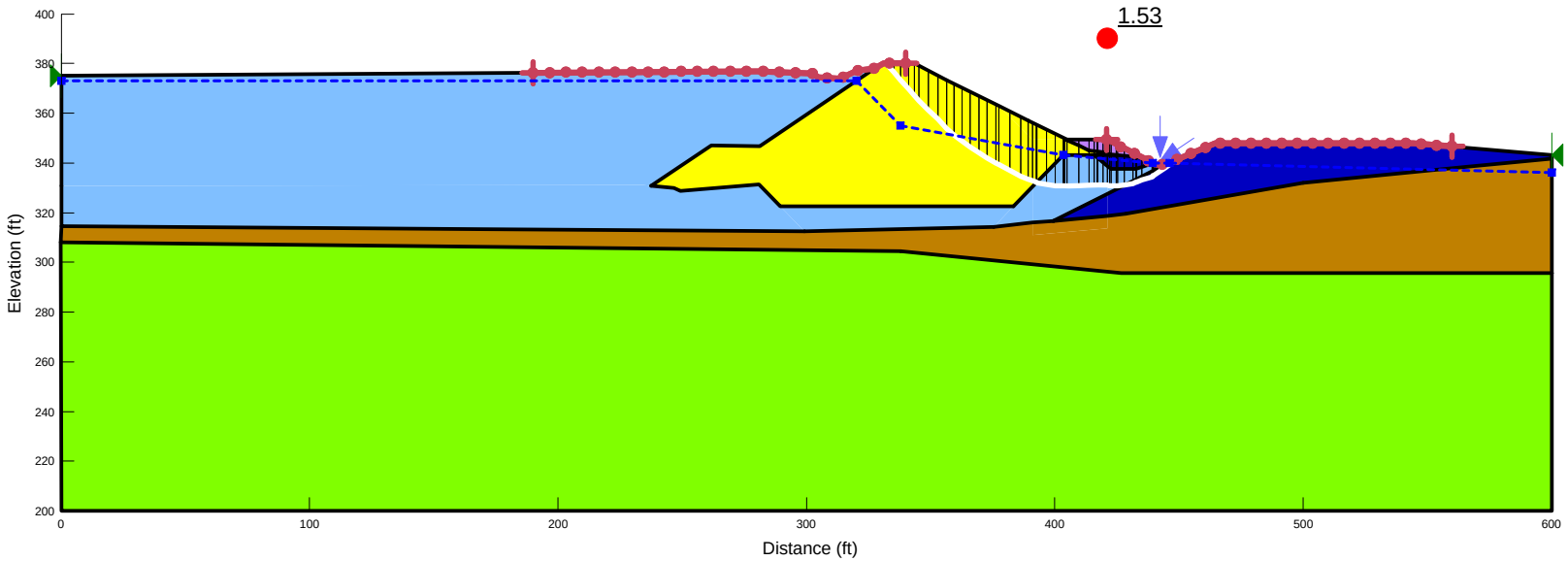
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Cohesion': 0 psf Phi': 25 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)
- Soft NC Clay

Section K Max Storage Pool

Kind: SLOPE/W
Method: Spencer
F of S: 1.53



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Joppa Section K DMM Design
Long-Termed Drained Stability

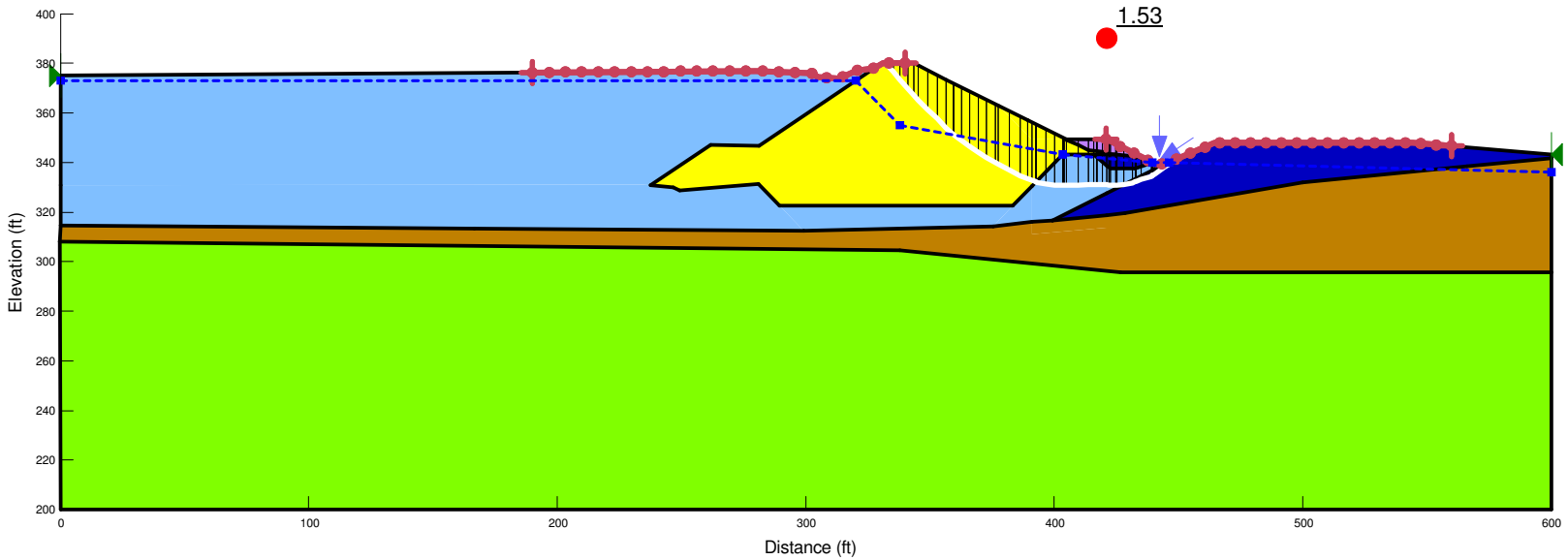
Computed By: LPC
Date: 4/13/2016

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Cohesion': 0 psf Phi': 25 ° Piezometric Line: 1

Materials
- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)
- Soft NC Clay

Section K Max Storage Pool

Kind: SLOPE/W
Method: Spencer
F of S: 1.53



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Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.245		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.151667	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.23	seconds	
Moment Magnitude (Mw)	7.6		
Spectral Acceleration (Sa(1.5Ts))	1.225	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	91.44	cm

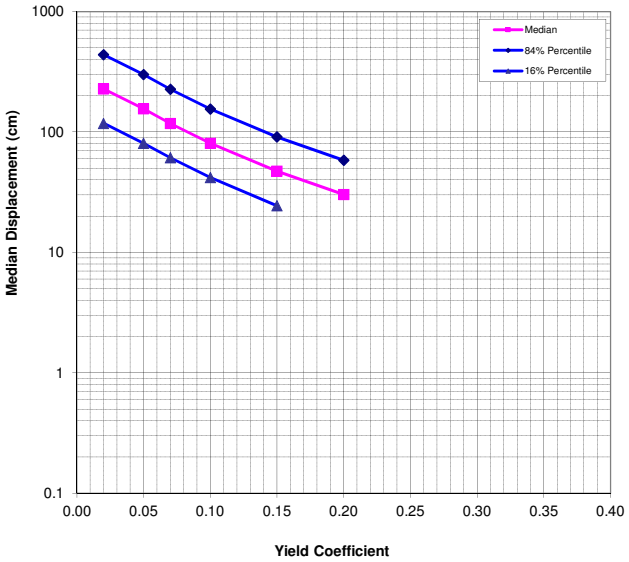
Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	21.35	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results			
Probability of Negligible Displ. (P(D=0))	0.00		eq. (3)
D1	11.1	cm	calc. using eq. (7)
D2	21.4	cm	calc. using eq. (7)
D3	41.2	cm	calc. using eq. (7)
P(D>d_threshold)	0.01		eq. (7)

Notes
1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
(e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s, i.e. Ts = 0.0. If Ts is just less than 0.05 s, set Ts = 0.050 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

Dependence on ky

ky	P(D="0")	D (cm)	Dmedian (cm)	D-84% (cm)	D-16% (cm)
0.020	0.00	227.4	227.4	438.3	118.0
0.05	0.00	155.5	155.5	299.7	80.7
0.07	0.00	117.5	117.5	226.5	61.0
0.1	0.00	80.4	80.4	155.1	41.7
0.15	0.00	47.2	47.2	90.9	24.5
0.2	0.00	30.2	30.2	58.3	15.7
0.3	0.00	14.7	14.7	28.3	7.6
0.4	0.02	8.2	8.1	15.7	4.0



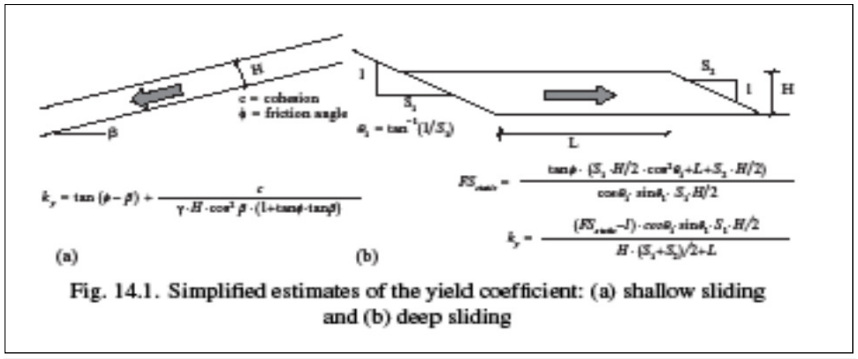


Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

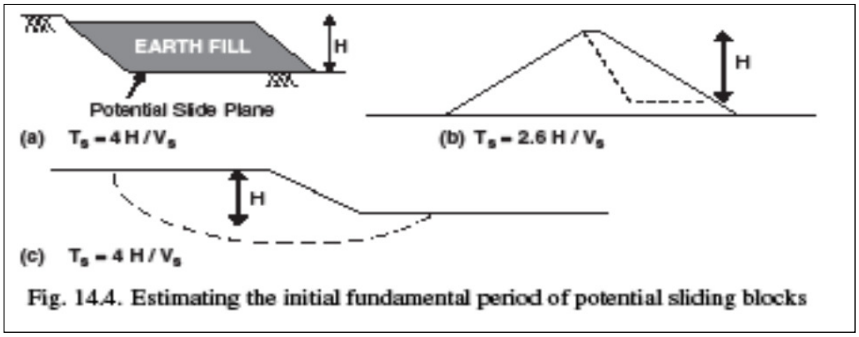


Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

Figures from Bray, J.D. (2007) "Chapter 14: Simplified Seismic Slope Displacement Procedures," Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

Calculation Notes

Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50) Project Name: Dynegy CCR

By: Lucas Carr Date: 4/14/2016 Project No: 60440155

Checked By: Andy Wilding Date: 4/26/2016 Task No.: 01

1.C – Section K – 88+30

Section K - 88+30 - Peak Undrained DMM Design Shear Strengths

Replacement Ratio: 0.37

Composite DMM Strengths at Embankment Centerline (x=337 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	380.1	0	0	0	0	600	8640	3197	3575
	131	355.1	0	3275	3275	3275	2475	8640	3197	4756
	131	322.7	2022	4244	7519	5498	3900	8640	3197	5654
Ash	106	322.7	2022	0	7519	5498	2419	8640	3197	4721
	106	313.4	2602	986	8505	5903	2597	8640	3197	4833
Fdxn Clay	128	313.4	2602	0	8505	5903	3120	8640	3197	5162
	128	304.6	3151	1126	9632	6480	3350	8640	3197	5307
Sand	128	304.6	3151	0	9632	6480	4538	8640	3197	6056
	128	200.0	9678	13389	23020	13342	9342	8640	3197	9082

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
336.0	380.1	3575
336.0	355.1	4756
336.0	322.7	5654
336.0	322.7	4721
336.0	313.4	4833
336.0	313.4	5162
336.0	304.6	5307
336.0	304.6	6056
336.0	200.0	9082

335.0	380.1	3575
335.0	355.1	4756
335.0	322.7	5654
335.0	322.7	4721
335.0	313.4	4833
335.0	313.4	5162
335.0	304.6	5307
335.0	304.6	6056
335.0	200.0	9082

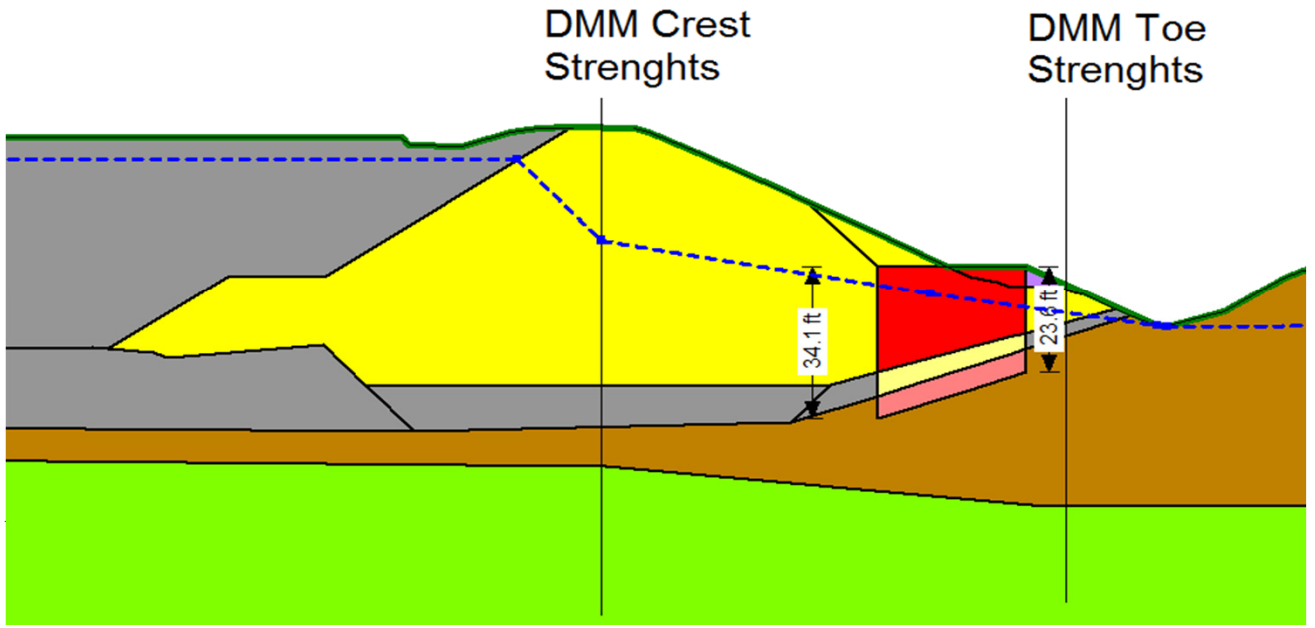
Composite DMM Strengths at Embankment Toe (x=430.6 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	344						8640	3197	3575
	131	334						8640	3197	3575
Ash	106	344	0	0	0	0	0	8640	3197	3197
	106	334	661	1124	1124	462	203	8640	3197	3325
Fdxn Clay	128	334	661	0	1124	462	900	8640	3197	3764
	128	296	3026	4851	5975	2948	1940	8640	3197	4419
Sand	128	296	3026	0	5975	2948	2064	8640	3197	4497
	128	200	8992	12237	18212	9220	6456	8640	3197	7264

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
430.6	344.0	3575
430.6	336.8	3575
430.6	344.1	3197
430.6	333.5	3325
430.6	333.5	3764
430.6	295.6	4419
430.6	295.6	4497
430.6	200.0	7264

431.6	344.0	3575
431.6	336.8	3575
431.6	344.1	3197
431.6	333.5	3325
431.6	333.5	3764
431.6	295.6	4419
431.6	295.6	4497
431.6	200.0	7264



Section K - 88+30 - Post-EQ DMM Design Shear Strengths

Replacement Ratio: 0.37

Composite DMM Strengths at Embankment Centerline (x=337 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	380.1	0	0	0	0	600	8640	3197	3575
	131	355.1	0	3275	3275	3275	2475	8640	3197	4756
	131	322.7	2022	4244	7519	5498	3900	8640	3197	5654
Ash	106	322.7	2022	0	7519	5498	385	8640	3197	3439
	106	313.4	2602	986	8505	5903	413	8640	3197	3457
Fdxn Clay	128	313.4	2602	0	8505	5903	3120	8640	3197	5162
	128	304.6	3151	1126	9632	6480	3350	8640	3197	5307
Sand	128	304.6	3151	0	9632	6480	4538	8640	3197	6056
	128	200.0	9678	13389	23020	13342	9342	8640	3197	9082

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
336.0	380.1	3575
336.0	355.1	4756
336.0	322.7	5654
336.0	322.7	3439
336.0	313.4	3457
336.0	313.4	5162
336.0	304.6	5307
336.0	304.6	6056
336.0	200.0	9082

335.0	380.1	3575
335.0	355.1	4756
335.0	322.7	5654
335.0	322.7	3439
335.0	313.4	3457
335.0	313.4	5162
335.0	304.6	5307
335.0	304.6	6056
335.0	200.0	9082

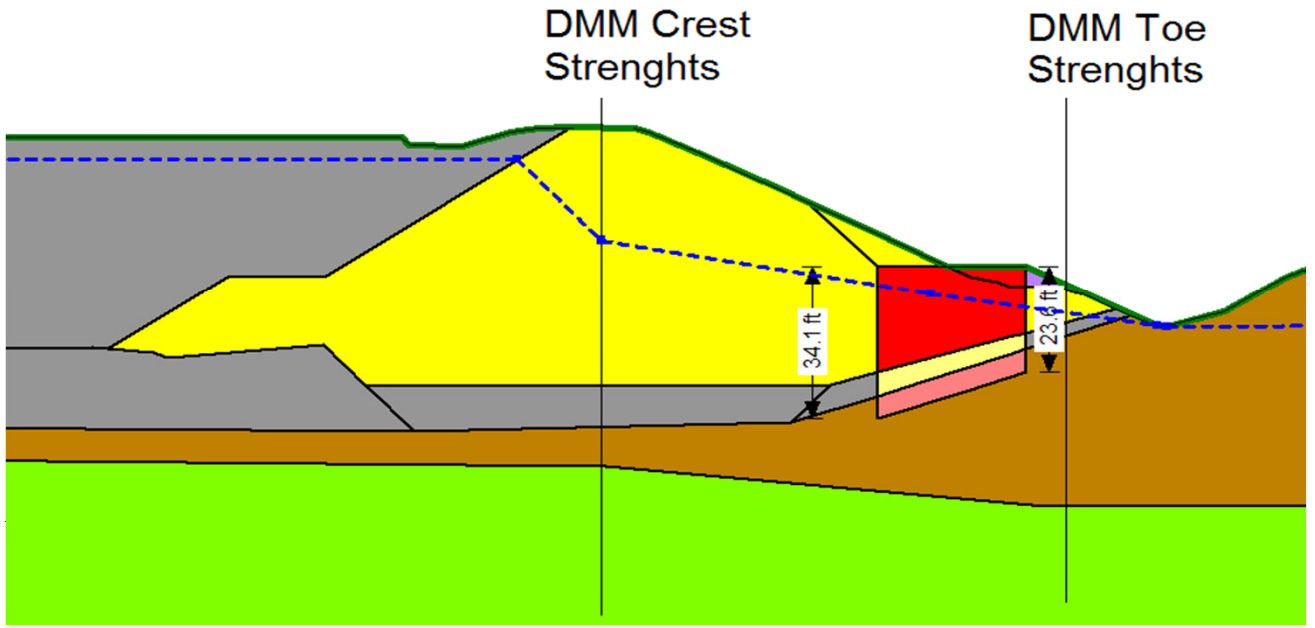
Composite DMM Strengths at Embankment Toe (x=430.6 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	344						8640	3197	3575
	131	334						8640	3197	3575
Ash	106	344	0	0	0	0	0	8640	3197	3197
	106	334	661	1124	1124	462	32	8640	3197	3217
Fdxn Clay	128	334	661	0	1124	462	900	8640	3197	3764
	128	296	3026	4851	5975	2948	1940	8640	3197	4419
Sand	128	296	3026	0	5975	2948	2064	8640	3197	4497
	128	200	8992	12237	18212	9220	6456	8640	3197	7264

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
430.6	344.0	3575
430.6	336.8	3575
430.6	344.1	3197
430.6	333.5	3217
430.6	333.5	3764
430.6	295.6	4419
430.6	295.6	4497
430.6	200.0	7264

431.6	344.0	3575
431.6	336.8	3575
431.6	344.1	3197
431.6	333.5	3217
431.6	333.5	3764
431.6	295.6	4419
431.6	295.6	4497
431.6	200.0	7264



Joppa Section K DMM Design - Ground Surface Geo at Sta. 88+30

Computed By: LPC
Date: 4/18/2016

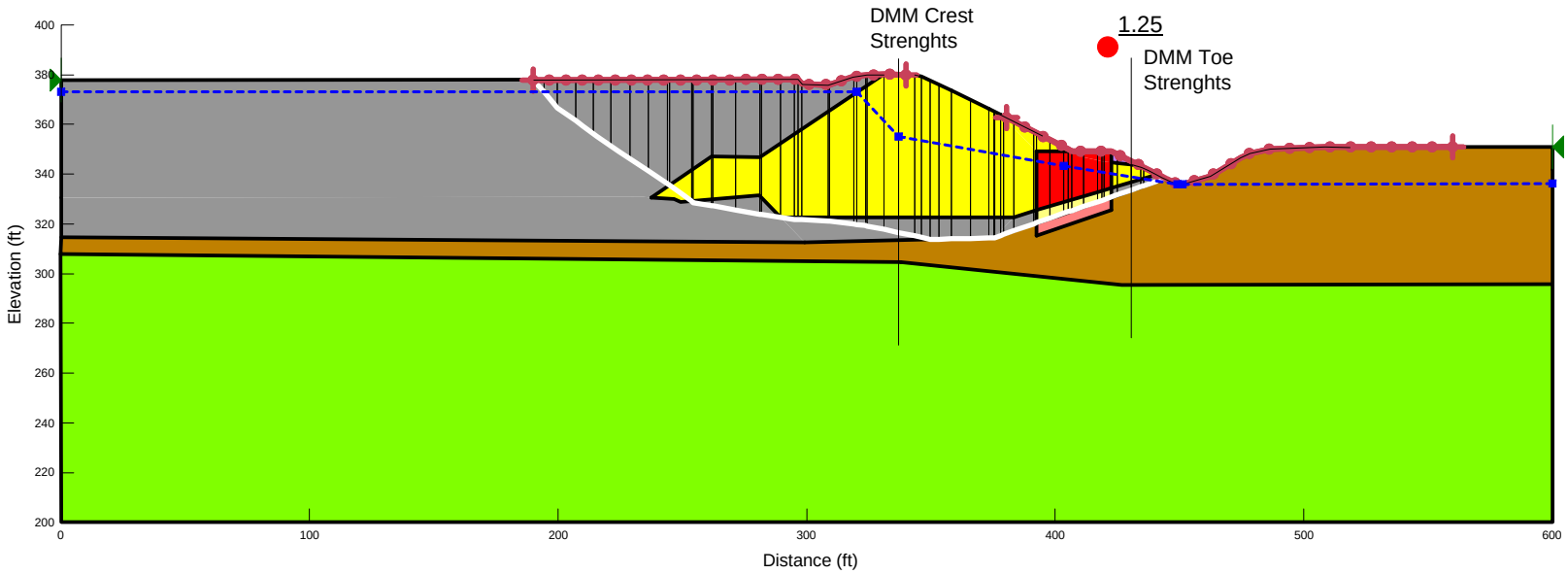
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Fly Ash (Post-Liquefaction) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.07 Minimum Strength: 0 psf Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: DMM - Embankment Unit Weight: 131 pcf Cohesion Spatial Fn: Embankment Fill DMM Phi': 0 ° Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: DMM - Foundation Unit Weight: 128 pcf Cohesion Spatial Fn: Foundation DMM Phi': 0 ° Piezometric Line: 1
Name: DMM - Ash (Liquified) Unit Weight: 106 pcf Cohesion': 3,200 psf Phi': 0 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Fly Ash (Post-Liquefaction)
- Foundation Sand (Peak Drained)
- DMM - Embankment
- Toe Buttress (Peak Undrained)
- DMM - Foundation
- DMM - Ash (Liquified)

Section K Post-EQ

Kind: SLOPE/W
Method: Spencer
F of S: 1.25



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Joppa Section K DMM Design - Ground Surface Geo at Sta. 88+30

Computed By: LPC
Date: 4/18/2016

Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: DMM - Embankment Unit Weight: 131 pcf Cohesion Spatial Fn: Embankment Fill DMM Phi': 0 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: DMM - Ash Unit Weight: 106 pcf Cohesion Spatial Fn: Ash DMM Phi': 0 ° Piezometric Line: 1
Name: DMM - Foundation Unit Weight: 128 pcf Cohesion Spatial Fn: Foundation DMM Phi': 0 ° Piezometric Line: 1

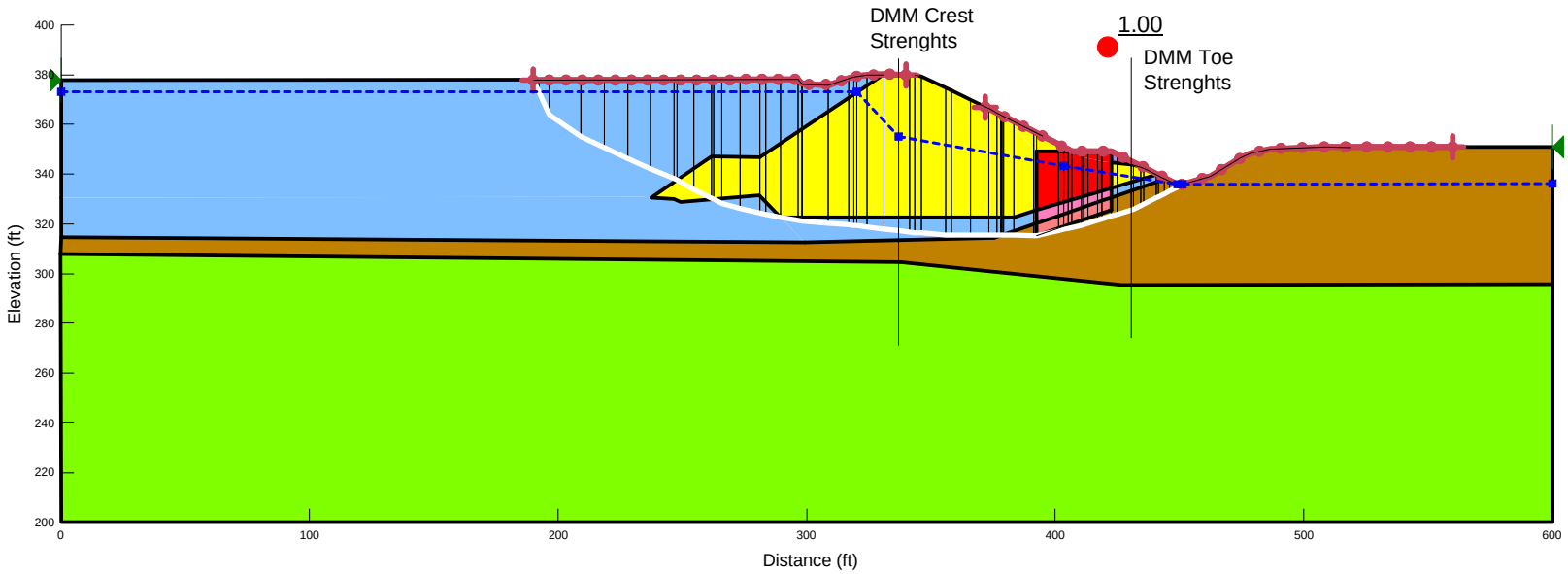
Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- DMM - Embankment
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- DMM - Ash
- DMM - Foundation

Section K Pseudostatic

Kind: SLOPE/W
Method: Spencer
F of S: 1.00

Pseudostatic Seismic Yield
ky = 0.266 g



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Joppa Section K DMM Design - Ground Surface Geo at Sta. 88+30

Computed By: LPC
Date: 4/18/2016

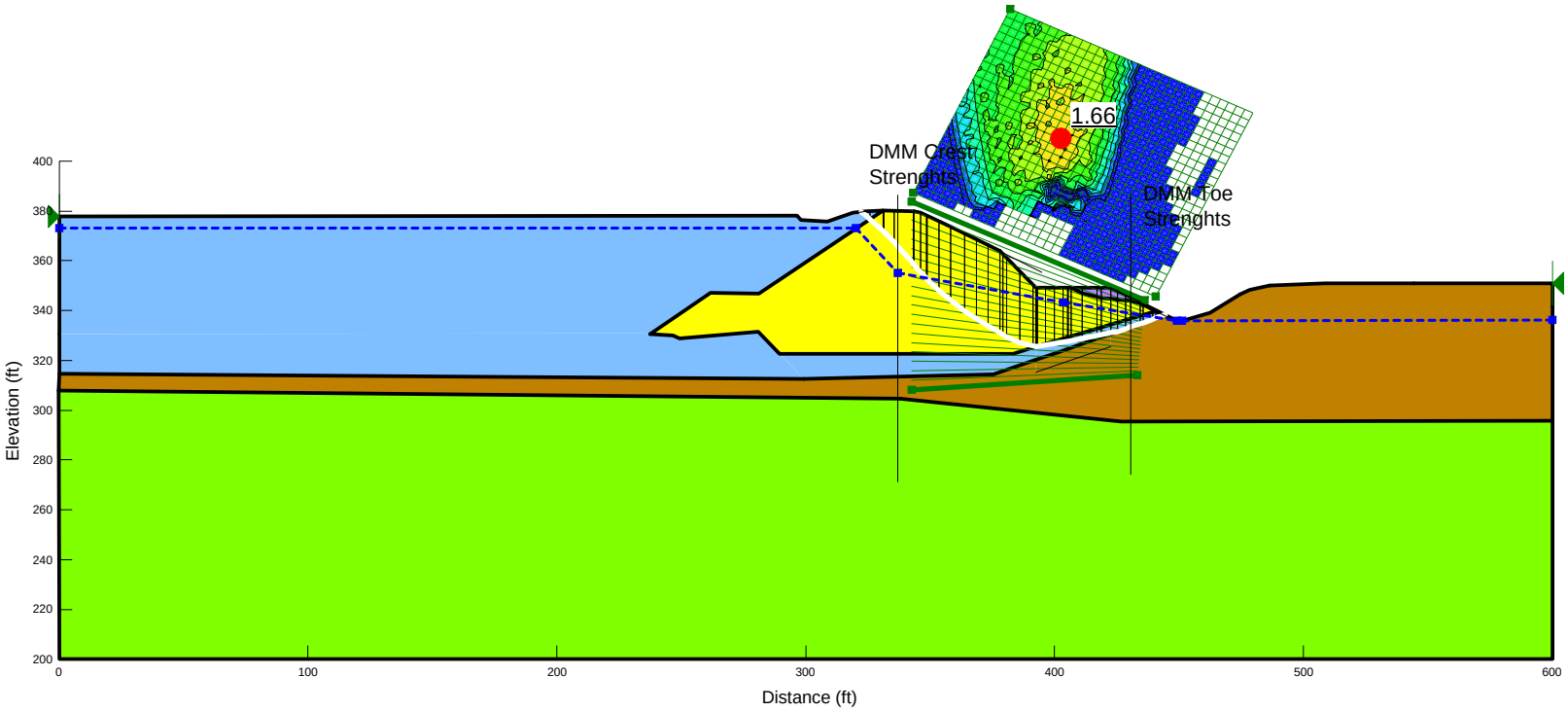
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)

Section K Temp Construction

Kind: SLOPE/W
Method: Spencer
F of S: 1.66



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Joppa Section K DMM Design - Ground Surface Geo at Sta. 88+30

Computed By: LPC
Date: 4/18/2016

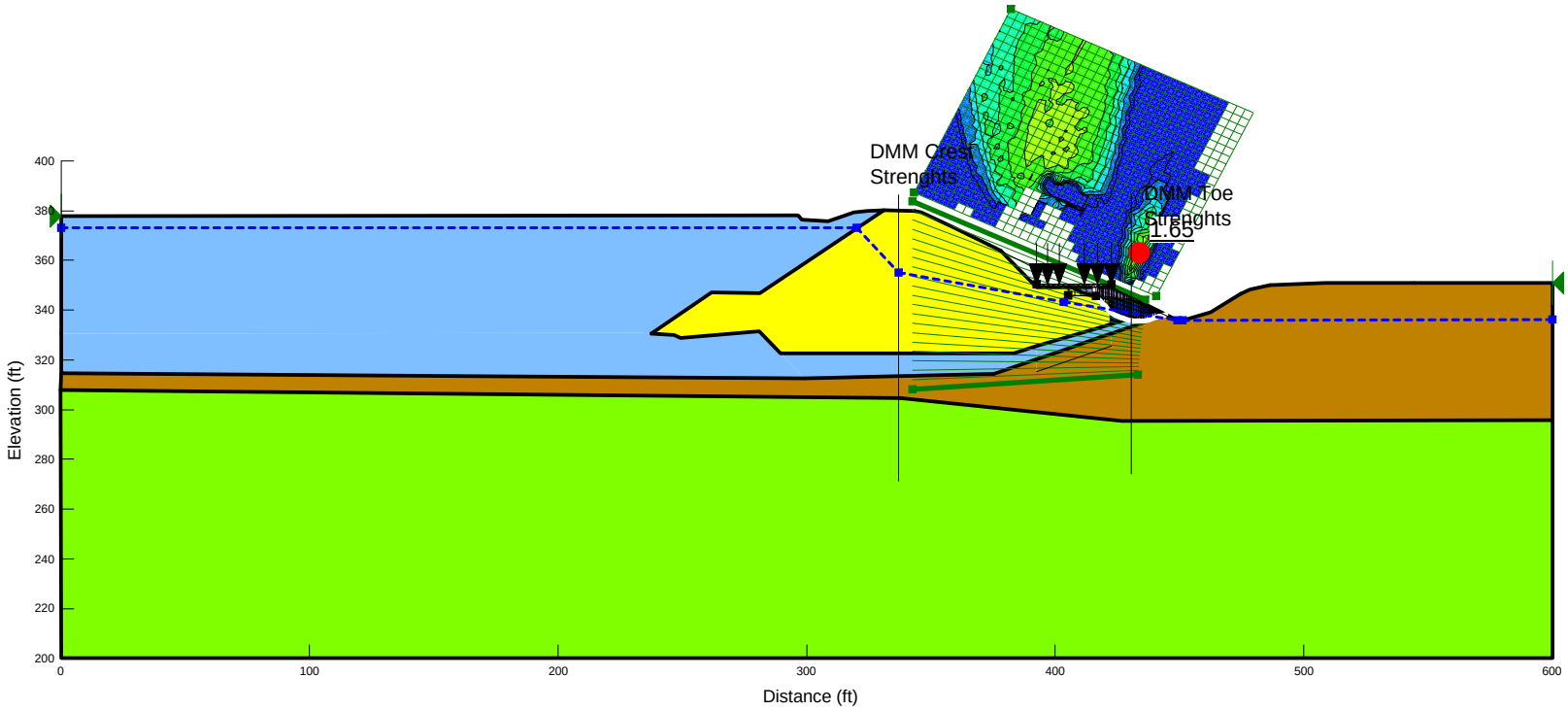
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: Soft NC Clay Unit Weight: 125 pcf Tau/Sigma Ratio: 0.23 Minimum Strength: 500 psf Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- Soft NC Clay

Section K Temp Construction - Rig Load

Kind: SLOPE/W
Method: Spencer
F of S: 1.65



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Joppa Section K DMM Design - Ground Surface Geo at Sta. 88+30
Long-Term Drained Stability

Computed By: LPC
Date: 4/18/2016

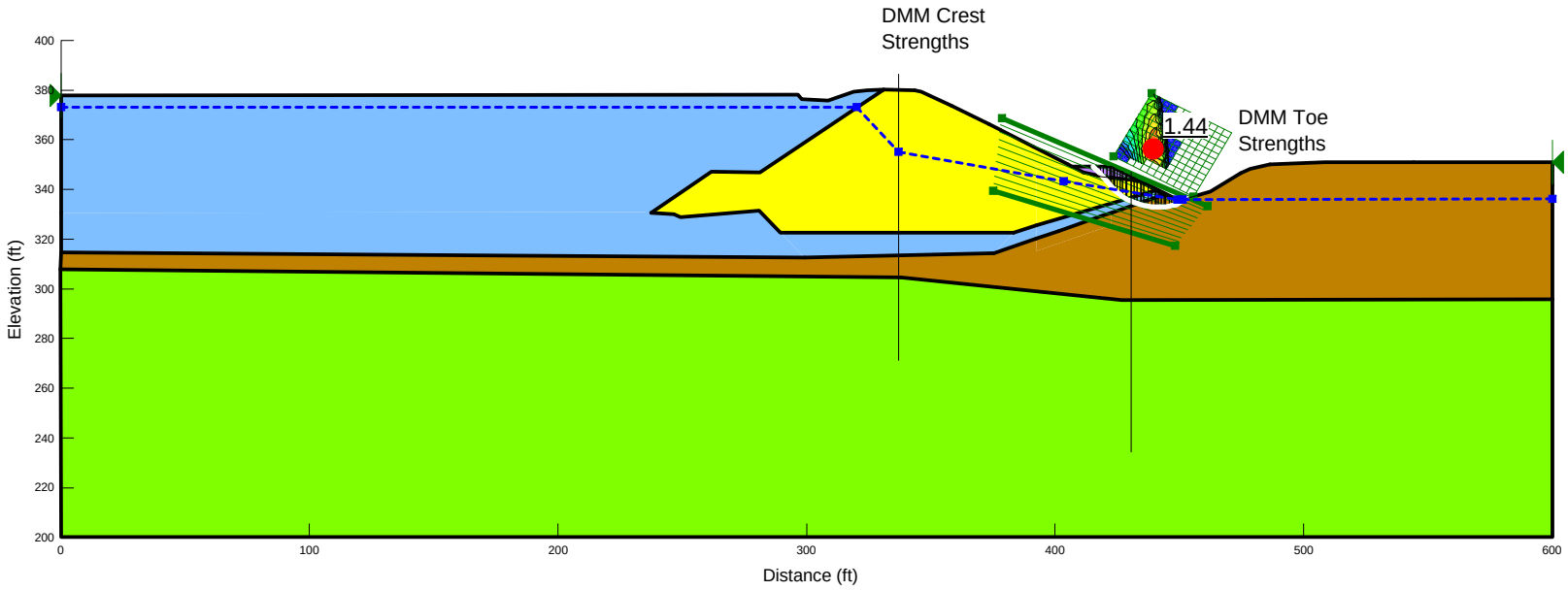
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)

Section K Local Stability

Kind: SLOPE/W
Method: Spencer
F of S: 1.44



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Joppa Section K DMM Design - Ground Surface Geo at Sta. 88+30
Long-Term Drained Stability

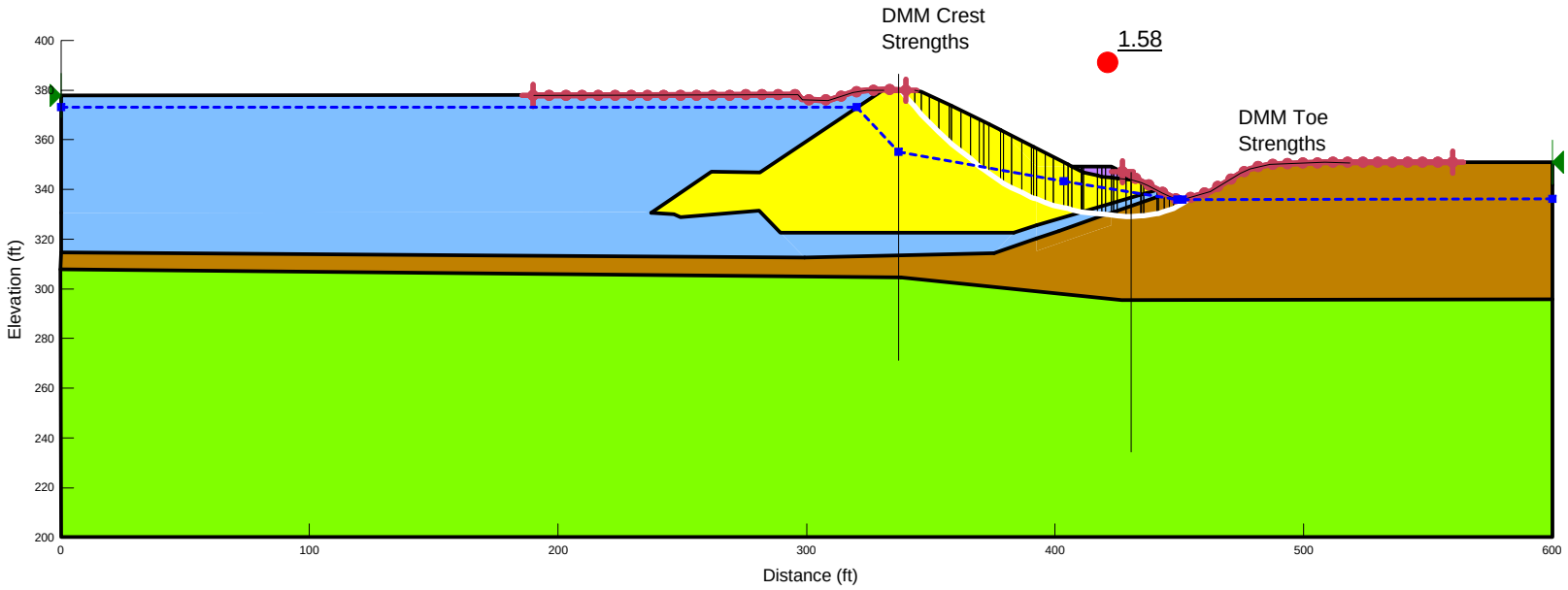
Computed By: LPC
Date: 4/18/2016

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1

Materials
- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)

Section K Max Storage Pool

Kind: SLOPE/W
Method: Spencer
F of S: 1.58



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Joppa Section K DMM Design - Ground Surface Geo at Sta. 88+30
Long-Term Drained Stability

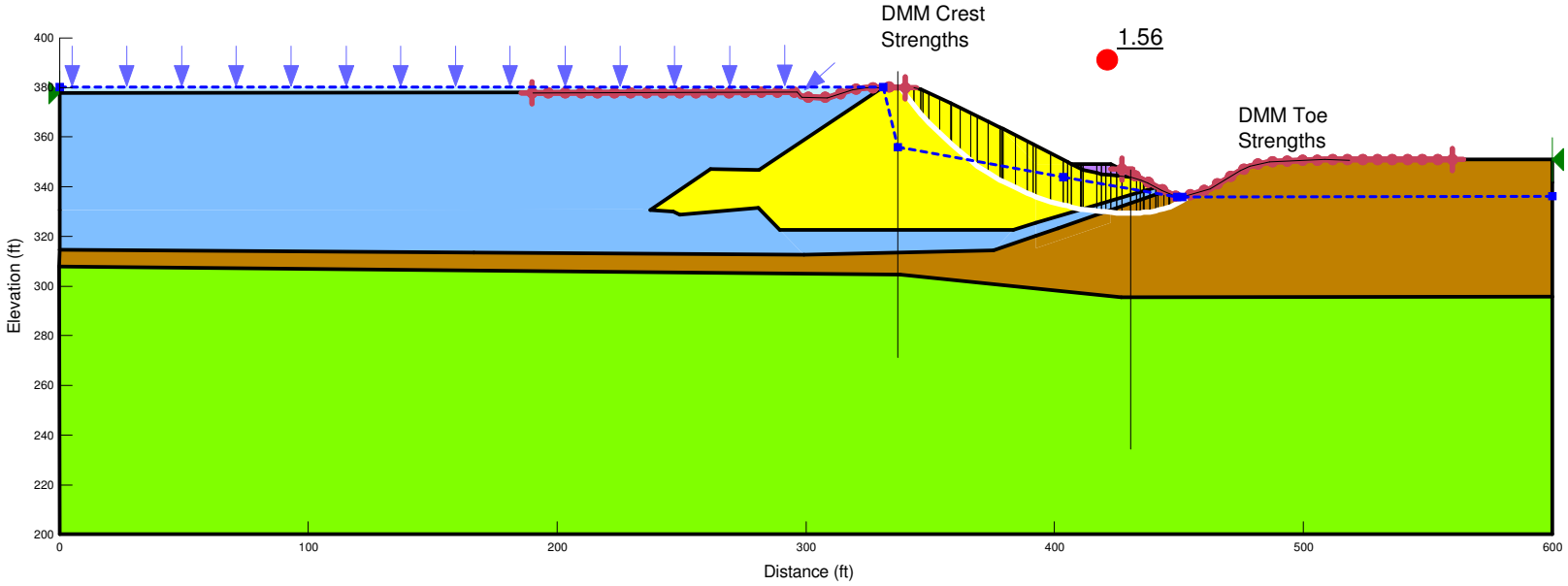
Computed By: LPC
Date: 4/26/2016

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1

Materials
- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)

Section K Max Surcharge Pool

Kind: SLOPE/W
Method: Spencer
F of S: 1.56



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Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.266		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.151667	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.23	seconds	
Moment Magnitude (Mw)	7.6		
Spectral Acceleration (Sa(1.5Ts))	1.225	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	91.44	cm

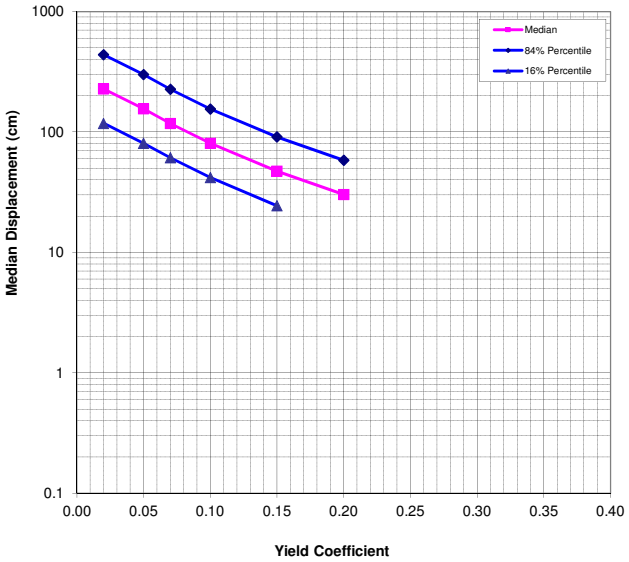
Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	18.41	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results			
Probability of Negligible Displ. (P(D=0))	0.00		eq. (3)
D1	9.5	cm	calc. using eq. (7)
D2	18.4	cm	calc. using eq. (7)
D3	35.5	cm	calc. using eq. (7)
P(D>d_threshold)	0.01		eq. (7)

Notes
1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
(e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s, i.e. Ts = 0.0. If Ts is just less than 0.05 s, set Ts = 0.050 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

Dependence on ky

ky	P(D="0")	D (cm)	Dmedian (cm)	D-84% (cm)	D-16% (cm)
0.020	0.00	227.4	227.4	438.3	118.0
0.05	0.00	155.5	155.5	299.7	80.7
0.07	0.00	117.5	117.5	226.5	61.0
0.1	0.00	80.4	80.4	155.1	41.7
0.15	0.00	47.2	47.2	90.9	24.5
0.2	0.00	30.2	30.2	58.3	15.7
0.3	0.00	14.7	14.7	28.3	7.6
0.4	0.02	8.2	8.1	15.7	4.0



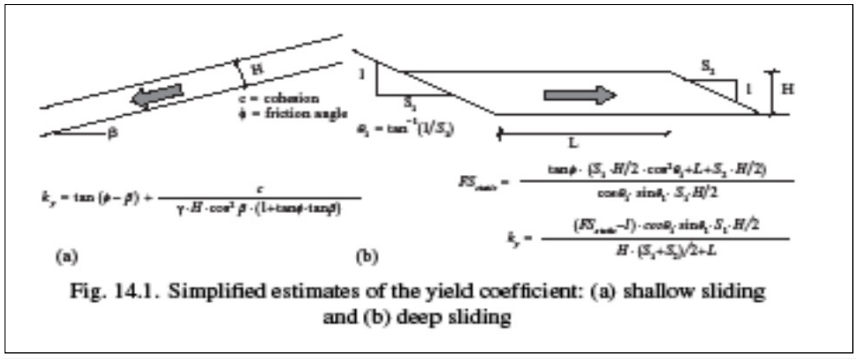


Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

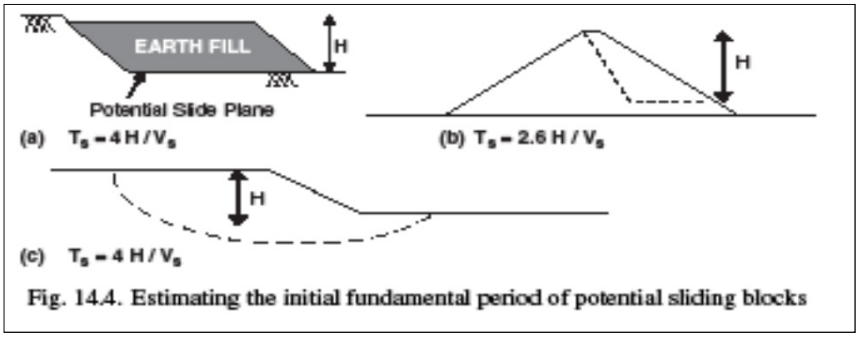


Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

Figures from Bray, J.D. (2007) "Chapter 14: Simplified Seismic Slope Displacement Procedures," Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

Calculation Notes

Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50) Project Name: Dynegy CCR

By: Lucas Carr Date: 4/14/2016 Project No: 60440155

Checked By: Andy Wilding Date: 4/26/2016 Task No.: 01

1.D – Section A

Section A - Peak Undrained DMM Design Shear Strengths

Replacement Ratio: 0.37

Composite DMM Strengths at Embankment Centerline (x=621ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	379.1	0	0	0	0	600	8640	3197	3575
	131	354.1	0	3275	3275	3275	2450	8640	3197	4740
	131	314.7	2459	5161	8436	5978	4225	8640	3197	5859
Ash	106	314.7	2459	0	8436	5978	2630	8640	3197	4854
	106	307.6	2902	753	9189	6287	2766	8640	3197	4940
Fdxn Clay	128	307.6	2902	0	9189	6287	3300	8640	3197	5276
	128	289.5	4031	2317	11506	7475	3750	8640	3197	5559
Sand	128	289.5	4031	0	11506	7475	5234	8640	3197	6494
	128	200.0	9616	11456	22962	13346	9345	8640	3197	9084

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
621.0	379.1	3575
621.0	354.1	4740
621.0	314.7	5859
621.0	314.7	4854
621.0	307.6	4940
621.0	307.6	5276
621.0	289.5	5559
621.0	289.5	6494
621.0	200.0	9084

620.0	379.1	3575
620.0	354.1	4740
620.0	314.7	5859
620.0	314.7	4854
620.0	307.6	4940
620.0	307.6	5276
620.0	289.5	5559
620.0	289.5	6494
620.0	200.0	9084

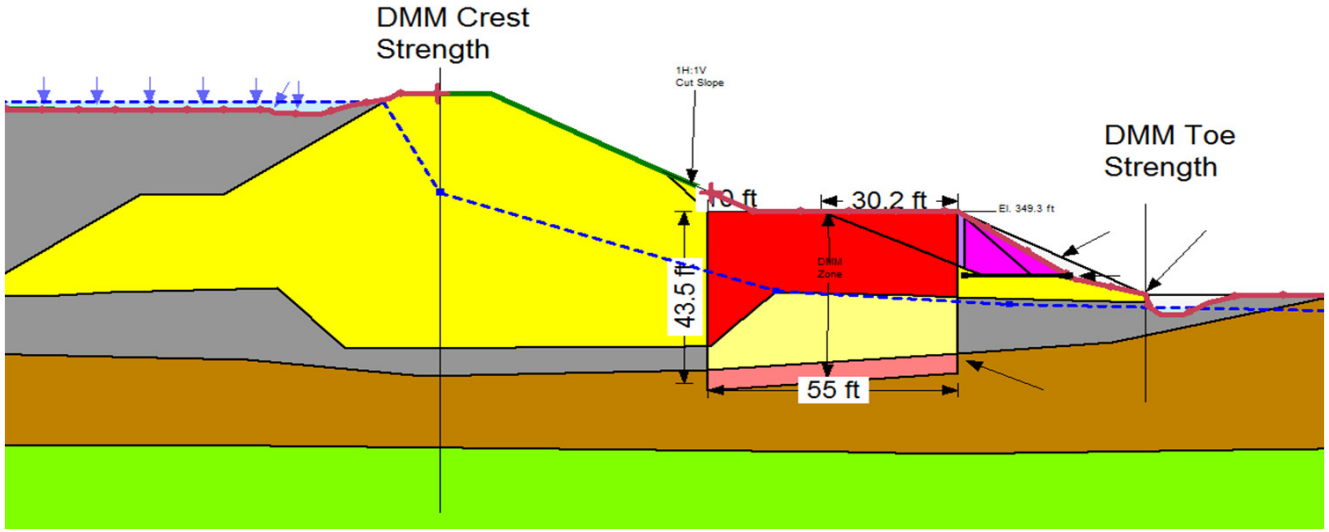
Composite DMM Strengths at Embankment Toe (x=776 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	328	0	0	0	0	600	8640	3197	3575
	131	326	0	262	262	262	600	8640	3197	3575
Ash	106	326.2	0	0	262	262	115	8640	3197	3269
	106	325.0	0	127	389	389	171	8640	3197	3305
	106	317.9	443	753	1142	699	307	8640	3197	3390
Fdxn Clay	128	317.9	443	0	1142	699	1000	8640	3197	3827
	128	288.6	2271	3750	4892	2621	1800	8640	3197	4331
Sand	128	288.6	2271	0	4892	2621	1835	8640	3197	4353
	128	200.0	7800	11341	16233	8433	5905	8640	3197	6917

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
776.0	328.2	3575
776.0	326.2	3575
776.0	326.2	3269
776.0	325.0	3305
776.0	317.9	3390
776.0	317.9	3827
776.0	288.6	4331
776.0	288.6	4353
776.0	200.0	6917

777.0	328.2	3575
777.0	326.2	3575
777.0	326.2	3269
777.0	325.0	3305
777.0	317.9	3390
777.0	317.9	3827
777.0	288.6	4331
777.0	288.6	4353
777.0	200.0	6917



Section A - Post-EQ DMM Design Shear Strengths

Replacement Ratio: 0.37

Composite DMM Strengths at Embankment Centerline (x=621ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	379.1	0	0	0	0	600	8640	3197	3575
	131	354.1	0	3275	3275	3275	2450	8640	3197	4740
	131	314.7	2459	5161	8436	5978	4225	8640	3197	5859
Ash	106	314.7	2459	0	8436	5978	418	8640	3197	3460
	106	307.6	2902	753	9189	6287	440	8640	3197	3474
Fdxn Clay	128	307.6	2902	0	9189	6287	3300	8640	3197	5276
	128	289.5	4031	2317	11506	7475	3750	8640	3197	5559
Sand	128	289.5	4031	0	11506	7475	5234	8640	3197	6494
	128	200.0	9616	11456	22962	13346	9345	8640	3197	9084

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
621.0	379.1	3575
621.0	354.1	4740
621.0	314.7	5859
621.0	314.7	3460
621.0	307.6	3474
621.0	307.6	5276
621.0	289.5	5559
621.0	289.5	6494
621.0	200.0	9084

620.0	379.1	3575
620.0	354.1	4740
620.0	314.7	5859
620.0	314.7	3460
620.0	307.6	3474
620.0	307.6	5276
620.0	289.5	5559
620.0	289.5	6494
620.0	200.0	9084

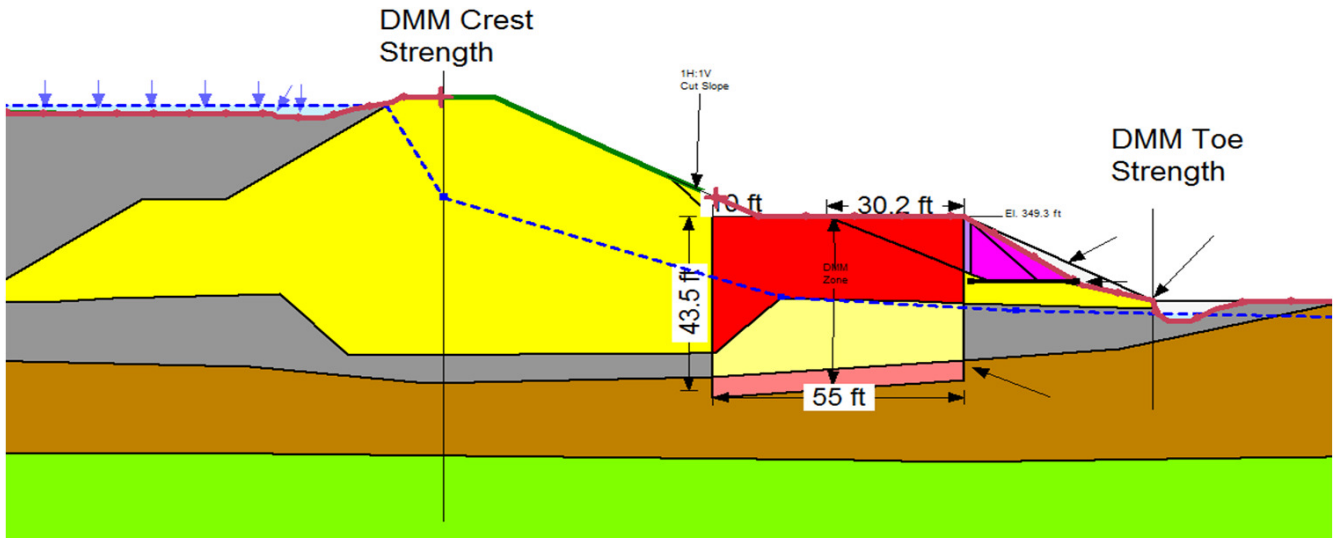
Composite DMM Strengths at Embankment Toe (x=776 ft)

Material	Unit Weight (pcf)	Elevation (ft)	PWP (psf)	Layer Weight (psf)	Total Stress (psf)	Effective Stress (psf)	Soil Strength (psf)	DMM Su (psf)	DMM Only Strength (psf)	DMM + Soil Strength (psf)
Embankment Fill	131	328	0	0	0	0	600	8640	3197	3575
	131	326	0	262	262	262	600	8640	3197	3575
Ash	106	326.2	0	0	262	262	18	8640	3197	3208
	106	325.0	0	127	389	389	27	8640	3197	3214
	106	317.9	443	753	1142	699	49	8640	3197	3228
Fdxn Clay	128	317.9	443	0	1142	699	1000	8640	3197	3827
	128	288.6	2271	3750	4892	2621	1800	8640	3197	4331
Sand	128	288.6	2271	0	4892	2621	1835	8640	3197	4353
	128	200.0	7800	11341	16233	8433	5905	8640	3197	6917

Centerline Summary

x (ft)	y (ft)	DMM Zone Su (psf)
776.0	328.2	3575
776.0	326.2	3575
776.0	326.2	3208
776.0	325.0	3214
776.0	317.9	3228
776.0	317.9	3827
776.0	288.6	4331
776.0	288.6	4353
776.0	200.0	6917

777.0	328.2	3575
777.0	326.2	3575
777.0	326.2	3208
777.0	325.0	3214
777.0	317.9	3228
777.0	317.9	3827
777.0	288.6	4331
777.0	288.6	4353
777.0	200.0	6917



Joppa Section A DMM Design

Computed By: LPC
Date: 4/18/2016

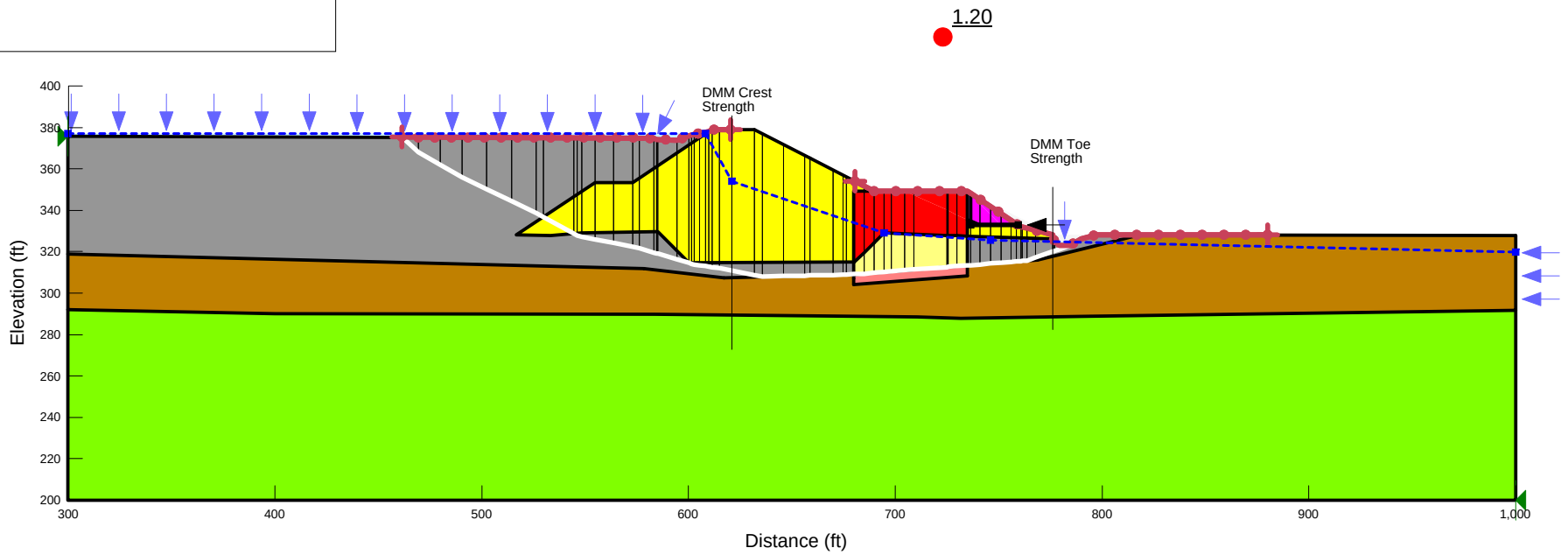
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Fly Ash (Post-Liquefaction) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.07 Minimum Strength: 0 psf Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: DMM - Embankment Unit Weight: 131 pcf Cohesion Spatial Fn: Embankment Fill DMM Phi': 0 ° Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: DMM - Foundation Unit Weight: 128 pcf Cohesion Spatial Fn: Foundation DMM Phi': 0 ° Piezometric Line: 1
Name: DMM - Ash (Post-EQ) Unit Weight: 106 pcf Cohesion Spatial Fn: Ash DMM - Post-EQ Phi': 0 ° Piezometric Line: 1
Name: 3" Minus Crushed Stone Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Fly Ash (Post-Liquefaction)
- Foundation Sand (Peak Drained)
- DMM - Embankment
- Toe Buttress (Peak Undrained)
- DMM - Foundation
- DMM - Ash (Post-EQ)
- 3" Minus Crushed Stone

Section A Post-EQ

Kind: SLOPE/W
Method: Spencer
F of S: 1.20



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Joppa Section A DMM Design

Computed By: LPC
Date: 4/18/2016

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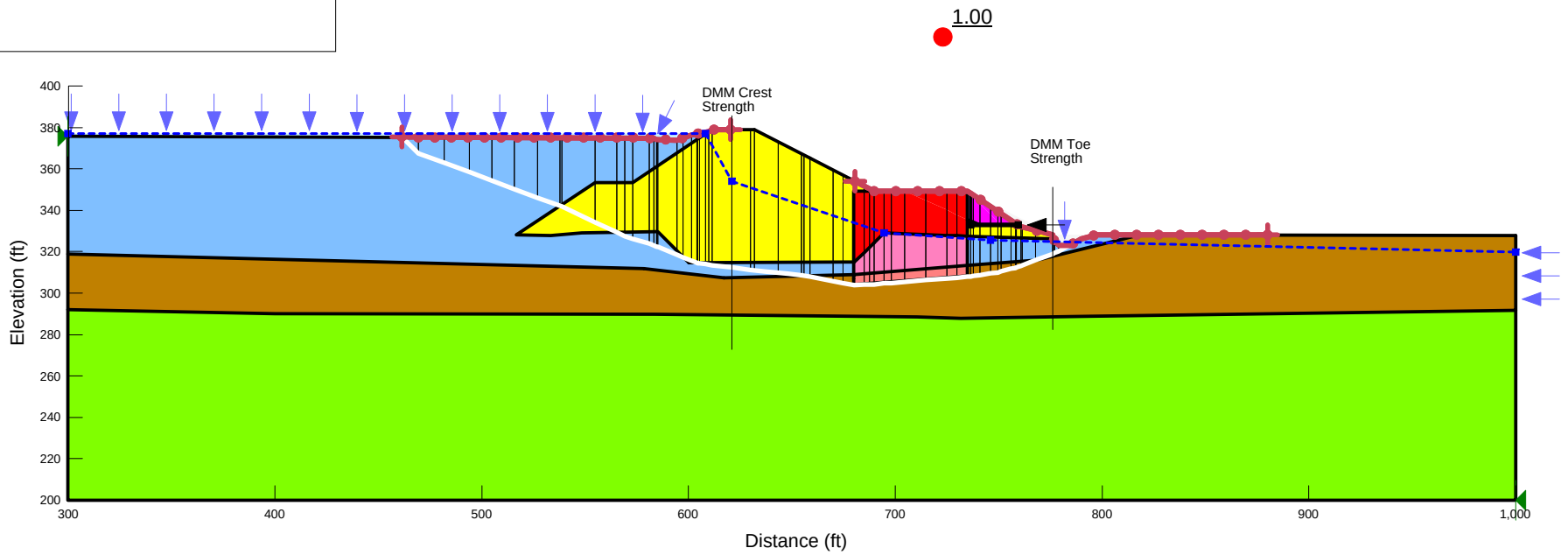
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: DMM - Embankment Unit Weight: 131 pcf Cohesion Spatial Fn: Embankment Fill DMM Phi': 0 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: DMM - Ash Unit Weight: 106 pcf Cohesion Spatial Fn: Ash DMM (Peak Undrained) Phi': 0 ° Piezometric Line: 1
Name: DMM - Foundation Unit Weight: 128 pcf Cohesion Spatial Fn: Foundation DMM Phi': 0 ° Piezometric Line: 1
Name: 3" Minus Crushed Stone Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- DMM - Embankment
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- DMM - Ash
- DMM - Foundation
- 3" Minus Crushed Stone

Section A Pseudostatic

Kind: SLOPE/W
Method: Spencer
F of S: 1.00
Pseudostatic Yield
kh = 0.224 g



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Joppa Section A DMM Design

Computed By: LPC
Date: 4/18/2016

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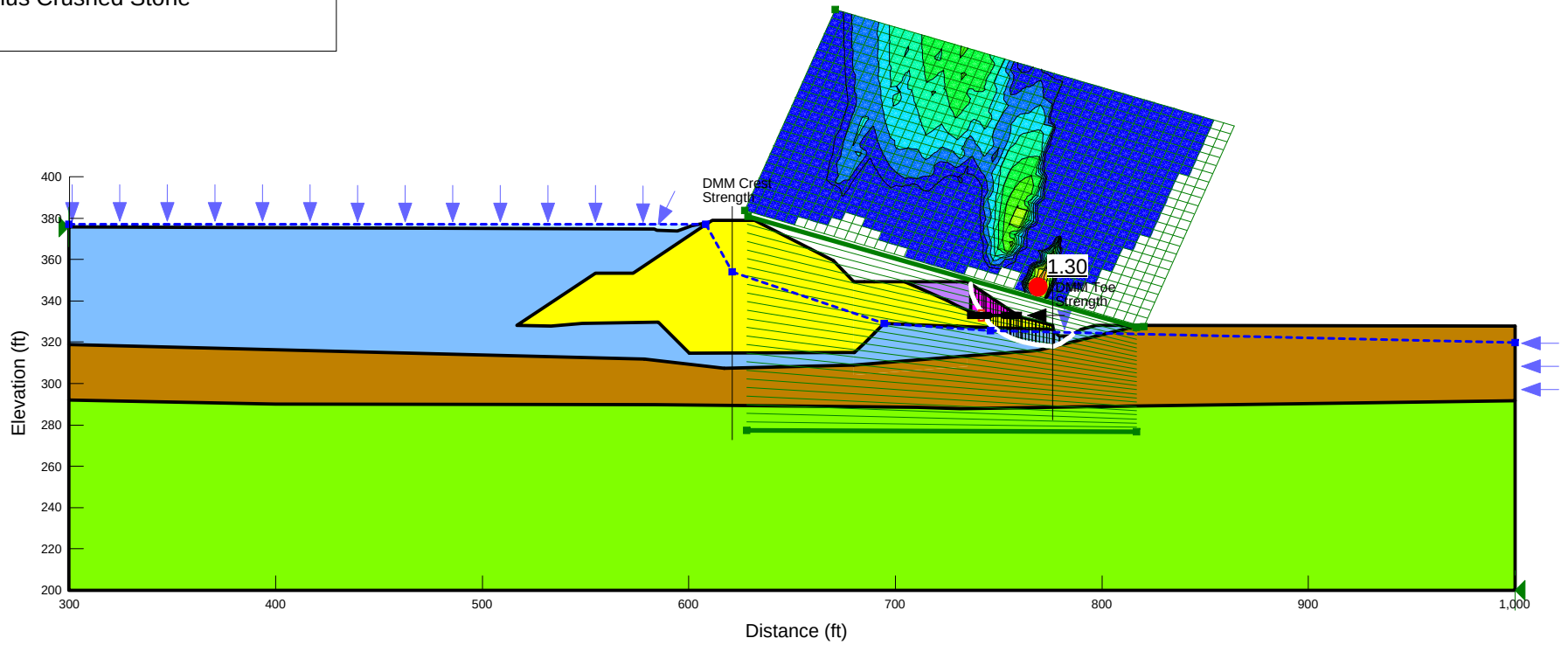
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: 3" Minus Crushed Stone Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- 3" Minus Crushed Stone

Section A Temp Construction

Kind: SLOPE/W
Method: Spencer
F of S: 1.30



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Joppa Section A DMM Design

Computed By: LPC
Date: 4/18/2016

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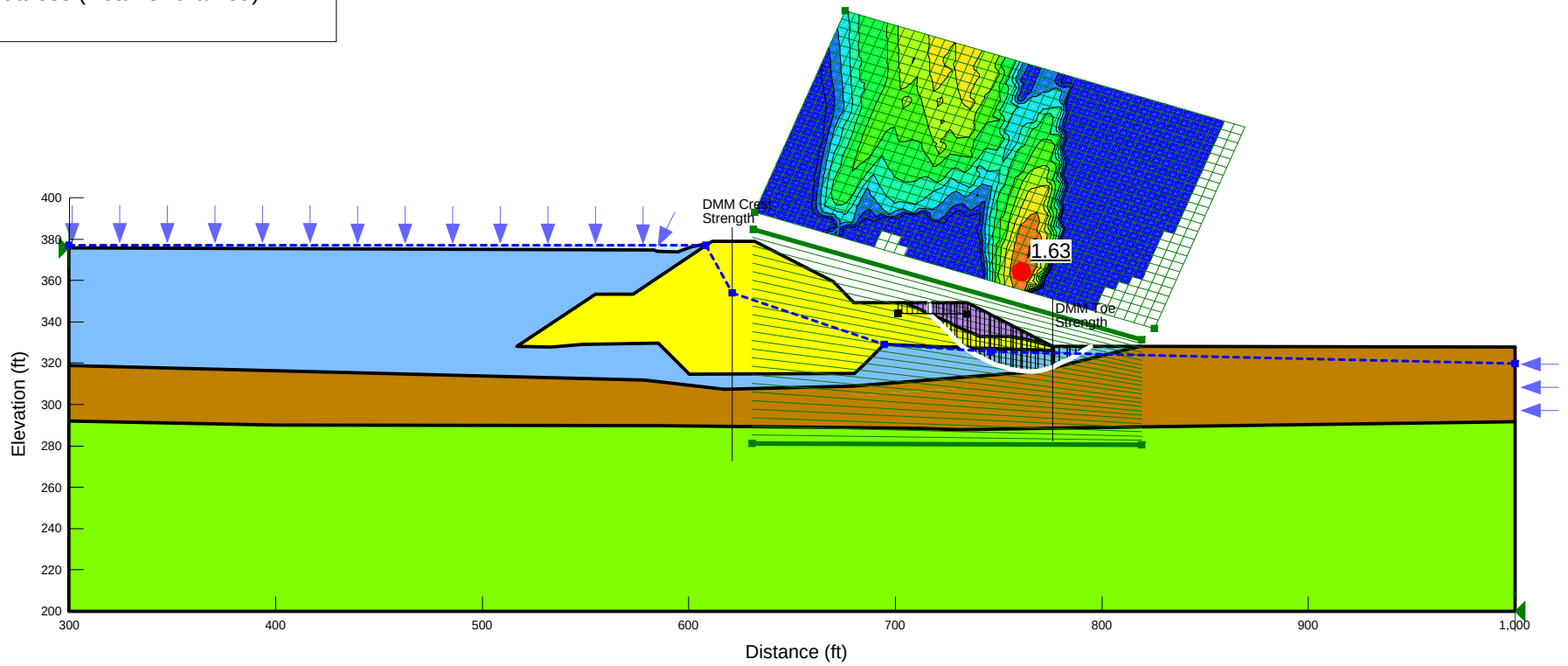
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)

Section A Temp Construction - No Ditch

Kind: SLOPE/W
Method: Spencer
F of S: 1.63



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Joppa Section A DMM Design

Computed By: LPC
Date: 4/18/2016

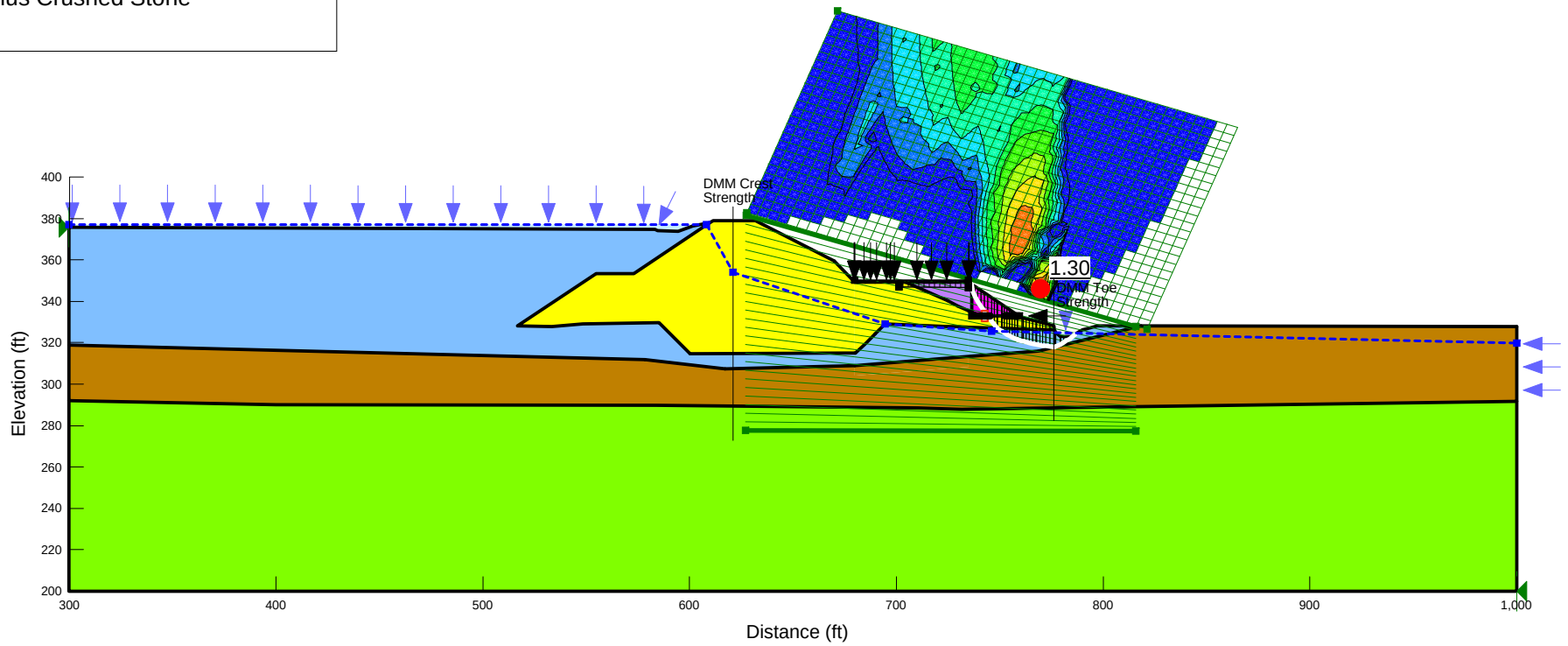
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1
Name: 3" Minus Crushed Stone Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)
- 3" Minus Crushed Stone

Section A Temp Construction - Rig Load

Kind: SLOPE/W
Method: Spencer
F of S: 1.30



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Joppa Section A DMM Design

Computed By: LPC
Date: 4/18/2016

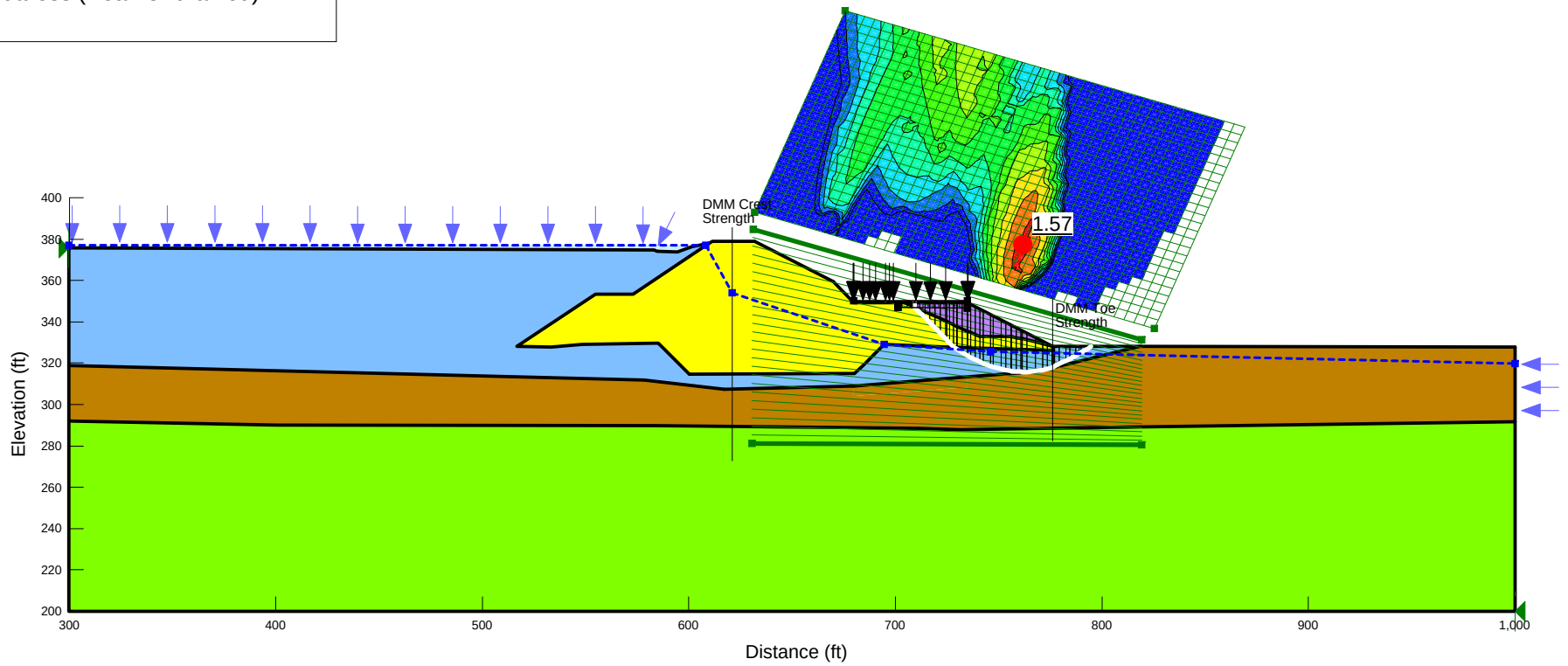
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1
Name: Toe Buttress (Peak Undrained) Unit Weight: 125 pcf Cohesion': 1,500 psf Phi': 0 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)
- Toe Buttress (Peak Undrained)

Section A Temp Construction - Rig Load - No Ditch

Kind: SLOPE/W
Method: Spencer
F of S: 1.57



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Joppa Section A DMM Design
Long-Term Drained Analysis

Computed By: LPC
Date: 4/19/2016

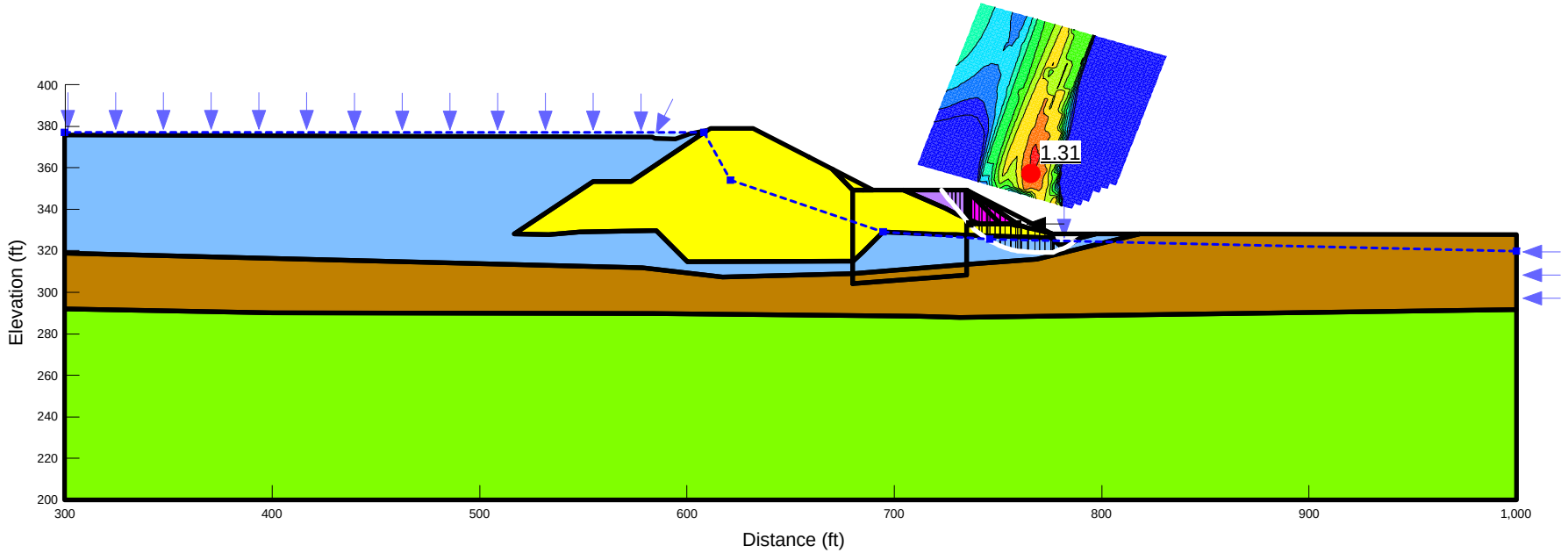
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: 3" Minus Stone Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)
- 3" Minus Stone

Section A Local Stability

Kind: SLOPE/W
Method: Spencer
F of S: 1.31



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Joppa Section A DMM Design
Long-Term Drained Analysis

Computed By: LPC
Date: 4/19/2016

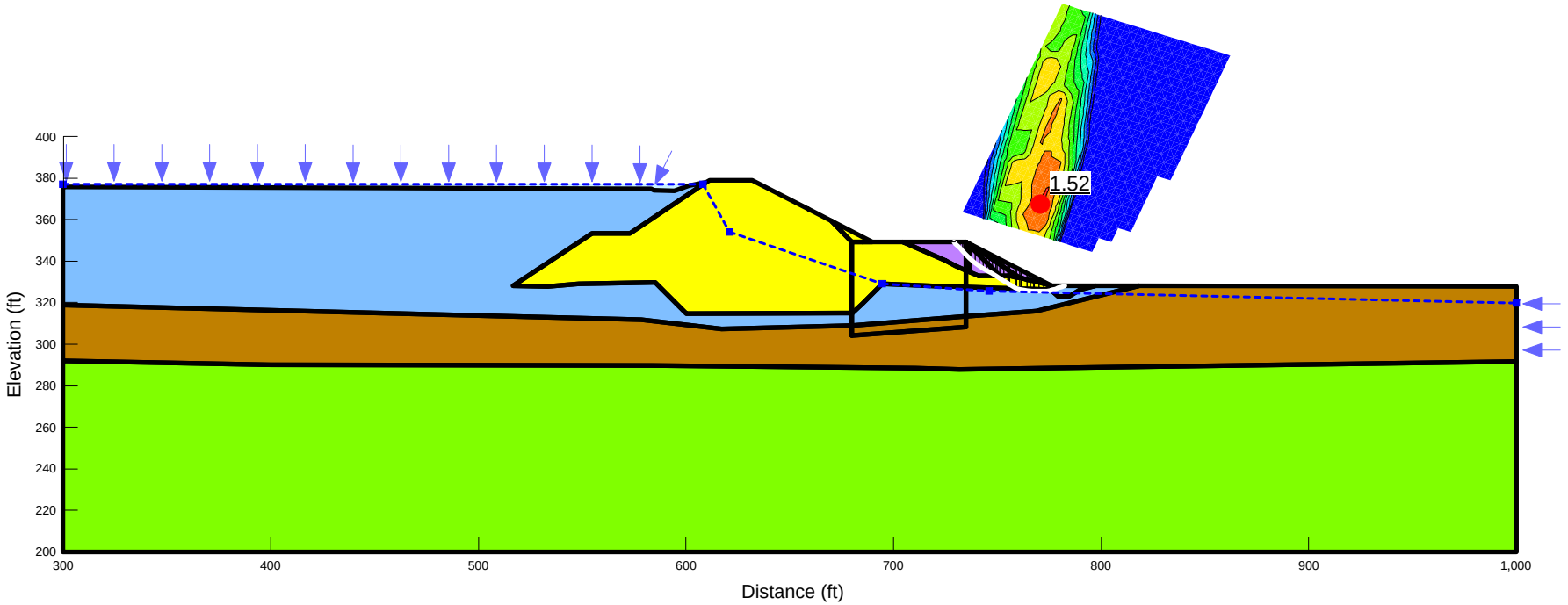
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)

Section A Local Stability - No Ditch

Kind: SLOPE/W
Method: Spencer
F of S: 1.52



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Joppa Section A DMM Design
Long-Term Drained Analysis

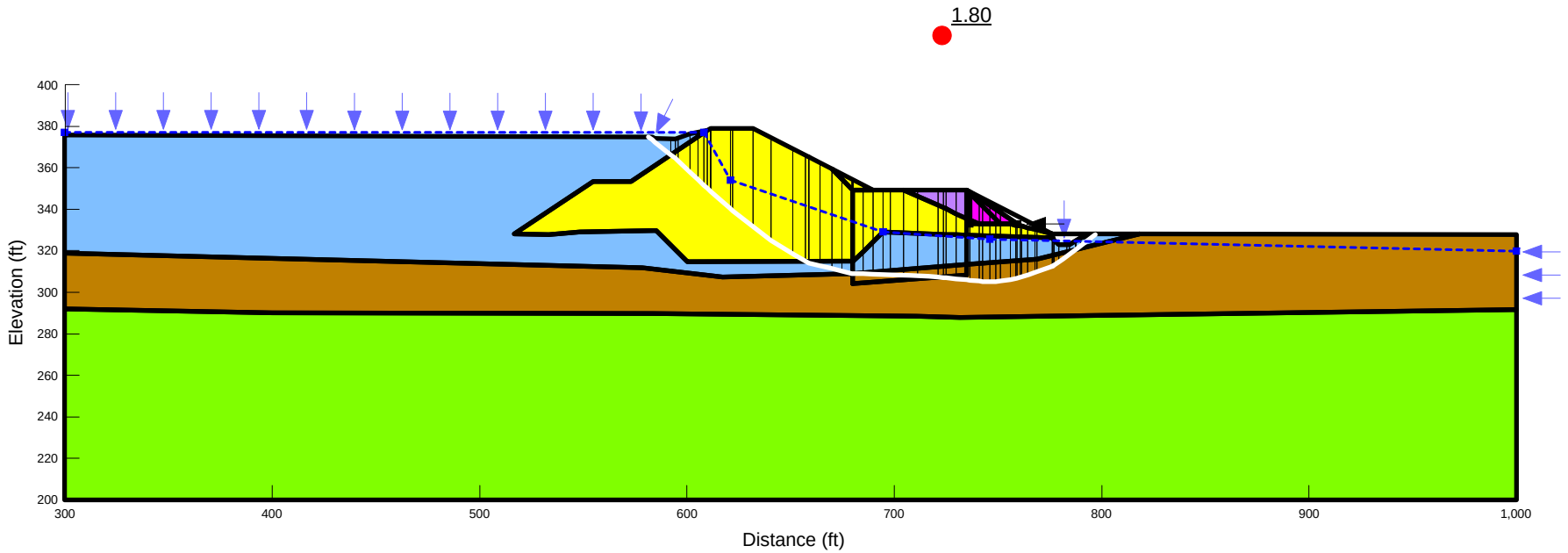
Computed By: LPC
Date: 4/19/2016

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: 3" Minus Stone Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Piezometric Line: 1

Materials
- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)
- 3" Minus Stone

Section A Static Max Storage

Kind: SLOPE/W
Method: Spencer
F of S: 1.80



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Joppa Section A DMM Design
Long-Term Drained Analysis

Computed By: LPC
Date: 4/26/2016

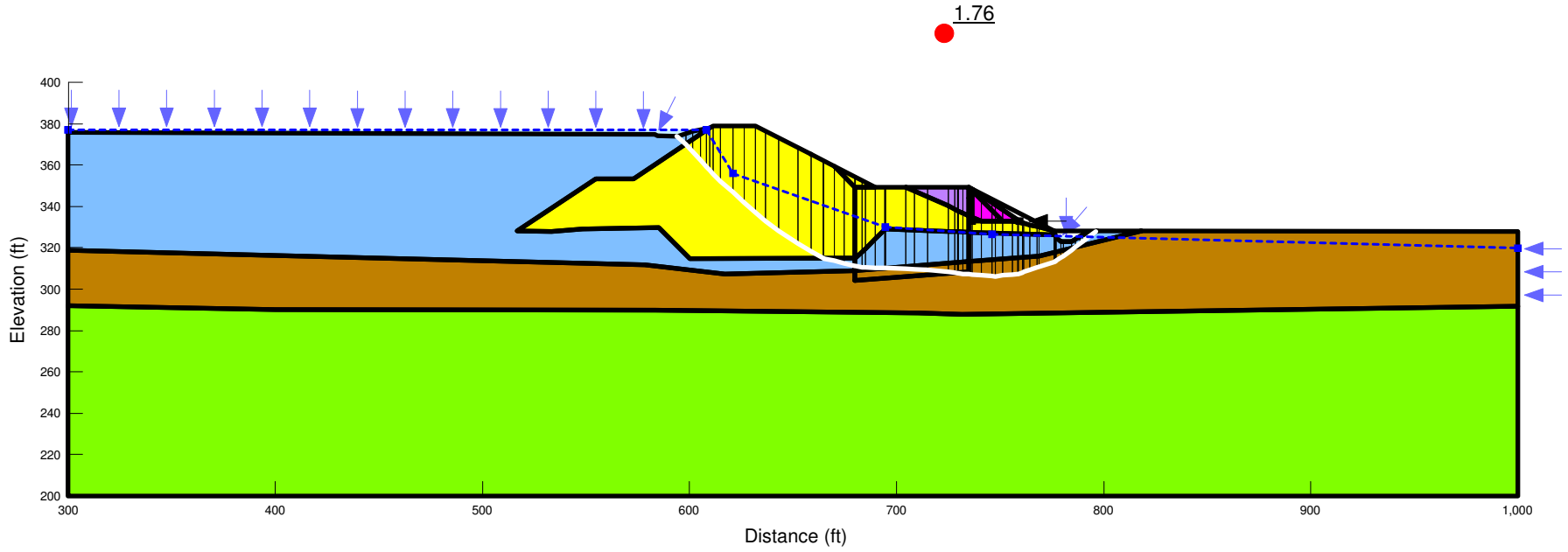
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Toe Buttress (Peak Drained) Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Piezometric Line: 1
Name: 3" Minus Stone Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Piezometric Line: 1

Materials

- Embankment Fill (Peak Drained)
- Foundation Clay (Peak Drained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Drained)
- Toe Buttress (Peak Drained)
- 3" Minus Stone

Section A Static Max Storage

Kind: SLOPE/W
Method: Spencer
F of S: 1.76



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Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.224		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.199767	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.30	seconds	
Moment Magnitude (Mw)	7.6		
Spectral Acceleration (Sa(1.5Ts))	1.125	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	91.44	cm

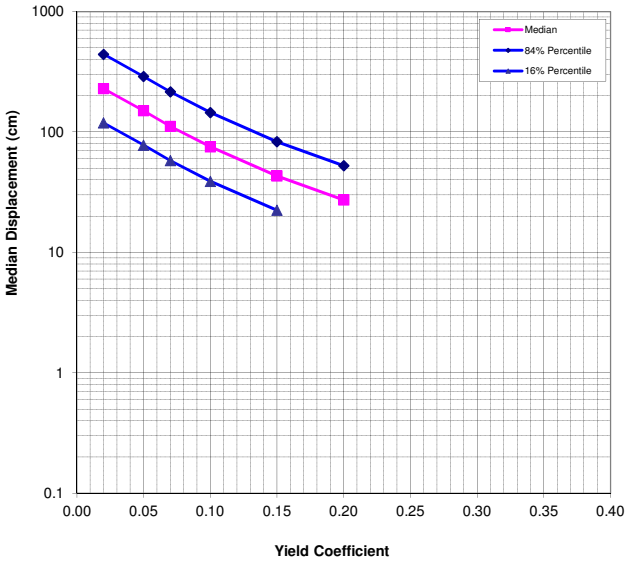
Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	22.42	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results			
Probability of Negligible Displ. (P(D=0))	0.00		eq. (3)
D1	11.6	cm	calc. using eq. (7)
D2	22.4	cm	calc. using eq. (7)
D3	43.2	cm	calc. using eq. (7)
P(D>d_threshold)	0.02		eq. (7)

Notes
1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
(e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s, i.e. Ts = 0.0. If Ts is just less than 0.05 s, set Ts = 0.050 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

Dependence on ky

ky	P(D="0")	D (cm)	Dmedian (cm)	D-84% (cm)	D-16% (cm)
0.020	0.00	229.3	229.3	442.1	119.0
0.05	0.00	150.0	150.0	289.2	77.8
0.07	0.00	111.6	111.6	215.1	57.9
0.1	0.00	75.1	75.1	144.7	38.9
0.15	0.00	43.2	43.2	83.2	22.4
0.2	0.00	27.3	27.3	52.6	14.1
0.3	0.00	13.0	13.0	25.0	6.7
0.4	0.05	7.2	6.9	13.6	3.3



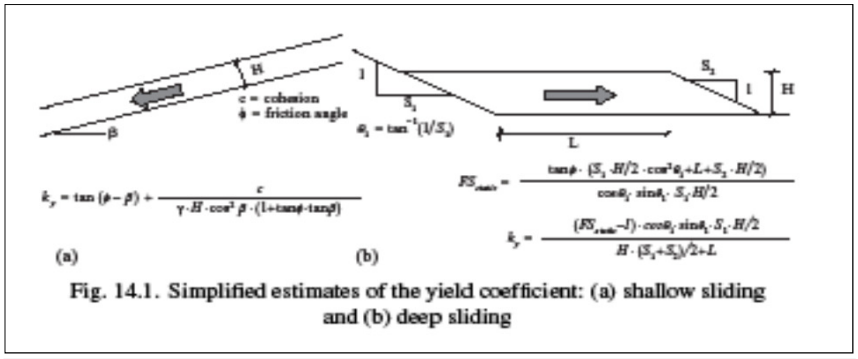


Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

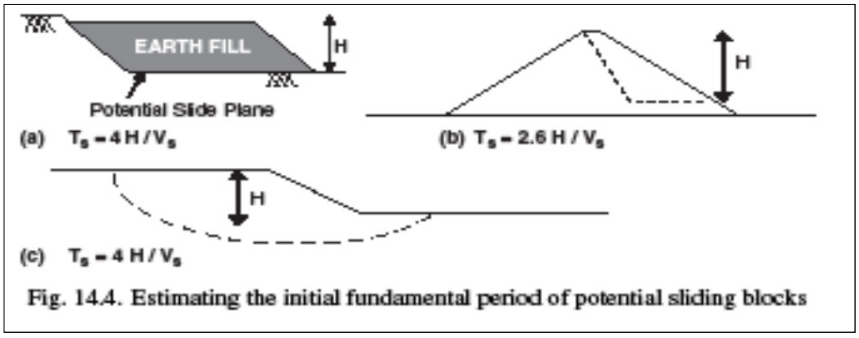


Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

Figures from Bray, J.D. (2007) "Chapter 14: Simplified Seismic Slope Displacement Procedures," Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

Calculation Notes

Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50) Project Name: Dynegy CCR

By: Lucas Carr Date: 4/14/2016 Project No: 60440155

Checked By: Andy Wilding Date: 4/26/2016 Task No.: 01

Attachment 2

Geosynthetic Calculations

1 - Select Appropriate Geosynthetic Reduction Factors.

Allowable Long-Term Strength Equation

Equation 3-12: FHWA NIH-10-024 (November 2009):

$$T_{al} = \frac{T_{ult}}{RF} = \frac{T_{ult}}{RF_{ID} * RF_{CR} * RF_{D}}$$

Where

T_{al} = Available Long-Term Strength

T_{ult} = Ultimate tensile strength (strength per unit width), per ASTM D4595 (geotextiles) or D6637 (geogrids), based on the minimum average roll value (MARV)

RF = Reduction factor. The product of all applicable reduction factors.

RF_{ID} = Installation Damage Reduction Factor. A reductionf actor that accoutns for the damage effects of placement and compaction fo soil or aggregate over the geosynethetic suring installation. A minimum reduction factor of 1.1 should be used to account for testing uncertainties.

RF_{CR} = Creep Reduction Factor. A reduction actor that accounts for the effect of creep resulting from long-term sustained tensile load applied to geosynthetic.

RF_{D} = Durability Reduction Factor. A reduction factor that accounts for the strength loss caused by chemical degradation (aging) of the polymer used in the geosynthetic reinforcement (e.g., oxidation of polyolefins, hydrolysis of polyesters, etc.)

Installation Damage Reduction Factor

Table 3-9. Installation Damage Reduction Factors.

Geosynthetic	Reduction Factor, RF_{ID}: Type 1 Backfill Max. Size 4 in. (100mm) D_{50} about 1¼-in. (30 mm)	Type 2 Backfill Max. Size ¾ -in. (20mm) D_{50} about #30 (0.7 mm)
HDPE uniaxial geogrid	1.20 - 1.45	1.10 - 1.20
PP biaxial geogrid	1.20 - 1.45	1.10 - 1.20
PVC coated PET geogrid	1.30 - 1.85	1.10 - 1.30
Acrylic coated PET geogrid	1.30 - 2.05	1.20 - 1.40
Woven geotextiles (PP&PET)[a]	1.40 - 2.20	1.10 - 1.40
Non woven geotextiles (PP&PET)[a]	1.40 - 2.50	1.10 - 1.40
Slit film woven PP geotextile[a]	1.60 - 3.00	1.10 - 2.00

a. Minimum weight 8.0 oz/yd^2 (270 g/m^2).

Geosynthetic will be installed in gravel backfill, which is similar to Type 1. Resulting reduction factors of PVC-coated PET geogrids range from 1.4 to 2.5, while factors of woven and non-woven geotextiles range from 1.1-1.4. Due to the potential large size of the rock, which could damage the geotextile, a factor of 2.0 is selected.

RF_{ID} = 2

Creep Reduction Factor

Typical ranges of RF_{CR} as a function of polymer type are:

Polymer Type	Creep Reduction Factors
Polyester (PET)	2.5 to 1.6
Polypropylene (PP)	5 to 4.0
High Density Polyethylene (HDPE)	5 to 2.6

Use 2.0, which is midway between 1.6 and 2.5 (reccomended reduction factor for PET)

RF_{CR} = 2.0

Durability Reduction Factor

Table 3-11. Durability (Aging) Reduction Factors for PET.

Product[a]	Durability Reduction Factor, RF_D: $5 \le pH \le 8$	$3^b < pH \le 5$ $8 \le pH < 9$
Geotextiles $M_n < 20{,}000$, $40 < CEG < 50$	1.6	2.0
Coated geogrids, Geotextiles $M_n > 25{,}000$, $CEG < 30$	1.15	1.3

M_n = number average molecular weight
CEG = carboxyl end group
Notes:
a. Use of materials outside the indicated molecular property range requires specific product testing. Use of products outside of $3 < pH < 9$ range is not recommended.
b. Lower limit of pH for permanent applications is 4.5 and lower limit for temporary applications is 3, per Article 11.10.6.4.2b (AASHTO, 2007).

Use 1.15. The geosynthetic is not expected to be installed in an excessivly alkaline or acidic environment.

RF_{D} = 1.15

Calculate Total RF

RF = 4.6

2 - Analyze PET Geotextiles and Geogrids

Develop Tal values for various geosynethtic in order to select a cost-effective geosynethetic type. Evaluated geosynthetics are limited to products from TenCate-Mirafi. Geosynthetic produced by other manufacturers may be appropriate, provided they meet the specifications develop herein.

a. TenCate Mirafi PET-Series Geotextiles

Product	Ultimate Tensile Strength (lbs/ft)	Tensile Strength @ 5% Strain (lbs/ft)	Long-Term Design Strength (lbs/ft)	T_{al} (lbs/ft)
PET70/70	4800	1080	2280	1043
PET100	7200	2700	3420	1565
PET150	10283	3600	4877	2235
PET200	13800	6000	6545	3000
PET300	20580	8400	10205	4474
PET 400/50	27417	9594	13590	5960
PET600/100	41124	14400	24674	8940
PET800/100	54828	19200	27192	11919
PET1000/100	68522	27409	33980	14896

b. TenCate Mirafi Miragrid XT-Series GeoGrids

Product	Ultimate Tensile Strength (lbs/ft)	Tensile Strength @ 5% Strain (lbs/ft)	Long-Term Design Strength (lbs/ft)	T_{al} (lbs/ft)
2XT	2000		1096	435
3XT	3050	1056	1918	663
5XT	4700	1740	2575	1022
7XT	5900	2160	3233	1283
8XT	7400	2520	4055	1609
10XT	9500	3120	5206	2065
20XT	13705	5340	7510	2979
22XT	20559	6700	11266	4469
24XT	27415	7000	15023	5960

3 - Check Pullout Resistance

Per NHI-10-024, pullout resistance is calculated usign the following equation:

$$P_r = F^* \alpha \sigma'_v L_e C \qquad (3\text{-}2)$$

where:

$L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface

L_e = the embedment or adherence length in the resisting zone behind the failure surface

C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids

F^* = the pullout resistance (or friction-bearing-interaction) factor

α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).

σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

L_c =	7.8	ft	(from SLOPE/W model - Section A, Temporary Construction, Rig Load)
C =	2		see above

Table 3-6. Summary of Pullout Capacity Design Parameters.

Reinforcement Type	S_{opt}	Grid Spacing	Tan ρ	F_q	α_β	α Default Value
Inextensible strips		NA	Obtain Tan ρ from tests, or use default values	NA	NA	1.0
Inextensible grids (bar mats and welded wire)	$\frac{t F_q}{2 \tan\phi}$	$S_t \le S_{opt}$	Obtain Tan ρ from tests	NA	NA	1.0*
	$\frac{t F_q}{2 \tan\phi}$	$S_t > S_{opt}$	NA	Obtain F_q from tests, or use default values	$\frac{t}{2S_t}$	1.0*
Extensible grids with $\frac{\text{min. grid opening}}{d_{50}} > 1$	$\frac{t F_q}{2 \tan\phi}$	$S_t \le S_{opt}$	Obtain Tan ρ from tests	NA	NA	0.8
	$\frac{t F_q}{2 \tan\phi}$	$S_t > S_{opt}$	NA	Obtain F_q from tests, or use default values	$\frac{f_b t}{2S_t}$	0.8
Extensible grids with $\frac{\text{min. grid opening}}{d_{50}} < 1$		NA	Obtain Tan ρ from tests	NA	NA	0.8
Extensible sheets		NA	Obtain Tan ρ from tests	NA	NA	0.6

NOTES:
(i) It is acceptable to use the empirical values provided in or referenced by this table to determine F* in the absence of product and backfill specific test data, provided granular reinforced fill as specified in Table 3-1 for MSE walls is used and $C_u \ge 4$. For fill outside these limits, tests must be run.
(ii) Pullout testing to determine α is recommended if α shown in table is less than 1.0. These values of α represent highly extensible geosynthetics.
(iii) For grids where Tan ρ is applicable, apply Tan ρ to the entire surface area of the reinforcement sheet (i.e., soil and grid), not just the surface area of the grid elements.
(iv) NA means "not applicable." ϕ is the soil friction angle. ρ is the interface friction angle mobilized along the reinforcement. S_{opt} is the optimum transverse grid element spacing to mobilize maximum pullout resistance as obtained from pullout tests (typically 6 in. (150 mm) or greater). S_t is the spacing of the transverse grid elements. t is the thickness of the transverse elements. F_q is the embedment (or surcharge) bearing capacity factor. α_β is a structural geometric factor for passive resistance. f_b is the fraction of the transverse member on which bearing can be fully developed (typically ranging from 0.6 to 1.0) as obtained from an evaluation of the bearing surface shape. D_{50} is the backfill grain size at 50% passing by weight. α is the scale effect correction factor.
(v) Definitions of the geometric variables are illustrated in Figure 3-4.

* For longitudinal bars/wires spacing greater than 6 inches, α may be less than 1.0 and pullout tests are required.

α =	0.6	for geotextiles
α =	0.8	for geogrids

For geosynthetic (i.e., geogrid and geotextile) sheet reinforcement, the pullout resistance is based on a reduction in the available soil friction with the reduction factor often referred to as an Interaction Factor, C_i. In the absence of test data, the F* value for geosynthetic reinforcement should conservatively be taken as:

$$F^* = \tfrac{2}{3} \tan\phi \qquad (3\text{-}8)$$

ϕ' =	40	deg	
			740.15
F* =	0.56		
σ'_v =	1664	psf	Vertical effective stress at x = 740 ft, which is midpoint of grid behind failure plane.
Pr (Geotextile) =	8756	lbs	
Pr (Geogrid) =	11675	lbs	

Pullout resistance is higher than long-term allowable geosynthetic strength, so the geosynethetic would rupture prior to pullout. Therefore, the geosynthetic strength controls design.

TENCATE GEOSYNTHETICS
Americas

Mirafi® PET70/70

Mirafi® PET70/70 geotextile is composed of high tenacity polyester multifilament yarns which are woven into a stable network such that the yarns retain their relative position. Mirafi® PET70/70 geotextile is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP).

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Tensile Strength (at ultimate)	ASTM D4595	lbs/ft (kN/m)	4800 (70.0)	4800 (70.0)
Tensile Strength (at 5% strain)	ASTM D4595	lbs/ft (kN/m)	1080 (15.8)	2400 (35.0)
Tensile Strength (at 10% strain)	ASTM D4595	lbs/ft (kN/m)	3360 (49.0)	4800 (70.0)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	2880 (42.0)	
Long Term Design Strength[1,2]	GRI GT-7	lbs/ft (kN/m)	2280 (33.2)	
Permittivity	ASTM D4491	sec^{-1}	0.10	
Apparent Opening Size (AOS)[3]	ASTM D4751	U.S. Sieve (mm)	40 (0.43)	
UV Resistance (at 250 hours)	ASTM D4355	% strength retained	50	

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Factory Sewn Seam	ASTM D4884	lbs/ft (kN/m)	2400 (35.0)

[1] Machine Direction
[2] Long Term Allowable Design values are for sand, silt and clay
[3] ASTM D4751: AOS is a Maximum Opening Diameter Value
Note: To obtain Secant Modulus, divide tensile strength by the appropriate strain level (i.e. Secant Modulus at 5% = 1080/0.05=21,600 lb/ft)

Physical Properties	Unit	Typical Value
Roll Dimensions (width x length)	ft (m)	15 x 300 (4.5 x 91.5)
Roll Area	yd^2 (m^2)	500 (418)
Estimated Roll Weight	lb (kg)	234 (107)

Creep Reduced Strength (ASTM D5262) and Long Term Design Strength (GRI GT-7) are not covered by our current A2LA accreditation.

[3] ASTM D4439 Standard Terminology for Geosynthetics: typical value, *n—for geosynthetics,* the mean value calculated from documented manufacturing quality control test results for a defined population obtained from one test method associated with on specific property.

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Pendergrass, GA 30567

Tel 706 693 2226
Tel 888 795 0808

Fax 706 693 4400
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TENCATE GEOSYNTHETICS
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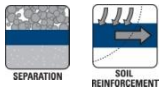
Mirafi® PET100



Mirafi® PET100 is composed of high tenacity polyester multifilament yarns which is woven into a stable network such that the yarns retain their relative position. Mirafi® PET100 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP).

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at Ultimate)	ASTM D4595	lbs/ft (kN/m)	7200 (105.1)
Tensile Strength (at 5% strain)	ASTM D4595	lbs/ft (kN/m)	2400 (35.0)
Tensile Strength (at 10% strain)	ASTM D4595	lbs/ft (kN/m)	5760 (84.0)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	4320 (63.0)
Long Term Design Strength[1]	GRI GT-7	lbs/ft (kN/m)	3420 (49.9)
Permittivity	ASTM D4491	sec^{-1}	0.32
Apparent Opening Size (AOS)[2]	ASTM D4751	U.S. Sieve (mm)	20 (0.85)
UV Resistance (at 250 hours)	ASTM D4355	% strength retained	50

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Factory Sewn Seam	ASTM D4884	lbs/ft (kN/m)	2400 (35.0)

[1] Long Term Allowable Design values are for sand, silt and clay
[2] ASTM D4751: AOS is a Maximum Opening Diameter Value
Note: To obtain Secant Modulus, divide tensile strength by the appropriate strain level (i.e. Secant modulus at 5% = 2400/0.05=48,000 lb/ft)

Physical Properties	Unit	Typical Value[3]
Roll Dimensions (width x length)	ft (m)	15 x 300 (4.5 x 91)
Roll Area	yd^2 (m^2)	500 (418)
Estimated Roll Weight	lb (kg)	398 (181)

Creep Reduced Strength (ASTM D5262) and Long Term Design Strength (GRI GT-7) are not covered by our current A2LA accreditation.

[3] ASTM D4439 Standard Terminology for Geosynthetics: typical value, *n—for geosynthetics,* the mean value calculated from documented manufacturing quality control test results for a defined population obtained from one test method associated with on specific property.

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Pendergrass, GA 30567

Tel 706 693 2226
Tel 888 795 0808

Fax 706 693 4400
www.tencate.com

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TENCATE GEOSYNTHETICS
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Mirafi® PET150

Mirafi® PET150 is composed of high tenacity polyester multifilament yarns which are woven into a stable network such that the yarns retain their relative position. Mirafi® PET150 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas Laboratories are accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP).

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Tensile Strength (at ultimate)[1]	ASTM D4595	lbs/ft (kN/m)	10283 (150.0)
Tensile Strength (at 5% strain)[1]	ASTM D4595	lbs/ft (kN/m)	3600 (52.5)
Tensile Strength (at 10% strain)[1]	ASTM D4595	lbs/ft (kN/m)	9000 (131.3)
Creep Reduced Strength[1]	ASTM D5262	lbs/ft (kN/m)	6170 (90.0)
Long Term Design Strength[1,2]	GRI GT-7	lbs/ft (kN/m)	4877 (71.2)
Permittivity	ASTM D4491	sec^{-1}	0.20
Apparent Opening Size (AOS)[3]	ASTM D4751	U.S. Sieve (mm)	20 (0.85)
UV Resistance (at 250 hours)	ASTM D4355	% strength retained	50

[1] Machine Direction
[2] Long Term Allowable Design values are for sand, silt and clay
[3] ASTM D4751: AOS is a Maximum Opening Diameter Value

Physical Properties Test Method	Unit	Typical Value
Roll Dimensions (length x width)	ft (m)	15 x 300 (4.5 x 91.5)
Roll Area	yd^2 (m^2)	500 (418)
Estimated Roll Weight	lbs (kg)	490 (221)

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Creep Reduced Strength (ASTM D5262), Long Term Design Strength (GRI GT-7) and UV Resistance (ASTM D4355) is not covered by our current A2LA accreditation.

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TENCATE GEOSYNTHETICS
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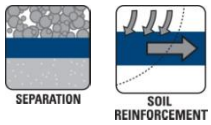
Mirafi® PET200



Mirafi® PET200 geotextile is composed of high tenacity polyester multifilament yarns which are woven into a stable network such that the yarns retain their relative position. Mirafi® PET200 geotextile is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

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Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Tensile Strength (at ultimate)[1]	ASTM D4595	lbs/ft (kN/m)	13800 (201.4)
Tensile Strength (at 5% strain)[1]	ASTM D4595	lbs/ft (kN/m)	6000 (87.6)
Tensile Strength (at 10% strain)[1]	ASTM D4595	lbs/ft (kN/m)	12000 (175.1)
Creep Reduced Strength [1]	ASTM D5262	lbs/ft (kN/m)	8280 (120.8)
Long Term Design Strength[1,2]	GRIGT-7	lbs/ft (kN/m)	6545 (95.5)
Factory Sewn Seam	ASTM D4884	lbs/ft (kN/m)	2400 (35.0)
Permittivity	ASTM D4491	sec^{-1}	0.32
Apparent Opening Size (AOS)[3]	ASTM D4751	U.S. Sieve (mm)	30 (0.60)
UV Resistance (at 250 hours)	ASTM D4355	% strength retained	50

[1] Machine Direction
[2] Long Term Allowable Design values are for sand, silt and clay
[3] ASTM D4751: AOS is a Maximum Opening Diameter Value
NOTE: To obtain Secant Modulus, divide tensile strength by the appropriate strain level
(i.e. Secant Modulus at 5% = 6000/0.05 = 120,000 lb/ft)

Physical Properties	Unit	Typical Value
Roll Dimensions (length x width)	ft (m)	15 x 300 (4.5 x 91.5)
Roll Area	yd^2 (m^2)	500 (418)
Estimated Roll Weight	lbs (kg)	714 (324)

Creep Reduced Strength (ASTM D5262) and Long Term Design Strength (GRI GT-7) are not covered by our current A2LA accreditation.

[3] ASTM D4439 Standard Terminology for Geosynthetics: typical value, *n—for geosynthetics,* the mean value calculated from documented manufacturing quality control test results for a defined population obtained from one test method associated with on specific property.

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TENCATE GEOSYNTHETICS
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Mirafi® PET300

Mirafi® PET300 is composed of high tenacity polyester multifilament yarns which are woven into a stable network such that the yarns retain their relative position. Mirafi® PET300 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

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Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D4595	lbs/ft (kN/m)	20580 (300.4)
Tensile Strength (at 5% strain)	ASTM D4595	lbs/ft (kN/m)	8400 (122.6)
Tensile Strength (at 10% strain)	ASTM D4595	lbs/ft (kN/m)	16800 (245.1)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	12348 (180.2)
Long Term Design Strength[1]	GRI GT-7	lbs/ft (kN/m)	10205 (148.9)
Permittivity	ASTM D4491	sec^{-1}	0.1
Apparent Opening Size (AOS)[2]	ASTM D4751	U.S. Sieve (mm)	20 (0.85)
UV Resistance (at 250 hours)	ASTM D4355	% strength retained	50

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Factory Sewn Seam	ASTM D4884	lbs/ft (kN/m)	2400 (35.0)

[1] Long Term Allowable Design values are for sand, silt and clay
[2] ASTM D 4751: AOS is a Maximum Opening Diameter Value
NOTE: To obtain Secant Modulus, divide tensile strength by the appropriate strain level
(i.e. Secant Modulus at 5% = 8400/0.05 = 168,000 lb/ft)

Physical Properties	Unit	Typical Value[3]
Roll Dimensions (width x length)	ft (m)	15 X 300 (4.5 x 91.5)
Roll Area	yd^2 (m^2)	500 (418)
Estimated Roll Weight	lbs (kg)	883 (400)

Creep Reduced Strength (ASTM D5262) and Long Term Design Strength (GRI GT-7) are not covered by our current A2LA accreditation.

[3] ASTM D4439 Standard Terminology for Geosynthetics: typical value, *n—for geosynthetics,* the mean value calculated from documented manufacturing quality control test results for a defined population obtained from one test method associated with on specific property.

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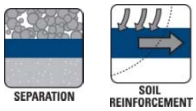
TENCATE GEOSYNTHETICS
Americas

Mirafi® PET 400/50



Mirafi® PET 400/50 is composed of high tenacity polyester multifilament yarns which are woven into a stable network such that the yarns retain their relative position. Mirafi® PET 400/50 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D4595	lbs/ft (kN/m)	27417 (400.0)
Tensile Strength (at 5% strain)	ASTM D4595	lbs/ft (kN/m)	9594 (140.0)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	16447 (240.0)
Long Term Design Strength[1]	GRI GT7	lbs/ft (kN/m)	13590 (198.3)
Carboxyl End Group	GRI GG7	mmol/kg	< 30
Molecular Weight	GRI GG8	--	> 25000
UV Resistance (at 500 hours)	ASTM D4355	% strength retained	50

[1] Long Term Allowable Design values are for sand, silt and clay.

Physical Properties	Unit	Typical Value
Roll Dimensions (length x width)	ft (m)	16.4 x 656 (5 x 200)
Roll Area	yd^2 (m^2)	1195 (1000)

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materials that make a difference

Mirafi® PET600/100

Mirafi® PET600/100 is composed of high tenacity polyester multifilament yarns which are woven into a stable network such that the yarns retain their relative position. Mirafi® PET600/100 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D4595	lbs/ft (kN/m)	41124 (600)
Tensile Strength (at 5% strain)	ASTM D4595	lbs/ft (kN/m)	14400 (210)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	24674 (360)
Long Term Design Strength[1]	GRI GT7	lbs/ft (kN/m)	20392 (298)
Carboxyl End Group	GRI GG7	mmol/kg	<30
Molecular Weight	GRI GG8	--	>25000

[1] Long Term Allowable Design values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Roll Dimensions (width x length)	ft (m)	16.4 x 492 (5 x 150)
Roll Area	yd^2 (m^2)	896 (750)

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Mirafi® PET800/100

Mirafi® PET800/100 is composed of high tenacity polyester multifilament yarns which are woven into a stable network such that the yarns retain their relative position. Mirafi® PET800/100 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D4595	lbs/ft (kN/m)	54828 (800)
Tensile Strength (at 5% strain)	ASTM D4595	lbs/ft (kN/m)	19200 (280)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	32892 (480)
Long Term Design Strength[1]	GRI GT7	lbs/ft (kN/m)	27192 (397)
Carboxyl End Group	GRI GG7	mmol/kg	<30
Molecular Weight	GRI GG8	--	>25000

[1] Long Term Allowable Design values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Roll Dimensions (width x length)	ft (m)	16.4 x 328 (5 x 100)
Roll Area	yd^2 (m^2)	598 (500)

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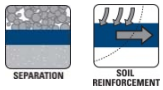
Mirafi® PET 1000/100



Mirafi® PET 1000/100 geotextile is composed of high tenacity polyester multifilament yarns which are woven into a stable network such that the yarns retain their relative position. Mirafi® PET 1000/100 geotextile is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Tensile Strength (at ultimate)	ASTM D4595	lbs/ft (kN/m)	68522 (1000)	6852 (100)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	41113 (600)[2]	
Long Term Design Strength[1]	GRI-GT7	lbs/ft (kN/m)	33980 (496)[2]	
Tensile Strength in Machine Direction (at 5% strain)	ASTM D4595	lbs/ft (kN/m)	27409 (400)	
Carboxyl End Group	GRI-GG7	mmol/kg	< 30	
Molecular Weight	GRI-GG8	--	> 25000	

[1] Long Term Allowable Design values are for sand, silt and clay.
[2] Machine Direction; based on third party testing.

Physical Properties	Unit	Typical Value
Roll Dimensions (width x length)	ft (m)	16.4 x 328 (5 x 100)
Roll Area	yd^2 (m^2)	598 (500)
Estimated Roll Weight	lbs (kg)	2519 (1143)

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materials that make a difference

Miragrid® 2XT

Miragrid® 2XT biaxial geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 2XT biaxial geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP test data.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	2000 (29.2)	2000 (29.2)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	1266 (18.5)	
Long Term Allowable Design Load[1]	GRI GG-4(b)	lbs/ft (kN/m)	1096 (16.0)	

[1] NOTE: Allowable Long Term Strength values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	7.6 (258)
Roll Dimensions (width x length)	ft (m)	12 x 150 (3.6 x 46)
Roll Area	yd^2 (m^2)	200 (165)
Estimated Roll Weight	lbs (kg)	101 (46)

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Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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Pendergrass, GA 30567

Tel 706 693 2226
Tel 888 795 0808

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Miragrid® 3XT

Miragrid® 3XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 3XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

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Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	3500 (51.1)
Tensile Strength (at 5% strain)	ASTM D6637	lbs/ft (kN/m)	1056 (15.4)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	2215 (32.3)
Long Term Allowable Design Load[1]	GRI GG-4(b)	lbs/ft (kN/m)	1918 (28.0)

[1] NOTE: Allowable Long Term Strength values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	8.2 (278)
Roll Dimensions (width x length)	ft (m)	12 x 150 (3.6 x 46)
Roll Area	yd^2 (m^2)	200 (165)
Estimated Roll Weight	lbs (kg)	119 (54)

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Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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Tel 706 693 2226
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TENCATE GEOSYNTHETICS
Americas

Miragrid® 5XT

Miragrid® 5XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 5XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP test data.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	4700 (68.6)
Tensile Strength (at 5% strain)	ASTM D6637	lbs/ft (kN/m)	1740 (25.4)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	2975 (43.4)
Long Term Allowable Design Load[1]	GRI GG-4(b)	lbs/ft (kN/m)	2575 (37.6)

[1] NOTE: Long Term Allowable Design values are for sand, silt and clay

Physical Properties	Unit	Typical Value[2]
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	9.3 (315)
Roll Dimensions (width x length)	ft (m)	12 x 150 (3.6 x 46)
Roll Area	yd^2 (m^2)	200 (165)
Estimated Roll Weight	lbs (kg)	123 (56)

[2] ASTM D4439 Standard Terminology for Geosynthetics: typical value, *n—for geosynthetics,* the mean value calculated from documented manufacturing quality control test results for a defined population obtained from one test method associated with on specific property.

Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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Tel 888 795 0808

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GAI-LAP-25-97

Testing Lab 1291.01 & 1291.02

TENCATE GEOSYNTHETICS
Americas

Miragrid® 7XT

Miragrid® 7XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 7XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP test data.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	5900 (86.1)
Tensile Strength (at 5% strain)	ASTM D6637	lbs/ft (kN/m)	2160 (31.5)
Creep Reduced Strength[1]	ASTM D5262	lbs/ft (kN/m)	3734 (54.5)
Long Term Allowable Design Load[1,2]	GRI GG-4(b)	lbs/ft (kN/m)	3233 (47.2)

[1] Based on Third Party Testing.
[2] NOTE: Long Term Allowable Design values are for sand, silt and clay.

Physical Properties	Unit	Typical Value[3]
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	9.4 (346)
Roll Dimensions (width x length)	ft (m)	12 x 200 (3.6 x 61)
Roll Area	yd^2 (m^2)	267 (220)
Estimated Roll Weight	lbs (kg)	163 (75)

[3] ASTM D4439 Standard Terminology for Geosynthetics: typical value, *n—for geosynthetics,* the mean value calculated from documented manufacturing quality control test results for a defined population obtained from one test method associated with on specific property.

Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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Tel 888 795 0808
Fax 706 693 4400
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Testing Lab 1291.01 & 1291.02

Miragrid® 8XT

Miragrid® 8XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 8XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP test data.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	7400 (108.0)
Tensile Strength (at 5% strain)	ASTM D6637	lbs/ft (kN/m)	2520 (36.8)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	4684 (68.3)
Long Term Allowable Design Load[1]	GRI GG-4(b)	lbs/ft (kN/m)	4055 (59.2)

[1] NOTE: Long Term Allowable Design values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	10.8 (366)
Roll Dimensions (width x length)	ft (m)	12 x 200 (3.6 x 61)
Roll Area	yd^2 (m^2)	267 (220)
Estimated Roll Weight	lbs (kg)	187 (85)

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Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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Tel 706 693 2226
Tel 888 795 0808

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Miragrid® 10XT

Miragrid® 10XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 10XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP test data.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	9500 (138.6)
Tensile Strength (at 5% strain)	ASTM D6637	lbs/ft (kN/m)	3120 (45.5)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	6013 (87.7)
Long Term Allowable Design Load[1]	GRI GG-4(b)	lbs/ft (kN/m)	5206 (76.0)

[1] NOTE: Long Term Allowable Design values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	13.4 (454)
Roll Dimensions (width x length)	ft (m)	12 x 200 (3.6 x 61)
Roll Area	yd^2 (m^2)	267 (220)
Estimated Roll Weight	lbs (kg)	237 (107)

Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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TENCATE GEOSYNTHETICS
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Miragrid® 20XT

Miragrid® 20XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 20XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP test data.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	13705 (200)
Tensile Strength (at 5% strain)	ASTM D6637	lbs/ft (kN/m)	5340 (78)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	8674 (127)
Long Term Allowable Design Load[1]	GRI GG-4(b)	lbs/ft (kN/m)	7510 (110)

[1] NOTE: Long Term Allowable Design values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	19.6 (664)
Roll Dimensions (width x length)	ft (m)	12 x 200 (3.6 x 61)
Roll Area	yd^2 (m^2)	267 (220)
Estimated Roll Weight	lbs (kg)	346 (157)

Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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GAI-L

Miragrid® 22XT

Miragrid® 22XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 22XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP test data.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	20559 (300)
Tensile Strength (at 5% strain)	ASTM D6637	lbs/ft (kN/m)	6700 (98)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	13012 (190)
Long Term Allowable Design Load[1]	GRI GG-4(b)	lbs/ft (kN/m)	11266 (164)

[1] NOTE: Long Term Allowable Design values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	28.2 (956)
Roll Dimensions (width x length)	ft (m)	12 x 200 (3.6 x 61)
Roll Area	yd^2 (m^2)	267 (220)
Estimated Roll Weight	lbs (kg)	499 (226)

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Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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Tel 888 795 0808

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Miragrid® 24XT

Miragrid® 24XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Miragrid® 24XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

TenCate Geosynthetics Americas is accredited by a2La (The American Association for Laboratory Accreditation) and Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP test data.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
			Machine Direction
Tensile Strength (at ultimate)	ASTM D6637	lbs/ft (kN/m)	27415 (400)
Tensile Strength (at 5% strain)	ASTM D6637	lbs/ft (kN/m)	7000 (102)
Creep Reduced Strength	ASTM D5262	lbs/ft (kN/m)	17351 (253)
Long Term Allowable Design Load[1]	GRI GG-4(b)	lbs/ft (kN/m)	15023 (219)

[1] NOTE: Long Term Allowable Design values are for sand, silt and clay

Physical Properties	Unit	Typical Value
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	32.6 (1119)
Roll Dimensions (width x length)	ft (m)	12 x 200 (3.6 x 61)
Roll Area	yd^2 (m^2)	267 (220)
Estimated Roll Weight	lbs (kg)	576 (261)

Creep Reduced Strength (ASTM D5262), and Long Term Allowable Design Load (GRI GG-4(b)) is not covered by our current A2LA accreditation.

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Calculation Notes AECOM

Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50) Project Name: Dynegy CCR

By: Lucas Carr Date: 4/14/2016 Project No: 60440155

Checked By: Andy Wilding Date: 4/26/2016 Task No.: 01

Attachment 3

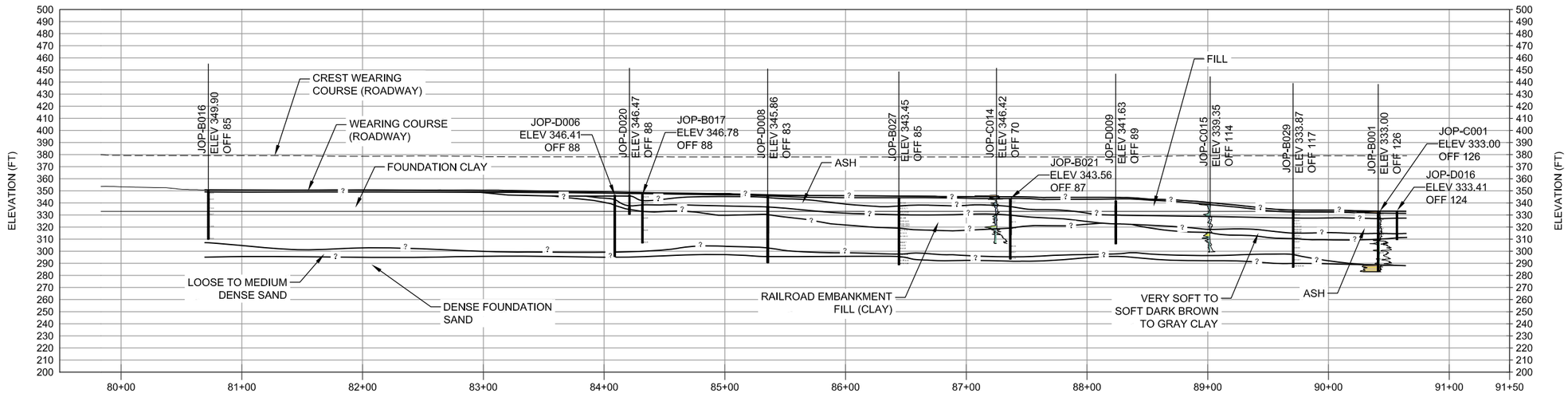
Section and Profile Drawings

RAU, MICHAEL, 4/22/2016 1:44 PM

AECOM

CREST PROFILE

TOE PROFILE



NOTES:

1. GROUND SURFACE: 2012 LIDAR DATA FROM THE ILLINOIS GEOSPATIAL DATA CLEARINGHOUSE - ILLINOIS GEOSPATIAL DATA CLEARINGHOUSE [IGDC]. (2015). LIDAR DATA FOR MASSAC COUNTY.
2. BORING LOCATIONS: 2015 POINTS LOCATED IN 2015 TOPOGRAPHIC AND BATHYMETRIC SURVEY 2016 POINTS WERE ESTIMATED LOCATIONS IN THE FIELD AND ELEVATIONS ESTIMATED FROM THE CAD SURFACE.
3. DATUMS: HORIZONTAL - NAD83 ILLINOIS STATE PLANE EAST ZONE VERTICAL - NAVD88
4. THE INTERPRETATION AND CONTINUITY OF SOILS BETWEEN ADJACENT FIELD INVESTIGATIONS ASSUMED A GENERALLY LINEAR RELATIONSHIP WITH NATURAL VARIATION BETWEEN POINTS; HOWEVER, THE SECTIONS AND PROFILES ARE ONLY INTERPOLATED AND DO CONTAIN SIGNIFICANT UNCERTAINTY. SPECIFIC KNOWLEDGE OBTAINED FROM HISTORIC AERIALS, EYE WITNESS ACCOUNTS OF CONSTRUCTION, CONSTRUCTION DRAWINGS, DESIGN SECTIONS (UNKNOWN DATUM), FIELD OBSERVATIONS, AND HISTORIC AND MODERN PHOTOS, WERE ALSO USED TO INTERPRET SECTION AND PROFILE GEOMETRIES BETWEEN FIELD INVESTIGATIONS.

0 50 100 150
SCALE IN FEET

Job No. :	60440155
Prepared By :	RS
Date :	04/22/2016

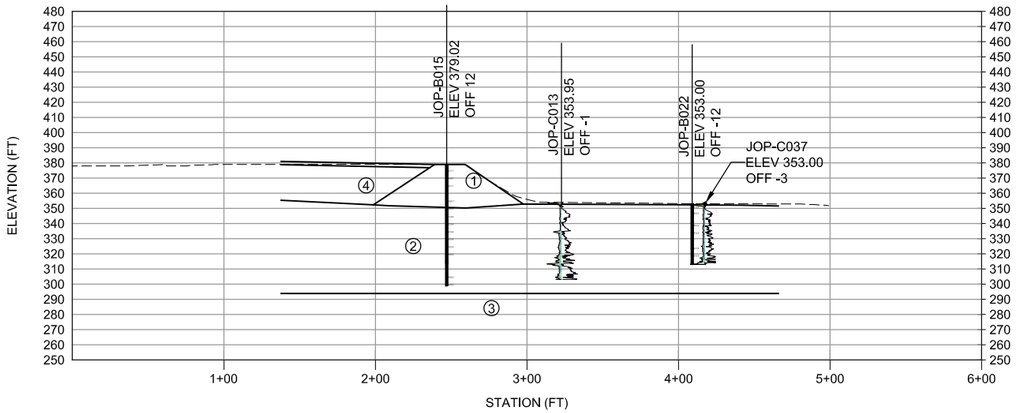
JOPPA ASH POND DMM DESIGN PROFILES

AECOM DRAWING PATH:M:\DCS\Resources\WTR\GeoCivil\Dynegy\Joppa\05-MODELS\JOPPA GEOTECH SECTIONS-SOUTH-2016.dwg

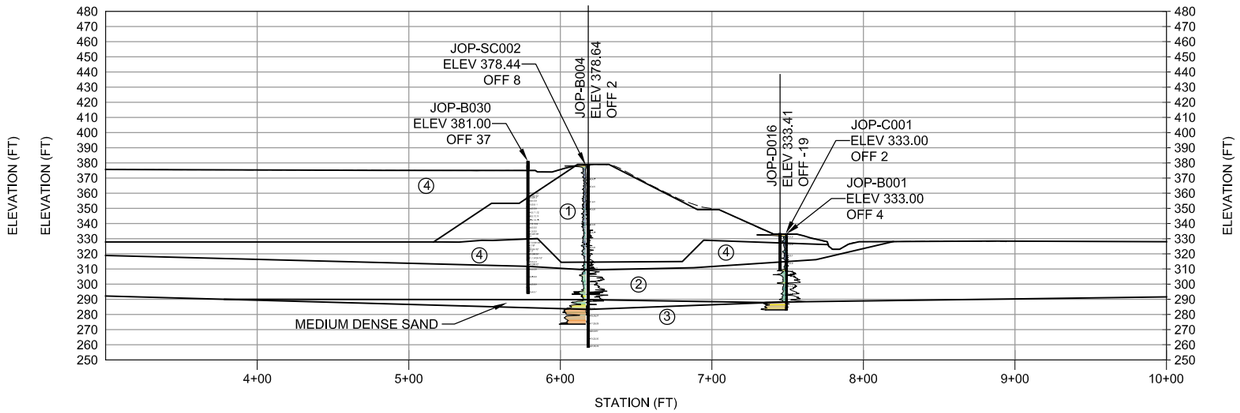
RAU, MICHAEL, 4/22/2016 1:44 PM

AECOM

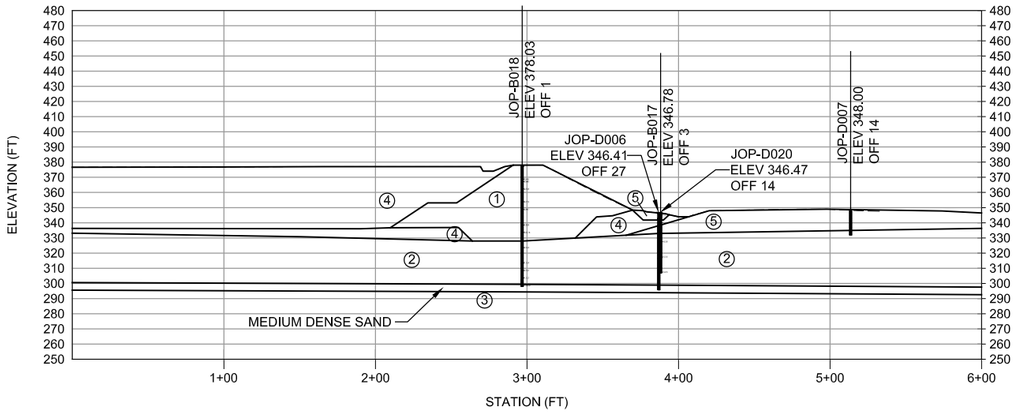
SECTION G



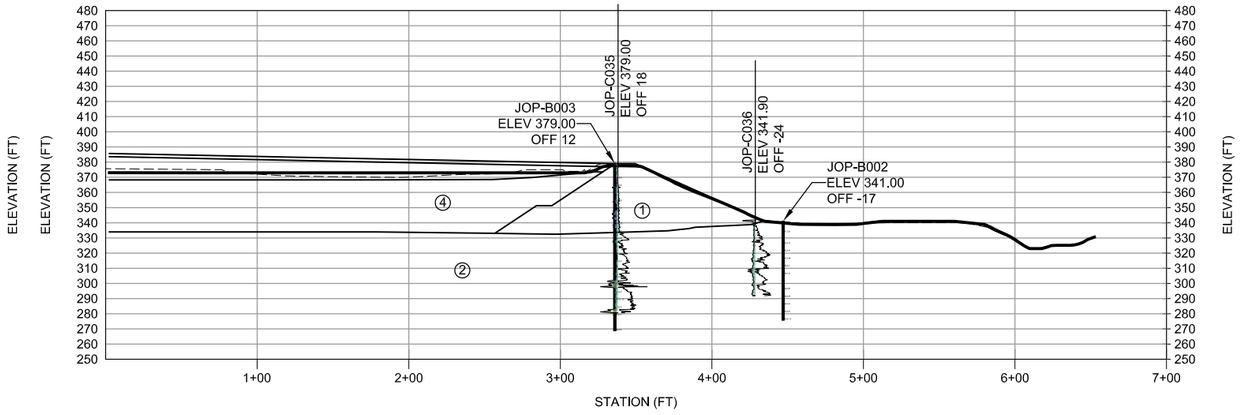
SECTION A



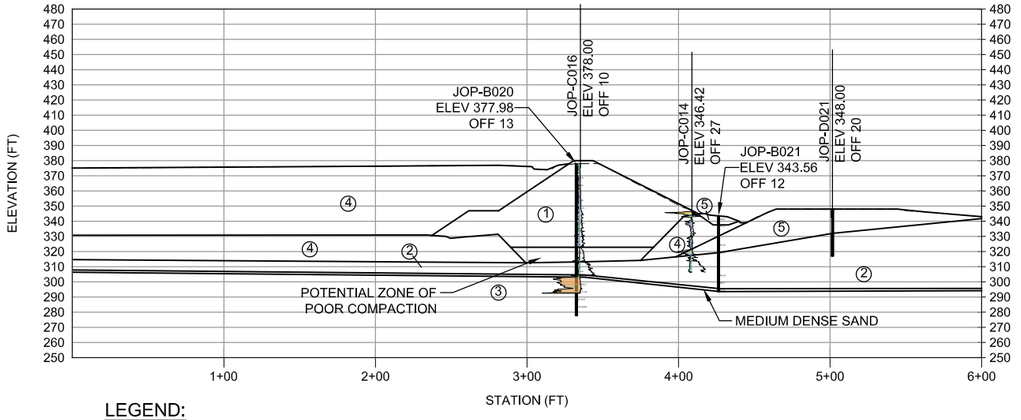
SECTION H



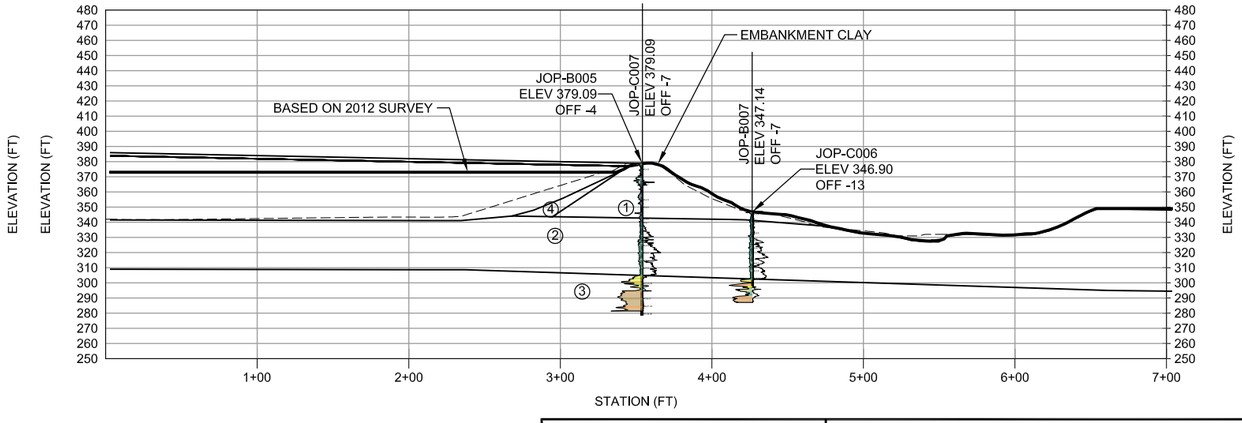
SECTION I



SECTION K



SECTION B



LEGEND:

1. EMBANKMENT CLAY
2. FOUNDATION CLAY
3. FOUNDATION SAND
4. ASH
5. MISCELLANEOUS FILL

0 50 100 150
SCALE IN FEET

Job No. :	60440155
Prepared By :	RS
Date :	04/22/2016

JOPPA ASH POND DMM DESIGN SECTIONS

AECOM DRAWING PATH:M:\DCS\Resources\WTR\GeoCiv\!Dynegy\Joppa\05-MODELS\JOPPA GEOTECH SECTIONS-SOUTH-2016.dwg

AECOM

QMS Form 3-3 (MM)

Date: September 2014

Dynegy CCR Program Quality Management — Calculation Check and Review Record

Project Name	Dynegy – Joppa East Ash Pond	Client Name	Dynegy
Project Location	Joppa, Illinois	PM Name	Vic Modeer
Project Number / Office Code	60506864 99	PIC Name	Ron Hager

This form may be used instead of Form 3-4 – Check and Review Record for Detail Checks of calculations. If the calculation is a standalone deliverable, an Independent Technical Review (ITR) may be required, and this form can be used for that purpose as well.

Type	☒ Calculation Detail Check	☐ Calculation ITR

IDENTIFYING INFORMATION

(This section is to be completed by the PM, PM's Designee, or Originator.)

Calculation Medium: *(Select as appropriate)*

☒ Electronic — File Name: JOP_Material_Characterization_20160427v0.pdf

☐ Hard-copy — Unique Identification:

Number of pages *(including cover sheet)*:

Discipline:	Geotechnical
Title of Calculation:	Slope Stability Analysis
Calculation Originator Name:	Vonmarie Martinez
Calculation Contributor Names:	Lucas Carr
Calculation Checker Names:	Zachary Fallert, Lucas Carr
Calculation Reviewer Names:	Doug Cauble

DESCRIPTION & PURPOSE

Slope Stability Analysis for two critical sections (B and C) at Dynegy Joppa East Ash Pond

BASIS / REFERENCE / ASSUMPTIONS

2015 AECOM data and data provided by Dynegy

ISSUE / REVISION RECORD

For comments, select N (None), HC (Hard Copy), EF (Electronic File), or Form 3-5 from drop-down. For a given Revision, indicate P (Preliminary), S (Superseded) or F (Final). If there are no revisions to the Initial Issue, check F (Final).

Rev. No.	Description	Comments	P	S	F	Originator Initials	Date	Checker Initials	Date	Reviewer Initials	Date
0	Initial Issue EF		☐	☒	☐	VMCh	8/25/16	ZJF	8/25/16		
1	Comments EF		☐	☐	☒	VMCh	8/29/16	ZJF	8/30/16		
2	N		☐	☐	☐						
3	N		☐	☐	☐						

APPROVAL and DISTRIBUTION

☒ The below individuals confirm that the Calculation Check and Review process has been followed.

Vonmarie Martinez — Originator Signature	25-Aug-16 — Date
Checker Signature	8/30/16 — Date
Douglas F. Cauble — Reviewer Signature	9-7-16 — Date
Project Manager (or Designee) Signature	Date

DISTRIBUTION	Project Central File – Quality File Folder Other – Specify:

Calculation Notes AECOM

Subject: Joppa Ash Pond Global Stability | Project Name: Dynegy CCR

By: Vonmarie Martinez Date: 8/24/2016 | Project No: 60440155

Checked By: Zachary Fallert Date: 8/25/2016 | Task No.: 01

Objective

The objective of the slope stability analysis is to determine the factors of safety (FoS) at critical cross sections for existing conditions in the Joppa Ash Pond embankments for the following loading cases:

- Static, Steady-State, Normal Pool Conditions;
- Static, Maximum Pool Surcharge Conditions; and
- Seismic Slope Stability Analysis.

Note that the analyses herein are for existing conditions outside of the DMM remediation area in the southeast corner of the Ash Pond. Slope stability analyses performed at the southeast corner of the Ash Pond determined that remediation measures were needed to meet the safety factor criteria in the USEPA CCR Rule, with the post-earthquake stability being the controlling design case. The deep mixing method (DMM) was selected as the remediation measure. *Joppa DMM Global Stability* calculation package includes more details about slope stability analyses performed in the southeast corner of the Ash Pond.

Information on the slope stability analyses for selected critical sections is discussed in the following sections.

Development of Sections for Analysis

Slope stability analyses were performed at two cross-sections (B and C), both located in the east side of the Joppa Ash Pond. The location of the cross-sections was selected based on the available geotechnical data and existing topography. Existing topography indicates that these two cross-sections possess the critical geometries.

Cross-sections were drawn in SLOPE/W using survey data from the site, historic design drawings, and AECOM subsurface explorations from 2015. A plan view of the area and cross section locations are included as Attachment 1.

Subsurface Conditions

Subsurface materials and stratigraphy at each cross-section was developed using nearby subsurface explorations advanced by AECOM in 2015. The subsurface conditions generally encountered the following materials:

- Embankment Clay [Fill];
- Foundation Clay;

- Foundation Sand; and
- Ash.

Piezometric levels were determined using CPT and piezometer data. The location of the piezometric line was taken from explorations advanced and instrumentation installed by AECOM in 2015. Beneath the crest of the embankment, CPTs advanced by AECOM showed that pore water was encountered around El. 363.1 ft in Section B and El. 360.1 ft in Section C. Piezometers installed by AECOM in 2015, confirmed the groundwater level beneath the crest of the embankment with elevations between 362.6 ft and 360.1 ft. The piezometric line was assumed to linearly decrease from the normal pool elevation (El. 372.7 ft) to an elevation between 362.6 ft and 360.1 ft at the crest of the embankment. Beyond the crest, the piezometric line was assumed to gradually decrease to the groundwater elevation encountered at the CPTs and piezometers installed at the toe of the embankment. Water level at the toe of the embankment in Section B was determined between 313.4 ft and 315.4 ft, and at 346.0 ft in Section C.

Table 1 summarizes the explorations and piezometer data used at each cross section.

Table 1 – Nearby Subsurface Explorations[1] and Piezometric Elevation

Section	Explorations		Piezometric Elevation, ft
B	CPT	JOP-C007	363.1
	Boring	JOP-B005	362.6
	CPT	JOP-C006	313.4
	Boring	JOP-B007	315.4
C	CPT	JOP-C008	360.1
	Boring	JOP-B009	360.1
	CPT	JOP-C009	346.0

[1] Vibrating wire piezometers installed at boring locations

Analysis Methodology

Loading Conditions

The slope stability analysis evaluated the following loading conditions, as required by the USEPA CCR Rule (except as noted):

- Long-Term, Maximum Storage Pool Loading Condition (Static Drained), Min FoS (minimum factor of safety) = 1.50: This case models the static stability of the embankment under long-term conditions, using drained soil strengths. A normal operating pool elevation of 372.7 ft was assumed and pore pressures for analysis are taken from a piezometric line based on AECOM's interpretation of groundwater levels from piezometer, CPT, and boring data.

- Maximum Surcharge Pool Loading Condition (Surcharge), Min FoS = 1.40: This case models the static stability of the embankment under short-term flood loading conditions. The flood pool elevation was assumed to be equal to the crest of the embankment for this analysis case. The piezometric surface within the embankment was assumed to increase by 2 ft under the crest. Due to the short-term nature of the loading, and the low permeability of the embankment and foundation soils, this is a conservative assumption.
- Seismic Condition (Pseudostatic), Min FoS = 1.00: This case models the stability of the embankment under earthquake loading. Normal pool conditions (El. 372.7 ft) and groundwater conditions are assumed. A Probabilistic Seismic Hazard Analysis was performed to determine the pseudostatic seismic coefficient (k_h). This analysis resulted in a kh = 0.275g. Peak undrained soil strengths were used for this analysis, due to the short duration of the loading and the fine-grained, slow-draining nature of the embankment and foundation soils.
- Liquefaction Condition (Post-Earthquake), Min FoS = 1.20: For the selected critical cross sections, there is no need to analyze this case since no liquefiable material was encountered in the foundation materials.

Stability Analysis Approach

The slope stability analysis was conducted using SLOPE/W within the GeoStudio 2012 software package (Version 8.15.1.11236). The following approach was used to conduct the analysis:

- Analysis Method: Spencer.
- Global Slip Surface Definition: Entry and exit. Slip surfaces were allowed to enter the ground surface upstream of the middle of the embankment crest and downstream of the embankment toe for global stability.
- Minimum Slip Surface Depth: 10 ft.
- Optimization: Critical slip surfaces were optimized. This allowed the critical slip surface to pass through the ash material in a nearly horizontal manner for many of the analysis cases.
- Tension Cracks: Added if necessary to reduce interslice tensile forces for all loading cases except pseudostatic stability. For pseudostatic stability, the short-duration nature of the loading was assumed to prevent a tension crack from opening. Where included, the tension crack was assumed to be full of water.
- Pore Pressures: From piezometric line.

Material Properties

Material properties for analysis were taken from the *Joppa Material Characterization* calculation package. The material properties are summarized in Tables 2, 3, and 4.

Table 2 – Joppa Soil Material Properties

Material	Unit Weight (pcf)	Peak Drained Shear Strength		Peak Undrained Shear Strength
		Friction Angle (phi'), degrees	Cohesion (c'), psf	
Embankment Fill (Compacted Clay)	131	Shear/Normal Function[1]		Shear/Normal Function[1]
Foundation Clay	128	33 (vertical) 29 (horizontal)	0	Shear/Normal Function[2]
Ash	106	33 (vertical) 29 (horizontal)	0	Su/p' = 0.44
Foundation Sand	130	35	0	Peak Drained

Notes:

[1,2] Shear normal function is based on a Su/p' characterization. See Table 3 for Embankment Fill and Table 4 for Foundation clay.

Table 3 – Embankment Fill Shear/Normal Function for Peak Drained and Undrained Shear Strength

Peak Drained Shear Strength		Peak Undrained Shear Strength	
Effective Stress (psf)	Shear Strength (psf)	Effective Stress (psf)	Shear Strength (psf)
0	0	0	600
585.2	561.0	500	600
1,308.6	1,050.4	10,000	6,800
1,497.4	1,124.6	-	-
2,000.0	1,400.4	-	-
10,000.0	7,002.1	-	-

Table 4 – Foundation Clay Shear/Normal Function for Peak Undrained Shear Strength

Effective Stress (psf)	Shear Strength (psf)
0	700
10,000	4,800

Results

Both critical cross sections analyzed pass the static loading and earthquake induced loading conditions. Resulting factors of safety are listed in Table 5. Engineering Analysis Output is presented in Attachment 2.

Table 5 – Slope Stability Analysis Factor of Safety

Section	Loading Conditions		
	Pseudostatic	Max Storage	Max Surcharge
	Min FS = 1.00	Min FS = 1.50	Min FS = 1.40
B	1.14	1.88	1.77
C	1.26	1.77	1.71

Attachments

1. Plan View
2. Engineering Analysis Output
    A. Section B
    B. Section C

Calculation Notes

Subject: Joppa Ash Pond Global Stability

Project Name: Dynegy CCR

By: Vonmarie Martinez Date: 8/24/2016

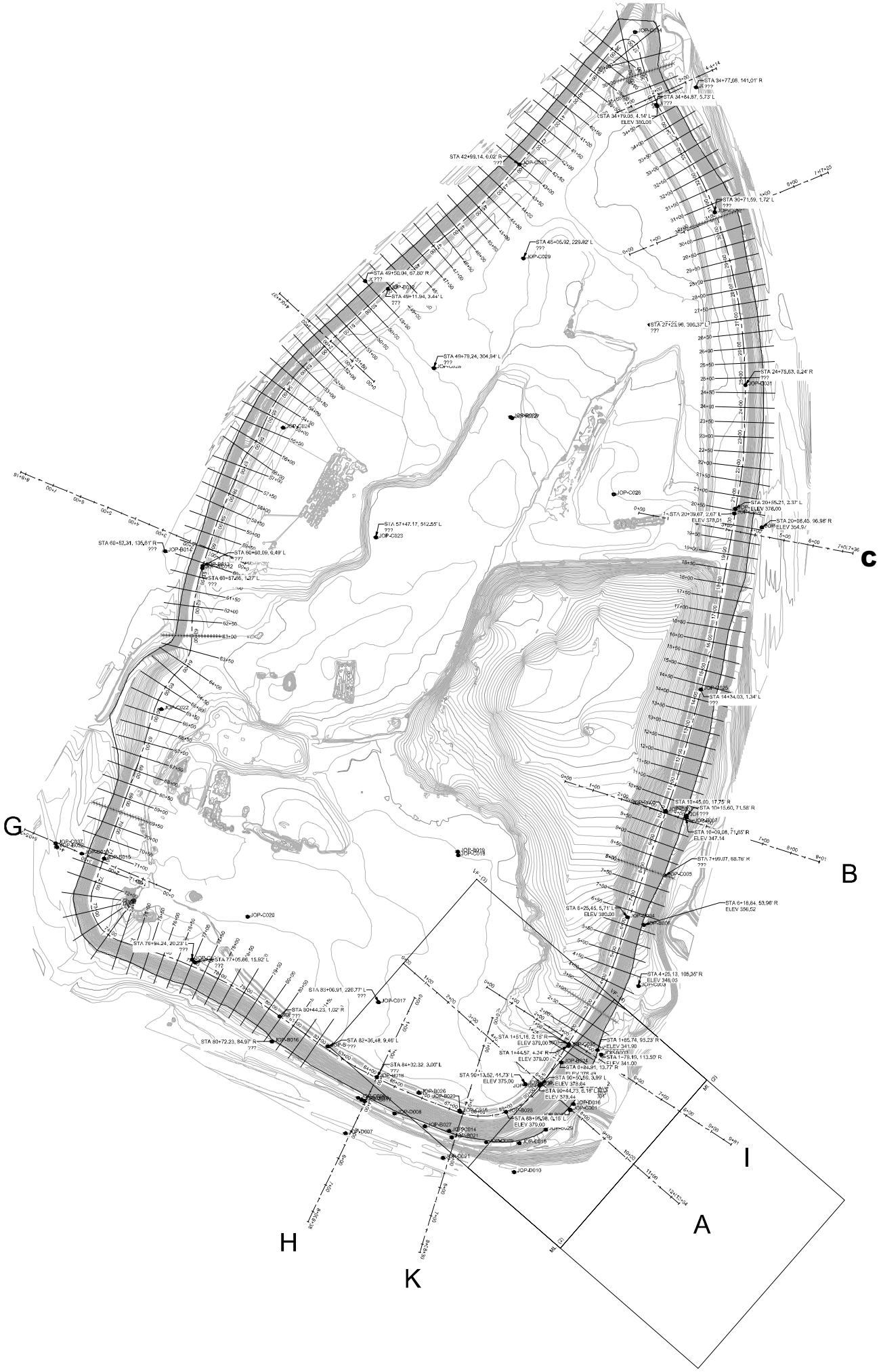
Project No: 60440155

Checked By: Zachary Fallert Date: 8/25/2016

Task No.: 01

Attachment 1

Plan View


A
B
C
G
H
I
K

Calculation Notes

Subject: Joppa Ash Pond Global Stability

Project Name: Dynegy CCR

By: Vonmarie Martinez Date: 8/24/2016

Project No: 60440155

Checked By: Zachary Fallert Date: 8/25/2016

Task No.: 01

Attachment 2

Engineering Analysis Output

Calculation Notes

Subject: Joppa Ash Pond Global Stability

Project Name: Dynegy CCR

By: Vonmarie Martinez Date: 8/24/2016

Project No: 60440155

Checked By: Zachary Fallert Date: 8/25/2016

Task No.: 01

2.A – Section B

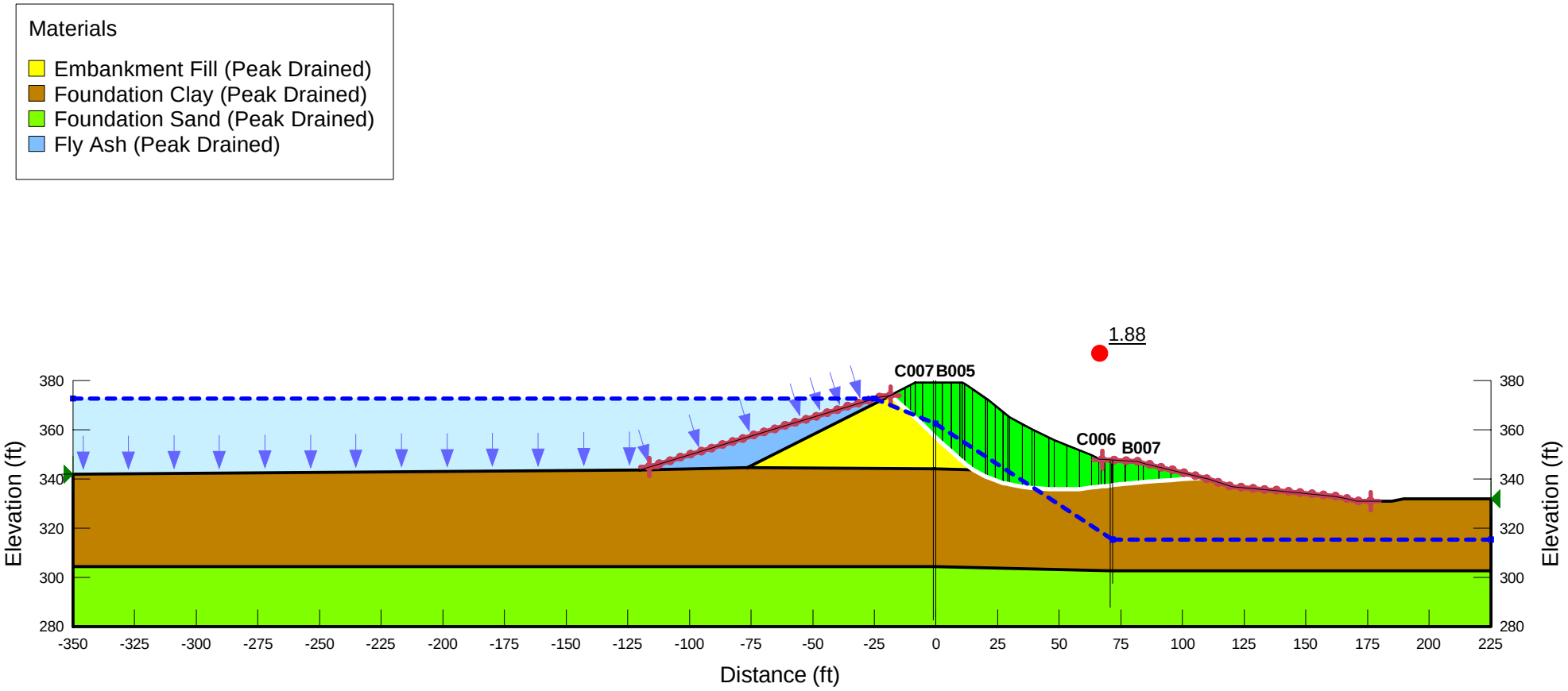
Joppa Section B
Long-Termed Drained Stability

Computed By: VMCh Date: 8/25/2016
Checked By: ZJF Date: 8/25/2016

Kind: SLOPE/W
Method: Spencer
F of S: 1.88

Section B Normal Pool

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Drained Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1



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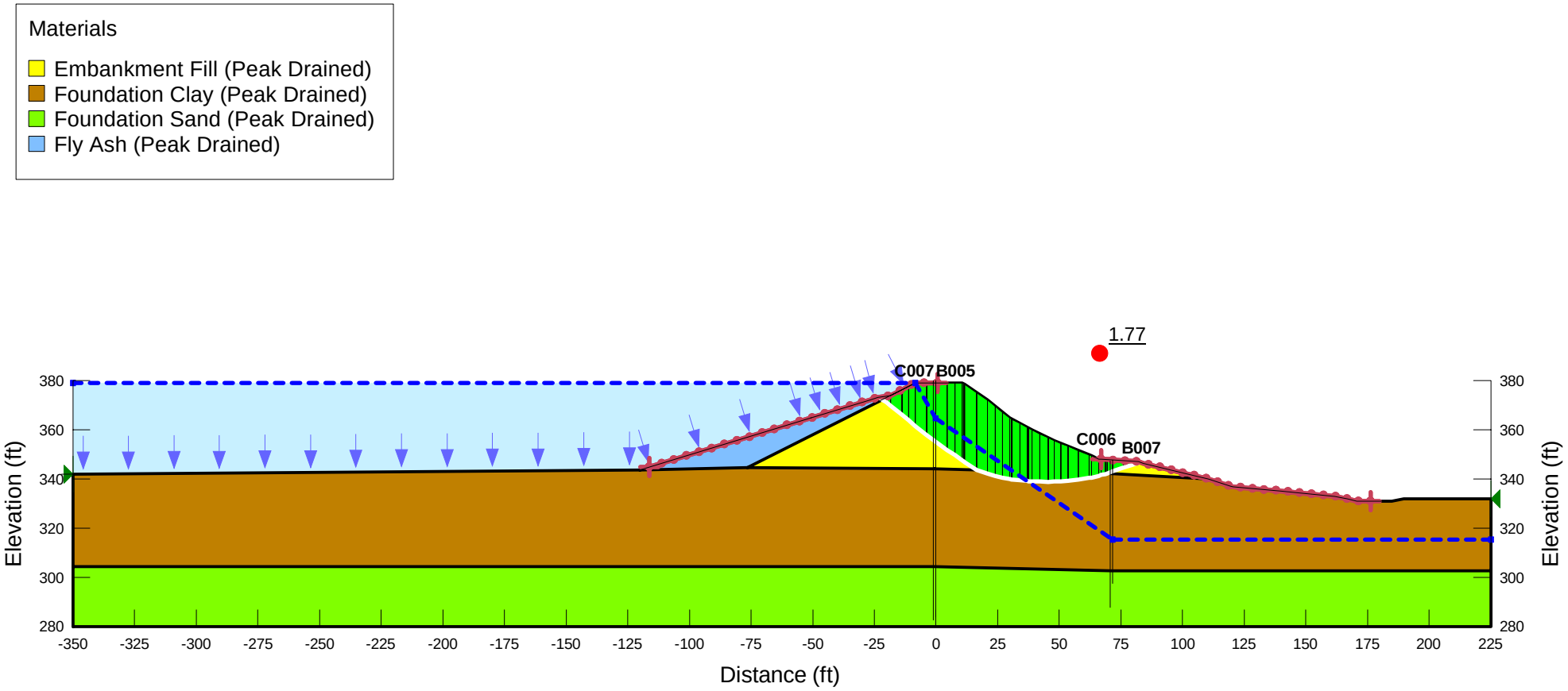
Joppa Section B
Long-Termed Drained Stability

Computed By: VMCh Date: 8/25/2016
Checked By: ZJF Date: 8/25/2016

Kind: SLOPE/W
Method: Spencer
F of S: 1.77

Section B Surcharge Pool

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Drained Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1



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Joppa Section B
Seismic Slope Stability

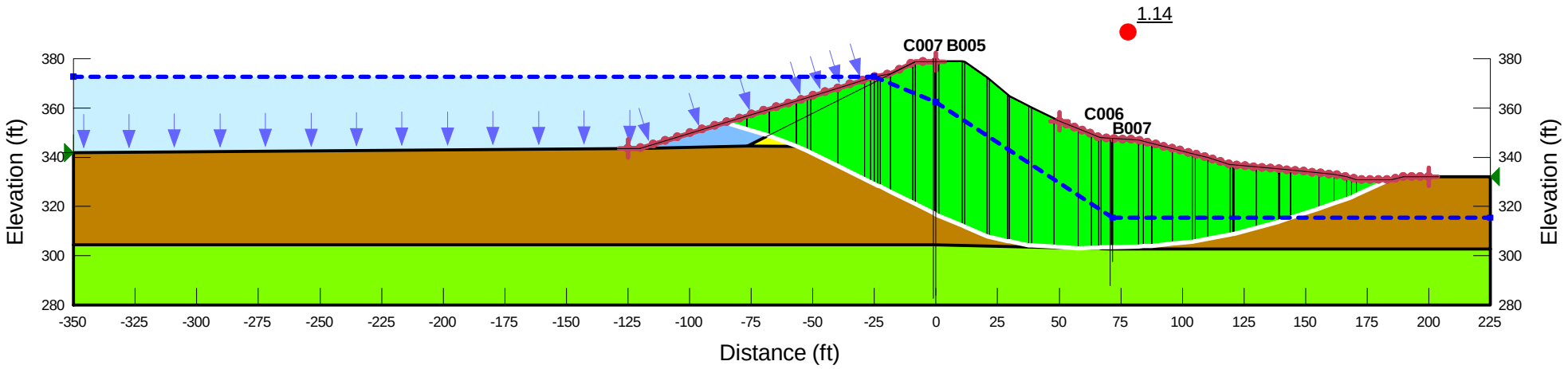
Computed By: VMCh Date: 8/23/16
Checked By: ZJF Date: 8/25/16

Kind: SLOPE/W
Method: Spencer
F of S: 1.14

Section B Pseudostatic (kh)

Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1

Horizontal Seismic Coefficient:
kh = 0.275 g



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Calculation Notes

Subject: Joppa Ash Pond Global Stability

Project Name: Dynegy CCR

By: Vonmarie Martinez Date: 8/24/2016

Project No: 60440155

Checked By: Zachary Fallert Date: 8/25/2016

Task No.: 01

2.B – Section C

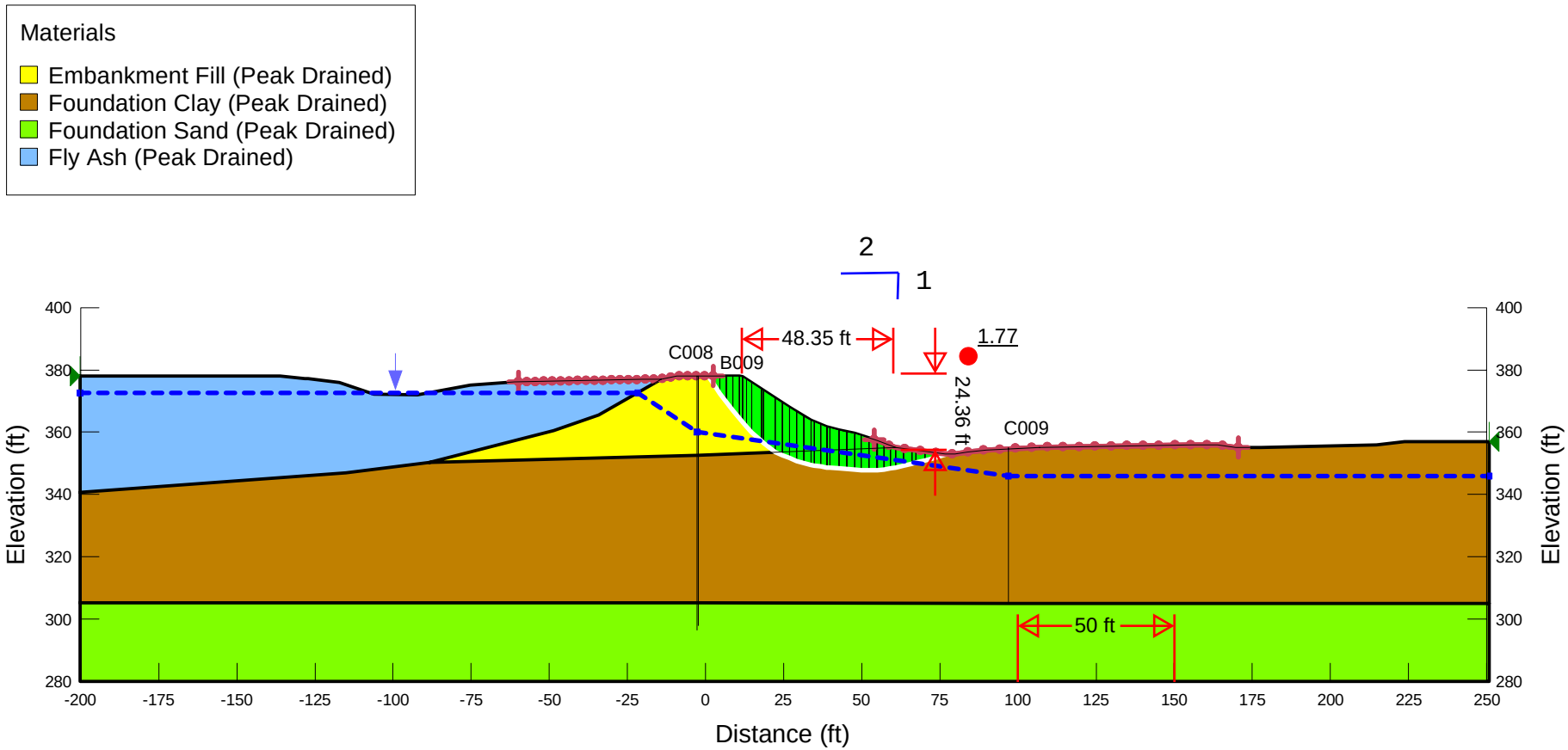
Joppa Section C DMM Design
Long-Termed Drained Stability

Computed By: VMCh Date: 8/25/2016
Checked By: ZJF Date: 8/25/2016

Section C Normal Pool

Kind: SLOPE/W
Method: Spencer
F of S: 1.77

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Drained Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1



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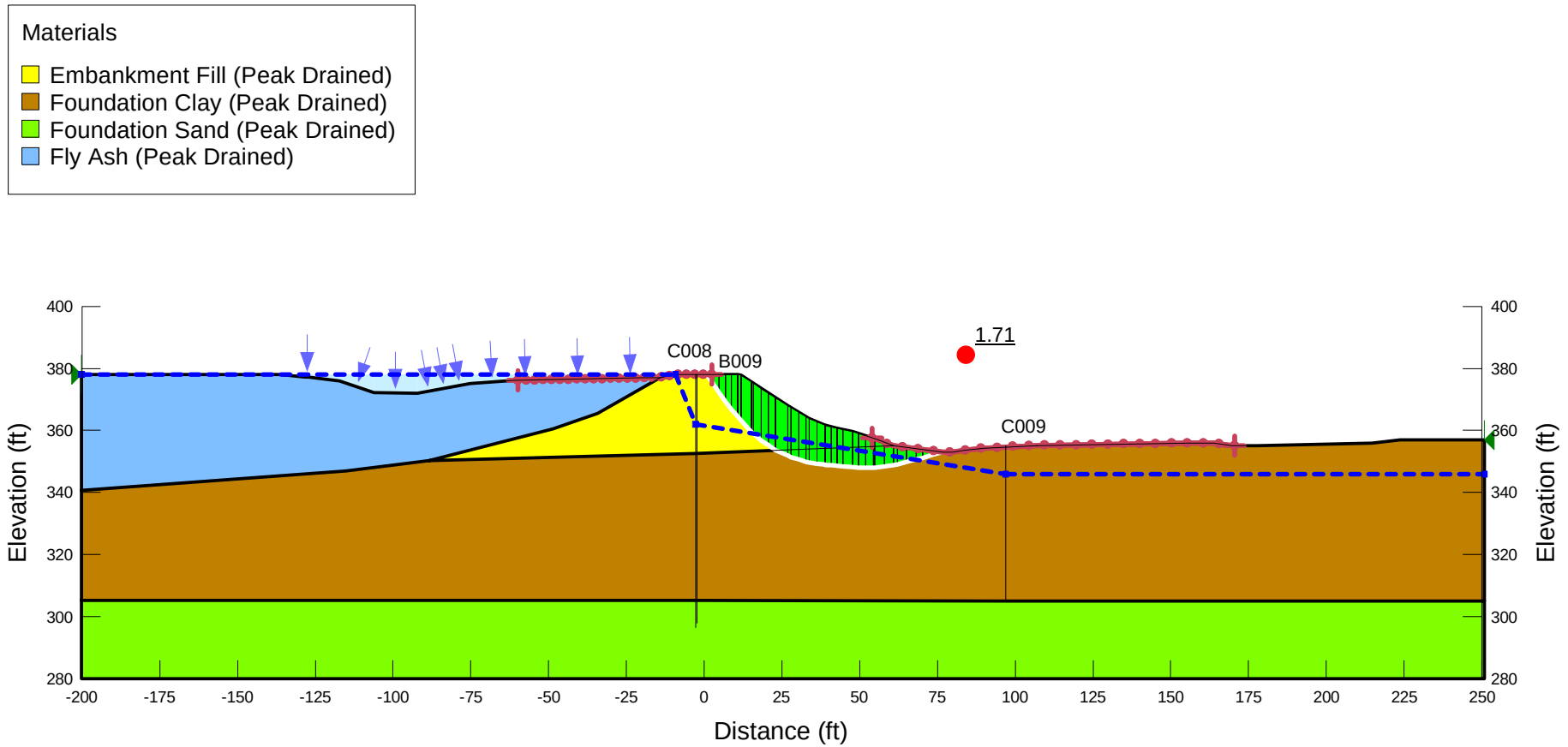
Joppa Section C DMM Design
Long-Termed Drained Stability

Computed By: VMCh Date: 8/25/2016
Checked By: ZJF Date: 8/25/2016

Section C Surchage Pool

Kind: SLOPE/W
Method: Spencer
F of S: 1.71

Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Drained Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Drained) Unit Weight: 106 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1



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Joppa Section C DMM Design
Seismic Slope Stability

Computed By: VMCh Date: 8/23/16
Checked By: ZJF Date: 8/25/16

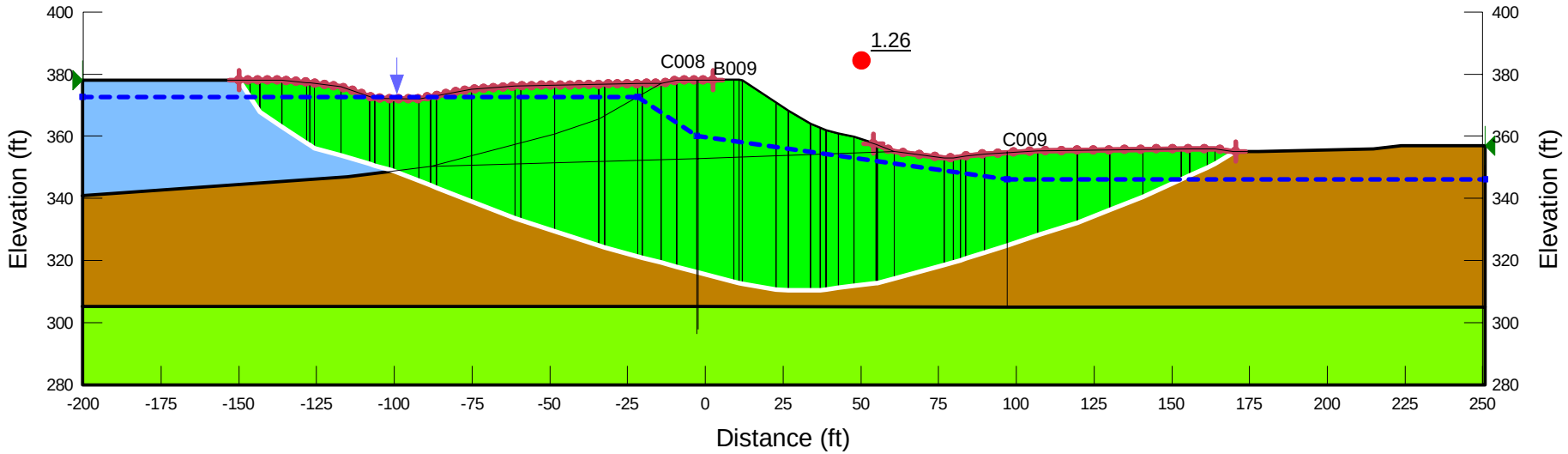
Section C Pseudostatic (kh)

Kind: SLOPE/W
Method: Spencer
F of S: 1.26

Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 0.44 Minimum Strength: 0 psf Piezometric Line: 1

Materials
- Embankment Fill (Peak Undrained)
- Foundation Clay (Peak Undrained)
- Foundation Sand (Peak Drained)
- Fly Ash (Peak Undrained)

Horizontal Seismic Coefficient:
kh = 0.275 g



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Geosyntec
consultants

ATTACHMENT B

Excerpts from 2021 Geosyntec Investigation

Legend

- Leachate Wells
- Monitoring Wells
- Staff Gauge
- CCR Unit Boundary

Notes

- Coal Combustion Residual (CCR) Unit boundary is approximate.
- Aerial imagery provided by ArcGIS.

460 230 0 460 920 1,380 Feet

N

Monitoring Well and Staff Gauge Map

Joppa Power Station
Joppa, Illinois

Geosyntec consultants

GLP 8021 | March 2021

Figure 2

\\stlouismo-01\data\Company\Projects_post_2014\GLP8021_Vistra_Joppa Part 845 Field Efforts\01_Field Efforts\GIS\WellLocations.mxd 3/25/2021 12:25:00 PM

Geosyntec consultants
engineers | scientists | innovators

Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 1 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	67	Well Depth (ft):	67
Drilling End Date:	02/02/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	38.23	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	358.56	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	354.84	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.22078, -88.85045	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	14/24	2 2 3 6	5	(0') CLAY (CL); some silt, high organics/roots, brown (10YR 4/3). (0.25') CLAYEY SILT (ML); brownish yellow (10YR 6/6), soft, dry, some light gray mottling.		
				SS	20/24	2 3 4 5	7	(2') As above: higher plasticity. (MH)		
5				SS	23/24	2 3 5 6	8	(4') As above: few sand, lower plasticity. (ML)		
				SS	24/24	2 3 4 6	7	(6') SILT (ML); few sand and clay, yellowish brown (10YR 5/6), medium dense, dry, some light gray mottling.		
				SS	23/24	1 4 6 7	10	(8') As above.		
10				SS	23/24	2 6 6 8	12	(11') As above: trace fine gravel from 11 to 11.5' bgs.		
				SS	24/24	2 6 7 10	13	(12') As above: brownish yellow (10YR 6/6).		
				SS	24/24	2 3 5 5	8	(14') As above: more light gray (10YR 7/2) mottling.		
15				SS	24/24	2 3 5 6	8	(16') As above: trace sand.		
				SS	24/24	3 4 5 9	9	(18') As above: light gray (10YR 7/2) becomes dominant.		
20										

NOTES:

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 2 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	67	Well Depth (ft):	67
Drilling End Date:	02/02/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	38.23	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	358.56	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	354.84	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.22078, -88.85045	Filter Pack:	Sand

DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
20	SS	24/24	1 4 8 10	12	(20') SILT (ML); few clay, brownish yellow (10YR 6/6), very stiff, dry.	
	SS	24/24	4 6 7 4	13	(22') SANDY SILT (ML); yellowish brown (10YR 5/6), soft, dry.	
	SS	24/24	2 5 5 8	10	(24') As above: becomes moist, few red (2.5YR 4/6) silt.	
25	SS	24/24	1 5 5 6	10	(26') As above: red silt disappears.	
	SS	24/24	1 3 4 6	7	(28') As above: becomes grayish brown (10YR 5/2).	
	SS	24/24	1 4 4 5	8	(30') As above.	30-32 Chem
30	SH	24/24				32-34 Geotech
	SS	24/24	3 4 5 6	9	(34') POORLY GRADED SAND (SP-SM); fine grained, few silt, brownish yellow (10YR 6/6), loose, moist to wet.	
	SS	24/24	2 2 3 5	5	(36') SANDY SILT (ML); light yellowish brown (10YR 6/4), soft, moist, medium plasticity.	
35	SS	24/24	2 2 3 5	5	(38') As above: becomes evenly mottled with light gray (10YR 7/2).	
40						

NOTES: SBG03- (32-34)-20210202: 15.5% moisture content, 730 U mg/kg total organic carbon, 112.7 pcf dry unit weight, 2.659 specific gravity, 4.7x 10^{-7}, 27 LL, 16 PL, 11 PI, 0.6% gravel, 53.8% sand, 45.6% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 3 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	67	Well Depth (ft):	67
Drilling End Date:	02/02/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	38.23	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	358.56	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	354.84	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.22078, -88.85045	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	24/24	1 4 4 4	8	(40') SILT (ML); little sand, brownish yellow (10YR 6/6), soft, moist, medium plasticity.		
				SS	24/24	1 3 4 5	7	(42') As above.		
				SS	24/24	2 4 6 6	10	(44') As above: becomes dry, stiff.		
45				SS	24/24	2 4 13 13	17	(46') SILTY SAND (SP-SM); very pale brown (10YR 7/3), loose, moist.		
				SS	23/24	8 10 10 9	20	(48') As above: becomes brownish yellow (10YR 6/8).		
50				SS	20/24	1 6 10 13	16	(50.5') Wet at 50.5 to 50.8' bgs.		
								(51') SAND (SP); fine grained, light gray (10YR 7/2), loose, moist.		
				SS	24/24	1 1 1 5	2	(52') As above: brownish yellow (10YR 6/6).		
				SS	12/24	1 1 1 3	2	(54') GRAVELLY SAND (SW); very pale brown (10YR 7/4), loose, wet.		
55				SS	24/24	1 1 1 3	2	(56') As above: moist, very loose.		
				SS	11/24	1 1 1 7	2	(58') WELL-GRADED SAND (SW); medium to coarse grained, few gravel, very pale brown (10YR 7/4), very loose, moist.	58-60 Chem and Geotech (not tested)	
60										

NOTES:

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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 4 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	67	Well Depth (ft):	67
Drilling End Date:	02/02/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	38.23	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	358.56	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	354.84	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.22078, -88.85045	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	20/24	2 6 10 11	16	(60') WELL-GRADED SAND (SW); medium to coarse grained, few gravel, very pale brown (10YR 7/4), wet, loose.	60-62 Geotech	
				SS	24/24	1 3 13 12	16	(62') As above: reddish yellow (7.5YR 6/6).		
65				SS	24/24	1 15 14 13	29	(64') GRAVELLY SAND (SW); reddish yellow (7.5YR 6/8), wet, loose.		
				SS	8/12	1 4		(66') As above: brownish yellow (10YR 6/6).		
70								(67') End of Boring.		

NOTES: SBG03- (60-62)-20210202: 20.0% moisture content, 740 U mg/kg total organic carbon, 2.671 specific gravity, 1.5% gravel, 94.4% sand, 4.1% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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WELL LOG
Well No. G04
Page: 1 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	02/02/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	359.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	356.15	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21902, -88.8494	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	12/24	2 3 3	6	(0') TOPSOIL. (0.25') CLAY (CL); low plasticity, brown (7.5YR 5/6), dry, very stiff.		
				SS	12/24	2 3 3	6	(3') As above.		
5				SS	18/24	2 2 2 3	4	(4') CLAY (CH); high plasticity, dry, moist, soft, brown (7.5YR 5/6) mottled with light gray (8/1).		
				SS	12/24	1 2 2 3	4	(6') As above: some organics (black).		
				SS	18/24	2 2 2 1	4	(8') As above: light gray dominant (brown mottled), moist.		
10				SS	24/24	3 3 3 5	6	(11') As above: now stiff, low plasticity. (CL)		
				SS	24/24	3 4 6 7	12	(12') As above: dry, some silt and fine to very fine sand.		
15				SS	24/24	3 6 7 9	13	(14') As above.		
				SS	24/24	3 5 7 9	12	(16-17') As above: medium stiff. (17-18') As above: stiff.		
20				SS	24/24	5 9 2 4	11	(18') SILTY SAND (SM); light gray (8/1), tight, moist (18-19'), dry (19-20'), poorly graded, mostly very fine to fine grained sand and silt, some clay.		

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WELL LOG
Well No. G04
Page: 2 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	02/02/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	359.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	356.15	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21902, -88.8494	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	4 6 8 4	14	(20') SILTY SAND AND CLAY (CL/SM); light gray (8/1), interbedded, stiff/tight, mostly clay.		
				SS	24/24	8 7 8 8	15	(22') SANDY CLAY (CL); low plasticity, dry, medium stiff, mostly clay with some silt and very fine sand.		
				SS	24/24	3 6 7 9	15	(24') As above: trace fine gravel.		
25				SS	24/24	3 4 7 15	11	(26') As above: soft to medium stiff.		
				SS	24/24	8 7 8 9	15	(28') As above: less sand, very stiff, moist to dry, less brown mottling.		
30				SS	24/24	5 7 9 11	16	(30') As above: moist/wet.		
				SH	24/24	4 5 8 8	13	(32') As above: dry, brown mottling back.		
				SS	24/24	3 6 7 9	13	(34') As above: little sand/silt, moist, stiff.		
35				SS	24/24	4 7 10 10	17	(36') As above: dry.		
				SS	24/24	4 5 7 9	12	(38') As above: very stiff to hard.		
40										

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WELL LOG
Well No. G04
Page: 3 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	02/02/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	359.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	356.15	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21902, -88.8494	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	24/24	5 7 9 12	16	(40') As above: all clay, moderate plasticity, gray dominant (8/1).		
				SS	24/24	3 5 7 8	12	(42') As above: brown dominant (5YR 5/8).		
				SS	24/24	5 5 7 11	12	(44') As above: sandy clay, some black splotches.		
45				SS	24/24	19 33 15 11	48	(46') As above: wet.		
								(47') SILTY SAND (SM); mostly silt, very fine to fine grained sand, poorly graded, dry, very tight, light gray (8/1).		
				SS	24/24	5 7 5 6	9	(48') SANDY CLAY (CL); stiff, low plasticity, gray/brown mottled, dry, mostly clay, some sand.		
50				SS	24/24	9 5 8 11	14	(50') CLAY (CL); little sand, very stiff to hard, low plasticity, moist to dry, brown/gray mottled.		
				SS	24/24	3 4 6 8	14	(52') As above: moist, stiff to medium stiff.		
				SS	24/24	4 5 8 8	13	(54-55') As above: soft. (55-56') As above: trace coarse gravel, stiff.		
55				SS	24/24	4 7 21 32	28	(56') SANDY CLAY (CH); soft, high plasticity, gray/brown mottled, moist.		
								(57.25') SILTY SAND (SM); tight, poorly graded, moist, very fine to fine grained sand and silt, gray/brown mottled.		
				SS	24/24	17 21 22 19	43	(58') SILTY SAND (SM); pinkish white (7.5YR 8/2), poorly graded, tight, saturated for middle 4", rest is moist.		
60										

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WELL LOG
Well No. G04
Page: 4 of 4

Drilling Start Date:	02/02/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	02/02/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	359.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	356.15	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21902, -88.8494	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	24/24	8 9 12 20	21	(60') As above.		
								(62') End of Boring.		
65										

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WELL LOG
Well No. G05
Page: 1 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	66	Well Depth (ft):	60
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	361.68	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	358.45	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21716, -88.84883	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	MEASURE: DEPTH (ft)
0				SS	18/24	6 8 3	11	(0') TOPSOIL.		
								(0.25') POORLY GRADED GRAVEL (GP)		
						4 2 3	7	(1.5') CLAY (CL); light brown (10YR 7/3), very stiff, low plasticity, dry.		
				SS	12/24			(2') As above.		
						4 4 3	10	(4') As above: medium stiff.		
5				SS	24/24	3 7 7				
						3 6 7	13	(6') As above: mottled light brown (10YR 7/3) and light gray (8/1).		
				SS	24/24	9 3 5	10	(8') As above: trace coarse gravel.		
						5 7 3				
10				SS	24/24	4 5 6	9	(10') As above: stiff.		
						2 3 5	8	(12') As above.		
						6 4 5		(13') CLAY (CL); mostly same as above with some very fine to fine grained sand and silt.		
				SS	24/24	8 9 2	13	(14') As above: slightly moist.		
15						3 5 7				
				SS	24/24	2 3 4	8	(16') As above: dry.		
				SS	24/24	4	7	(18') As above.		
20										

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WELL LOG
Well No. G05
Page: 2 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	66	Well Depth (ft):	60
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	361.68	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	358.45	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21716, -88.84883	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	4 6 6 9	12	(20') As above.		
				SS	24/24	3 5 6 7	11	(22') As above: medium stiff.		
				SS	24/24	4 7 7 4	14	(24') As above.		
25				SS	24/24	3 4 7 9	11	(26') As above: stiff.		
				SS	24/24	4 5 8 10	13	(28') As above.		
30				SS	24/24	2 4 6 7	10	(30') As above.		
				SH	24/24	3 8 11 12	19	(32') As above.		
				SS	24/24	8 10 11 12	21	(34') As above.		
35				SS	24/24	3 5 7 9	12	(36') As above.		
				SS	24/24	3 8 11 14	19	(38') SILTY CLAY (CL); same as above with more silt.		
40										

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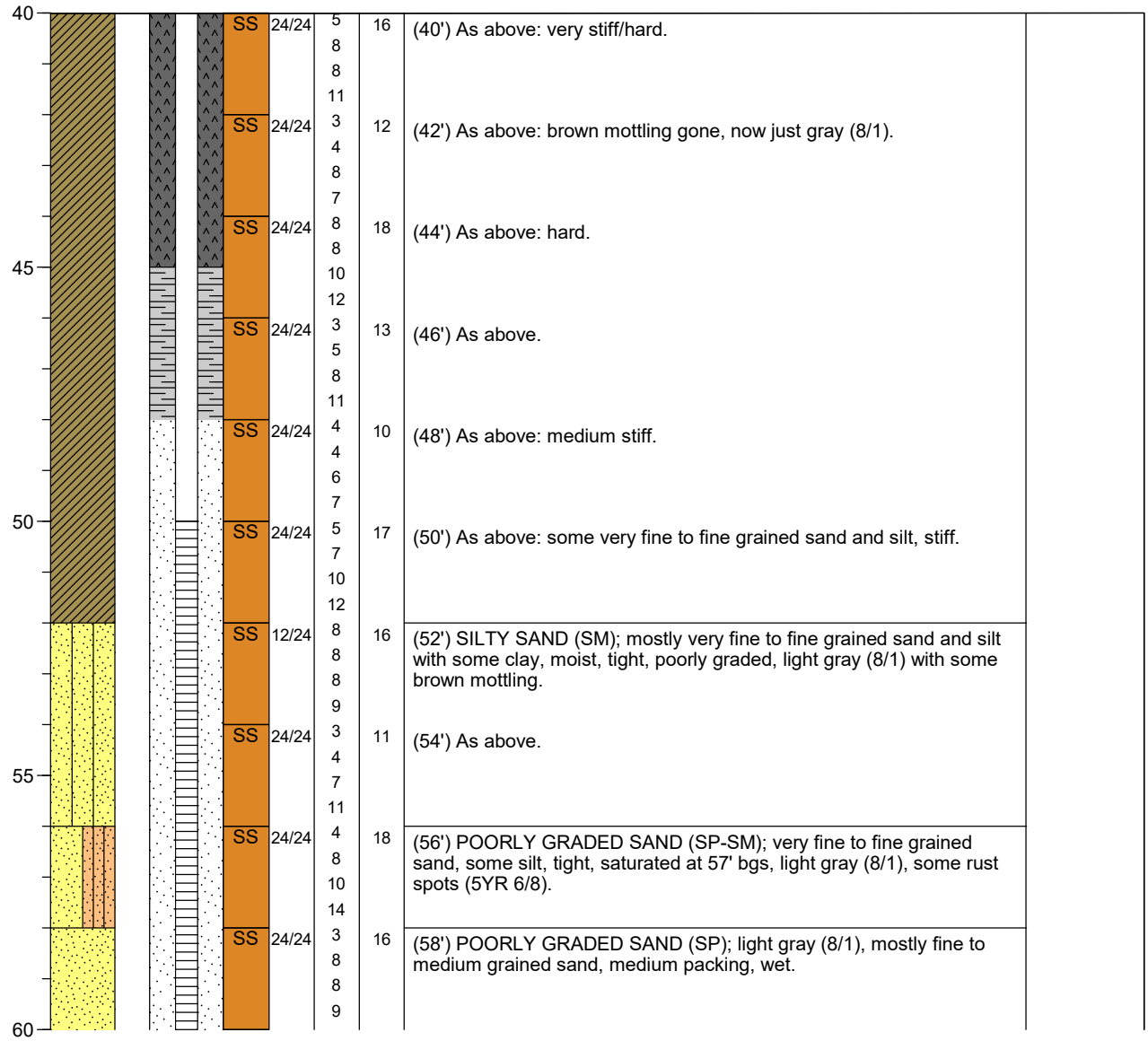
WELL LOG
Well No. G05
Page: 3 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	66	Well Depth (ft):	60
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	361.68	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	358.45	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21716, -88.84883	Filter Pack:	Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	24/24	5 8 8 11	16	(40') As above: very stiff/hard.		
				SS	24/24	3 4 8 7	12	(42') As above: brown mottling gone, now just gray (8/1).		
				SS	24/24	8 8 10 12	18	(44') As above: hard.		
45				SS	24/24	3 5 8 11	13	(46') As above.		
				SS	24/24	4 4 6 7	10	(48') As above: medium stiff.		
50				SS	24/24	5 7 10 12	17	(50') As above: some very fine to fine grained sand and silt, stiff.		
				SS	12/24	8 8 8 9	16	(52') SILTY SAND (SM); mostly very fine to fine grained sand and silt with some clay, moist, tight, poorly graded, light gray (8/1) with some brown mottling.		
				SS	24/24	3 4 7 11	11	(54') As above.		
55				SS	24/24	4 8 10 14	18	(56') POORLY GRADED SAND (SP-SM); very fine to fine grained sand, some silt, tight, saturated at 57' bgs, light gray (8/1), some rust spots (5YR 6/8).		
				SS	24/24	3 8 8 9	16	(58') POORLY GRADED SAND (SP); light gray (8/1), mostly fine to medium grained sand, medium packing, wet.		
60										

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WELL LOG
Well No. G05
Page: 4 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	66	Well Depth (ft):	60
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	361.68	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	358.45	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21716, -88.84883	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	24/24	2 4 5 8	9	(60') As above: wet. (61') As above: moist, some red color lamination.		
				SS	24/24	2 2 3 4	5	(62') As above: some silt, saturated, poorly graded, medium packing/toughness. (SP-SM) (63') As above: moist, some red lamination.		
65				SS	24/24	1 2 3 5	5	(64') As above: saturated, medium to loose toughness. (65.5') SAND (SW); some gravel, color change to (5YR 7/6) (66') End of Boring.		
70										

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WELL LOG
Well No. G06
Page: 1 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	12/24	2 3 3 3	6	(0') TOPSOIL. (0.25') FAT CLAY (CH); brown (5YR 6/8), soft, dry.		
				SS	12/24	2 3 3 4	6	(2') As above: trace coarse gravel.		
5				SS	6/24	2 2 3 3	5	(4') CLAY (CH); brown (5YR 6/8), high plasticity, dry, soft. ~2" coal seam.		
				SS	12/24	2 1 2 2	3	(6') As above: moist.		
				SS	12/24	1 1 3 2	4	(8') CLAY (CH); dark gray, trace coarse gravel, friable, dry.		
10				SS	12/24	2 2 3 4	5	(9') CLAY (CH); brown (5YR 6/8), high plasticity, moist, soft. (10') As above: trace fine gravel.		
				SS	12/24	1 1 2 3	3	(12') As above: dry.		
15				SS	24/24	3 3 4 4	7	(14') CLAY (CH); mottle (brown and light gray), high plasticity, soft, dry.		
				SS	12/24	3 3 4 4	7	(16') As above: wet.		
				SS	18/24	1 2 1 2	3	(18') As above: dry.		
20										

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WELL LOG
Well No. G06
Page: 2 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	MEASURE: DEPTH (ft)
20				SS	18/24	1 2 4 7	6	(20') CLAY (CH); soft, dry, light brown (7.5YR 8/2), moderate plasticity.		
				SS	24/24	5 7 7 8	14	(22') CLAY (CL); stiff, low plasticity, light brown (7.5YR 8/2) with dark brown mottling, dry.		
25				SS	24/24	3 2 3 3	5	(24') As above.		
				SS	24/24	2 3 3 7	6	(26') CLAY (CL); low plasticity, very stiff, dry, light brown (7.5YR 8/2) mottled with dark brown.		
				SS	24/24	3 4 4 4	8	(28') CLAY (CH); dry, high plasticity, medium stiffness, light brown (7.5YR 8/2) mottled with dark brown.		
30				SS	24/24	8 17 15 12	32	(30') SILTY SAND (SM); mostly silt and fine sand, poorly graded, dry, light gray (7.5YR 8/1), tight.		
				SH	12/24	8 7 7 9	14	(32') As above: with dark brown (7.5YR 5/8) mottling.		
				SS	18/24	3 14 12 12	26	(34') POORLY GRADED (SP); light gray (7.5YR 8/1), tight, dry, some silt, mostly very fine to fine grained sand, some rust marks.		
35				SS	18/24	4 4 9 12	13	(36') As above: moist.		
				SS	18/24	6 7 12 14	19	(38') As above: dry.		
40										

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WELL LOG
Well No. G06
Page: 3 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	18/24	9 12 18 18	30	(40') As above: mottled with orange (5YR 6/8) color, medium packing, poorly graded, dry.		
				SS	12/24	8 15 16 21	31	(42') POORLY GRADED SAND (SP); red (5YR 7/8), loose, dry, mostly fine grained sand.		
				SS	18/24	7 11 12 12	23	(44') As above. (45') As above: wet.		
45				SS	24/24	8 7 14 8	21	(46') CLAY (CL); low plasticity, moist to wet, stiff, gray to reddish orange (5YR 7/8).		
				SS	24/24	5 8 10 11	18	(48') SILTY SAND (SM); mostly silt, very fine to fine grained sand, some clay, poorly sorted, tight, moist, gray (8/1).		
50				SS	24/24	10 11 9 3	20	(50') As above: saturated, mottled with (5YR 7/8) and (8/1).		
				SS	24/24	3 6 7 14	13	(52') POORLY GRADED SAND (SP); red (5YR 7/8), loose, wet, coarse gravel at bottom 1".		
				SS	24/24	4 18 18 15	36	(54') As above: sand with 1-2" gravel at bottom.		
55				SS	24/24	3 7 8 14	15	(56') POORLY GRADED SAND (SP); mostly fine to medium grained sand, wet, medium packing, reddish yellow (5YR 7/6).		
				SS	24/24	8 12 26 27	38	(58') As above: some fine to coarse gravel. (59') DIAMICTON - mostly fine-coarse grained WELL-GRADED GRAVEL and SAND (GW-SW); wet, medium packing, reddish yellow		
60										

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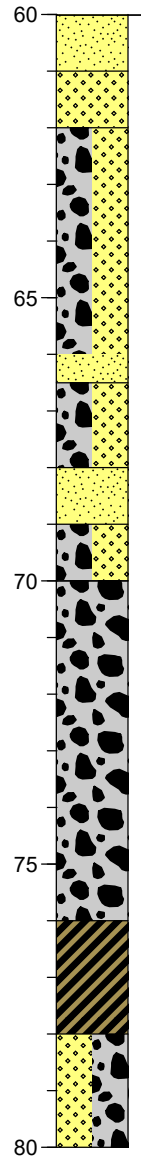
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G06
Page: 4 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
60	SS	18/24	8 11 36 23	47	(5YR 7/6). (60') POORLY GRADED SAND (SP); reddish yellow (5YR 7/6), tight, wet.		
	SS	18/24	7 18 29 31	47	(61') WELL-GRADED SAND (SW); lots of coarse gravel (orange chert), loose. (62') DIAMICTON - mostly fine-coarse grained GRAVEL AND SAND (GW-SW); (orange chert), wet, very loose, reddish yellow (5YR 7/6).		
65	SS	12/24	11 12 28 26	40	(64') As above: saturated.		
	SS	18/24	21 33 52	85	(66') 6" tan (5YR 7/6), same as above (SP) (66.5') DIAMICTON same as above (GW-SW)		
	SS	18/24	5 3 10 16	13	(68') POORLY GRADED SAND same as above (SP) (69') DIAMICTON same as above (GW-SW)		
70	SS	18/24	7 12 15 17	27	(70') GRAVELLY SILT DIAMICTON (GW/SM); mostly fine to coarse gravel, fine to coarse sand, silt and some clay, wet, stiff, well-graded, orangish tan (5YR 7/6).		
	SS	24/24	9 9 14 9	23	(72') As above: saturated.		
	SS	12/24	6 7 10 11	17	(74') As above: very stiff/tight.		
75	SS	18/24	6 6 10 11	16	(76') As above: more clay than sand (medium to high plasticity). (CH/MH/GW)		
	SS	12/24	7 9 7 5	16	(78') As above: less clay. (GW/SW) (79') Moist, 1cm dark brown layer diamicton gravel up to 1.5" diameter.		
80							

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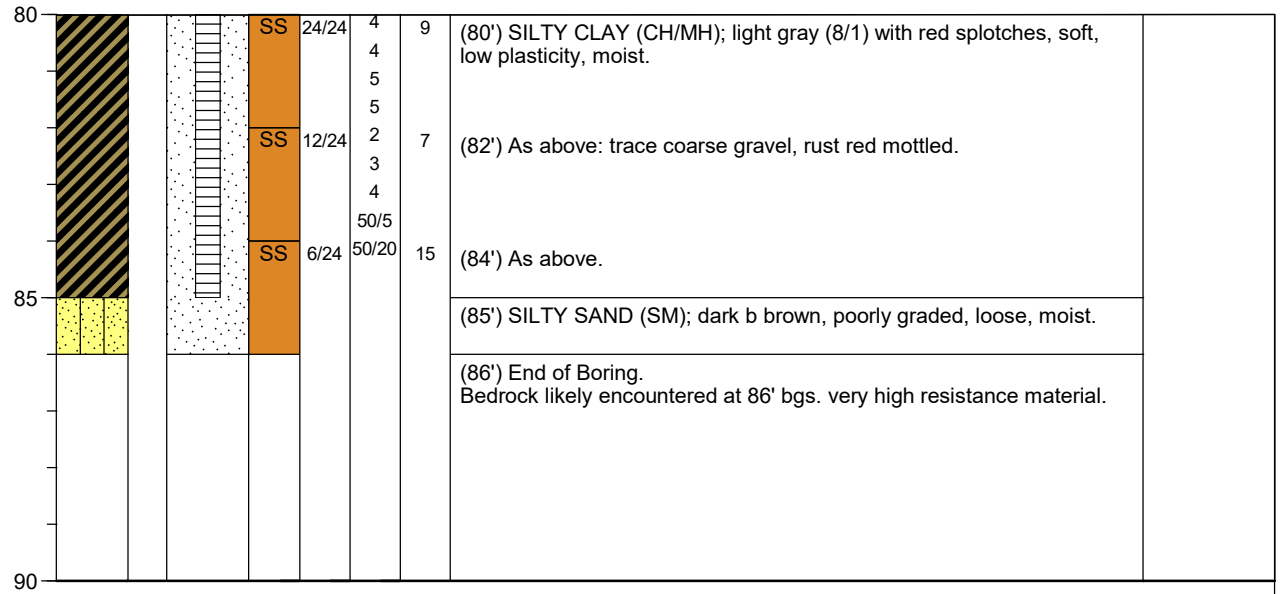
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G06
Page: 5 of 5

Drilling Start Date:	01/29/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.65	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.46	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.21294, -88.84915	Filter Pack:	Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80				SS	24/24	4 4 5 5	9	(80') SILTY CLAY (CH/MH); light gray (8/1) with red splotches, soft, low plasticity, moist.		
				SS	12/24	2 3 4 50/5	7	(82') As above: trace coarse gravel, rust red mottled.		
85				SS	6/24	50/20	15	(84') As above. (85') SILTY SAND (SM); dark b brown, poorly graded, loose, moist. (86') End of Boring. Bedrock likely encountered at 86' bgs. very high resistance material.		
90										

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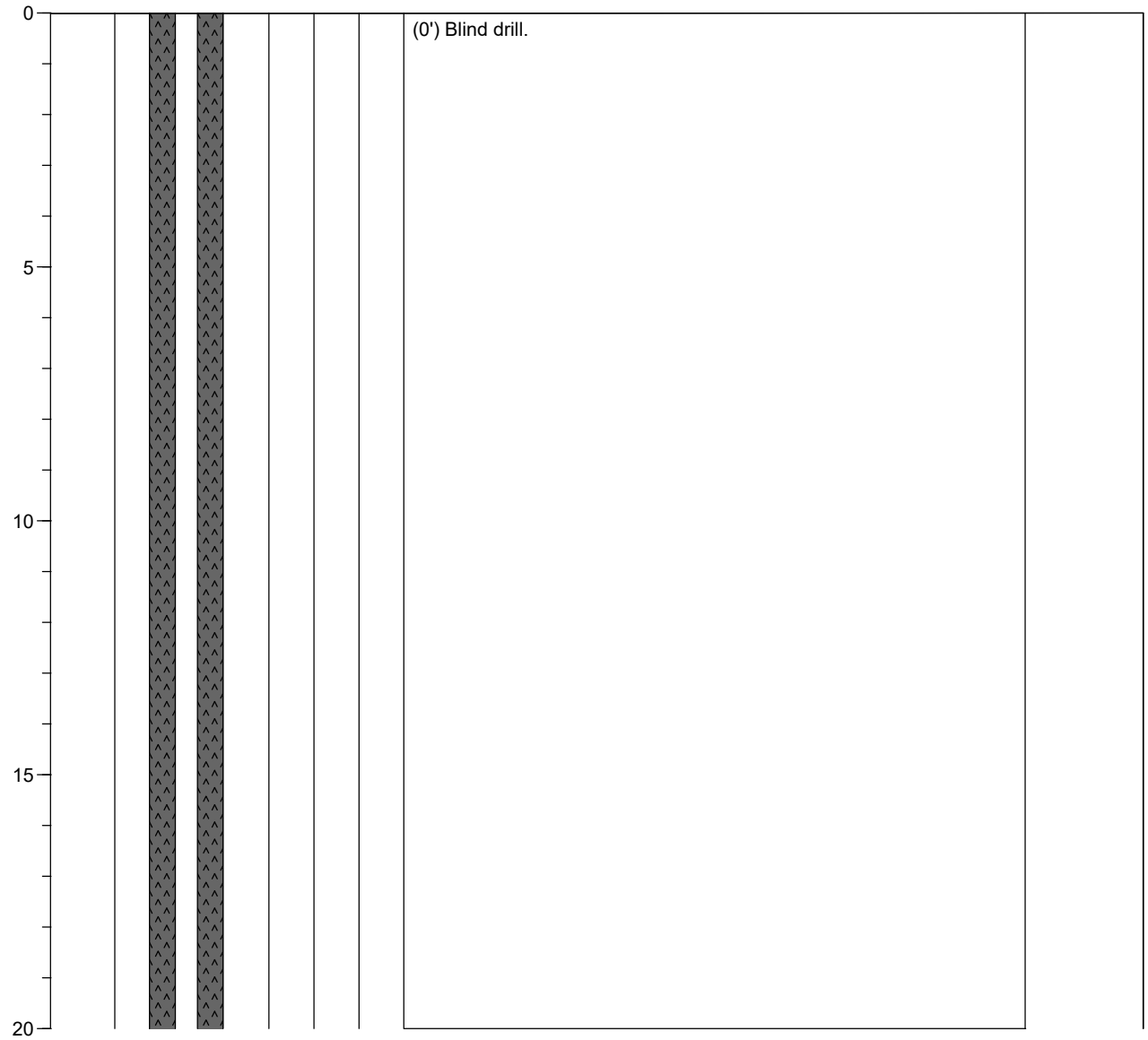
WELL LOG
Well No. G06S
Page: 1 of 3

Drilling Start Date:	02/01/2021	Boring Depth (ft):	44	Well Depth (ft):	40
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.92	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.22187, -88.84904	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		



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Project: GLP0821, Joppa Ash Pond
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WELL LOG
Well No. G06S
Page: 2 of 3

Drilling Start Date:	02/01/2021	Boring Depth (ft):	44	Well Depth (ft):	40
Drilling End Date:	02/01/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	355.92	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.22187, -88.84904	Filter Pack:	Sand

DTW

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		
25				SS	24/24	4 7 8 9	15	(26') CLAY (CH); light gray (7.5YR 8/1) mottled with brown, dry, very stiff, low plasticity.		
				SS	24/24	5 5 9 8	14	(28') As above.		
30				SS	24/24	3 7 14 24	21	(30') As above.		
				SH	24/24	4 1 8 11	9	(31') SILTY SAND (SM); very tight, mostly silt and fine to very fine grained sand, poorly graded, dry, (8/1) with (5YR 7/8), some clay. (32') As above.		
35				SS	12/24	9 22 10 10	32	(34') SAND AND SILTY SAND (SP-SM); mostly very fine to fine grained sand with some silt, poorly graded, tight, dry, light gray/organic.		
				SS	24/24	3 6 8 16	14	(36') As above. (SM)		
				SS	18/24	7 10 12 17	22	(38') As above. (SP-SM)		
40										

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WELL LOG
Well No. G06S
Page: 3 of 3

Drilling Start Date:	**02/01/2021**	Boring Depth (ft):	**44**	Well Depth (ft):	**40**
Drilling End Date:	**02/01/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**355.92**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**352.47**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**BA**	Location (Lat/Long):	**37.22187, -88.84904**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	24/24	8		(40') POORLY GRADED SAND (SP); (5YR 7/8), mostly fine grained sand, medium density, dry.		
				SS	24/24			(42') As above.		
45								(44') End of Boring.		

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WELL LOG
Well No. G07
Page: 1 of 4

Drilling Start Date:	01/29/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	01/29/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.86	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA & CL	Location (Lat/Long):	37.21116, -88.8492	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	24/24	4 8 6 6	14	(0') TOPSOIL. (0.25') FAT CLAY (CH); light brown (5YR 6/8), stiff, dry.		
				SS	12/24	4 5 5 6	10	(2') As above.		
5				SS	24/24	4 4 7 5	11	(4') As above.		
				SS	24/24	4 6 7 8	13	(6') As above.		
				SS	24/24	4 3 3 5	6	(8') As above: medium stiffness.		
10				SS	24/24	4 4 7 8	11	(10') LEAN CLAY (CL); light brown (5YR 7/4) to gray (mottled), stiff, dry.		
				SS	24/24	4 5 5 6	10	(12') As above: top 6" soft with plant material.		
				SS	24/24	3 3 4 4	7	(14') As above.		
15				SS	24/24			(16') As above.		
				SS	24/24	3 4 5 7	9	(18') As above: silt and clay, some fine sand, stiff, dry. (ML-CL)		
20										

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Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G07
Page: 2 of 4

Drilling Start Date:	01/29/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	01/29/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.86	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA & CL	Location (Lat/Long):	37.21116, -88.8492	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	3 4 6 7	10	(20') As above: rust spots.		
				SS	24/24	3 3 4 6	7	(22') As above: moist.		
				SS	24/24	3 3 4 5	7	(24') As above: mottled (10R 8/1).		
25				SS	24/24	3 4 7 7	11	(26') SILTY SAND (SP-SM); mostly silt, fine grained sand, some mottling as previous, poorly graded, tight, moist.		
				SS	24/24	3 6 7 7	13	(28') POORLY GRADED SAND (SP); very fine to fine grained sand, light gray (10R 8/1), tight, moist.		
30				SS	24/24	9 20 21 26	41	(30') As above. (31') POORLY GRADED SAND (SP); medium to coarse grained, loose, moist, (10R 8/1).		
				SH	18/24	10 6 9 9	15	(32') As above: color change to orange (5YR 6/8), clay at bottom.		
				SS	24/24	4 5 6 7	11	(34') FAT CLAY (CH); stiff, moist, light gray/orange mottled (10R 8/1 to 5YR 6/8).		
35				SS	24/24	3 3 5 5	8	(36') As above: medium stiffness.		
				SS	24/24	2 2 2 3	4	(38') As above.		
40										

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WELL LOG
Well No. G07
Page: 3 of 4

Drilling Start Date:	01/29/2021	Boring Depth (ft):	62	Well Depth (ft):	60
Drilling End Date:	01/29/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.86	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	352.47	Seal Material(s):	Grout & Bentonite
Logged By:	BA & CL	Location (Lat/Long):	37.21116, -88.8492	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	MEASURE: DEPTH (ft)
40				SS	24/24	3 3 5 8	8	(40') As above.		
				SS	24/24	6 12 23 24	35	(42') SILTY SAND (SP-SM); very fine grained sand and silt, tight, moist, poorly graded, light gray (10R 8/1).		
				SS	18/24	7 18 27 33	45	(44') As above. (45') POORLY GRADED SAND (SP); very fine to fine grained sand, tight, moist, (10R 8/1).		
				SS	24/24	7 18 43 47	61	(46') POORLY GRADED SAND (SP); fine to medium grained sand, loose, wet, interbedded gray to reddish orange (5YR 6/8) - seams 2cm.		
45				SS	18/24	14 17 18 7	35	(48') DIAMICTON (GW); mostly fine to coarse gravel and medium to coarse sand, saturated, very loose, well graded, (5YR 7/8).		
				SS	24/24	12 22 36 39	58	(50') WELL-GRADED SAND (SW); medium to coarse grained with fine gravel, saturated, loose.		
				SS	24/24	9 11 14 18	25	(52') As above: (5YR 7/6). (53') DIAMICTON (GW-SW); same as above, (5YR 6/8).		
				SS	24/24	19 31 53	84	(54') Same as above (SW).		
50				SS	24/24	7 21 14 8	35	(55') WELL-GRADED GRAVEL and SAND (GW-SW); mostly fine to coarse grained gravel and fine to medium sand, loose, wet, light gray (10R 8/1), orangish tan chert nodules. (57') As above: top 1' tan (5YR 6/8) bottom gray (10R 8/1), wet.		
				SS	24/24	6 9 11 16	20	(58') POORLY GRADED SAND (SP); mostly very fine to fine grained sand, wet, loose, tan (7.5YR 8/4).		
55										
60										

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WELL LOG
Well No. G07
Page: 4 of 4

Drilling Start Date:	**01/29/2021**	Boring Depth (ft):	**62**	Well Depth (ft):	**60**
Drilling End Date:	**01/29/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**353.86**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**352.47**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**BA & CL**	Location (Lat/Long):	**37.21116, -88.8492**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	24/24	32 48 38 8	86	(60') As above. (62') DIAMICTON (GW-SW); same as above.		
								(62') End of Boring.		
65										

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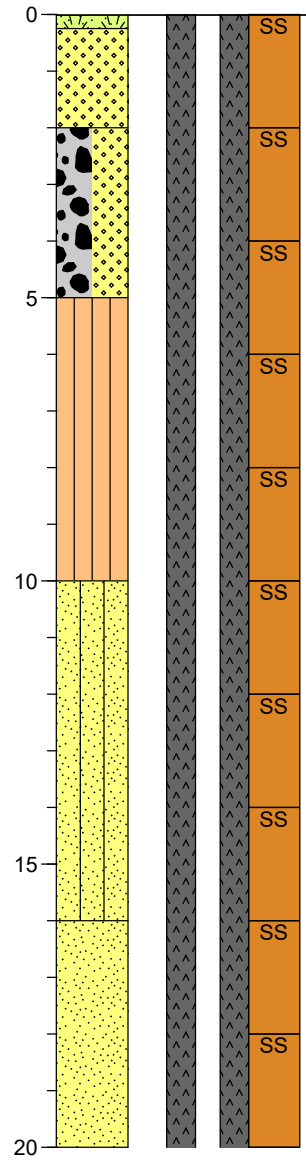
WELL LOG
Well No. G08
Page: 1 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
0	SS	7	3 4	7	(0') TOPSOIL. (0.25') WELL-GRADED SAND (SW); light brown/gray, loose, dry.		
	SS	18	6 14	18	(2') GRAVELLY SAND (GW-SW); loose, dry, mostly fine to coarse grained gravel and sand.		
	SS	7	11 7	7			
5	SS	4	6 4	4	(5') SILT (ML); low plasticity, dark gray, dry, trace coarse gravel. (6') As above.		
	SS	4	3 4	4	(8') As above: trace fine gravel.		
	SS	8	3 2	8	(10') SILTY SAND (SM); dark gray, loose, dry, well-graded.		
	SS	5	4 4	5	(12') As above.		
15	SS	5	2 2	5	(14') As above: clay seam at 15' (1-2").		
	SS	4	3 2	4	(16') POORLY GRADED SAND and CLAY (SP/CL); dark gray interbedded with dark gray, medium stiff, clay - 2" beds alternating.		
	SS	3	2 2	3			
20			1 1				

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WELL LOG
Well No. G08
Page: 2 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS		1 1 1	2	(20') CLAY (CH); high plasticity, soft, moist, gray to green.		
				SS		2 1 1 1 1	2	(21.5') SILTY SAND (SM); wet, loose, gray to green. (22') As above.		
25				SS		3 2 2 2 2	4	(24') SILT (ML); loose, dark gray, black clay seam - 2".		
				SS		2 2 1 2	3	(26') CLAY (CH); gray to green, saturated, high plasticity. (27') SILT (ML); soft, moist, gray to green.		
				SS		1 1 1 2	2	(28') SILTY SAND (SM-SP); light gray, firm, saturated, mostly poorly graded fine to medium grained sand and silt.		
30				SS		2 3 2 3	5	(30') As above.		
				SS		4 3 3 4	7	(31') SILTY SAND (SM); tight, light gray, poorly graded, fine to medium grained sand. (32') As above.		
				SS		4 4 4 4	7	(33') CLAY (CL); light gray, hard, low plasticity, dry.		
35				SS		3 3 3 4	8	(35') As above: some fine grained sand. (36') As above: gradually grades to fine to medium sand.		
				SS		4 5 3 3	6	(37') POORLY GRADED SAND (SP); fine to medium grained sand, tight, trace gravel, mottled with rusty red color. (38') As above.		
40						3 3 3 3				

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Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G08
Page: 3 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	MEASURE: DEPTH (ft)
40				SS		5 10 12 12	22	(40') POORLY GRADED SAND (SP); fine to medium grained, tight, light gray, mottled with rust color. (41') As above: saturated.		
				SS		3 5 8 8	13	(42') As above: some fine to coarse gravel. (43.5') As above: nodule (red chert), saturated.		
45				SS		3 6 7 7	13	(44') As above: lots of fine to coarse gravel, yellow/orange/red, gravel/nodules.		
				SS		5 7 7 11	14	(46') GRAVELLY SAND (GW-SW); mostly fine grained sand and fine to coarse gravel, light gray, gravel bits are red/yellow, saturated.		
				SS		1 5 5 5	10	(48') As above: very loose.		
50				SS		9 9 5 14	14	(50') As above. (51.5') As above: some silt.		
				SS		3 11 11 10	22	(52') WELL-GRADED SAND (SW); fine to coarse grained, trace fine gravel, tan, very loose.		
				SS		9 14 12 10	26	(54') WELL-GRADED GRAVELLY SAND (GW-SW); tan, moist, coarse grained gravel, fine to coarse sand, very loose, wet. (55') As above: light gray.		
55				SS		17 19 17 17	36	(56') POORLY GRADED SAND (SP); fine to medium grained, wet, loose, dark tan.		
				SS		6 8 11 12	19	(57.5') WELL-GRADED GRAVELLY SAND (GW); dark tan, loose. (58') As above. (59') WELL-GRADED SAND (SW); dark tan, wet, loose, trace fine gravel.		
60										

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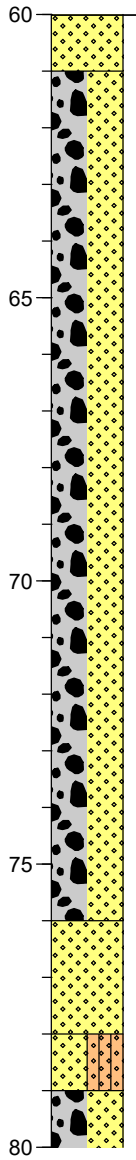
WELL LOG
Well No. G08
Page: 4 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
60	SS	24/24	14, 10	24	(60') As above.		
			14, 11		(61') GRAVELLY SAND (GW-SW); dark tan, well-graded, coarse chert nodules, wet, loose.		
	SS	18/24	5, 3	7	(62') As above.		
			4, 5				
	SS	12/24	4, 8	13	(64') As above.		
65			5, 8				
	SS	18/24	5, 8	16	(66') As above.		
			8, 7				
	SS	18/24	5, 7	14	(68') As above: saturated.		
			7, 8				
70	SS	12/24	5, 6	13	(70') As above.		
			7, 7				
	SS	18/24	7, 9	18	(72') As above.		
			9, 11				
	SS	24/24	7, 7	15	(74') As above: mostly silt and gravel, (5YR 6/8).		
75			8, 9				
	SS	18/24	10, 16	33	(76') WELL-GRADED SAND (SW); mostly medium to coarse grained sand, wet, loose, (5YR 6/8).		
			17, 25				
	SS	24/24	8, 15	54	(78') DIAMICTON (SW-SM); mostly coarse grained gravel, fine sand, silt, wet, medium density, (5YR 6/8).		
80			39, 42		(79') Same fine to coarse gravel, more coarse gravel, (5YR 6/8). (GW-SW)		

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WELL LOG
Well No. G08
Page: 5 of 5

Drilling Start Date:	01/27/2021	Boring Depth (ft):	86	Well Depth (ft):	85
Drilling End Date:	01/28/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	344.22	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	341.72	Seal Material(s):	Grout & Bentonite
Logged By:	BA	Location (Lat/Long):	37.20984, -88.85066	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80				SS	18/24	6 11 12 14	23	(80') As above. (SW)		
				SS	24/24	7 14 19 21	33	(81.5') 1/2" seam - orangish sand, medium packing, moist, (7.5YR 8/6). (SP) (82') Same as above. (SW) (83') Same as above, top 3" (10R 6/6), tight, moist. (SP)		
85				SS	12/24	19 27 15 5	42	(84') As above. (85') 2cm seam of reddish/oxidized fine grained sand, dry.		
90								(86') End of Boring.		

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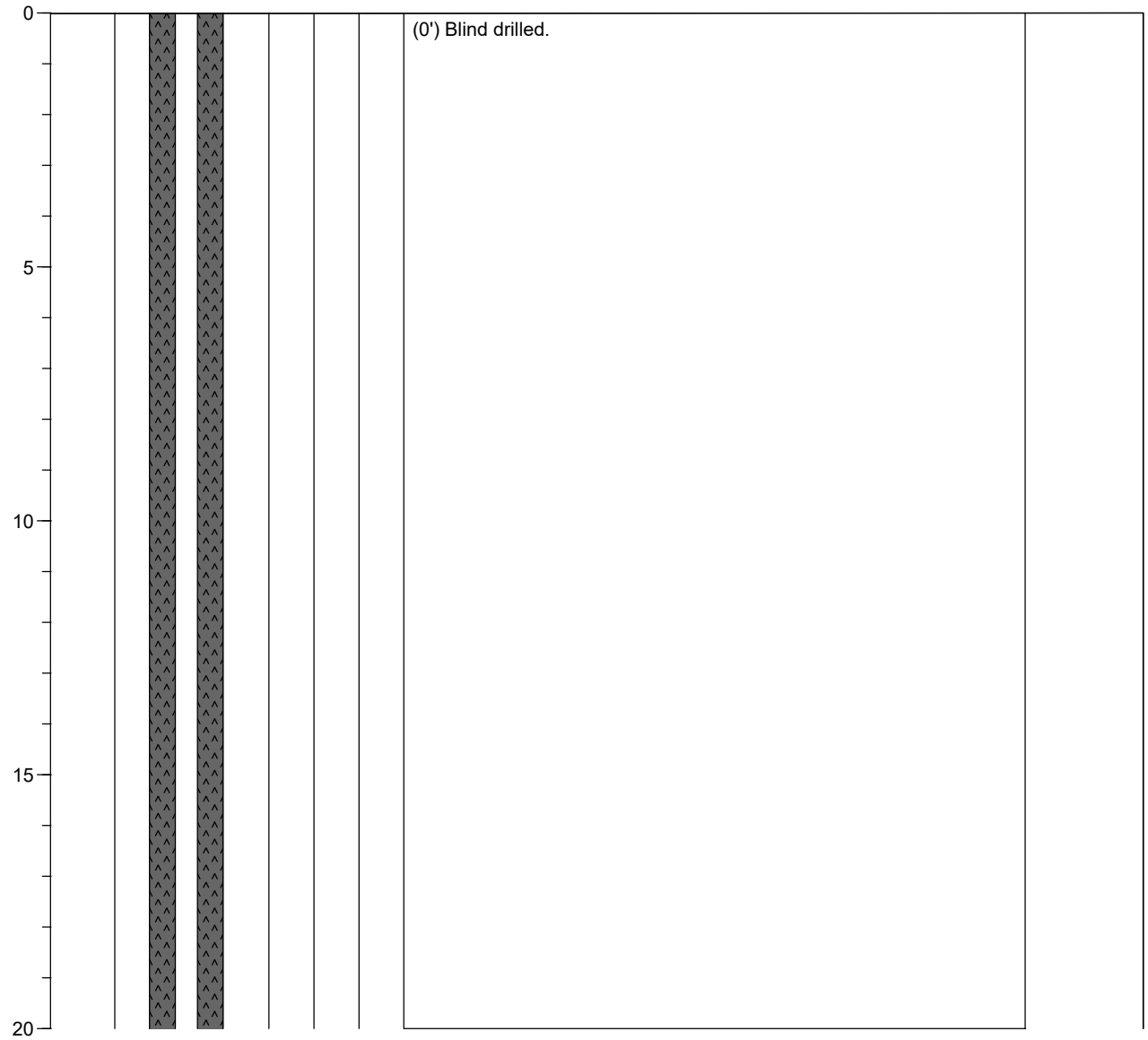
WELL LOG
Well No. G09
Page: 1 of 4

Drilling Start Date:	01/31/2021	Boring Depth (ft):	72	Well Depth (ft):	70
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	36.31	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.99	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.69	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21039, -88.54247	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drilled.		



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WELL LOG
Well No. G09
Page: 2 of 4

Drilling Start Date:	01/31/2021	Boring Depth (ft):	72	Well Depth (ft):	70
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	36.31	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.99	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.69	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21039, -88.54247	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drilled.		
25										
30										
35		▼								
40										

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WELL LOG
Well No. G09
Page: 3 of 4

Drilling Start Date:	01/31/2021	Boring Depth (ft):	72	Well Depth (ft):	70
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	36.31	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.99	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.69	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21039, -88.54247	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') Blind drilled.		
45										
50										
55				SS	13/24	1 1 5 15	6	(54') POORLY GRADED SAND (SP); fine to medium grained sand, light gray (2.5Y 7/1), medium dense, dry, few coarse gravel.		
				SS	23/24	8 13 15 20	28	(56') As above.		
				SS	15/24	4 9 17 16	26	(58') WELL-GRADED SAND (SW); coarse grained with gravel, reddish yellow (7.5YR 6/6), loose, moist. (59') Becomes wetter.		
60										

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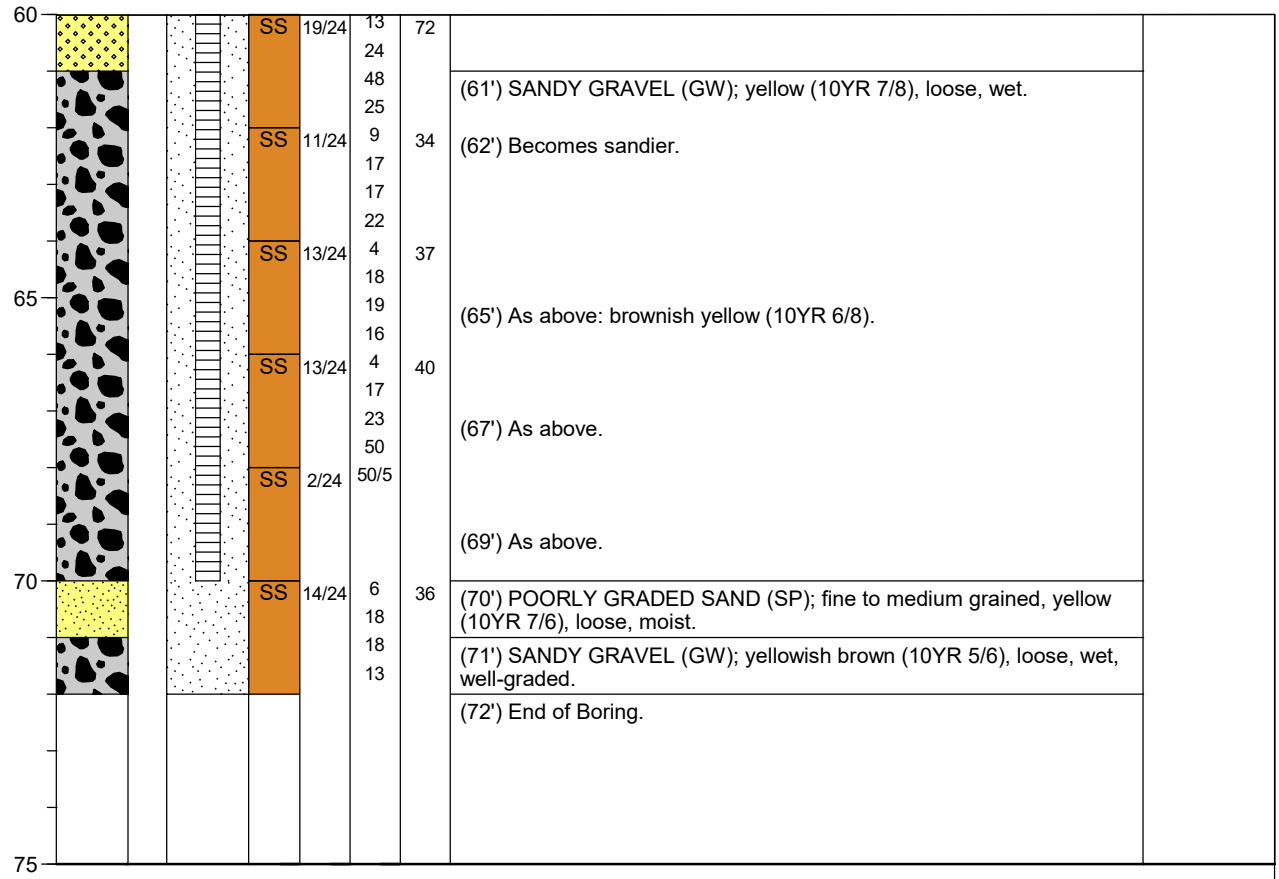
WELL LOG
Well No. G09
Page: 4 of 4

Drilling Start Date:	01/31/2021	Boring Depth (ft):	72	Well Depth (ft):	70
Drilling End Date:	01/31/2021	Boring Diameter (in):	7.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	36.31	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.99	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.69	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21039, -88.54247	Filter Pack:	Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	19/24	13 24 48 25	72			
								(61') SANDY GRAVEL (GW); yellow (10YR 7/8), loose, wet.		
				SS	11/24	9 17 17 22	34	(62') Becomes sandier.		
				SS	13/24	4 18 19 16	37			
65								(65') As above: brownish yellow (10YR 6/8).		
				SS	13/24	4 17 23 50	40			
								(67') As above.		
				SS	2/24	50/5				
								(69') As above.		
70				SS	14/24	6 18 18 13	36	(70') POORLY GRADED SAND (SP); fine to medium grained, yellow (10YR 7/6), loose, moist.		
								(71') SANDY GRAVEL (GW); yellowish brown (10YR 5/6), loose, wet, well-graded.		
								(72') End of Boring.		
75										

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WELL LOG
Well No. G09M
Page: 1 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	6/24	6 4 5	9	(0') LEAN CLAY (CL); brown (7.5YR 5/3), stiff, dry, some reddish brown mottling, trace sand.		
				SS	22/24	6 4 5	11			
				SS	24/24	4 2 3	6	(4') FAT CLAY (CH); light brown (7.5YR 6/4), medium dense, moist.		
5				SS	24/24	3 4 0	6	(6') As above: lean clay, moist. (CL)		
				SS	24/24	3 4 2	8	(8') As above: brown (7.5YR 5/4), some reddish brown mottling.		
10				SS	20/24	3 5 5	7	(10') As above.	10-12 Chem	
				SS	22/24	2 3 4	9	(12') CLAY (CL); gray to light brown (7.5YR 6/1) mottled, medium dense, dry, few sand.		
				SS	21/24	5 5 2	8	(14') As above: brown (7.5YR 5/4).		
15				SH	24/24	3 5 5		(16') As above: light brown (7.5YR 6/3).	16-18 Geotech	
				SS	23/24	2 5 6	11	(18') CLAY (CL); gray to light brown (7.5YR 6/1) mottled, very stiff, moist, few sand.		
20						7				

NOTES: SBG09M- (16-18)-20210127: 20.6% moisture content, 950 mg/kg total organic carbon, 105.4 pcf dry unit weight, 2.666 specific gravity, 8.3x 10^{-8} cm/s vertical hydraulic conductivity, 39 LL, 16PL, 23PI, 0.0% gravel, 5.0% sand, 95.0% fines.

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WELL LOG
Well No. G09M
Page: 2 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	24/24	2 4 7 8	11	(20') CLAY (CL); light gray with brown (10YR 7/1) mottling, very stiff, moist, trace sand and silt.	20-22 Chem	
				SS	24/24	4 6 7 8	13	(22') As above: (10YR 7/2).		
				SS	24/24	2 5 7 8	12	(24') As above: fewer brown mottling.		
25				SS	24/24	3 3 6 7	9	(27-28') As above: increased reddish brown mottling.		
				SS	24/24	4 8 8 7	16	(28') SILT (ML); with few sand and clay, light gray (10YR 7/2) with some brown mottling, dry, stiff.		
				SS	24/24	4 8 6 8	14	(30') As above: moist.		
30				SS	24/24	4 5 6 7	11	(32') As above.		
				SS	24/24	2 4 4 6	8	(34') SANDY CLAY (SC); light gray (10YR 7/2) with some brown mottling, moist.		
								(34.5') SILT (ML); with some sand, few clay, stiff.		
35				SS	24/24	3 4 5 8	9	(36') As above: trace black organics.		
				SS	24/24	5 20 18 17	38	(38') SANDY CLAY (SC); fine grained sand, few silt, gray (7.5YR 5/1), moist.		
40										

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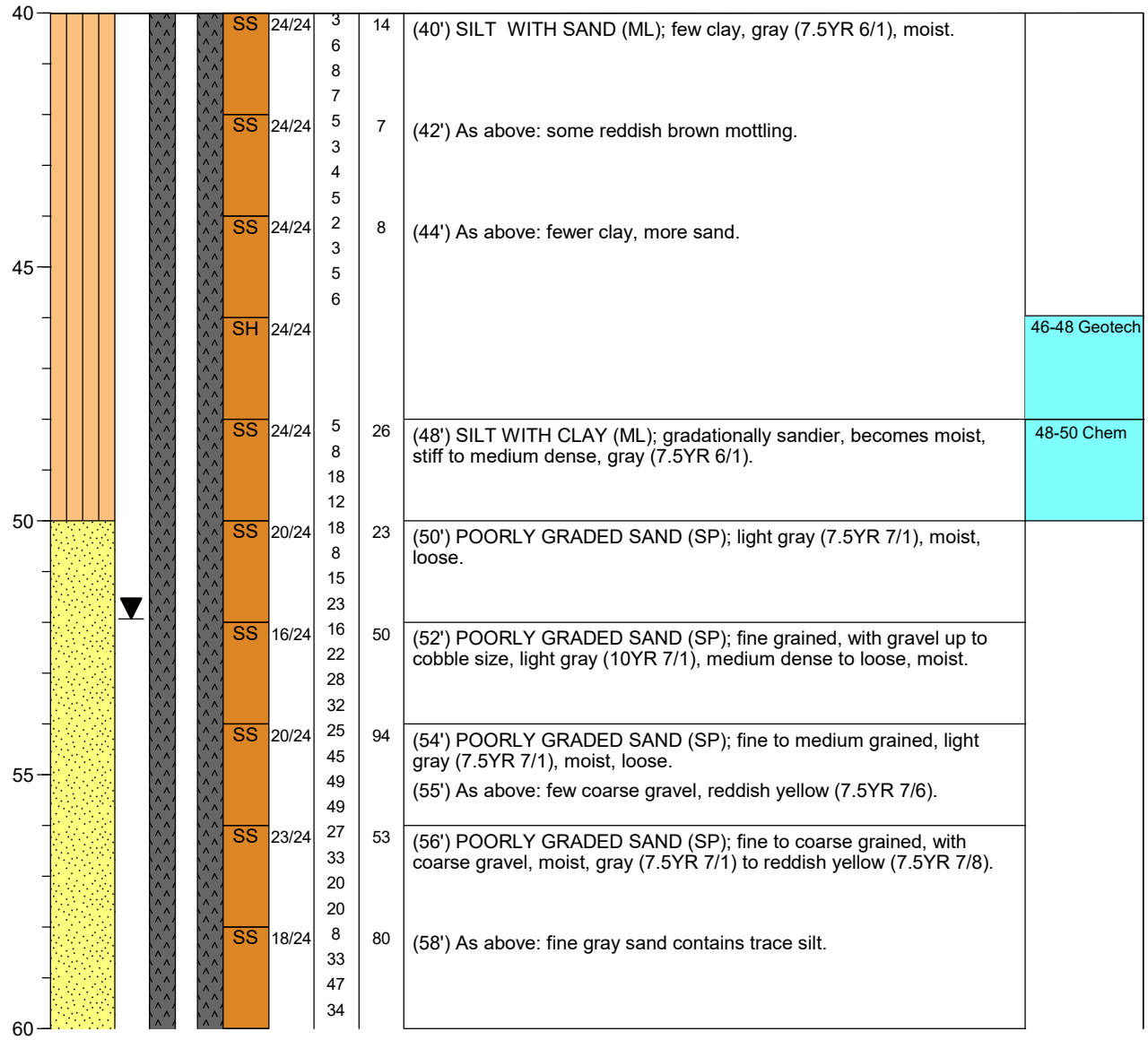
WELL LOG
Well No. G09M
Page: 3 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand



NOTES: SBG09M- (46-48)-20210127: 19.8% moisture content,105.4 pcf dry unit weight, 2.715 specific gravity, 3.5x 10^{-7} cm/s vertical hydraulic conductivity, 35 LL, 15 PL, 20 PI, 0.0% gravel, 17.2% sand, 82.8% fines.

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WELL LOG
Well No. G09M
Page: 4 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	16/24	32 35 47 21	82	(60') POORLY GRADED SAND (SP); coarse grained, reddish yellow (7.5YR 6/8), moist, loose.		
				SS	16/24	22 50/5 14	64	(62') POORLY GRADED SAND (SP); coarse grained, reddish yellow (7.5YR 6/8), medium dense, some coarse gravel pebble size.		
				SS	13/24	17 11 12 12	23	(64') As above: increasing fine to coarse gravel.		
65				SS	12/24	15 16 15 11	31	(66') As above.		
				SS	11/24	38 50	50	(68') POORLY GRADED GRAVEL WITH SAND (GP); strong brown (7.5YR 5/6), loose, moist.		
70				SS	12/24	14 17 30 32	47	(70') As above.		
				SS	12/24	25 24 15 16	39	(72') As above: reddish yellow (7.5YR 6/8).		
				SS	8/24	6 25 20 12	45	(74') As above: sand disappears, wet.		
75				SS	14/24	7 7 8 7	15	(76') As above: strong brown (7.5YR 5/8).		
				SS	16/24	11 22 14 8	36	(78') As above: with some sand.		
80										

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WELL LOG
Well No. G09M
Page: 5 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80				SS	12/24	2 17 19 12	36	(80') POORLY GRADED GRAVEL (GP); little sand, reddish yellow (7.5YR 6/8), very loose, wet.	80-82 Chem	
				SS	10/24	5 18 13 14	31		82-84 Geotech	
85				SS	14/24		19	(83.7') POORLY GRADED SAND (SP); medium grained, trace gravel, reddish brown (7.5YR 6/8), loose, moist.		
				SS	14/24	12 9 10 10	22	(86') WELL-GRADED GRAVEL (GW); few sand, trace clay, reddish brown (7.5YR 6/8), loose, wet.		
				SS	14/24	25 14 8 6	14	(88') As above: clay disappears.		
90				SS		4 6 8 7		(91') GRAVELLY LEAN CLAY (CL); very pale brown (10YR 8/2), moist, soft.		
				SS		2 3 3 4	6	(92') CLAY (CL); trace gravel, gray (7.5YR 6/1), medium dense.		
95				SS		2 1 3 3	4	(94') As above: gray (10YR 5/1).		
				SS		1 6 23 23	29	(96') POORLY GRADED SAND (SP); fine grained, strong brown (7.5YR 5/8), loose.		
				SS		5 14 25 23	39	(98') As above.		
100										

NOTES: SBG09M- (82-84)-20210127: 7.6% moisture content, 740 U mg/kg total organic carbon, 100.0 pcf dry unit weight, 2.686 specific gravity, 22.7% gravel, 75.4% sand, 1.9% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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Project: GLP0821, Joppa Ash Pond
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WELL LOG
Well No. G09M
Page: 6 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100				SS	14/24	14 14	27	(100') CLAY (CL); (10YR 6/1), very soft, trace gravel.		
						13 15		(101') CLAYEY GRAVEL (GC); (7.5YR 5/8), moist, loose.		
				SS	15/24	14 12	20	(102') As above: some sand, brown (7.5YR 4/4).		
						8 15				
				SS	9/24	12 12	21	(104') GRAVELLY CLAY (CL); light gray (2.5Y 7/2), stiff, moist.		
105						9 14				
				SS	15/24	12 12	24	(106') CLAYEY GRAVEL (GC); pinkish gray (7.5YR 7/2), medium dense, moist.		
						12 20				
				SS	14/24	9 28	39	(108') POORLY GRADED SAND (SP); fine grained, yellow (10YR 7/6) to white (10YR 8/1) at 109.8' bgs, moist, loose.		
						11 11				
110				SS	15/24	8 12	20	(110') As above: light gray (10YR 7/1).	110-112 Chem	
						8 12				
				SH	8/24				112-114 Geotech	
				SS	13/24	10 11	20	(114') As above: yellow (10YR 7/6), trace gravel.		
115						9 10				
				SS	12/24	7 9	18	(116') As above: light gray (10YR 7/2), no gravel.	116-118 Geotech (not tested)	
						9 12				
				SS	22/24	7 1	3	(118') SILT WITH SAND (ML); gray (10YR 6/1) with some light brown mottling, soft, moist.		
						2 3				
120								(119.5') CLAY (CL); little silt, gray (10YR 6/1), stiff, moist.		

NOTES: SBG09M- (110-112)-20210127: 25.5% moisture content, 760 U mg/kg total organic carbon, 87.0 pcf dry unit weight, 2.675 specific gravity, 0.7% gravel, 84.1% sand, 15.2% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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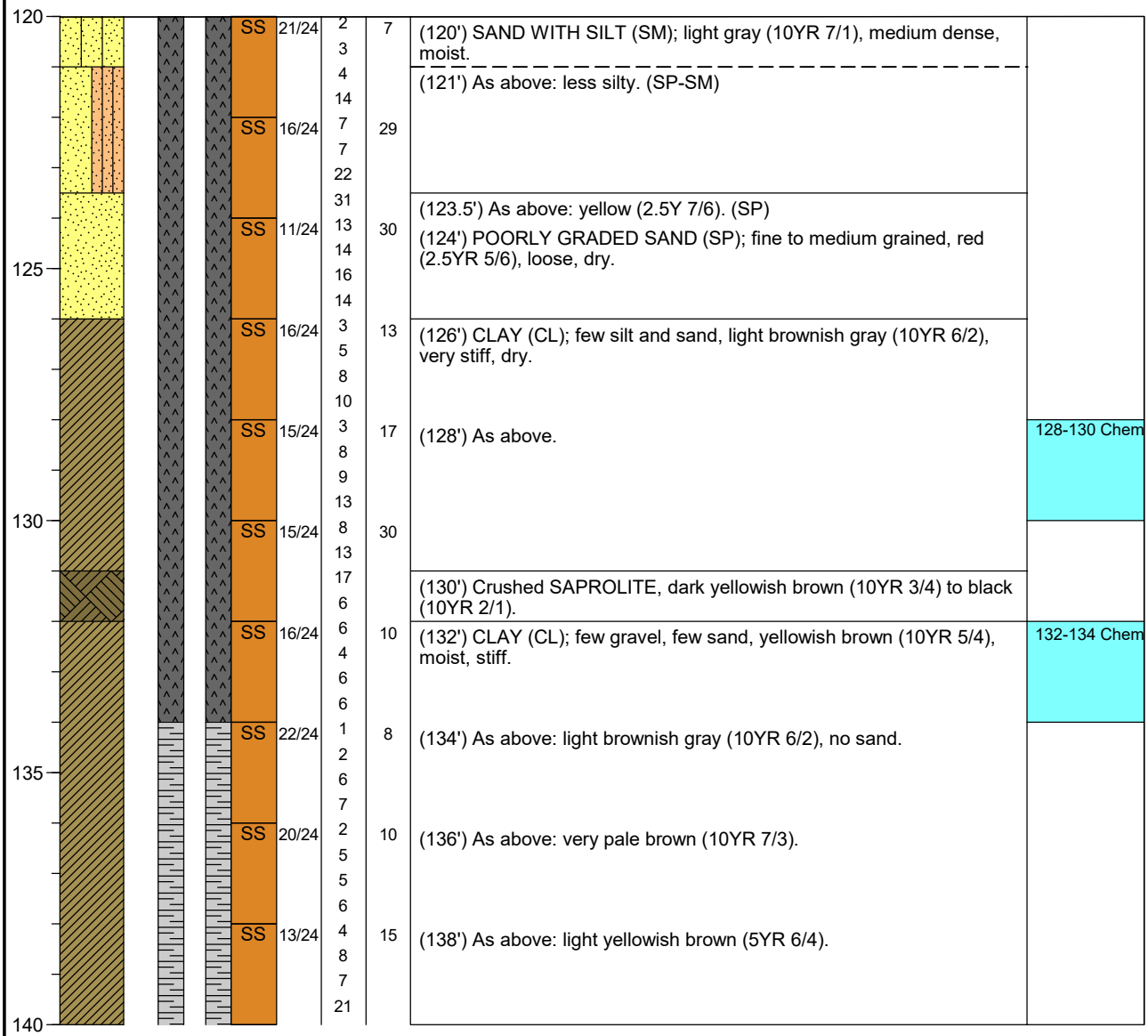
WELL LOG
Well No. G09M
Page: 7 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
120	SS	21/24	2 3 4	7	(120') SAND WITH SILT (SM); light gray (10YR 7/1), medium dense, moist.		
			14		(121') As above: less silty. (SP-SM)		
	SS	16/24	7 7 22	29			
			31		(123.5') As above: yellow (2.5Y 7/6). (SP)		
	SS	11/24	13 14 16	30	(124') POORLY GRADED SAND (SP); fine to medium grained, red (2.5YR 5/6), loose, dry.		
125			14				
	SS	16/24	3 5 8	13	(126') CLAY (CL); few silt and sand, light brownish gray (10YR 6/2), very stiff, dry.		
			10				
	SS	15/24	3 8 9	17	(128') As above.	128-130 Chem	
			13				
130	SS	15/24	8 13 17	30			
			6		(130') Crushed SAPROLITE, dark yellowish brown (10YR 3/4) to black (10YR 2/1).		
	SS	16/24	6 4 6	10	(132') CLAY (CL); few gravel, few sand, yellowish brown (10YR 5/4), moist, stiff.	132-134 Chem	
			6				
	SS	22/24	1 2 6	8	(134') As above: light brownish gray (10YR 6/2), no sand.		
135			7				
	SS	20/24	2 5 5	10	(136') As above: very pale brown (10YR 7/3).		
			6				
	SS	13/24	4 8 7	15	(138') As above: light yellowish brown (5YR 6/4).		
140			21				

NOTES:

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WELL LOG
Well No. G09M
Page: 8 of 8

Drilling Start Date:	01/26/2021	Boring Depth (ft):	158	Well Depth (ft):	155
Drilling End Date:	01/28/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	51.93	Riser Material:	Sch 80 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	351.53	Screen Material:	Sch 80 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK & AT	Location (Lat/Long):	37.21040, -88.85422	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
140				SS	6/24	70/1		(140') CALCARENITE, very pale brown (10YR 7/3), dry.	140-142 Chem	
145										
150										
155								(155') End of Boring.		
								(158') Redrilled to 158' due to well installation difficulties.		
160										

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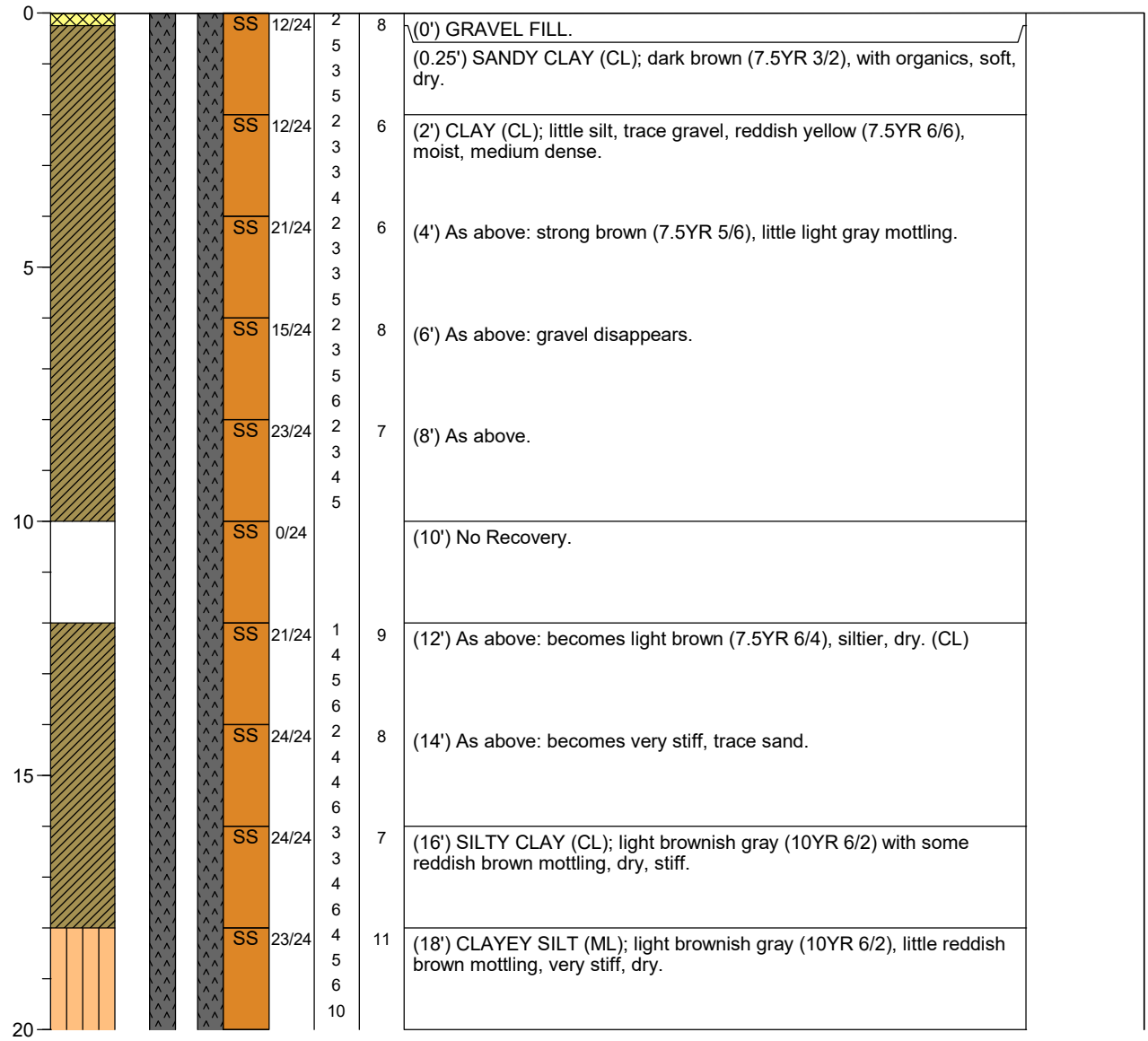
WELL LOG
Well No. G10
Page: 1 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	72	Well Depth (ft):	72
Drilling End Date:	02/01/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	33.35	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.83	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21125, -88.85573	Filter Pack:	Sand



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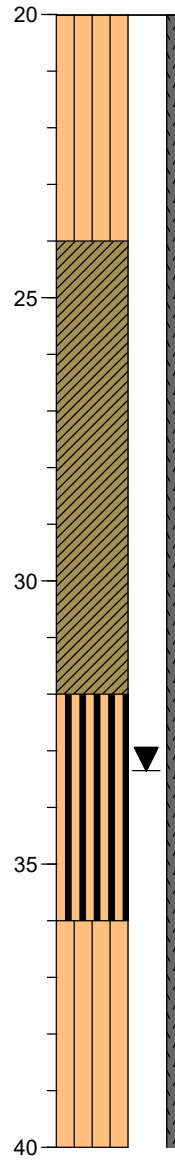
WELL LOG
Well No. G10
Page: 2 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	72	Well Depth (ft):	72
Drilling End Date:	02/01/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	33.35	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.83	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21125, -88.85573	Filter Pack:	Sand



DEPTH (ft)	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20	SS	20/24	4 6 6 9	12	(20') SILT (ML); some sand and little clay, very pale brown (10YR 7/3), very stiff, dry.		
	SS	24/24	3 4 7 8	11	(22') As above: becomes more clayey.		
25	SS	24/24	3 5 6 7	11	(24') SILTY CLAY (CL); light yellowish brown (10YR 6/4), very stiff, dry.		
	SS	24/24	2 4 5 7	9	(26') As above: becomes gray (10YR 6/1) with little reddish brown mottling.		
	SS	24/24	2 4 1 8	5	(28') As above.		
30	SS	24/24	3 5 8 7	13	(30') As above: becomes light brownish gray (10YR 6/2).		
	SS	24/24	3 4 4 6	8	(32') SILT (MH); little clay, pale brown (10YR 6/3), stiff, dry, high plasticity.		
35	SS	24/24	3 4 5 6	9	(34') As above: moist.		
	SS	24/24	3 7 6 7	13	(36') As above: clay disappears, lower plasticity. (ML)		
	SS	21/24	3 8 27 32	35	(38') SANDY SILT (ML); pale brown (10YR 6/3), very stiff, wet.		
40							

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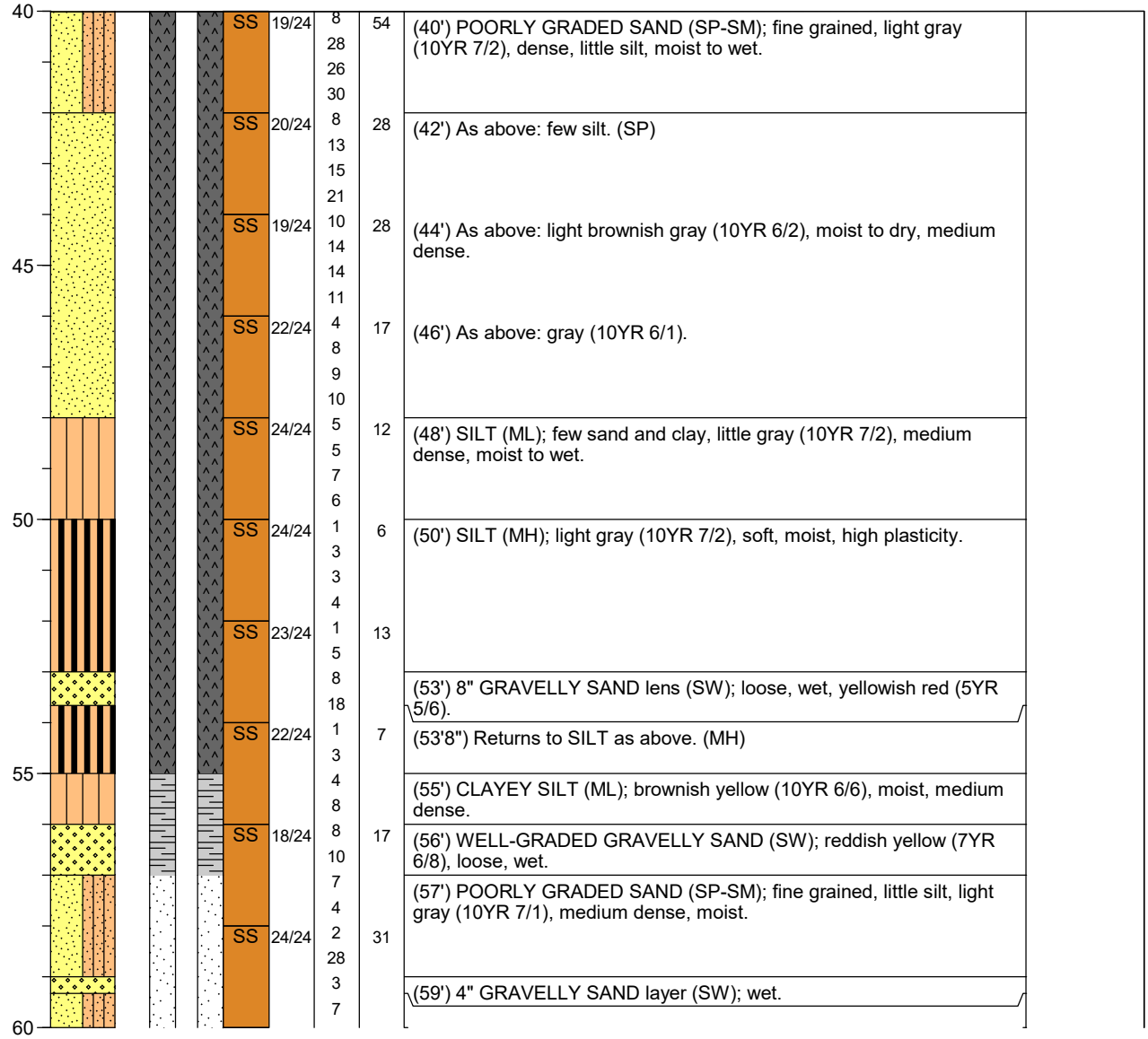
WELL LOG
Well No. G10
Page: 3 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	72	Well Depth (ft):	72
Drilling End Date:	02/01/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	33.35	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.83	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21125, -88.85573	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
40	SS	19/24	8, 28, 26, 30	54	(40') POORLY GRADED SAND (SP-SM); fine grained, light gray (10YR 7/2), dense, little silt, moist to wet.		
	SS	20/24	8, 13, 15, 21	28	(42') As above: few silt. (SP)		
45	SS	19/24	10, 14, 14, 11	28	(44') As above: light brownish gray (10YR 6/2), moist to dry, medium dense.		
	SS	22/24	4, 8, 9, 10	17	(46') As above: gray (10YR 6/1).		
	SS	24/24	5, 5, 7, 6	12	(48') SILT (ML); few sand and clay, little gray (10YR 7/2), medium dense, moist to wet.		
50	SS	24/24	1, 3, 3, 4	6	(50') SILT (MH); light gray (10YR 7/2), soft, moist, high plasticity.		
	SS	23/24	1, 5, 8, 18	13	(53') 8" GRAVELLY SAND lens (SW); loose, wet, yellowish red (5YR 5/6).		
	SS	22/24	1, 3, 4, 8	7	(53'8") Returns to SILT as above. (MH)		
55					(55') CLAYEY SILT (ML); brownish yellow (10YR 6/6), moist, medium dense.		
	SS	18/24	8, 10, 7, 4	17	(56') WELL-GRADED GRAVELLY SAND (SW); reddish yellow (7YR 6/8), loose, wet.		
	SS	24/24	2, 28, 3, 7	31	(57') POORLY GRADED SAND (SP-SM); fine grained, little silt, light gray (10YR 7/1), medium dense, moist.		
60					(59') 4" GRAVELLY SAND layer (SW); wet.		

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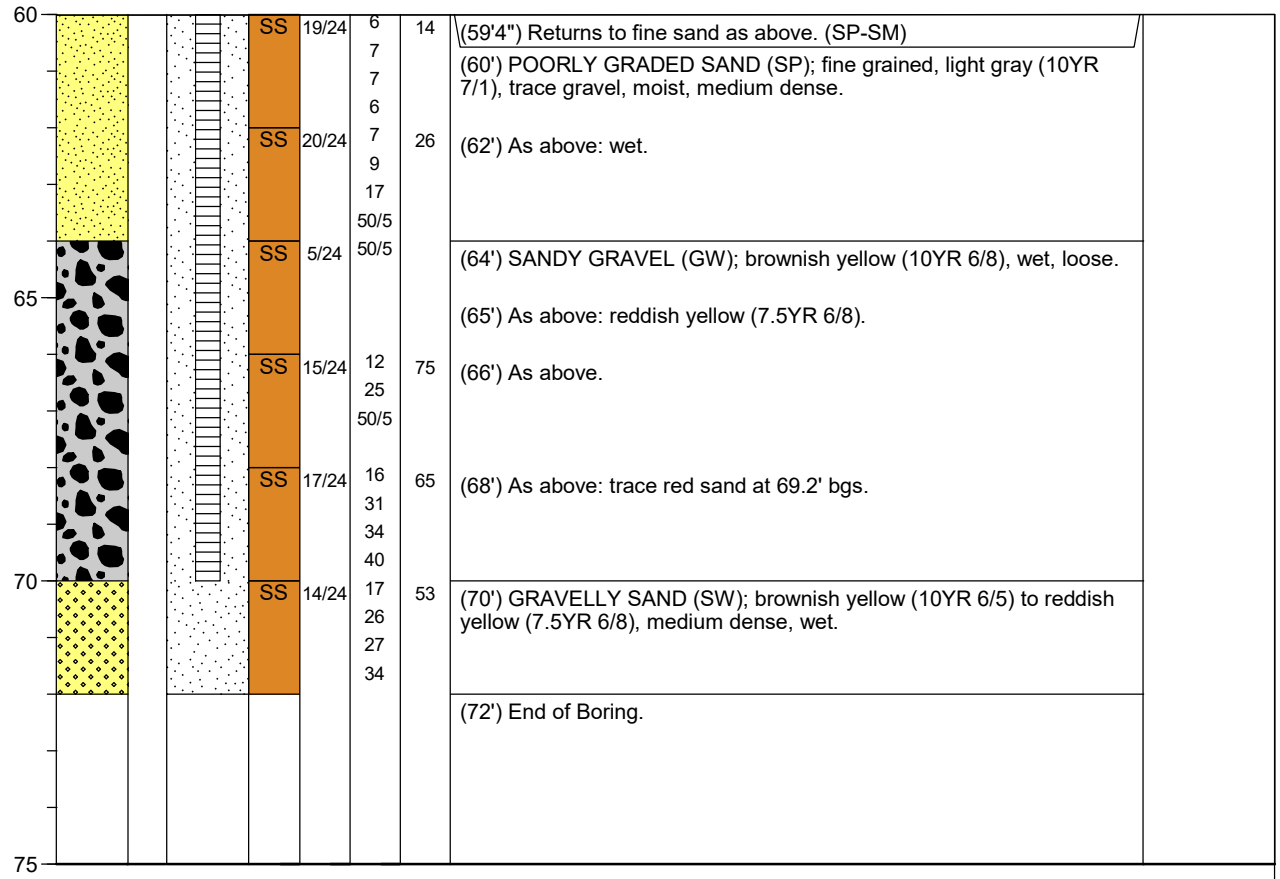
WELL LOG
Well No. G10
Page: 4 of 4

Drilling Start Date:	02/01/2021	Boring Depth (ft):	72	Well Depth (ft):	72
Drilling End Date:	02/01/2021	Boring Diameter (in):	4.25	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	33.35	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	353.83	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	348.60	Seal Material(s):	Grout & Bentonite
Logged By:	SK	Location (Lat/Long):	37.21125, -88.85573	Filter Pack:	Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	19/24	6 7 7 6	14	(59'4") Returns to fine sand as above. (SP-SM) (60') POORLY GRADED SAND (SP); fine grained, light gray (10YR 7/1), trace gravel, moist, medium dense.		
				SS	20/24	7 9 17 50/5	26	(62') As above: wet.		
65				SS	5/24	50/5		(64') SANDY GRAVEL (GW); brownish yellow (10YR 6/8), wet, loose. (65') As above: reddish yellow (7.5YR 6/8).		
				SS	15/24	12 25 50/5	75	(66') As above.		
				SS	17/24	16 31 34 40	65	(68') As above: trace red sand at 69.2' bgs.		
70				SS	14/24	17 26 27 34	53	(70') GRAVELLY SAND (SW); brownish yellow (10YR 6/5) to reddish yellow (7.5YR 6/8), medium dense, wet.		
75								(72') End of Boring.		

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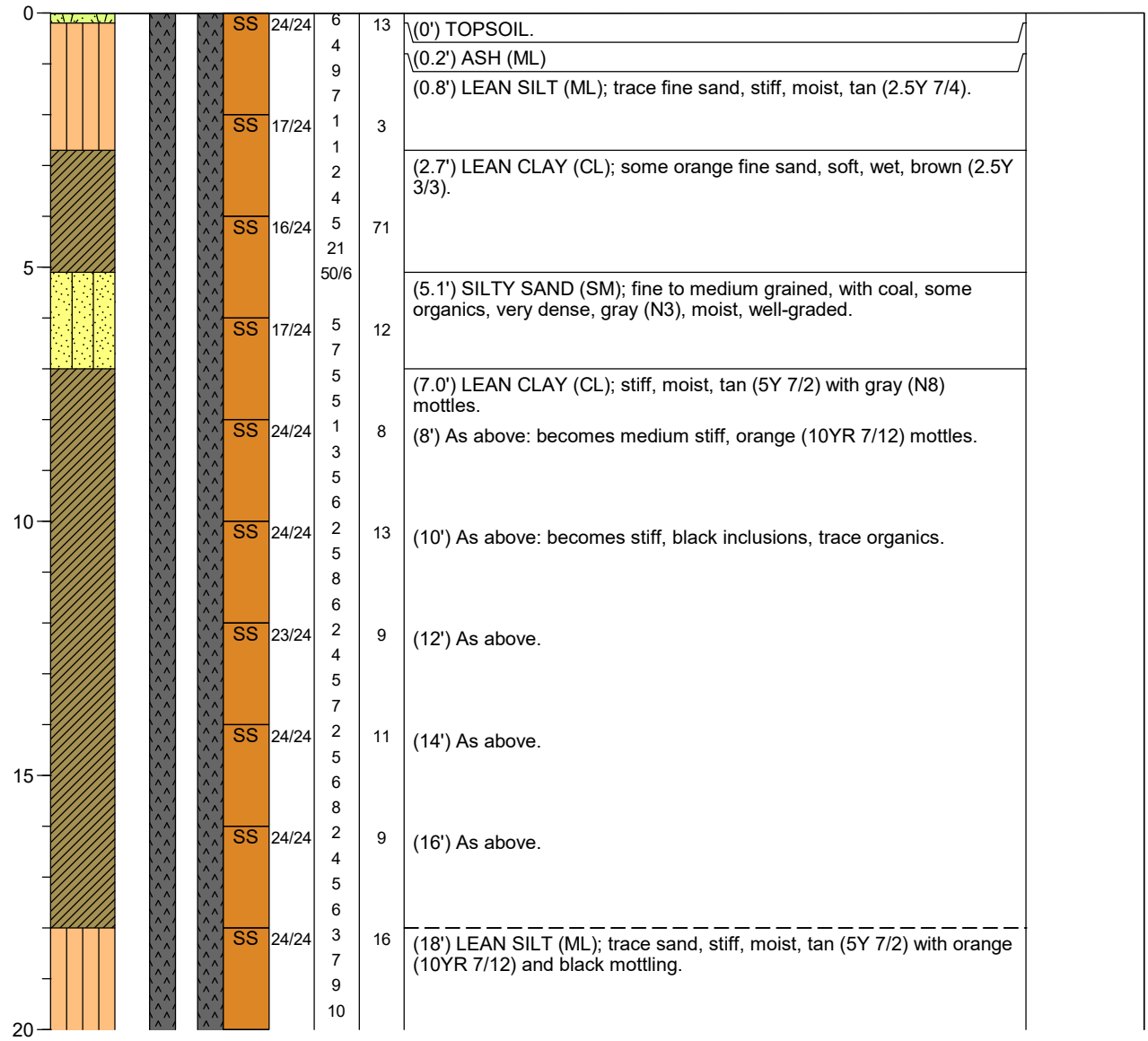
WELL LOG
Well No. G11
Page: 1 of 4

Drilling Start Date:	01/19/2021	Boring Depth (ft):	66	Well Depth (ft):	66
Drilling End Date:	01/19/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	45.66	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	366.88	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	363.38	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF & AT	Location (Lat/Long):	37.21436, -88.85636	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
0	SS	24/24	6 4 9 7	13	(0') TOPSOIL. (0.2') ASH (ML) (0.8') LEAN SILT (ML); trace fine sand, stiff, moist, tan (2.5Y 7/4).		
	SS	17/24	1 1 2 4	3	(2.7') LEAN CLAY (CL); some orange fine sand, soft, wet, brown (2.5Y 3/3).		
	SS	16/24	5 21 50/6	71	(5.1') SILTY SAND (SM); fine to medium grained, with coal, some organics, very dense, gray (N3), moist, well-graded.		
5	SS	17/24	5 7 5 5	12	(7.0') LEAN CLAY (CL); stiff, moist, tan (5Y 7/2) with gray (N8) mottles.		
	SS	24/24	1 3 5 6	8	(8') As above: becomes medium stiff, orange (10YR 7/12) mottles.		
10	SS	24/24	2 5 8 6	13	(10') As above: becomes stiff, black inclusions, trace organics.		
	SS	23/24	2 4 5 7	9	(12') As above.		
	SS	24/24	2 5 6 8	11	(14') As above.		
15	SS	24/24	2 4 5 6	9	(16') As above.		
	SS	24/24	3 7 9 10	16	(18') LEAN SILT (ML); trace sand, stiff, moist, tan (5Y 7/2) with orange (10YR 7/12) and black mottling.		
20							

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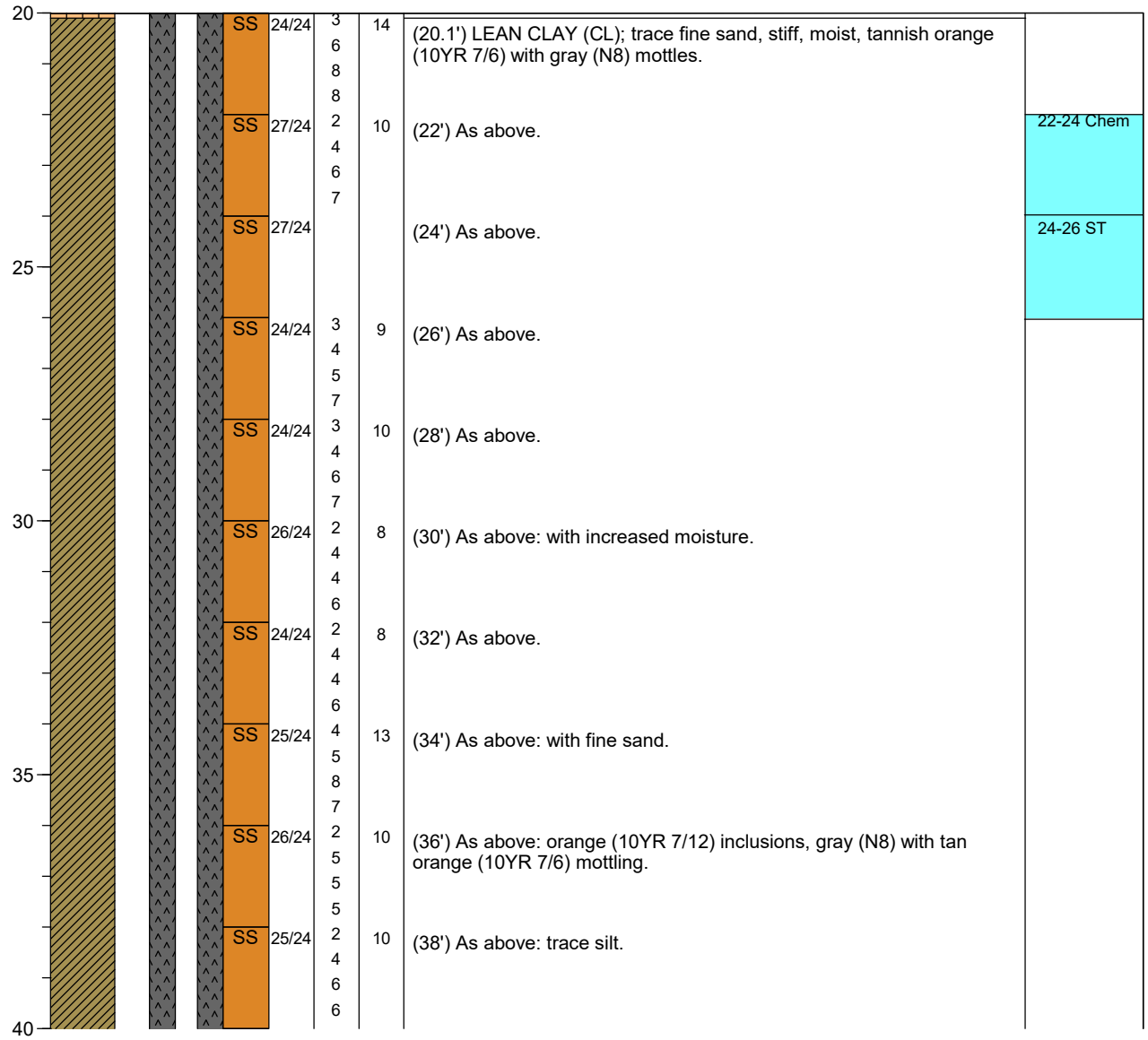
WELL LOG
Well No. G11
Page: 2 of 4

Drilling Start Date:	01/19/2021	Boring Depth (ft):	66	Well Depth (ft):	66
Drilling End Date:	01/19/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	45.66	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	366.88	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	363.38	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF & AT	Location (Lat/Long):	37.21436, -88.85636	Filter Pack:	Sand



NOTES: SBG11-(24-26)-20210119: 18.5% moisture content, 415 U mg/kg total organic carbon, 109.1 pcf dry unit weight, 2.688 specific gravity, 5.6×10^{-8} cm/s vertical hydraulic conductivity, 36 LL, 15 PL, 21 PI, 0.0% gravel, 11.5% sand, 88.5% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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WELL LOG
Well No. G11
Page: 3 of 4

Drilling Start Date:	01/19/2021	Boring Depth (ft):	66	Well Depth (ft):	66
Drilling End Date:	01/19/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	45.66	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	366.88	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	363.38	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF & AT	Location (Lat/Long):	37.21436, -88.85636	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				SS	25/24	2 3 4 4	7	(40') As above: becomes medium stiff.		
				SS	27/24	2 4 4 6	8	(42') LEAN CLAY (CL); orange (10YR 7/6) silty fine sand seams, medium stiff, moist, gray (N8).		
45		▼		SS	25/24	2 4 5 6	9	(44') As above: stiff.		
				SS	25/24	3 6 9 10	15	(46') As above: seams are silt only.		
				SS	24/24	3 4 5 8	9	(48') As above: no seams, trace orange (10YR 7/6) silt, increased moisture.		
50				SS	27/24	1 3 3 0	3	(50') As above: increased moisture.		
				SS	27/24	3 2 3 6	6	(52') As above: gray (N9) sand layer.		
				SS	27/24	3 8 26 26	34	(53.2') POORLY GRADED SAND (SP); fine to medium grained, trace silt, loose, gray (N9), wet. (54') As above: becomes dense, trace clay, trace orange (10YR 7/6) silt inclusions.		
55				SS	8/24			(56') As above.	56-58 Geotech	
				SS	24/24	7 14 16 13	30	(58') As above: trace gravel, no silt, some orange (10YR 7/6) fine to medium sand.	58-60 Chem	
60										

NOTES:
SBG11-(56-58)-20210119: 14.4% moisture content, 679 U mg/kg total organic carbon, 110.0 pcf dry unit weight, 2.661 specific gravity, 0.2% gravel, 87.7% sand, 12.1% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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WELL LOG
Well No. G11
Page: 4 of 4

Drilling Start Date:	**01/19/2021**	Boring Depth (ft):	**66**	Well Depth (ft):	**66**
Drilling End Date:	**01/19/2021**	Boring Diameter (in):	**7.5**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**45.66**	Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**366.88**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**363.38**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**ZJF & AT**	Location (Lat/Long):	**37.21436, -88.85636**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	20/24	6 14 15 16	29	(60') As above: increased orange sand.		
				SS	14/24	0 6 11 13	17	(62') WELL-GRADED SAND (SW); fine to medium grained, medium dense, wet, orangish tan (7.5YR 8/8) with some gray (N9) sand layers.		
				SS	18/24	2 10 15 11	25	(64') As above: with sandy gravel layer (~5" thick).		
65										
								(66') End of Boring.		
70										

NOTES:

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Project: GLP0821, Joppa Ash Pond
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WELL LOG
Well No. XPW01
Page: 1 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	24/24	5 4 3 4	7	(0') SILTY SANDY WELL-GRADED GRAVEL (GM); loose, wet, gray (N4). [BOTTOM ASH]		
				SS	19/24	3 3 4 3	7	(2') As above.		
5				SS	18/24	3 2 2 4	4	(4') As above.	4-6 Chem	
				SS	24/24			(6') As above.	6-8 Geotech	
				SS	15/24	4 4 3 2	7	(8') As above.		
10		▼		SS	18/24	1 1 1 1	2	(9.6') LEAN SILT (ML); some fine sand, very soft, wet, grayish brown (N4) with white speckling. [FLY ASH MIXTURE] (10') As above: trace organics.		
				SS	14/24	0 0 1 2	1	(12') As above: trace coarse sand.		
				SS	14/24	0 1 1 1	2	(14') As above: trace gravel.		
15				SS	4/24	1 1 1 1	2	(16') POORLY GRADED SAND (SP); fine grained, some silt, very loose, wet, grayish brown (N4) with black and orange speckles. [BOTTOM ASH]		
				SS	8/24	0 1 0 1	1	(18') As above.		
20										

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.
XPW01-(06-08)-20210120: 34.2% moisture content, 85.6 pcf dry unit weight, 2.711 specific gravity, 2.1×10^{-5} cm/s vertical hydraulic conductivity, 26.3% gravel, 45.4% sand, 58.3% fines.

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WELL LOG
Well No. XPW01
Page: 2 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	10/24	0 0 0	0	(20') As above.		
						1		(21.3') LEAN SILT (ML); very soft, wet, grayish brown (N4) with white and orange speckling. [FLY ASH MIXTURE]		
				SS	1/24	0 0 0 0 0	0	(22') As above: little fine sand, trace coal.		
				SS	24/24	0 0 0 0 0	0	(24') LEAN SILT (ML); very soft, wet, grayish brown (N4). [FLY ASH]		
25				SS	24/24	0 0 0 0 0	0	(26') As above.		
				SS	26/24	0 0 0 0 0	0	(28') As above.		
30				SS	26/24	0 0 0 0 0	0	(30') As above.		
				SS	26/24	0 0 0 0 0	0	(32') As above.		
35				SS	26/24	0 0 0 0 0	0	(34') As above.		
				SS	24/24	0 0 0 0 0	0	(36') As above.		
				SS	25/24	0 0 0 0 0	0	(38') As above.		
40										

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.

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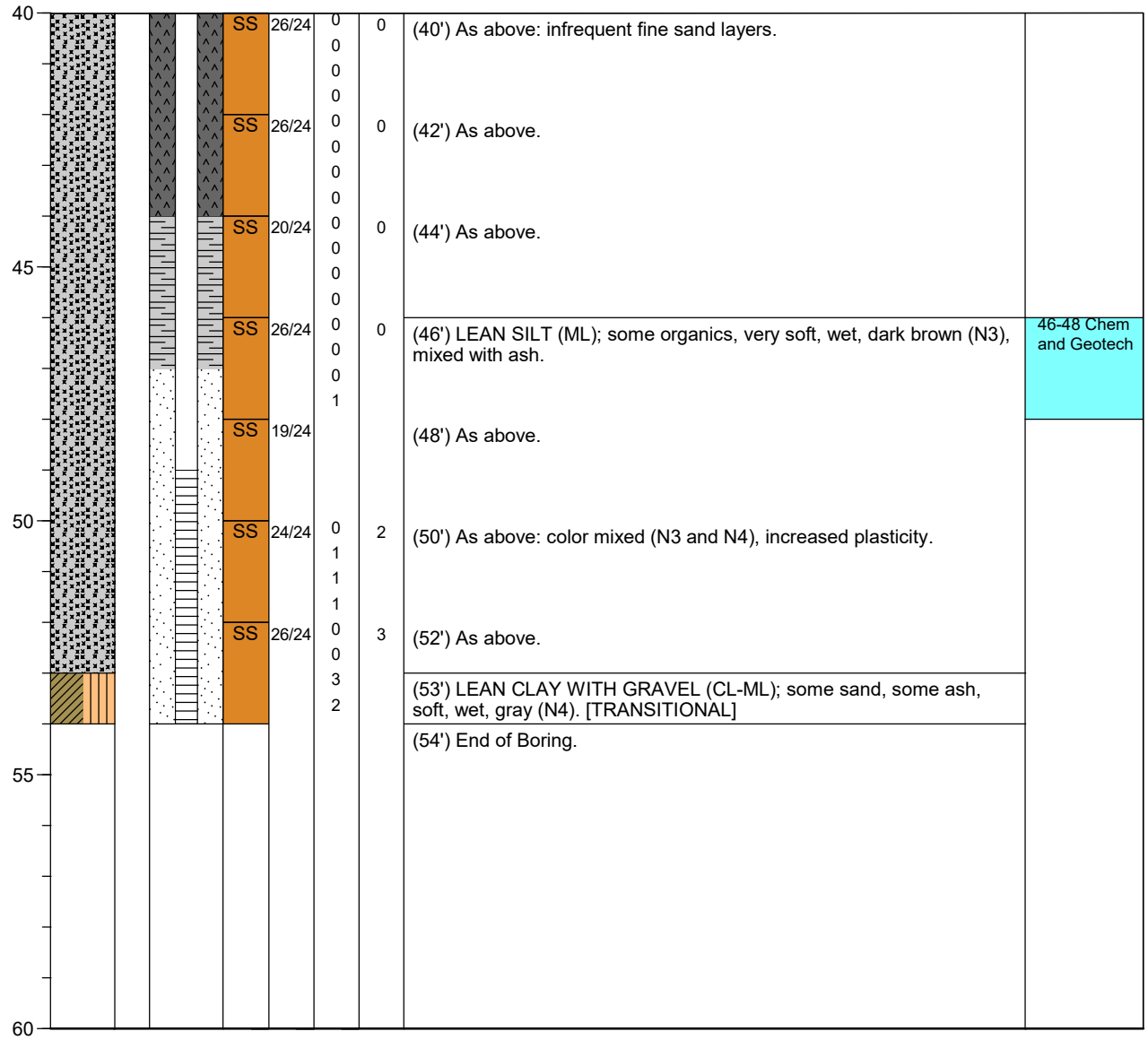
WELL LOG
Well No. XPW01
Page: 3 of 3

Drilling Start Date:	01/20/2021	Boring Depth (ft):	54	Well Depth (ft):	54
Drilling End Date:	01/20/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):	13.05	Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	383.82	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	380.75	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21702,-88.85187	Filter Pack:	Sand



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
	SS	26/24	0 0 0 0	0	(40') As above: infrequent fine sand layers.		
	SS	26/24	0 0 0 0	0	(42') As above.		
	SS	20/24	0 0 0 0	0	(44') As above.		
	SS	26/24	0 0 0 0	0	(46') LEAN SILT (ML); some organics, very soft, wet, dark brown (N3), mixed with ash.	46-48 Chem and Geotech	
	SS	19/24	1		(48') As above.		
	SS	24/24	0 1 1 1	2	(50') As above: color mixed (N3 and N4), increased plasticity.		
	SS	26/24	0 0 3 2	3	(52') As above.		
					(53') LEAN CLAY WITH GRAVEL (CL-ML); some sand, some ash, soft, wet, gray (N4). [TRANSITIONAL]		
					(54') End of Boring.		

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.
XPW01-(46-48)-20210120: 31.7% moisture content, 87.7 pcf dry unit weight, 2.675 specific gravity, 2.8×10^{-7} cm/s vertical hydraulic conductivity, 25 LL, 20 PL, 5 PI, 0.0% gravel, 18.7% sand, 81.3% fines.

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WELL LOG
Well No. XPW02
Page: 1 of 2

Drilling Start Date:	01/20/2021	Boring Depth (ft):	30	Well Depth (ft):	30
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	376.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	373.23	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21575, -88.85504	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				SS	24/24	4 17 44 22	61	(0') SANDY WELL-GRADED GRAVEL WITH SILT (GW); very dense, moist, gray (N4).		
				SS	22/24	3 9 6 7	15	(2') GRAVELLY LEAN SILT WITH SAND (ML); very soft, moist, gray (N4).		
5				SS	26/24	17 17 10 7	27	(4') As above: becomes wet.	4-6 Chem	
				SS	18/24	2 5 3 2	8	(6.2') SILTY SANDY GRAVEL (GM); loose, wet, gray (N4).		
				SS	14/24	2 1 1 1	2	(8.1') LEAN SILT WITH SAND (ML); some gravel, very soft, wet, gray (N4 to brown (10YR 3/1).		
10				SS	12/24	12 13 7 5	20	(10') As above: becomes very stiff, sandy, gravelly.		
				SS	10/24	2 5 3 2	8	(12') GRAVELLY WELL-GRADED SAND WITH SILT (ML); loose, wet, brown (10YR 3/1).		
				SS	10/24	1 2 2 2	4	(14') As above: with gravel, white speckles.		
15				SS	16/24	3 2 2 2	4	(16') As above: silty, trace coal.		
				SS	8/24	1 2 2 3	4	(18') As above: gravelly layer.		
20										

NOTES: Augers were washed out using water & tremie pipe.
Ash mixed with logged materials throughout boring

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WELL LOG
Well No. XPW02
Page: 2 of 2

Drilling Start Date:	01/20/2021	Boring Depth (ft):	30	Well Depth (ft):	30
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	376.53	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	373.23	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21575, -88.85504	Filter Pack:	Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value / RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				SS	20/24	3 7 10 9	17	(20') As above. (20.4') LEAN SILT (ML); with fine sand, very stiff, wet, gray to brown (N4 to 10YR 3/1) with white speckles.		
				SS	23/24			(22') As above.		
25				SS	24/24	2 5 8 8	13	(24') As above: becomes stiff, coal fragment layer.	24-26 Chem	
				SS	24/24	6 8 8 6	16	(26') As above: very stiff.		
30				SS	6/24	3 5 6 8	11	(27.8') LEAN CLAY (CL); some organics, soft, moist, tan (10YR 7/8 and gray (N8). (30') End of Boring.		
35										

NOTES: Augers were washed out using water & tremie pipe. Ash mixed with logged materials throughout boring
XPW02-(22-24)-20210120: 47.6% moisture content, 74.0 pcf dry unit weight, 2.567 specific gravity, 9.3% gravel, 74.1% sand, 16.6% fines.

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Project: GLP0821, Joppa Ash Pond
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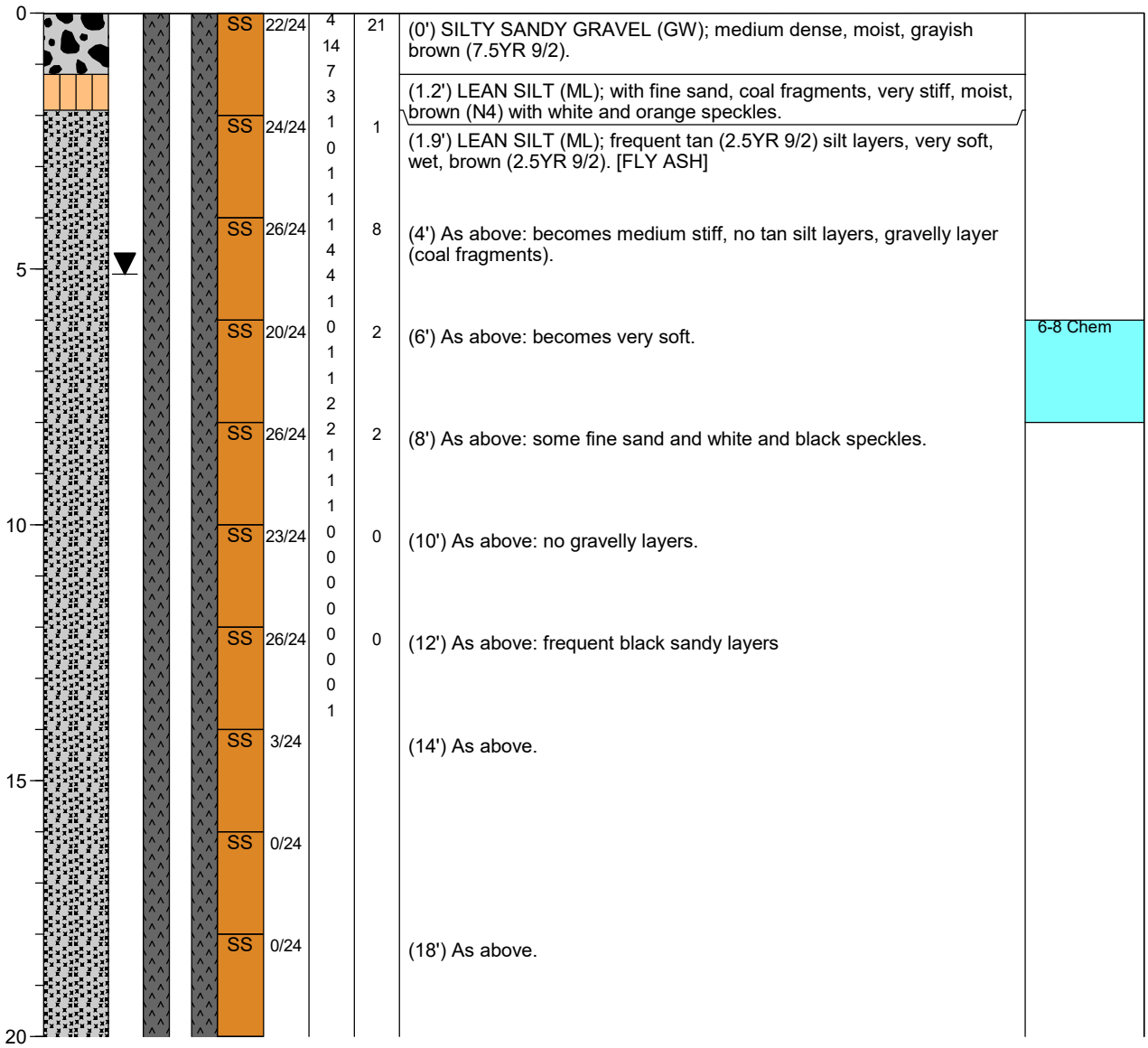
WELL LOG
Well No. XPW03
Page: 1 of 2

Drilling Start Date:	01/21/2021	Boring Depth (ft):	30	Well Depth (ft):	37
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	382.04	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	378.65	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21197, -88.85555	Filter Pack:	Sand



NOTES:

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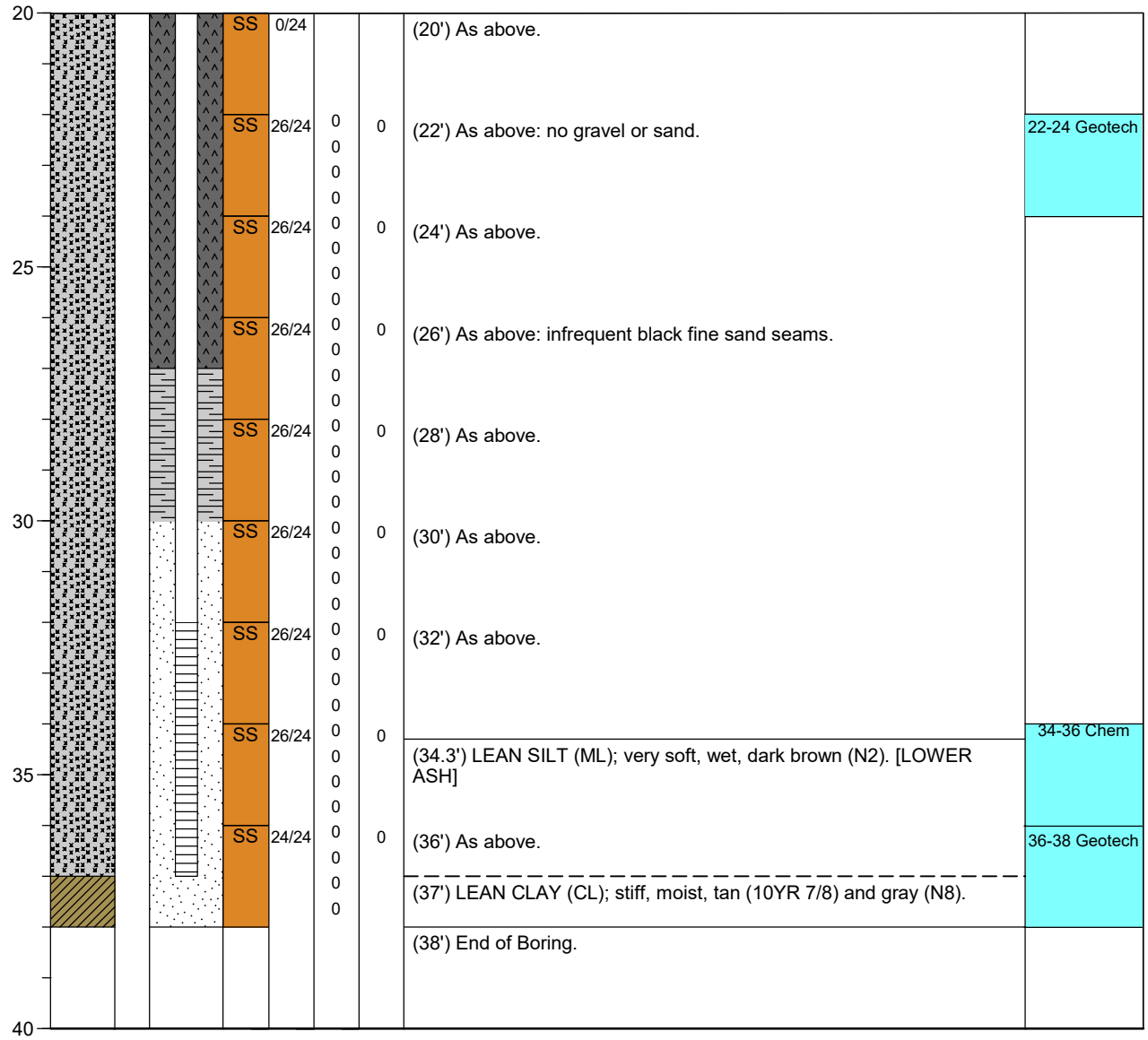
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. XPW03
Page: 2 of 2

Drilling Start Date:	01/21/2021	Boring Depth (ft):	30	Well Depth (ft):	37
Drilling End Date:	01/21/2021	Boring Diameter (in):	7.5	Well Diameter (in):	2
Drilling Company:	Geotechnology	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Hollow Stem Auger	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CME 55LC	Top of Casing Elev. (ft):	382.04	Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):	378.65	Seal Material(s):	Grout & Bentonite
Logged By:	ZJF	Location (Lat/Long):	37.21197, -88.85555	Filter Pack:	Sand



NOTES: XPW03-(22-24)-20210121: 45.4% moisture content, 2.410 specific gravity, 0.0% gravel, 4.2% sand, 95.8% fines.
XPW03-(36-38)-20210121: 46.5% moisture content, 65.7 pcf dry unit weight, 1.999 specific gravity, 1.8×10^{-7} cm/s vertical hydraulic conductivity, 46 LL, 31 PL, 15 PI, 0.0% gravel,9.4% sand, 90.6% fines.

Via email: akreinberg@geosyntec.com

March 29, 2021

Ms. Allison Kreinberg
Geosyntec Consultants, Inc.
941 Chatham Lane Suite 103
Columbus, Ohio 43221

Re: Laboratory Testing Services
Vistra Energy
Joppa, Illinois
Geotechnology Project No. J037936.01

Dear Ms. Kreinberg:

Provided herein are the laboratory test results for the referenced project. Our services were performed in accordance with ASTM procedures.

This report has been prepared for the exclusive use of Geosyntec Consultants, Inc. Our scope of services was limited to performing specific tests on the provided samples and did not include engineering or interpretation of the test results.

Our services shall not be construed to constitute an expressed or implied warranty, including, but not limited to, any warranty for merchantability or fitness for a particular use. We do not accept responsibility for the manner in which the test results are used.

It has been our pleasure to provide laboratory testing services to you, and we would welcome the opportunity to provide other services during the course of the project. Please contact us if you need further information or clarification about this document.

* * * * *

Yours very truly,
GEOTECHNOLOGY, INC.

Erin Grimes
Laboratory Manager

EKG/CKK:ekg

Attachments: Appendix A – Summary of Laboratory Results
Appendix B – Atterberg Limits Results
Appendix C – Grain Size Distribution
Appendix D – Test Report

Copies submitted: PDF

APPENDIX A

Summary of Laboratory Results

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Moisture Content (%)	Dry Unit Weight (pcf)	Qu/2 (tsf)	Specific Gravity (20°C)
G03	32.0	27	16	11	9.5	45.6	SC	15.5	113.0		2.659
G03	60.0				12.5	4.1	SP	20.0			2.671
G09M	16.0	39	16	23	2	95.0	CL	20.6	105.0		2.666
G09M	46.0	35	15	20	2	82.8	CL	19.8	106.0		2.715
G09M	84.0				9.5	1.9	SP	7.6	100.0		2.686
G09M	112.0				9.5	15.2		25.5	87.0		2.675
G11	24.0	36	15	21	2	88.5	CL	18.5	109.0		2.688
G11	56.0	NP	NP	NP	9.5	12.1	SM	14.4	110.0		2.661
XPW01	6.0	NP	NP	NP	25	28.3	SM	34.7	85.0		2.711
XPW01	48.0	25	20	5	2	81.3	CL-ML	31.7	88.0		2.675
XPW02	22.0	NP	NP	NP	12.5	16.6	SM	47.6	74.0		2.567
XPW03	22.0				2	95.8		45.4			2.410
XPW03	36.0	46	31	15	2	90.6	ML	46.5	66.0		1.999

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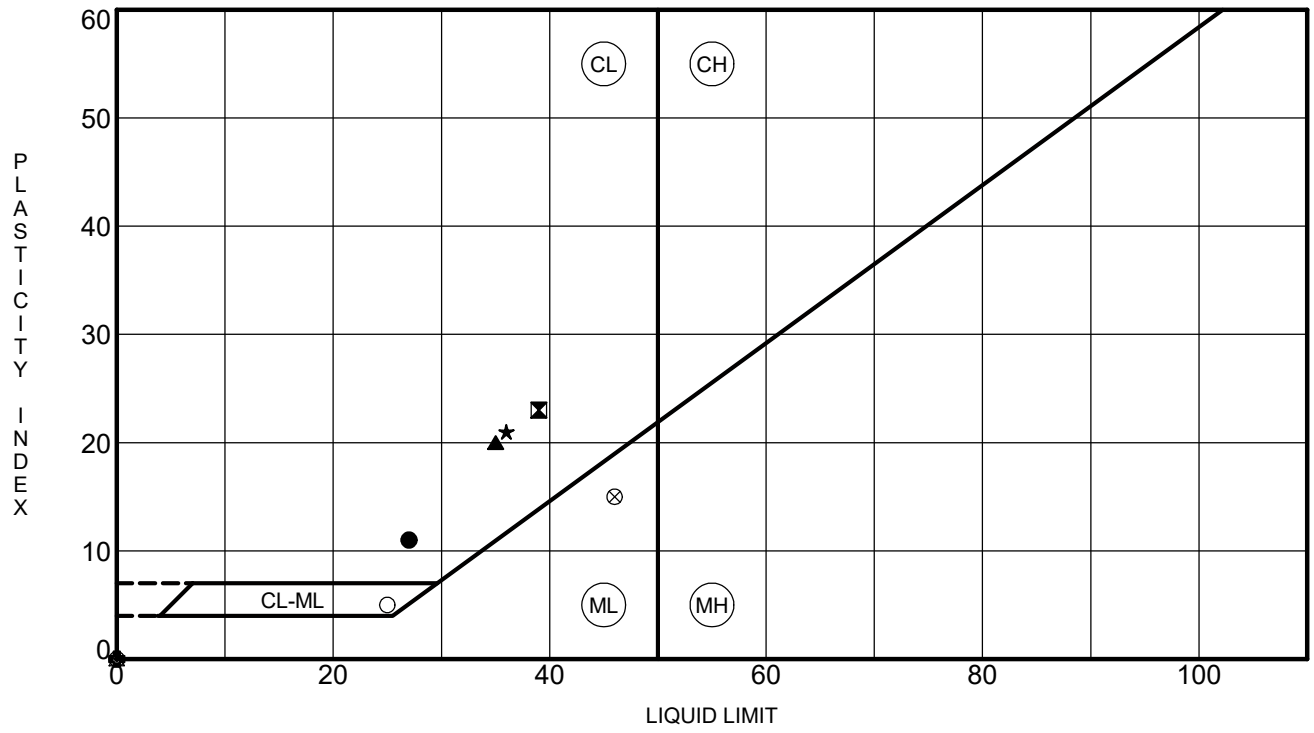
Summary of Laboratory Results

Vistra Energy
Joppa, Illinois
J037936.01

APPENDIX B

Atterberg Limits Results



	Boring	Depth (ft.)	LL	PL	PI	Fines	Sample Description
●	G03	32.0	27	16	11	46	CLAYEY SAND(SC)
⧓	G09M	16.0	39	16	23	95	LEAN CLAY(CL)
▲	G09M	46.0	35	15	20	83	LEAN CLAY with SAND(CL)
★	G11	24.0	36	15	21	89	LEAN CLAY(CL)
⊙	G11	56.0	NP	NP	NP	12	SILTY SAND(SM)
✿	XPW01	6.0	NP	NP	NP	28	SILTY SAND with GRAVEL(SM)
○	XPW01	48.0	25	20	5	81	SILTY CLAY with SAND(CL-ML)
△	XPW02	22.0	NP	NP	NP	17	SILTY SAND(SM)
⊗	XPW03	36.0	46	31	15	91	SILT(ML)

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ATTERBERG LIMITS RESULTS

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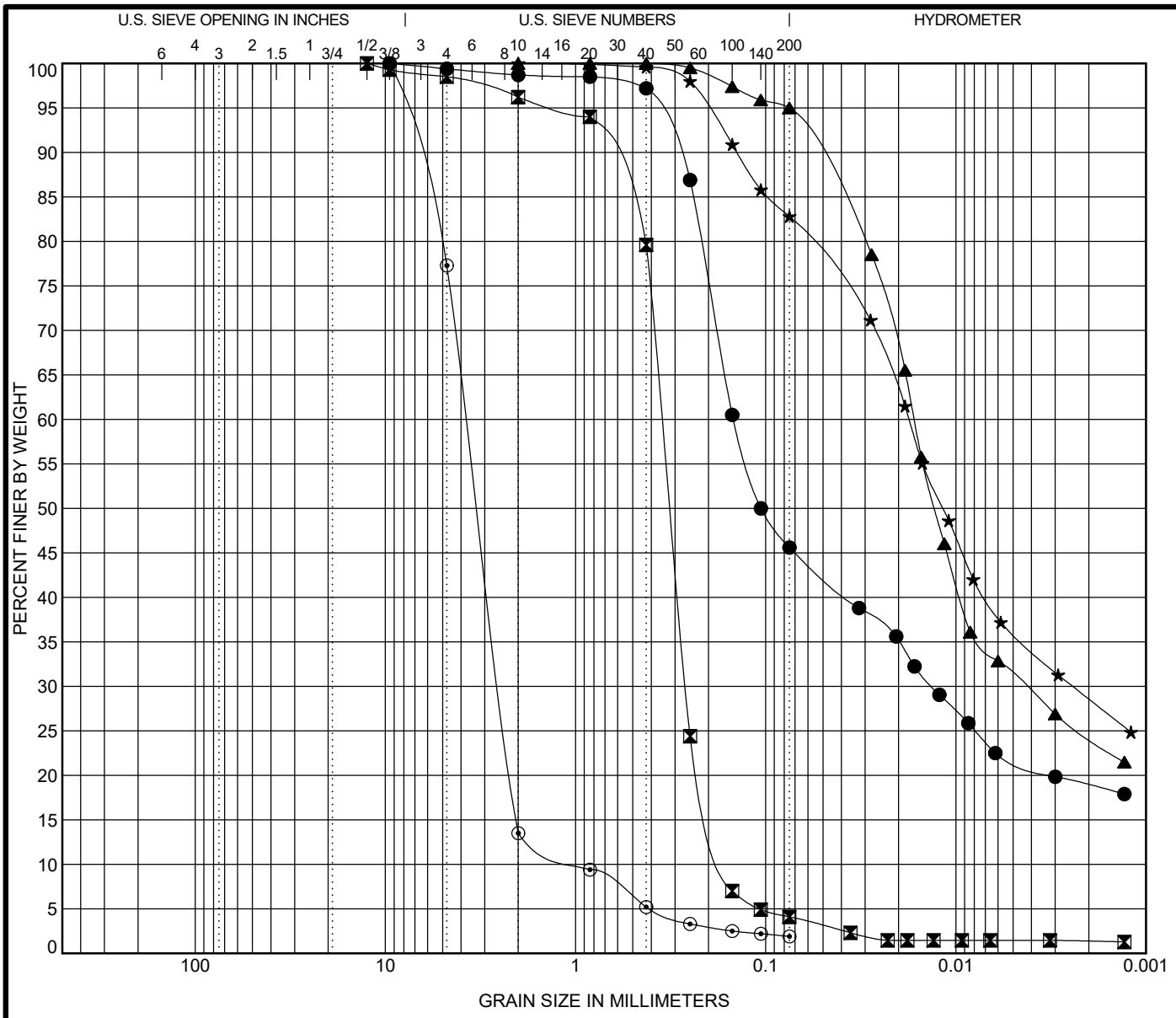
Joppa, Illinois
J037936.01

ATTERBERG LIMIT 2018 J037936.01 - VISTRA JOPPA.GPJ 00 CLONE ME.GPJ 3/25/21

APPENDIX C

Grain Size Distribution



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Depth (ft.)	Sample Description	LL	PL	PI	Cc	Cu
●	G03	32.0	CLAYEY SAND(SC)	27	16	11		
⊠	G03	60.0	POORLY GRADED SAND(SP)				1.21	2.15
▲	G09M	16.0	LEAN CLAY(CL)	39	16	23		
★	G09M	46.0	LEAN CLAY with SAND(CL)	35	15	20		
⊙	G09M	84.0	POORLY GRADED SAND with GRAVEL(SP)				1.75	3.94

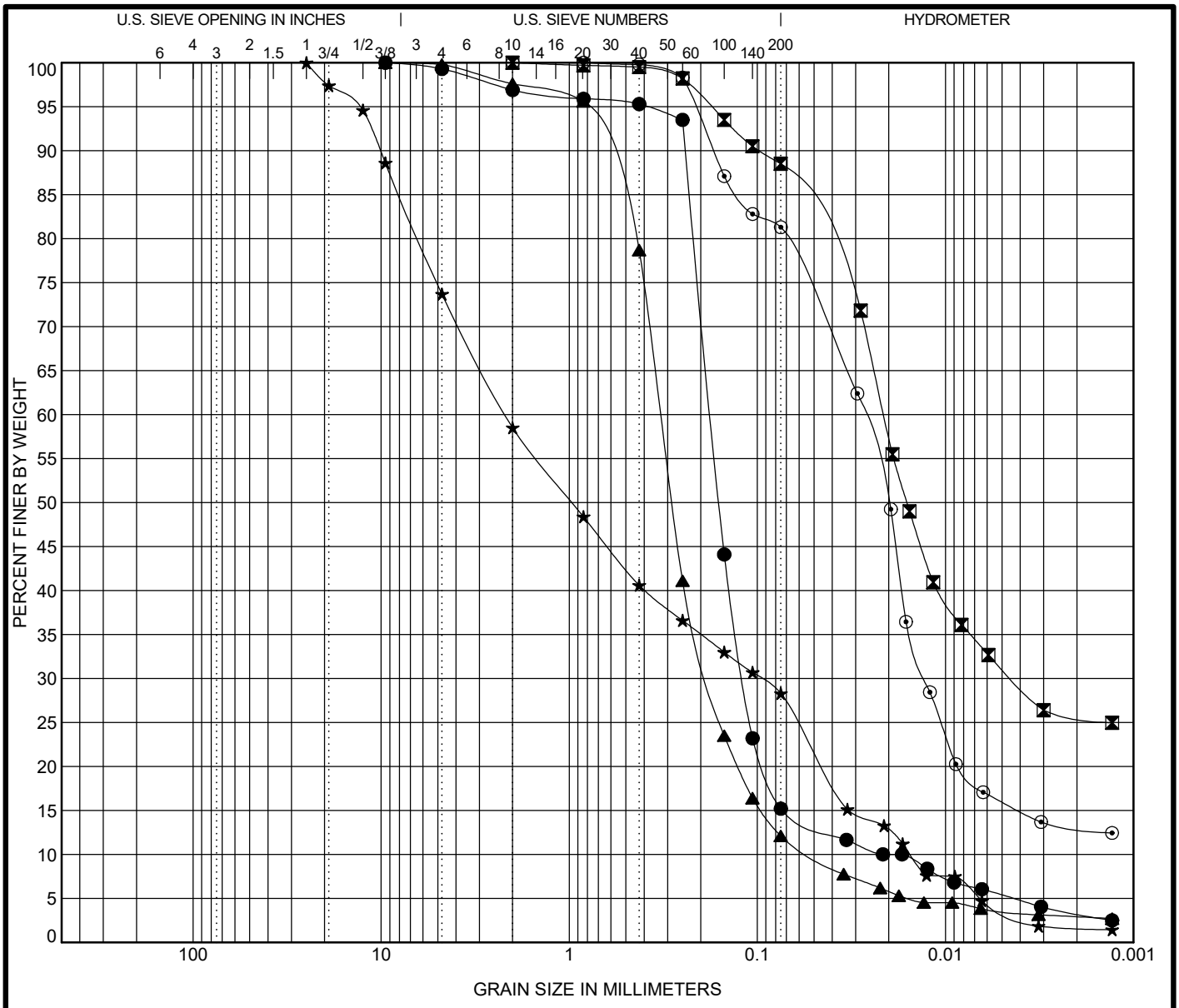
	Boring	Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	G03	32.0	9.5	0.15	0.01		0.6	53.8	23.9	21.7
⊠	G03	60.0	12.5	0.35	0.26	0.164	1.5	94.4	2.6	1.5
▲	G09M	16.0	2	0.02	0		0.0	5.0	63.7	31.3
★	G09M	46.0	2	0.02	0		0.0	17.2	46.9	35.9
⊙	G09M	84.0	9.5	3.76	2.5	0.954	22.7	75.4	1.9	

GEOTECHNOLOGY INC
FROM THE GROUND UP

GRAIN SIZE DISTRIBUTION

Vistra Energy
Joppa, Illinois
J037936.01

GRAIN SIZE 2018 J037936.01 - VISTRA JOPPA.GPJ 00 CLONE ME.GPJ 3/25/21



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Depth (ft.)	Sample Description	LL	PL	PI	Cc	Cu
●	G09M	112.0					4.69	10.42
⊠	G11	24.0	LEAN CLAY(CL)	36	15	21		
▲	G11	56.0	SILTY SAND(SM)	NP	NP	NP	1.94	6.30
★	XPW01	6.0	SILTY SAND with GRAVEL(SM)	NP	NP	NP	0.28	142.34
⊙	XPW01	48.0	SILTY CLAY with SAND(CL-ML)	25	20	5		

	Boring	Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	G09M	112.0	9.5	0.18	0.12	0.017	0.7	84.1	9.8	5.4
⊠	G11	24.0	2	0.02	0		0.0	11.5	57.4	31.1
▲	G11	56.0	9.5	0.33	0.18	0.052	0.2	87.7	8.5	3.6
★	XPW01	6.0	25	2.18	0.1	0.015	26.3	45.4	24.6	3.7
⊙	XPW01	48.0	2	0.03	0.01		0.0	18.7	65.3	16.0

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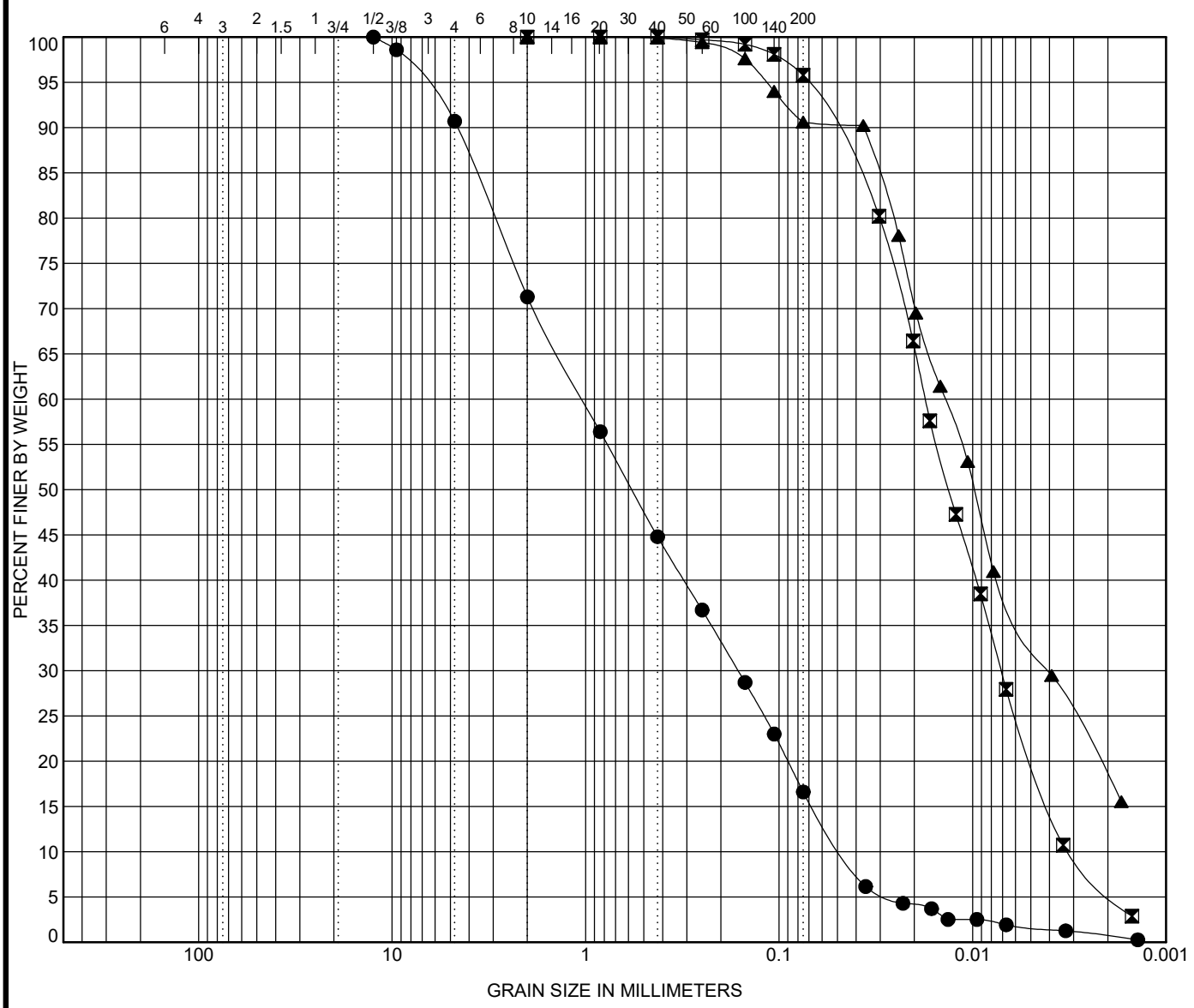

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Depth (ft.)	Sample Description	LL	PL	PI	Cc	Cu
●	XPW02	22.0	SILTY SAND(SM)	NP	NP	NP	0.55	22.08
⊠	XPW03	22.0					0.91	5.56
▲	XPW03	36.0	SILT(ML)	46	31	15		

	Boring	Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	XPW02	22.0	12.5	1.04	0.16	0.047	9.3	74.1	15.0	1.6
⊠	XPW03	22.0	2	0.02	0.01	0.003	0.0	4.2	75.3	20.5
▲	XPW03	36.0	2	0.01	0		0.0	9.4	57.0	33.6

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APPENDIX D

Test Report

Geotechnology, Inc.
11816 Lackland Road, Suite 150
St. Louis, MO 63146
314-997-7440

TEST REPORT

Prepared For:
Geosyntec Consultants, Inc.
941 Chatham Lane Suite 103
Columbus, Ohio 43221

Project No.:	**J037936.01**	**March 29, 2021**
Project Name:	**Vistra Energy - Joppa**	**Page 1 of 1**
Sampled By:	**Geotechnology, Inc.**	
Attention:	**Ms. Allison Kreinberg**	

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST & DENSITY DETERMINATION (UNIT WEIGHT) ASTM D5084 & D7263

Sample #	Moisture Content (%)	Initial Wet Density (pcf)	Initial Dry Density (pcf)	Hydraulic Conductivity (cm/s)
G03-(32-34)	15.5	130.2	112.7	4.7×10^{-7}
G09M-(16-18)	20.6	127.1	105.4	8.3×10^{-8}
G09M-(46-48)	19.8	126.6	105.7	3.5×10^{-7}
G11-(24-26)	18.5	129.4	109.1	5.6×10^{-8}
XPW01-(6-8)*	34.2	114.8	85.6	2.1×10^{-5}
XPW01-(48-50)	31.7	115.5	87.7	2.8×10^{-7}
XPW03-(36-38)	46.5	96.3	65.7	1.8×10^{-7}

* Remolded sample.

Geosyntec
consultants

ATTACHMENT C

Summary of 2022 Geosyntec Subsurface Characterization

EAST ASH POND
Joppa Power Plant, Illinois
Summary of All Lab Data
GLP8025

Geosyntec consultants

Boring ID	Sample No.	Test ID	Depth (ft)	In Situ Vertical Effective Stress (psf)	Water Content (%)	Material Type	USCS Symbol	Liquid Limit	Plastic Limit	Plasticity Index	Specific Gravity	% Passing No. 200	Total Unit Weight (pcf)	Test Type	Strain at Failure (%)	Consolidation Stress, σ'c (psf)	Su, UU (psf)	Normal Stress on Failure Plane at Filure, σ' (psf)	τff (psf)	Maximum Past Pressure (psf)	Consolidation Stress / In Situ Effective Stress	Accept /Reject for Undrained Strength Calculation	OCR
JOP-B001	ST-1C	1	5	654.4	21.1	E	CL						123.6	UU	4.2	NA	2105	NA	NA	NA	NA	NA	NA
	ST-4C	2	44.35	3048.9	14.5	F	SC	29	12	17	2.64	38.5	131.5	CIU	10.0	6000	NA	5989	3800	NA	2.0	Not OK	NA
JOP-B002	ST-2B	3	9.2	1166.9	24.3	F	CL						123	UU	7.5	NA	1195	NA	NA	NA	NA	NA	NA
	ST-3C	4	39.55	3409.4	21.4	F	CL	35	17	18	2.62	92.1	127.9	CIU	10.0	3000	4055	7224	4055	NA	0.9	OK	NA
JOP-B003	ST-2B	5	19.05	2493.1	16.2	E	CL					85.7	126.5	CIU	10.0	1500	2881	4594	2881	NA	0.6	OK	NA
	ST-2C	6	19.6	2565.1	14.7	E								LV	NA	NA	4700	NA	NA	NA	NA	NA	NA
JOP-B004	ST-4A	7	18.4	2408.1	15.8	E								LV	NA	NA	5200	NA	NA	NA	NA	NA	NA
	ST-4C	8	19.6	2565.1	16.6	E	CL	36	14	22		83.8	133.3	CIU	10.0	1500	2724	4421	2724	NA	0.6	OK	NA
	ST-10B	9	49.15	6432.4	15.7	E	CL						134.8	UU	10.0	NA	3500	NA	NA	NA	NA	NA	NA
	ST-10C	10	49.7	6504.4	16.2	E	CL	34	16	18		83.8	133.4	CIU	10.0	3000	6256	9464	6256	NA	0.5	OK	NA
	ST-12A	11	58.3	7629.9	19.9	E	CL	37	14	23		81.5	134.6	CIU	10.0	6000	1964	2636	1964	NA	0.8	OK	NA
	ST-14B	12	65.9	8507.3	22.7	A	CL-ML	25	19	6		80.4	123	CIU	10.0	5500	4377	6412	4377	NA	0.6	OK	NA
	ST-16C	13	70.1	8724.4	19.2	F	CL	32	16	16		93.1	131.1	CIU	7.6	12000	NA	18131	8044	NA	1.4	Not OK	NA
JOP-B005	ST-2A	14	8.3	1086.2	16.4	E	CL						130.5	UU	10.0	NA	2575	NA	NA	NA	NA	NA	NA
	ST-2B	15	9	1177.9	17.7	E	CL					96.1	127.5	CIU	10.0	1500	NA	2200	2569	NA	1.3	Not OK	NA
	ST-4B	16	19.15	2506.2	20.1	E	CL	37	21	16		95.3	129.1	CIU	10.0	3000	4912	10757	4912	NA	1.2	OK	NA
	ST-7A	17	33.3	4358.1	21.4	E	CL						124	UU	10.0	NA	2125	NA	NA	NA	NA	NA	NA
	ST-7B	18	33.6	4371.2	18.7	E	CL	38	19	19		97.5	129.6	CIU	10.0	6000	NA	14039	9071	NA	1.4	Not OK	NA
	ST-10A	19	433.6	5134.7	21	F								LV	NA	NA	4100	NA	NA	NA	NA	NA	NA
	ST-10C	20	44.7	5205.5	20.6	F	CL	39	14	25		81.2	129.4	CIU	10.0	6000	3811	6600	3811	NA	1.2	OK	NA
JOP-B007	ST-2C	21	10.05	1278.7	18.6	F	CL	36	16	20			127.9	Consolidation	NA	NA	NA	NA	NA	23000.0	NA	NA	18.0
	ST-2C	22	10.1	1285.0	20.6	F	CL						117	DSS	10.0	1500	1400	NA	NA	NA	1.2	OK	NA
	ST-3A	23	28.5	3618.8	16.8	F								LV	NA	NA	6700	NA	NA	NA	NA	NA	NA
	ST-3C	24	29.6	3758.3	18.7	F	CL	37	15	22		91	129.8	CIU	10.0	1500	3347	5599	3347	NA	0.4	OK	NA
JOP-B008	ST-2B	25	26.7	3494.3	18.8	E	CL	41	18	23		91.2	129.5	UU	10.0	NA	2650	NA	NA	NA	NA	NA	NA
	ST-3B	26	39.25	5041.6	21.3	F	CL						127.3	UU	10.0	NA	3000	NA	NA	NA	NA	NA	NA
	ST-3C	27	39.8	5077.0	20.6	F	CL					95.8	125.3	Consolidation	NA	NA	NA	NA	NA	21800.0	NA	NA	4.3
	ST-4B	28	43.9	5341.2	22.2	F	CL	42	16	26				LV	NA	NA	2600	NA	NA	NA	NA	NA	NA
	ST-5B	29	64.2	6649.2	17.6	F								LV	NA	NA	2400	NA	NA	NA	NA	NA	NA
	ST-5C	30	64.75	6684.6	19.3	F	CL					93.5	130.2	CIU	8.2	6000	3702	6262	3702	NA	0.9	OK	NA
	ST-6C	31	79.5	7635.0	15.1	F	SC-SM	21	15	6		36.2		LV	NA	NA	2900	NA	NA	NA	NA	NA	NA
JOP-B009	ST-3B	32	13.8	1806.0	16.9	E	CL						134.2	CIU	10.0	500	1786	2201	1786	NA	0.3	OK	NA
	ST-3C	33	14.35	1878.0	15.5	E	CL	34	14	20		76.5	134.9	CIU	10.0	1500	1987	3145	1987	NA	0.8	OK	NA
	ST-11C	34	49.3	4870.7	18.2	F	CL						128.6	UU	10.0	NA	3525	NA	NA	NA	NA	NA	NA
	ST-11D	35	49.85	4906.2	20.1	F	CL	37	15	22			127.9	DSS	10.0	6440	NA	NA	NA	NA	1.3	Not OK	NA
	ST-14B	36	64.2	5830.8	18.9	F	CL						128.3	UU	4.4	NA	3835	NA	NA	NA	NA	NA	NA
	ST-14C	37	64.85	5872.7	17.8	F	CL	27	10	17		69.1	130.6	CIU	5.2	12000	NA	9319	3958	NA	2.0	Not OK	NA
JOP-B010	ST-1C	38	1.4	177.6	20.2	F	CL	37	15	22			122.5	Consolidation	NA	NA	NA	NA	NA	11400.0	NA	NA	64.2
	ST-1D	39	1.65	209.3	19.8	F	CL						122.5	DS	1.2	500	NA	500	530	NA	NA	NA	NA
	ST-1E	40	1.9	241.0	18.1	F	CL						122.6	DS	4.0	1500	NA	1500	1100	NA	NA	NA	NA
	ST-1F	41	2.2	279.0	18	F	CL						124.8	DS	2.4	3000	NA	3000	2130	NA	NA	NA	NA
	ST-3B	42	34.35	4356.7	15.8	F	CL						120.3	DSS	10.0	3000	1280	NA	NA	NA	0.7	OK	NA
	ST-3C	43	34.8	4413.7	15.1	F	CL	27	11	16			130.5	Consolidation	NA	NA	NA	NA	NA	16200.0	NA	NA	3.7
	ST-3D	44	35.35	4483.5	16.7	F	CL					53.5	132.9	CIU	10.0	3000	2195	3456	2195	NA	0.7	OK	NA
JOP-B011	ST-5B	45	23.8	3114.8	17.8	E	CL						126.1	UU	8.2	NA	2760	NA	NA	NA	NA	NA	NA
	ST-5C	46	24.25	3173.7	18	E	CL	33	18	15		92.7	129.4	CIU	10.0	3000	5870	9037	5870	NA	0.9	OK	NA
	ST-9C	47	44.8	4879.8	18.3	F	CL	36	14	22		87.6	128.9	CIU	10.0	3000	2384	3638	2384	NA	0.6	OK	NA
	ST-14B	48	69.25	6455.1	16.8	F								LV	NA	NA	2200	NA	NA	NA	NA	NA	NA
	ST-14C	49	69.8	6490.6	16.4	F	SC	34	11	23		45.3	130.2	DSS	6.0	12000	NA	NA	NA	NA	1.8	Not OK	NA
JOP-B012	ST-3A	50	15.25	1995.8	16.7	E								LV	NA	NA	3100	NA	NA	NA	NA	NA	NA
	ST-3C	51	16.45	2152.9	17.4	E	CL	37	13	24		72.8	131.9	CIU	10.0	6000	NA	7449	4185	NA	2.8	Not OK	NA
	ST-8B	52	33.05	4155.9	28.8	F	CL						121	UU	10.0	NA	475	NA	NA	NA	NA	NA	NA
	ST-8C	53	33.6	4191.4	29.1	F	CL	40	19	21	2.653	98.2	120.8	CIU	10.0	1500	663	982	663	NA	0.4	OK	NA
	ST-13A	54	53.4	5467.1	16.8	F								LV	NA	NA	3500	NA	NA	NA	NA	NA	NA
	ST-13B	55	53.95	5502.6	17	F	CL	27	12	15		63.9	132.3	CIU	10.0	3000	2484	3668	2484	NA	0.5	OK	NA
	ST-13C	56	54.55	5541.2	17.4	F	CL						132	CIU	10.0	6000	2592	3949	2592	NA	1.1	OK	NA
	ST-16C	57	66.6	6317.6	20	F	CL	33	13	20		62.7	126.8	CIU	1.8	12000	NA	6543	3486	NA	1.9	Not OK	NA

EAST ASH POND
Joppa Power Plant, Illinois
Summary of All Lab Data
GLP8025

Geosyntec consultants

Boring ID	Sample No.	Test ID	Depth (ft)	In Situ Vertical Effective Stress (psf)	Water Content (%)	Material Type	USCS Symbol	Liquid Limit	Plastic Limit	Plasticity Index	Specific Gravity	% Passing No. 200	Total Unit Weight (pcf)	Test Type	Strain at Failure (%)	Consolidation Stress, σ'c (psf)	Su, UU (psf)	Normal Stress on Failure Plane at Filure, σ' (psf)	τff (psf)	Maximum Past Pressure (psf)	Consolidation Stress / In Situ Effective Stress	Accept /Reject for Undrained Strength Calculation	OCR
JOP-B014	ST-2B	58	9.75	827.5	20.7	F								LV	NA	NA	2100	NA	NA	NA	NA	NA	NA
	ST-2C	59	10.3	863.0	21.55	F	CL	33	20	13		91.8	126.8	DSS	10.0	1500	NA	NA	NA	NA	1.7	Not OK	NA
	ST-3A	60	33.5	2357.8	13.8	F	CL	26	11	15			135.1	Consolidation	NA	NA	NA	NA	NA	11200.0	NA	NA	4.8
	ST-3C	61	34.65	2431.9	16.1	F	SC					45.2	130.2	UU	6.2	NA	4305	NA	NA	NA	NA	NA	NA
	ST-4A	62	43.9	3027.9	17.6	F								LV	NA	NA	3400	NA	NA	NA	NA	NA	NA
	ST-4C	63	44.6	3073.0	16.7	F	CL	33	12	21		63.7	132.5	CIU	10.0	6000	NA	5740	3480	NA	2.0	Not OK	NA
JOP-B015	ST-1A	64	18.25	2388.4	17.4	E								LV		NA	4100	NA	NA	NA	NA	NA	NA
	ST-1A	65	18.8	2460.4	16.5	E	CL						132.2	UU	10.0	NA	3850	NA	NA	NA	NA	NA	NA
	ST-1C	66	19.35	2532.4	18.7	E	CL	38	17	21			128.4	CIU	10.0	3000	2484	3668	2484	NA	1.2	OK	NA
	ST-2B	67	41.7	5404.1	23.3	F	CL						122.7	CIU	10.0	3000	1985	3387	1985	NA	0.6	OK	NA
	ST-3B	68	46.75	5810.6	20.1	F								LV	NA	NA	1600	NA	NA	NA	NA	NA	NA
	ST-3C	69	47.3	5846.0	19.5	F	CL	31	15	16			128	CIU	10.0	1500	1731	2596	1731	NA	0.3	OK	NA
	ST-4B	70	69.25	7260.3	21.4	F	CL					91	124.7	CIU	6.6	7990	4179	7459	4179	NA	1.1	OK	NA
JOP-B016	ST-1B	71	4.25	555.2	25.2	F	CL	33	21	12			120.9	Consolidation	NA	NA	NA	NA	NA	11800.0	NA	NA	21.3
	ST-1C	72	4.8	625.0	26.6	F	CL					98.3	123.7	UU	3.6	NA	1085	NA	NA	NA	NA	NA	NA
	ST-3A	73	23.2	1897.9	23	F								LV	NA	NA	1100	NA	NA	NA	NA	NA	NA
	ST-3B	74	23.7	1930.1	19.5	F	CL	35	15	20	2.63	98.8	127.5	CIU	10.0	1500	3024	5187	3024	NA	0.8	OK	NA
	ST-3C	75	24.19	1961.7	19.1	F	CL						129.1	DS	1.6	3000	NA	3000	1940	NA	NA	NA	NA
	ST-3D	76	24.5	1981.6	17.6	F	CL						127.5	DS	8.8	6000	NA	6000	3670	NA	NA	NA	NA
	ST-3E	77	24.8	2001.0	18.2	F	CL						129.2	DS	10.0	12000	NA	12000	6750	NA	NA	NA	NA
	ST-4C	78	44.6	3276.7	18.1	F	CL	27	17	10			129.2	DSS	8.3	5970	NA	NA	NA	NA	1.8	Not OK	NA
JOP-B017	ST-2A	79	8.25	1014.7	22.5	F	CL	33	17	16			123	Consolidation	NA	NA	NA	NA	NA	3400.0	NA	NA	3.35
	ST-2B	80	8.85	1090.8	17.1	F	CL					67.1	129.6	CIU	10.0	2000	NA	1260	884	NA	1.8	Not OK	NA
	ST-3C	81	24.8	3113.8	21.3	F	CL	34	14	20		93.3	127.2	CIU	10.0	1500	1162	1962	1162	NA	0.5	OK	NA
	ST-4D	82	34.85	4388.5	21.2	F	CL	35	14	21		82.4	128.1	CIU	10.0	3000	3245	5322	3245	NA	0.7	OK	NA
JOP-B018	ST-3C	83	34.5	4515.1	15.6	E	CL	38	14	24			133.9	UU	6.3	NA	4475	NA	NA	NA	NA	NA	NA
JOP-B019	ST-2A	84	43.25	2413.8	41.8	A							109.6	DSS	10.0	3930	NA	NA	NA	NA	1.6	Not OK	NA
	ST-2B	85	43.8	2439.7	54.5	A	ML	-	35	NP		83.5	102.9	CIU	10.0	4000	NA	2037	1401	NA	1.6	Not OK	NA
JOP-B020	ST-1A	86	3.4	445.0	16.5	E	G							LV	NA	NA	6800	NA	NA	NA	NA	NA	NA
	ST-1B	87	3.95	516.9	15.8	E	CL	35	16	19			134.3	UU	4.3	NA	4790	NA	NA	NA	NA	NA	NA
	ST-2B	88	19.25	2519.3	15.3	E	CL					97.8	130	CIU	10.0	4500	NA	9743	5969	NA	1.8	Not OK	NA
	ST-4C	89	49.75	6510.9	13.3	E	CL	31	14	17	2.62		134	CIU	10.0	6000	5445	7597	5445	NA	0.9	OK	NA
	ST-5C	90	69.8	8782.8	18.2	F	CL					82.9	128.6	CIU	10.0	9000	6221	10675	6221	NA	1.0	OK	NA
JOP-B021	ST-1A	91	3.25	425.3	19.5	E								LV	NA	NA	2300	NA	NA	NA	NA	NA	NA
	ST-1B	92	3.75	490.8	16.6	E	CL						129.6	UU	10.0	NA	1750	NA	NA	NA	NA	NA	NA
	ST-1C	93	4.25	556.2	15	E	CL	39	13	26			131.5	CIU	10.0	1500	NA	4511	3483	NA	2.7	Not OK	NA
	ST-2A	94	13.55	1204.5	44.8	F	CL						106.9	UU	10.0	NA	245	NA	NA	NA	NA	NA	NA
	ST-2B	95	14.1	1239.9	25.1	F	CL						124.3	Consolidation	NA	NA	NA	NA	NA	9201.6	NA	NA	7.4
	ST-2C	96	14.6	1272.2	23.1	F	CL					99	125.4	CIU	10.0	2000	NA	2747	1701	NA	1.6	Not OK	NA
	ST-3B	97	34.1	2528.6	15	F	CL	22	13	9		62.2	127.6	CIU	10.0	3000	4320	5760	4320	NA	1.2	OK	NA
	ST-3C	98	34.65	2564.0	18.9	F	CL							LV	NA	NA	3000	NA	NA	NA	NA	NA	NA
JOP-B022	ST-2A	99	8.3	1058.8	20.8	F	CL							Consolidation	NA	NA	NA	NA	NA	20203.2	NA	NA	19.1
	ST-2B	100	8.85	1128.5	21.3	F	CL						128.3	UU	6.2	NA	2225	NA	NA	NA	NA	NA	NA
	ST-2C	101	9.4	1198.3	21.4	F		35	18	17		93.7	128.2	CIU	10.0	500	2057	2980	2057	NA	0.4	OK	NA
	ST-3B	102	23.9	2887.6	19.3	F	CL						129.1	UU	10.0	NA	1700	NA	NA	NA	NA	NA	NA
	ST-3C	103	24.5	2926.2	19.5	F	CL	38	14	24		92.4	130.6	CIU	10.0	1500	2620	4143	2620	NA	0.5	OK	NA
	ST-4B	104	38.8	3847.6	18	F	CL	23	14	9		71	131.8	UU	10.0	NA	2050	NA	NA	NA	NA	NA	NA
JOP-B023	ST-1B	105	43.7	2871.8	27.1	A	CL	32	22	10		93	123.2	CIU	10.0	1000	751	968	751	NA	0.3	OK	NA
	ST-2A	106	48.45	3095.7	20.9	A	CL						129.6	UU	10.0	NA	2025	NA	NA	NA	NA	NA	NA
	ST-2B	107	49	3121.7	18.1	F	CL	35	14	21		74	132.1	CIU	10.0	8000	NA	8100	4677	NA	2.6	Not OK	NA

Notes:

1- Letters used in the "Material Type" coloumn are defined as follows: "A"= CCR (Ash); "E"=Embankment Fill; "F"=Foundation Clay.

2- Abbreviations used in the "Test Type" coloumn are defined as follows: "UU"=Triaxial Unconsolidated Undrained Test; "CU"=Triaxial Consolidated Undrained Test; "DS"=Direct Shear Test; "DSS"= Direct Simple Shear Test; "LV"=Laboratory Shear Vane Test.

3- Other abreviations used in this spreadsheet are defined as follows: "OK"= Can be used for undrained shear strength assessment; "Not OK"=Cannot be used for undrained shear strength assessment; "NA"= Not applicaple.

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ATTACHMENT D

3D Settlement Analysis

Settle3 Analysis Information
Joppa Closure Design_Region A

Project Settings

Document Name	JOP_Closure Design_Region A_PK_042222
Project Title	Joppa Closure Design_Region A
Author	Pourya Kargar
Company	Gesosyntec Consultants Inc.
Date Created	4/22/2022, 9:53:14 AM
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	years
Permeability Units	feet/minute
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [years]
1	Stage 1	0
2	3 Months	0.25
3	Drawdown	0.5
4	Final	10

Results

Time taken to compute: 0 seconds

Stage: Stage 1 = 0 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Loading Stress XX [ksf]	0	0
Loading Stress YY [ksf]	0	0
Effective Stress ZZ [ksf]	0	4.69364
Effective Stress XX [ksf]	0	4.69364
Effective Stress YY [ksf]	0	4.69364
Total Stress ZZ [ksf]	0	9.80838
Total Stress XX [ksf]	0	9.80838
Total Stress YY [ksf]	0	9.80838
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0	5.12456
Excess Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	3.14415e-05	15.9504
Over-consolidation Ratio	1	3.4
Void Ratio	0	0.59
Permeability [ft/min]	0	7.67675e-07
Coefficient of Consolidation [ft^2/min]	0	0.0032
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0

Stage: 3 Months = 0.25 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	1.65492
Loading Stress XX [ksf]	-1.41913	1.4427
Loading Stress YY [ksf]	-0.511246	1.99802
Effective Stress ZZ [ksf]	0	4.69364
Effective Stress XX [ksf]	-1.39124	5.30762
Effective Stress YY [ksf]	-0.511246	5.22457
Total Stress ZZ [ksf]	0	11.1052
Total Stress XX [ksf]	-0.944671	11.7754
Total Stress YY [ksf]	-0.490665	11.7071
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0	6.5065
Excess Pore Water Pressure [ksf]	0	1.65492
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	3.96143e-05	15.9504
Over-consolidation Ratio	1	3.4
Void Ratio	0	0.59
Permeability [ft/min]	0	7.67675e-07
Coefficient of Consolidation [ft^2/min]	0	0.0032
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	-3.33067e-16	0.0212521

Stage: Drawdown = 0.5 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.577338
Total Consolidation Settlement [in]	0	0.577338
Virgin Consolidation Settlement [in]	0	0.00095053
Recompression Consolidation Settlement [in]	0	0.576387
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	3.97932
Loading Stress XX [ksf]	-3.41235	3.46903
Loading Stress YY [ksf]	-1.22931	4.80433
Effective Stress ZZ [ksf]	0	6.15097
Effective Stress XX [ksf]	-2.97097	8.20459
Effective Stress YY [ksf]	-1.2293	7.89177
Total Stress ZZ [ksf]	0	13.3001
Total Stress XX [ksf]	-2.35712	15.1901
Total Stress YY [ksf]	-1.20871	15.013
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	431.582
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	431.582
Total Strain	0	0.00287434
Pore Water Pressure [ksf]	0	7.1514
Excess Pore Water Pressure [ksf]	0	2.4709
Degree of Consolidation [%]	0	54.124
Pre-consolidation Stress [ksf]	3.96143e-05	15.9504
Over-consolidation Ratio	1	3.39998
Void Ratio	0	0.59
Permeability [ft/min]	0	1.19357e-06
Coefficient of Consolidation [ft^2/min]	0	0.0032
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.100518

Stage: Final = 10 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	2.84137
Total Consolidation Settlement [in]	0	2.84137
Virgin Consolidation Settlement [in]	0	1.77297
Recompression Consolidation Settlement [in]	0	1.06841
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	3.97932
Loading Stress XX [ksf]	-3.41235	3.46903
Loading Stress YY [ksf]	-1.22931	4.80433
Effective Stress ZZ [ksf]	0	8.41124
Effective Stress XX [ksf]	-2.39019	10.5225
Effective Stress YY [ksf]	-1.22928	10.2009
Total Stress ZZ [ksf]	0	13.3001
Total Stress XX [ksf]	-2.35712	15.1901
Total Stress YY [ksf]	-1.20871	15.013
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	212.541
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	212.541
Total Strain	0	0.0298948
Pore Water Pressure [ksf]	0	5.12456
Excess Pore Water Pressure [ksf]	-1.53411e-06	2.87946e-06
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	3.96143e-05	15.9504
Over-consolidation Ratio	1	3.39995
Void Ratio	0	0.59
Permeability [ft/min]	0	1.56825e-06
Coefficient of Consolidation [ft^2/min]	0	0.0032
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.245652

Loads

1. Fill Load: "Compacted CCR"

Label	Compacted CCR
Load Type	Flexible
Area of Load	1.44068e+06 ft^2
Load	1.65492 ksf
Depth	-380.377 ft
Installation Stage	3 Months = 0.25 y

Coordinates

X [ft]	Y [ft]
831717	198953
832465	198669
833103	200353
832354	200636

2. Fill Load: "GW Drawdown Equivalent Loading"

Label	GW Drawdown Equivalent Loading
Load Type	Flexible
Area of Load	1.44068e+06 ft^2
Load	2.3244 ksf
Depth	-380.377 ft
Installation Stage	Drawdown = 0.5 y

Coordinates

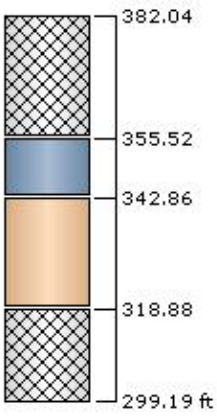
X [ft]	Y [ft]
831717	198953
832465	198669
833103	200353
832354	200636

Soil Layers

Ground Surface Drained: Yes

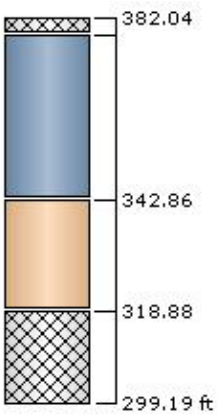
Borehole 1: (831717, 198953)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	12.669	-355.524	No
2	Foundation Clay	23.973	-342.855	Yes



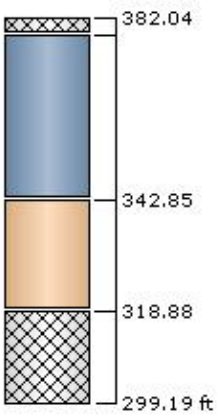
Borehole 2: (831904, 198882)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	35.522	-378.377	No
2	Foundation Clay	23.973	-342.855	Yes



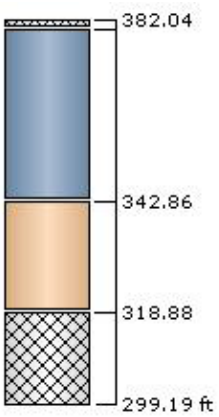
Borehole 3: (832091, 198811)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	35.439	-378.294	No
2	Foundation Clay	23.973	-342.855	Yes



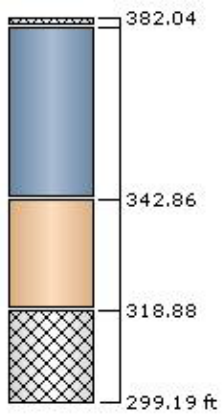
Borehole 4: (832278, 198740)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	37.145	-380	No
2	Foundation Clay	23.973	-342.855	Yes



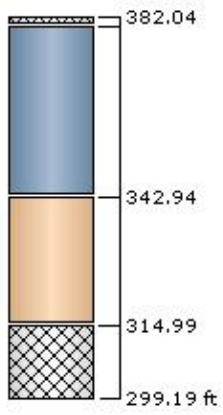
Borehole 5: (832465, 198669)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	37.145	-380	No
2	Foundation Clay	23.973	-342.855	Yes



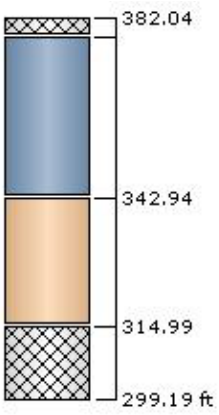
Borehole 6: (831823, 199233)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	36.908	-379.849	No
2	Foundation Clay	27.949	-342.941	Yes



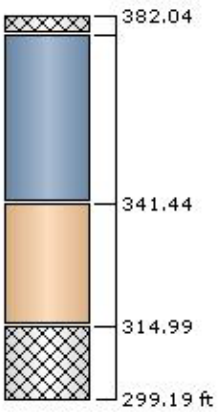
Borehole 7: (832010, 199162)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	34.953	-377.894	No
2	Foundation Clay	27.949	-342.941	Yes



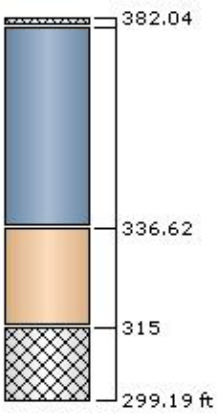
Borehole 8: (832197, 199092)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	36.562	-378	No
2	Foundation Clay	26.447	-341.438	Yes



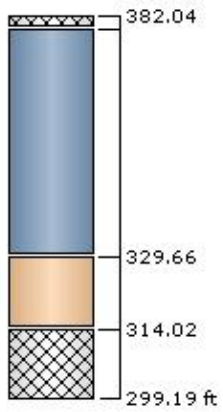
Borehole 9: (832384, 199021)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	43.321	-379.943	No
2	Foundation Clay	21.622	-336.622	Yes



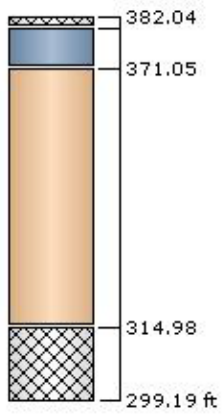
Borehole 10: (832571, 198950)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	49.351	-379.01	No
2	Foundation Clay	15.642	-329.659	Yes



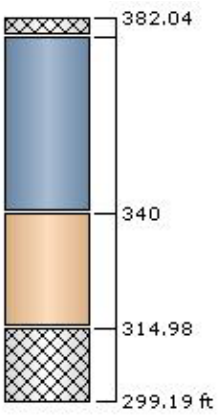
Borehole 11: (831929, 199514)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	8.649	-379.696	No
2	Foundation Clay	56.065	-371.047	Yes



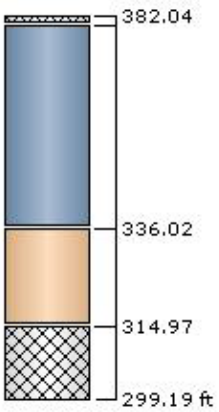
Borehole 12: (832117, 199443)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	38.007	-378.006	No
2	Foundation Clay	25.017	-339.999	Yes



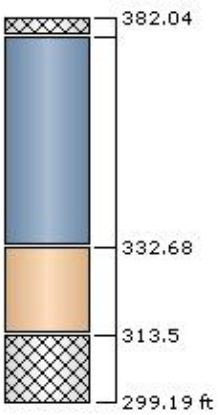
Borehole 13: (832304, 199372)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	43.978	-380	No
2	Foundation Clay	21.051	-336.022	Yes



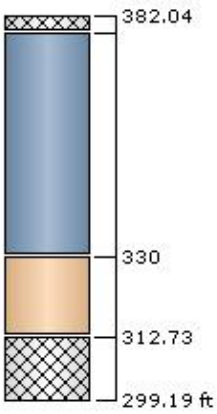
Borehole 14: (832491, 199301)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	45.426	-378.102	No
2	Foundation Clay	19.174	-332.676	Yes



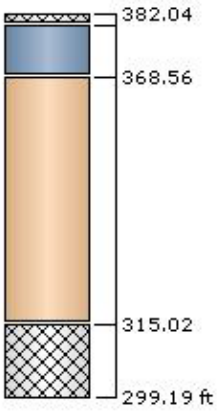
Borehole 15: (832678, 199231)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	48.456	-378.455	No
2	Foundation Clay	17.268	-329.999	Yes



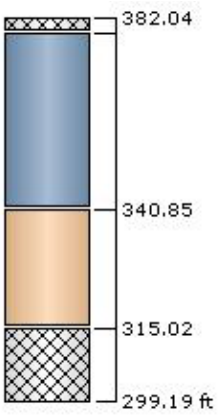
Borehole 16: (832036, 199794)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	11.188	-379.746	No
2	Foundation Clay	53.538	-368.558	Yes



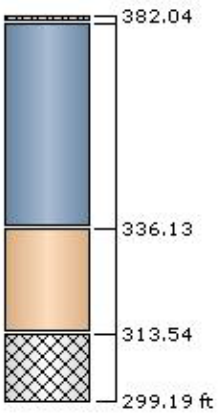
Borehole 17: (832223, 199724)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	38.072	-378.92	No
2	Foundation Clay	25.828	-340.848	Yes



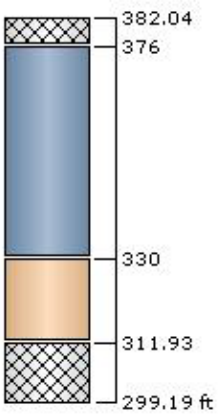
Borehole 18: (832410, 199653)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	44.251	-380.378	No
2	Foundation Clay	22.585	-336.127	Yes



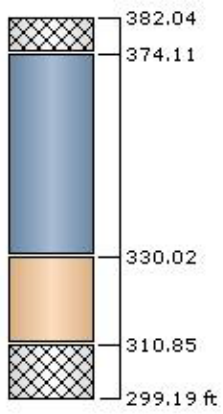
Borehole 19: (832597, 199582)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	45.997	-375.997	No
2	Foundation Clay	18.069	-330	Yes



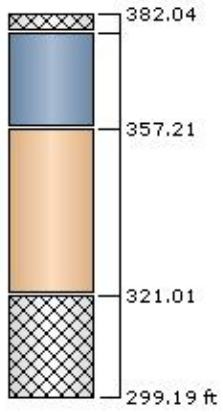
Borehole 20: (832784, 199511)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	44.09	-374.114	No
2	Foundation Clay	19.174	-330.024	Yes



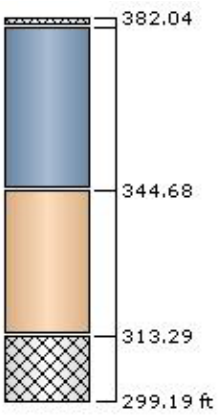
Borehole 21: (832142, 200075)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	20.794	-378	No
2	Foundation Clay	36.192	-357.206	Yes



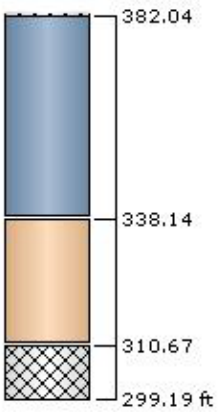
Borehole 22: (832329, 200004)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	35.325	-380	No
2	Foundation Clay	31.381	-344.675	Yes



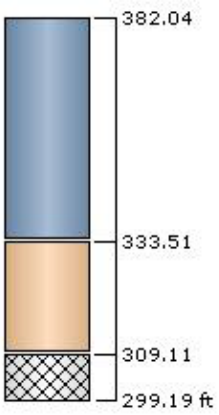
Borehole 23: (832516, 199933)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	43.773	-381.917	No
2	Foundation Clay	27.475	-338.144	Yes



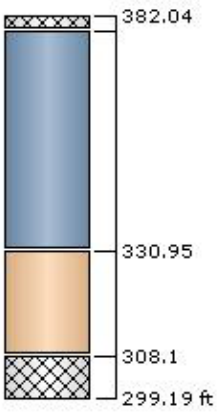
Borehole 24: (832703, 199862)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	48.532	-382.044	No
2	Foundation Clay	24.401	-333.512	Yes



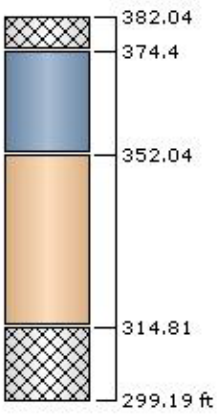
Borehole 25: (832890, 199792)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	47.831	-378.779	No
2	Foundation Clay	22.843	-330.948	Yes



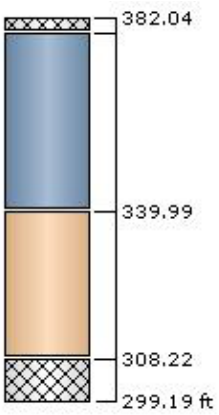
Borehole 26: (832248, 200355)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	22.365	-374.401	No
2	Foundation Clay	37.223	-352.036	Yes



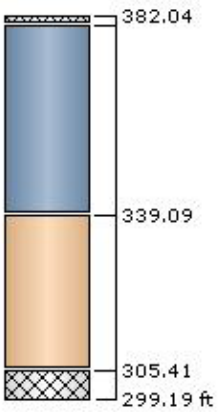
Borehole 27: (832435, 200285)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	38.615	-378.604	No
2	Foundation Clay	31.772	-339.989	Yes



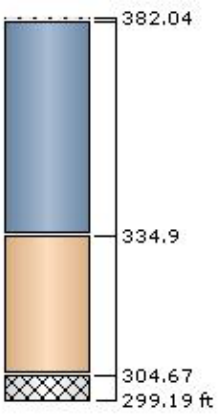
Borehole 28: (832622, 200213)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	40.907	-380	No
2	Foundation Clay	33.679	-339.093	Yes



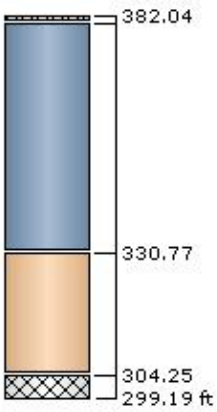
Borehole 29: (832809, 200143)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	46.238	-381.135	No
2	Foundation Clay	30.224	-334.897	Yes



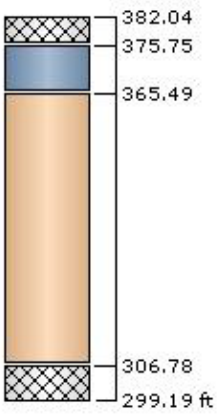
Borehole 30: (832996, 200072)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	49.543	-380.316	No
2	Foundation Clay	26.527	-330.773	Yes



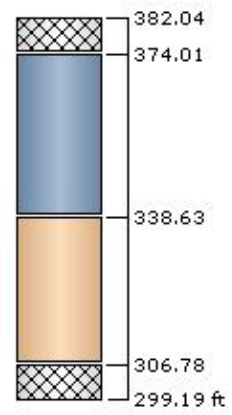
Borehole 31: (832354, 200636)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	10.263	-375.754	No
2	Foundation Clay	58.708	-365.491	Yes



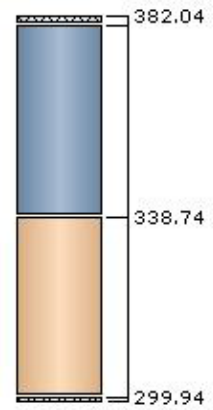
Borehole 32: (832541, 200565)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	35.379	-374.012	No
2	Foundation Clay	31.85	-338.633	Yes



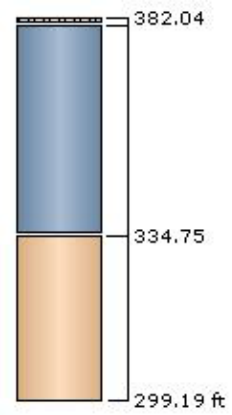
Borehole 33: (832729, 200494)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	41.239	-379.98	No
2	Foundation Clay	38.803	-338.741	Yes



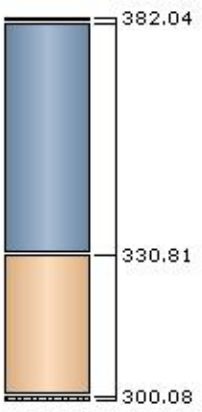
Borehole 34: (832916, 200424)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	45.665	-380.417	No
2	Foundation Clay	35.563	-334.752	Yes



Borehole 35: (833103, 200353)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	50.096	-380.907	No
2	Foundation Clay	30.732	-330.811	Yes



Soil Properties

Property	CCR	Foundation Clay
Color		
Unit Weight [kips/ft^3]	0.115	0.127
Saturated Unit Weight [kips/ft^3]	0.115	0.127
K0	1	1
Primary Consolidation	Disabled	Enabled
Material Type		Non-Linear
Cc	-	0.143
Cr	-	0.007
e0	-	0.59
OCR	-	3.4
Cv [ft^2/min]	-	0.00032
Cvr [ft^2/min]	-	0.0032
B-bar	-	1
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Grid Name	Default Grid	Default Grid

Groundwater

Groundwater method	Grids
Water Unit Weight	0.0624 kips/ft^3

Groundwater Grid: Default Grid

X	Y	Depth (ft)
831717	198953	-355.524
831904	198882	-378.377
832091	198811	-378.294
832278	198740	-380
832465	198669	-380
831823	199233	-379.849
832010	199162	-377.894
832197	199092	-378
832384	199021	-379.943
832571	198950	-379.01
831929	199514	-379.696
832117	199443	-378.006
832304	199372	-380
832491	199301	-378.102
832678	199231	-378.455
832036	199794	-379.746
832223	199724	-378.92
832410	199653	-380.378
832597	199582	-375.997
832784	199511	-374.114
832142	200075	-378
832329	200004	-380
832516	199933	-381.917
832703	199862	-382.044
832890	199792	-378.779
832248	200355	-374.401
832435	200285	-378.604
832622	200213	-380
832809	200143	-381.135
832996	200072	-380.316
832354	200636	-375.754
832541	200565	-374.012
832729	200494	-379.98
832916	200424	-380.417
833103	200353	-380.907

Groundwater Grid: Grid 2

X	Y	Depth (ft)
831717	198953	-350.524
831904	198882	-373.377
832091	198811	-373.294
832278	198740	-375
832465	198669	-375
831823	199233	-374.849
832010	199162	-372.894
832197	199092	-373
832384	199021	-374.943
832571	198950	-374.01
831929	199514	-374.696
832117	199443	-373.006
832304	199372	-375
832491	199301	-373.102
832678	199231	-373.455
832036	199794	-374.746
832223	199724	-373.92
832410	199653	-375.378
832597	199582	-370.997
832784	199511	-369.114
832142	200075	-373
832329	200004	-375
832516	199933	-376.917
832703	199862	-377.044
832890	199792	-373.779
832248	200355	-369.401
832435	200285	-373.604
832622	200213	-375
832809	200143	-376.135
832996	200072	-375.316
832354	200636	-370.754
832541	200565	-369.012
832729	200494	-374.98
832916	200424	-375.417
833103	200353	-375.907

Field Point Grid

Number of points 601
Expansion Factor 1

Grid Coordinates

X [ft]	Y [ft]
834086	201619
834086	197686
830734	197686
830734	201619

Settle3 Analysis Information
Joppa Closure Design_Region B

Project Settings

Document Name	JOP_Closure Design_Region B_PK_042222
Project Title	Joppa Closure Design_Region B
Author	Pourya Kargar
Company	Gesosyntec Consultants Inc.
Date Created	4/22/2022, 9:53:14 AM
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	years
Permeability Units	feet/minute
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [years]
1	Stage 1	0
2	3 Months	0.25
3	Drawdown	0.5
4	Final	5

Results

Time taken to compute: 0 seconds

Stage: Stage 1 = 0 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Loading Stress XX [ksf]	0	0
Loading Stress YY [ksf]	0	0
Effective Stress ZZ [ksf]	0	4.91246
Effective Stress XX [ksf]	0	4.91246
Effective Stress YY [ksf]	0	4.91246
Total Stress ZZ [ksf]	0	10.3335
Total Stress XX [ksf]	0	10.3335
Total Stress YY [ksf]	0	10.3335
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0	6.30567
Excess Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	3.71713e-05	16.694
Over-consolidation Ratio	1	3.4
Void Ratio	0	0.59
Permeability [ft/min]	0	4.99766e-06
Coefficient of Consolidation [ft^2/min]	0	0.0032
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0

Stage: 3 Months = 0.25 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.000927278
Total Consolidation Settlement [in]	0	0.000927278
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0.000927278
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	2.23366
Loading Stress XX [ksf]	-1.34828	3.70814
Loading Stress YY [ksf]	-3.05753	2.52095
Effective Stress ZZ [ksf]	0	4.91246
Effective Stress XX [ksf]	-1.17743	6.02884
Effective Stress YY [ksf]	-2.91114	6.21072
Total Stress ZZ [ksf]	0	12.4493
Total Stress XX [ksf]	-0.137121	13.5657
Total Stress YY [ksf]	-2.27275	13.7476
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	164.832
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	164.832
Total Strain	0	4.11877e-05
Pore Water Pressure [ksf]	0	7.53904
Excess Pore Water Pressure [ksf]	0	2.23366
Degree of Consolidation [%]	0	21.6281
Pre-consolidation Stress [ksf]	3.71713e-05	16.694
Over-consolidation Ratio	1	3.4
Void Ratio	0	0.59
Permeability [ft/min]	0	4.99766e-06
Coefficient of Consolidation [ft^2/min]	0	0.0032
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	-1.11022e-16	0.0341472

Stage: Drawdown = 0.5 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.864361
Total Consolidation Settlement [in]	0	0.864361
Virgin Consolidation Settlement [in]	0	0.215705
Recompression Consolidation Settlement [in]	0	0.712141
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	4.55806
Loading Stress XX [ksf]	-2.75133	7.56691
Loading Stress YY [ksf]	-6.23927	5.14431
Effective Stress ZZ [ksf]	0	7.13885
Effective Stress XX [ksf]	-1.74286	9.43708
Effective Stress YY [ksf]	-5.62816	9.78811
Total Stress ZZ [ksf]	0	14.7662
Total Stress XX [ksf]	-0.668522	17.0607
Total Stress YY [ksf]	-4.97089	17.4154
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	206.578
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	206.578
Total Strain	0	0.0131026
Pore Water Pressure [ksf]	0	7.62952
Excess Pore Water Pressure [ksf]	0	2.60544
Degree of Consolidation [%]	0	60.9046
Pre-consolidation Stress [ksf]	3.71713e-05	16.694
Over-consolidation Ratio	1	3.39998
Void Ratio	0	0.59
Permeability [ft/min]	0	4.99766e-06
Coefficient of Consolidation [ft^2/min]	0	0.0032
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.136293

Stage: Final = 5 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.37267
Total Consolidation Settlement [in]	0	3.37267
Virgin Consolidation Settlement [in]	0	2.44056
Recompression Consolidation Settlement [in]	0	1.11605
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	4.55806
Loading Stress XX [ksf]	-2.75133	7.56691
Loading Stress YY [ksf]	-6.23927	5.14431
Effective Stress ZZ [ksf]	0	9.45568
Effective Stress XX [ksf]	-0.871206	11.7554
Effective Stress YY [ksf]	-5.14456	12.1049
Total Stress ZZ [ksf]	0	14.7662
Total Stress XX [ksf]	-0.668522	17.0607
Total Stress YY [ksf]	-4.97089	17.4154
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	122.47
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	122.47
Total Strain	0	0.0362424
Pore Water Pressure [ksf]	0	6.30567
Excess Pore Water Pressure [ksf]	-0.000211816	0.000279718
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	3.71713e-05	16.694
Over-consolidation Ratio	1	3.39995
Void Ratio	0	0.59
Permeability [ft/min]	0	4.99766e-06
Coefficient of Consolidation [ft^2/min]	0	0.0032
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.287317

Loads

1. Fill Load: "Fill Load 1"

Label	Fill Load 1
Load Type	Flexible
Area of Load	1.7145e+06 ft^2
Load	2.23366 ksf
Depth	-375.728 ft
Installation Stage	3 Months = 0.25 y

Coordinates

X [ft]	Y [ft]
832360	200681
832360	200281
833960	200281
833960	201281
833675	201681
833560	201881

2. Fill Load: "GW Drawdown Equivalent Loading"

Label	GW Drawdown Equivalent Loading
Load Type	Flexible
Area of Load	1.7145e+06 ft^2
Load	2.3244 ksf
Depth	-375.728 ft
Installation Stage	Drawdown = 0.5 y

Coordinates

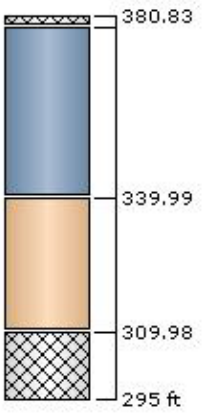
X [ft]	Y [ft]
832360	200681
832360	200281
833960	200281
833960	201281
833675	201681
833560	201881

Soil Layers

Ground Surface Drained: Yes

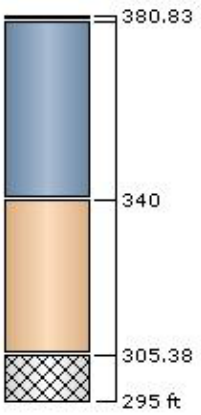
Borehole 1: (832360, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	38.132	-378.125	No
2	Foundation Clay	30.013	-339.993	Yes



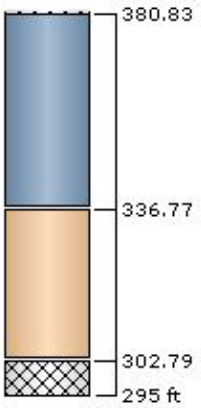
Borehole 2: (832560, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	39.732	-379.733	No
2	Foundation Clay	34.617	-340.001	Yes



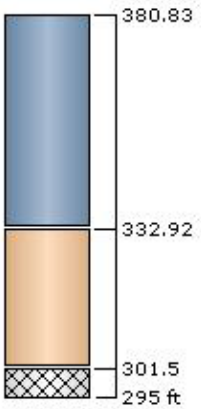
Borehole 3: (832760, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	43.885	-380.656	No
2	Foundation Clay	33.982	-336.771	Yes



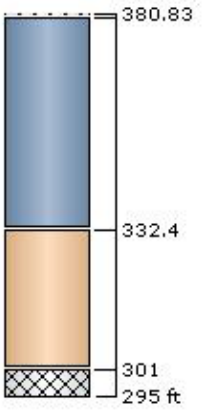
Borehole 4: (832960, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	47.908	-380.83	No
2	Foundation Clay	31.426	-332.922	Yes



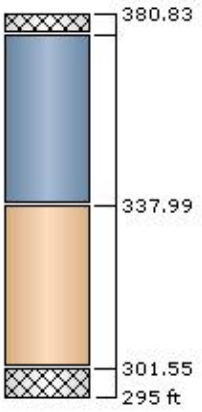
Borehole 5: (833160, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	47.778	-380.177	No
2	Foundation Clay	31.402	-332.399	Yes



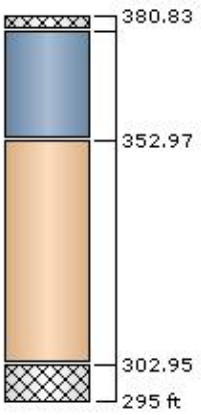
Borehole 6: (833360, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	38.009	-376	No
2	Foundation Clay	36.441	-337.991	Yes



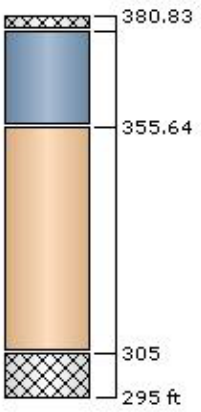
Borehole 7: (833560, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	24.269	-377.237	No
2	Foundation Clay	50.021	-352.968	Yes



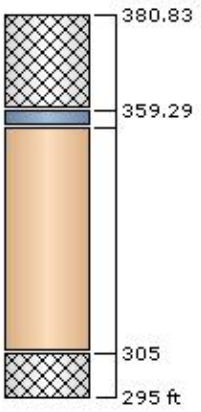
Borehole 8: (833760, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	21.584	-377.22	No
2	Foundation Clay	50.631	-355.636	Yes



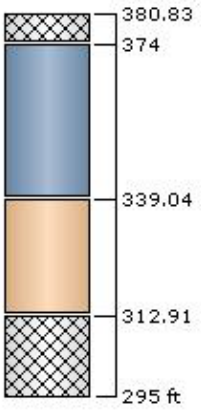
Borehole 9: (833960, 200281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	3.649	-359.285	No
2	Foundation Clay	50.631	-355.636	Yes



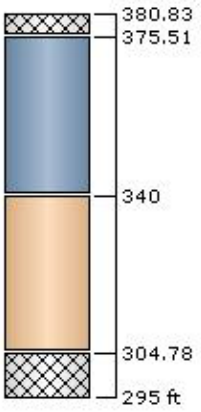
Borehole 10: (832360, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	34.962	-374	No
2	Foundation Clay	26.128	-339.038	Yes



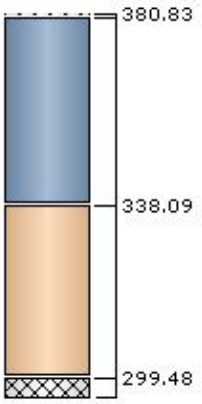
Borehole 11: (832560, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	35.504	-375.506	No
2	Foundation Clay	35.218	-340.002	Yes



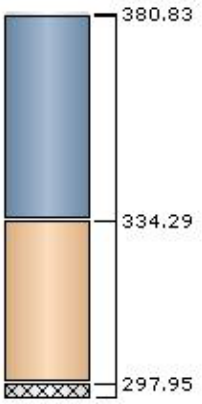
Borehole 12: (832760, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	41.915	-380.004	No
2	Foundation Clay	38.61	-338.089	Yes



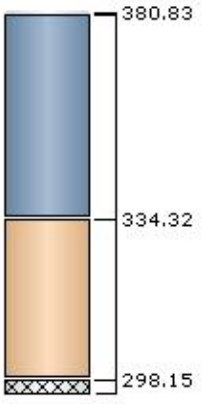
Borehole 13: (832960, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	46.071	-380.361	No
2	Foundation Clay	36.337	-334.29	Yes



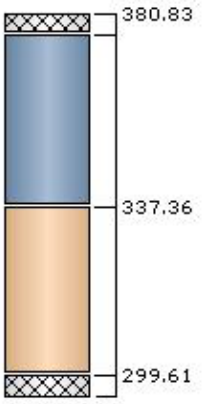
Borehole 14: (833160, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	45.947	-380.266	No
2	Foundation Clay	36.169	-334.319	Yes



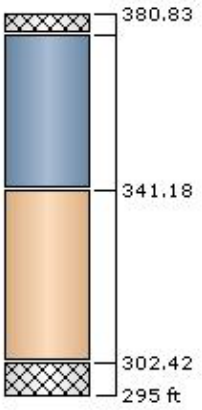
Borehole 15: (833360, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	38.634	-375.998	No
2	Foundation Clay	37.753	-337.364	Yes



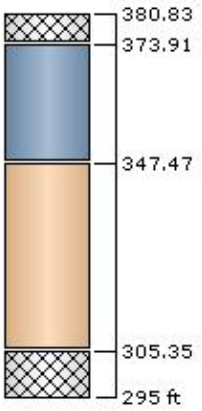
Borehole 16: (833560, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	34.82	-376	No
2	Foundation Clay	38.757	-341.18	Yes



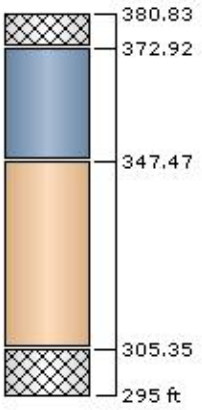
Borehole 17: (833760, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	26.434	-373.907	No
2	Foundation Clay	42.123	-347.473	Yes



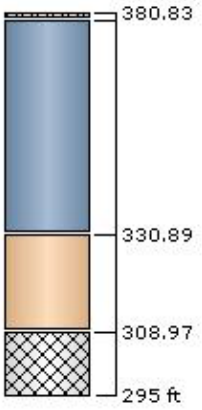
Borehole 18: (833960, 200481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	25.449	-372.922	No
2	Foundation Clay	42.123	-347.473	Yes



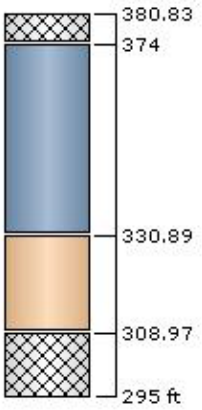
Borehole 19: (832360, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	48.084	-378.976	No
2	Foundation Clay	21.923	-330.892	Yes



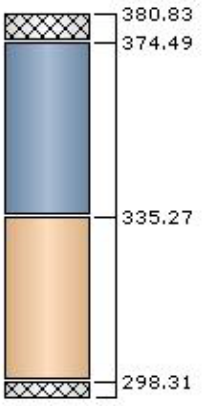
Borehole 20: (832560, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	43.106	-373.998	No
2	Foundation Clay	21.923	-330.892	Yes



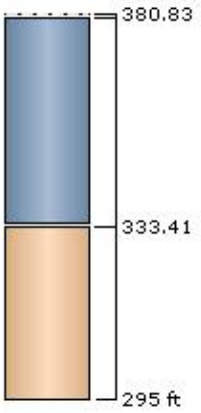
Borehole 21: (832760, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	39.211	-374.485	No
2	Foundation Clay	36.967	-335.274	Yes



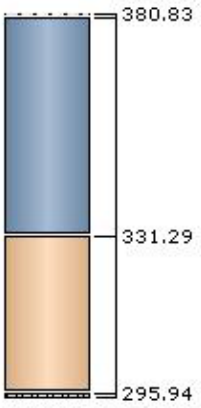
Borehole 22: (832960, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	46.589	-380	No
2	Foundation Clay	38.411	-333.411	Yes



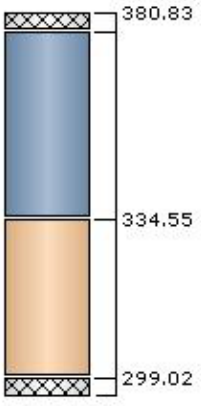
Borehole 23: (833160, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	48.711	-380	No
2	Foundation Clay	35.346	-331.289	Yes



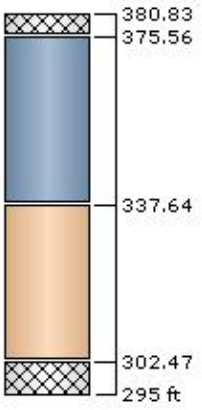
Borehole 24: (833360, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	42.095	-376.641	No
2	Foundation Clay	35.529	-334.546	Yes



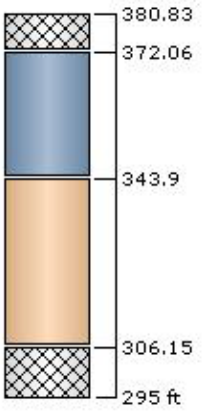
Borehole 25: (833560, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	37.924	-375.565	No
2	Foundation Clay	35.172	-337.641	Yes



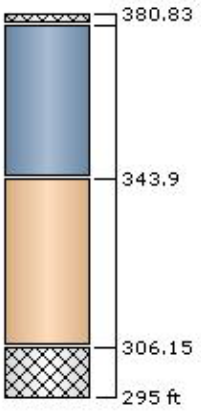
Borehole 26: (833760, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	28.163	-372.064	No
2	Foundation Clay	37.754	-343.901	Yes



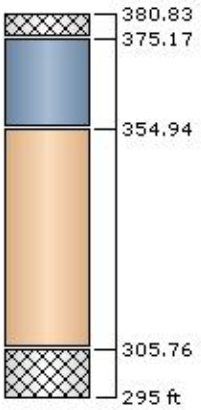
Borehole 27: (833960, 200681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	34.154	-378.055	No
2	Foundation Clay	37.754	-343.901	Yes



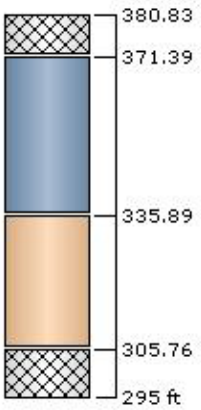
Borehole 28: (832560, 200881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	20.23	-375.167	No
2	Foundation Clay	49.173	-354.937	Yes



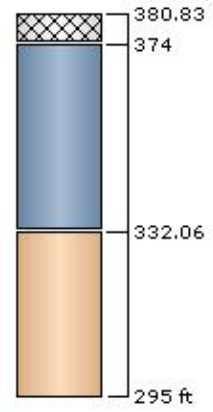
Borehole 29: (832760, 200881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	35.505	-371.395	No
2	Foundation Clay	30.126	-335.89	Yes



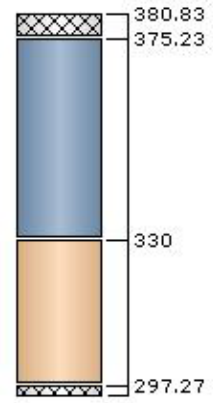
Borehole 30: (832960, 200881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	41.942	-373.999	No
2	Foundation Clay	37.057	-332.057	Yes



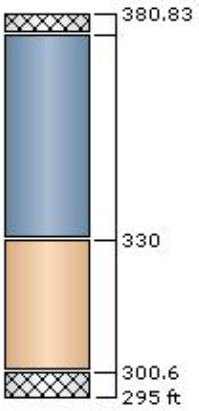
Borehole 31: (833160, 200881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	45.231	-375.231	No
2	Foundation Clay	32.725	-330	Yes



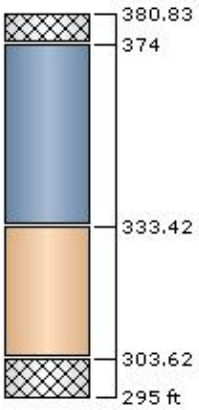
Borehole 32: (833360, 200881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	46	-376	No
2	Foundation Clay	29.402	-330	Yes



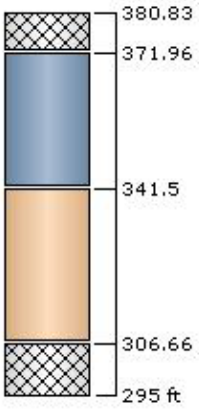
Borehole 33: (833560, 200881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	40.585	-374.002	No
2	Foundation Clay	29.794	-333.417	Yes



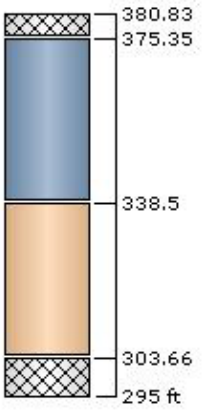
Borehole 34: (833760, 200881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	30.454	-371.957	No
2	Foundation Clay	34.841	-341.503	Yes



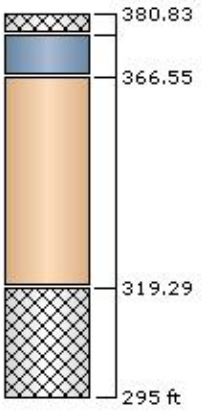
Borehole 35: (833960, 200881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	36.847	-375.35	No
2	Foundation Clay	34.841	-338.503	Yes



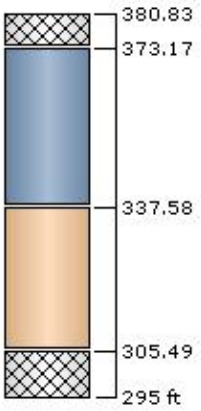
Borehole 36: (832760, 201081)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	9.451	-376.002	No
2	Foundation Clay	47.265	-366.551	Yes



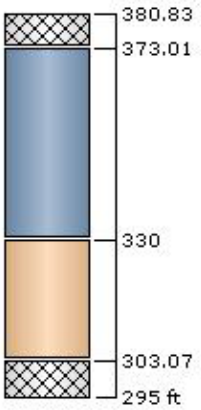
Borehole 37: (832960, 201081)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	35.586	-373.167	No
2	Foundation Clay	32.093	-337.581	Yes



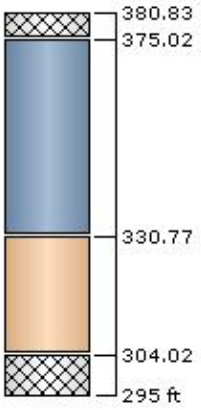
Borehole 38: (833160, 201081)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	43.014	-373.014	No
2	Foundation Clay	26.928	-330	Yes



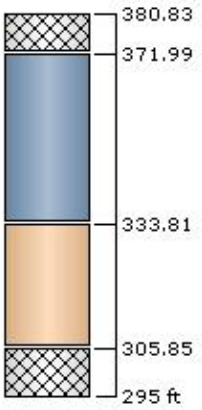
Borehole 39: (833360, 201081)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	44.246	-375.017	No
2	Foundation Clay	26.754	-330.771	Yes



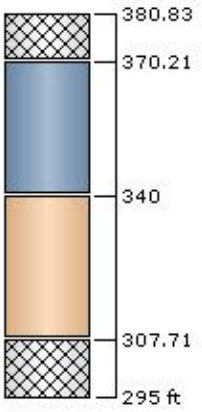
Borehole 40: (833560, 201081)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	38.176	-371.99	No
2	Foundation Clay	27.964	-333.814	Yes



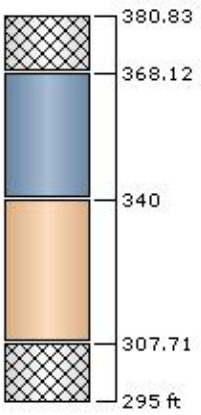
Borehole 41: (833760, 201081)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	30.213	-370.211	No
2	Foundation Clay	32.292	-339.998	Yes



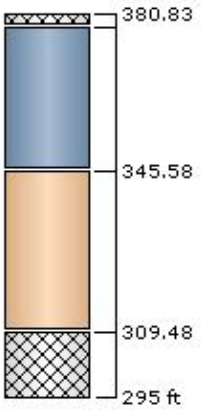
Borehole 42: (833960, 201081)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	28.121	-368.119	No
2	Foundation Clay	32.292	-339.998	Yes



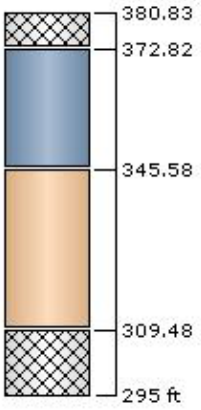
Borehole 43: (832960, 201281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	32.241	-377.819	No
2	Foundation Clay	36.099	-345.578	Yes



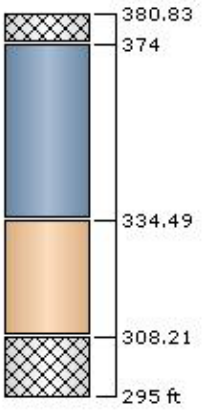
Borehole 44: (833160, 201281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	27.246	-372.824	No
2	Foundation Clay	36.099	-345.578	Yes



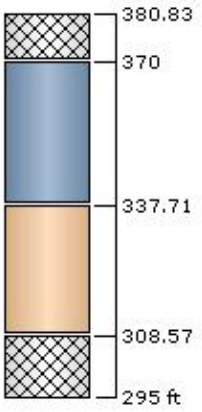
Borehole 45: (833360, 201281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	39.513	-374	No
2	Foundation Clay	26.275	-334.487	Yes



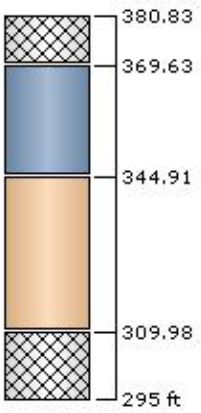
Borehole 46: (833560, 201281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	32.291	-370.005	No
2	Foundation Clay	29.143	-337.714	Yes



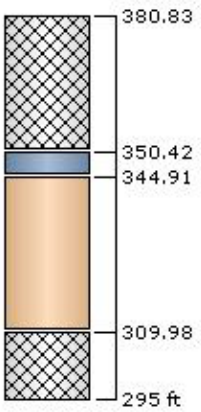
Borehole 47: (833760, 201281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	24.729	-369.635	No
2	Foundation Clay	34.926	-344.906	Yes



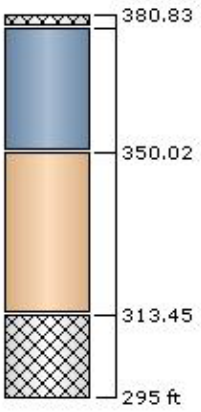
Borehole 48: (833960, 201281)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	5.512	-350.418	No
2	Foundation Clay	34.926	-344.906	Yes



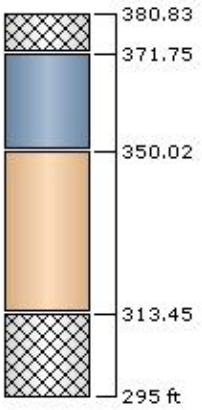
Borehole 49: (833160, 201481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	27.993	-378.013	No
2	Foundation Clay	36.567	-350.02	Yes



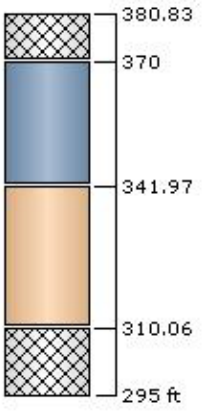
Borehole 50: (833360, 201481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	21.733	-371.753	No
2	Foundation Clay	36.567	-350.02	Yes



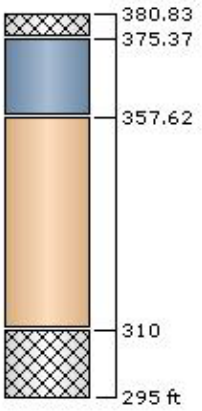
Borehole 51: (833560, 201481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	28.032	-370	No
2	Foundation Clay	31.904	-341.968	Yes



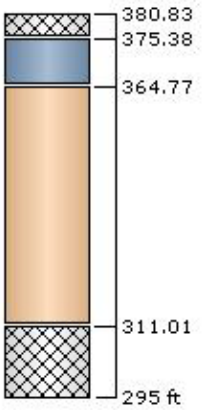
Borehole 52: (833760, 201481)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	17.751	-375.368	No
2	Foundation Clay	47.617	-357.617	Yes



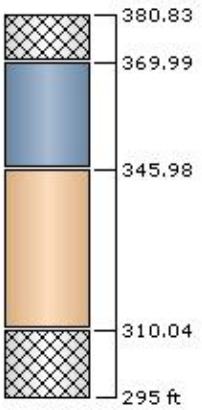
Borehole 53: (833360, 201681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	10.61	-375.38	No
2	Foundation Clay	53.761	-364.77	Yes



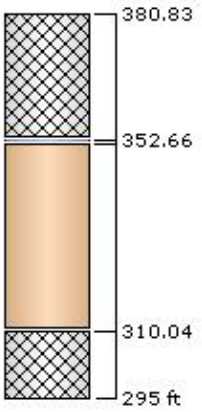
Borehole 54: (833560, 201681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	24.013	-369.991	No
2	Foundation Clay	35.938	-345.978	Yes



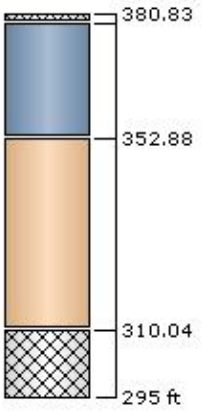
Borehole 55: (833760, 201681)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	0.661	-352.661	No
2	Foundation Clay	41.96	-352	Yes



Borehole 56: (833560, 201881)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	CCR	25.628	-378.511	No
2	Foundation Clay	42.843	-352.883	Yes



Soil Properties

Property	CCR	Foundation Clay
Color		
Unit Weight [kips/ft^3]	0.115	0.127
Saturated Unit Weight [kips/ft^3]	0.115	0.127
K0	1	1
Primary Consolidation	Disabled	Enabled
Material Type		Non-Linear
Cc	-	0.143
Cr	-	0.007
e0	-	0.59
OCR	-	3.4
Cv [ft^2/min]	-	0.00032
Cvr [ft^2/min]	-	0.0032
B-bar	-	1
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Grid Name	Default Grid	Default Grid

Groundwater

Groundwater method	Grids
Water Unit Weight	0.0624 kips/ft^3

Groundwater Grid: Default Grid

X	Y	Depth (ft)
832360	200281	-378.125
832560	200281	-379.733
832760	200281	-380.656
832960	200281	-380.83
833160	200281	-380.177
833360	200281	-376
833560	200281	-377.237
833760	200281	-377.22
833960	200281	-359.285
832360	200481	-374
832560	200481	-375.506
832760	200481	-380.004
832960	200481	-380.361
833160	200481	-380.266
833360	200481	-375.998
833560	200481	-376
833760	200481	-373.907
833960	200481	-372.922
832360	200681	-378.976
832560	200681	-373.998
832760	200681	-374.485
832960	200681	-380
833160	200681	-380
833360	200681	-376.641
833560	200681	-375.565
833760	200681	-372.064
833960	200681	-378.055
832560	200881	-375.167
832760	200881	-371.395
832960	200881	-373.999
833160	200881	-375.231
833360	200881	-376
833560	200881	-374.002
833760	200881	-371.957
833960	200881	-378.35
832760	201081	-376.002
832960	201081	-373.167
833160	201081	-373.014
833360	201081	-375.017
833560	201081	-371.99
833760	201081	-370.211
833960	201081	-368.119
832960	201281	-377.819
833160	201281	-372.824
833360	201281	-374
833560	201281	-370.005
833760	201281	-369.635
833960	201281	-350.418
833160	201481	-378.013
833360	201481	-371.753
833560	201481	-370
833760	201481	-375.368
833360	201681	-375.38
833560	201681	-369.991
833760	201681	-352.661
833560	201881	-378.511

Field Point Grid

Number of points 530
Expansion Factor 1

Grid Coordinates

X [ft]	Y [ft]
834760	202681
834760	199481
831560	199481
831560	202681

Geosyntec consultants

ATTACHMENT E

2016 AECOM Seismic Hazard Assessment

Final Report

Site-Specific Probabilistic Seismic Hazard Analysis, Site Response Analysis and Development of Time Histories for the Joppa Power Station in Southern Illinois

Prepared for

Dynegy
Houston, Texas

12 February 2016

Prepared by

AECOM
Eliza Nemser, Patricia Thomas, Mark Dober, and Ivan Wong
Seismic Hazards Group, AECOM
1333 Broadway, Suite 800, Oakland, California 94612

Earl Underwood
AECOM
8181 East Tufts Avenue, Denver, Colorado 80237

Walter Silva and Robert Darragh
Pacific Engineering and Analysis
856 Sea View Drive, El Cerrito, CA 94530

TABLE OF CONTENTS

Executive Summary **ES-1**

Section 1 – Introduction **1-1**

1.1 Scope of Work 1-1
1.2 Acknowledgments 1-2

Section 2 – Probabilistic Seismic Hazard Analysis Methodology **2-1**

2.1 Seismic Source Characterization 2-2
2.1.1 Source Geometry 2-2
2.1.2 Fault Recurrence 2-3
2.2 Ground Motion Prediction 2-4

Section 3 – Regional Geologic and Seismotectonic Setting **3-1**

3.1 Seismotectonic Setting 3-1
3.2 Historical Seismicity 3-1
3.2.1 Historical Seismicity Catalog 3-1
3.2.2 Significant Earthquakes 3-2

Section 4 – Inputs to Analysis **4-1**

4.1 Seismic Source Model 4-1
4.1.1 Seismotectonic Zones 4-4
4.1.2 Mmax Zones 4-6
4.1.3 Recurrence for Seismic Zonation 4-8
4.1.4 RLME 4-8
4.2 EPRI Ground Motion Prediction Models 4-16
4.3 Site Conditions 4-20

Section 5 – PSHA Results **5-1**

Section 6 – Site Response Analysis **6-1**

6.1 Implementation of Approach 3 6-2
6.1.1 RVT-Based Equivalent-Linear Site Response Approach 6-3
6.1.2 Inputs and Analysis 6-4
6.2 Site-Specific Horizontal Results 6-5
6.3 Comparison With USGS National Hazard Maps 6-5

Section 7 – Development of Time Histories **7-1**

Section 8 References **8-1**

TABLE OF CONTENTS

Tables

1 Seismic Source Zones Incorporated Into Analysis

2 New Madrid Fault System RLME Source Model

3 RLME (Fault) Sources Incorporated Into Analysis

4 Updated EPRI (2013) GMM Clusters and Models

5 Elements of the CENA Ground Motion Models

6 V_S Profile

7 2,500-Year Return Period UHS for Hard Rock

8 Modal M* and D* at 2,500-year Return Period

9 Simplified V_S Profile Used in the Analysis

10 2,500-Year Return Period UHS at the Ground Surface

11 Seed Time Histories

12 Spectrally-Matched Time Histories

Figures

1 Historical Seismicity of the Central and Eastern United States (1699 – 2015)

2 Example Seismic Hazard Model Logic Tree

3 New Madrid RLME Logic Tree

4 Historical Seismicity and Seismic Zones in Eastern U.S.

5 Isoseismal Map of the 16 December 1811 **M** 7.2 – 7.3 New Madrid Earthquake

6 New Madrid Fault System, 1811-1812 NMFS Earthquakes, and Neighboring RLMEs

7 Isoseismal Map of the 27 September 1891 m_b 5.8 Southern, Illinois Earthquake

8 Isoseismal Map of the 31 October 1895 M_S 6.7 Charleston, Missouri Earthquake

9 Isoseismal Map of the 9 November 1968 m_b 5.5 Southern, Illinois Earthquake

10 Isoseismal Map for the 27 July 1980 **M** 5.1 Sharpsburg, Kentucky Earthquake

11 Seismotectonic Zones and RLMEs

12 Mmax Zones

13 Simplified V_S Profile Used in the Analysis

14 Seismic Hazard Curves for Peak Ground Acceleration on Hard Rock

15 Seismic Hazard Curves for 1.0 Sec Horizontal Spectral Acceleration on Hard Rock

16 Seismic Source Contributions to Mean Peak Horizontal Acceleration Hazard on Hard Rock

17 Seismic Source Fractional Contributions to Mean Peak Horizontal Acceleration Hazard on Hard Rock

TABLE OF CONTENTS

18 Seismic Source Contributions to Mean 1.0 Sec Horizontal Spectral Acceleration Hazard on Hard Rock

19 Seismic Source Fractional Contribution to Mean 1.0 Sec Horizontal Spectral Acceleration Hazard on Hard Rock

20 Magnitude, Distance and Epsilon Contributions to the Mean Peak Horizontal Acceleration Hazard at 2,500-Year Return Period on Hard Rock

21 Magnitude, Distance and Epsilon Contributions to the Mean 1.0 Sec Horizontal Spectral Acceleration Hazard at 2,500-Year Return Period on Hard Rock

22 5%-Damped Mean Horizontal UHS on Hard Rock at 2,500-Year Return Period

23 Comparison of Mean Horizontal UHS on Hard Rock and Ground Surface at 2,500-Year Return Period

24 Horizontal Target and Selected Seed Response Spectra

25 Seed Time Histories RSN1153 – 1999 Kocaeli Botas

26 Seed Time Histories RSN1404 – 1999 Chi Chi PNG

27 Seed Time Histories RSN2112 – 2002 Denali TAPS Pump Station #08

28 Response Spectra for the Time History Spectrally-Matched to the 2,500-Year Return Period UHS Horizontal Target 1999 Kocaeli Botas (000) Seed

29 Time History Spectrally Matched to the 2,500-Year Return Period UHS Horizontal Target 1999 Kocaeli Botas (000) Seed

30 Response Spectra for the Time History Spectrally-Matched to the 2,500-Year Return Period UHS Horizontal Target 1999 Kocaeli Botas (090) Seed

31 Time History Spectrally Matched to the 2,500-Year Return Period UHS Horizontal Target 1999 Kocaeli Botas (090) Seed

32 Response Spectra of the Time History Spectrally-Matched to the 2,500-Year Return Period UHS Horizontal Target 1999 Chi Chi PNG (E) Seed

33 Time History Spectrally Matched to the 2,500-Year Return Period UHS Horizontal Target 1999 Chi Chi PNG (E) Seed

34 Response Spectra of the Time History Spectrally-Matched to the 2,500-Year Return Period UHS Horizontal Target 1999 Chi Chi PNG (N) Seed

35 Time History Spectrally Matched to the 2,500-Year Return Period UHS Horizontal Target 1999 Chi Chi PNG (N) Seed

36 Response Spectra for the Time History Spectrally-Matched to the 2,500-Year Return Period UHS Horizontal Target 2002 Denali TAPS Pump Station #08 (049) Seed

37 Time History Spectrally Matched to the 2,500-Year Return Period UHS Horizontal Target 2002 Denali TAPS Pump Station #08 (049) Seed

38 Response Spectra for the Time History Spectrally-Matched to the 2,500-Year Return Period UHS Horizontal Target 2002 Denali TAPS Pump Station #08 (319) Seed

39 Time History Spectrally Matched to the 2,500-Year Return Period UHS Horizontal Target 2002 Denali TAPS Pump Station #08 (319) Seed

A site-specific seismic hazard analysis has been performed for the Joppa Power Station in southern Illinois to develop Safety Evaluation Earthquake (SEE) ground motions for use in liquefaction and dynamic deformation analyses of the facility. The SEE ground motions consist of acceleration response spectra and time histories. The power station is located in the Midcontinent of the U.S. away from active plate boundaries but in a region that exhibits a moderate level of historical seismicity. The site is capable of experiencing strong ground shaking from moderate to large earthquakes (moment magnitude [**M**] > 6) particularly from the adjacent New Madrid Seismic Zone (NMSZ) and the Wabash Valley Seismic Zone (WVSZ). The New Madrid fault system (NMFS) which is located within the NMSZ produced the series of three **M** > 7 earthquakes in 1811 and 1812. These are the largest earthquakes known to have occurred in the central and eastern U.S. (CEUS).

In this study, four major tasks were performed: 1) seismic source characterization; 2) probabilistic seismic hazard analysis (PSHA); 3) site response analysis; and 4) development of the SEE ground motion parameters. The SEE ground motions are based on a probabilistic assessment of the seismic hazard at the site using the PSHA approach. The annual probability considered in this study was 1/2500 or a return period of 2,500 years. There are two major inputs into a PSHA: a characterization of all seismic sources that can generate significant ground shaking at the site and ground motion prediction models that relate primarily magnitude, distance, and site condition to levels of ground shaking at a site. For the seismic source characterization, we used the recently developed seismic source model developed for the CEUS by the Electric Power Research Institute (EPRI), the U.S. Department of Energy (DOE), and the U.S. Nuclear Regulatory Commission (NRC). This model is being used in the PSHAs for nuclear power plants and other critical facilities in the CEUS.

In a similar fashion, we used the EPRI ground motion prediction models developed in 2013 that are also being used in the PSHAs for nuclear power plants. A limitation of all existing ground motion models for the CEUS including the EPRI models is that they were developed for a hard rock site condition (shear-wave velocity [V_S] of 2,830 m/sec and greater).

The products of the PSHA are hard rock hazard curves and deaggregation information. The deaggregation indicated that the most important seismic sources to the power station site were the Illinois Basin Extended Basement Zone (IBEB) in which the site is located and the NMFS.

The power station is situated on soil. Hard rock (unweathered limestone), is relatively shallow, at a depth greater than 200 ft. A site response analysis was performed to estimate the ground motions at the ground surface by accounting for any site effects of the geology beneath the site down to basement rock. The inputs required in a site response analysis are a best-estimate V_S profile and dynamic properties of the geologic units beneath the site. A V_S profile was developed from the ground surface down to basement rock based on available data, none of it being site-specific in nature. Dynamic properties were assigned to the unconsolidated materials and firm rock above the basement in the analysis. The hard rock hazard curves from the PSHA were adjusted to the ground surface using amplification factors computed from the site response analysis.

Based on the results of the PSHA and site response analysis, a horizontal SEE Uniform Hazard Spectrum (UHS) was calculated. The SEE UHS is provided in the table below. The SEE peak

horizontal ground acceleration (PGA) at the site is 0.18 g. Three sets of two-component horizontal time histories were spectrally matched to the SEE UHS.

2,500-Year Return Period Mean UHS for the Ground Surface

Period (sec)	SA (g)
0.01	0.65
0.02	0.82
0.03	0.92
0.04	1.00
0.10	1.20
0.20	1.30
0.40	0.97
1.0	0.60
2.0	0.25
3.0	0.15
4.0	0.12
5.0	0.10

At the request of Dynegy, a site-specific probabilistic seismic hazard analysis (PSHA) and site response analysis has been performed for the Joppa Power Station in southern Illinois to develop Safety Evaluation Earthquake (SEE) ground motions (Figure 1). The SEE ground motions will be used to evaluate the seismic design of the station. Both horizontal acceleration response spectra and time histories were developed. The hazard was defined at the top of the natural soil beneath the site and will be used in liquefaction and deformation analyses of the power station.

Joppa Power Station is located in the Midcontinent region of the U.S. away from active plate boundaries in a region that exhibits a moderate level of historical seismicity (Figure 1). There have been twelve known earthquakes larger than moment magnitude (**M**) 5.0 within 200 km of the site. The region is capable of experiencing strong ground motions from moderate to large earthquakes (**M** > 6) particularly from the New Madrid Seismic Zone (NMSZ) and the Wabash Valley Seismic Zone (WVSZ) to the northeast of the site (Figure 1). In 1811 to 1812, a series of three **M** > 7 earthquakes occurred along the New Madrid fault system (NMFS), which is located within the NMSZ.

This report presents the results of the site-specific PSHA, the site response analysis, and development of the horizontal acceleration time histories consistent with the 2,500-year return period SEE Uniform Hazard Spectrum (UHS) at the ground surface.

1.1 SCOPE OF WORK

In site-specific seismic hazard analyses, the available geologic and seismologic data are used to evaluate and characterize (1) potential seismic sources, (2) the likelihood of earthquakes of various magnitudes occurring on those sources, and (3) the likelihood of the earthquakes producing ground motions over a specified level. Based on a site-specific PSHA and site response analysis, SEE spectra and time histories can be developed. The following tasks were performed:

Task 1 – Seismic Source Characterization

Seismic source parameters that are needed in order to characterize an active (seismogenic) fault for ground motion hazard assessments include: the geometry and rupture dimensions of the fault; the size of the maximum earthquake; the nature (style) and amount of slip on the fault expected for the maximum earthquake; and the rate and nature of earthquake recurrence. These parameters should be estimated for all significant seismic sources. In addition to the known active faults located in the region that can impact the site, the hazard from buried and unknown faults must also be accounted for. Hence, seismic sources will consist of active and potentially active faults and regional seismic source zones, which account for buried and unknown faults. In this study, we will utilize the recently developed seismic source model developed for the central and eastern U.S. (CEUS) by the Electric Power Research Institute (EPRI), the U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. This model is being used in the seismic hazard analyses for nuclear power plants and other critical structures/facilities in the CEUS.

Task 2 – Probabilistic Seismic Hazard Analysis

Site-specific probabilistic ground motions were calculated for the project site for a 2,500-year return period. The PSHA methodology allows for the explicit inclusion of the range of possible

interpretations in components of the seismic hazard model, including seismic source characterization and ground motion estimation. Uncertainties in models and parameters are incorporated into the hazard analysis through the use of logic trees. State-of-the-art ground motion prediction models were selected for the types of seismic sources considered in the PSHA. In this case, the EPRI (2013) models for hard rock and the CEUS were used in the PSHA. Hard rock is defined by a V_S30 (time-averaged shear-wave velocity [V_S] in the top 30 m) greater than 2,830 m/sec.

Task 3 – Site Response Analysis

Site response analyses were performed consistent with NUREG/CR-6728 to adjust the hard rock hazard to site-specific free-field ground surface conditions. The inputs into the analyses were V_S profiles representative of the site and non-linear dynamic properties. The V_S profiles were randomized using a correlation model to capture the variability in V_S across the site. A site response analysis was performed to calculate a suite of amplification factors at selected spectral frequencies i.e., PGA, 0.2 and 1.0 sec spectral acceleration and input motions. A state-of-the-art random-vibration-theory (RVT) methodology based on an equivalent-linear approach was used.

Task 4 – Development of SEE Ground Motion Parameters and Final Report

Horizontal SEE response spectra for a 2,500-year return period were developed and provided for the SSI analysis. A total of three time histories were developed. A final report was produced that describes and summarizes the above analyses.

1.2 ACKNOWLEDGMENTS

The seismic hazard analysis of Joppa Power Station was performed by Eliza Nemser, Patricia Thomas, Mark Dober, and Ivan Wong of the Oakland Seismic Hazards Group and Earl Underwood, Denver of AECOM, and Walt Silva and Bob Darragh of Pacific Engineering & Analysis. Our appreciation to Rob Snow for project management support and Melinda Lee for her assistance in the preparation of this report.

The PSHA approach used in this study is based on the model developed principally by Cornell (1968). The occurrence of earthquakes on a fault is assumed to be a Poisson process. The Poisson model is widely used and is a reasonable assumption in regions where data are sufficient to provide only an estimate of average recurrence rate (Cornell, 1968). The occurrence of ground motions at the site in excess of a specified level is also a Poisson process, if (1) the occurrence of earthquakes is a Poisson process, and (2) the probability that any one event will result in ground motions at the site in excess of a specified level is independent of the occurrence of other events.

The probability that a ground motion parameter "*Z*" exceeds a specified value "*z*" in a time period "t" is given by:

$$p(Z > z) = 1\text{-}e^{-\nu(z)\cdot t} \qquad (2\text{-}1)$$

where $\nu(z)$ is the annual mean number (or rate) of events in which *Z* exceeds *z*. It should be noted that the assumption of a Poisson process for the number of events is not critical. This is because the mean number of events in time t, $\nu(z) \bullet t$, can be shown to be a close upper bound on the probability $p(Z > z)$ for small probabilities (less than 0.10) that generally are of interest for engineering applications. The annual mean number of events is obtained by summing the contributions from all sources, that is:

$$\nu(z) = \sum_{n} \nu_n(z) \qquad (2\text{-}2)$$

where $\nu_n(z)$ is the annual mean number (or rate) of events on source n for which *Z* exceeds *z* at the site. The parameter $\nu_n(z)$ is given by the expression:

$$\nu_n(z) = \sum_{i}\sum_{j} ß_n(m_i) \bullet p(R=r_j|m_i) \bullet p(Z>z|m_i,r_j) \qquad (2\text{-}3)$$

where:

$ß_n(m_i)$ = annual mean rate of recurrence of earthquakes of magnitude increment m_i on source n;

$p(R=r_j|m_i)$ = probability that given the occurrence of an earthquake of magnitude m_i on source n, r_j is the closest distance increment from the rupture surface to the site;

$p(Z > z|m_i,r_j)$ = probability that given an earthquake of magnitude m_i at a distance of r_j, the ground motion exceeds the specified level *z*.

The calculations were made using the computer program HAZ38CEUS. The basic program (HAZ38) has been validated in the Pacific Earthquake Engineering Research (PEER) Center-sponsored "Validation of PSHA Computer Programs" Project (Thomas *et al.*, 2010). Modifications were made to HAZ38 to incorporate the CEUS-SSC model and the resulting revision, HAZ38CEUS, was validated by comparing hazard results with the test case results contained in EPRI/DOE/NRC (2012).

The following is a general overview of PSHA methodology used by AECOM. For this study, we have adopted the EPRI/DOE/NRC (2012) seismic source model, which required modifications to our general approach. For a detailed description, see EPRI/DOE/NRC (2012). A sample logic tree is shown on Figure 2. Logic trees such as shown on Figure 3 are used in the EPRI/DOE/NRC (2012) model.

2.1 SEISMIC SOURCE CHARACTERIZATION

Three types of earthquake sources are characterized in the CEUS-SSC model: (1) known fault sources; (2) seismotectonic zones; and (3) Mmax zones. Fault sources are modeled as three-dimensional fault surfaces and details of their behavior are incorporated into the source characterization. The inventory of fault sources in the CEUS is small and undoubtedly incomplete. Given this shortcoming, the historical seismicity is used as a proxy to address the hazard from those buried or unknown faults. The spatial density of the historical seismicity was assumed to be stationary; in this model the recurrence rates per area for each small area were smoothed using a Gaussian filter.

The geometric source parameters for faults include fault location, segmentation model, dip, and thickness of the seismogenic zone (Figure 2). The recurrence parameters include recurrence model, recurrence rate (slip rate or average recurrence interval for the maximum event), slope of the recurrence curve (*b*-value), and maximum magnitude. Clearly, the geometry and recurrence are not totally independent. For example, if a fault is modeled with several small segments instead of large segments, the maximum magnitude is lower, and a given slip rate requires many more small earthquakes to accommodate a cumulative seismic moment. For areal source zones, only the area, seismogenic thickness, maximum magnitude, and recurrence parameters (based on the historical earthquake record) need to be defined.

Uncertainties in the CEUS-SSC source parameters are modeled using logic trees. In this procedure, values of the source parameters are represented by the branches of logic trees with weights that define the distribution of values. Sample logic trees are shown on Figures 2 and 3. In general, three or five values for each parameter were weighted and used in the analysis. Note that the weights associated with the percentiles are not equivalent to probabilities for these values, but rather are weights assigned to define the distribution.

2.1.1 Source Geometry

In the PSHA, it is assumed that earthquakes of a certain magnitude may occur randomly along the length of a given fault or segment. The distance from an earthquake to the site is dependent on the source geometry, the size and shape of the rupture on the fault plane, and the likelihood of the earthquake occurring at different points along the fault length. The distance to the fault is defined to be consistent with the specific ground motion prediction model used to calculate the ground motions. The distance, therefore, is dependent on both the dip and depth of the fault plane, and a separate distance function is calculated for each geometry and each ground motion prediction model. The size and shape of the rupture on the fault plane are dependent on the magnitude of the earthquake, with larger events rupturing longer and wider portions of the fault plane. For a given magnitude, the associated rupture surface is uniformly distributed along the fault length and width. Ruptures are constrained to occur entirely on the defined fault plane.

The rupture dimensions can be modeled using magnitude-rupture area and rupture width relationships.

2.1.2 Fault Recurrence

The recurrence relationships for faults are generally modeled using the exponentially truncated Gutenberg-Richter, characteristic earthquake, and the maximum moment (magnitude) recurrence models (Figure 2). These models are weighted to represent judgment on their applicability to the sources. For the areal source zones, only a truncated exponential recurrence relationship is assumed appropriate.

The general approach of Molnar (1979) and Anderson (1979) is often used to arrive at the recurrence for the exponentially truncated model. The number of events exceeding a given magnitude, *N(m)*, for the truncated exponential relationship is

$$N(m) = \alpha(m^o)\frac{10^{-b(m-m^o)} - 10^{-b(m^u-m^o)}}{1-10^{-b(m^u-m^o)}} \qquad (2\text{-}4)$$

where $\alpha(m^o)$ is the annual frequency of occurrence of earthquake greater than the minimum magnitude, m^o; b is the Gutenberg-Richter parameter defining the slope of the recurrence curve; and m^u is the upper-bound magnitude event that can occur on the source. A m^o of **M** 5.0 was used for the hazard calculations; this value is also used by the USGS in the National Hazard Maps (Frankel *et al*., 1996; Petersen *et al*., 2008).

A popular model often used in PSHA is where faults rupture with a "characteristic" magnitude on specific segments; this model is described by Aki (1983) and Schwartz and Coppersmith (1984). For the characteristic model, the numerical model of Youngs and Coppersmith (1985) is often used. In the characteristic model, the number of events exceeding a given magnitude is the sum of the characteristic events and the non-characteristic events. The characteristic events are distributed uniformly over a ± 0.25 magnitude unit around the characteristic magnitude and the remainder of the moment rate is distributed exponentially up to the characteristic range using the above equation (Youngs and Coppersmith, 1985).

The maximum moment model can be regarded as an extreme version of the characteristic model. The model proposed by Wesnousky (1986) is often used when there is no exponential portion of the recurrence curve, i.e., no events can occur between the minimum magnitude of **M** 5.0 and the distribution about the maximum magnitude.

The recurrence rates for the fault sources are defined by either the slip rate or the average return time for the maximum or characteristic event and the recurrence *b*-value. The slip rate is used to calculate the moment rate on the fault using the following equation defining the seismic moment:

$$M_o = \mu A D \qquad (2\text{-}5)$$

where M_o is the seismic moment, μ is the shear modulus, A is the area of the rupture plane, and D is the slip on the plane. Dividing both sides of the equation by time results in the moment rate as a function of slip rate:

$$\dot{M}_o = \mu A S \quad (2\text{-}6)$$

where $\dot{M}_o$ is the moment rate and S is the slip rate. M_o has been related to moment magnitude, **M**, by Hanks and Kanamori (1979):

$$\mathbf{M} = 2/3 \log M_o - 10.7 \quad (2\text{-}7)$$

Using this relationship and the relative frequency of different magnitude events from the recurrence model, the slip rate can be used to estimate the absolute frequency of different magnitude events.

The average return time for the characteristic or maximum magnitude event defines the high magnitude (low likelihood) end of the recurrence curve. When combined with the relative frequency of different magnitude events from the recurrence model, the recurrence curve is established.

2.2 GROUND MOTION PREDICTION

To characterize the ground motions at a specified site as a result of the seismic sources considered in the PSHA, we used ground motion prediction models for spectral accelerations (Figure 2; Section 4.2). Ground motion prediction models have at a minimum the variables of magnitude, distance, and site condition (e.g., rock, soil).

The uncertainty in ground motion models was included in the PSHA by using the log-normal distribution about the median values as defined by the standard deviation associated with each model. This distribution was truncated at five standard deviations above the median value predicted by the each model. We have tested our approach using the five sigma truncation against the test cases contained in EPRI/DOE/NRC (2012) where sigma was untruncated. The differences are insignificant.

In this section, we describe the seismotectonic setting and historical seismicity of the site region and the site geology.

3.1 SEISMOTECTONIC SETTING

Joppa Power Station is located in southern Illinois, within the NMSZ and about 65 km southwest of the WVSZ (Figure 4). Although the site is located within the continental interior and far from active plate boundaries, the preexisting structures formed in earlier tectonic settings are still capable of generating seismicity that can pose a hazard to the region. This seismicity has included several large historical earthquakes in the region (**M** > 7), e.g., the 1811 and 1812 New Madrid earthquakes (Figure 1).

The CEUS is part of a broad mid-plate compressive stress province that also includes most of Canada (Zoback and Zoback, 1991). Over this large region, the stress field is oriented with a relatively uniform east-northeast direction of maximum horizontal compression. This compression direction corresponds well to the direction of absolute plate motion of the North American Plate, which suggests that a far-field tectonic source such as ridge-push or basal drag at the Mid-Atlantic Ridge may be the primary source of stress in the mid-plate region (Zoback and Zoback, 1991).

3.2 HISTORICAL SEISMICITY

The following is a discussion of the historical seismicity and significant earthquakes in the region surrounding the Joppa Power Station.

3.2.1 Historical Seismicity Catalog

A historical seismicity catalog was derived mainly from the CEUS Seismic Source Characterization (CEUS-SSC) catalog (EPRI/NRC/DOE, 2012). This catalog includes data primarily from the catalog compiled by the U.S. Geological Survey (USGS) for the National Seismic Hazard Mapping Project (Mueller *et al*., 1997; Petersen *et al*., 2008) and from the Geological Survey of Canada (GSC) catalog for seismic hazard analyses (Adams and Halchuk, 2003). The main source for the USGS catalog was the NCEER-91 catalog (Seeber and Ambruster, 1991) which updated the original EPRI-SOG (EPRI 1988) catalog. The catalog was then updated using the National Earthquake Information Center's (NEIC) Preliminary Determination of Epicenters (PDE) and data from the National Earthquake Database (NEDB) of Canada. Researchers reviewed original catalogs and special earthquake studies to verify and if needed update original entries, and regional catalogs were incorporated into the continental scale catalogs described above (see EPRI/NRC/DOE, 2012 for details of special study references and list of regional catalogs used). The CEUS-SSC catalog spans the time period of 1568 to 2008. We updated this catalog with more recent data (up to May 2015) from the Advanced National Seismic System (ANSS) and NEIC PDE catalogs (Figure 1).

All of the events in the USGS catalog used to compile the CEUS-SSC catalog have body-wave (m_b) magnitude values, which were converted to **M** using the equations of Atkinson and Boore (1995):

$$\mathbf{M} = -0.39 + 0.98Mn \text{ for magnitudes} \leq 5.5$$

$\mathbf{M} = 2.715 - 0.277Mn + 0.127(Mn^2)$ for magnitudes > 5.5

and Johnston (1996):

$\mathbf{M} = 1.14 + 0.24\ m_b + 0.0933\ m_b^2$

Mn (Nuttli magnitude) was considered to be equivalent to m_b. All events in the ANSS catalog that we used to update the CEUS-SSC catalog were Mn or M_D. We converted the ANSS Mn magnitudes to **M** using the average of Atkinson and Boore (1995) and Johnston (1996). For the M_D values, we used the same conversion used in the CEUS-SSC catalog to convert them to **M** values for the Midcontinent U.S. east of 100º W (EPRI/DOE/NRC, 2012).

$\mathbf{M} = 0.869 + 0.762\ M_D$

3.2.2 Significant Earthquakes

The most significant earthquakes to have occurred in the CEUS are the 1811-1812 **M** 7 to 8 New Madrid earthquake sequence and the 1886 **M** 6.8 Charleston, South Carolina, earthquake (Figure 1). The New Madrid earthquake sequence occurred over the winter of 1811-1812 in southeastern Missouri/northeastern Arkansas. This sequence, which was felt as far away as the East Coast (Figure 5), consisted of three principal events on 16 December 1811, 23 January 1812, and 7 February 1812 (referred to as NM1, NM2, and NM3, respectively in Hough *et al*., 2000) (Figure 6). Because the epicentral region was sparsely populated at the time of the events, little structural damage occurred, and the maximum Modified Mercalli (MM) intensity is IX (NM1) as reinterpreted by Hough *et al.* (2000). The power station site probably underwent strong ground shaking of MM VIII to IX in the 16 December 1811 mainshock (Figure 5). The NMSZ is currently the most seismically active area in the CEUS (Figure 1).

The Wabash Valley, which encompasses southern Illinois and southwestern Indiana and is 65 km northeast of the site, has historically been seismically active with several earthquakes of **M** 4.5 and larger (Figure 4). Hence, the site has been strongly shaken numerous times after the 1811-1812 and 1886 earthquakes. An event on 27 September 1891 occurred near Mt. Vernon, Illinois, which caused chimney damage in the epicentral area (Stover and Coffman, 1993). The size of the earthquake was estimated to be a body-wave magnitude (m_b) 5.8 and the event was felt widely in several states (Figure 7). Shaking at the site could have been as strong as MM IV.

On 31 October 1895, an earthquake of estimated surface wave magnitude (M_S) 6.7 struck the northern end of the NMSZ (Figure 8). This is the largest earthquake to have occurred in the central Mississippi Valley since 1811-1812 (Stover and Coffman, 1993). The event caused extensive damage in the town of Charleston, Missouri. Sand blows due to liquefaction were also reported in the epicentral area (Stover and Coffman, 1993). In the area of the site, the ground shaking was probably at MM VI to VII level (Figure 8).

On 9 November 1968, a m_b 5.5 earthquake struck southern Illinois and neighboring states with a maximum reported MM VII (Figure 9). Damage consisted of damaged chimneys, broken windows, cracked or fallen plaster, cracked foundations, and scattered instances of collapsed parapets (Stover and Coffman, 1993). The site was probably subjected to MM V to VI ground shaking from this event. Another notable earthquake was the 18 April 2008 **M** 5.4 Southern Illinois earthquake northeast of the site (Figure 1).

On 27 July 1980, a **M** 5.1 earthquake struck the area near Sharpsburg, Kentucky. This event, the strongest in the history of Kentucky, occurred approximately 450 km northeast of the site and caused over $1 million in property damage (Stover and Coffman, 1993). The site was probably subjected to intensities of MM II to III (Figure 10).

3.3 SITE GEOLOGY

The site lies in the central portion of the Illinois Basin, a northwest-southeast oriented regional-scale structural depression that includes Illinois, Indiana, Kentucky and portions of Tennessee and Missouri. Underlying the region is a thick sequence of Paleozoic sedimentary rock. More recent deposits of clay, silty clay, sandy clay, sand, gravel, and weathered limestone cover the bedrock. The regional bedrock consists of sequences of shale, siltstone, sandstone, coal, and limestone overlying Precambrian crystalline basement rock. The thickness of the sedimentary bedrock units varies and is controlled by depositional environment and geologic structure.

Recent borings completed after August 3, 2015, show clay, silty-clay, and sandy clay underlain by a dense sand stratum encountered between approximately 45 and 65 ft below the ground surface. Sampling generally indicates that this denser stratum consists of varying degrees of fine to medium sand, medium to coarse sand, and gravel. The actual thickness of this layer was not determined, as none of the recent borings extended through this denser layer. Hard limestone was reportedly encountered between approximately 195 and 245 ft below the ground surface as recorded during the installation of deep wells. The limestone was reported to contain occasional streaks of shale and/or siltstone and/or flint. Between the denser sand and gravel layer encountered in the recent field investigations and the hard limestone reportedly encountered in the deep well logs is a layer which is believed to consist largely of broken and/or weathered limestone.

The following discusses the two major inputs into the PSHA: the seismic source model and the ground motion prediction models.

4.1 SEISMIC SOURCE MODEL

Seismic source characterization is concerned with three fundamental elements: (1) the location, geometry, and characteristics of significant sources of future earthquakes; (2) the maximum size of these earthquakes; and (3) the rate at which different size earthquakes occur. Two types of seismic sources were considered in this PSHA: discrete fault or fault zone sources and regional seismic source zones.

The seismic source characterization presented here is adopted from the comprehensive seismic source characterization of the CEUS, developed for nuclear facilities by EPRI/DOE/NRC (2012). Two zonation models that account for earthquakes associated with buried or generally unknown faults (background) were characterized and included in the PSHA; these models include multiple zones, many having alternative geometries (Figures 11 and 12). In addition, the source parameters for several fault sources or RLMEs (repeated large magnitude earthquakes) (Figure 11) were characterized for input into the PSHA.

A major challenge in understanding the earthquake potential in the CEUS has been associating the observed seismicity with specific geologic structures. Few active faults are known east of the Rocky Mountains. Thus the traditional approach in addressing the seismic hazard in the CEUS has been to rely on the historical earthquake record in conjunction with seismic source zones that separate regions of different seismotectonic characteristics and hence possibly different earthquake potential. Each seismic source zone is defined and characterized according to geologic, tectonic, and seismicity data. The zones comprise regions having a common geologic history that distinguishes them from neighboring areas. They may have a similar structure (e.g., faults or fractures of similar age, type, orientation), a similar pattern of seismicity, and/or a homogeneous stress regime. The EPRI/DOE/NRC (2012) model retains this methodology by dividing the CEUS into numerous “seismotectonic zones”, defined by differences in various seismic source assessment criteria such as style of faulting, earthquake recurrence, maximum magnitude, seismogenic thickness, etc. The model includes an alternative approach to dividing the CEUS into source zones, which is based solely on the expected maximum magnitude in the zone. This alternative zonation approach divides the study area into “Mmax zones” (Figure 12). The seismotectonic zone approach receives slightly higher weight, 0.6, than the Mmax zone approach, 0.4.

Figures 11 and 12 show the locations of the seismotectonic and Mmax zones. There are three Mmax zones and 12 seismotectonic zones in the EPRI/DOE/NRC model. The Mmax zones and some seismotectonic zones have one or more alternate geometries. Table 1 summarizes the source zone parameters used in the analysis. (Not all seismic source zones are shown on Figure 11.) The station lies in the Reelfoot Rift zone (RR), 16 km from the New Madrid North fault (NMN) (Figures 6 and 11).

Table 1
Seismic Source Zones Incorporated Into Analysis

Source Zone	Symbol	Mmax (M)[1]	Seismogenic Depth[2] (km)	Area (km^2)
Seismotectonic Zones				
Atlantic Highly Extended Crust	AHEX	6.0 6.7 7.2 7.7 8.1	8 (0.5) 15 (0.5)	177683
Extended Continental Crust–Atlantic Margin Zone	ECC-AM	6.0 6.7 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	881480
Extended Continental Crust–Gulf Coast	ECC-GC	6.0 6.7 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	1239288
Gulf Highly Extended Crust	GHEX	6.0 6.7 7.2 7.7 8.1	8 (0.5) 15 (0.5)	509090
Great Meteor Hotspot Zone	GMH	6.0 6.7 7.2 7.7 8.1	25 (0.5) 30 (0.5)	32250
Illinois Basin Extended Basin Zone	IBEB	6.5 6.9 7.4 7.8 8.1	13 (0.4) 17 (0.4) 22 (0.2)	114526
Midcontinent Craton Zone (all alternatives)	MidC	5.6 6.1 6.6 7.2 8.0	13 (0.4) 17 (0.4) 22 (0.2)	4258598 4246625 4025001 4013028
Northern Appalachian Zone	NAP	6.1 6.7 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	378331
Oklahoma Aulacogen Zone	OKA	5.8 6.4 6.9 7.4 8.0	15 (0.5) 20 (0.5)	53583

Source Zone	Symbol	Mmax (M)[1]	Seismogenic Depth[2] (km)	Area (km^2)
Paleozoic Extended Crust (Narrow and Wide alternatives)	PEZ	5.9 6.4 6.8 7.2 7.9	13 (0.4) 17 (0.4) 22 (0.2)	365395 598992
Reelfoot Rift Zone	RR	6.2 6.7 7.2 7.7 8.1	13 (0.4) 15 (0.4) 17 (0.2)	69479
Reelfoot Rift with Rough Creek Graben Zone	RR and RR_RCG	6.1 6.6 7.1 7.6 8.1	13 (0.4) 15 (0.4) 17 (0.2)	81452
St. Lawrence Rift Zone	SLR	6.2 6.8 7.3 7.7 8.1	25 (0.5) 30 (0.5)	329322
Mmax Zones				
Mesozoic and Younger Extended Crust - Narrow	MESE-N	6.4 6.8 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	3616923
Mesozoic and Younger Extended Crust - Wide	MESE-W	6.5 6.9 7.3 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	4342413
Non-Mesozoic and Younger Extended Crust - Narrow	NMESE-N	6.4 6.8 7.1 7.5 8.0	13 (0.4) 17 (0.4) 22 (0.2)	4792101
Non-Mesozoic and Younger Extended Crust - Wide	NMESE-W	5.7 6.1 6.6 7.2 7.9	13 (0.4) 17 (0.4) 22 (0.2)	4066611
Study Region	Study Region	6.5 6.9 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	8409024

Notes:

[1] Weights for all magnitude distributions are 0.101/0.244/0.310/0.244/0.101, a discrete five-point approximation to an arbitrary continuous distribution (EPRI/DOE/NRC, 2012).

[2] Weights for depth in parentheses

The EPRI/DOE/NRC (2012) model includes sources defined based on RLMEs rather than only fault sources. Many of the RLMEs correlate with identified geologic faults, but some are defined solely by geographically clustered paleoliquefaction events that suggest a localized source even if the responsible fault has not been identified and characterized. The site lies approximately 16 km to the east of the New Madrid fault system (NMFS), 60 km southwest of the Wabash Valley RLME, and 60 km north of the Reelfoot Rift-Eastern Rift Margin (ERM) fault (Figures 6 and 11). Although quite distant from the site, we include the Charleston source (Figure 11) in the PSHA because its maximum earthquakes and relatively high activity rates often dominate the hazard in the CEUS, particularly at long-period ground motions. Tables 2 and 3 summarize the RLME (fault) source parameters used in the analysis.

4.1.1 Seismotectonic Zones

This section describes the seismotectonic characteristics of the most significant seismotectonic zones to the site, the basis for delineating the zones and for defining the model values for style of faulting, geometry, seismogenic depth, and Mmax. Recurrence for the zones is discussed in Section 4.1.3.

Reelfoot Rift Zone (RR)

The Reelfoot Rift zone (RR) is a north-northeast-trending major crustal rift located within the Mississippi Embayment of the south-central United States; southern Illinois and the site are located in the RR zone (Figure 6). The RR originally formed in late Precambrian to early Paleozoic time during the breakup of Rodinia and Iapetan rifting (Bond *et al*., 1971; Hildenbrand, 1985; Thomas, 2006), but experienced middle to late Paleozoic uplift and Mesozoic extension and deposition (Kolata and Nelson, 1991). Geologic evidence for faulting from post-Cretaceous to Holocene time in the RR and adjacent areas includes shallow seismic reflection data (Koffi *et al*., 1997; Schweig and Van Arsdale, 1996; Sexton *et al*., 1996); faulting and fault-related deformation exposed in exploratory trenches (Kelson *et al*., 1996); and regional paleoliquefaction features (Tuttle and Schweig, 1995; Tuttle *et al*., 1996a and 1996b; Tuttle and Schweig, 1996; Wolf *et al*., 1996).

The RR contains several RLME sources in the EPRI/DOE/NRC source model, including the NMFS, the Eastern Rift Margin (ERM), Marianna zone (MAR), and Commerce fault zone (CFZ), which is part of the Commerce Geophysical lineament (CGL) (Figure 6). The NMFS is discussed in detail in Section 4.1.4 because of its relatively high rate of activity.

The RR is characterized by having experienced Mesozoic extension and having a higher rate of seismicity than the surrounding MidC cratonic seismotectonic zone, as well as containing a unique concentration of Quaternary active faults. The RR has two alternative geometries, based on inclusion or exclusion of the east-west-trending Rough Creek graben. The Rough Creek graben was formed as part of the late Proterozoic-Cambrian Iapetan intracontinental rifting episode that created the Reelfoot Rift. Some structures may have been reactivated during the Appalachian-Ouachita Orogeny (Kolata and Nelson, 1991) like the RR. However, due to the lack of associated igneous rocks, Wheeler (1997) infers that deeply penetrating faults were not reactivated. This coupled with the different strike of the major faults in the RCG compared to those in the RR leads EPRI/DOE/NRC (2012) to put lower weight (0.33) on the combined RR-RCG zone; rather, they prefer to include the RCG in the MidC zone.

The largest historical earthquakes in the RR are the 1811-1812 **M** 7.5 to 8 events, which are included in the characterization of the NMFS RLME (Figure 6). Large magnitude paleoseismic events are also included in nearby RLME characterizations. The largest non-RLME historical earthquakes include two approximately **M** 6 events in 1843 and 1895. The Mmax distribution for the RR ranges from **M** 6.1 to **M** 8.1, with a preferred value of **M** 7.1 (Table 1). Seismogenic depth in the RR, based on seismicity, ranges from 13 to 17 km (8.1 to 10.6 mi).

Illinois Basin Extended Basement Zone (IBEB)

The Illinois Basin Extended Basement Zone (IBEB) encompasses southwestern Indiana and southeastern Illinois (Figure 11). Southern Indiana and southern Illinois are characterized by several moderate-sized paleoearthquakes and by higher rates of seismicity than adjacent craton regions (Figure 4). Several characteristics combine to support the delineation of IBEB as a separate seismotectonic zone. The southern part of the Illinois basin is one of the most structurally complex areas of the Midcontinent (McBride *et al*., 2002), with a crust distinct from that of the neighboring craton. Numerous moderately dipping reflectors interpreted to be faults are present in the basement. Moderate-sized historical earthquakes that appear to be spatially associated with Precambrian basement faults and with Paleozoic faults suggest continued reactivation of older basement features as well as younger Paleozoic structures (McBride *et al*., 2002). Stresses induced by Mesozoic rifting possibly extend into the southern Illinois basin causing the reactivation of deep structures (Braile *et al*., 1984). The IBEB is defined to characterize sources of moderate- to large-magnitude earthquakes (excluding those attributed to the Wabash Valley RLME source) that may occur on deep structures in the Precambrian basement and as Paleozoic faults that extend into the overlying Paleozoic sedimentary rocks (EPRI/DOE/NRC 2012).

Fault dips are generalized based on sense of slip, with strike-slip ruptures assigned steep dips between 70° and 90° and reverse ruptures assigned moderate dips between 40° and 70°. Seismogenic thickness ranges from 13 to 22 km (8.1 to 13.8 mi), the default values for the entire study area (EPRI/NRC/DOE, 2012). The seismogenic thickness is based on reported depths of seismicity within the IBEB. The deepest well-constrained earthquake hypocenters in the deep part of the Illinois basin, are located at depths of 20 to 22 km (12.4 to 13.7 mi) (McBride *et al.*, 2002; Yang *et al*., 2009). However, the average depth throughout the IBEB based on other historical earthquakes may be less (EPRI/DOE/NRC, 2012).

The largest earthquakes in the IBEB include an August 1891 **M** 5.5 event, a September 1891 **M** 5.0 event in eastern Nebraska, and a 2008 **M** 5.3 event. Four prehistoric earthquakes inferred from the paleoliquefaction studies have estimated magnitudes (**M** 6.2 to 6.3) that are larger than the historical earthquakes (EPRI/DOE/NRC, 2012). Maximum magnitudes modeled in the IBEB range from **M** 6.5 to 8.1, with a value of **M** 7.4 being preferred.

Midcontinent-Craton Zone (MidC)

The MidC occupies most of the CEUS study area, dominating the central United States and encompassing most of the Great Plains area (Figure 11). The MidC includes those regions of the continent that have not occupied the Phanerozoic continental margin, specifically Precambrian basement rocks of the Canadian shield and the platform (EPRI/DOE/NRC, 2012). The craton was formed by Paleoproterozoic accretion and now forms a cold, strong crustal core to the

continent. Two orthogonal sets of structures, northeast-striking ductile shear zones and northwest-striking brittle-ductile faults dominate the Precambrian basement structure (Sims *et al*., 2005). Numerous geophysical anomalies have been observed within the MidC zone and may represent zones of crustal weakness that could localize future seismicity. Seismicity in the MidC zone is spatially variable and includes a few concentrations of activity that constitute seismic zones within the greater seismotectonic zone, such as the Anna seismic zone and Northeast Ohio seismic zone in Ohio, and the Nehama Ridge seismic zone in Kansas.

The fundamental distinguishing characteristic of the MidC is that it contains crust that has not experienced Mesozoic or younger extension, and generally not Paleozoic extension either. The characterization of the seismotectonic zone includes four alternative geometries, based on the inclusion or exclusion of smaller Midcontinent regions. These smaller zones include a northeast-trending band of crust along the Appalachian Mountains that is included either within the PEZ or within the MidC zone, and the Rough Creek Graben, which is included either in the RR or in the MidC zone (Figure 11).

The largest earthquakes in the MidC include a 1909 **M** 5.7 event in eastern Montana, an 1877 **M** 5.5 event in eastern Nebraska, and a 1964 **M** 4.8 earthquake in eastern Ontario. Maximum magnitudes have a broader distribution in the MidC than most other seismotectonic zones, ranging from **M** 5.6 to 8.0, with a value of **M** 6.6 being preferred.

Few data exist to characterize independently the deep Precambrian structures within the intracratonic MidC region on which future earthquakes might be preferentially located. Thus the characterization of the MidC region is equivalent to what EPRI/DOE/NRC (2012) calls the "default" seismotectonic characteristics, representative of the entire study region. Thus both strike-slip and reverse mechanisms are included, with a 2/3 weight on strike-slip, reflecting the occurrence of both mechanisms in focal mechanism data, the state of stress, and the orientation of existing geologic structures in the region. Strikes include northwest, north-south, northeast and east-west orientations, determined based on focal mechanism data, tectonic stress, and structural grain within the study area. The dips are generalized based on sense of slip, with strike-slip ruptures assigned steep dips between 60° and 90° and reverse ruptures assigned moderate dips between 30° and 60°. Seismogenic thickness ranges from 13 to 22 km (8.1 to 13.8 mi).

4.1.2 Mmax Zones

The Mmax zones are based on the observation that within the global catalogue of earthquakes within stable continental regions, there is little to distinguish any of them in a statistically significant way except that larger earthquakes seem to occur more commonly within those parts of the stable continental regions that have undergone extension, especially Mesozoic or younger extension (Johnston *et al*., 1994). Consequently, the zonation model is based on using global analogues to characterize the maximum magnitudes, with regions divided into extended and cratonic categories, each with a different distribution of maximum magnitudes. We adopt the zone boundaries and maximum magnitude distribution of EPRI/DOE/NRC (2012). The maximum magnitude distributions are used for the background seismicity.

The EPRI/DOE/NRC statistical analysis of the global database of earthquakes in stable continental regions (SCR) showed that the distinction between Mesozoic extended crust and non-

extended crust noted by Johnston *et al*. (1994), while present, is only marginally significant. Therefore, within the Mmax zonation approach, two models are included: 1) the CEUS is divided into two Mmax zones, each with its own Mmax distribution, based on the presence or absence of Mesozoic-extended crust, and 2) the CEUS can be described by a single Mmax zone with a single Mmax distribution (Figure 12). The former model has slightly higher weight because of the marginally significant difference observed in the statistical analyses.

Mesozoic and Younger Extended Crust (MESE)

The Mesozoic extended zone (MESE) includes areas that underwent Paleozoic and Mesozoic or younger extension and includes the Atlantic and Gulf coastal regions as well as the failed rifts in the central U.S. (including the RR and southern Oklahoma aulocogen) (Figure 12). The site is located within the MESE (Figure 12).

Non-Mesozoic and Younger Extended Crust (NMESE)

The Non-Mesozoic and Younger extended crust (NMESE) includes that part of the CEUS stable continental region that has not undergone Mesozoic or younger extension. This includes primarily interior cratonic regions and overlaps significantly with the MidC seismotectonic zone (Figure 12).

The boundaries between the extended and non-extended Mmax zones have two alternatives, reflecting uncertainty in the geographic extent of extended crust (Figure 12). The MESE-N (N = "narrow") zone includes regions that have definitively experienced Mesozoic extension as inferred based on the presence of certain distinguishing characteristics. These may include: Mesozoic grabens and rift basins, Mesozoic and younger plutons, Mesozoic and younger uplift and unroofing associated with normal faulting (EPRI/DOE/NRC, 2012). Generally, regions that meet most of these criteria are considered to be extended and are assigned to the MESE-N zone. Regions with less compelling evidence, such as localized Mesozoic and younger reactivation of older structures or the presence of structures favorably oriented for reactivation, are less certainly extended and are assigned to the MESE-W (W = "wide") zone. The NMESE-N and NMESE-W zones include the rest of the CEUS region outside the MESE-N and MESE-W zones, respectively (Figure 12). The narrow boundary, dividing definitively extended crust from the rest of the craton receives most of the weight (0.8) due to the lack of clear evidence for extension in the MESE-W zone.

The narrow and wide geometry for each zone has its own maximum magnitude distribution for this region, based on the largest historical earthquake known in each zone. These appear in Table 1 (Table 6.3.2-1 in EPRI/DOE/NRC, 2012).

Study Region

The single-zone alternative of the Mmax zone model includes the Study Region (StudyR) source zone (Figure 12), which encompasses the entire study area, which is represented by a single Mmax distribution. The distributions for seismogenic depth and Mmax for this zone appear in Table 1.

4.1.3 Recurrence for Seismic Zonation

The CEUS-SSC model is based on the spatial stationarity of seismicity, which is defined from small- to moderate-magnitude earthquakes that have occurred during a relatively short historical and instrumental record (EPRI/DOE/NRC, 2012).

For the seismotectonic and Mmax source zones, the seismicity rates are determined from the historical seismicity catalog. All dependent earthquakes were removed from the catalog, and earthquakes associated with the RLME sources were also removed to avoid double-counting. The cell size for all seismotectonic source zones except MidC was 0.25 degrees; the cell size for MidC was set to 0.5 degrees. The spatial smoothing operation, a penalized-likelihood function, is based on calculations of earthquake recurrence within each cell. Both *a*- and *b*- values are allowed to vary, but the degree of variation has been optimized such that *b*-values vary little across the study region, and the *a*-values are neither too smooth or spikey. Also, the recurrence calculations consider weighting of magnitudes in the recurrence rate calculations, with moderate events assigned more weight than smaller events.

Five alternative cases were considered for weights, which affect the degree of smoothing, for various magnitude bins; Cases A, B, C, D, and E (EPRI/DOE/NRC, 2012). Case C was dropped as it is very similar to Case B, and Case D was considered too extreme. Thus for each source zone three magnitude weighted cases were used: A, B, and E, with weights of 0.3, 0.3, and 0.4, respectively.

Furthermore, more than point estimates of the recurrence parameters are needed as modern PSHA requires an assessment of the epistemic uncertainty associated with these estimates, including correlations between the recurrence parameters of cells in the same geographical region, which may jointly affect the hazard at one site. The approach used to generate alternative maps of the recurrence parameters uses a technique known as Markov Chain Monte Carlo (MCMC) (EPRI/DOE/NRC, 2012).

This resulted in eight alternative maps representing the uncertainty in recurrence parameters that result from the limited duration of the catalog. If the smoothing parameters are treated as uncertain and estimated objectively from the data, the eight alternative maps also include the uncertainty about the appropriate values of the smoothing parameters. The eight realizations are equally weighted. For computational efficiency, the mean of the eight realizations was utilized in these calculations.

4.1.4 RLME

The following describes the New Madrid fault system RMLE, which is the closest and most significant RLME to the site.

New Madrid Fault System (NMFS) RLME

The New Madrid Seismic Zone (NMSZ) is the most likely site of the 1811-1812 New Madrid earthquake sequence, which includes three of the largest earthquakes to have occurred within the North American plate in historical times (Johnston and Shedlock, 1992) (Figure 6). The pattern of seismicity and surface uplift is generally interpreted as delineating a left-stepping, right-lateral, strike-slip fault system (Cox *et al*., 2001; Johnston and Schweig, 1996). Johnston and

Schweig (1996) developed faulting models for the 1811-1812 sequence based on geological, geophysical, seismological, and historical data. They concur with the commonly held assumption that the current seismicity is illuminating the most active faults; i.e., those that ruptured in 1811–1812 and also prior to 1811.

Schweig and Ellis (1994) and Johnston and Schweig (1996) provide summaries of the seismological, geodetic, and paleoseismologic data that have been used to assess the repeat times of large-magnitude events in the New Madrid region. In addition, Wheeler and Perkins (2000) provide additional information from the 2002 USGS National Hazard Maps for the CEUS. Correlation of dated liquefaction features suggest that widespread liquefaction occurred within the zone in A.D. 1811-1812, 1450, 900, 300 as well as about 2350 B.C. (Tuttle *et al*., 2005). Liquefaction deposits can constrain the ages of prehistoric events but not the causative faults. However, several of the prehistoric liquefaction deposits are composite, indicating they were formed in multiple episodes within a short period and thus may have occurred in a rapid sequence of large earthquakes similar to the 1811-1812 sequence.

The occurrence of two large events in A.D. ~900 and 2500-1400 B.C. is supported by recent studies of Mississippi River channel morphology that suggest that the Mississippi River changed its course in response to a sudden localized change in base level at those times (Holbrook *et al*., 2006). That change in base level is attributed to uplift of the downstream side of the channel across the Reelfoot reverse fault (described below).

These paleoseismic results indicate a recurrence interval of about 500 years for large earthquakes or earthquake sequences in the NMSZ over the past 2,000 years. The absence of paleoseismic evidence for earthquakes between 300 A.D. and 2200-2350 B.C. has been cited as indicative of temporal clustering of earthquakes in the NMSZ, with large earthquakes or earthquake sequences happening every few hundred years over a period of time followed by a long hiatus in activity (Holbrook *et al*., 2006). However, at this point it remains uncertain if the lack of events documented between A.D. 300 and 2200 B.C. in New Madrid is due to clustering or an incomplete paleoseismic record.

The possibly clustered behavior in the NMSZ, coupled with the discovery of paleoliquefaction features in the RR (indicative of large earthquakes between about 5,000 and 7,000 years ago but not during the New Madrid cycles), has led to the suggestion that the locus of earthquake activity moves around the RR on time scales of 5 to 15 kyr. In this model, the New Madrid region is the current, or most recent, locus of activity, but other areas have been so in the past, and the locus may shift again.

In the seismic source model, the elevated seismicity in the NMSZ is included in the RR seismotectonic zone, whereas large historical and paleoseismic events that likely occurred on the structures that ruptured in 1811-1812 are modeled as part of the NMFS RLME, in keeping with the CEUS-SSC model. The source zone accommodates the hazard from background seismicity; the NMFS contributes an additional hazard (Tables 1 and 2). In the seismic source model, the NMFS comprises three distinct fault zones, located within the NMSZ source zone (Figure 6). The three NMFS faults, defined after the models of Van Arsdale (2000) and Johnston and Schwieg (1996), include: 1) the southern section (NMS), comprising the Blytheville arch (BA), extending into the Blytheville fault zone (BFZ) and Bootheel lineament (BL) area, 2) the central section, comprising the Reelfoot reverse fault (RFT), and 3) the northern section, comprising the

New Madrid North fault and the Northwestern Seismicity Arm (NMN) (Figure 6; Table 2). Each of these sections ruptured to produce the 1811 and 1812 earthquakes.

The faults of the NMFS are defined primarily based on concentrations of seismicity as geomorphic expression of faulting is poor; only the RFT is well expressed as a definitively tectonic feature. Several different geologic faults have been postulated as the source of the events but there remains considerable uncertainty in defining the causative faults. The southern and northern sections of the fault system are northeast-striking features that are probably ancient faults related to rifting that have been reactivated in the modern stress regime as primarily right-lateral strike-slip faults. Focal mechanisms from these areas are consistent with predominantly dextral motion. The RFT strikes northwest and dips southwest; earthquakes associated with it have a variety of focal mechanisms. The fault has been described as a cross-structure in a compressional left step between right-lateral strike-slip faults.

Van Arsdale (2000) reports that the first of the 1811 and 1812 earthquakes, the NM1 event in December 1811, occurred on the southern section (NMS), which extends about 110 km (69 mi) from northeastern Arkansas to the southeastern bootheel of Missouri (EOI, 2008). The rupture occurred along the Blytheville arch, a 10 to 15-km (6.25 to 9.4-mi) wide northeast-trending Paleozoic upwarp that lies along the axis of the RR, and extended northeast of the arch proper. Van Arsdale (2000) considers that the event may have resulted from rupture of the 65-km (41-mi) long, steeply dipping to vertical, dextral-oblique Cottonwood Grove-Ridgely fault. Johnston and Schweig (1996) assign the northern extension of the rupture to the Blytheville fault, a 55-km (34-mi) long structure that continues on trend with the Blytheville arch and lies about 4 km east of the Cottonwood Grove fault. However, they suggest the Blytheville fault and the Cottonwood Grove fault may be essentially the same structure.

Johnston and Schweig (1996) propose two alternative rupture scenarios for the December earthquake: 1) the Blytheville Arch region ruptured along with its extension to the northeast, the Blytheville fault (NMS: BA-BFZ) and 2) the Blytheville Arch ruptured, but the rupture branched onto the Bootheel lineament and ruptured the northernmost 70 km of that structure (NMS: BA-BL) (Figure 6). In each scenario, the structure that did not rupture in the main event was the source of one of more of the large aftershocks, which have been proposed as smaller mainshocks (Johnston and Schweig, 1996). In other words, the Bootheel lineament and Blytheville fault sustained the aftershocks in the first and second scenarios, respectively.

The second mainshock of the New Madrid 1811-1812 sequence was the NM2 earthquake, in January 1812, on the northern margin of the fault system (NMN; Figure 6). The source of this event is also uncertain. The region is delineated by a line of seismicity, the Northwestern Seismicity Arm. Concentrated seismicity extends about 40 km (25 mi), with more sparse seismicity extending another 20 km (12.5 mi) to near the Illinois border. This seismicity has been postulated to be correlated with the New Madrid North fault (sometimes the East Prairie fault), which has been seen in the subsurface, geomorphically, and in trench exposures (Baldwin *et al*., 2005; Johnston and Schweig, 1996). That fault is at least 30 km (18.8 mi) long; the seismicity extends beyond the known fault. Wheeler (1997) postulated that the structure continued still farther north to merge with the Rough Creek graben in western Kentucky; he considered this

Table 2
New Madrid Fault System RLME Source Model

Cluster?	wt	Localizing Structures	Southern Fault Geometry	wt	Northern Fault Geometry	wt	Central Fault Geometry	wt	Thickness (km)	wt	Mmax	wt	Recurrence method	wt	Recurrence Data	wt	Earthquake Recurrence Model	wt	Repeat Time Coefficient of Variation	wt	Rate (yrs)	wt
All In	0.9	NMS NMN RFT	BA-BL	0.6	NMN-S	0.7	RFT-S	0.7	13	0.4	NMS, RFT, NMN 7.9, 7.8, 7.6	0.167	Intervals	1.0	1811-1812, 1450, and 900 AD	1.0	Poisson	0.75	NA		167	0.101
																					270	0.244
																					417	0.310
																					714	0.244
																					1613	0.101
											7.8, 7.7, 7.5	0.167	same as above				Renewal	0.25	0.3	0.2	286	0.101
											7.6, 7.8, 7.5	0.25									909	0.244
											7.2, 7.4, 7.2	0.085									3125	0.310
											6.9, 7.3, 7.0	0.25									15625	0.244
											6.7, 7.1, 6.8	0.085									212766	0.101
									15	0.4	same as above								0.5	0.5	208	0.101
									17	0.2											455	0.244
							RFT-L	0.3	same as above												1124	0.310
					NMN-L	0.3	same as above														3846	0.244
																					32258	0.101
			BA-BFZ	0.4	same as above														0.7	0.3	227	0.101
																					455	0.244
																					1000	0.310
																					2941	0.244
																					21277	0.101
All out except RFT	0.05	RFT	NA		NA		RFT-S	0.7	13	0.4	7.8	0.167	Intervals	1.0	2000 BC and 1000 AD	1.0	Poisson	1.0	NA		769	0.101
																					1389	0.244
																					2381	0.310
																					4545	0.244
																					12500	0.101
											7.7	0.167	same as above									
											7.8	0.25										
											7.4	0.085										
											7.3	0.25										
											7.1	0.085										
									15	0.4	same as above											
									17	0.2												
							RFT-L	0.3	same as above													
All Out	0.05	None	Revert to background																			

extent, about 100 km (62.5 mi), to be the maximum extent of RR faults. There is little in the sparse distribution of seismicity and lack of significant Quaternary faulting in the northern extent to support that assertion, and based on surface and subsurface expression as well as focal mechanisms, this fault is likely a steeply dipping dextral fault (DTEE, 2011).

The last of the three 1811-1812 mainshocks, NM3, occurred in February 1812, on the central section, the RFT, the proposed cross-structure in a compressional step-over between the dextral southern and northern sections of the system (Figure 6). The RFT is a south-dipping blind reverse fault that has a dip that varies laterally and down dip. The dip can be as steep as 45°-75° in the upper few kilometers and as shallow as 25°-30° at depth (Mueller and Pujol 2001; Csontos and Van Arsdale, 2008). This fault is well-expressed geomorphically with a pronounced scarp, but its extent is also uncertain because seismicity extends beyond the scarp in both directions, beyond the strike-slip faults of the postulated stepover. Johnston and Schweig (1996) define three distinct fault segments: 1) the central RFT, defined by its mapped surface extent of about 32 km (20 mi) (Van Arsdale *et al*., 1995); 2) the Reelfoot South seismicity trend, extending 35 km (21.9 mi) east of the RFT; and 3) the New Madrid West seismicity trend, extending about 40 km (25 mi) west of the RFT. Their proposed rupture scenarios include rupture of the RFT with one or the other of the flanking seismicity trends in the NM3 mainshock.

The third event may have served to accommodate the strain produced by the previous two bounding events (Van Arsdale, 2000). Van Arsdale (2000) also suggests that this sequence of multiple, temporally-clustered events may not be unusual for the NMFS. He cites evidence from subsurface analyses that suggests that these three faults may have identical displacement histories since the Late Cretaceous. Thus, he suggests that the paleoseismic history for the RFT can serve as a proxy for the other two faults. Trench exposures of the RFT indicate that deformation occurs primarily as folding rather than faulting at the surface and that the structure has experienced at least three earthquakes in the past 2400 years at times consistent with those determined from regional paleoliquefaction studies (Kelson *et al*., 1996). This interpretation is supported by paleoliquefaction studies, which indicate that large magnitude earthquakes on the faults of the New Madrid system have occurred in clusters like those of 1811-1812 (e.g., Tuttle *et al*., 2002; 2005).

There is significant uncertainty regarding the exact identification and geometry of the faults that ruptured in the 1811-1812 and earlier earthquakes, and some models of rupture (e.g., EPRI/DOE/NRC, 2012; STNOC 2011; USNRC, 2006) include weighted alternative geometries for each of the three faults. We adopt the characterization of EPRI/DOE/NRC (2012; Table 2). We include two alternative geometries for the northern extent of the southern section, the Blytheville fault zone (NMS: BA-BL), weighted 0.4, and the Bootheel Lineament (NMS: BA-BFZ), weighted 0.6. For the central and northern sections, we include two alternatives: short and long (RFT-S, RFT-L, NMN-S, NMN-L). The short central section (RFT-S) includes only that part of the RFT that is defined by the Reelfoot scarp and extends from the Blytheville fault to the New Madrid North fault; the long alternative (RFT-L) extends both east and west, based on continued seismicity. The short alternative for the New Madrid north fault (NMN-S) is the fault as defined by Johnston and Schweig (1996); the long alternative (NMN-L) extends the source along northward continuations of seismicity identified by Wheeler (1997). Because the causative faults are not well understood, the dips are not well constrained. The northern and southern

sections of the system are modeled as vertical. The RFT is modeled with a 40-degree southwest dip.

The EPRI/DOE/NRC (2012) characterization also addresses the apparent clustering of activity along the NMFS faults using the approach of Toro and Silva (2001). The rate of earthquakes and geomorphic expression of faulting on the RFT in the late Holocene suggests that the system is or has recently been in a cluster. However, geodetic data gathered over the last decade or so suggest that little or no interseismic deformation is occurring across the NMSZ, which some researchers have interpreted as evidence that the system is shutting down and entering an inter-cluster period of quiescence (e.g., Calais *et al*., 2005; Calais and Stein, 2009). The EPRI/DOE/NRC model strongly favors the interpretation that the system is currently in a cluster (0.9), based on the recent history of activity and the unlikelihood that we have just happened upon the exact moment the system is shutting down. However, they, and we, give some weight to two alternative models: 1) only the RFT is currently in a cluster, and the other faults are quiescent (0.5), and 2) the entire system is out of a cluster (0.5) (Table 3). In the former case, the RFT is active, but at a lower rate than the in-cluster case; in the latter case, no faults are active and the system defaults to the RR background zone characterization.

Several recent hazard analyses have developed source characterizations for the New Madrid faults. The USGS National Seismic Hazard Maps (Petersen *et al*., 2008) compiled recent data to develop a model with lower weighted mean magnitudes for the faults than in previous models, and with a recurrence model reflecting possibly clustered timing of events. Their magnitudes range from **M** 7.3 to 8.0 for the southern and central sections, with a preferred magnitude of **M** 7.7 and weighted mean of **M** 7.6, and from **M** 7.1 to 7.8 for the northern section, with a preferred value of **M** 7.5 and weighted mean of **M** 7.4. Models developed for the Site Safety Analysis for Exelon Generation Company in Illinois (USNRC, 2006) include a lower magnitude distribution, with **M** 7.2 to 7.9 (weighted mean **M** 7.5), **M** 7.4 to 7.8 (weighted mean of **M** 7.6), and **M** 7.0 to 7.6 (weighted mean of **M** 7.3) for the southern, central, and northern faults, respectively. EPRI/DOE/NRC (2012) include distributions for the NMS, RFT, and NMN sections of the NMFS of **M** 6.7 to 7.9, **M** 7.1 to 7.8, and **M** 6.8 to 7.6, respectively. In our model, we adopt the EPRI/DOE/NRC distribution of maximum magnitudes. The preferred values and weighted means are similar to those developed in the nuclear studies described above.

Table 3
RLME (Fault) Sources Incorporated Into Analysis

Fault	Geometry	Style of Faulting[1]	Mmax (M)	Dip (deg)	Seismogenic Thickness (km)	Recurrence Data[2]	Recurrence Interval (yr)[3]
Reelfoot Rift - Eastern Rift Margin Fault (ERM)							
ERM-N	ERM-N (1.0)	SS	6.7 (0.3) 6.9 (0.3) 7.1 (0.3) 7.4 (0.1)	90	13 (0.3) 15 (0.5) 17 (0.2)	1 event in 12-35 kyr (0.9)	3448 6667 12500 25000 71429
						2 events in 12-35 kyr (0.1)	2564 4545 7692 13889 31250
ERM-S	ERM-SCC (0.6)	SS	6.7 (0.15) 6.9 (0.2) 7.1 (0.2) 7.3 (0.2) 7.5 (0.2) 7.7 (0.05)	90	same as above	2 events in 17.7-21.7 kyr (0.333)	2857 4762 7143 12500 27778
						3 events in 17.7-21.7 kyr (0.334)	2326 3571 5263 8333 16129
						4 events in 17.7-21.7 kyr (0.333)	2000 2941 4167 6250 11111
	ERM-SRP (0.4)	same as above	same as above	same as above	same as above	same as above	same as above
Reelfoot Rift-Marianna In cluster (0.5) [Out of cluster (0.5) - default to background]	Marianna NW-strike (0.5)	SS	6.7 (0.15) 6.9 (0.2) 7.1 (0.2) 7.3 (0.2) 7.5 (0.2) 7.7 (0.05)	90	13 (0.3) 15 (0.5) 17 (0.2)	3 events in 9.6-10.2 kyr	1449 2381 3704 6250 13889
						4 events in 9.6-10.2 kyr	1190 1818 2703 4167 8333
	Marianna NE-strike (0.5)	same as above	same as above	same as above	same as above	same as above	same as above

Fault	Geometry	Style of Faulting[1]	Mmax (M)	Dip (deg)	Seismogenic Thickness (km)	Recurrence Data[2]	Recurrence Interval (yr)[3]
Reelfoot Rift - Commerce Fault Zone	Commerce fault (1.0)	SS	6.7 (0.15) 6.9 (0.35) 7.1 (0.35) 7.3 (0.1) 7.7 (0.05)	90	13 (0.3) 15 (0.5) 17 (0.2)	2 events in 18.9-23.6 kyr	4000 7143 12500 25000 71429
						3 events in 18.9-23.6 kyr	3030 5000 7692 13158 29412
Wabash Valley	Wabash Valley zone (1.0)	SS	6.75 (0.05) 7 (0.25) 7.25 (0.35) 7.5 (0.35)	90		2 events in 11-13 kyr	2273 4000 7143 13889 41667
Charleston	Local (0.5)	SS	6.7 (0.1) 6.9 (0.25) 7.1 (0.3) 7.3 (0.25) 7.5 (0.1)	90	13 (0.4) 17 (0.4) 22 (0.2)	2,000-yr record (0.8) 4 events in 2 kyr (1.0)	213 323 476 769 1471
						5,500-yr record (0.2) 4 events in 5.5 kyr (0.2)	213 323 476 769 1471
						5 events in 5.5 kyr (0.3)	370 526 769 1136 2000
						5 events in 5.5 kyr (0.2)	526 769 1086 1562 2941
						6 events in 5.5 kyr (0.3)	455 667 909 1282 2174
	Narrow (0.3)	SS	same as above	90	same as above	same as above	same as above
	Regional (0.2)	SS	same as above	90	same as above	same as above	same as above
New Madrid Fault System (NMFS)	see Table 2						

Note: Values in parentheses are weights. All faults are modeled with the Characteristic recurrence model

[1] SS Strike-slip

[2] "Recurrence Data" describes datasets used to calculate recurrence intervals.

[3] Weights for all distributions are: 0.101/0.244/0.310/0.244/0.101.

4.2 EPRI GROUND MOTION PREDICTION MODELS

Several factors control the level and character of earthquake ground shaking. These factors are in general: (1) rupture dimensions, geometry, and orientation of the causative fault; (2) distance from the causative fault; (3) magnitude of the earthquake; (4) the rate of attenuation of the seismic waves along the propagation path from the source to site; and (5) site factors, including the effects of near-surface geology, particularly from soils and unconsolidated sediments. Other factors, which vary in their significance depending on specific conditions, include slip distribution along the fault, rupture process, footwall/hanging-wall effects, and the effects of crustal structure such as basin effects.

Several parameters may be used to characterize earthquake ground motions. The common parameters include: peak ground acceleration, velocity, and displacement; response spectral accelerations or velocities, duration, and time histories in acceleration, velocity, or displacement. In this analysis, we have estimated peak horizontal ground acceleration (PGA) and horizontal spectral accelerations (SA) at 0.04, 0.1, 0.2, 0.4, 1.0, and 2.0 sec.

Crustal ground motion prediction models for tectonically active regions like the western U.S. are empirical in nature and derived from strong motion data from such areas as California, Taiwan, Japan, and Italy. In contrast, few useable strong motion records exist for earthquakes in the Central and Eastern North America (CENA). Thus ground motion prediction models for the CENA have been developed, in large part, using seismological-based numerical models. During the past decade, ground motion models for the CENA have been derived using three different approaches: the stochastic method, the Green's function method, and the complex/empirical source method.

Recent efforts have been made to update the ground motion models for the CENA. One project is called the Next Generation of Attenuation (NGA) – East sponsored by Pacific Earthquake Engineering Research (PEER) Center. The objective of the project is to develop a new suite of ground motion prediction model for the CENA. The median ground motion models were just released but no standard deviations for the models were specified. There are 20 new NGA-East models and we expect it will be several months before the models become vetted.

In a second project, EPRI (2013) updated the 2004/2006 EPRI models in the near-term so that preliminary Ground Motion Response Spectra (GMRS) could be developed for existing nuclear power plant sites as required by the NRC's Recommendation 2.1 pending completion of the NGA East Project. The models were used in this study. The EPRI Ground-Motion Model (GMM) Review Project (EPRI, 2013), an enhanced SSHAC Level 2 assessment process, established a methodology to evaluate the existing 2004 EPRI GMM and determine if it should be updated. After reviewing the current literature and conducting interviews and convening a workshop with ground-motion experts and seismologists it was decided to update the 2004 GMM because (1) seven of the thirteen developers of the 2004 EPRI GMM recommended that their models be replaced; (2) three new models have been developed for the CENA by ground-motion experts; (3) 80% of the earthquake records in a new ground-motion database provided by the NGA-East Project are from earthquakes that occurred after the development of the 2004 EPRI GMM; (4) comparisons to the updated CENA database indicate the 2004 EPRI GMM overpredicts ground motions at some magnitude-distance and structural frequency ranges that are

important to nuclear power plant PSHA; and (5) the models used to develop the aleatory portion of the 2006 EPRI GMM have been superseded.

The 2013 EPRI GMM retains the structure of the 2004 EPRI GMM, grouping the candidate individual models into four clusters according to their seismological characteristics, weighting the models within each cluster according to their consistency with the data, representing each cluster by three fitted relationships (5th percentile, median, and 95th percentile), and assessing cluster weights based on consistency with observed data and seismological attributes of the models within each cluster. The GMM Review Project identified new candidate models for the updated GMM clusters, models and weights, as shown in Table 4; a summary of the overall elements of the model are listed in Table 5.

For reference, the ground motion prediction models used by the USGS to develop the 2014 National Seismic Hazard Maps include Toro *et al.* (1997), Frankel *et al.* (1996), Silva *et al.* (2002), Atkinson and Boore (2006), Atkinson (2008), Campbell (2003), Tavakoli and Pezeshk (2005), Pezeshk *et al.* (2011), and Somerville *et al*. (2001). The versions of Atkinson and Boore (2006) and Atkinson (2008) in the EPRI study have been updated with Atkinson and Boore (2011). All the ground motion prediction models are for hard rock characterized by a time-averaged shear-wave (V_S) in the top 30 m (V_S30) of 2,800 m/sec.

Comparisons indicate that the 2013 GMM is somewhat lower than 2004 EPRI GMM when the two models are taken as a whole, but these differences are moderate, given the broad uncertainty range spanned by both GMMs. The greater differences occur at low frequencies. For PGA the bulk of the curves are consistent between the two GMMs. In addition, there is a substantial overlap in the 10 to 200 km range indicating that the updated GMM does not represent a radical departure from the 2004 EPRI GMM. The observed differences are the result of possessing and using substantially more data and having acquired additional insights from other regions over a period of nearly 10 years.

The 2006 EPRI model for aleatory uncertainty (sigma) was based on preliminary NGA-West 1 models for sigma from active tectonic regions, adjusted to account for differences in properties of the earth's crust between active (western North America [WNA]) and stable tectonic regions (i.e., CENA) (EPRI, 2006). The EPRI GMM Review Project updated the model to incorporate the nearly final NGA-West 2 aleatory models, with the same adjustments for differences between WNA and CENA. The updated sigma model is frequency and magnitude dependent, with inter-event and intra-event components. There is additional aleatory variability for distances of R_{JB} < 20 km. The updated aleatory variability model has higher values of total sigma than the 2006 EPRI model for **M** 5 earthquakes, and lower values for **M** 6 and 7 earthquakes for motions at 2.5 Hz and higher. At 1 Hz, the values of sigma are comparable in the two models and at 0.5 Hz, the updated GMM has slightly higher sigma than the 2006 EPRI model.

Table 4

EPRI (2013) GMM Clusters and Models

Cluster	Model Types and Cluster Weights (repeated large-magnitude earthquake sources/area earthquake sources)	Models
1	Single-corner Brune source (0.15/0.185)	Silva *et al*. (2002) – SC-CS-Sat[1] Silva *et al*. (2002) – SC-VS[1] Toro *et al*. (1997) Frankel et al. (1996)
2	Complex/Empirical Source $\sim R^{-1}$ geometrical spreading (0.31/0.383)	Silva *et al*. (2002) – DC-Sat Atkinson (2008) with 2011 modifications (A08′)
3	Complex/Empirical Source $\sim R^{-1.3}$ geometrical spreading (0.35/0.432)	Atkinson-Boore (2006) with 2011 modifications (AB06′) Pezeshk *et al*. (2011)
4	Finite-source /Green's function (0.19/0)	Somerville *et al*. (2001); slightly different models for rifted and nonrifted (not used for distributed seismicity sources with large contribution from **M** < 6)

SC = single-corner; DC = double-corner; CS = constant stress; VS = variable stress; Sat = saturation.
[1] Treated as one model for calculation of weights.

Table 5

Elements of the CENA Ground Motion Models

Feature	Attribute
Ground Motion Measure	Peak ground acceleration Spectral acceleration at frequencies of 0.5, 1, 2.5, 5, 10, 25 Hz
Site Conditions	Hard rock (V_S 2.8 km/sec, 9200 ft/sec)
Regions	Midcontinent (includes east coast) Gulf Coast
Ground Motion Model Types	Four types included: • Single-corner Brune source • Complex/empirical source ~R^{-1} geometrical spreading • Complex/empirical source ~$R^{-1.3}$ geometrical spreading • Finite-source/Green's function
Aleatory Variability	Magnitude and frequency dependent Includes additional variability for distances of R_{JB} < 20 km

4.3 SITE CONDITIONS

Subsurface investigations for the site have been limited to shallow soil borings in the upper Quaternary soils. Site response analysis requires detailed information on subsurface stratigraphy and accurate representation of V_S characteristics for rock and soil. *In situ* measurements of V_S and deep exploration of bedrock at the site were not within the scope of this project. At the site, seismic cone penetration tests (SCPT) were used to measure V_S of the upper layers; V_S identified below 145 ft were largely scattered and not well represented as a result of SCPT refusal. Table 6 illustrates a set of estimated unit thicknesses and estimated V_S used to develop the V_S profile at the site.

Based on Table 6, the mean basecase V_S profile used in the site response analysis (Section 6) was developed by combining layers of identical V_S (Figure 13). The mean value in the V_S ranges given in Table 6 were adopted for the mean basecase profile and the variability (factor of 1.57; Section 6.1.2) about that mean value was considered in developing the lower-range and upper-range basecase models.

Classification for site stratigraphy was based on the Nuclear Power Station report (Exelon, 2014), where rock groups were aggregated and classified according to geologic systems that each contain various rock types with thicknesses. Ranges for V_S are given to reflect the range of rocks included in each geologic system. In cases where weaker rock is thought to have an appreciable thickness that could affect the site response model, the layer was reported separately in the geologic system and assigned the lower range of values for V_S.

Table 6
Shear Wave Velocity Profile

Formation Bottom Depth at Joppa Plant (ft)	Thickness of Unit/Formation at Joppa Plant (ft)	Soil/Rock Description	Estimated Shear wave velocity (ft/sec)
45	45	Clay, Silty Clay, Sandy Clay	800-1,200
145	100	Sand and Gravel	800-2,000
200	55	Broken and weathered limestone	-
-	-	limestone	>9,000

The results of the PSHA are presented in terms of ground motion for hard rock site conditions as a function of annual frequency of exceedance (AFE). AFE is the reciprocal of the average return period. Figure 14 shows the mean, median (50th percentile), 5th, 15th, 85th, and 95th percentile hazard curves for PGA. (PGA is defined as the 0.01 sec spectral acceleration [SA].) These fractiles indicate the range of epistemic uncertainties about the mean hazard. The uncertainties are very large due to both the large uncertainties in the ground motion prediction models and the source parameters of the controlling seismic source. The 1.0 sec horizontal SA hazard is shown in Figure 15. The 2,500 year return period mean PGA is 0.71 g (Table 7).

The contributions of the various seismic sources to the mean PGA hazard are shown on Figure 16. The hazard at the site for a return period of 2,500 years is dominated by the NMFS RLME and the RR seismotectonic zone. The NMFS RLME contributes 69 percent of the PGA hazard at 2,500-year return period with the RR contributing 19 percent (Figure 17). At 1.0 sec SA, the NMFS RLME relative contribution increases to 87 percent of the hazard at 2,500 years (Figures 18 and 19).

By deaggregating the PGA and 1.0 sec SA hazard by magnitude, distance and epsilon bins, we can illustrate the contributions by events at a return period of 2,500 years (Figures 20 and 21). Epsilon is the difference between the logarithm of the ground motion amplitude and the mean logarithm of ground motion (for that M and R) measured in units of the standard deviation (σ) of the logarithm of the ground motion. As shown on Figures 20 and 21, a majority of the PGA and 1.0 sec SA hazard at the site is coming from the NMFS RLME (**M** 7.5 to 8.0 at 100 to 125 km and to a lesser extent **M** 7.25 to 7.75 within 50 km); background events (**M** 5.0 to 6.0 within 25 km) also contribute to the PGA hazard.

The deaggregation shown in Figures 20 and 21 also provides the modal magnitude M* and modal distance D*, which represent the largest contributor to the hazard at the defined return period. The M* and D* for the 2,500-year return period for PGA and 1.0 sec horizontal SA are listed in Table 8.

A horizontal Uniform Hazard Spectrum (UHS) on hard rock computed at 7 spectral periods for the 2,500-year return period is shown on Figure 22. A UHS shows the hazard across all periods for the same annual exceedance probability or return period. The SA hazard has been calculated at 0.01 (PGA), 0.04, 0.1, 0.2, 0.4, 1.0 and 2.0 sec. These are the spectral periods specified in the EPRI (2013) ground motion models.

Table 7

2,500-Year Return Period UHS for Hard Rock

Period (sec)	SA (g)
0.01	0.71
0.04	1.46
0.10	1.18
0.20	0.83
0.40	0.54
1.00	0.23
2.00	0.13

Table 8

Modal M* and D* at 2,500-year Return Period

	M*	D* (km)
PGA	7.6	113
1.0 Sec SA	7.6	113

The PSHA results are for hard rock and so we performed a site response analysis to adjust the ground motions to the ground surface. Traditionally in the estimation of site-specific probabilistic ground motions for a soil site, a rock ground motion is calculated and modified by deterministic site response analyses derived for the soil column to arrive at the ground motions at the soil surface. In doing so, the annual exceedance probability of that soil motion is generally unknown, varies with period, and may be of a higher probability than the control (rock) motion. If a risk analysis is desired, the surface motions must be hazard consistent, i.e., the annual exceedance probability of the soil ground motion should be the same as the rock ground motion.

In NUREG/CR-6728 (McGuire *et al.*, 2001), several site response approaches are recommended to produce soil motions consistent with the rock outcrop hazard. The approaches also incorporate the aleatory variabilities in the soil properties into the soil motions. McGuire *et al.* (2001) identified four basic approaches for determining the ground motions at a soil site. The approaches range from a PSHA using ground motion prediction models for the specific site (or location) of interest (Approach 4) to scaling the rock motion on the basis of a site response analysis using a broadband input motion (Approach 1). Conceptually, Approach 4 is the ideal approach and other approaches are approximations to it. However, Approach 4 is seldom used because rarely data are sufficient to develop site-specific ground motion models.

To compute the ground motions for the Joppa Station site, we implemented Approach 3 as it is called (McGuire *et al.*, 2001; Bazzurro and Cornell, 2004). Approach 3 is a fully probabilistic analysis procedure which moves the site response, in an approximate way, into the hazard integral. The approach is described by Bazzurro and Cornell (2004) and NUREG/CR-6769 (McGuire *et al*., 2002). In this approach, the hazard at the surface is computed by integrating the site-specific hazard curve at generic rock or soil level with the probability distribution of the amplification factors (Lee *et al*., 1998; 1999). The site-specific amplification, relative to a reference rock, in this case hard rock, is characterized by a suite of frequency-dependent amplification factors that can account for nonlinearity in soil/rock response. Approach 3 involves approximations to the hazard integration using suites of transfer functions, which result in complete hazard curves at the ground surface for specific ground motion parameters (e.g., spectral accelerations) and a range of frequencies.

The basis for Approach 3 is a modification of the standard PSHA integration:

$$P[A_S>z] = \int\int\int P\left[AF > \frac{z}{a} \middle| m,r,a \right] f_{M,R|A}\ (m,r;a) f_A(a) dm dr da \qquad (6\text{-}1)$$

where A_S is the random ground-motion amplitude on soil at a certain natural frequency; z is a specific level of A_S; m is earthquake magnitude; r is distance; a is an amplitude level of the random rock ground motion, A, at the same frequency as A_S; $f_A(a)$ is derived from the rock hazard curve for this same frequency (namely it is the absolute value of its derivative); and $f_{M,R|A}$ is the deaggregated hazard (i.e., the joint distribution of M and R, given that the rock amplitude is level a). AF is an amplification factor defined as:

$$AF = A_S/a \qquad (6\text{-}2)$$

where AF is a random variable with a distribution that can be a function of m, r, and a. To accommodate epistemic uncertainties in site dynamic material properties, multiple suites of AF

may be used and the resulting hazard curves combined with weights to properly reflect mean hazard and fractiles.

The ground surface response is controlled primarily by the level of rock motion and m, so Equation 6-1 can be approximated by:

$$P[A_S>z] = \int\int P[AF > \frac{z}{a}(m,a)]f_{M|A}(m;a)f_A(a)dmda \qquad (6\text{-}3)$$

where r is dropped because it has an insignificant effect in most applications (McGuire *et al.*, 2001). To implement Equation 6-3, only the conditional magnitude distribution for relevant amplitudes of a is needed. $f_{M|A}(m;a)$ can be represented (with successively less accuracy) by a continuous function, with three discrete values or with a single point, (e.g., $m^1(a)$, the mean magnitude given a). With the latter, Equation 6-3 can be simplified to:

$$P[A_S>z] = \int\int P[AF > \frac{z}{a}|a,m^1(a)]f_A(a)da \qquad (6\text{-}4)$$

where, $f_{M|A}(m;a)$ has been replaced with m^1 derived from deaggregation. With this equation, one can integrate over the rock acceleration, a, to calculate $P[A_S>z]$ for a range of surface amplitudes, z.

6.1 IMPLEMENTATION OF APPROACH 3

In Approach 3, the following steps were performed:

- Randomization of base case site-dynamic material properties to produce a suite of velocity profiles as well as G/Gmax and hysteretic damping curves that incorporate site randomness.
- Computation of transfer functions (hereafter termed amplification factors) as characterized by a mean and distribution for each set of base case site properties using the RVT-based equivalent-linear site response model.
- Full integration of the fractile and mean hazard curves for the generic site condition in this case hard rock and amplification factors to arrive at a distribution of site-specific hazard curves.

Specifically, the suites of rock hazard curves are first combined into a single suite and site-specific amplification factors applied using Approach 3. Combining the empirical hazard curves, rather than applying Approach 3 to each suite independently, results in the same mean hazard—the desired product—but does not properly preserve the full epistemic variability in the fractile estimates. As a result, the range in probability reflected in the resulting fractiles is likely somewhat underestimated. Although the fractiles are likely not significantly in error since the differences in hazard fractiles between the empirical relations are not large, the site-specific hazard fractiles should not be used for hazard or risk assessment.

Approach 3 is implemented through a number of computer programs. The computation of the amplification factors is the first phase of the calculations and is similar to what is done in other site-response approaches.

6.1.1 RVT-Based Equivalent-Linear Site Response Approach

The conventional site response approach in quantifying the effects of soil and other unconsolidated sediments on strong ground motions involves the use of time histories compatible with the specified outcrop response spectra to serve as control (input) motions. The control motions are then used to drive a nonlinear computational formulation to transmit the motions through the profile.

The computational formulation that has been most widely employed to evaluate 1D site response assumes vertically-propagating plane S-waves. Departures of soil response from a linear constitutive relation are treated in an approximate manner through the use of the equivalent-linear formulation. The equivalent-linear formulation, in its present form, was introduced by Idriss and Seed (1968). A stepwise analysis approach was formalized into a 1D, vertically propagating S-wave code called SHAKE (Schnabel *et al*., 1972). Subsequently, this code has become the most widely used and validated analysis package for 1D site response calculations.

The computational scheme employed to compute the amplification factors in this study uses an alternative approach employing RVT (Silva and Lee, 1987). In this approach, as embodied in the computer program RASCALS, the control motion power spectrum is propagated through the 1D soil profile using the plane-wave propagators of Silva (1976). The power spectrum is derived from the uniform hazard spectrum by spectral matching assuming the controlling earthquake. In this formulation only SH waves are considered. Arbitrary angles of incidence may be specified. In this case, vertical incidence was assumed.

Inputs to RASCALS are as follows:

- Location of input and output motions within the site profile.
- Input (control) motions characterized by earthquake power spectra.
- Incidence angles of input motion.
- A vertical profile consisting of homogeneous layers with specified thickness, seismic velocity, and density.
- Dynamic properties of the material at the site, consisting of strain-dependent shear modulus and damping curves for each layer.

Control motions (power spectral density) must be calculated for input into the site response analysis that are representative of the earthquake magnitude and distance dominating the hazard at the desired rate of exceedance. The basis for the control motions are the magnitude and distances specified by the hazard deaggregation.

Evaluation of site-response using the equivalent-linear site response model is based on convolution of appropriate control motions through randomized velocity profiles combined with randomized G/Gmax and hysteretic damping curves. The randomized profiles and curves are generated from base case velocity and nonlinear dynamic properties. The convolutions yield amplification factors for 5%-damped response spectra and peak ground velocity (PGV).

6.1.2 Inputs and Analysis

To perform the site response analysis, representative V_S profiles of the site and shear modulus (G/Gmax) reduction and damping curves are required.

For the computation of spectra for a site with uncertain properties and exhibiting a degree of lateral variability, a best-estimate (mean) basecase velocity profile (or profiles) (Table 9; Figure 13) is developed and used to simulate a number of V_S profiles. To address the epistemic uncertainty in the basecase V_S profile, an upper-range and lower-range basecase profiles were computed by using a factor of 1.57 (Figure 13). This factor was adopted from EPRI (2013) for sites where there are no site-specific V_S data. The upper-range basecase V_S profile was constrained to not exceed 2,800 m/sec (hard rock). Additionally, strain-dependent shear modulus and hysteretic damping are also randomized about best-estimate basecases. A large number of simulations can be required to achieve stable statistics on the response. To achieve statistical stability, 30 randomizations were produced using the velocity correlation models for each basecase velocity profile and each basecase nonlinear dynamic property curve. In order to randomly vary the V_S profile, a profile randomization scheme has been developed which varies both layer velocity and thickness. The randomization is based on a correlation model developed from an analysis of variance on about 500 measured V_S velocity profiles (EPRI, 1993; Silva *et al.*, 1996). Profile depth (depth to competent material) is also varied on a site specific basis using a uniform distribution. The depth range is generally selected to reflect expected variability over the structural foundation as well as uncertainty in the estimation of depth to competent material.

Associated with each of the 30 randomized profiles was also a set of randomized dynamic material property curves. For the dynamic material properties, the EPRI (1993) and Peninsular Range curves for cohesionless soils (Silva *et al.*, 1996) were used to approximate a nonlinear response over the top 250 ft, with linear response below (Silva *et al*., 1996). To accommodate the large uncertainty in nonlinear dynamic material properties, two sets of curves were used in the site-specific analyses. In addition to the EPRI (1993) curves, a subset of the EPRI (1993) curves was also used for each profile to account for the possibility that the site may behave more linearly. The second set, termed Peninsular Range curves, use the EPRI (1993) 51 to 120 ft curves for 0 to 50 ft and the 501 to 1,000 ft curves for deeper materials and reflect much more linear response than the EPRI curves. The two sets of curves were given equal weights and are considered to cover the range in nonlinear dynamic material properties.

Based on the RASCALS runs for the 30 V_S profiles for the three base case profiles, a probability distribution of amplification factors was calculated. Input control motions are computed using RASCALS for each set of 30 V_S profiles and dynamic property curves. RASCALS is used for horizontal spectra using normally-incident and inclined SH-waves. For each control motion, mean and standard deviation are computed from the 30 response spectra (from 30 randomized profiles). Thirty realizations result in stable estimates. The mean response spectrum from the 30 convolutions is divided by the mean (log) spectrum for hard rock spectrum to produce the amplification factors. The amplification factors include the effects of the inherent aleatory variability (randomness) of the site properties about each base case and any possible effects of magnitude of the control motions. Epistemic variability (uncertainty) is captured in consideration of alternate base case (mean) profiles and properties.

Table 9
Simplified V_S Profile Used in Analysis

Depth (ft)	Lithology	V_S (ft/sec)
0 – 45	Clays and silts	800
45 – 145	Sand and gravel	1,200
145 – 250	Weathered and broken limestone	1,500
> 250	Limestone (hard)	9,200

RASCALS was used to generate control motions and acceleration power response spectra for two earthquakes, **M** 5.5 and 7.5, which approximately represents the range of magnitudes for events contributing to the hazard at the site at short- and long-period ground motions. The events were placed at a suite of distances to produce expected median rock peak accelerations of 0.01, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.75, 1.00, 1.25 and 1.50 g. The amplification factors (the ratios of the response spectra at the top of the site profiles to the hard rock profiles) are a function of the reference (hard rock) peak acceleration (or SA), spectral frequency, and nonlinear soil response.

6.2 SITE-SPECIFIC HORIZONTAL RESULTS

The hard rock hazard curves derived from the PSHA and the amplification factors relative to hard rock were multiplied to arrive at site-specific amplified hazard curves. The hazard curves calculated using the amplification factors from the **M** 5.5 and 7.5 earthquakes were weighted based on their contributions to the hazard at each spectral frequency. The uncertainty or epistemic variability in seismic hazard is typically represented by a set of weighted hazard curves. Using these sets of curves as discrete probability distributions, they can be sorted by the frequency of exceedance at each ground-motion level and summed into a cumulative probability mass function. When the cumulative probability mass function for a particular exceedance frequency equals or exceeds fractile y, then the exceedance frequency represents the yth fractile. The weighted-mean hazard curve is the weighted average of the exceedance frequency values. This approach is a standard practice in PSHA.

Figure 23 shows the ground surface spectrum for the return period of 2,500 years resulting from the site response analysis. Also shown is the input hard rock UHS for the same return period. The amplification is significant at spectral periods greater than about 0.1 seconds.

6.3 COMPARISON WITH USGS NATIONAL HAZARD MAPS

In 1996, the USGS released a "landmark" set of NSHMs for earthquake ground shaking, which was a significant improvement from previous maps they had developed (Frankel *et al.*, 1996). These maps were the result of the most comprehensive analyses of seismic sources and ground motion prediction ever undertaken on a national scale. The maps are the basis for the NEHRP Maximum Considered Earthquake (MCE_R) maps, which are used in the International Building Code. The maps are for NEHRP site class B/C (firm rock) (V_S30 760 m/sec).

For a 2,500-year return period, the 2014 NSHMs indicate firm rock (site class B/C) PGA, 0.2 sec SA and 1.0 sec SA values of 0.89, 1.63, and 0.46 g, respectively (USGS website). The site-

specific values of 0.66, 1.30, and 0.60 g for PGA, 0.2 and 1.0 sec SA, respectively, are comparable. The site-specific ground surface values are lower at short periods and higher at long periods. The differences are likely due to the differences in the site conditions.

Table 10

2,500-Year Return Period UHS for the Ground Surface

Period (sec)	SA (g)
0.01	0.65
0.02	0.82
0.03	0.92
0.04	1.00
0.10	1.20
0.20	1.30
0.40	0.97
1.0	0.60
2.0	0.25
3.0	0.15
4.0	0.12
5.0	0.10

Three sets of two-component time histories were spectrally-matched to a 2,500-year return period ground surface UHS. At short periods, and longer periods, the 2,500-year hazard is primarily from large events from the NMFS (**M** 7.5 to 8.0) at distances of 100 to 125 km (Figures 20 and 21). Hence, three sets of seed time histories were selected consistent with a **M** 7.5 to 8.0 event at distances of 100 to 125 km (Table 11).

Because the response spectrum of a time history has peaks and valleys that deviate from the design response spectrum (target spectrum), it is necessary to modify the motion to improve its response spectrum compatibility. The procedure proposed by Lilhanand and Tseng (1988), as modified by Al Atik and Abrahamson (2010) and contained in the computer code RSPMatch09 (Fouad and Rathje, 2012), was used to develop the acceleration time histories through spectral matching to the target (seed) spectrum. This time-domain procedure has been shown to be superior to previous frequency-domain approaches because the adjustments to the time history are only done at the time at which the spectral response occurs resulting in only localized perturbations on both the time history and the spectra (Lilhanand and Tseng, 1988).

To match the design (target) spectrum, seed time histories should be from events of similar magnitude and distance (for duration) and most importantly, spectral shape as the earthquake dominating the spectrum. Figure 24 shows the spectra from the seed time histories scaled to the target spectrum at PGA. The seed acceleration time history series are shown on Figures 25 to 27. The spectral matches and resulting time histories are shown on Figures 28 to 39. Arias intensities and durations of the spectrally-matched time histories are provided in Table 12.

Table 11

Seed Time Histories

Record Sequence Number	Year	Earthquake Name	Station Name	Earthquake Magnitude (M)	ClstD (km)	V_S30 (m/sec)	Comp	PGA(g)	PGV (cm/sec)	PGD (cm)	AI (m/sec)	5-95% Dur (sec)
1153	1999	Kocaeli, Turkey	Botas	7.5	127	342	000	0.099	11.74	4.26	0.102	29.36
							090	0.087	10.96	14.89	0.085	30.15
1404	1999	Chi-Chi, Taiwan	PNG	7.6	110	466	E	0.029	1.52	0.47	0.030	31.99
							N	0.034	2.27	0.66	0.033	28.10
2112	2002	Denali, Alaska	TAPS Pump Station #08	7.9	105	425	049	0.046	4.62	2.15	0.049	30.78
							319	0.036	4.22	2.52	0.043	36.28

ClstD closest distance
Comp component
PGA peak horizontal ground acceleration
PGV peak horizontal ground velocity
PGD peak horizontal ground displacement
AI Arias intensity
Dur duration

Table 12

Spectrally-Matched Time Histories

Record Sequence Number	Year	Earthquake Name	Station Name	Earthquake Magnitude (M)	ClstD (km)	V_S30 (m/sec)	Comp	PGA(g)	PGV (cm/sec)	PGD (cm)	AI (m/sec)	5-95% Dur (sec)
1153	1999	Kocaeli, Turkey	Botas	7.5	127	342	000	0.71	44.44	31.94	3.87	30.04
							090	0.67	71.29	102.35	4.02	31.52
1404	1999	Chi-Chi, Taiwan	PNG	7.6	110	466	E	0.65	46.96	21.43	11.58	33.86
							N	0.65	46.66	24.23	9.52	30.04
2112	2002	Denali, Alaska	TAPS Pump Station #08	7.9	105	425	049	0.66	54.65	29.57	6.96	35.66
							319	0.64	58.25	37.40	10.16	39.69

ClstD closest distance
Comp component
PGA peak horizontal ground acceleration
PGV peak horizontal ground velocity
PGD peak horizontal ground displacement
AI Arias intensity
Dur duration

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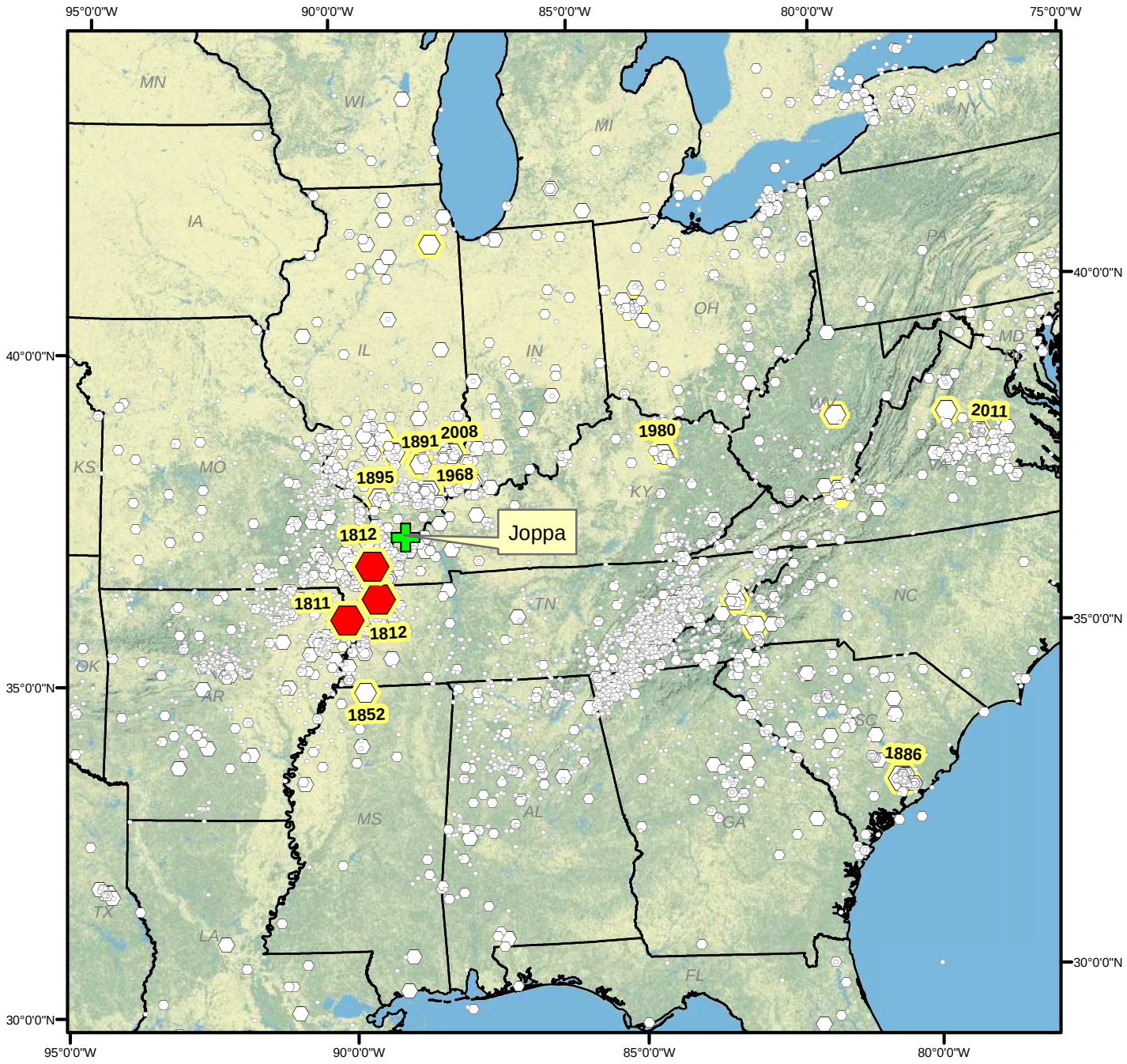


Magnitude Mw

- <= 3.0
- 3.0 - 4.0
- 4.1 - 5.0
- 5.1 - 6.0
- 6.1 - 7.0
- > 7.0

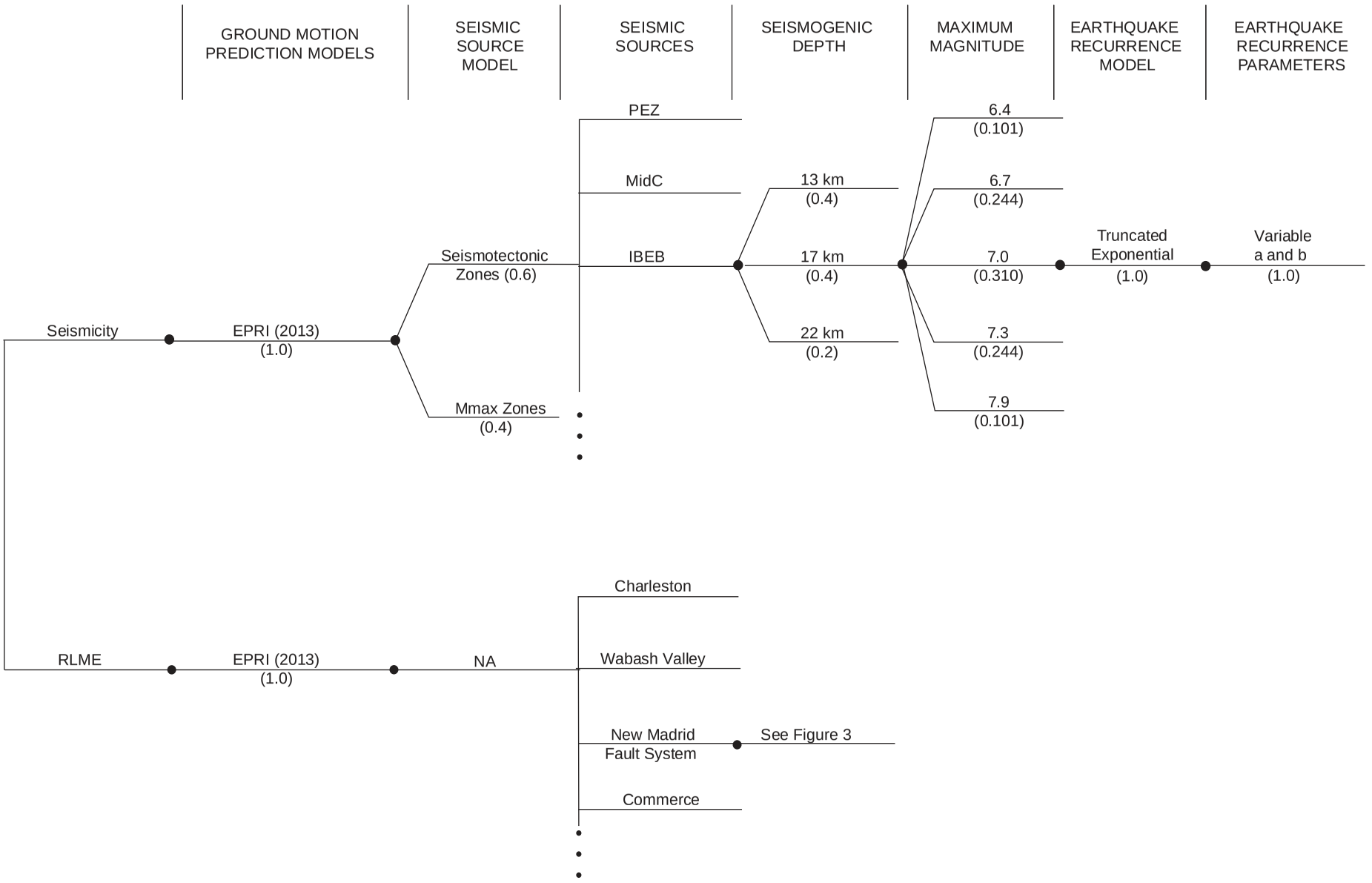
Data Sources: 1699 to 2008 from EPRI/DOE/NRC (2012)
2009 to May 2015 from ANSS

0 55 110 220 330 440 Kilometers

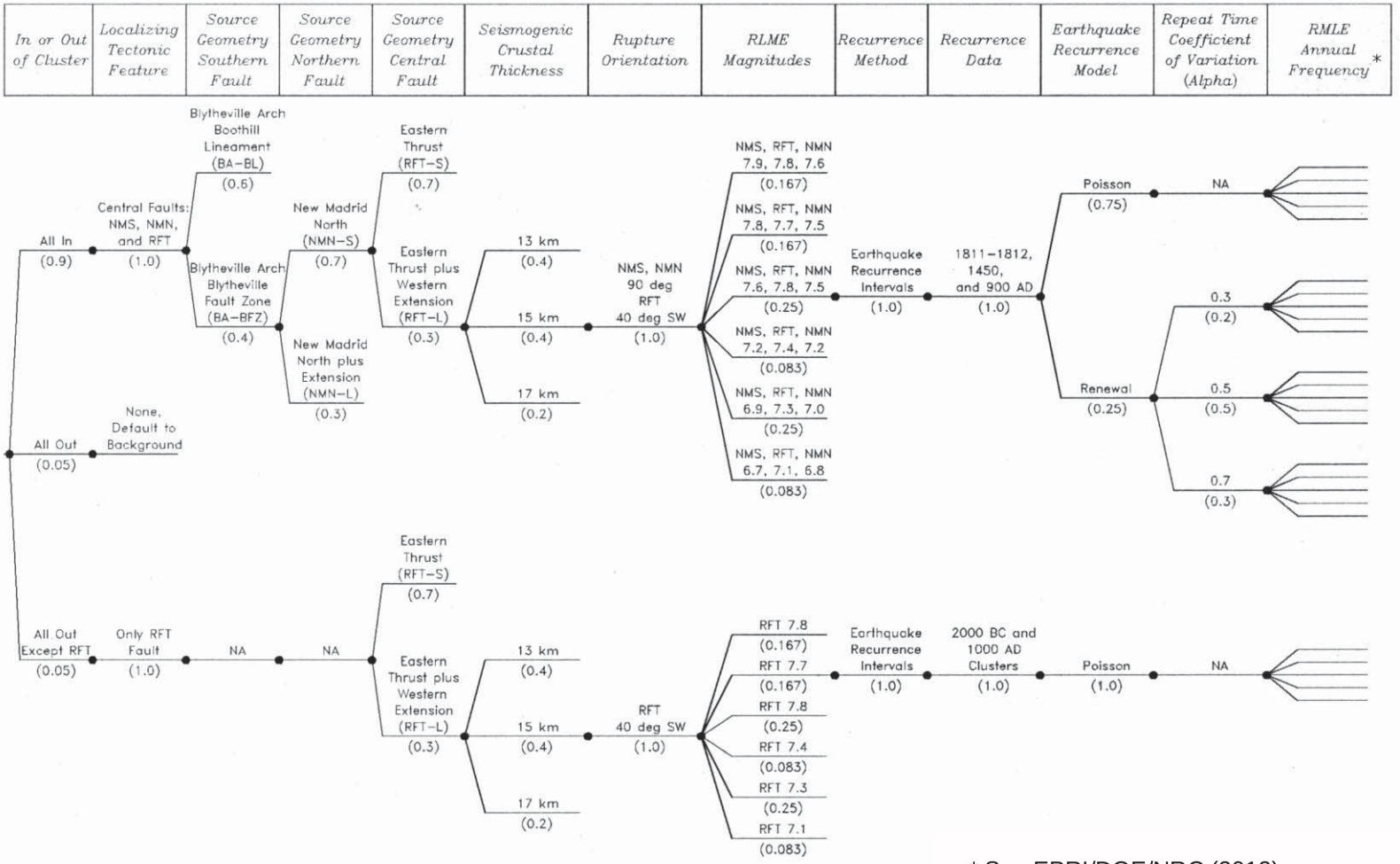
0 40 80 160 240 320 Miles

N

AECOM	Project No. 60440155 Joppa Power Station Dynegy	HISTORICAL SEISMICITY OF THE CENTRAL AND EASTERN UNITED STATES (1699 - 2015)	Figure 1

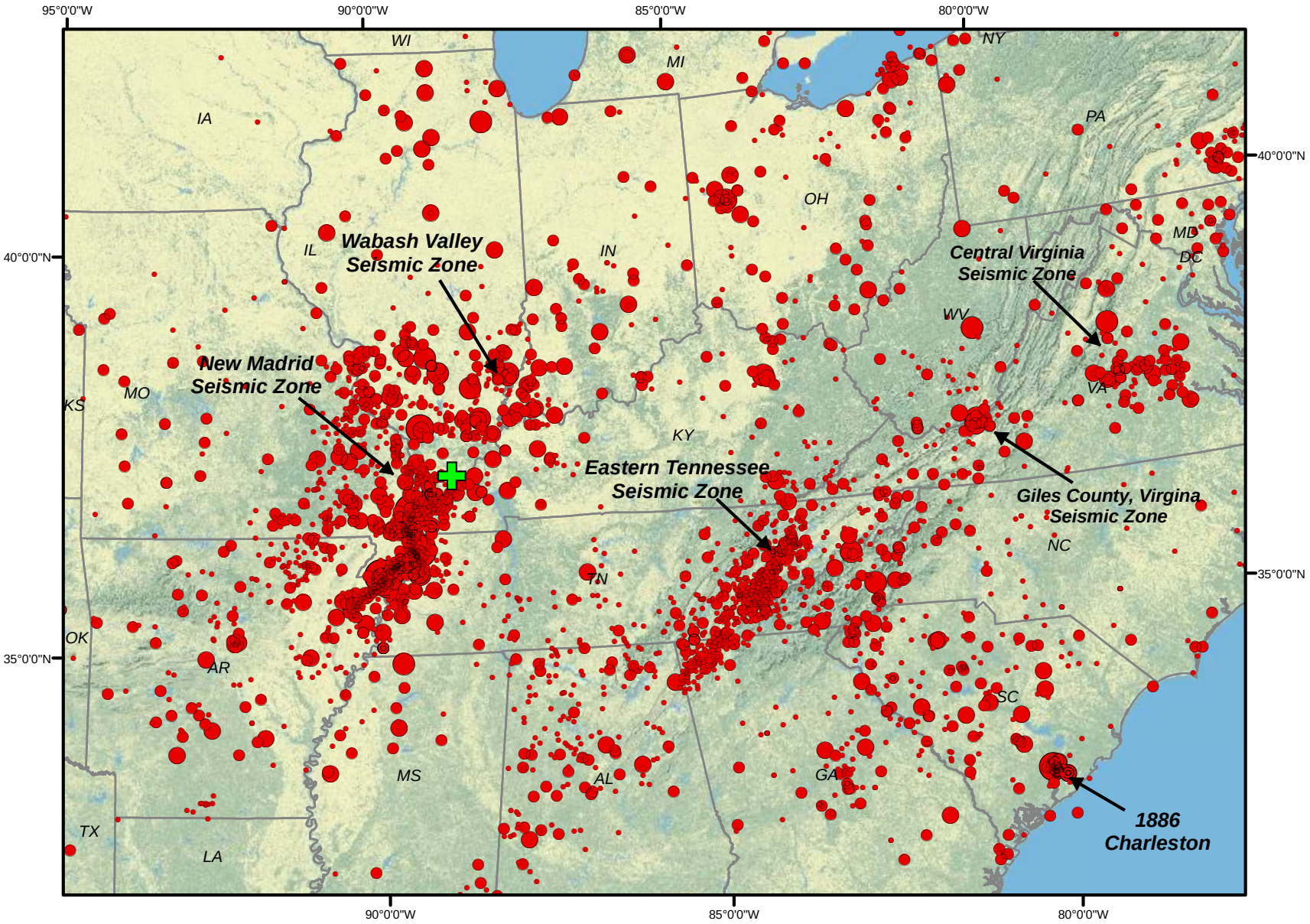


AECOM	Project No. 60440155 Joppa Power Station Dynegy	EXAMPLE SEISMIC HAZARD MODEL LOGIC TREE	Figure 2



* See EPRI/DOE/NRC (2012)

AECOM	Project No. 60440155 Joppa Power Station Dynegy	NEW MADRID RLME LOGIC TREE	Figure 3



Project Site

Earthquake Epicenters

Seismicity from:
EPRI/DOE/NRC (2012)

AECOM

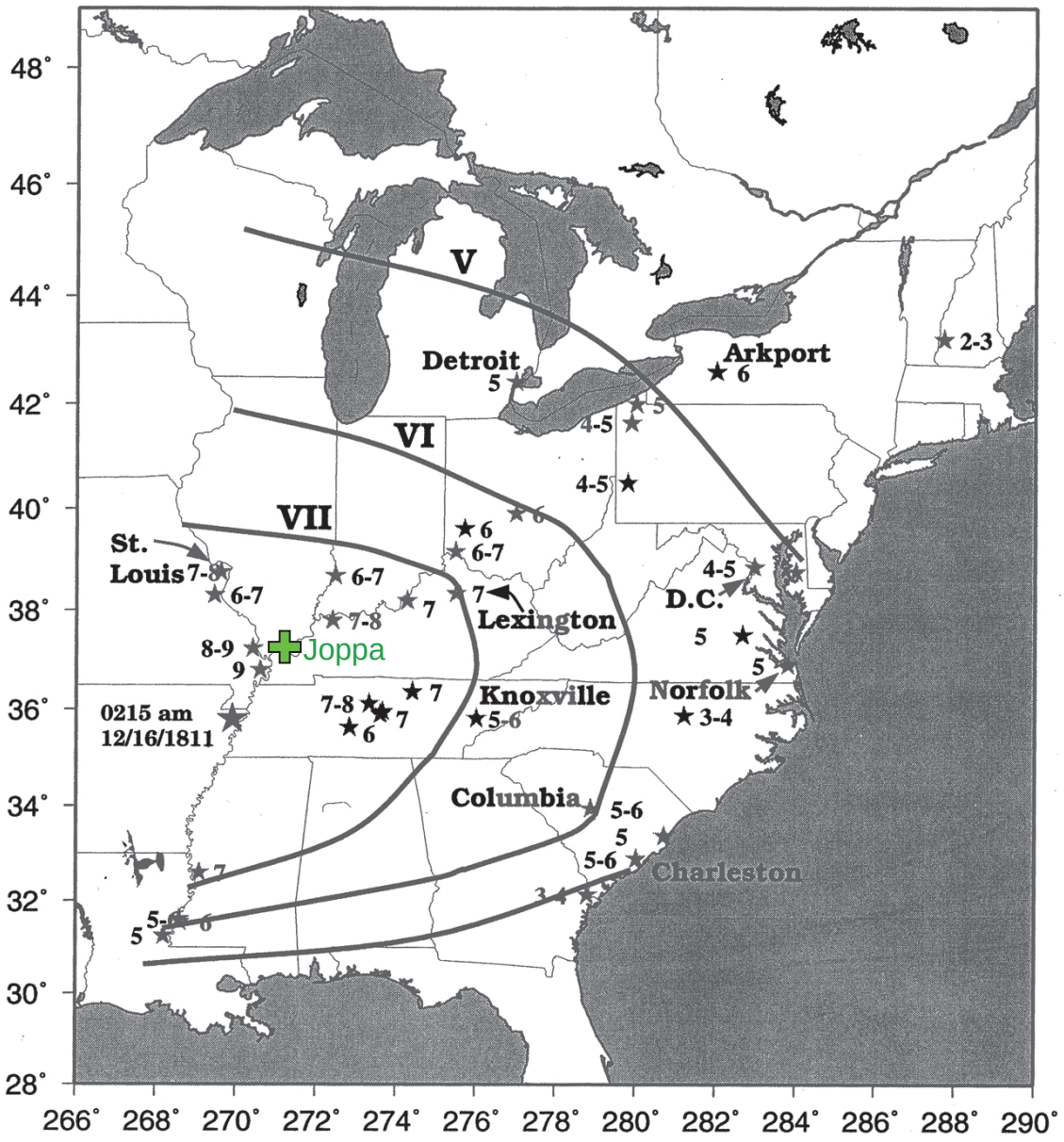
Project No. 60440155

Joppa Power Station
Dynegy

HISTORICAL SEISMICITY AND SEISMIC ZONES IN EASTERN U.S.

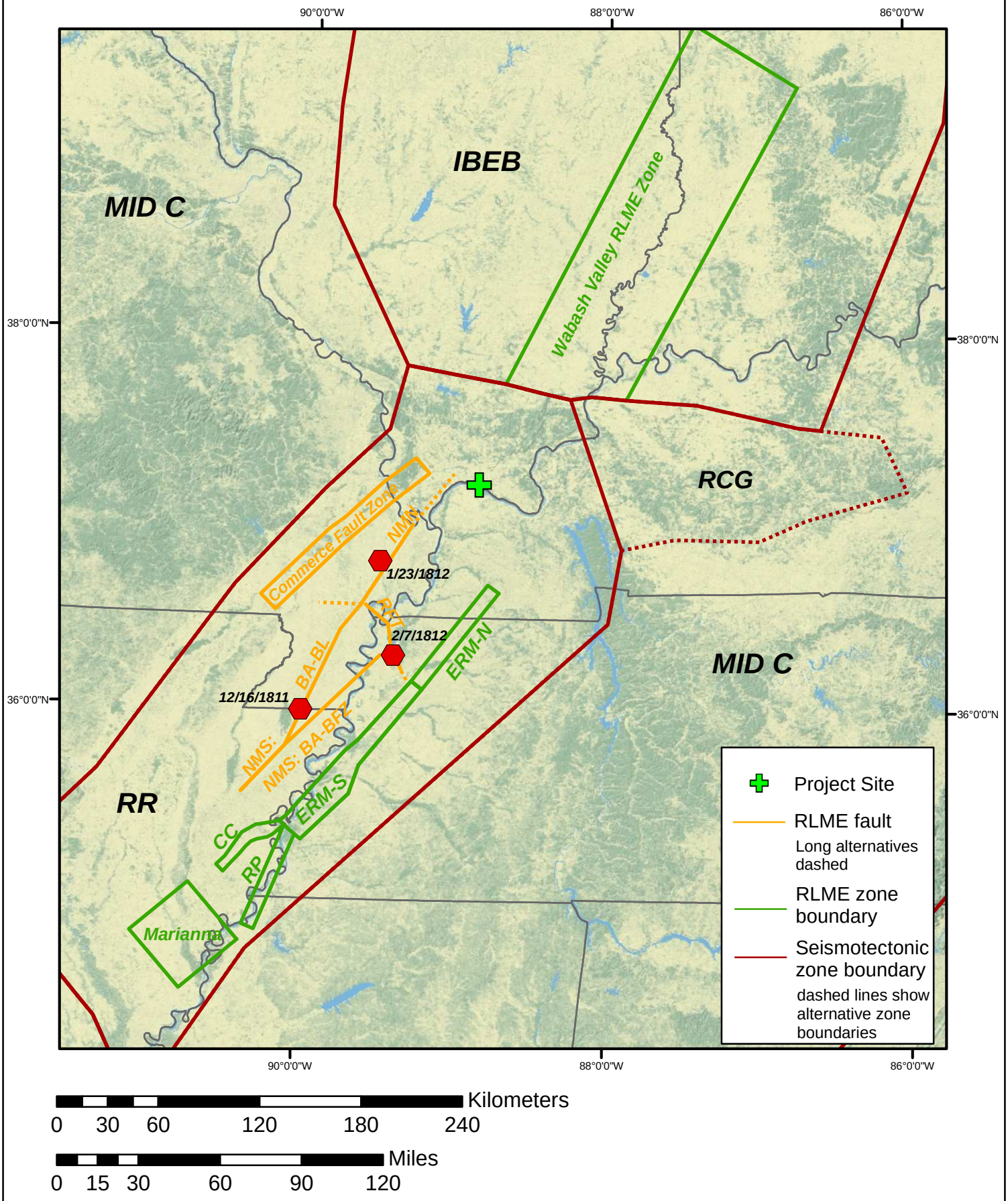
Figure

4

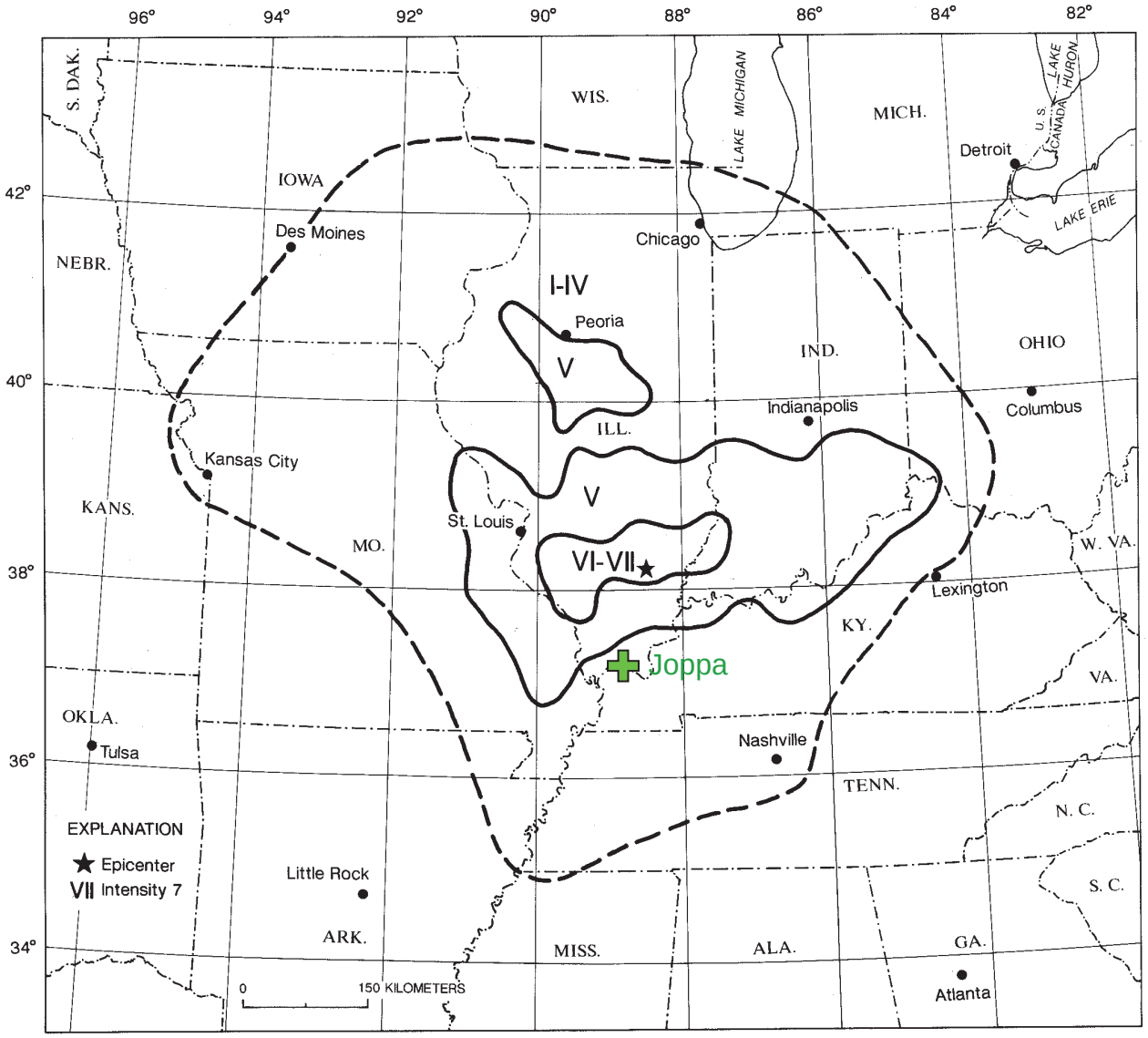


Source: Hough *et al*. (2000)

AECOM	Project No. 60440155 Joppa Power Station Dynegy	ISOSEISMAL MAP OF THE 16 DECEMBER 1811 **M** 7.2-7.3 NEW MADRID EARTHQUAKE	Figure 5

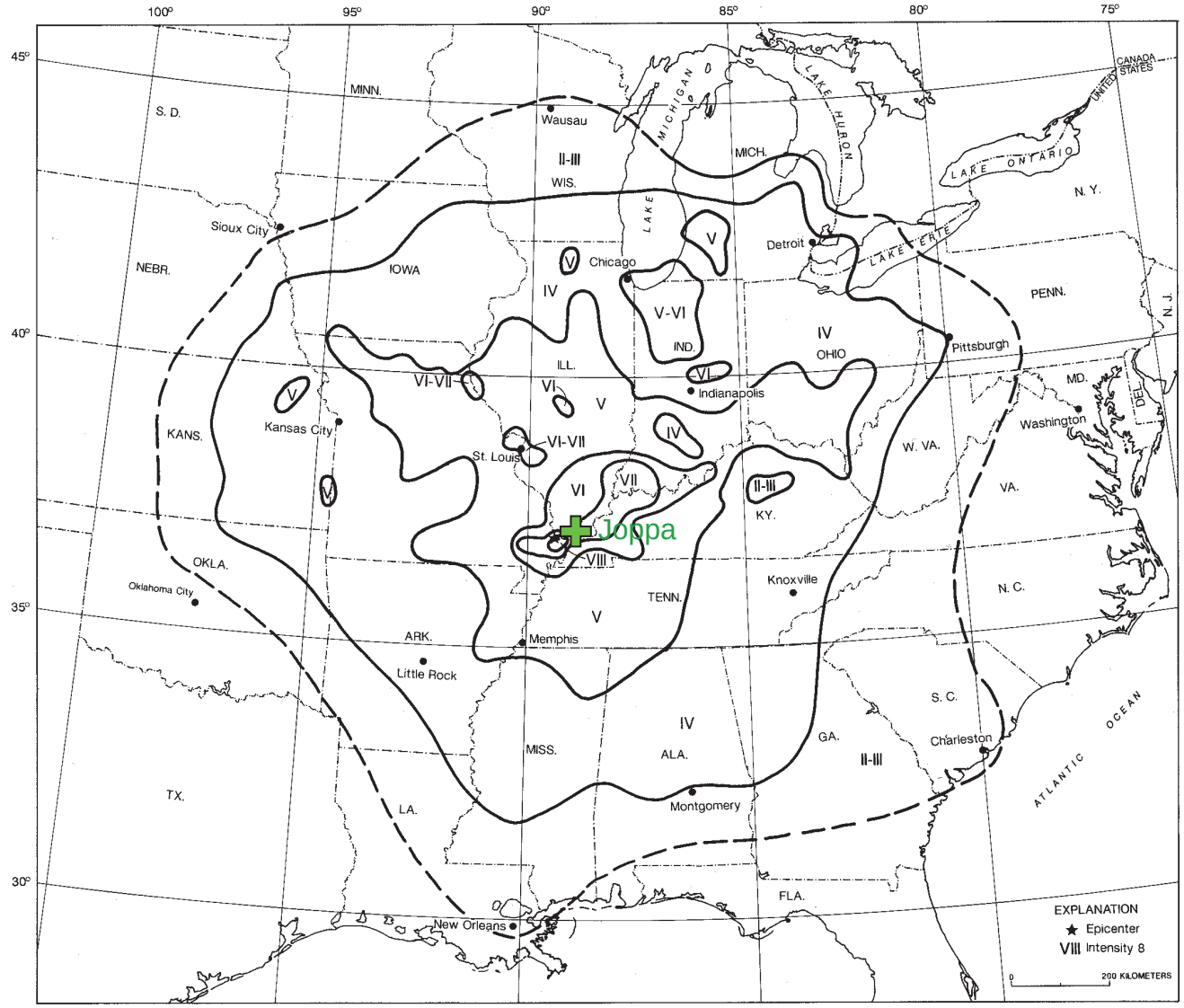


AECOM	Project No. 60440155 Joppa Power Station Dynegy	NEW MADRID FAULT SYSTEM, 1811-1812 NMFS EARTHQUAKES, AND NEIGHBORING RLMEs	Figure 6



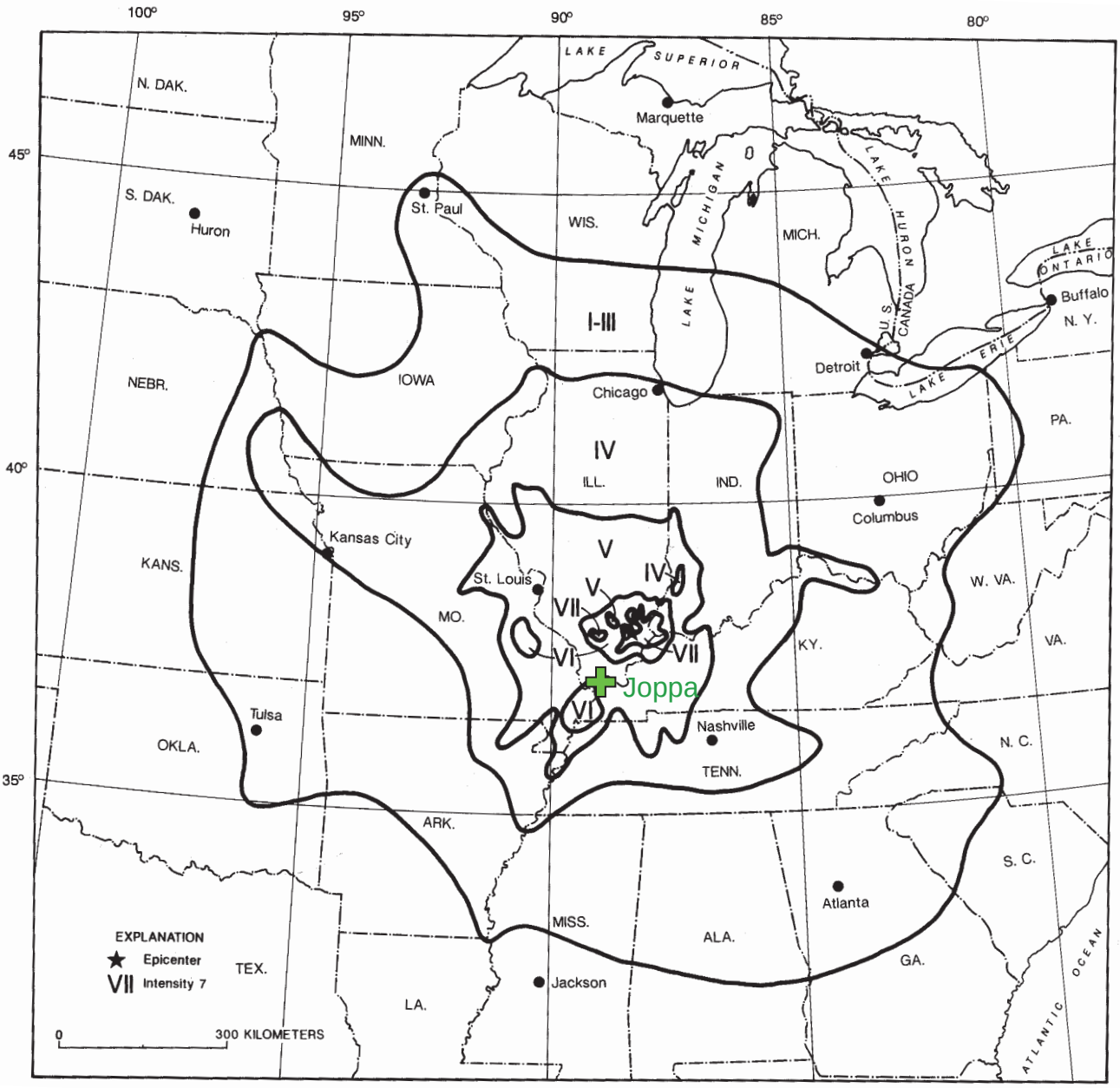
Source: Stover and Coffman (1993)

AECOM	Project No. 60440155 Joppa Power Station Dynegy	ISOSEISMAL MAP OF THE 27 SEPTEMBER 1891 m_b 5.8 SOUTHERN ILLINOIS EARTHQUAKE	Figure 7



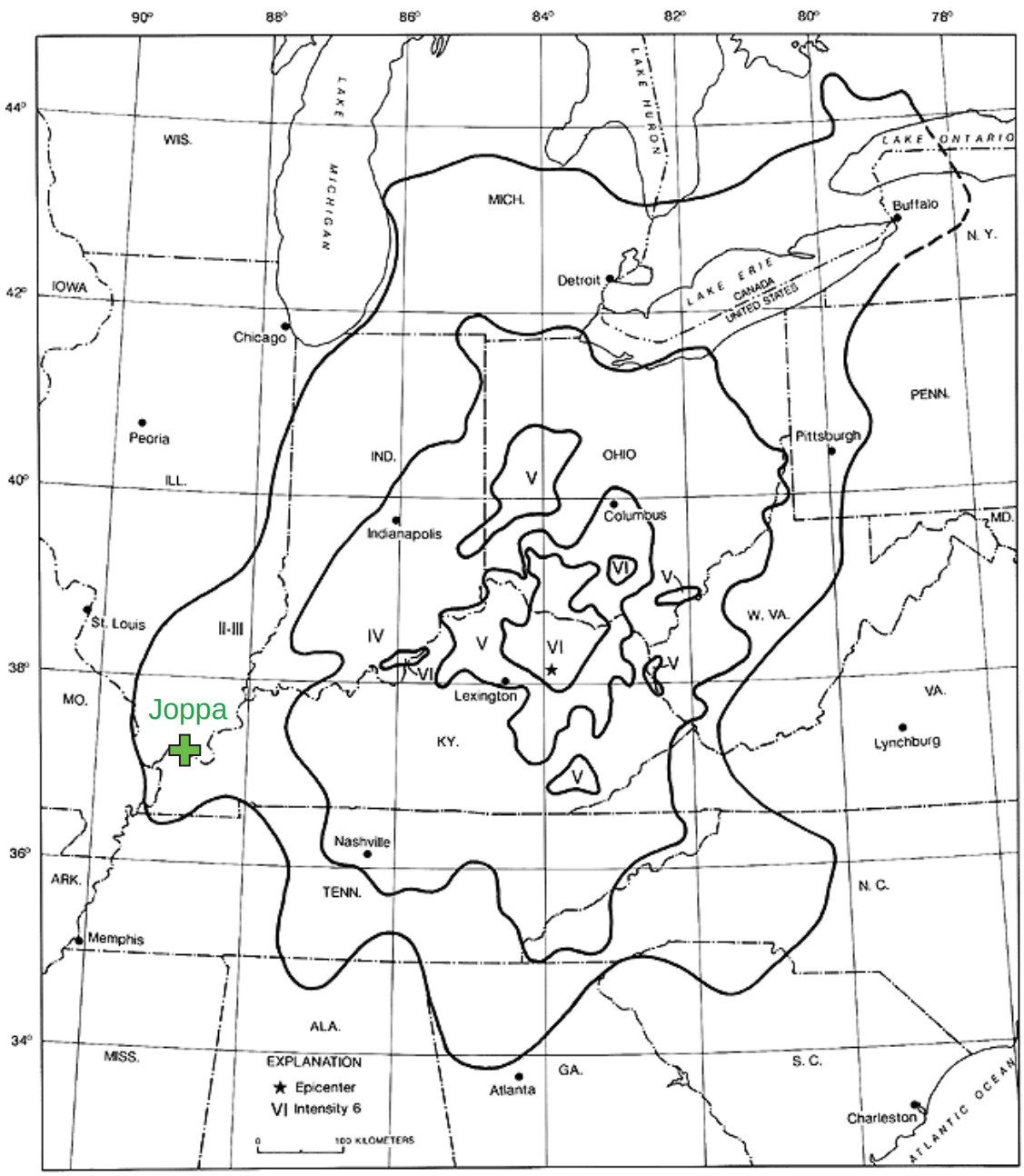
Source: Stover and Coffman (1993)

AECOM	Project No. 60440155 Joppa Power Station Dynegy	ISOSEISMAL MAP OF THE 31 OCTOBER 1895 M_S 6.7 CHARLESTON, MISSOURI EARTHQUAKE	Figure 8



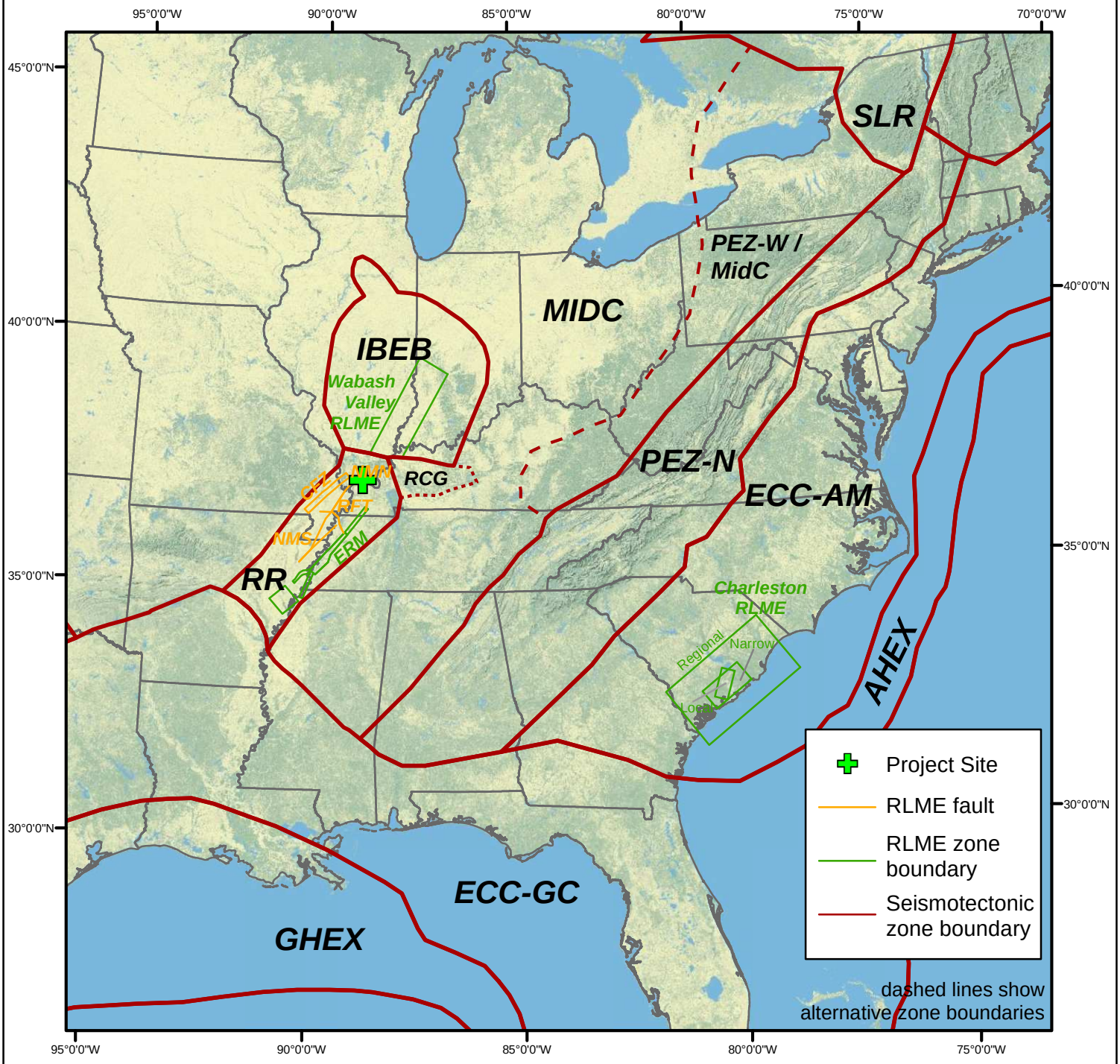
Source: Stover and Coffman (1993)

AECOM	Project No. 60440155 Joppa Power Station Dynegy	ISOSEISMAL MAP OF THE 9 NOVEMBER 1968 m_b 5.5 SOUTHERN ILLINOIS EARTHQUAKE	Figure 9



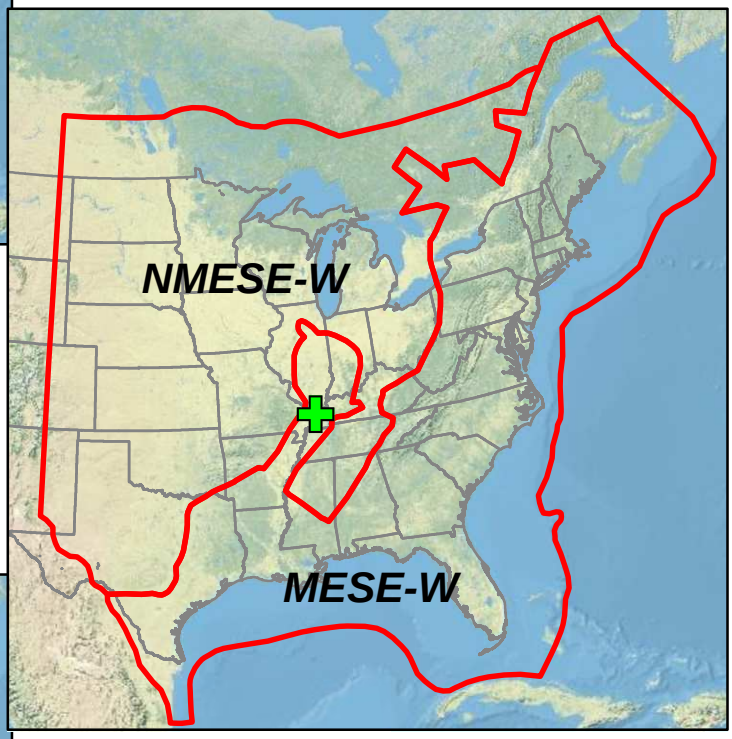
Source: Stover and Coffman (1993)

AECOM	Project No. 60440155 Joppa Power Station Dynegy	ISOSEISMAL MAP FOR THE 27 JULY 1980 M 5.1 SHARPSBURG, KENTUCKY EARTHQUAKE	Figure 10

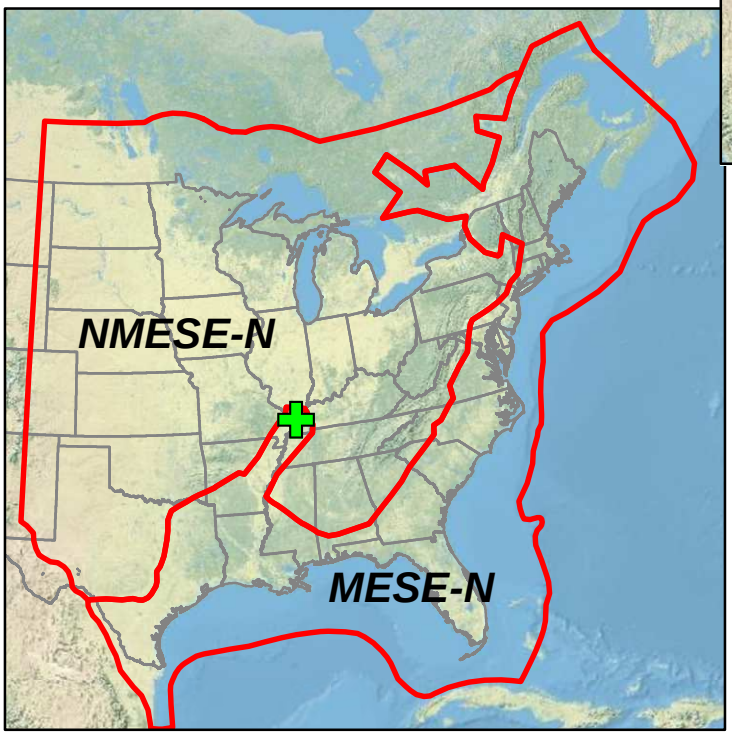


AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEISMOTECTONIC ZONES AND RLMES	Figure 11

1-Zone Mode

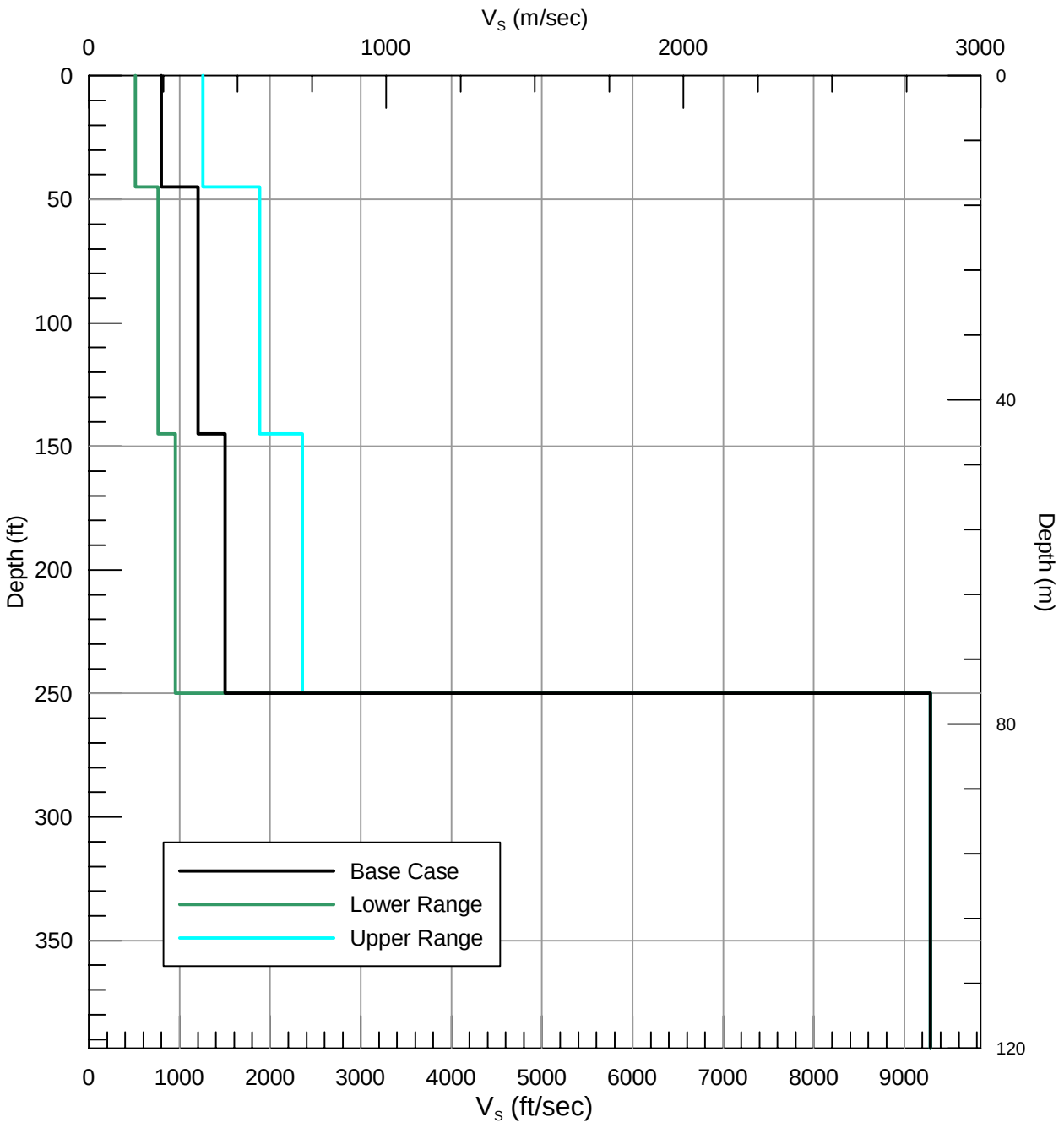


2-Zone Model
MESE-Wide

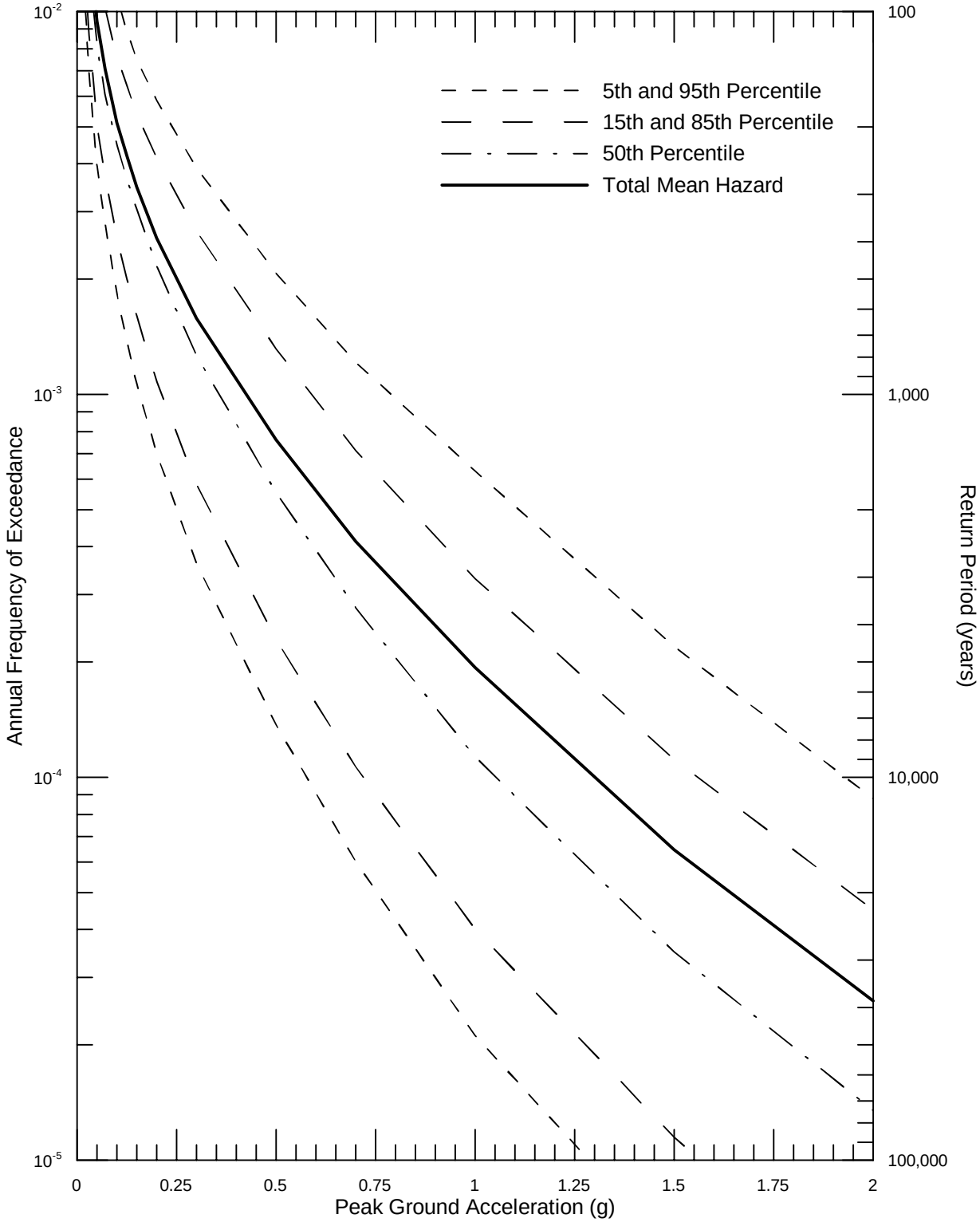


2-Zone Model
MESE-Narrow

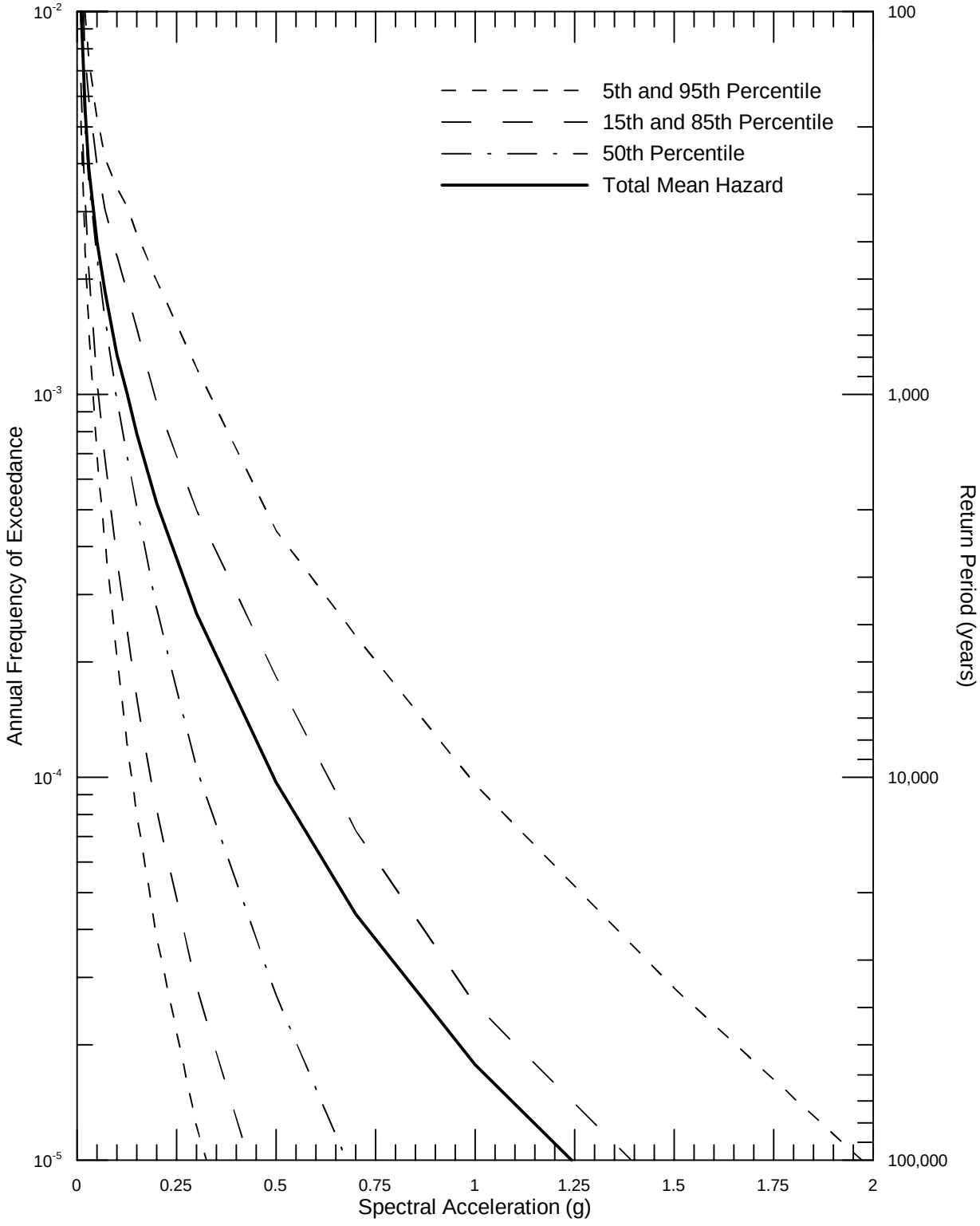
AECOM	Project No. 60440155 Joppa Power Station Dynegy	Mmax ZONES	Figure 12



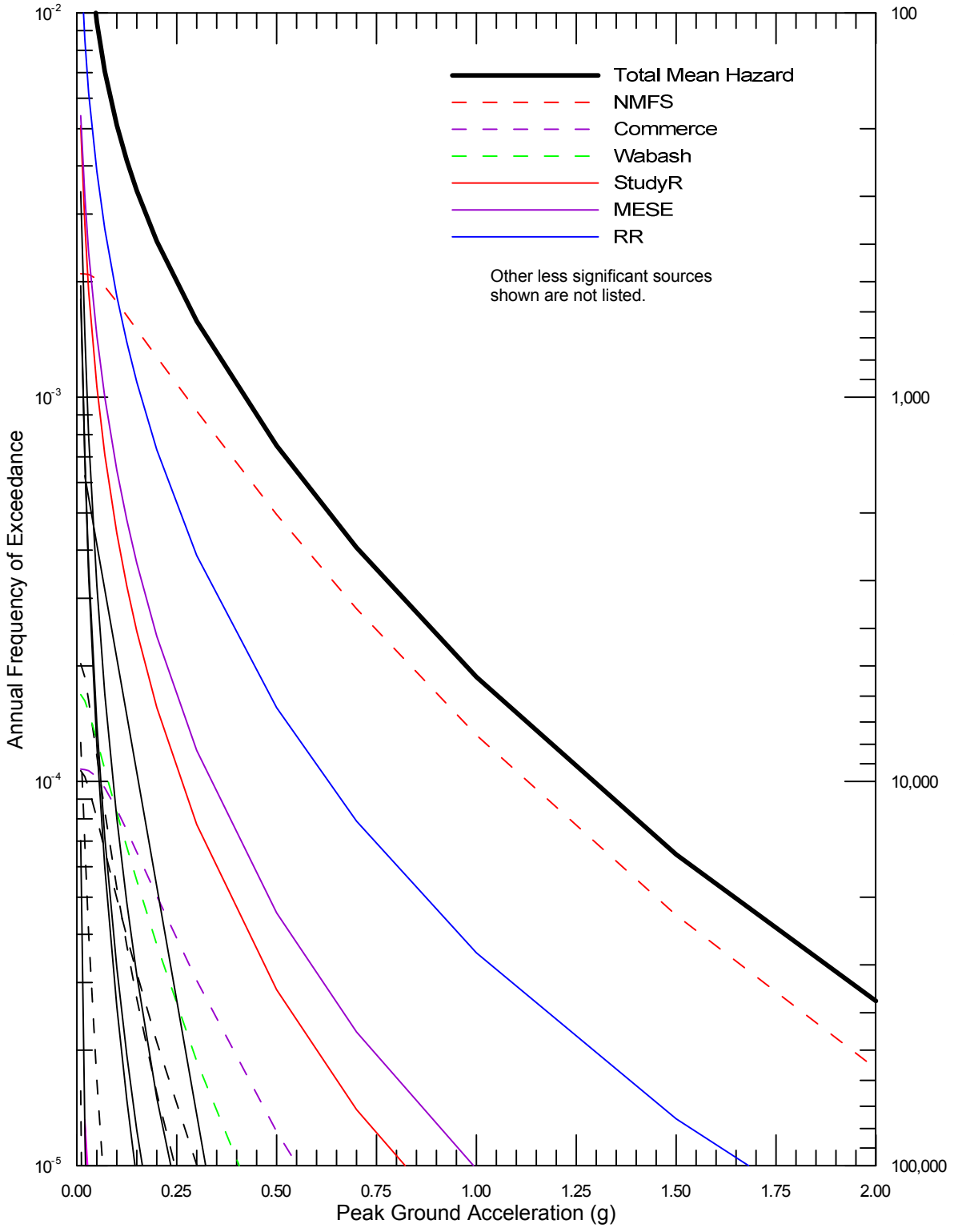
AECOM	Project No. 60440155 Joppa Power Station Dynegy	SITE RESPONSE VELOCITY PROFILES	Figure 13



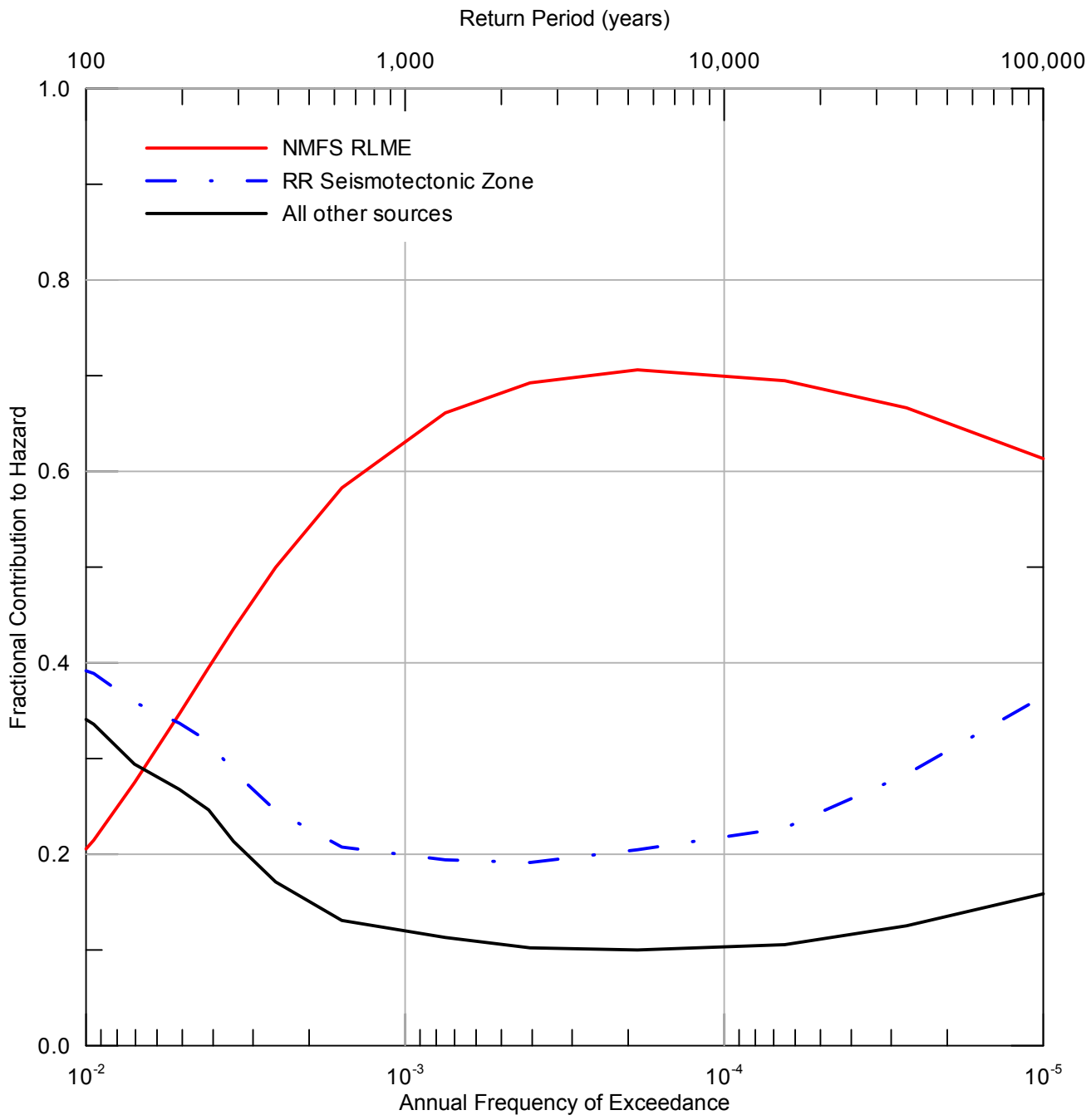
AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEISMIC HAZARD CURVES FOR PEAK HORIZONTAL ACCELERATION ON HARD ROCK	Figure 14



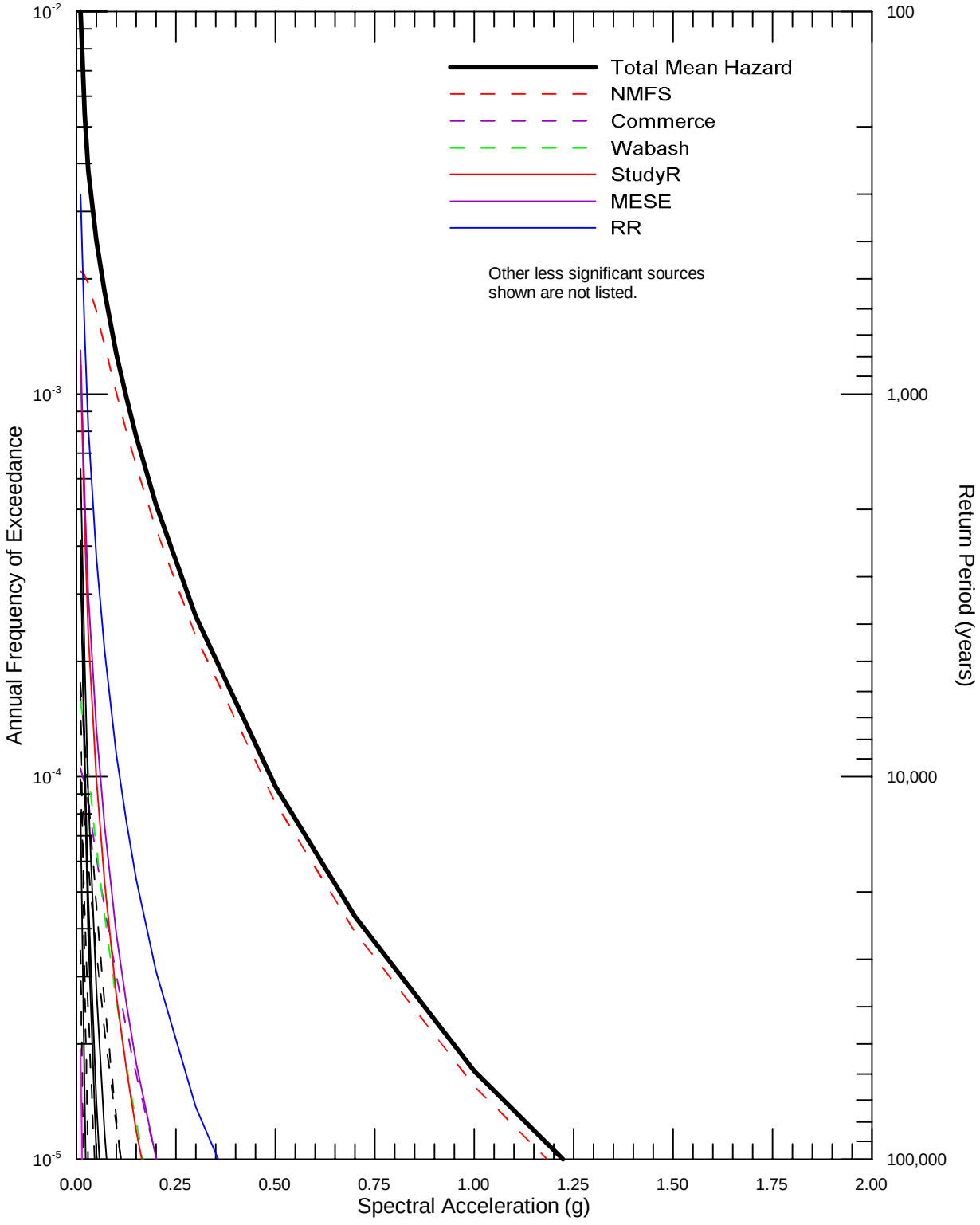
AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEISMIC HAZARD CURVES FOR 1.0 SEC HORIZONTAL SPECTRAL ACCELERATION ON HARD ROCK	Figure 15



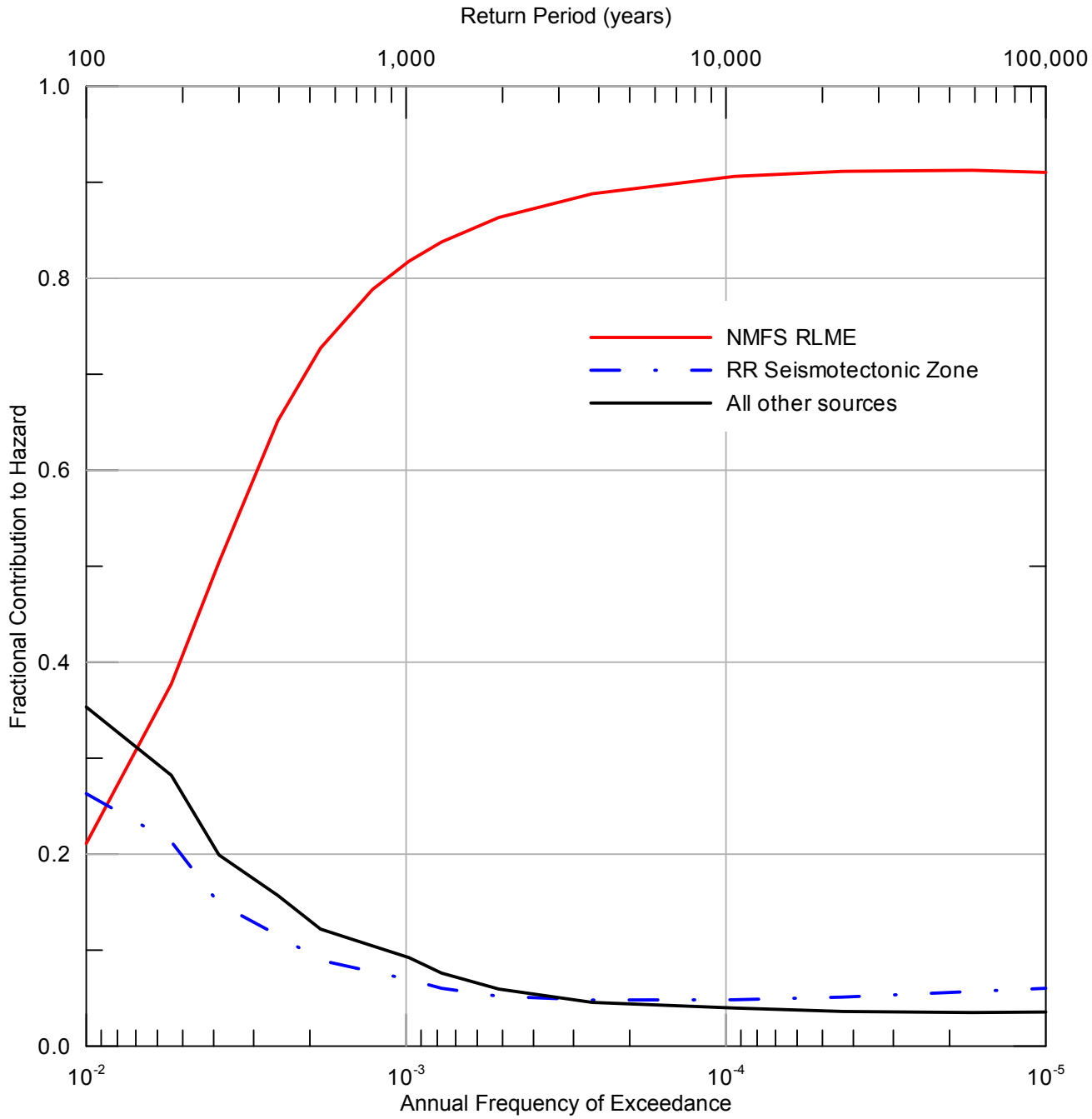
AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEISMIC SOURCE CONTRIBUTIONS TO MEAN PEAK HORIZONTAL ACCELERATION HAZARD ON HARD ROCK	Figure 16



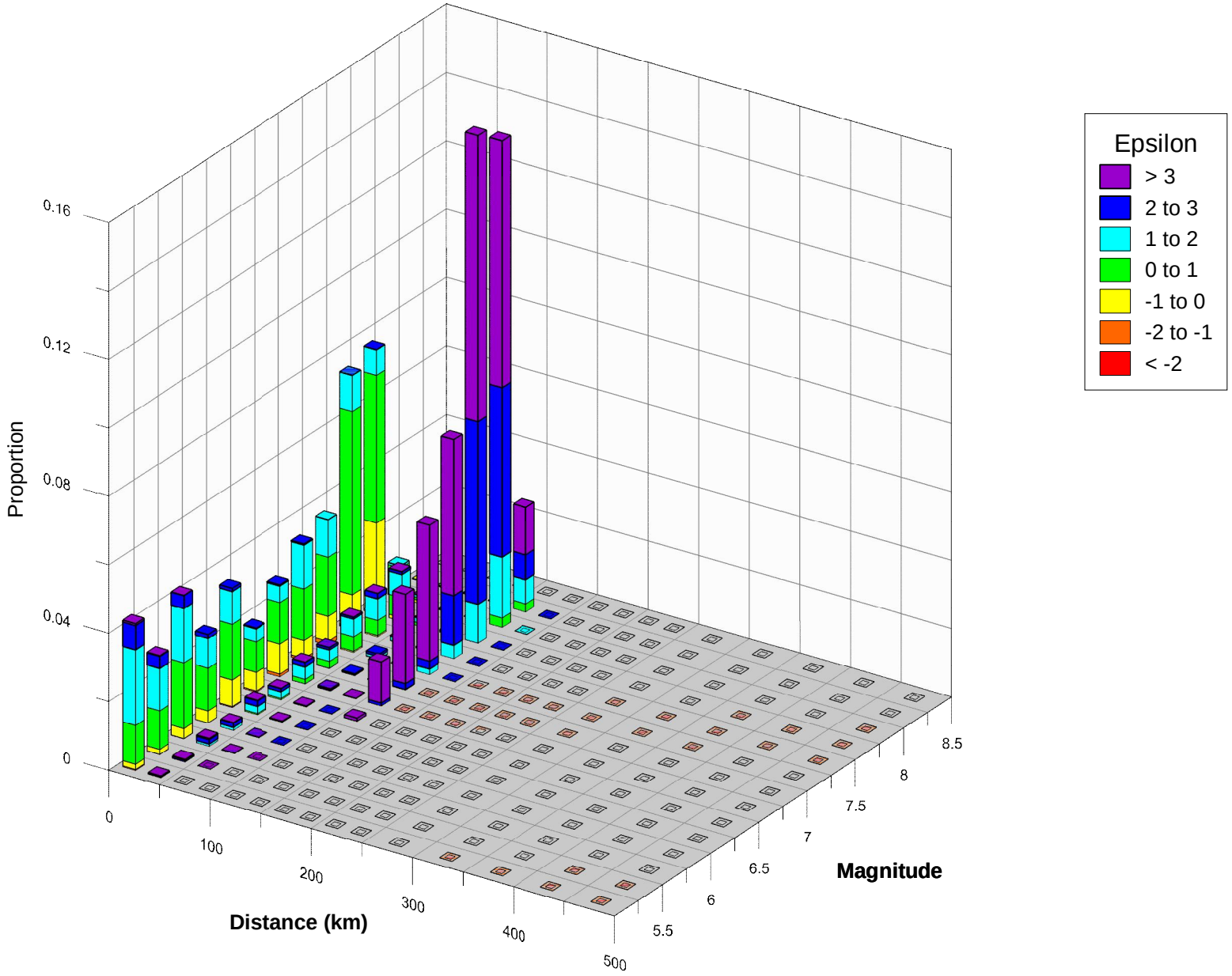
AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEISMIC SOURCE FRACTIONAL CONTRIBUTION TO MEAN PEAK HORIZONTAL ACCELERATION HAZARD ON HARD ROCK	Figure 17



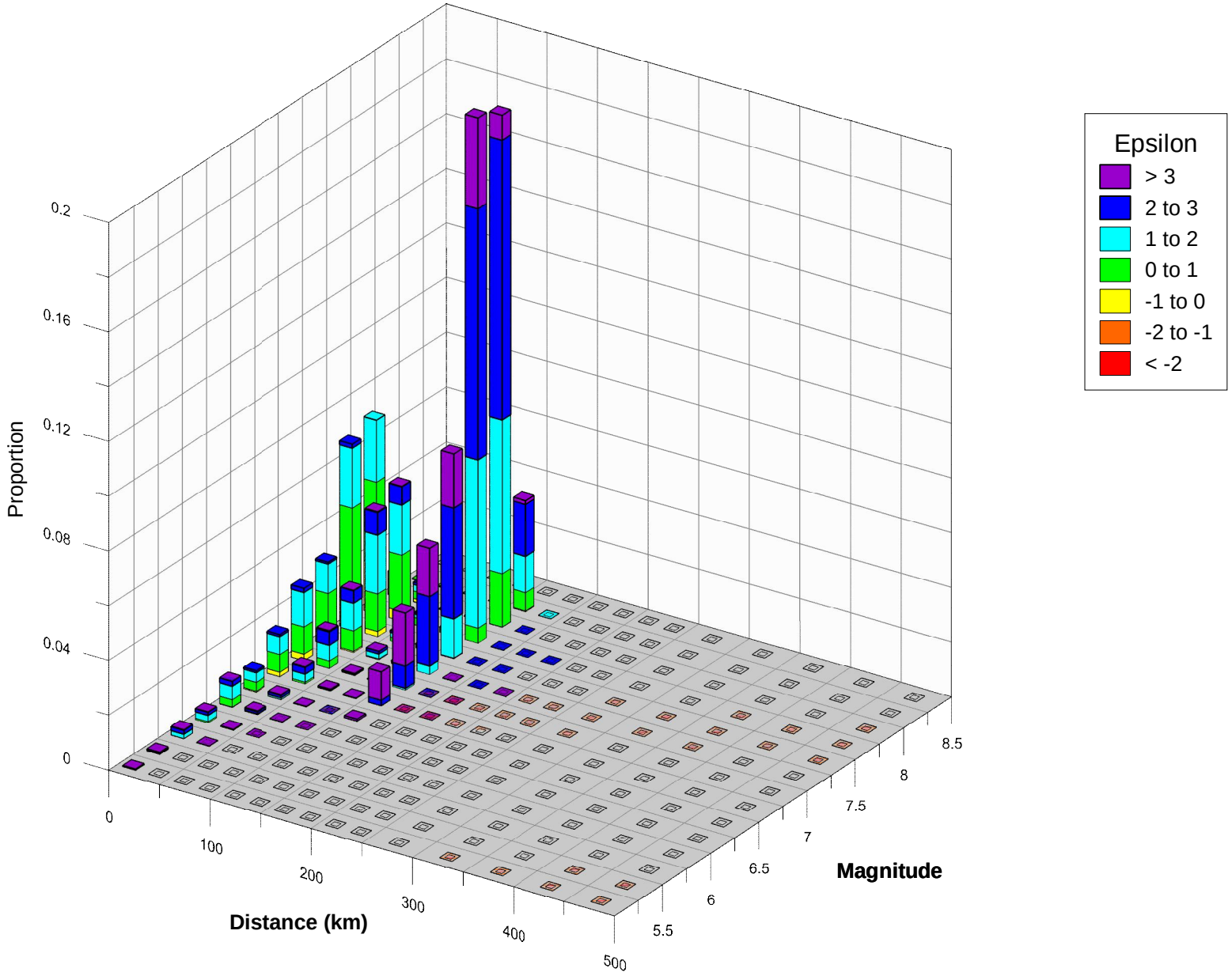
AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEISMIC SOURCE CONTRIBUTIONS TO MEAN 1.0 SEC HORIZONTAL SPECTRAL ACCELERATION HAZARD ON HARD ROCK	Figure 18



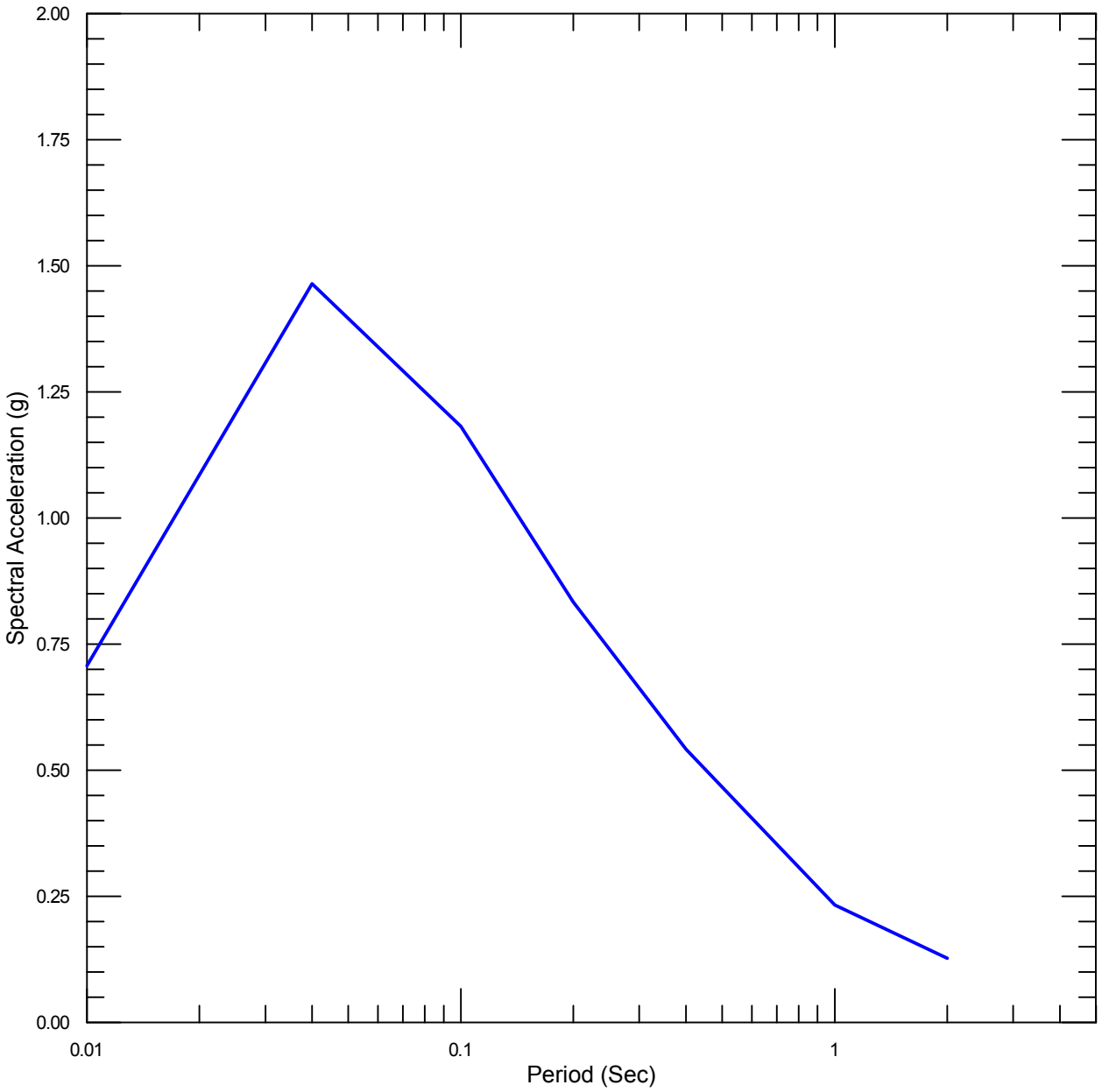
AECOM	Project No.60440155 Joppa Power Station Dynegy	SEISMIC SOURCE FRACTIONAL CONTRIBUTION TO MEAN 1.0 SEC HORIZONTAL SPECTRAL ACCELERATION HAZARD ON HARD ROCK	Figure 19



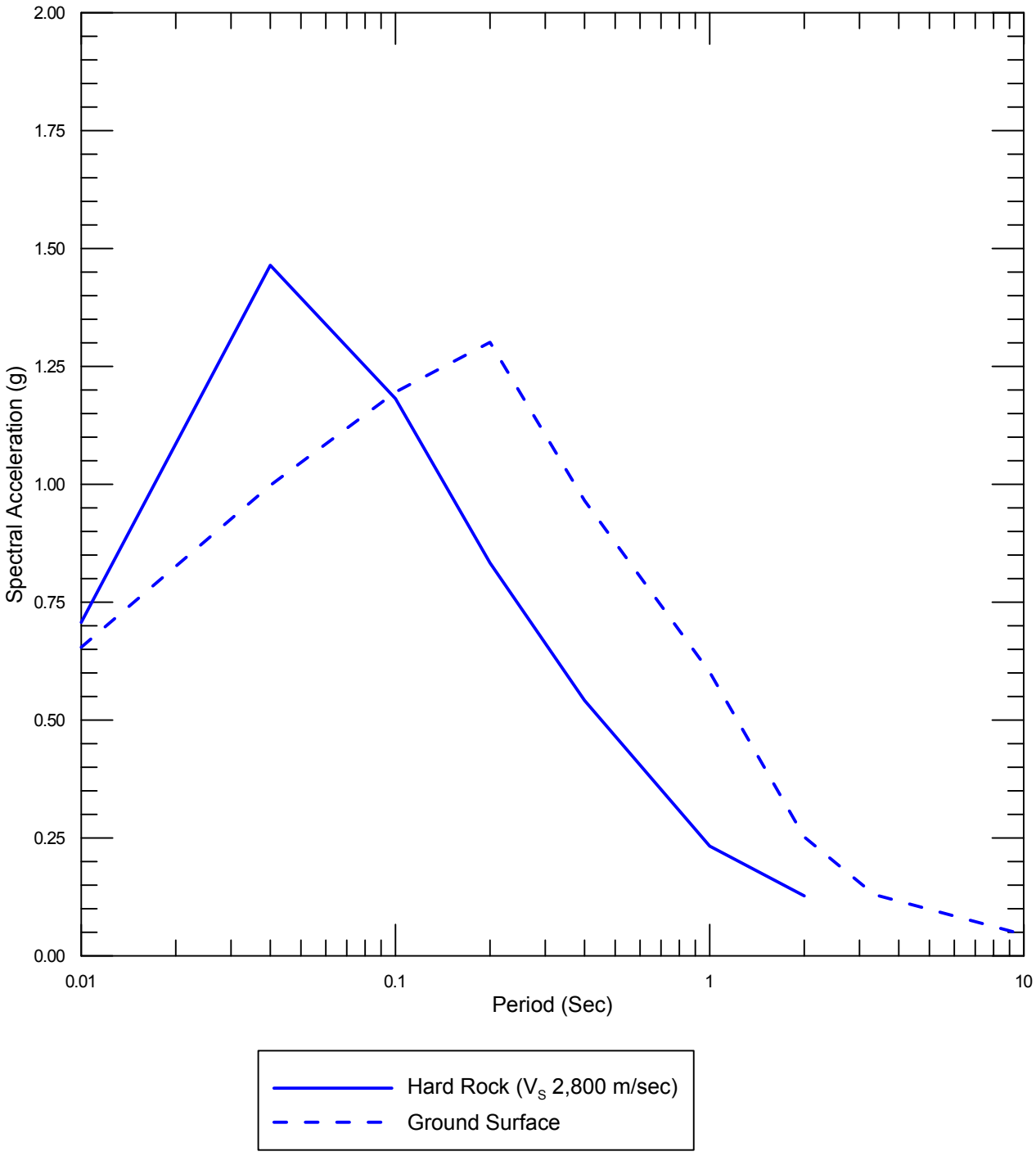
AECOM	Project No. 60440155 Joppa Power Station Dynegy	MAGNITUDE, DISTANCE AND EPSILON CONTRIBUTIONS TO THE MEAN PEAK HORIZONTAL ACCELERATIONHAZARD AT 2,475-YEAR RETURN PERIOD ON HARD ROCK	Figure 20



AECOM	Project No. 60440155 Joppa Power Station Dynegy	MAGNITUDE, DISTANCE AND EPSILON CONTRIBUTIONS TO THE MEAN 1.0 SEC HORIZONTAL SPECTRAL ACCELERATIONHAZARD AT 2,475-YEAR RETURN PERIOD ON HARD ROCK	Figure 21

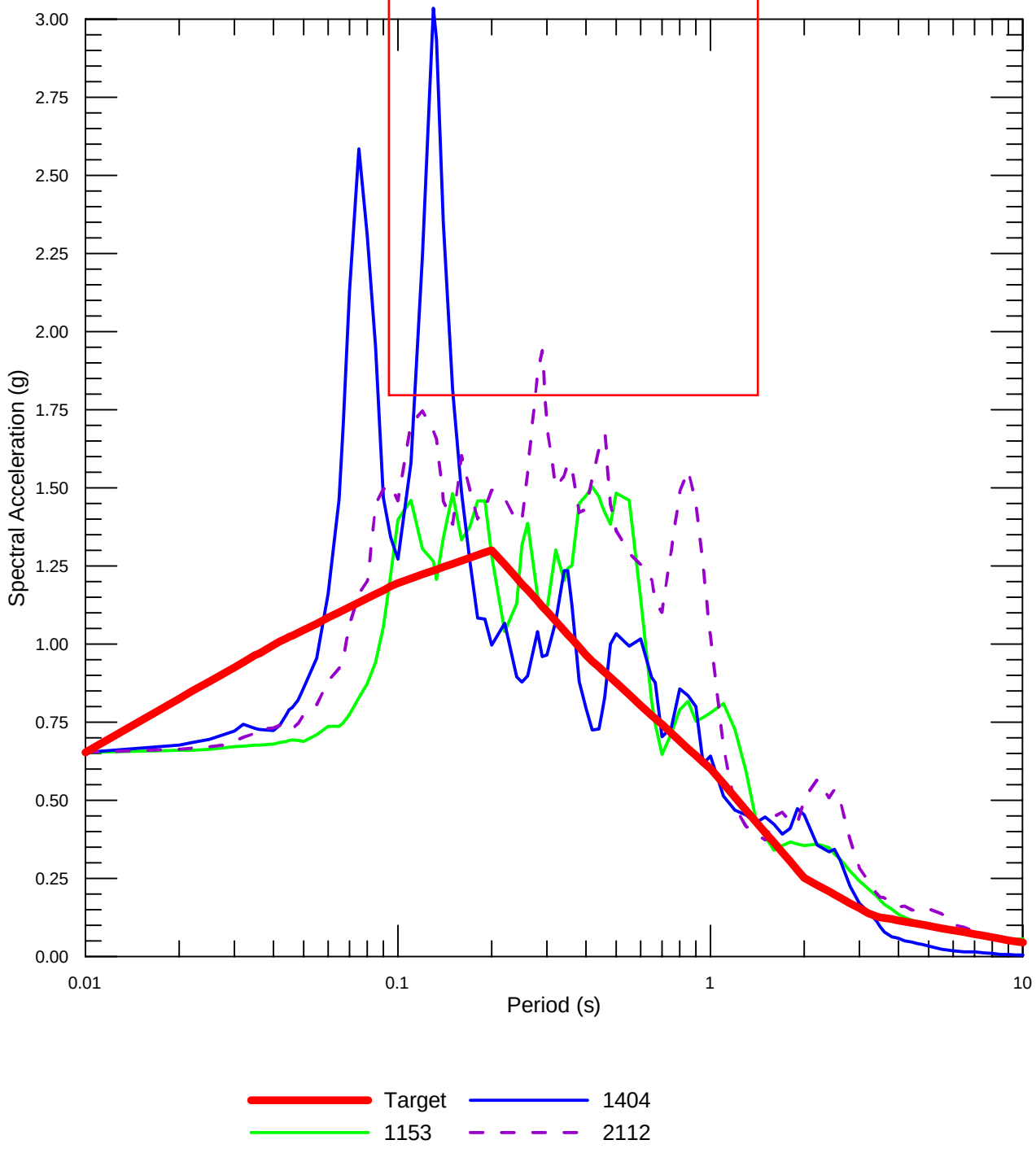


AECOM	Project No. 60440155 Joppa Power Station Dynegy	5%-DAMPED MEAN HORIZONTAL UHS ON HARD ROCK AT 2,500-YEAR RETURN PERIOD	Figure 22

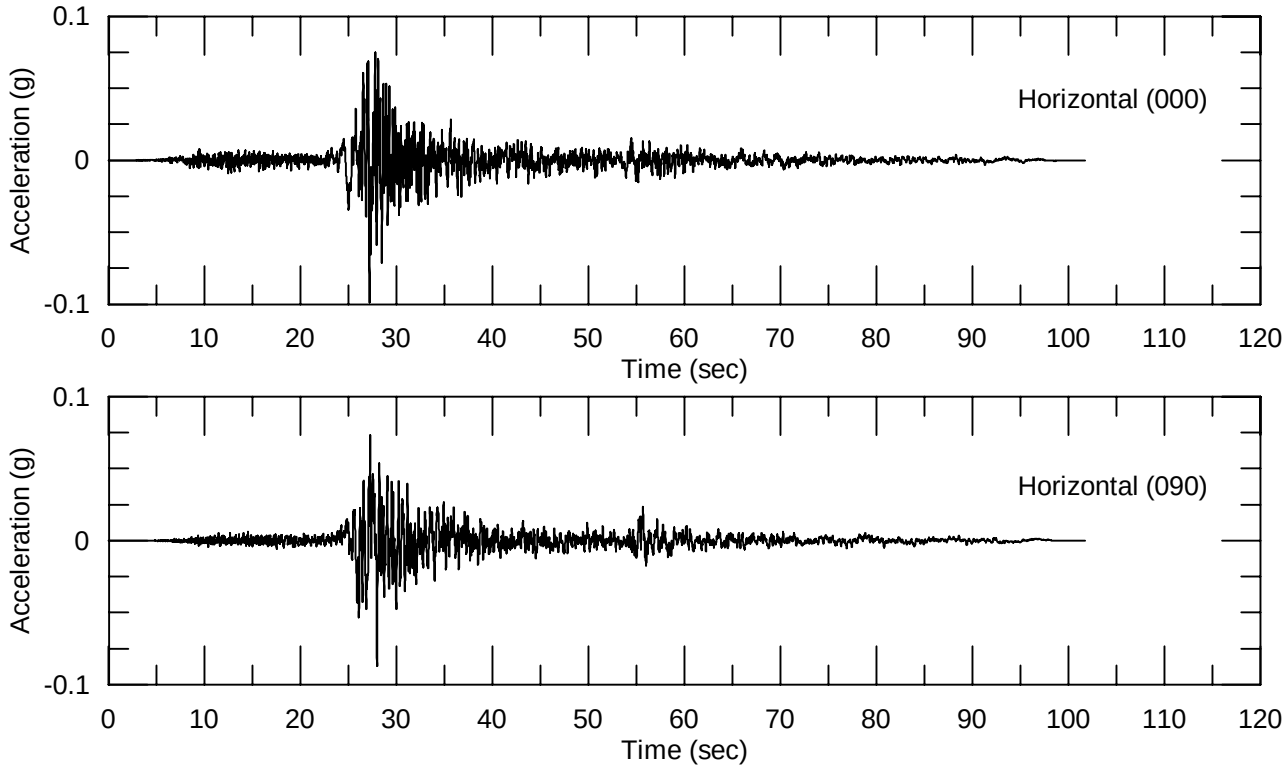


Sa = 1.25 g
1.3 Ts = 0.16

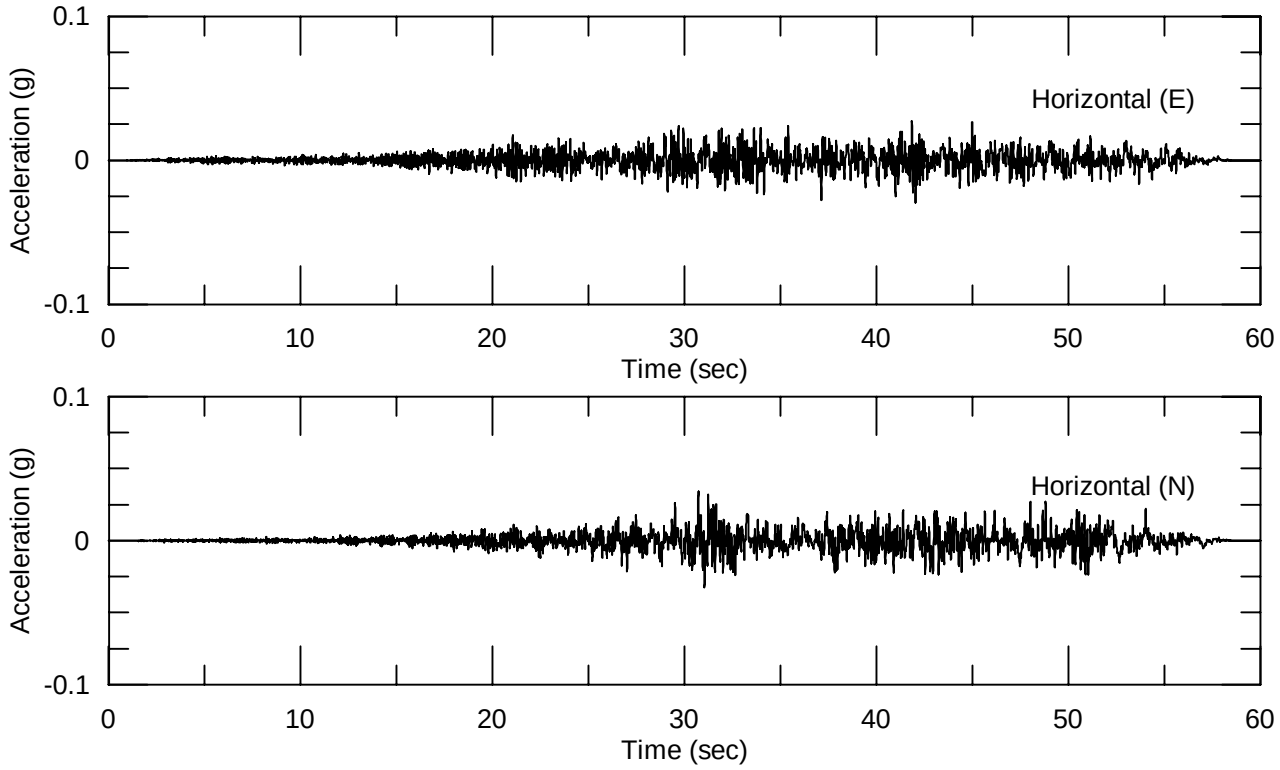
AECOM	Project No. 60440155 Joppa Power Station Dynegy	COMPARISON OF HORIZONTAL MEAN UHS ON HARD ROCK AND GROUND SURFACE AT 2,500-YEAR RETURN PERIOD	Figure 23



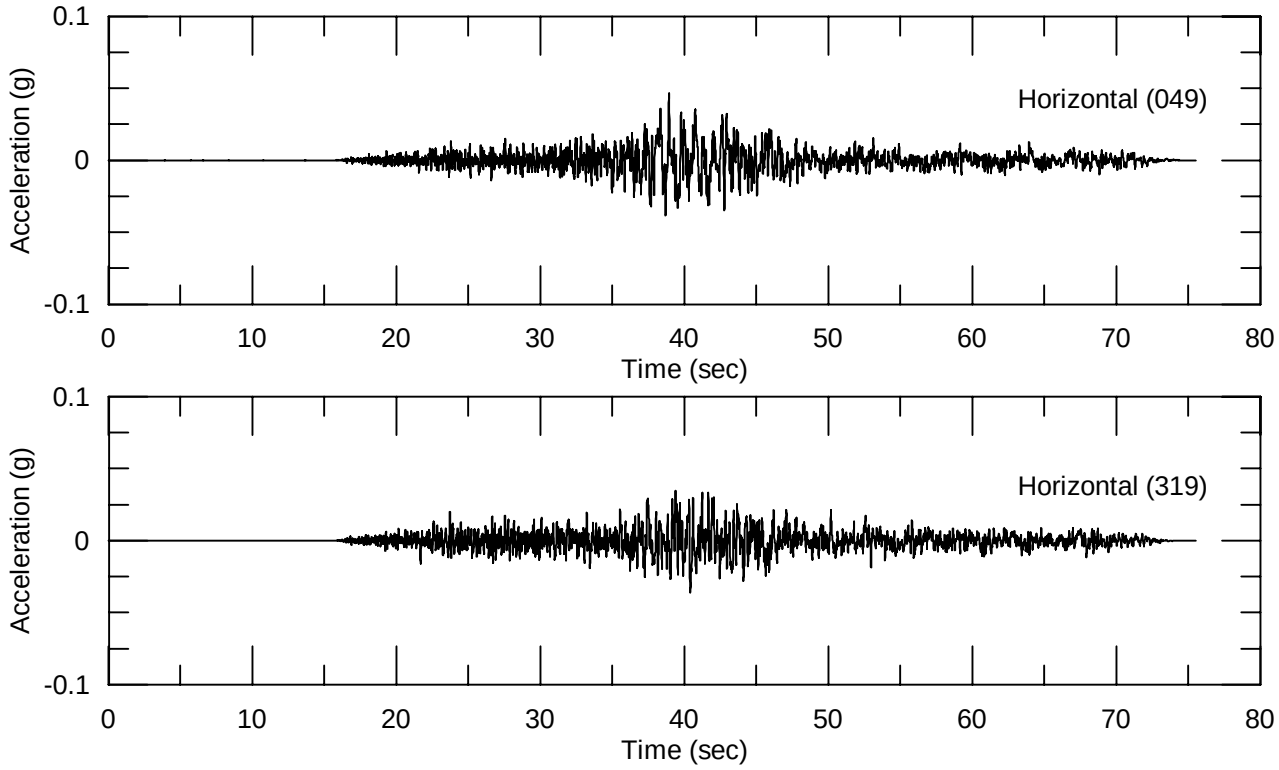
AECOM	Project No. 60440155 Joppa Power Station Dynegy	HORIZONTAL TARGET AND SELECTED SEED RESPONSE SPECTRA	Figure 24



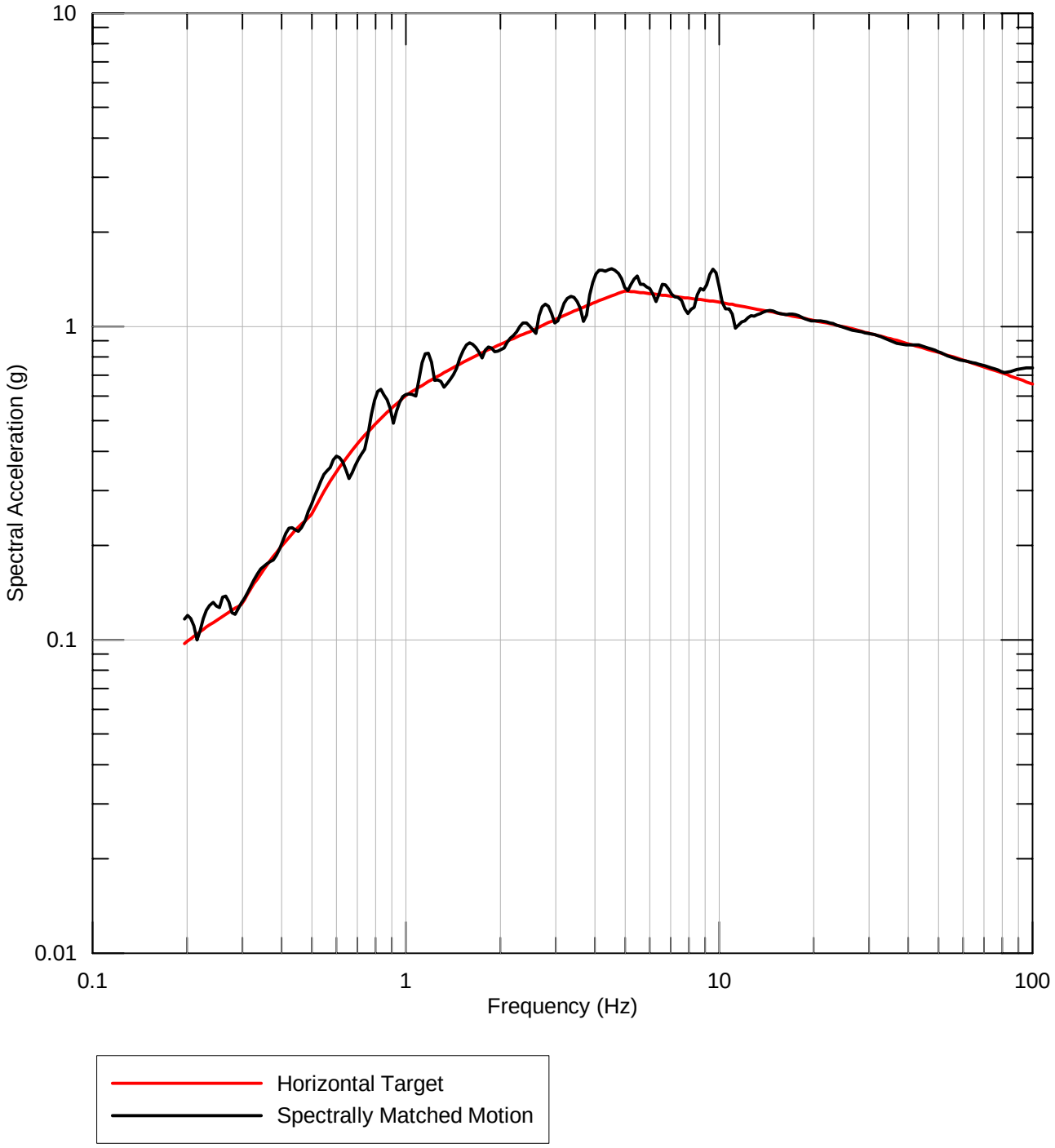
AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEED TIME HISTORIES RSN1153 - 1999 KOCAELI BOTAS	Figure 25



AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEED TIME HISTORIES RSN1404 - 1999 CHI CHI PNG	Figure 26

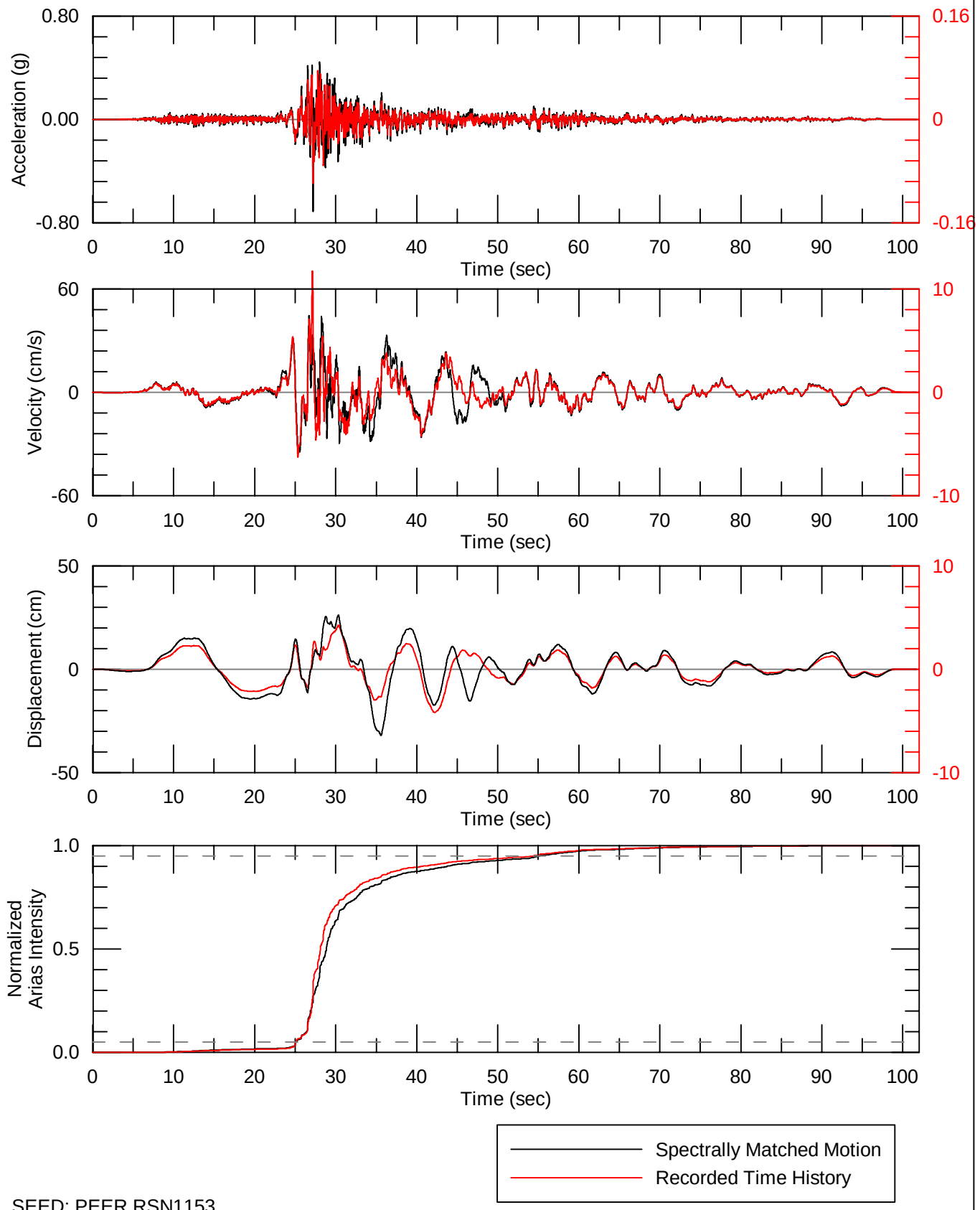


AECOM	Project No. 60440155 Joppa Power Station Dynegy	SEED TIME HISTORIES RSN2112 - 2002 DENALI TAPS PUMP STATION #08	Figure 27



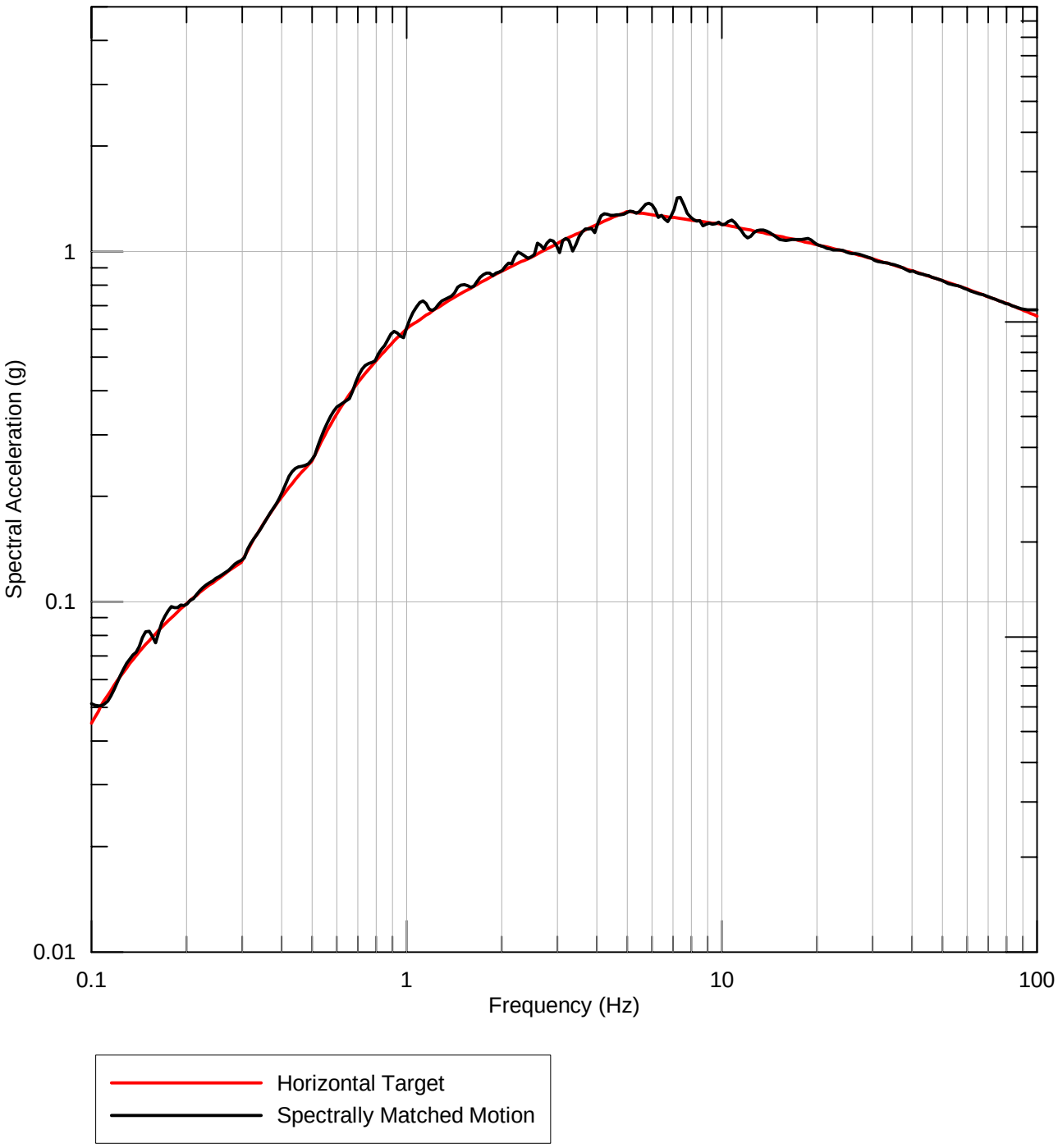
SEED: PEER RSN1153

AECOM	Project No. 60440155 Joppa Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 KOCAELI - BOTAS (000) SEED	Figure 28



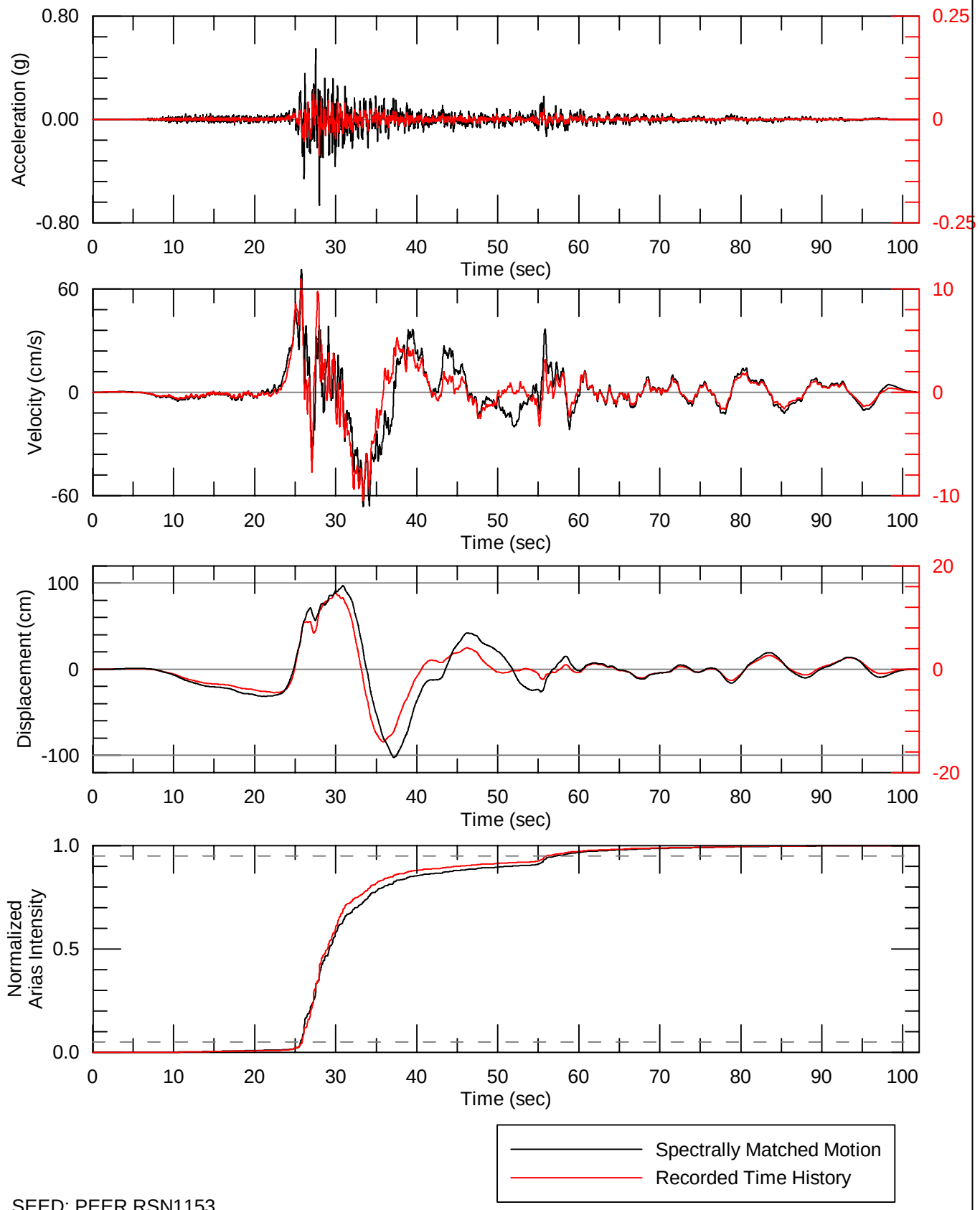
SEED: PEER RSN1153

AECOM	Project No. 60440155 Joppa Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 KOCAELI - BOTAS (000) SEED	Figure 29



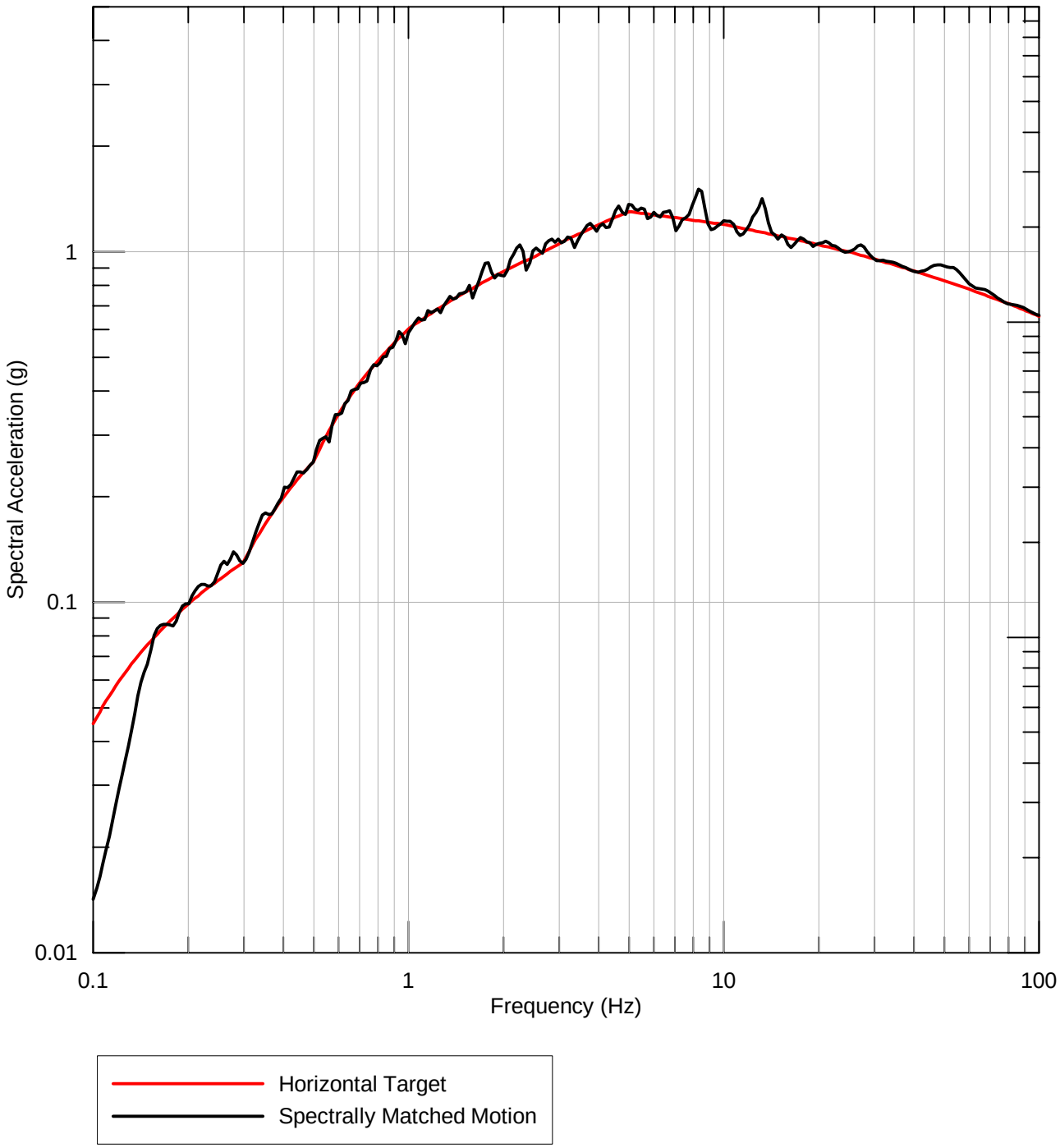
SEED: PEER RSN1153

AECOM	Project No. 60440155 Joppa Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 KOCAELI - BOTAS (090) SEED	Figure 30



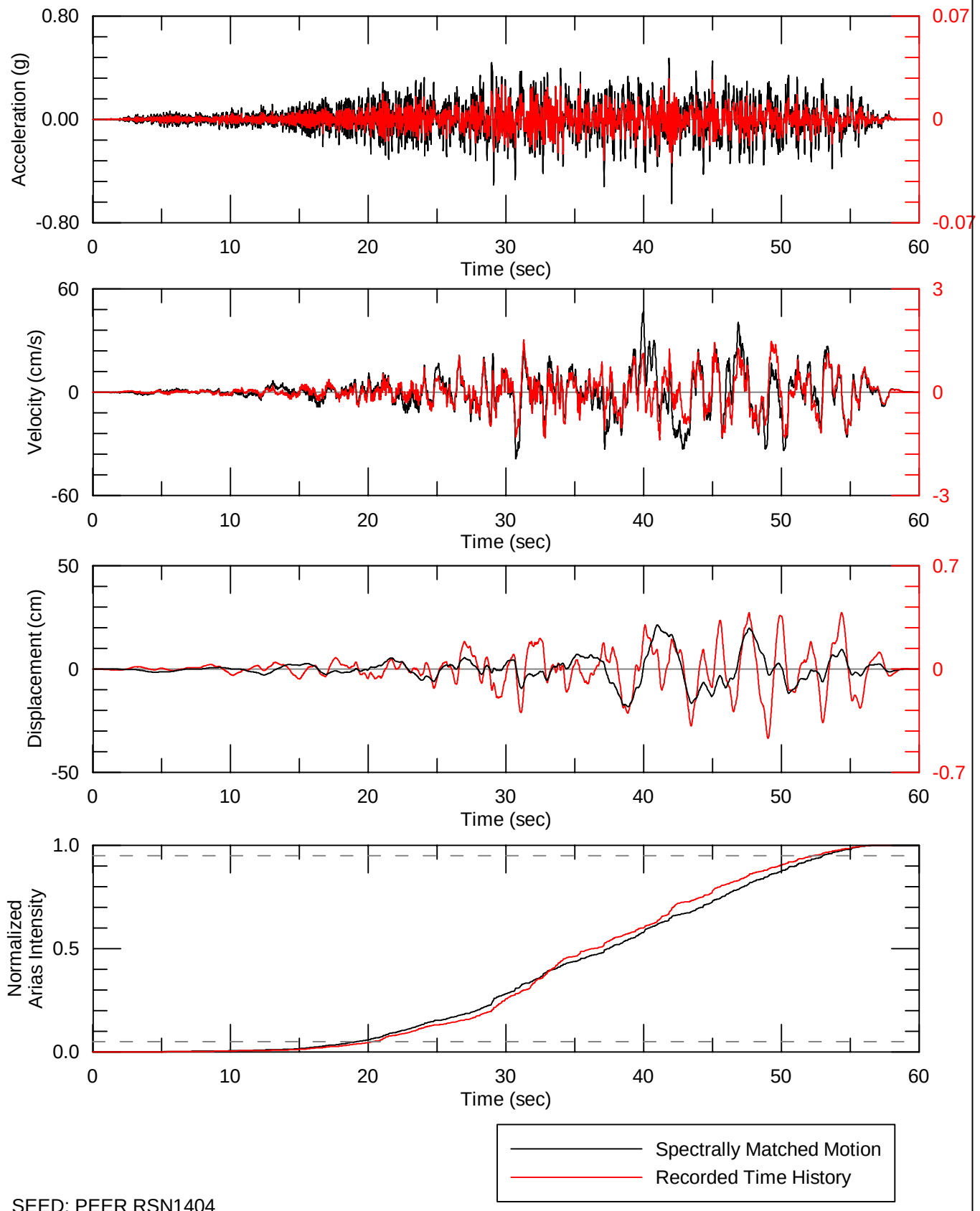
SEED: PEER RSN1153

AECOM	Project No. 60440155 Joppa Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 KOCAELI - BOTAS (090) SEED	Figure 31



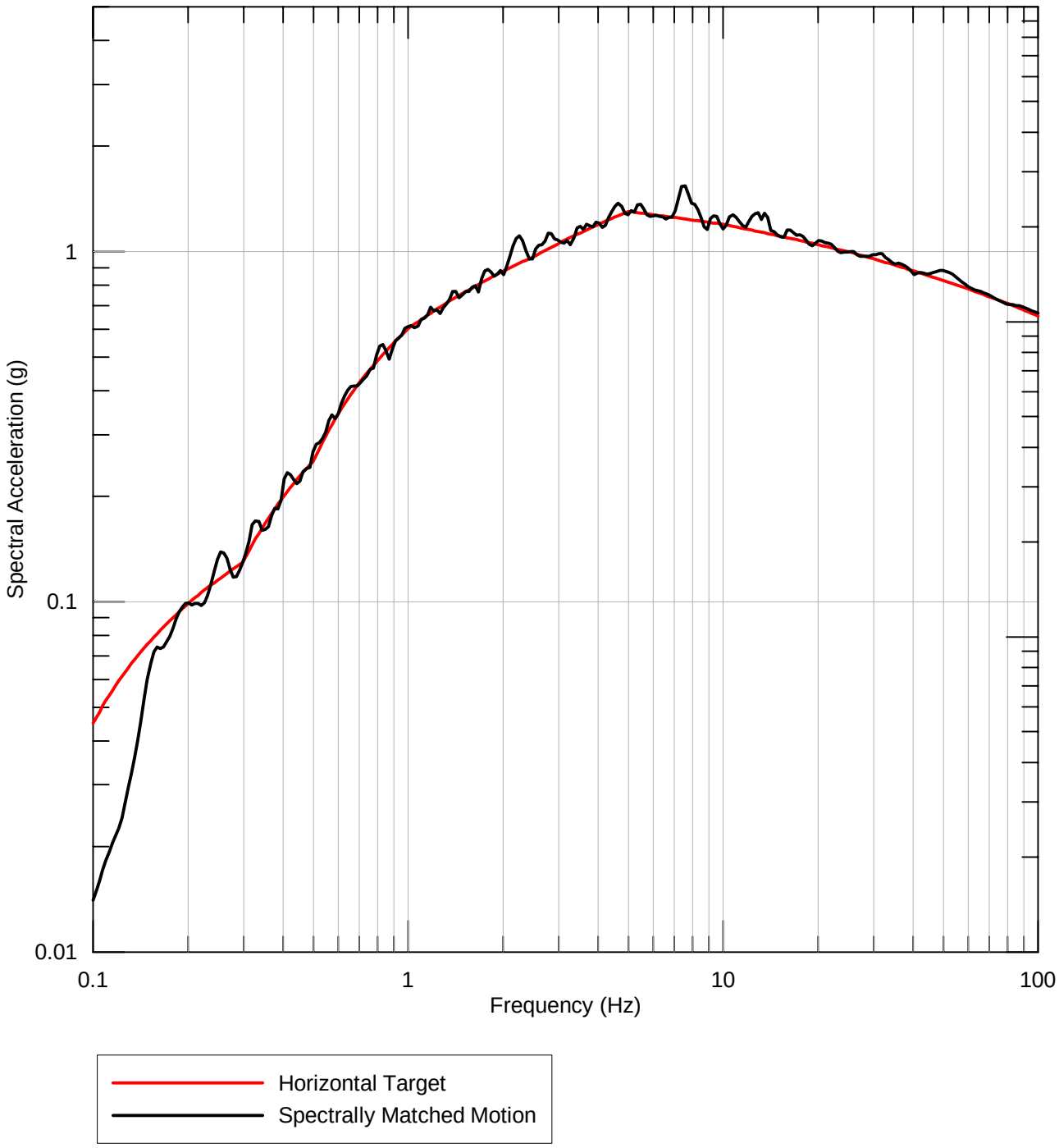
SEED: PEER RSN1404

AECOM	Project No. 60440155 Joppa Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 CHI-CHI - PNG (E) SEED	Figure 32



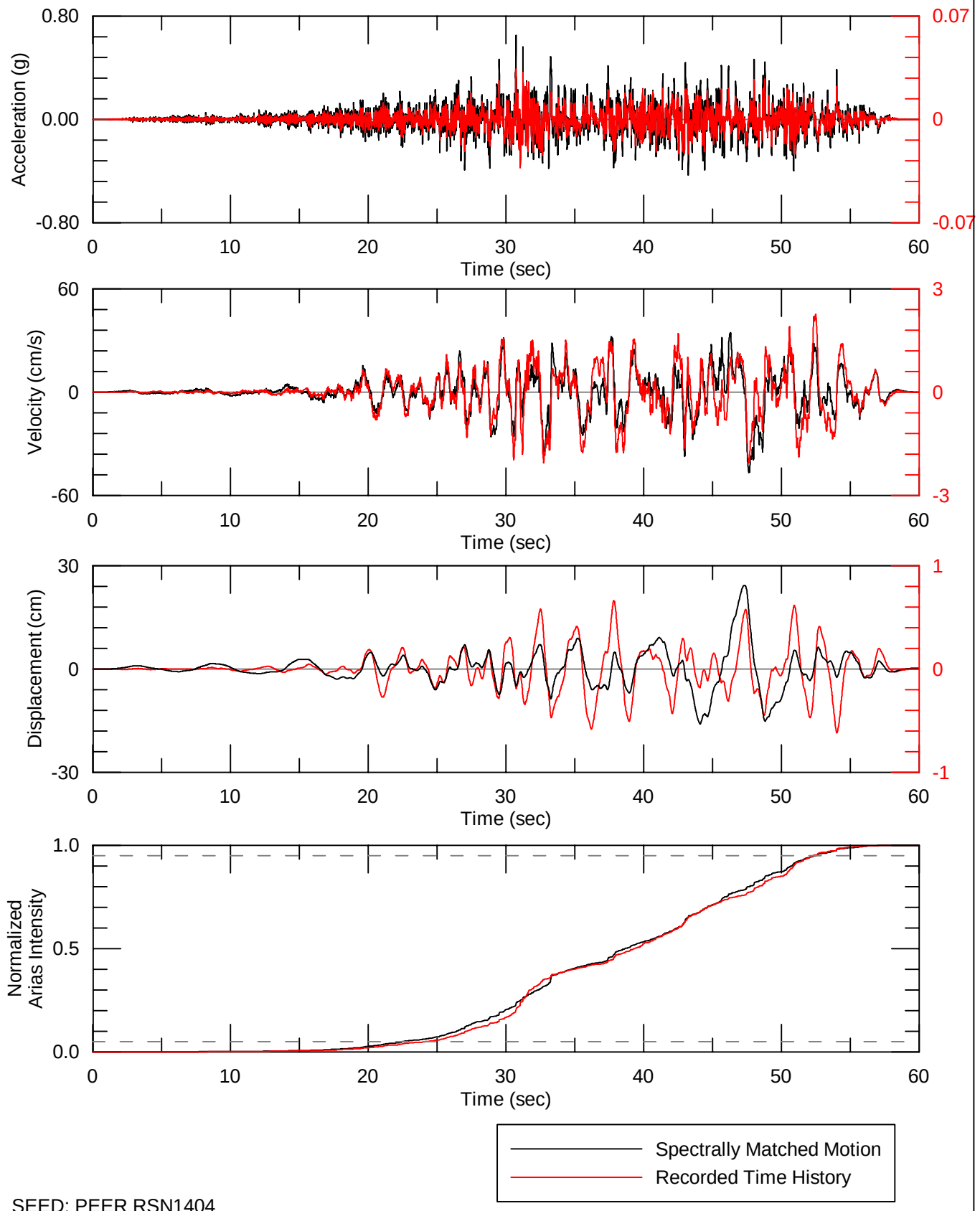
SEED: PEER RSN1404

AECOM	Project No. 60440155 Joppa Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 CHI-CHI - PNG (E) SEED	Figure 33



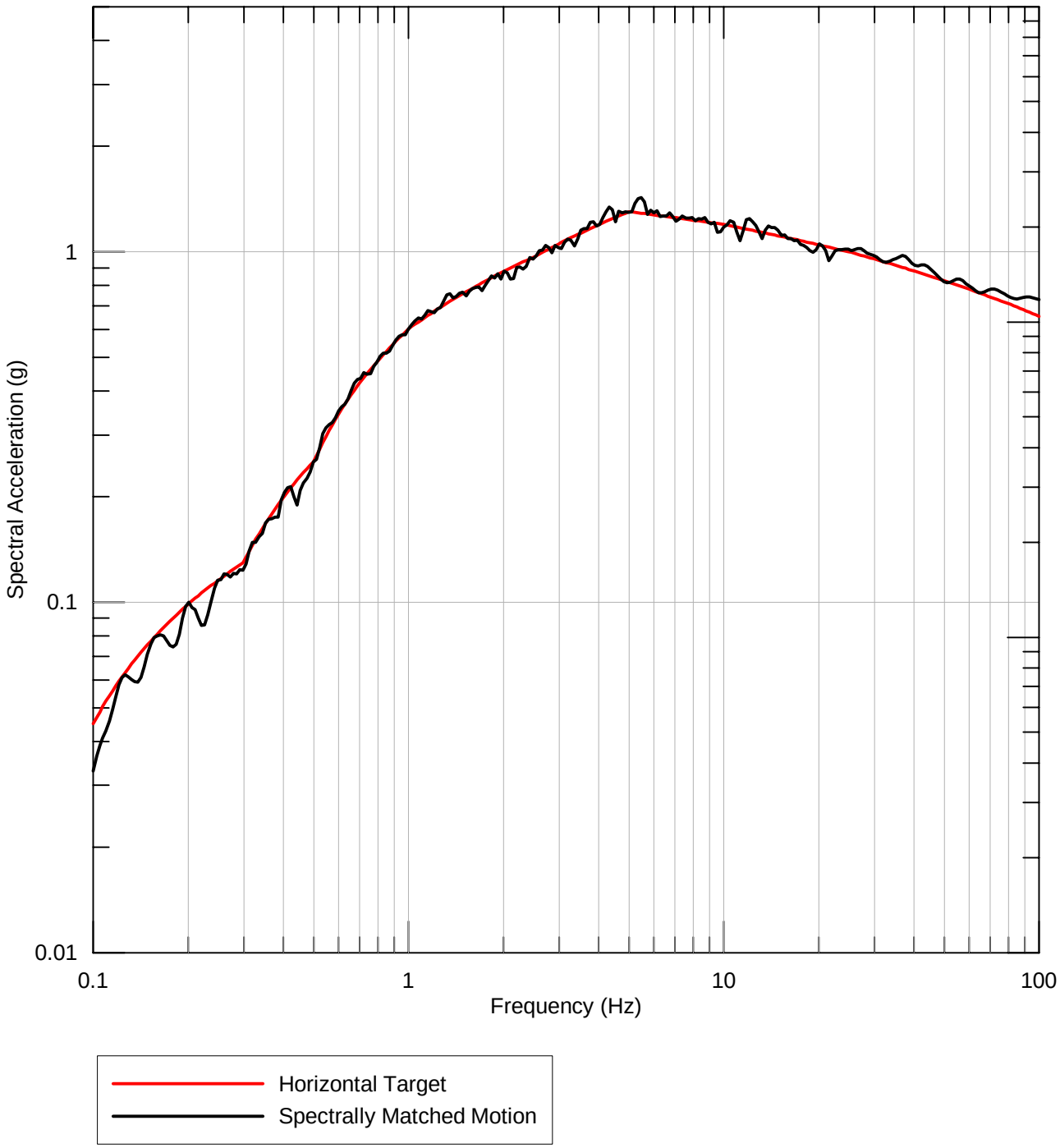
SEED: PEER RSN1404

AECOM	Project No. 60440155 Joppa Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 CHI-CHI - PNG (N) SEED	Figure 34



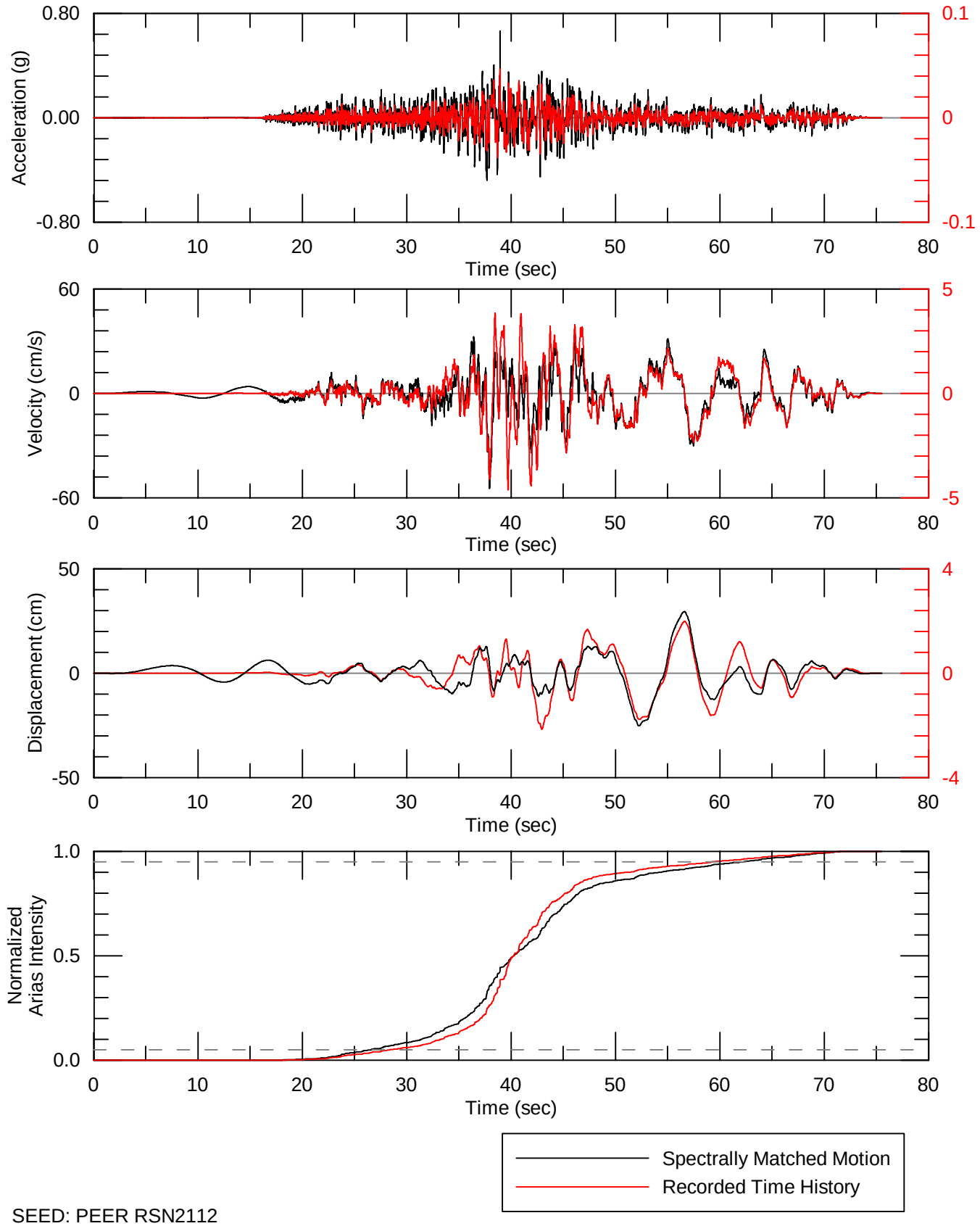
SEED: PEER RSN1404

AECOM	Project No. 60440155 Joppa Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 CHI-CHI - PNG (N) SEED	Figure 35



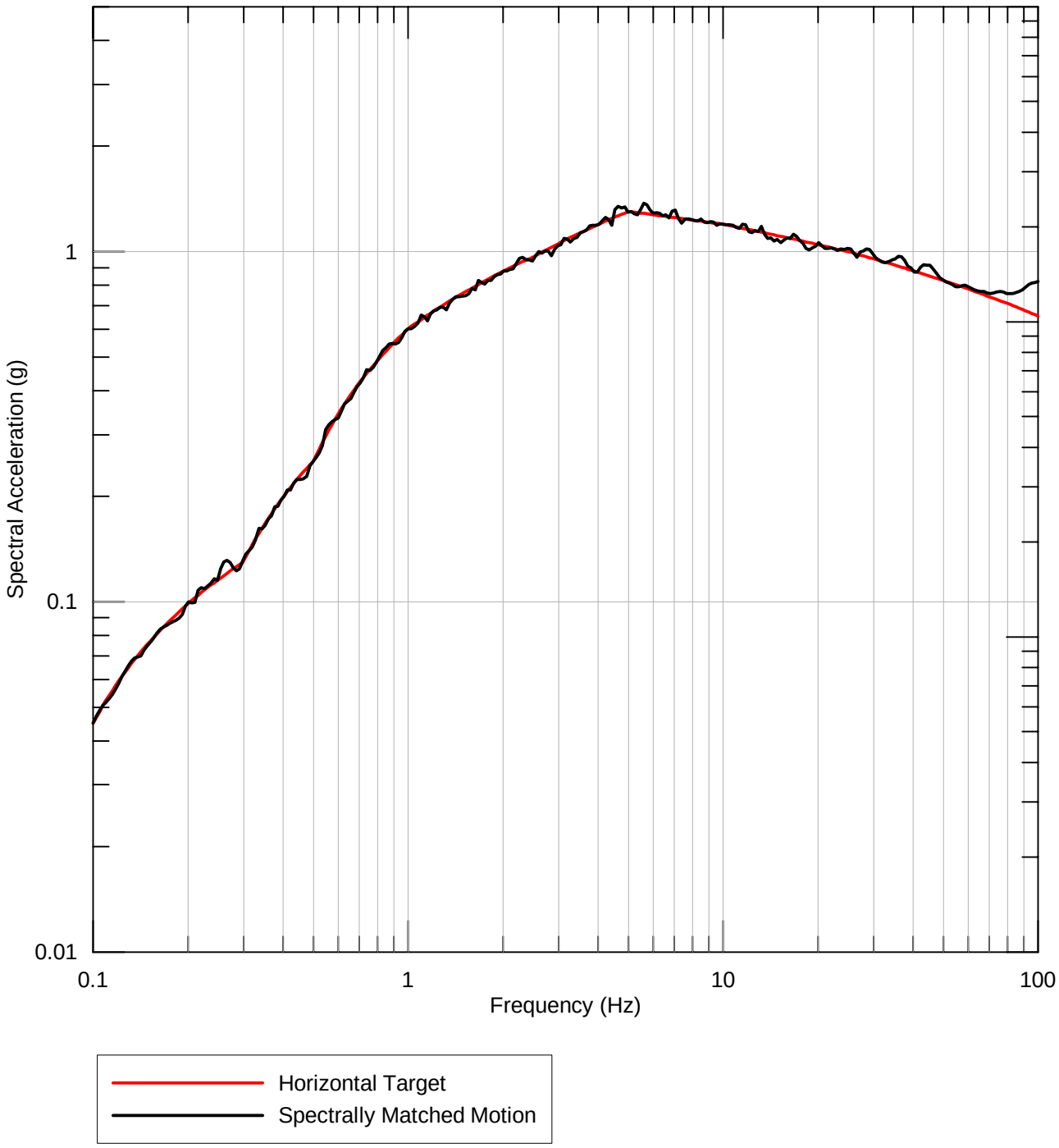
SEED: PEER RSN2112

AECOM	Project No. 60440155 Joppa Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 2002 DENALI - TAPS PUMP STATION #8 (049) SEED	Figure 36



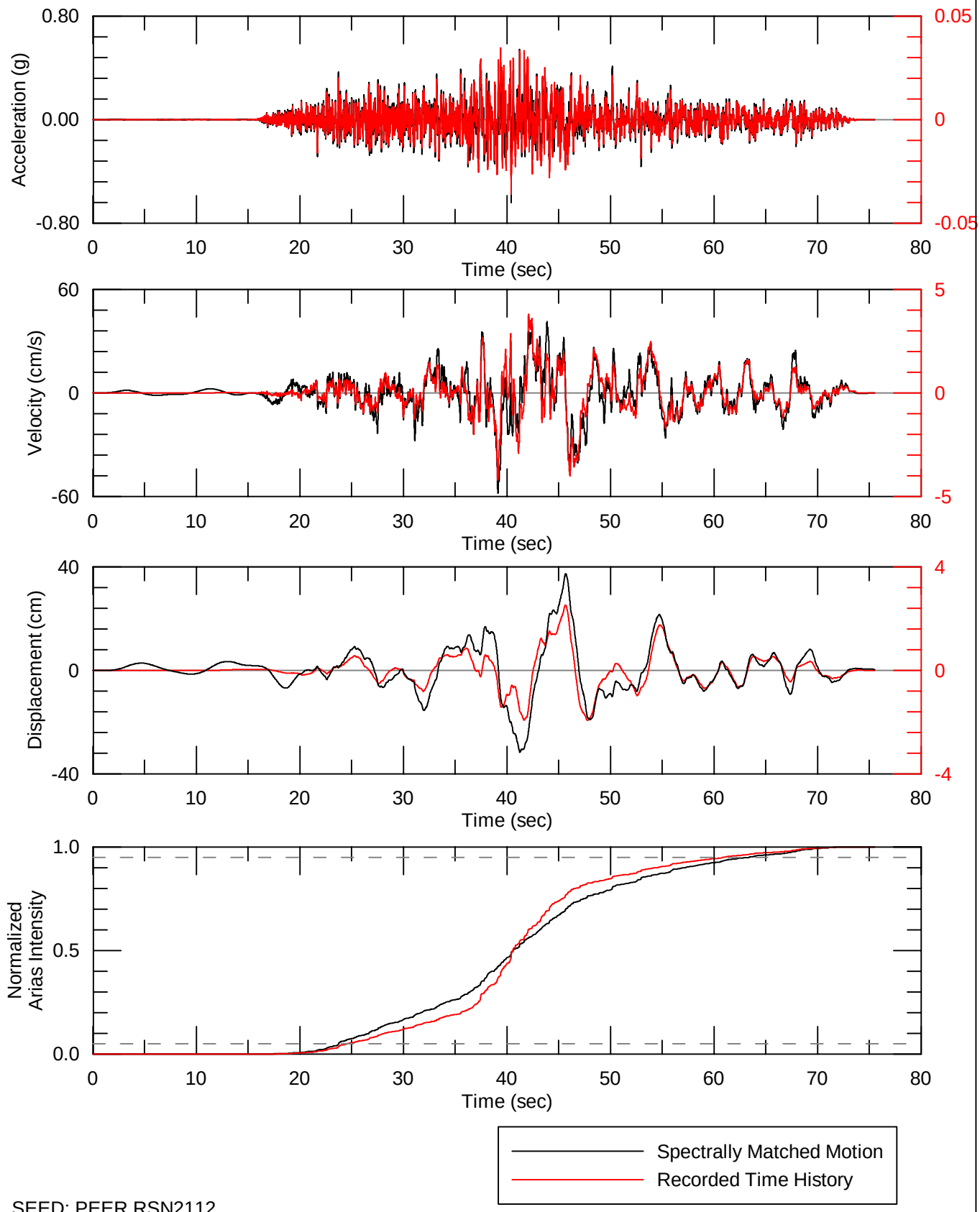
SEED: PEER RSN2112

AECOM	Project No. 60440155 Joppa Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 2002 DENALI - TAPS PUMP STATION #8 (049) SEED	Figure 37



SEED: PEER RSN2112

AECOM	Project No. 60440155 Joppa Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 2002 DENALI - PUMP STATION #8 (319) SEED	Figure 38



SEED: PEER RSN2112

AECOM	Project No. 60440155 Joppa Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 2002 DENALI - PUMP STATION #8 (319) SEED	Figure 39

Geosyntec
consultants

ATTACHMENT F

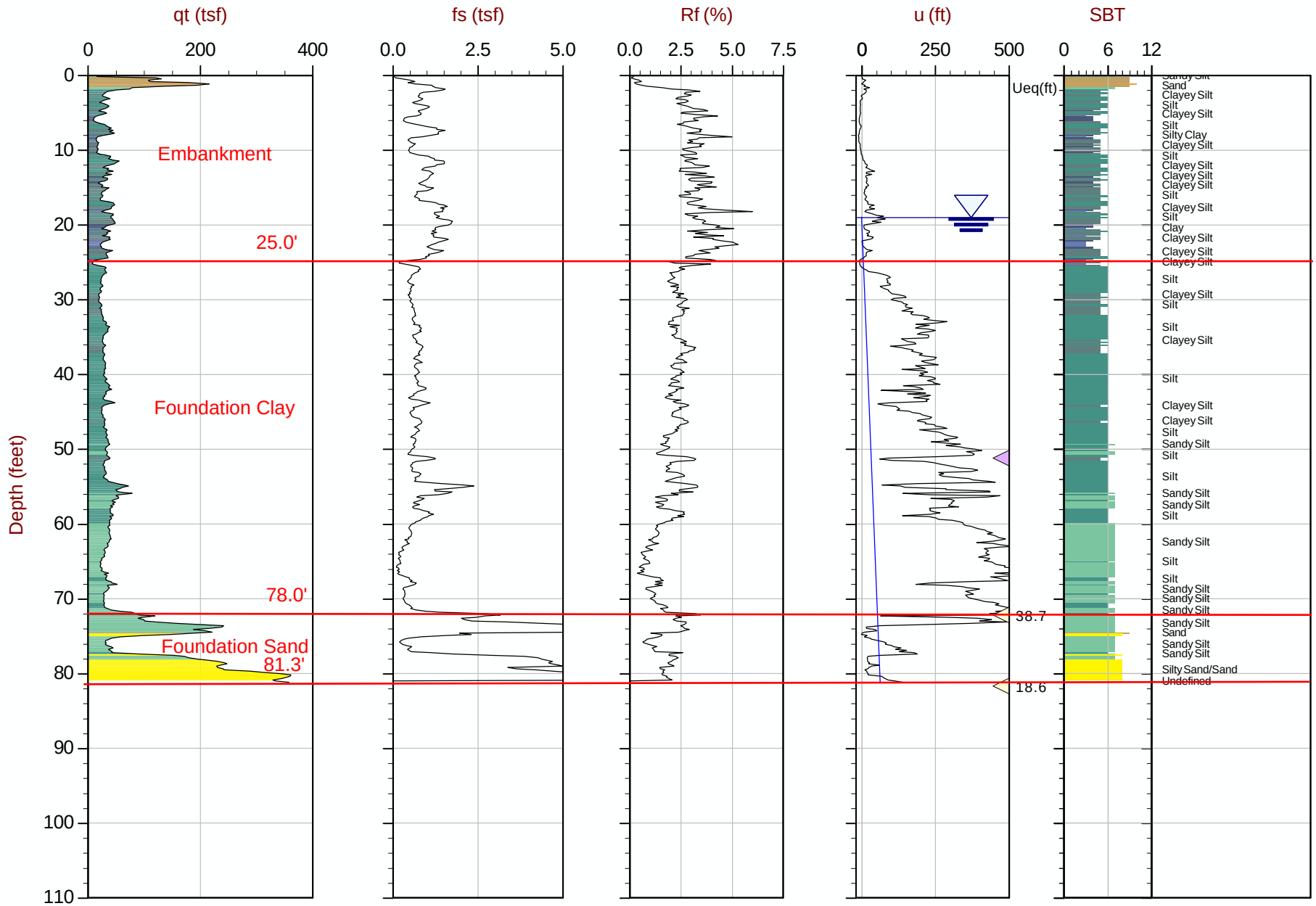
Liquefaction and Cyclic Softening Assessment

CONETEC

AECOM

Job No: 15-54071
Date: 08:12:15 08:08
Site: Dynegy Joppa IL

Sounding: JOP-C008
Cone: 184:T1500F15U500



Max Depth: 24.750 m / 81.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C008.COR
Unit Wt: SBT Zones

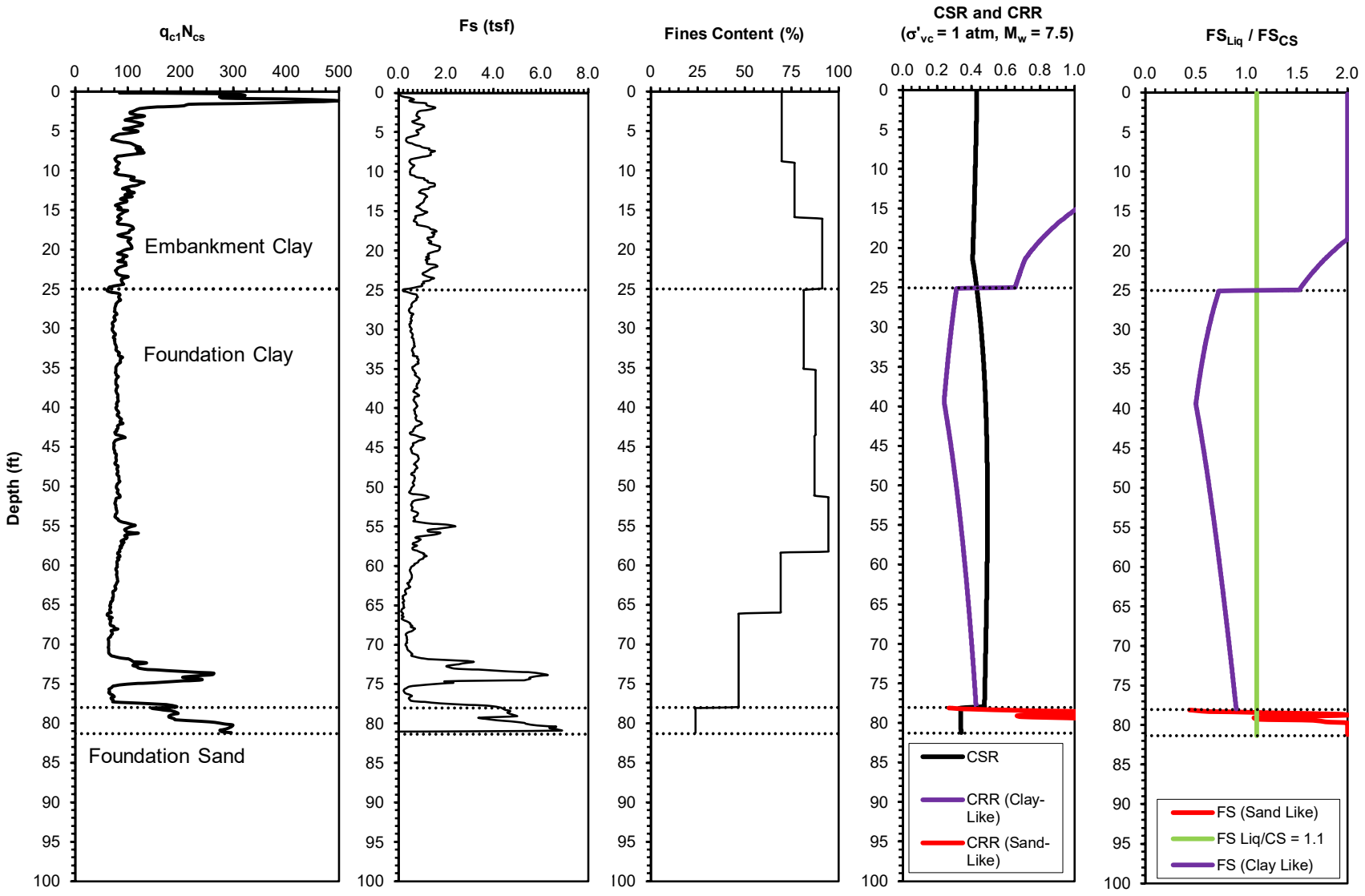
SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21582 Long: -88.84955

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Project Name: EEI Joppa East Ash Pond Closure Construction Permit
Location: Joppa, IL
Test Number: JOP-C008
Type of Sounding: CPTu
CPT Operator: ConeTec Inc.

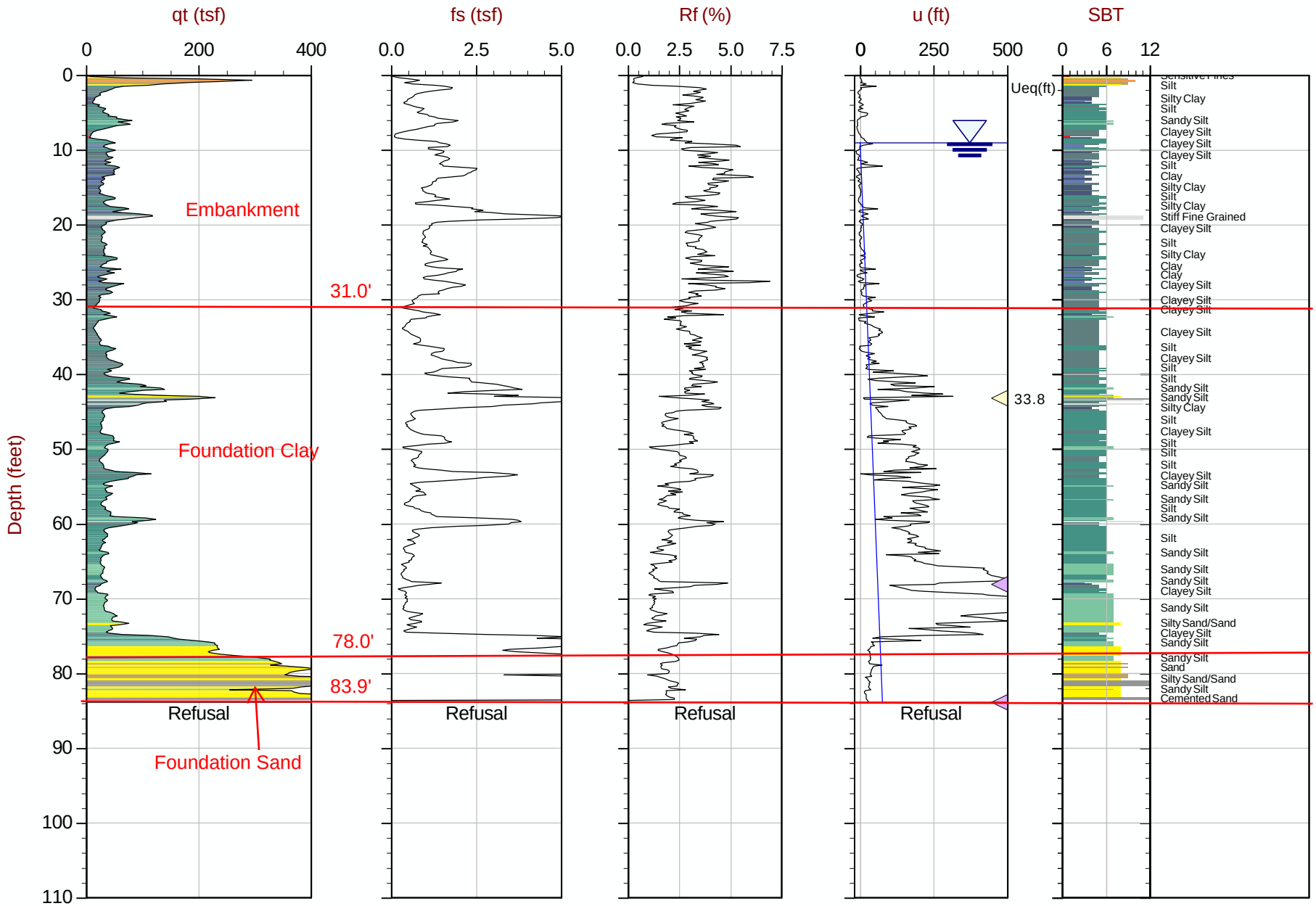


CONETEC

AECOM

Job No: 15-54071
Date: 08:11:15 07:46
Site: Dynegy Joppa IL

Sounding: JOP-SC010
Cone: 184:T1500F15U500



Max Depth: 25.550 m / 83.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC010.COR
Unit Wt: SBT Zones

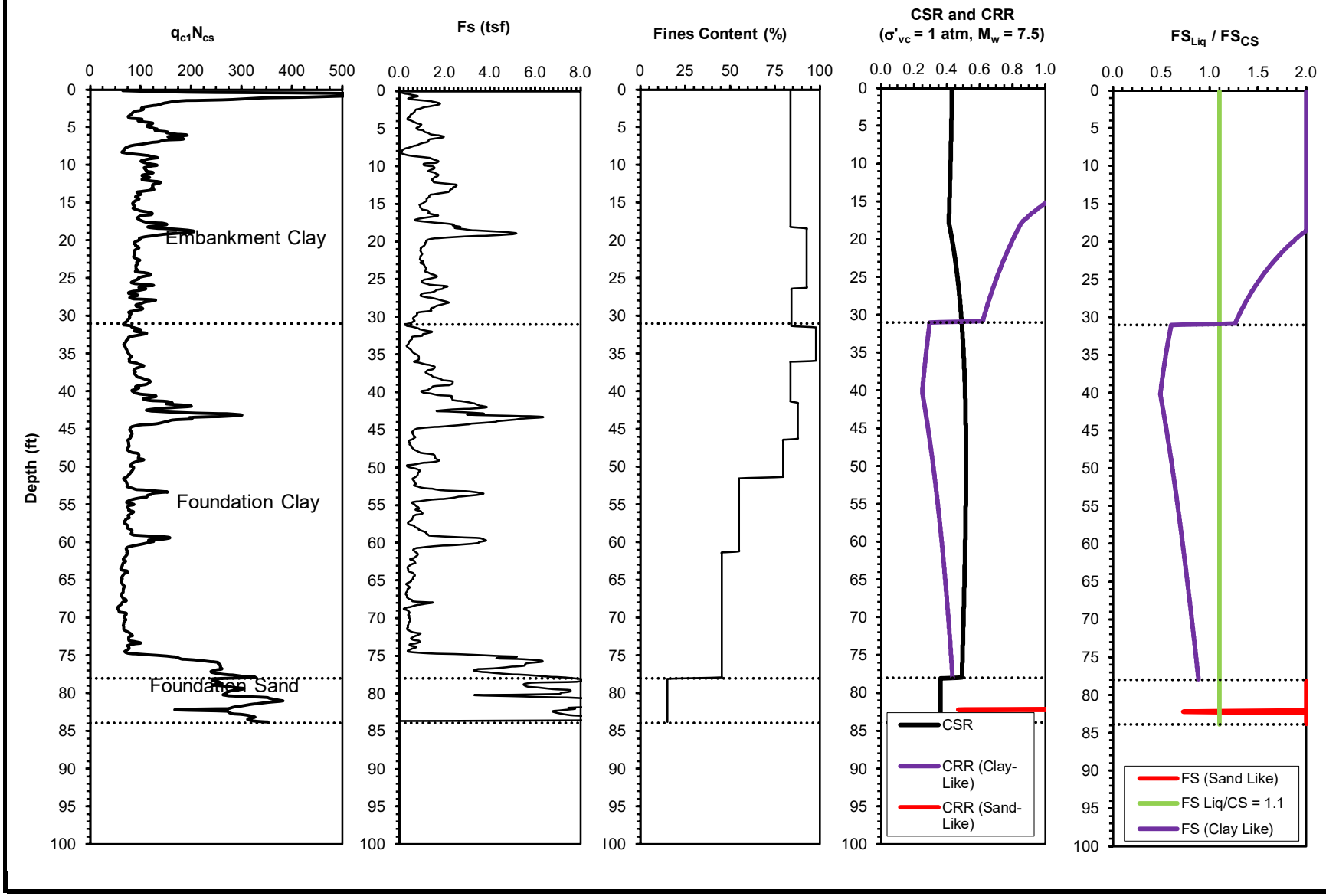
SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21962 Long: -88.85043

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Project Name: EEI Joppa East Ash Pond Closure Construction Permit
Location: Joppa, IL
Test Number: JOP-SC010
Type of Sounding: CPTu
CPT Operator: ConeTec Inc.

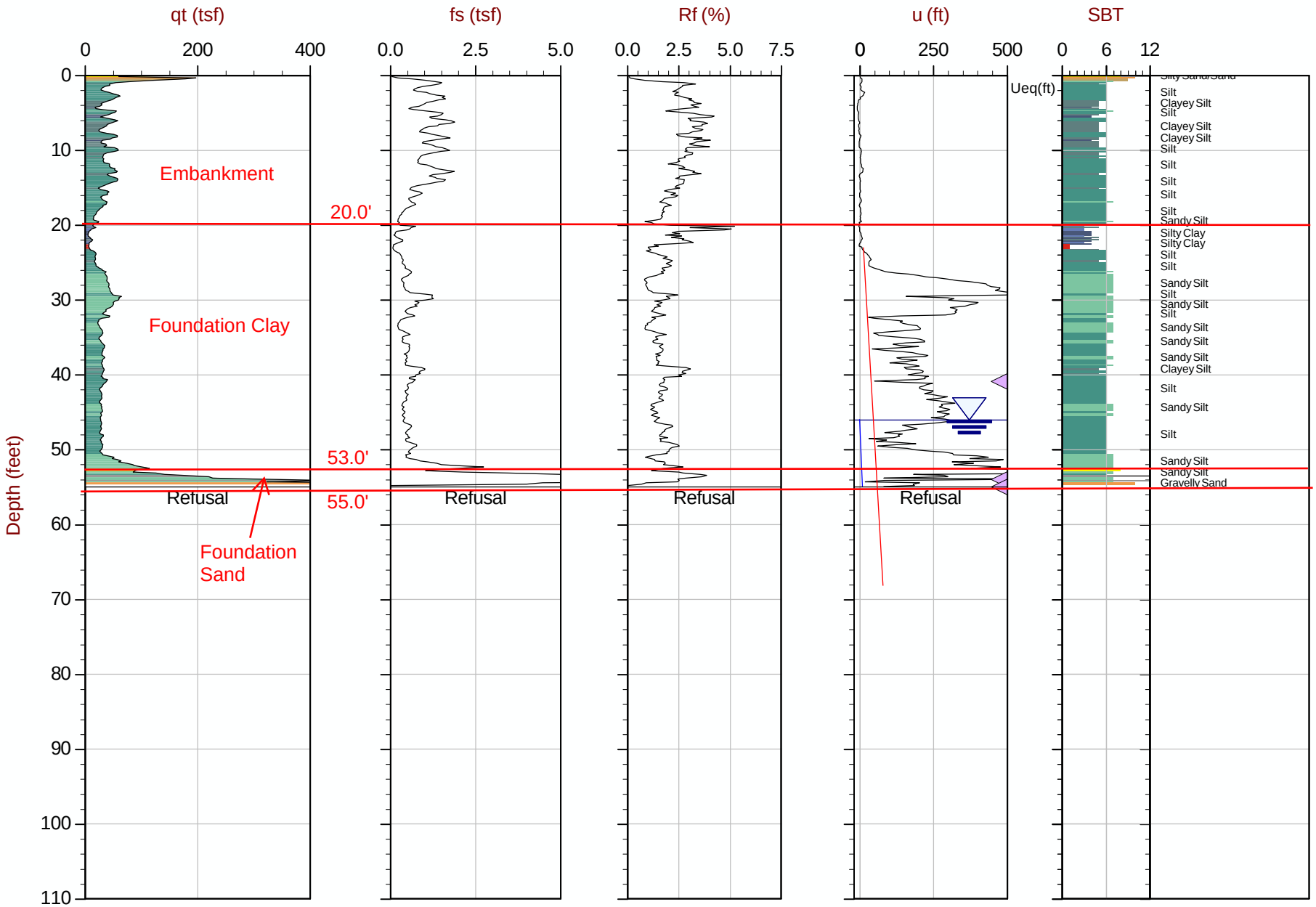


CONETEC

AECOM

Job No: 15-54071
Date: 08:10:15 08:43
Site: Dynegy Joppa IL

Sounding: JOP-SC012A
Cone: 184:T1500F15U500



Max Depth: 16.750 m / 54.95 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_SP JOP-SC012A.COR
Unit Wt: SBT Zones

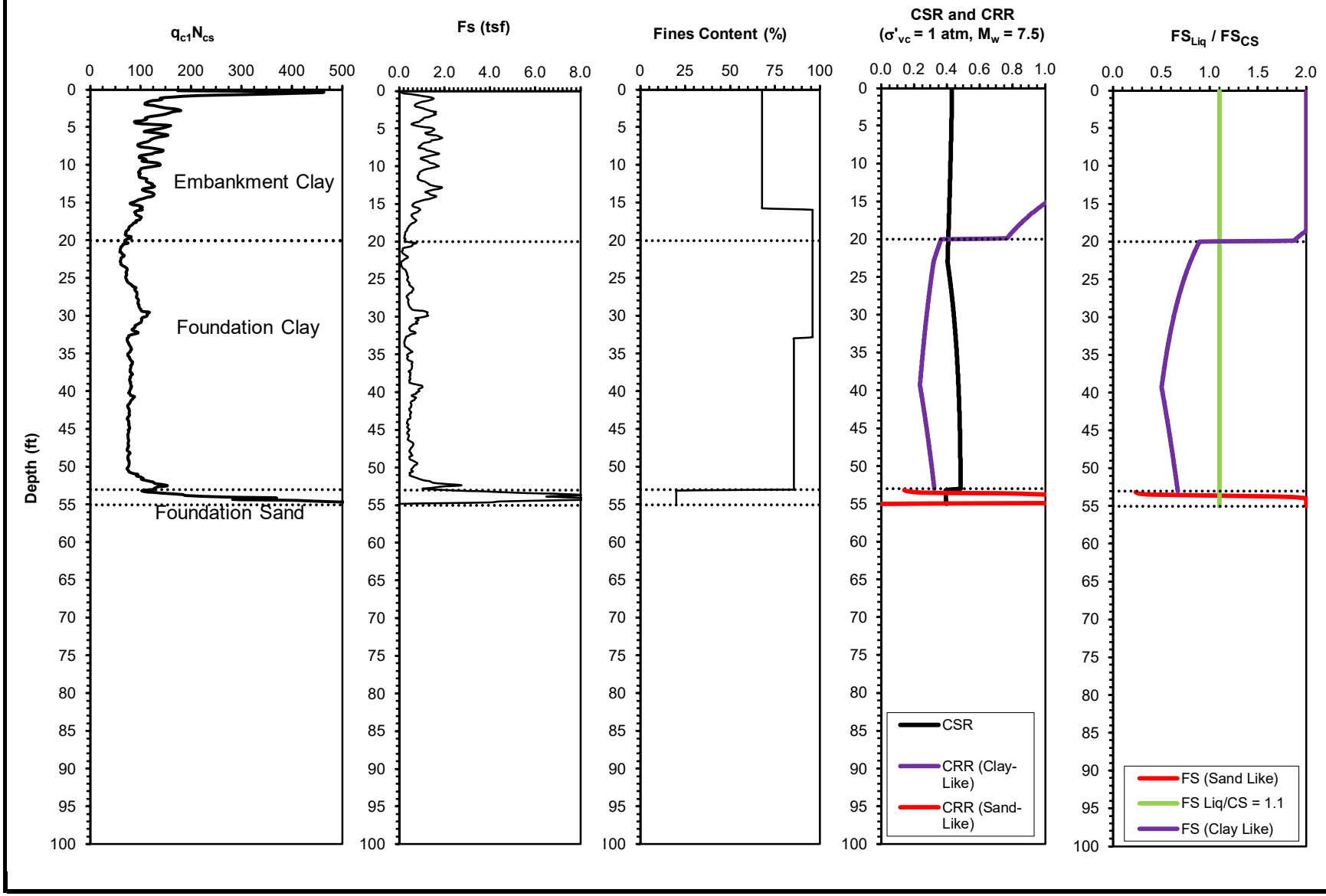
SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21535 Long: -88.85572

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Project Name: EEI Joppa East Ash Pond Closure Construction Permit
Location: Joppa, IL
Test Number: JOP-SC012A
Type of Sounding: CPTu
CPT Operator: ConeTec Inc.

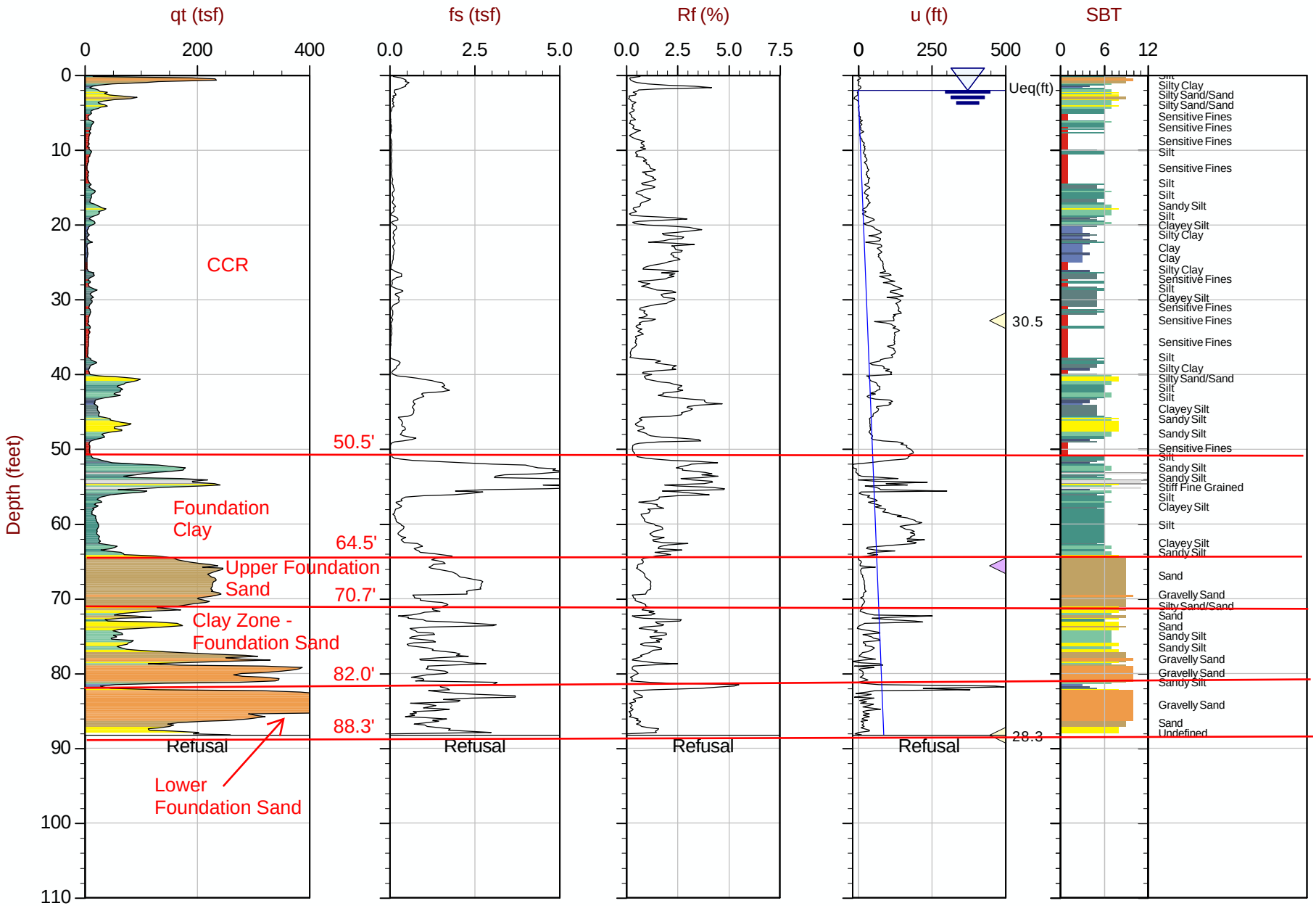


CONETEC

AECOM

Job No: 15-54071
Date: 08:20:15 07:39
Site: Dynegy Joppa IL

Sounding: JOP-C018
Cone: 349:T1500F15U500



Max Depth: 26.900 m / 88.25 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C018.COR
Unit Wt: SBT Zones

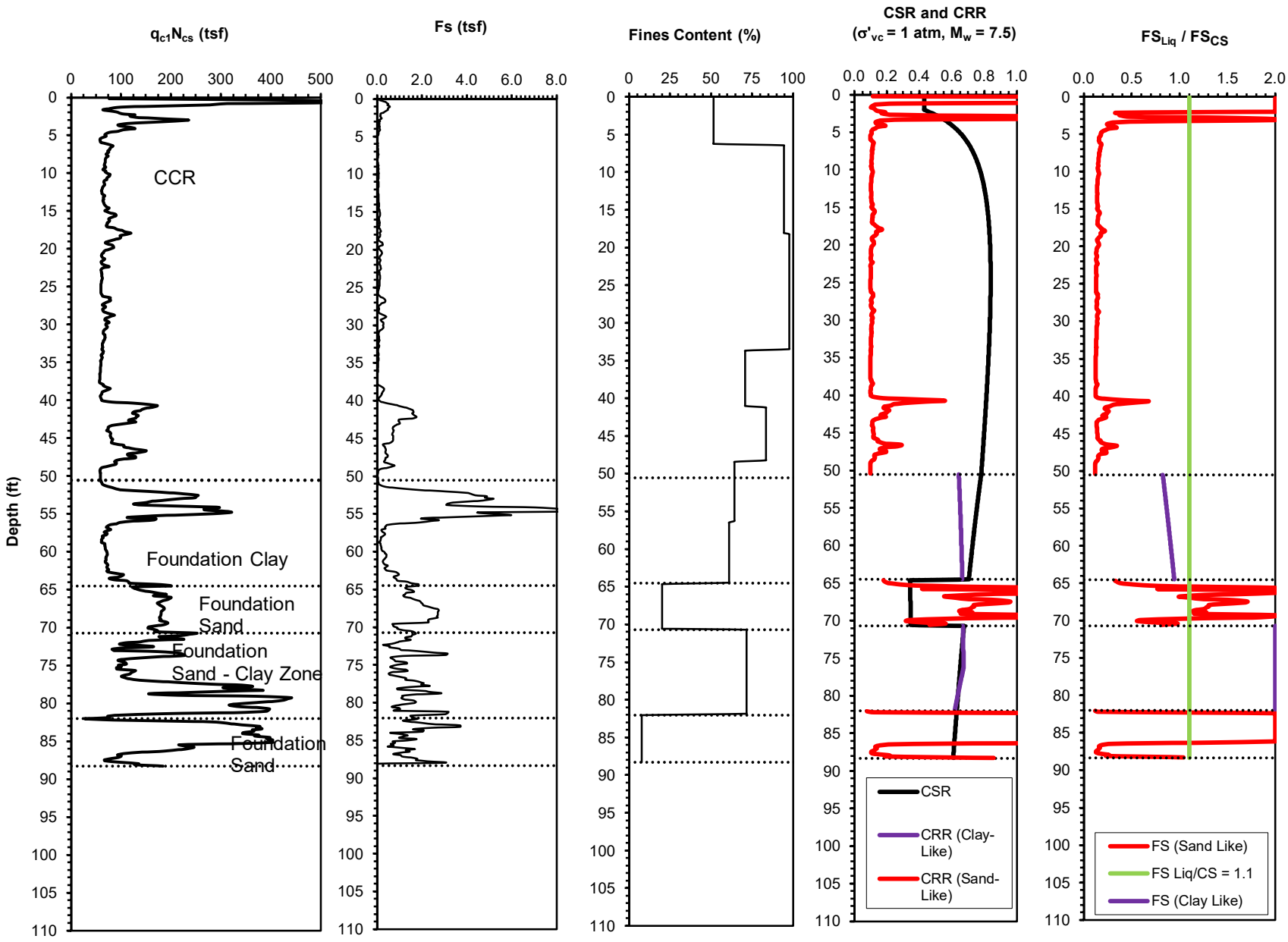
SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21265 Long: -88.85275

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Project Name: EEI Joppa East Ash Pond Closure Construction Permit
Location: Joppa, IL
Test Number: JOP-C018
Type of Sounding: CPTu
CPT Operator: ConeTec Inc.

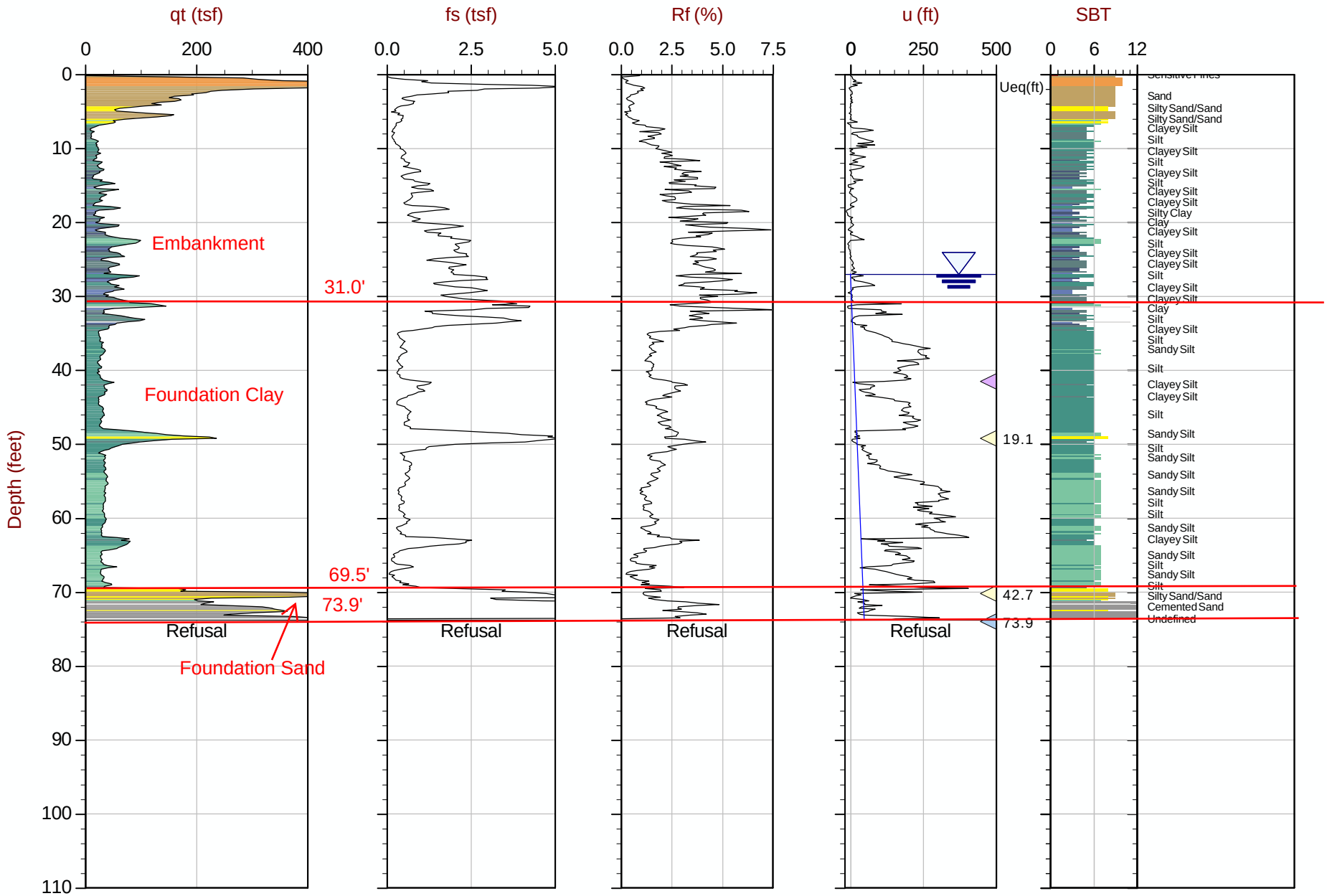


CONETEC

AECOM

Job No: 15-54071
Date: 08:09:15 09:29
Site: Dynegy Joppa IL

Sounding: JOP-C021
Cone: 349:T1500F15U500



Max Depth: 22.500 m / 73.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C021.COR
Unit Wt: SBT Zones

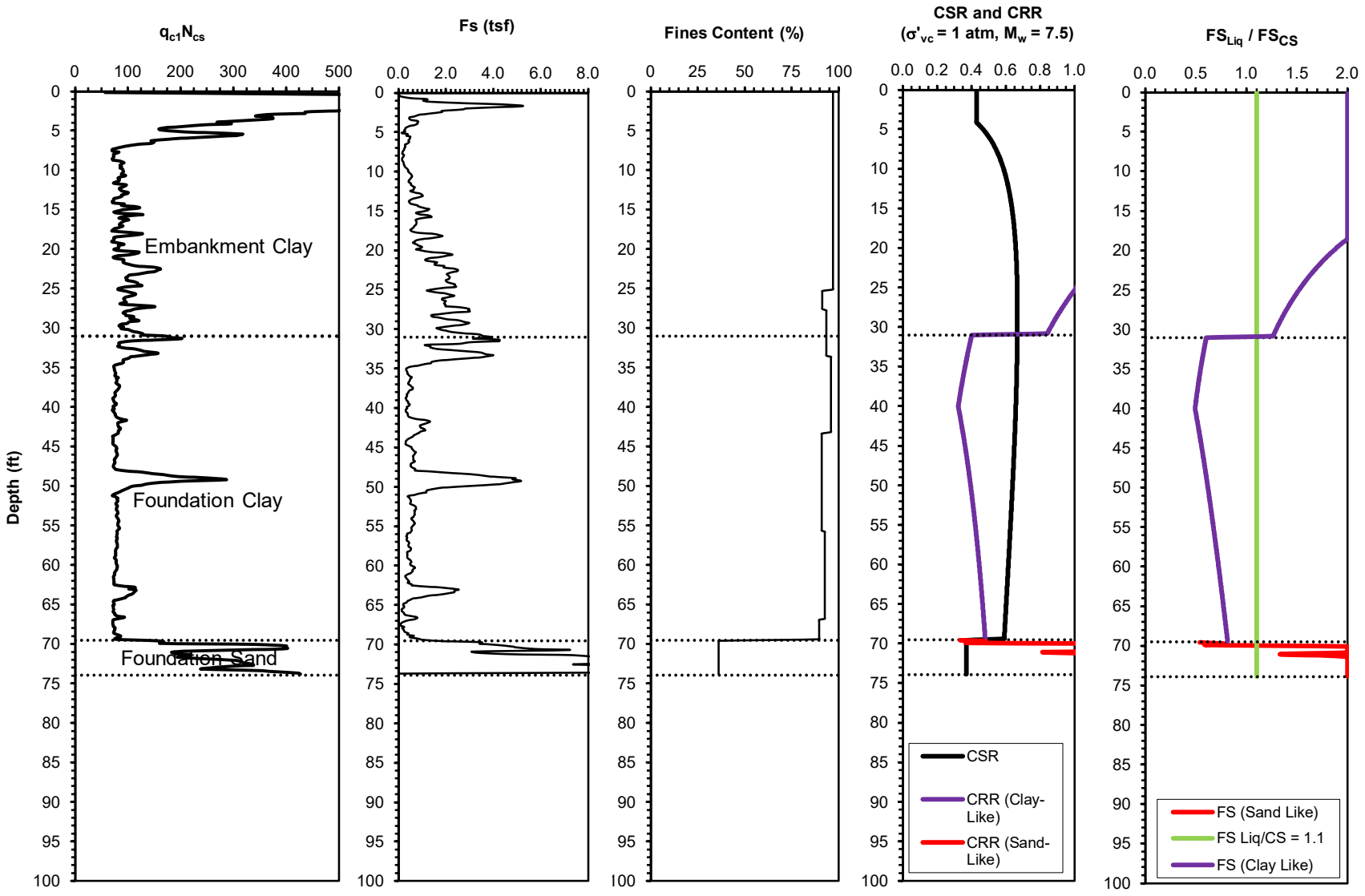
SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21165 Long: -88.85580

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Project Name: EEI Joppa East Ash Pond Closure Construction Permit
Location: Joppa, IL
Test Number: JOP-C021
Type of Sounding: CPTu
CPT Operator: ConeTec Inc.

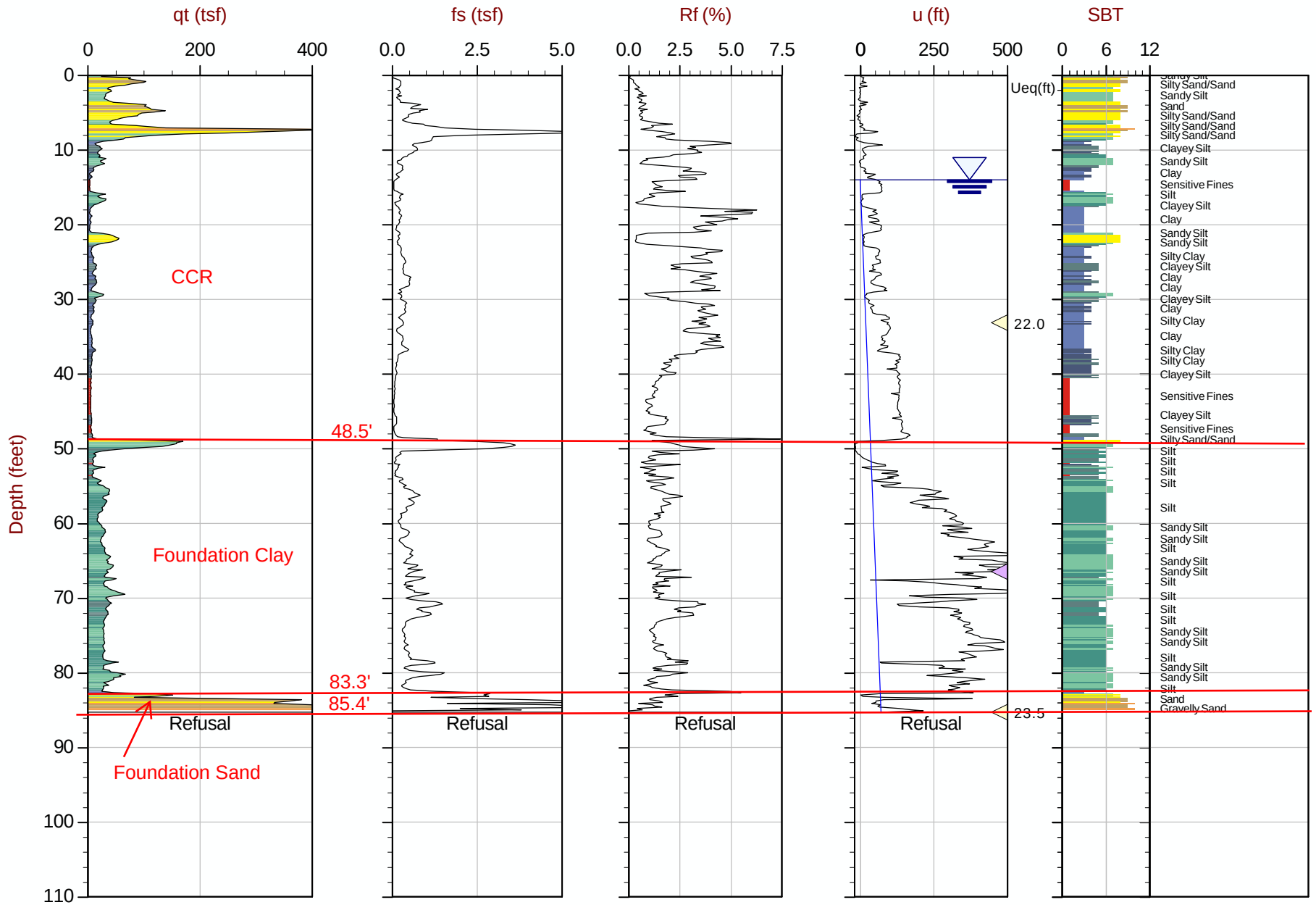


CONETEC

AECOM

Job No: 15-54071
Date: 08:13:15 07:28
Site: Dynegy Joppa IL

Sounding: JOP-C027
Cone: 184:T1500F15U500



Max Depth: 26.000 m / 85.30 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-54071_CP JOP-C027.COR
Unit Wt: SBT Zones

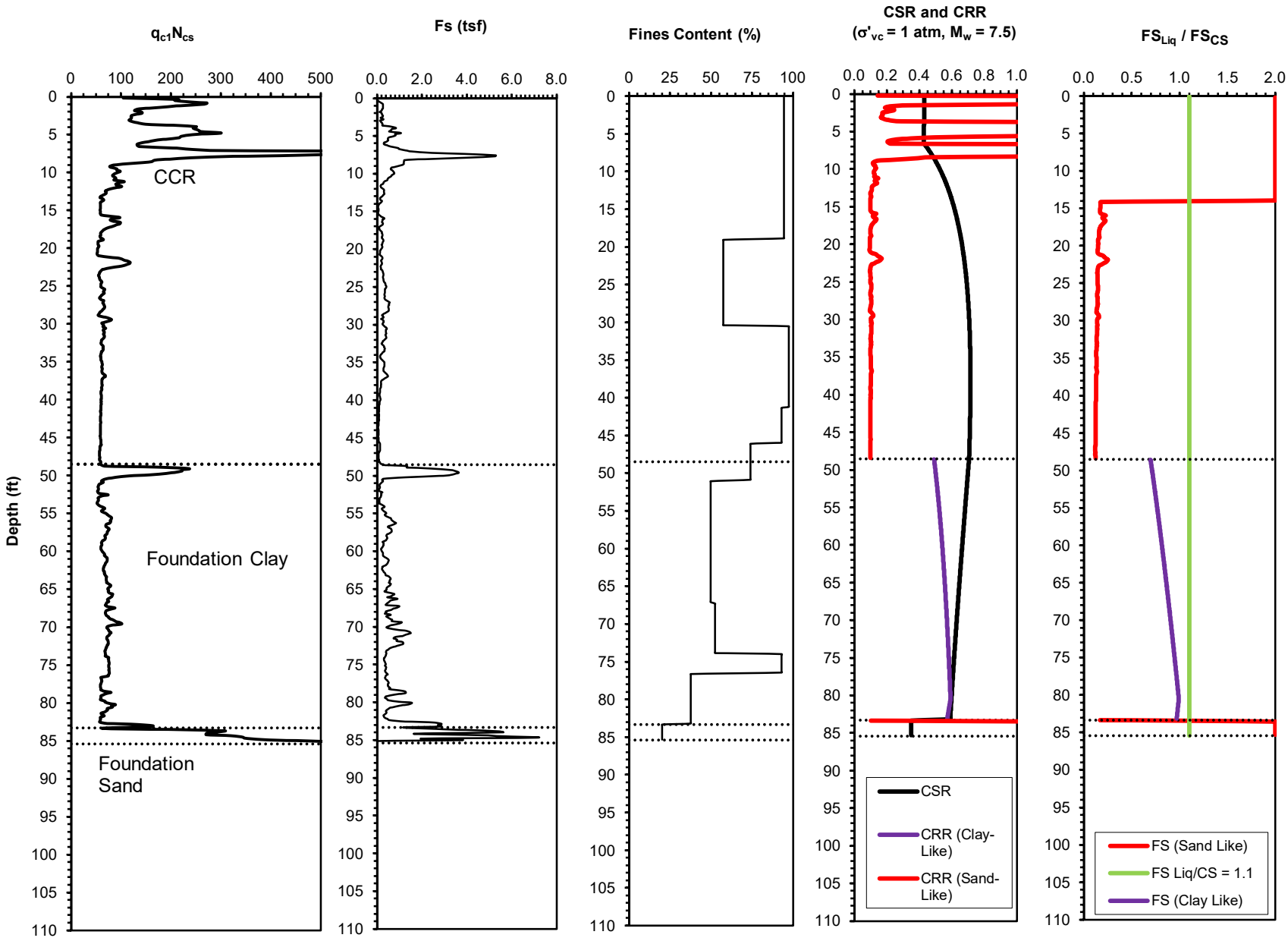
SBT: Robertson and Campanella, 1986
Coords: Lat: 37.21673 Long: -88.85213

△ Dissipation with estimated Ueq value

△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Project Name: EEI Joppa East Ash Pond Closure Construction Permit
Location: Joppa, IL
Test Number: JOP-C027
Type of Sounding: CPTu
CPT Operator: ConeTec Inc.



Geosyntec
consultants

ATTACHMENT G

Global Slope Stability Analysis Output

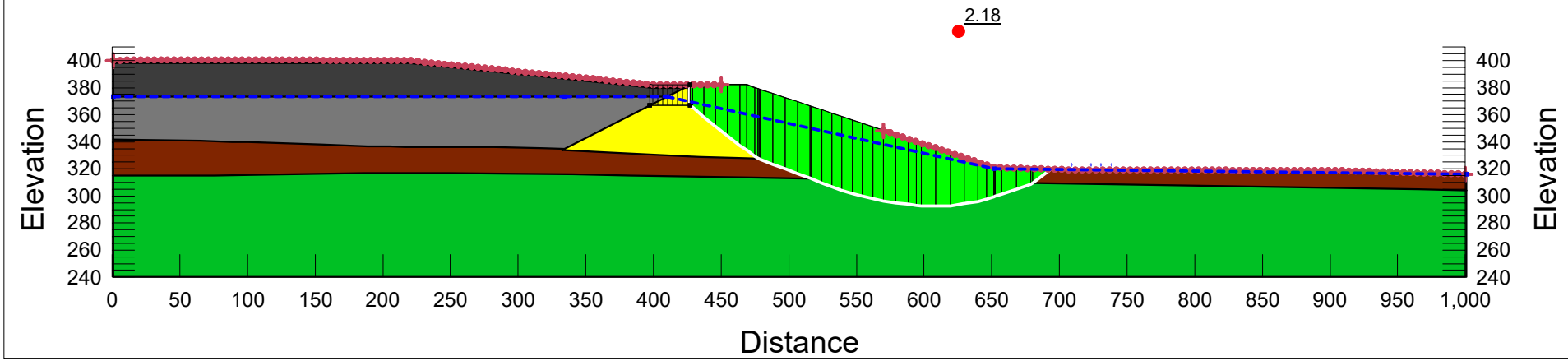
Joppa_East Ash Pond

Section A_End of Construction

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110			0	34	0	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0	1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500				1
	Final Cover System	Mohr-Coulomb	110			0	27	0	1
	Foundation Clays (Undrained)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0	1
	Foundation Sands	Mohr-Coulomb	130			0	35	0	1



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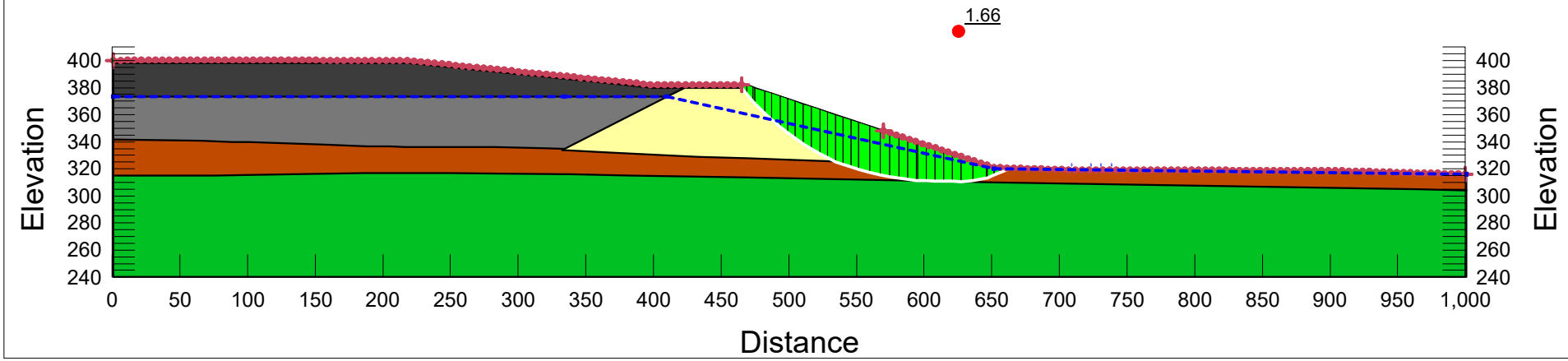
Joppa_East Ash Pond
Section A_Long Term

Calculated By: PK Date: 04/18/22
Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110	0	34	0	1
	Compacted CCR	Mohr-Coulomb	121	0	34	0	1
	Embankment Fill (Drained)	Mohr-Coulomb	131	300	30	0	1
	Final Cover System	Mohr-Coulomb	110	0	27	0	1
	Foundation Clays (Drained)	Mohr-Coulomb	127	150	29	0	1
	Foundation Sands	Mohr-Coulomb	130	0	35	0	1



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Joppa_East Ash Pond

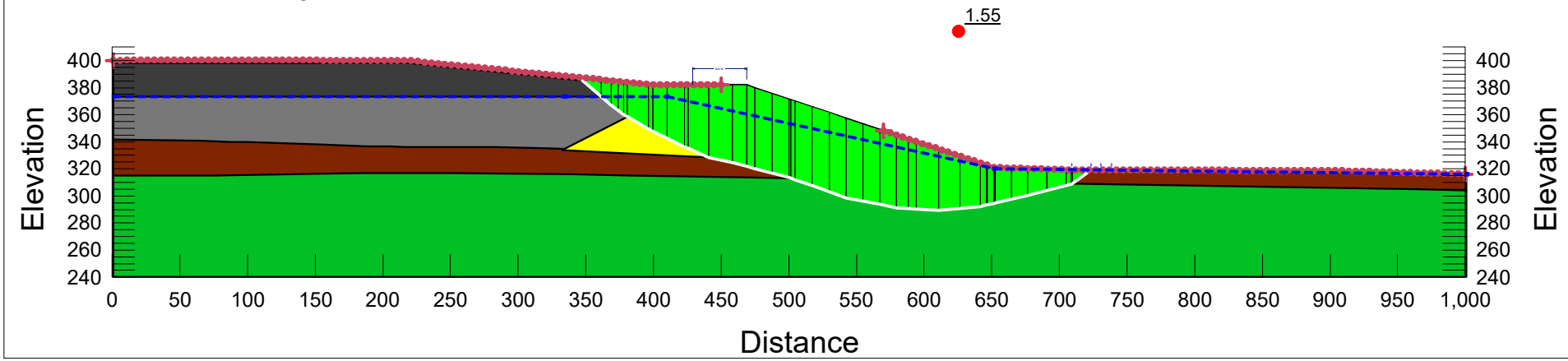
Section A_Pseudostatic Seismic

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110			0	34	0	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0	1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500				1
	Final Cover System	Mohr-Coulomb	110			0	27	0	1
	Foundation Clays (Undrained)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0	1
	Foundation Sands	Mohr-Coulomb	130			0	35	0	1

K_h= 0.108 g



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Pseudostatic Seismic Coefficient Based on the Bray and Macedo (2019) Seismic Slope Displacement Methodology

From "Procedure for Estimating Shear-Induced Seismic Slope Displacement for Shallow Crustal Earthquakes," ASCE JGGE, 2019, 145(12), doi: 10.1061/(ASCE)GT.1943-5606.0002143

Use only for cases in which the PGV <= 115 cm/s. The pseudostatic slope stability method should not be used for cases with higher PGV values (i.e. intense pulse motions).

Input Parameters		
D_a (cm)	45.72	**Allowable Seismic Displacement Threshold**
T_s (s)	0.29	**Initial Fundamental Period of Slide Mass**
$1.3T_s$ (s)	0.38	Degraded Period of Slide Mass
$S_a(1.3T_s)$ (g)	0.97	**Spectral Acceleration at $1.3T_s$ (5% damping) at the base of the sliding mass assuming there is no material above it**
M_w	7.6	**Moment Magnitude**
ε	0	**Normally distributed random variable with zero mean and standard deviation of 0.74**
		Set to 0.0 for D_a at the median (50%) estimate level, and set to 0.74 for D_a at the 16% probability of exceedance level

Intermediate Parameters		
x1 =	0.490	constant
a =	2.501	Eq. 12b
x2 =	4.348	value in parenthesis in Eq. 12c
b =	1.996	Eq. 12c
x3 =	-2.222	value in parenthesis in Eq. 12a

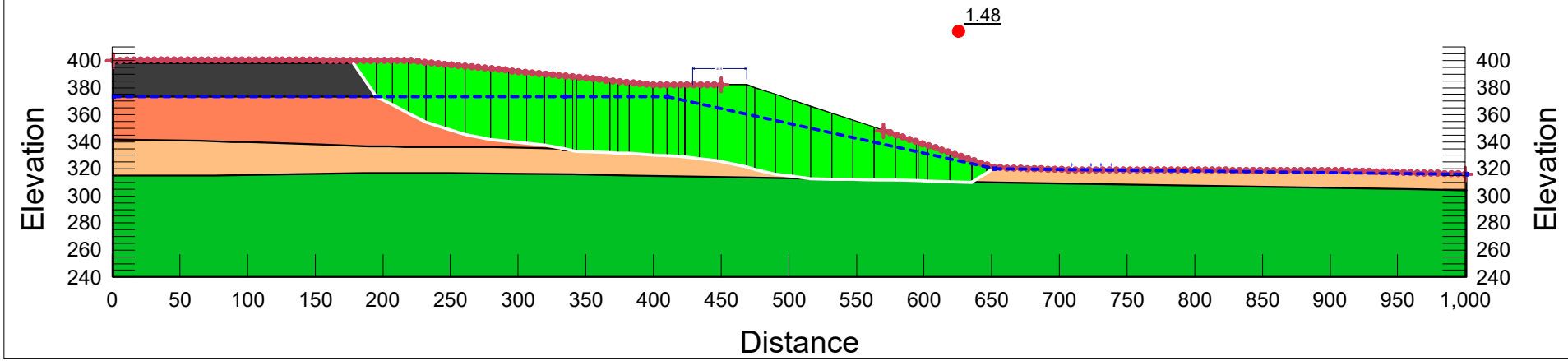
Pseudostatic k value	
k =	**0.108**

With this **k** value, if the pseudostatic FS >= 1.0, then the displacement will be less than 46 cm at the 50% or 16% probability of exceedance level (i.e., ε = 0 or 0.74, respectively).

Joppa_East Ash Pond
Section A_Post Earthquake

Calculated By: PK Date: 04/18/22
Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Minimum Strength (psf)	Tau/Sigma Ratio	Piezometric Line
	CCR-Liquefied	SHANSEP	110						0	0.07	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0			1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500						1
	Final Cover System	Mohr-Coulomb	110			0	27	0			1
	Foundation Clays (Undrained)-Softened	Spatial Mohr-Coulomb	127	Foundation Clay			0	0			1
	Foundation Sands	Mohr-Coulomb	130			0	35	0			1



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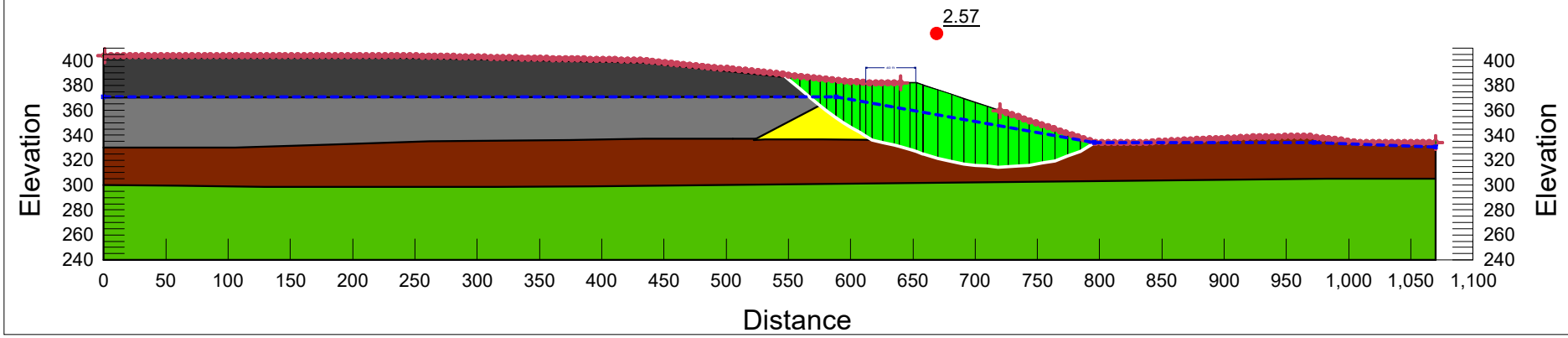
Joppa_East Ash Pond

Section B_End of Construction

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110			0	34	0	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0	1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500				1
	Final Cover System	Mohr-Coulomb	110			0	27	0	1
	Foundation Clays (Undrained)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0	1
	Foundation Sands	Mohr-Coulomb	130			0	35	0	1



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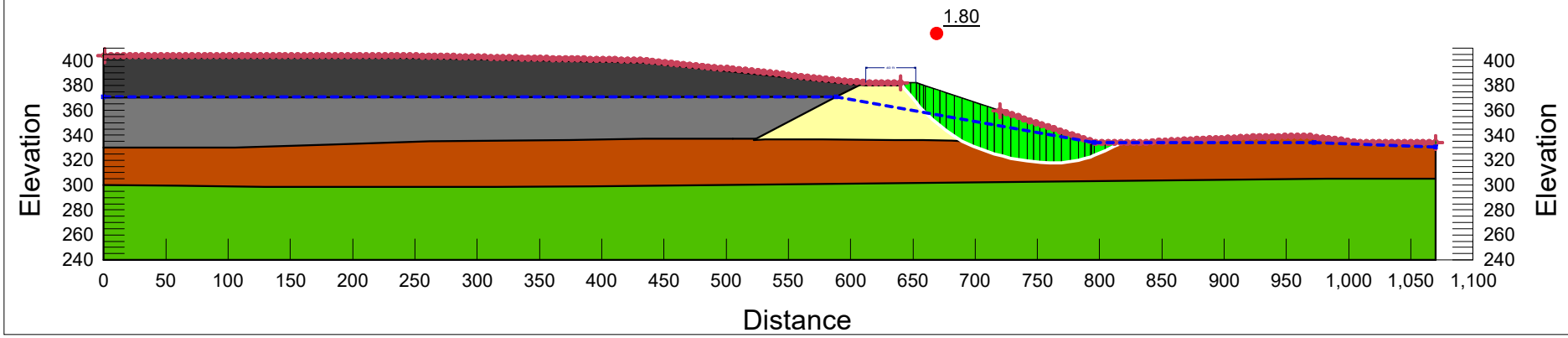
Joppa_East Ash Pond

Section B_Long Term

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110	0	34	0	1
	Compacted CCR	Mohr-Coulomb	121	0	34	0	1
	Embankment Fill (Drained)	Mohr-Coulomb	131	300	30	0	1
	Final Cover System	Mohr-Coulomb	110	0	27	0	1
	Foundation Clays (Drained)	Mohr-Coulomb	127	150	29	0	1
	Foundation Sands	Mohr-Coulomb	130	0	35	0	1



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Joppa_East Ash Pond

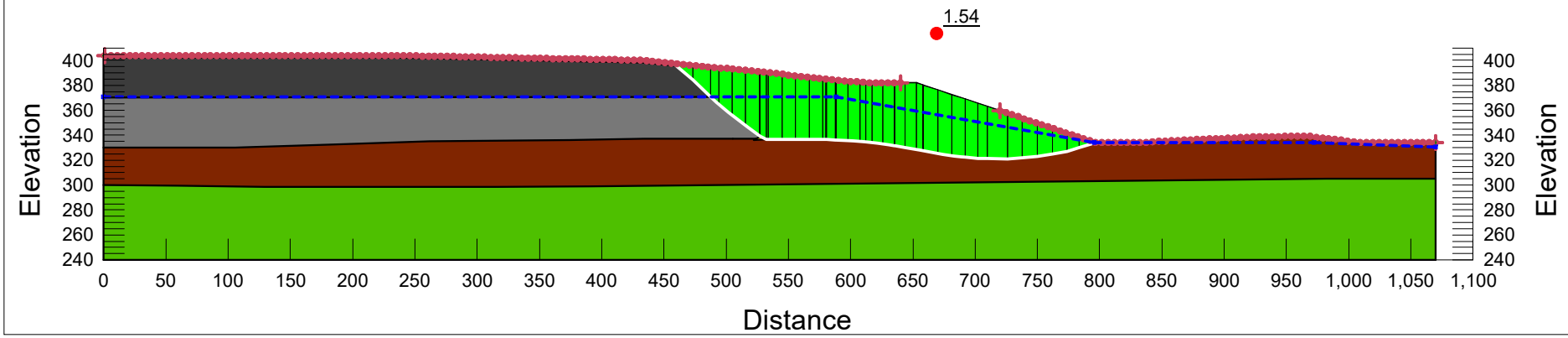
Section B_Pseudostatic Seismic

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110			0	34	0	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0	1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500				1
	Final Cover System	Mohr-Coulomb	110			0	27	0	1
	Foundation Clays (Undrained)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0	1
	Foundation Sands	Mohr-Coulomb	130			0	35	0	1

K_h= 0.108 g



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Pseudostatic Seismic Coefficient Based on the Bray and Macedo (2019) Seismic Slope Displacement Methodology

From "Procedure for Estimating Shear-Induced Seismic Slope Displacement for Shallow Crustal Earthquakes," ASCE JGGE, 2019, 145(12), doi: 10.1061/(ASCE)GT.1943-5606.0002143

Use only for cases in which the PGV <= 115 cm/s. The pseudostatic slope stability method should not be used for cases with higher PGV values (i.e. intense pulse motions).

Input Parameters		
D_a (cm)	45.72	**Allowable Seismic Displacement Threshold**
T_s (s)	0.29	**Initial Fundamental Period of Slide Mass**
$1.3T_s$ (s)	0.38	Degraded Period of Slide Mass
$S_a(1.3T_s)$ (g)	0.97	**Spectral Acceleration at $1.3T_s$ (5% damping) at the base of the sliding mass assuming there is no material above it**
M_w	7.6	**Moment Magnitude**
ε	0	**Normally distributed random variable with zero mean and standard deviation of 0.74**
		Set to 0.0 for D_a at the median (50%) estimate level, and set to 0.74 for D_a at the 16% probability of exceedance level

Intermediate Parameters		
x1 =	0.490	constant
a =	2.501	Eq. 12b
x2 =	4.348	value in parenthesis in Eq. 12c
b =	1.996	Eq. 12c
x3 =	-2.222	value in parenthesis in Eq. 12a

Pseudostatic k value	
k =	**0.108**

With this **k** value, if the pseudostatic FS >= 1.0, then the displacement will be less than 46 cm at the 50% or 16% probability of exceedance level (i.e., ε = 0 or 0.74, respectively).

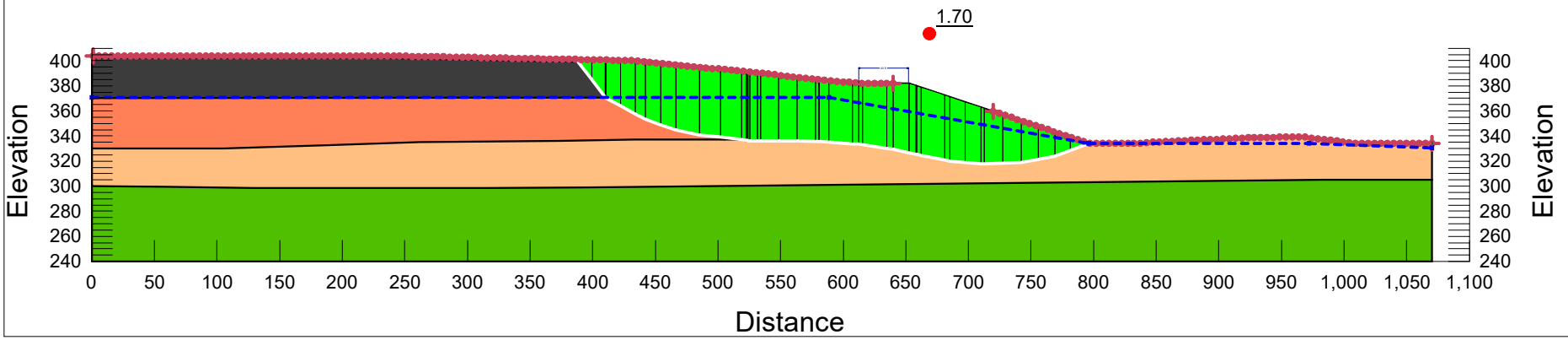
Joppa_East Ash Pond

Section B_Post Earthquake

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Minimum Strength (psf)	Tau/Sigma Ratio	Piezometric Line
	CCR-Liquefied	SHANSEP	110						0	0.07	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0			1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500						1
	Final Cover System	Mohr-Coulomb	110			0	27	0			1
	Foundation Clays (Undrained)-Softened	Spatial Mohr-Coulomb	127	Foundation Clay			0	0			1
	Foundation Sands	Mohr-Coulomb	130			0	35	0			1



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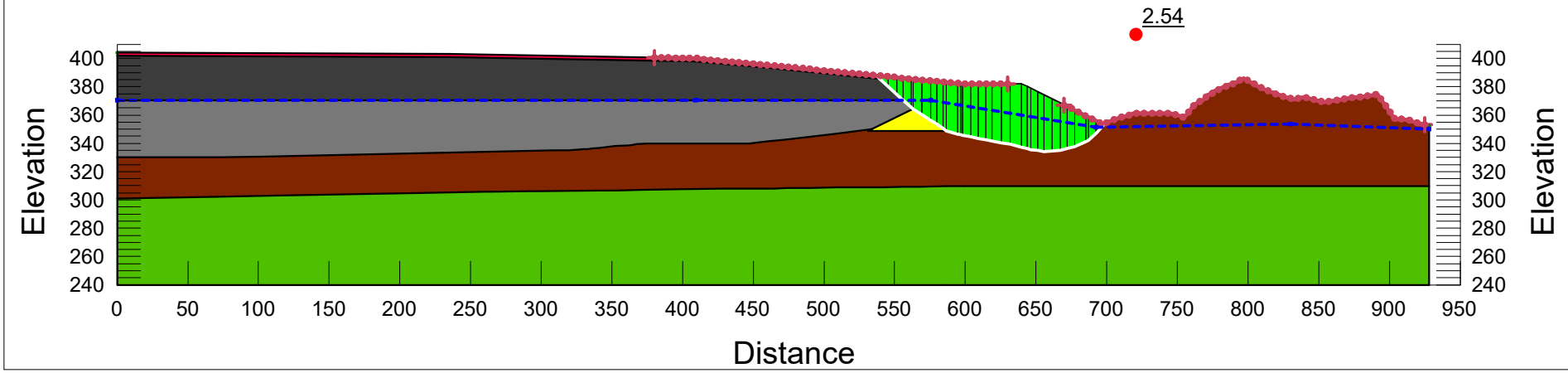
Joppa_East Ash Pond

Section C_End of Construction

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110			0	34	0	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0	1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500				1
	Final Cover System	Mohr-Coulomb	110			0	27	0	1
	Foundation Clays (Undrained)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0	1
	Foundation Sands	Mohr-Coulomb	130			0	35	0	1



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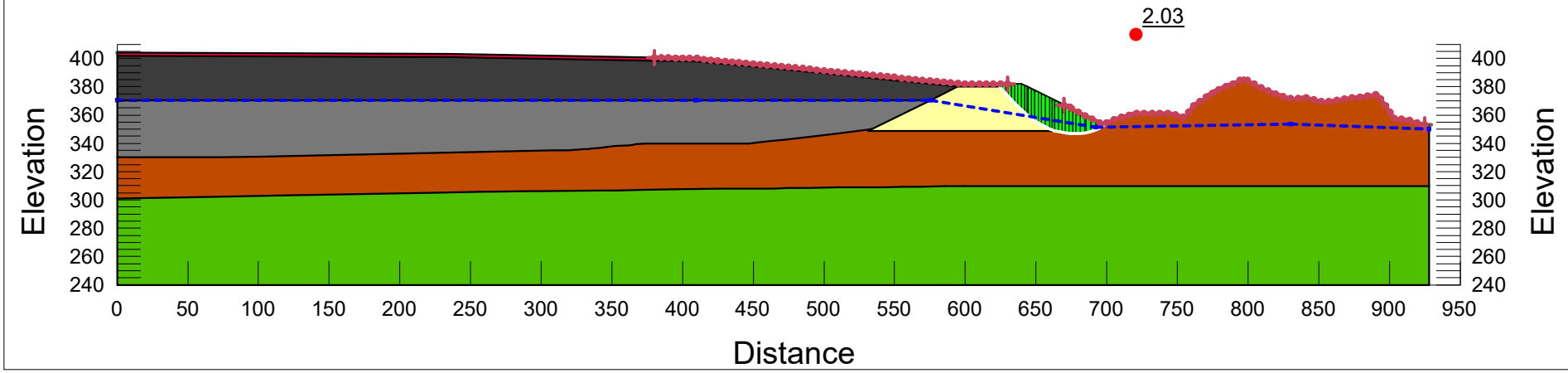
Joppa_East Ash Pond

Section C_Long Term

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110	0	34	0	1
	Compacted CCR	Mohr-Coulomb	121	0	34	0	1
	Embankment Fill (Drained)	Mohr-Coulomb	131	300	30	0	1
	Final Cover System	Mohr-Coulomb	110	0	27	0	1
	Foundation Clays (Drained)	Mohr-Coulomb	127	150	29	0	1
	Foundation Sands	Mohr-Coulomb	130	0	35	0	1



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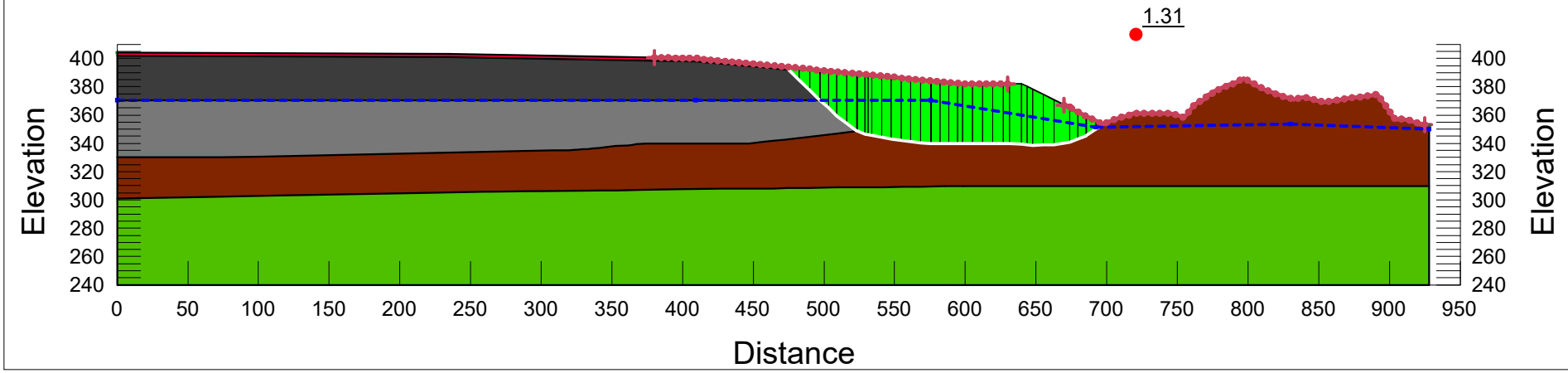
Joppa_East Ash Pond
Section C_Pseudostatic Seismic

Calculated By: PK Date: 04/18/22
Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110			0	34	0	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0	1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500				1
	Final Cover System	Mohr-Coulomb	110			0	27	0	1
	Foundation Clays (Undrained)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0	1
	Foundation Sands	Mohr-Coulomb	130			0	35	0	1

K_h= 0.124 g



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Pseudostatic Seismic Coefficient Based on the Bray and Macedo (2019) Seismic Slope Displacement Methodology

From "Procedure for Estimating Shear-Induced Seismic Slope Displacement for Shallow Crustal Earthquakes," ASCE JGGE, 2019, 145(12), doi: 10.1061/(ASCE)GT.1943-56

Use only for cases in which the PGV <= 115 cm/s. The pseudostatic slope stability method should not be used for cases with higher PGV values (i.e. intense pulse mot

Input Parameters		
D_a (cm)	45.72	**Allowable Seismic Displacement Threshold**
T_s (s)	0.15	**Initial Fundamental Period of Slide Mass**
$1.3T_s$ (s)	0.20	Degraded Period of Slide Mass
$S_a(1.3T_s)$ (g)	1.3	**Spectral Acceleration at $1.3T_s$ (5% damping) at the base of the sliding mass assuming there is no material above it**
M_w	7.6	**Moment Magnitude**
ε	0	**Normally distributed random variable with zero mean and standard deviation of 0.74**
		Set to 0.0 for D_a at the median (50%) estimate level, and set to 0.74 for D_a at the 16% probability of exceedance level

Intermediate Parameters		
x1 =	0.490	constant
a =	2.401	Eq. 12b
x2 =	3.948	value in parenthesis in Eq. 12c
b =	1.895	Eq. 12c
x3 =	-2.090	value in parenthesis in Eq. 12a

Pseudostatic k value	
k =	**0.124**

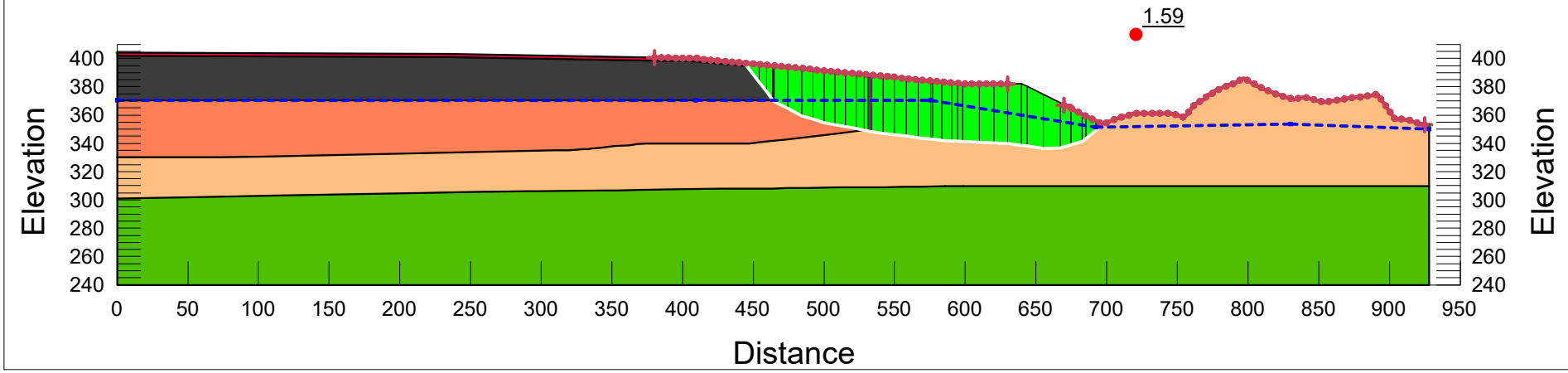
With this **k** value, if the pseudostatic FS >= 1.0, then the displacement will be less than 46 cm at the 50% or 16% probability of exceedance level (i.e., ε = 0 or 0.74, res

Joppa_East Ash Pond

Section C_Post Earthquake_Undrained Embankment

Calculated By: PK Date: 04/18/22
Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Minimum Strength (psf)	Tau/Sigma Ratio	Piezometric Line
	CCR-Liquefied	SHANSEP	110						0	0.07	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0			1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500						1
	Final Cover System	Mohr-Coulomb	110			0	27	0			1
	Foundation Clays (Undrained)-Softened	Spatial Mohr-Coulomb	127	Foundation Clay			0	0			1
	Foundation Sands	Mohr-Coulomb	130			0	35	0			1



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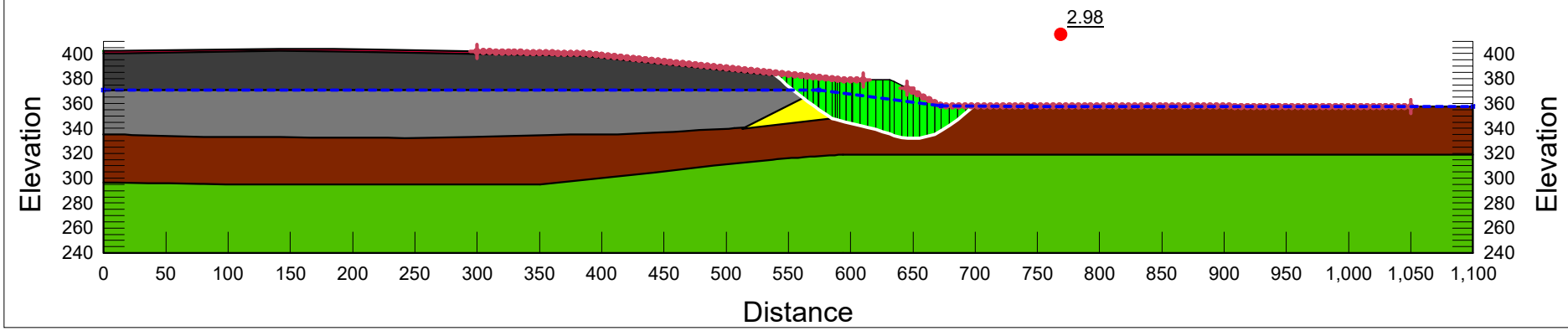
Joppa_East Ash Pond
Section D_End of Construction

Calculated By: PK Date: 04/18/22
Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110			0	34	0	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0	1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500				1
	Final Cover System	Mohr-Coulomb	110			0	27	0	1
	Foundation Clays (Undrained)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0	1
	Foundation Sands	Mohr-Coulomb	130			0	35	0	1



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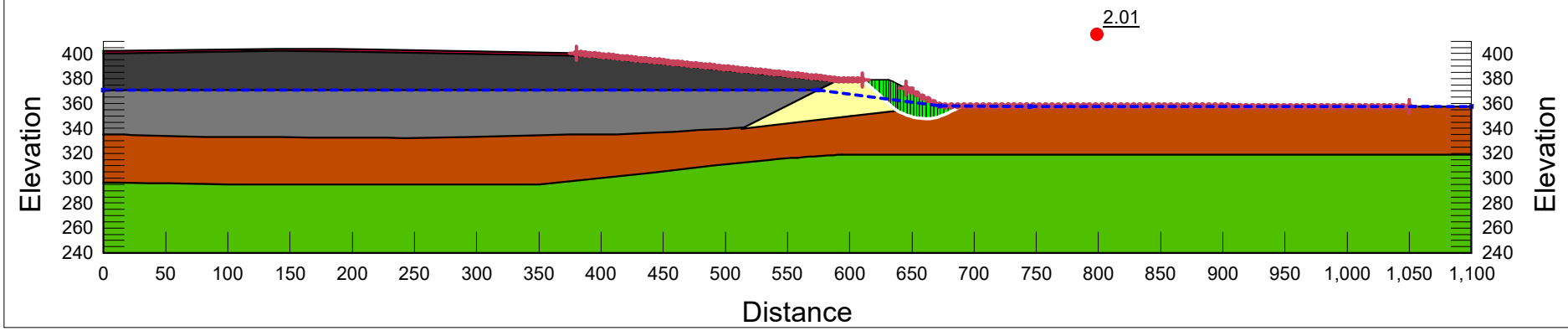
Joppa_East Ash Pond
Section D_Long Term

Calculated By: PK Date: 04/18/22
Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110	0	34	0	1
	Compacted CCR	Mohr-Coulomb	121	0	34	0	1
	Embankment Fill (Drained)	Mohr-Coulomb	131	300	30	0	1
	Final Cover System	Mohr-Coulomb	110	0	27	0	1
	Foundation Clays (Drained)	Mohr-Coulomb	127	150	29	0	1
	Foundation Sands	Mohr-Coulomb	130	0	35	0	1

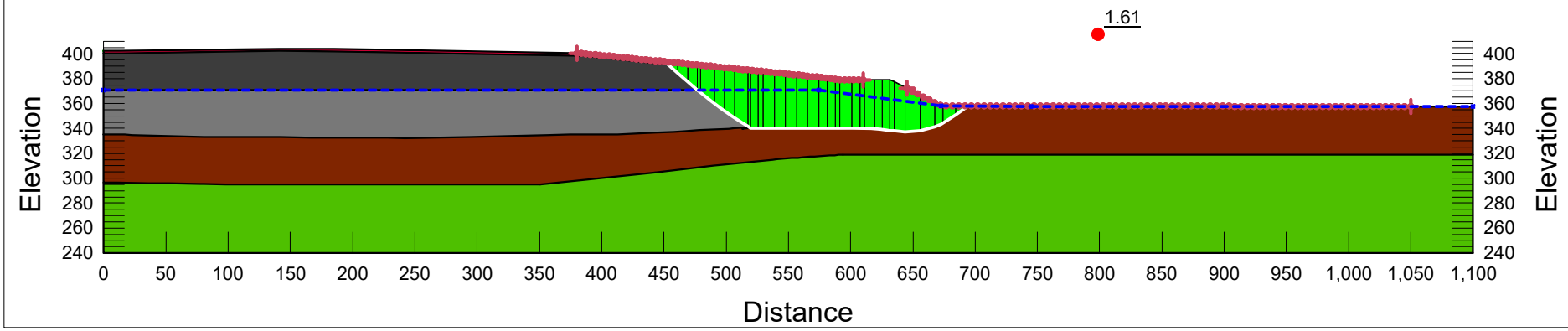


Joppa_East Ash Pond
Section D_Pseudostatic Seismic

Calculated By: PK Date: 04/18/22
Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	CCR	Mohr-Coulomb	110			0	34	0	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0	1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500				1
	Final Cover System	Mohr-Coulomb	110			0	27	0	1
	Foundation Clays (Undrained)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0	1
	Foundation Sands	Mohr-Coulomb	130			0	35	0	1

K_h= 0.110 g



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Pseudostatic Seismic Coefficient Based on the Bray and Macedo (2019) Seismic Slope Displacement Methodology

From "Procedure for Estimating Shear-Induced Seismic Slope Displacement for Shallow Crustal Earthquakes," ASCE JGGE, 2019, 145(12), doi: 10.1061/(ASCE)GT.1943-5606.0002143

Use only for cases in which the PGV <= 115 cm/s. The pseudostatic slope stability method should not be used for cases with higher PGV values (i.e. intense pulse motions).

Input Parameters		
D_a (cm)	45.72	**Allowable Seismic Displacement Threshold**
T_s (s)	0.12	**Initial Fundamental Period of Slide Mass**
$1.3T_s$ (s)	0.16	Degraded Period of Slide Mass
$S_a(1.3T_s)$ (g)	1.25	**Spectral Acceleration at $1.3T_s$ (5% damping) at the base of the sliding mass assuming there is no material above it**
M_w	7.6	**Moment Magnitude**
ε	0	**Normally distributed random variable with zero mean and standard deviation of 0.74**
		Set to 0.0 for D_a at the median (50%) estimate level, and set to 0.74 for D_a at the 16% probability of exceedance level

Intermediate Parameters		
x1 =	0.490	constant
a =	2.414	Eq. 12b
x2 =	4.139	value in parenthesis in Eq. 12c
b =	1.772	Eq. 12c
x3 =	-2.210	value in parenthesis in Eq. 12a

Pseudostatic k value	
k =	**0.110**

With this **k** value, if the pseudostatic FS >= 1.0, then the displacement will be less than 46 cm at the 50% or 16% probability of exceedance level (i.e., ε = 0 or 0.74, respectively).

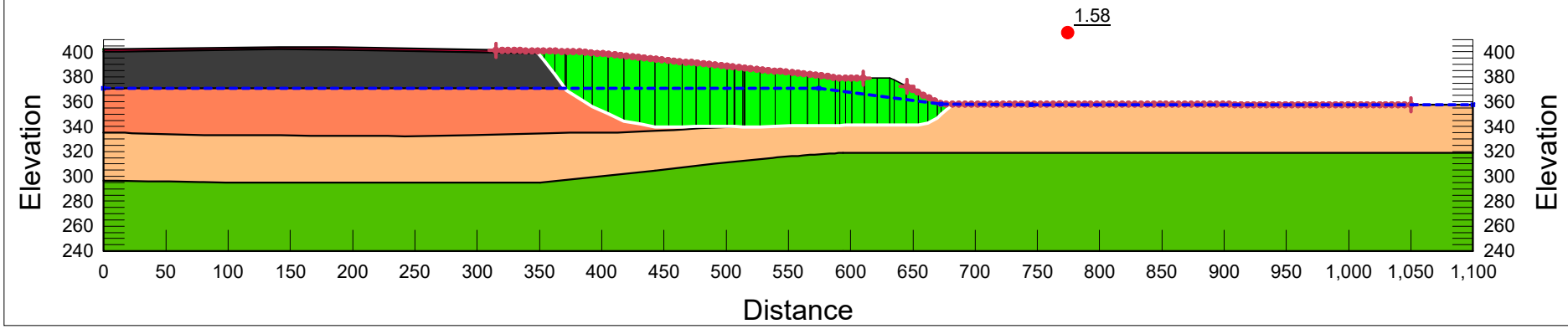
Joppa_East Ash Pond

Section D_Post Earthquake_Undrained Embankment

Calculated By: PK Date: 04/18/22

Checked By: LPC, TK Date: 04/18/22

Color	Name	Model	Unit Weight (pcf)	Cohesion Fn	Cohesion (psf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Minimum Strength (psf)	Tau/Sigma Ratio	Piezometric Line
	CCR-Liquefied	SHANSEP	110						0	0.07	1
	Compacted CCR	Mohr-Coulomb	121			0	34	0			1
	Embankment Fill (Undrained)	Undrained (Phi=0)	131		2,500						1
	Final Cover System	Mohr-Coulomb	110			0	27	0			1
	Foundation Clays (Undrained)-Softened	Spatial Mohr-Coulomb	127	Foundation Clay			0	0			1
	Foundation Sands	Mohr-Coulomb	130			0	35	0			1



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Geosyntec
consultants

ATTACHMENT H

Interface Friction Testing Data

Table K.1 - Summary of Interface Friction CQA Testing Results

Material	Sample ID	Friction Angle (°)[1]	Adhesion (psf)	Large Displacement Friction Angle (°)[2]	Pass/ Fail[1,2]
Clay Cover Soil	CB-03	23.4	142	17.1*	Pass
Skaps DSGC TN 270-2-10	-				
Skaps 40 mil LLDPE TXGM	-				
CCR	CF-02 (CCR-1)				
Clay Cover Soil	CB-03	27.8	81	21.5*	Pass
Skaps NWGT GE116	-				
Skaps 40 mil LLDPE TXGM	-				
CCR	CF-02 (CCR-1)				
Clay Cover Soil	CB-03	19.0	190	10.8	Pass[3]
Skaps DSGC TN 270-2-10	-				
Skaps 40 mil LLDPE TXGM	-				
Coal	CY-01				
Clay Cover Soil	CB-03	24.9	158	15.0	Pass
Skaps NWGT GE116	-				
Skaps 40 mil LLDPE TXGM	-				
Coal	CY-01				
Sand and Gravel Cover Soil	SCS-03	41.3*	-*	35.5*	Pass
Skaps DSGC TN 270-2-10	-				
Sand and Gravel Cover Soil	SCS-03	26.9	102	27.5	Pass
Skaps NWGT GE116	-				
Sand and Gravel Cover Soil	SCS-03	25.3	51	18.9*	Pass
Skaps 40 mil LLDPE TXGM	-				

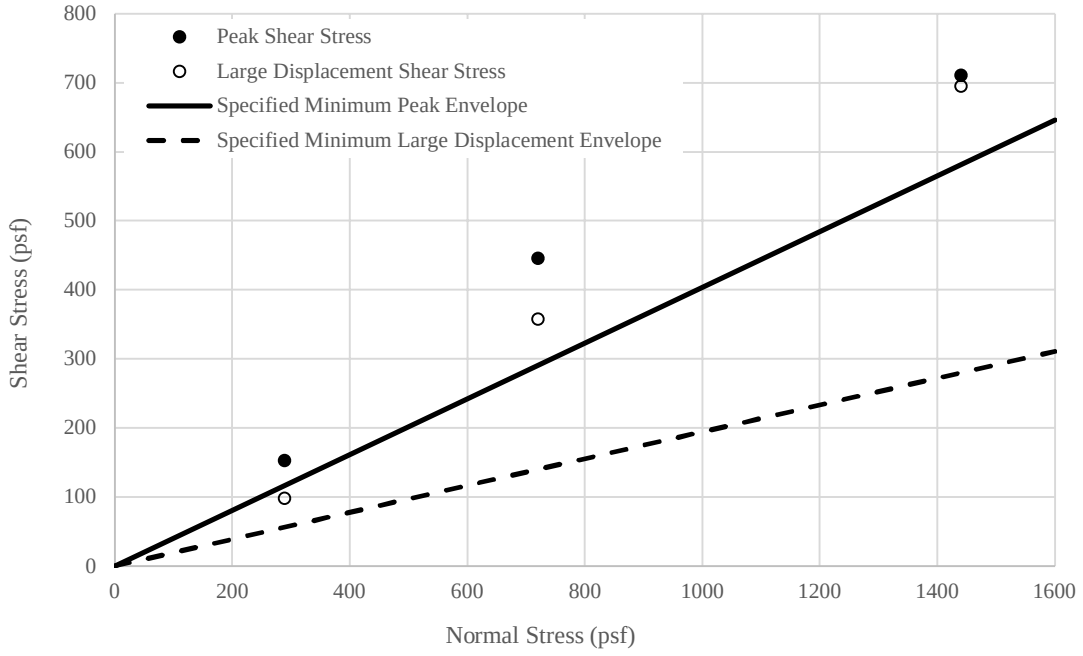
* Minimum Secant Angle results reported.

[1] Minimum Required Friction Angle = 22 degrees per Specification 31 05 19 03.01A

[2] Minimum Required Large Displacement Friction Angle = 11 degrees per Specification 31 05 19 03.01B

[3] Interface shear strength is in excess of specified values when adhesion is considered.

Figure K.1 - Interface Friction Testing Results Plot

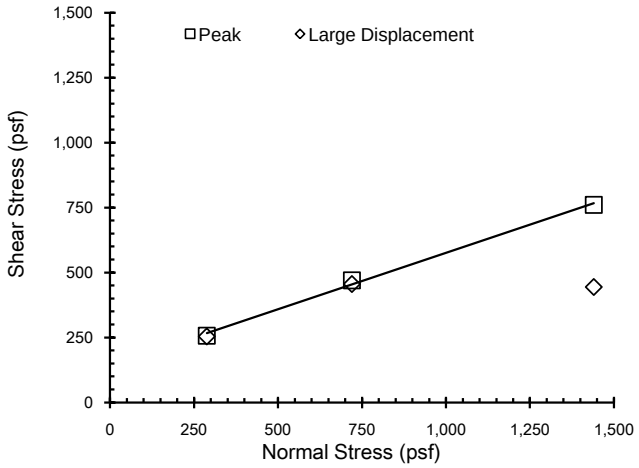


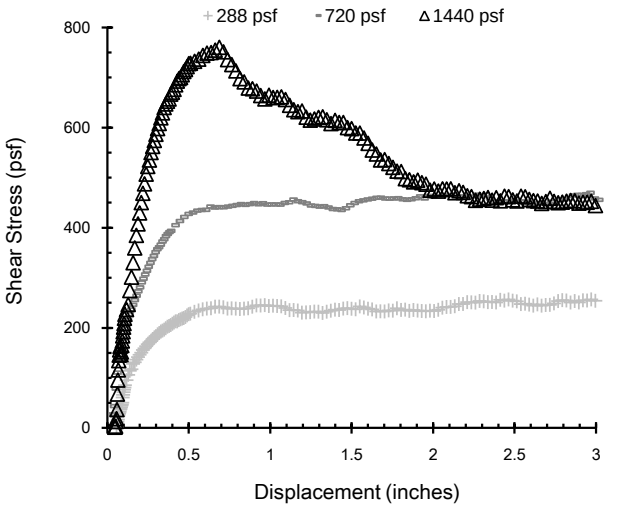
Multi-Layered Interface Friction Test (ASTM D5321 Modified)

Client: Geosyntec Consultants
Project: Dynegy Energy
Hennepin West Ash Pond System Closure

TRI Log #: 53888-3
Richard S. Lacey, P.E. 3/9/2020
Analysis & Quality Review/Date

CB-03 (Clay) vs. Skaps DSGC TN 270-2-10 (95161010001) vs. Skaps 40 mil LLDPE TXGM (3111002301) vs. CCR-1(coal ash) - Tamp





Test Results, Linear Regression			
Mohr-Coulomb Parameters		Peak	Large Displacement
Friction Angle	Degrees	23.4	Various failure modes Refer to per normal stress secant friction angles
Y-intercept or Adhesion	psf	142	
Minimum Secant Angle	Degrees	27.8	17.1

Note - Large Displacement Values Reported for 3.0 inches of Displacement

Test Conditions		
Upper Box	CB-03 (Clay) ω = 17.0 % γ_d = 104.0 pcf	
Floating	Skaps DSGC TN 270-2-10 (95161010001)	
	Skaps 40 mil LLDPE TXGM (3111002301)	
Lower Box	CCR-1(coal ash) Tamped in place	
Conditioning	Wet - Loading applied and Interface flooded for a minimum of 16 hours prior to shear.	
Shearing Rate	inches/minute	0.04

Test Notes

Shearing occurred at the TXGM vs Ash interface at 288 psf and 720 psf, and at the NWGT vs. TXGM interface at 1,440 psf.

Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	257	470	760
	Secant Angle	deg.	41.7	33.1	27.8
Large Displacement	Shear Stress	psf	254	456	444
	Secant Angle	deg.	41.4	32.3	17.1
Asperity Height, Avg. of 5 Meas.		mils	32	33	32

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

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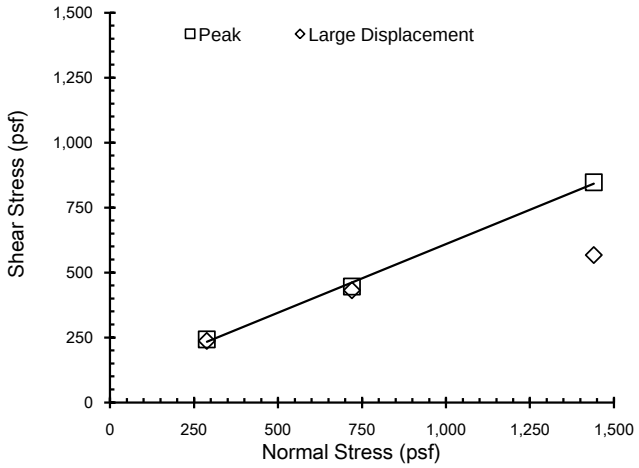
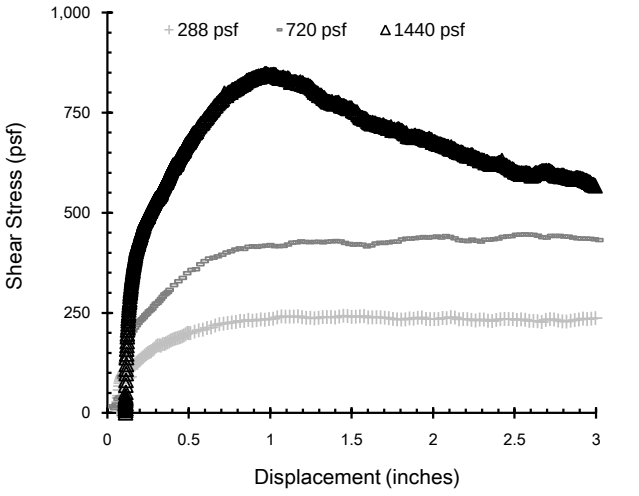
Multi-Layered Interface Friction Test (ASTM D5321 Modified)

Client: Geosyntec Consultants
Project: Dynegy Energy
Hennepin West Ash Pond System Closure

TRI Log #: 53888-1
Richard S. Lacey, P.E. 3/10/2020
Analysis & Quality Review/Date

CB-03 (Clay) vs. Skaps NWGT GE116 (60771.1) vs. Skaps 40 mil LLDPE TXGM (3111002301) vs. CCR-1(coal ash) - Tamp





Test Results, Linear Regression			
Mohr-Coulomb Parameters		Peak	Large Displacement
Friction Angle	Degrees	27.8	Various failure modes Refer to per normal stress secant friction angles
Y-intercept or Adhesion	psf	81	
Minimum Secant Angle	Degrees	30.5	21.5

Note - Large Displacement Values Reported for 3.0 inches of Displacement

Test Conditions		
Upper Box	CB-03 (Clay) ω = 17.0 % γ_d = 104.0 pcf	
Floating	Skaps NWGT GE116 (60771.1)	
	Skaps 40 mil LLDPE TXGM (3111002301)	
Lower Box	CCR-1(coal ash) Tamped in place	
Conditioning	Wet - Loading applied and Interface flooded for a minimum of 16 hours prior to shear.	
Shearing Rate	inches/minute	0.04

Test Notes

Shearing occurred at the TXGM vs Ash interface at 288 psf and 720 psf, and at the NWGT vs. TXGM interface at 1,440 psf.

Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	243	446	847
	Secant Angle	deg.	40.1	31.8	30.5
Large Displacement	Shear Stress	psf	237	432	567
	Secant Angle	deg.	39.4	30.9	21.5
Asperity Height, Avg. of 5 Meas.		mils	32	32	31

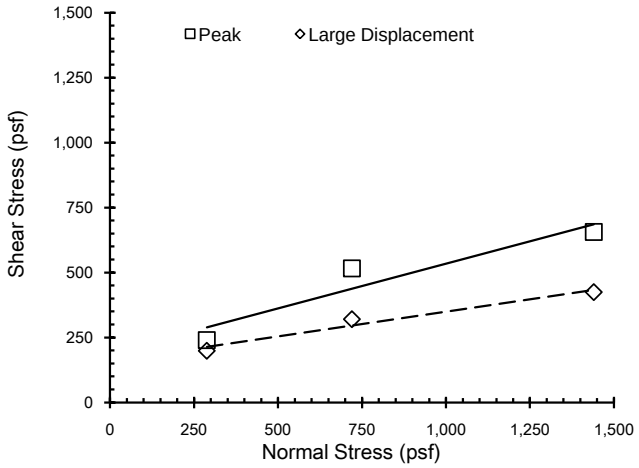
The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

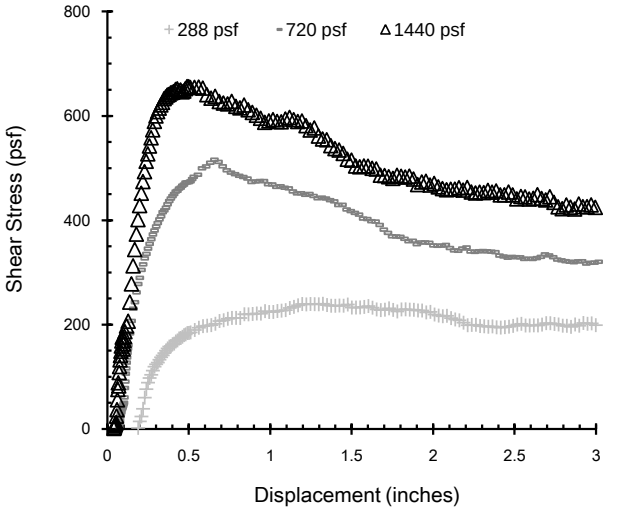
Multi-Layered Interface Friction Test (ASTM D5321 Modified)

Client: Geosyntec Consultants
Project: Dynegy Energy - Hennepin West Ash Pond System C

TRI Log #: 53888-4
Richard S. Lacey, P.E. 3/10/2020
Analysis & Quality Review/Date

CB-03 (Clay) vs. Skaps DSGC TN 270-2-10 (95161010001) vs. Skaps 40 mil LLDPE TXGM (3111002301) vs. CY-01 (Coal) - Tamp





Test Results, Linear Regression			
Mohr-Coulomb Parameters		Peak	Large Displacement
Friction Angle	Degrees	19.0	10.8
Y-intercept or Adhesion	psf	190	159
Minimum Secant Angle	Degrees	24.5	16.4

Note - Large Displacement Values Reported for 3.0 inches of Displacement

Test Conditions		
Upper Box	CB-03 (Clay) ω = 17.0 % γ_d = 104.0 pcf	
FLOATING	Skaps DSGC TN 270-2-10 (95161010001)	
	Skaps 40 mil LLDPE TXGM (3111002301)	
Lower Box	CY-01 (Coal) Tamped in place	
Conditioning	Wet - Loading applied and Interface flooded for a minimum of 16 hours prior to shear.	
Shearing Rate	inches/minute	0.04

Test Notes

Shearing occurred at the DSGC vs. TXGM interface at all stresses.

Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	240	516	656
	Secant Angle	deg.	39.8	35.6	24.5
Large Displacement	Shear Stress	psf	199	320	425
	Secant Angle	deg.	34.6	24.0	16.4
Asperity Height, Avg. of 5 Meas.		mils	33	33	34

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

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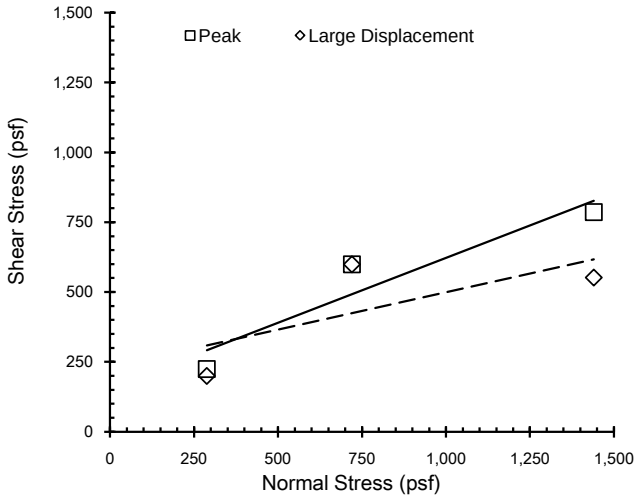
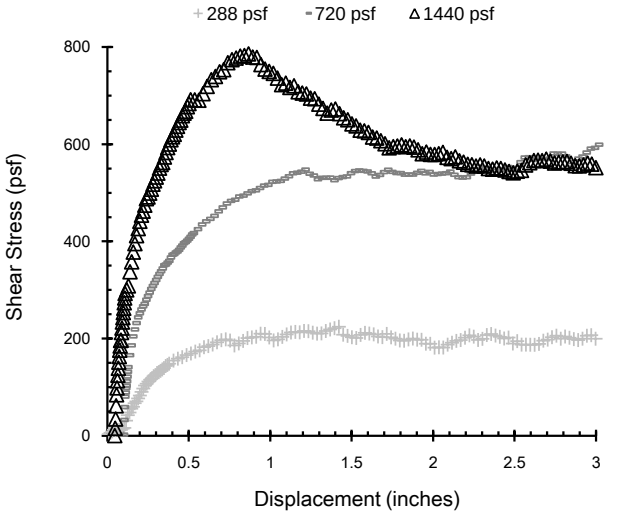
Multi-Layered Interface Friction Test (ASTM D5321 Modified)

Client: Geosyntec Consultants
Project: Dynegy Energy
Hennepin West Ash Pond System Closure

TRI Log #: 53888-2
Richard S. Lacey, P.E. 3/3/2020
Analysis & Quality Review/Date

CB-03 (Clay) vs. Skaps NWGT GE116 (60771.1) vs. Skaps 40 mil LLDPE TXGM (3111002301) vs. CY-01 (Coal)





Test Results, Linear Regression			
Mohr-Coulomb Parameters		Peak	Large Displacement
Friction Angle	Degrees	24.9	15.0
Y-intercept or Adhesion	psf	158	232
Minimum Secant Angle	Degrees	28.6	21.0

Note - Large Displacement Values Reported for 3.0 inches of Displacement

Test Conditions		
Upper Box	CB-03 (Clay) ω = 17.0 % γ_d = 104.0 pcf	
Floating	Skaps NWGT GE116 (60771.1)	
	Skaps 40 mil LLDPE TXGM (3111002301)	
Lower Box	CY-01 (Coal) Tamped in place	
Conditioning	Wet - Loading applied and Interface flooded for a minimum of 16 hours prior to shear.	
Shearing Rate	inches/minute	0.04

Test Notes

Shearing occurred at the Clay vs. NWGT interface at all stresses.

Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	224	599	786
	Secant Angle	deg.	37.9	39.8	28.6
Large Displacement	Shear Stress	psf	200	599	552
	Secant Angle	deg.	34.7	39.8	21.0
Asperity Height, Avg. of 5 Meas.		mils	32	33	31

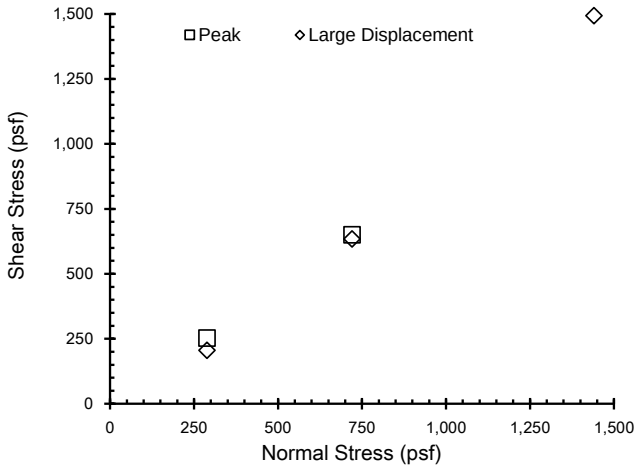
The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

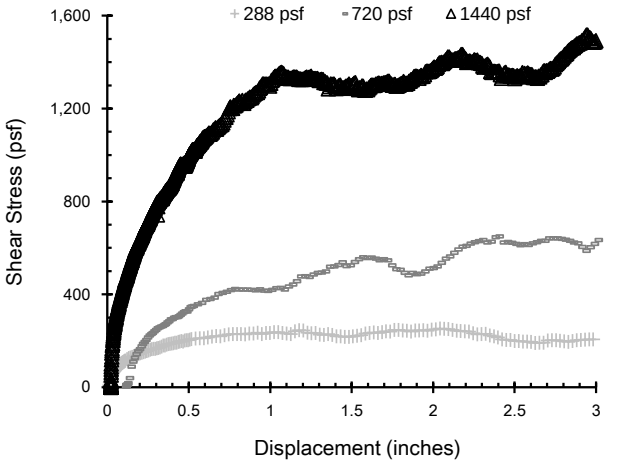
Shear Strength of Geosynthetic-Geosynthetic Interface by Direct Shear (ASTM D5321)

Client: Geosyntec Consultants
Project: Dynegy Energy - Hennepin
West Ash Pond System Closure

TRI Log #: 53888-7
Richard S. Lacey, P.E. 5/26/2020
Analysis & Quality Review/Date

SCS-03 vs.
Skaps DSGC TN 270-2-10 (95161010001)





Test Results, Linear Regression			
Mohr-Coulomb Parameters		Peak	Large Displacement
Friction Angle	Degrees	Negative Intercept *Refer to per-normal-stress secant angles*	
Y-intercept or Adhesion	psf		
Minimum Secant Angle	Degrees	41.3	35.5

Note - Large Displacement Values Reported for 3.0 inches of Displacement

Test Conditions		
Upper Box	SCS-03 Tamped in place	
Lower Box	Skaps DSGC TN 270-2-10 (95161010001)	
Conditioning	Wet - Loading applied and Interface flooded for a minimum of 24 hours prior to shear.	
Shearing Rate	inches/minute	0.04

Test Notes

Shearing occurred at the interface at all stresses.

Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	253	649	1,517
	Secant Angle	deg.	41.3	42.1	46.5
Large Displacement	Shear Stress	psf	206	634	1,493
	Secant Angle	deg.	35.5	41.4	46.0

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

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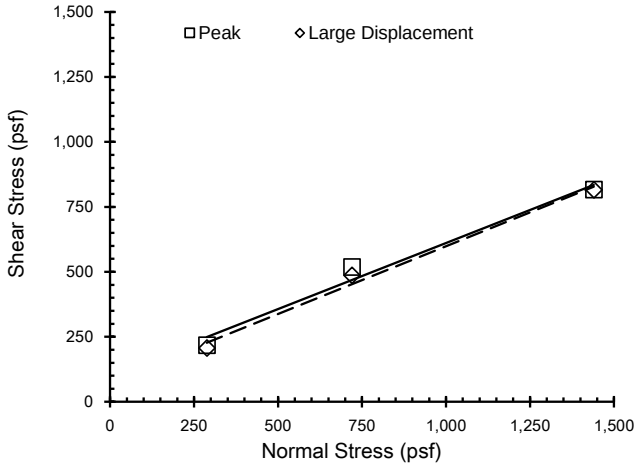
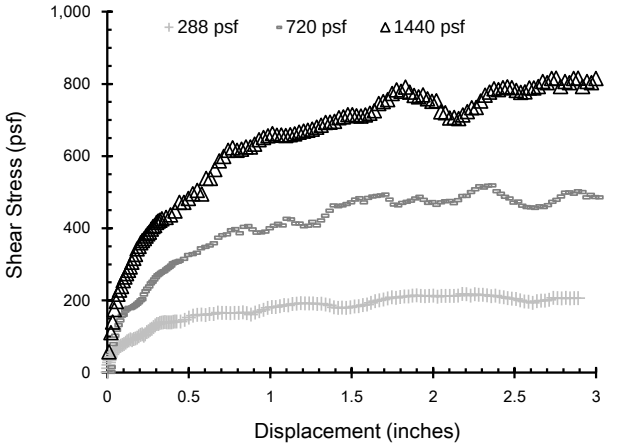
Shear Strength of Soil-Geosynthetic Interface by Direct Shear (ASTM D5321)

Client: Geosyntec Consultants
Project: Dynegy Energy - Hennepin
West Ash Pond System Closure

TRI Log #: 53888-5
Richard S. Lacey, P.E. 5/26/2020
Analysis & Quality Review/Date

SCS-03 vs.
Skaps NWGT GE116 (60771.30)





Test Results, Linear Regression			
Mohr-Coulomb Parameters		Peak	Large Displacement
Friction Angle	Degrees	26.9	27.5
Y-intercept or Adhesion	psf	102	77
Minimum Secant Angle	Degrees	29.5	29.5

Note - Large Displacement Values Reported for 3.0 inches of Displacement

Test Conditions		
Upper Box	SCS-03 Tamped in place	
Lower Box	Skaps NWGT GE116 (60771.30)	
Conditioning	Wet - Loading applied and Interface flooded for a minimum of 24 hours prior to shear.	
Shearing Rate	inches/minute	0.04

Test Notes

Shearing occurred at the interface at all stresses.

Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	218	518	816
	Secant Angle	deg.	37.1	35.8	29.5
Large Displacement	Shear Stress	psf	206	486	815
	Secant Angle	deg.	35.6	34.0	29.5

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

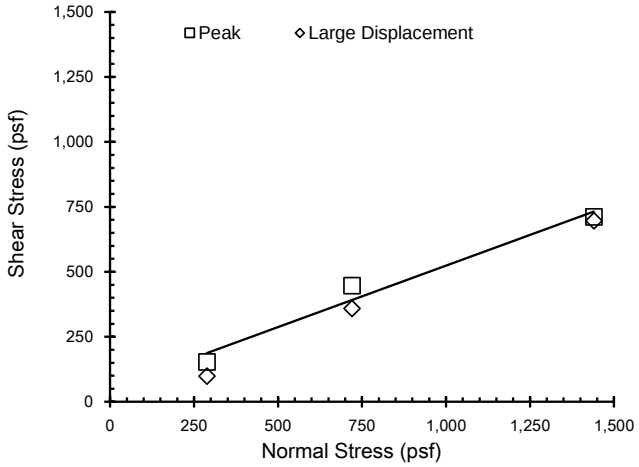
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

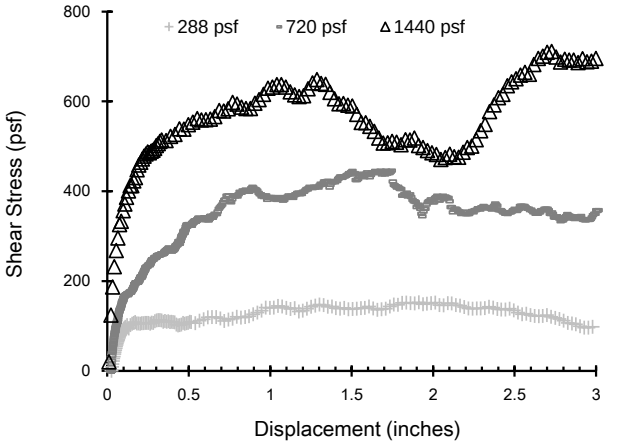
Shear Strength of Soil-Geosynthetic Interface by Direct Shear (ASTM D5321)

Client: Geosyntec Consultants
Project: Dynegy Energy - Hennepin
West Ash Pond System Closure

TRI Log #: 53888-6
Richard S. Lacey, P.E. 5/28/2020
Analysis & Quality Review/Date

SCS-03 vs.
Skaps 40 mil LLDPE TXGM (3111002301) - shiny side up





Test Results, Linear Regression			
Mohr-Coulomb Parameters		Peak	Large Displacement
Friction Angle	Degrees	25.3	Negative Intercept *Refer to per-normal-stress secant angles*
Y-intercept or Adhesion	psf	51	
Minimum Secant Angle	Degrees	26.3	18.9

Note - Large Displacement Values Reported for 3.0 inches of Displacement

Test Conditions		
Upper Box	SCS-03 Tamped in place	
Lower Box	Skaps 40 mil LLDPE TXGM (3111002301) - shiny side up	
Conditioning	Wet - Loading applied and Interface flooded for a minimum of 24 hours prior to shear.	
Shearing Rate	inches/minute	0.04

Test Notes

Shearing occurred at the interface at all stresses.

Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	153	446	711
	Secant Angle	deg.	27.9	31.8	26.3
Large Displacement	Shear Stress	psf	98	358	695
	Secant Angle	deg.	18.9	26.4	25.8
Asperity Height, Avg. of 5 Meas.		mils	29	32	32

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

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Geosyntec
consultants

ATTACHMENT I

Veneer Stability Analysis Output

VENEER SLOPE STABILITY CALCULATIONS - 2% SLOPE

Purple highlighted parameters are inputted

Internal Slope Failure (Unsaturated Static)

Analysis of all lower interfaces (subgrade-to-geomembrane, geomembrane-to-geocomposite, geocomposite-to-cover soil)

(Conversion of degrees to radians are performed for Excel spread sheet calculations)

2% (50H:1V slope) β =	1.15	degrees =	*0.02 radians*
Interface Friction, δ =	**25.30**	**degrees =**	*0.44 radians*
Interface Adhesion, a =	**51.00**	**psf**	
Thickness of soil above geomembrane, t =	**2.00**	**ft**	
Thickness of Saturation (water) t_w =	0.021	ft	
t_w* =	0.021	ft	
Height of slope, h =	7.6	ft	
Total Unit Weight of Soil Above Geomembrane, γ_t =	**110.00**	**pcf**	
Effective Unit Weight, γ_b =	57.60	pcf	
Saturated Unit Weight of Soil Above Geomembrane, γ_{sat} =	120.00	pcf	
Friction Angle of Soil Above Geomembrane, ϕ =	**27.00**	**degrees =**	*0.47 radians*
Cohesion of Soil Above Geomembrane, c =	**0.00**	**psf**	
Seismic Coeffecient, k_s =	0.000	g	

A	*B*	*C*	
$[\gamma_t \times (t-t_w) + \gamma_b \times t_w]$	$[\gamma_t \times (t-t_w) + \gamma_{sat} \times t_w]$	$\tan\delta/\tan\beta$	[A/B] x C
218.900	220.210	23.635	23.494

D		*E*	*F*	*G*	
[a/sinβ]	D/B	$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	$[\tan\phi/(2\sin\beta\cos^{-}\beta)]/(1-\tan\beta\tan\phi)$	t/h	E x F x G
2550.510	**11.58217133**	0.994	12.877	0.263	3.369

H	*I*	*J*	
1/B	$[1/(\sin\beta\cos\beta)]/[1-\tan\beta\tan\phi]$	ct/h	H x I x J
0.005	50.535	0.000	0.000

A'	*B'*	*C'*	*D'*	[A'+B'-C']/D'
$a/[\gamma_t \times t \times \cos^2(\beta)]$	$\tan\phi \times [1-(\gamma_w \times t_w)/(\gamma_t \times t)]$	$n_q \times \tan\beta \times \tan\phi$	$n_q + \tan\beta$	35.090
0.232	0.470	0.000	0.020	

FS (Static)	
38.445	

VENEER SLOPE STABILITY CALCULATIONS - 2% SLOPE

Purple highlighted parameters are inputted

Internal Slope Failure (Saturated Static)

Analysis of all lower interfaces (subgrade-to-geomembrane, geomembrane-to-geocomposite, geocomposite-to-cover soil)

(Conversion of degrees to radians are performed for Excel spread sheet calculations)

20% (5H:1V slope) β =	1.15	degrees =	*0.02 radians*
Interface Friction, δ =	**25.30**	**degrees =**	*0.44 radians*
Interface Adhesion, a =	**51.00**	**psf**	
Thickness of soil above geomembrane, t =	**2.00**	**ft**	
Thickness of Saturation (water) t_w =	2.000	ft	
t_w* =	2.000	ft	
Height of slope, h =	7.6	ft	
Total Unit Weight of Soil Above Geomembrane, γ_t =	**110.00**	**pcf**	
Effective Unit Weight, γ_b =	57.60	pcf	
Saturated Unit Weight of Soil Above Geomembrane, γ_{sat} =	120.00	pcf	
Friction Angle of Soil Above Geomembrane, ϕ =	**27.00**	**degrees =**	*0.47 radians*
Cohesion of Soil Above Geomembrane, c =	**0.00**	**psf**	
Seismic Coeffecient, k_s =	0.000	g	

A	*B*	*C*	
$[\gamma_t \times (t-t_w) + \gamma_b \times t_w]$	$[\gamma_t \times (t-t_w) + \gamma_{sat} \times t_w]$	tanδ/tanβ	[A/B] x C
115.200	240.000	23.635	11.345

D		*E*	*F*	*G*	
[a/sinβ]	D/B	$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	[tanϕ/(2sinβcosβ)]/(1-tanβtanϕ)	t/h	E x F x G
2550.510	**10.62712479**	0.480	12.877	0.263	1.627

H	*I*	*J*	
1/B	[1/(sinβcosβ)]/[1-tanβtanϕ]	ct/h	H x I x J
0.004	50.535	0.000	0.000

A'	*B'*	*C'*	*D'*	[A'+B'-C']/D'
$a/[\gamma_t \times t \times \cos^2(\beta)]$	tanϕ x [1-(γ_w x t_w)/(γ_t x t)]	n_q x tanβ x tanϕ	n_q + tanβ	21.823
0.232	0.205	0.000	0.020	

FS (Static)	
23.598	

0

VENEER SLOPE STABILITY CALCULATIONS - 2% SLOPE

Purple highlighted parameters are inputted

Internal Slope Failure (Unsaturated Seismic)

Analysis of all lower interfaces (subgrade-to-geomembrane, geomembrane-to-geocomposite, geocomposite-to-cover soil)

(Conversion of degrees to radians are performed for Excel spread sheet calculations)

20% (5H:1V slope) β =	1.15	degrees =	*0.02 radians*
Interface Friction, δ =	**25.30**	**degrees =**	*0.44 radians*
Interface Adhesion, a =	**51.00**	**psf**	
Thickness of soil above geomembrane, t =	**2.00**	**ft**	
Thickness of Saturation (water) t_w =	0.021	ft	
t_w* =	0.021	ft	
Height of slope, h =	7.6	ft	
Total Unit Weight of Soil Above Geomembrane, γ_t =	**110.00**	**pcf**	
Effective Unit Weight, γ_b =	57.60	pcf	
Saturated Unit Weight of Soil Above Geomembrane, γ_{sat} =	120.00	pcf	
Friction Angle of Soil Above Geomembrane, ϕ =	**27.00**	**degrees =**	*0.47 radians*
Cohesion of Soil Above Geomembrane, c =	**0.00**	**psf**	
Seismic Coeffecient, k_s =	0.429	g	

A	*B*	*C*	
$[\gamma_t \times (t-t_w) + \gamma_b \times t_w]$	$[\gamma_t \times (t-t_w) + \gamma_{sat} \times t_w]$	tanδ/tanβ	[A/B] x C
218.900	220.210	23.635	23.494

D		*E*	*F*	*G*	
[a/sinβ]	D/B	$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	$[\tan\phi/(2\sin\beta\cos^{-}\beta)]/(1-\tan\beta\tan\phi)$	t/h	E x F x G
2550.510	**11.58217133**	0.994	12.877	0.263	3.369

H	*I*	*J*	
1/B	$[1/(\sin\beta\cos\beta)]/[1-\tan\beta\tan\phi]$	ct/h	H x I x J
0.005	50.535	0.000	0.000

A'	*B'*	*C'*	*D'*	*[A'+B'-C']/D'*
$a/[\gamma_t \times t \times \cos^2(\beta)]$	$\tan\phi \times [1-(\gamma_w \times t_w)/(\gamma_t \times t)]$	$n_q \times \tan\beta \times \tan\phi$	$n_q + \tan\beta$	1.554
0.232	0.470	0.004	0.449	

	FS (Seismic)
	1.554

VENEER SLOPE STABILITY CALCULATIONS - 2% SLOPE

Purple highlighted parameters are inputted

Internal Slope Failure (Unsaturated Post-EQ)

Analysis of all lower interfaces (subgrade-to-geomembrane, geomembrane-to-geocomposite, geocomposite-to-cover soil)

(Conversion of degrees to radians are performed for Excel spread sheet calculations)

20% (5H:1V slope) β =	1.15	degrees =	*0.02 radians*
Interface Friction, δ =	**17.10**	**degrees =**	*0.30 radians*
Interface Adhesion, a =	**0.00**	**psf**	
Thickness of soil above geomembrane, t =	**2.00**	**ft**	
Thickness of Saturation (water) t_w =	0.021	ft	
t_w* =	0.021	ft	
Height of slope, h =	7.6	ft	
Total Unit Weight of Soil Above Geomembrane, γ_t =	**110.00**	**pcf**	
Effective Unit Weight, γ_b =	57.60	pcf	
Saturated Unit Weight of Soil Above Geomembrane, γ_{sat} =	120.00	pcf	
Friction Angle of Soil Above Geomembrane, ϕ =	**27.00**	**degrees =**	*0.47 radians*
Cohesion of Soil Above Geomembrane, c =	**0.00**	**psf**	
Seismic Coeffecient, k_s =	0.000	g	

A	*B*	*C*	
$[\gamma_t \times (t-t_w) + \gamma_b \times t_w]$	$[\gamma_t \times (t-t_w) + \gamma_{sat} \times t_w]$	$\tan\delta/\tan\beta$	[A/B] x C
218.900	220.210	15.382	15.290

D		*E*	*F*	*G*	
[a/sinβ]	D/B	$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	$[\tan\phi/(2\sin\beta\cos^{-}\beta)]/(1-\tan\beta\tan\phi)$	t/h	E x F x G
0.000	**0**	0.994	12.877	0.263	3.369

H	*I*	*J*	
1/B	$[1/(\sin\beta\cos\beta)]/[1-\tan\beta\tan\phi]$	ct/h	H x I x J
0.005	50.535	0.000	0.000

A'	*B'*	*C'*	*D'*	[A'+B'-C']/D'
$a/[\gamma_t \times t \times \cos^2(\beta)]$	$\tan\phi \times [1-(\gamma_w \times t_w)/(\gamma_t \times t)]$	$n_q \times \tan\beta \times \tan\phi$	$n_q + \tan\beta$	15.290
0.000	0.306	0.000	0.020	

FS (Post-EQ)	
18.659	

VENEER SLOPE STABILITY CALCULATIONS - 10% SLOPE

Purple highlighted parameters are inputted

Internal Slope Failure (Unsaturated Static)

Analysis of all lower interfaces (subgrade-to-geomembrane, geomembrane-to-geocomposite, geocomposite-to-cover soil)

(Conversion of degrees to radians are performed for Excel spread sheet calculations)

10% Slope, β =	5.71	degrees =	*0.10 radians*
Interface Friction, δ =	**25.30**	**degrees =**	*0.44 radians*
Interface Adhesion, a =	**51.00**	**psf**	
Thickness of soil above geomembrane, t =	**2.00**	**ft**	
Thickness of Saturation (water) t_w =	0.021	ft	
t_w* =	0.021	ft	
Height of slope, h =	20.0	ft	
Total Unit Weight of Soil Above Geomembrane, γ_t =	**110.00**	**pcf**	
Effective Unit Weight, γ_b =	57.60	pcf	
Saturated Unit Weight of Soil Above Geomembrane, γ_{sat} =	120.00	pcf	
Friction Angle of Soil Above Geomembrane, ϕ =	**27.00**	**degrees =**	*0.47 radians*
Cohesion of Soil Above Geomembrane, c =	**0.00**	**psf**	
Seismic Coeffecient, k_s =	0.000	g	

A	*B*	*C*	
$[\gamma_t \times (t-t_w) + \gamma_b \times t_w]$	**$[\gamma_t \times (t-t_w) + \gamma_{sat} \times t_w]$**	**tanδ/tanβ**	**[A/B] x C**
218.900	220.210	4.727	4.699

D		*E*	*F*	*G*	
[a/sinβ]	**D/B**	**$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$**	**$[\tan\phi/(2\sin\beta\cos^{-}\beta)]/(1-\tan\beta\tan\phi)$**	**t/h**	**E x F x G**
512.544	**2.327522168**	0.994	2.725	0.100	0.271

H	*I*	*J*	
1/B	**$[1/(\sin\beta\cos\beta)]/[1-\tan\beta\tan\phi]$**	**ct/h**	**H x I x J**
0.005	10.642	0.000	0.000

A'	*B'*	*C'*	*D'*	**[A'+B'-C']/D'**
$a/[\gamma_t \times t \times \cos^2(\beta)]$	**$\tan\phi \times [1-(\gamma_w \times t_w)/(\gamma_t \times t)]$**	**$n_q \times \tan\beta \times \tan\phi$**	**$n_q + \tan\beta$**	7.040
0.234	0.470	0.000	0.100	

FS (Static)	
7.297	

VENEER SLOPE STABILITY CALCULATIONS - 10% SLOPE

Purple highlighted parameters are inputted

Internal Slope Failure (Saturated Static)

Analysis of all lower interfaces (subgrade-to-geomembrane, geomembrane-to-geocomposite, geocomposite-to-cover soil)

(Conversion of degrees to radians are performed for Excel spread sheet calculations)

10% Slope, β =	5.71	degrees =	*0.10 radians*
Interface Friction, δ =	**25.30**	**degrees =**	*0.44 radians*
Interface Adhesion, a =	**51.00**	**psf**	
Thickness of soil above geomembrane, t =	**2.00**	**ft**	
Thickness of Saturation (water) t_w =	2.000	ft	
t_w* =	2.000	ft	
Height of slope, h =	20.0	ft	
Total Unit Weight of Soil Above Geomembrane, γ_t =	**110.00**	**pcf**	
Effective Unit Weight, γ_b =	57.60	pcf	
Saturated Unit Weight of Soil Above Geomembrane, γ_{sat} =	120.00	pcf	
Friction Angle of Soil Above Geomembrane, ϕ =	**27.00**	**degrees =**	*0.47 radians*
Cohesion of Soil Above Geomembrane, c =	**0.00**	**psf**	
Seismic Coeffecient, k_s =	0.000	g	

A	*B*	*C*	
$[\gamma_t \times (t-t_w) + \gamma_b \times t_w]$	$[\gamma_t \times (t-t_w) + \gamma_{sat} \times t_w]$	$\tan\delta/\tan\beta$	[A/B] x C
115.200	240.000	4.727	2.269

D		*E*	*F*	*G*	
[a/sinβ]	D/B	$\gamma_t (t-t_w^*) + \gamma_b \times t_w^*]/B$	$[\tan\phi/(2\sin\beta\cos\beta)]/(1-\tan\beta\tan\phi)$	t/h	E x F x G
512.544	**2.135598569**	0.480	2.725	0.100	0.131

H	*I*	*J*	
1/B	$[1/(\sin\beta\cos\beta)]/[1-\tan\beta\tan\phi]$	ct/h	H x I x J
0.004	10.642	0.000	0.000

A'	*B'*	*C'*	*D'*	*[A'+B'-C']/D'*
$a/[\gamma_t \times t \times \cos^2(\beta)]$	$\tan\phi \times [1-(\gamma_w \times t_w)/(\gamma_t \times t)]$	$n_q \times \tan\beta \times \tan\phi$	$n_q + \tan\beta$	4.387
0.234	0.205	0.000	0.100	

FS (Static)
4.535

VENEER SLOPE STABILITY CALCULATIONS - 10% SLOPE

Purple highlighted parameters are inputted

Internal Slope Failure (Unsaturated Seismic)

Analysis of all lower interfaces (subgrade-to-geomembrane, geomembrane-to-geocomposite, geocomposite-to-cover soil)

(Conversion of degrees to radians are performed for Excel spread sheet calculations)

10% Slope, β =	5.71	degrees =	*0.10 radians*
Interface Friction, δ =	**25.30**	**degrees =**	*0.44 radians*
Interface Adhesion, a =	**51.00**	**psf**	
Thickness of soil above geomembrane, t =	**2.00**	**ft**	
Thickness of Saturation (water) t_w =	0.021	ft	
t_w* =	0.021	ft	
Height of slope, h =	20.0	ft	
Total Unit Weight of Soil Above Geomembrane, γ_t =	**110.00**	**pcf**	
Effective Unit Weight, γ_b =	57.60	pcf	
Saturated Unit Weight of Soil Above Geomembrane, γ_{sat} =	120.00	pcf	
Friction Angle of Soil Above Geomembrane, ϕ =	**27.00**	**degrees =**	*0.47 radians*
Cohesion of Soil Above Geomembrane, c =	**0.00**	**psf**	
Seismic Coeffecient, k_s =	0.429	g	

A	*B*	*C*	
$[\gamma_t \times (t-t_w) + \gamma_b \times t_w]$	$[\gamma_t \times (t-t_w) + \gamma_{sat} \times t_w]$	$\tan\delta/\tan\beta$	[A/B] x C
218.900	220.210	4.727	4.699

D		*E*	*F*	*G*	
[a/sinβ]	D/B	$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	$[\tan\phi/(2\sin\beta\cos\beta)]/(1-\tan\beta\tan\phi)$	t/h	E x F x G
512.544	**2.327522168**	0.994	2.725	0.100	0.271

H	*I*	*J*	
1/B	$[1/(\sin\beta\cos\beta)]/[1-\tan\beta\tan\phi]$	ct/h	H x I x J
0.005	10.642	0.000	0.000

A'	*B'*	*C'*	*D'*	[A'+B'-C']/D'
$a/[\gamma_t \times t \times \cos^2(\beta)]$	$\tan\phi \times [1-(\gamma_w \times t_w)/(\gamma_t \times t)]$	$n_q \times \tan\beta \times \tan\phi$	$n_q + \tan\beta$	1.293
0.234	0.470	0.020	0.529	

	FS (Seismic)
	1.293

VENEER SLOPE STABILITY CALCULATIONS - 10% SLOPE

Purple highlighted parameters are inputted

Internal Slope Failure (Unsaturated Post-EQ)

Analysis of all lower interfaces (subgrade-to-geomembrane, geomembrane-to-geocomposite, geocomposite-to-cover soil)

(Conversion of degrees to radians are performed for Excel spread sheet calculations)

20% (5H:1V slope) β =	5.71	degrees =	*0.10 radians*
Interface Friction, δ =	**17.10**	**degrees =**	*0.30 radians*
Interface Adhesion, a =	**0.00**	**psf**	
Thickness of soil above geomembrane, t =	**2.00**	**ft**	
Thickness of Saturation (water) t_w =	0.021	ft	
t_w* =	0.021	ft	
Height of slope, h =	20.0	ft	
Total Unit Weight of Soil Above Geomembrane, γ_t =	**110.00**	**pcf**	
Effective Unit Weight, γ_b =	57.60	pcf	
Saturated Unit Weight of Soil Above Geomembrane, γ_{sat} =	120.00	pcf	
Friction Angle of Soil Above Geomembrane, ϕ =	**27.00**	**degrees =**	*0.47 radians*
Cohesion of Soil Above Geomembrane, c =	**0.00**	**psf**	
Seismic Coeffecient, k_s =	0.000	g	

A	*B*	*C*	
$[\gamma_t \times (t-t_w) + \gamma_b \times t_w]$	$[\gamma_t \times (t-t_w) + \gamma_{sat} \times t_w]$	$\tan\delta/\tan\beta$	[A/B] x C
218.900	220.210	3.076	3.058

D		*E*	*F*	*G*	
[a/sinβ]	D/B	$\gamma_t (t-t_w^*) + \gamma_b \times t_w^*]/B$	$[\tan\phi/(2\sin\beta\cos\beta)]/(1-\tan\beta\tan\phi)$	t/h	E x F x G
0.000	**0**	0.994	2.725	0.100	0.271

H	*I*	*J*	
1/B	$[1/(\sin\beta\cos\beta)]/[1-\tan\beta\tan\phi]$	ct/h	H x I x J
0.005	10.642	0.000	0.000

A'	*B'*	*C'*	*D'*	[A'+B'-C']/D'
$a/[\gamma_t \times t \times \cos^2(\beta)]$	$\tan\phi \times [1-(\gamma_w \times t_w)/(\gamma_t \times t)]$	$n_q \times \tan\beta \times \tan\phi$	$n_q + \tan\beta$	3.058
0.000	0.306	0.000	0.100	

FS (Post-EQ)	
3.329	

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ATTACHMENT H

Public Notification and Public Meeting Certification

845.220(a)(9)

July 2022

Byron Veech
Electric Energy, Inc.
2100 Portland Road
Joppa, IL 62953

July 27, 2022

Illinois Environmental Protection Agency
DWPC – Permits MC # 15
ATTN: Part 845 Coal Combustion Residual Rule Submittal
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

Re: 35 IAC 845.220(a)(9) Certification Statement
Joppa Power Plant; East Ash Pond (IEPA ID # W1270100004-02)

Dear Mr. Darin LeCrone:

For the above-refenced CCR surface impoundments and in accordance with 35 IAC 845.220(a)(9), Electric Energy, Inc. certifies that the public notification and public meetings required under 35 IAC 845.240 were completed. Please find enclosed both the public meeting summary and listserv.

Sincerely,
Electric Energy, Inc.

Byron Veech
Plant Manager

Joppa Public Meeting Summary, June 30, 2022

On May 23, 2022, Electric Energy, Inc. (EEI) made available to the public its plans to close the East Ash Pond (EAP) located at the Joppa Power Plant. On Thursday, June 30, 2022, EEI held in-person public meetings at 3:30 pm and 5:30 pm at the Joppa High School to present its decision-making process. A comparison of projected groundwater impacts for the alternatives presented, and an objective comparison of the pros and cons of each alternative were presented at these meetings. During the question-and-answer portion of the meeting, the public asked questions relating to the proposed closure which the company addressed. As required by Section 845.240(g), this document provides a general summary of the issues or comments raised by the public relating to the closure, a summary of the company's responses to those issues or comments, and a summary of any revisions or changes made to the proposed closure action as a result of issues and comments raised by the public.

Issue/Topic		Summary of Response Provided at Meeting	Additional Written Response
1.	Pond Closure	A risk assessment and groundwater model were completed to provide information needed in selecting an alternative closure method. The groundwater model results show that both Closed in Place (CIP) and Closed by Removal (CBR) are equally protective to groundwater. The Closure Alternatives Analysis (CAA) identified CIP as the most appropriate closure approach because it has the least negative impacts overall. The CAA is included in the Construction Permit Application posted on the Luminant website www.luminant.com/ccr/illinois-ccr/. For this current evaluation cost estimates were not considered.	
2.	Groundwater	The proposed monitoring well network is located around the perimeter of the Ash Pond. Observed groundwater flow is to the southeast near the Ash Pond and further from the pond the direction of flow is to the south toward the Ohio River. Potential exceedance of the boron groundwater	

		standard was identified along the southeast property boundary in the shallow aquifer. Groundwater delineation is currently being performed. Additional monitoring wells in both the shallow and lower aquifer have been installed within the direction of groundwater flow (ie. southeast of the ash pond) at distances of up to approximately 0.5 miles. These wells will be sampled regularly over the next several months. Recent surveys within the Village of Joppa did not identify any private, domestic water wells, thus there is no current exposure or risk associated with the potentially impacted groundwater. EEI requested that anyone within the Village that has a private well to leave their name and contact information. If the well is in the shallow aquifer (approximately 50 to 80 feet below ground surface) and in the direction of groundwater flow, EEI will sample the well for the presence of boron. The May 24, 2022 sampling test results affirm that the Village's public water supply, which is set in the lower aquifer, has not been impacted by the Joppa Power Plant and the drinking water from the municipal water system does not have elevated levels of boron or any other constituent associated with coal power plants or coal ash ponds. Also, recent sample results are consistent with historic results provided on the Public Water Supply System database.	
3.	Corrective Measures and Interim Corrective Measures	Corrective measures includes source control through closure of the pond, and groundwater remediation.	

		Additional data is needed to evaluate available technologies for groundwater corrective action, including a better understanding of groundwater flow rates. A pilot pumping well will be installed to evaluate groundwater flow rates and groundwater capture zones in the shallow aquifer. The pilot pumping well and observations wells to evaluate flow rates and capture zones, are scheduled for completion in the summer of 2022. Following completion of the pilot well testing, the interim extraction system, if needed, is expected to be operational in late 2022 to mid 2023.	
4.	Water Handling	Any water generated from closure or groundwater remediation will be discharged through an existing NPDES outfall, consistent with permit requirements. If necessary to meet permit limits, the water will be treated onsite prior to discharge.	
5.	Post-Closure Monitoring	Monitoring of the pond and groundwater will continue through construction and for at least 30 years. Part 845 specifies the minimum inspection requirement for the pond including events that trigger an inspection, reporting and certifications required. For the closure-in-place alternative, groundwater monitoring will continue for at least 30 years post-closure. However, if groundwater protection standards have not been achieved in that timeframe, groundwater monitoring will continue as required.	

6.	Earthquake	Following an earthquake, the pond would be inspected and repaired, if necessary.	The Emergency Action Plan (EAP) includes detailed information on handling emergency situations, such as an earthquake. The East Ash Pond meets the seismic safety requirements of 40 CFR Section 257.63(a) and IAC Section 845.330(a), and the overall risk of dike failure due to seismicity is expected to be low.
7.	Future Use	Once a plant has ceased coal-fired generation, development of the property or applicability for power generation using renewables to utilize existing infrastructure is evaluated. A 37 MW energy storage unit (battery) will be built and operated at the Joppa Power Plant. Due to insufficient land for installation of solar panels, only the battery storage was included in the legislation for the Joppa Power Plant. The company is evaluating installing solar panels on closed surface impoundments, including the Joppa East Ash Pond. The storage unit will be financed with grants from Illinois Department of Commerce and Economic Opportunity and will be taxed at full value for Massac County in 2025. There are no current plans to sell the Joppa Power Plant.	

8.	Plant Retirement	Under a binding settlement with Sierra Club, the Joppa Power Plant must permanently cease operating no later than December 31, 2022. There are no plans to demolish the plant structures. The existing transmission lines will be used in conjunction with the battery storage unit.	Concerns regarding grid stability were raised. Grid stability is a consideration when evaluating whether to install solar on closed surface impoundments.
9.	Other	Many attendees inquired about the large earth moving project located nearby that is thought to be for a solar farm. EEI informed attendees that this work is not being performed on their behalf and recommended interested parties contact the tax assessor to identify the parties involved.	
10.	Availability of Information Related to Public Meetings	Slides will not be posted on our publicly available website. Written responses will be provided to all issues raised in the public meetings.	

In accordance with 845.240(f)(4), a list of people who requested to be added to the IEPA Listserv for Joppa is as follows:

Joppa construction permit public meetings	
People requesting to be added to IEPA Listserv	
Name	Email address
Terra Temple	ttemple@metropolisplanet.com
Chris McGinness	mcginnesse@yahoo.com
Kevin Castlone	joppaschoolboard@yahoo.com
Theresa Monzulla	monzulla@aol.com
Bruce Monzulla	monzulla@aol.com
Stacey Reames	staceyreames@gmail.com
Sue Sandusky	sandusky@frontier.net
Rachel Henson	rhenson2016@gmail.com
Denise Meyer	dmeyer7878@gmail.com
Mike Lowery	bobbylowery@gmail.com

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ATTACHMENT I

Closure Prioritization Category Letter

845.220(d)(1)

July 2022

Phil Morris
Electric Energy, Inc.
Luminant
1500 Eastport Plaza Drive
Collinsville, IL 62234

May 19, 2021

Mr. Darin LeCrone, P.E.
Manager, Industrial Unit
Bureau of Water, Division of Water Pollution Control, Permits Section
Illinois Environmental Protection Agency
1021 North Grand Avenue, East
Springfield, IL 62794-9276

Re: CCR Surface Impoundment Category Designation and Justification for Electric Energy, Inc.

Dear Mr. LeCrone:

Pursuant to 35 I.A.C. 845.700(c), Electric Energy, Inc. (EEI) submits the information necessary to categorize the CCR surface impoundment located at the Joppa Power Plant. The following parameters were used in assessing and justifying each assigned category.

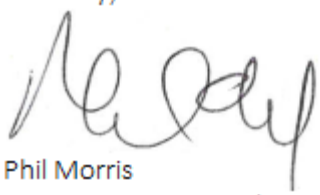
- Category 1 – *Impacts to existing potable water supply well or impacts to groundwater quality within the setback of an existing potable water supply well.*
    - This review includes an assessment of potable water wells within 2,500 feet of CCR surface impoundments to determine whether any potential impacts are occurring within the setback zone of any community water supply well established under the Illinois Groundwater Protection Act.
    - This information was developed during the Part 845 rulemaking and is summarized in Attachment 1, Table 2: Impacts to Potable Water Supply.
- Category 2 – *Imminent threat to human health or the environment or have been designated by IEPA under (g)(5)*
    - The surface impoundment at the Joppa Power Plant does not pose an imminent threat to human health or the environment. There are no known conditions at or around the facility where someone or something may be exposed to contaminant concentrations reasonably expected to cause harm
- Category 3 – *Located in areas of environmental justice ("EJ") concern*
    - EJ areas were evaluated using the EJ mapping link from IEPA's webpage located at https://www2.illinois.gov/epa/topics/environmental-justice. Per the IEPA mapping tool, the EJ Status thresholds were determined as twice the state averages for Minority and Low Income consistent with 35 IAC 845.700(g)(6).
    - An EJ map denoting the facilities with impoundments is located in Attachment 2.

- Category 4-7
    - Category 4 - Inactive CCR surface impoundments that have an exceedance of the groundwater protection standards in Section 845.600
    - Category 5 - Existing CCR surface impoundments that have exceedances of the groundwater protection standards in Section 845.600
    - Category 6 - Inactive CCR surface impoundments that are in compliance with the groundwater protection standards in Section 845.600.
    - Category 7 – Existing CCR surface impoundments that are in compliance with the groundwater protection standards in Section 845.600

Based on the information above, category designations have been assigned. The category designations for each CCR impoundment are shown in Attachment 1, Table 1: Category Designations.

If you have any questions regarding this submittal, please contact Phil Morris at 618-343-7794 or phil.morris@vistracorp.com.

Sincerely,



Phil Morris
Senior Environmental Director

Attachments

Attachment 1

Table 1: Category Designation

Facility	Pond Description	Classifications	Potable Water Supply Impacts (Category 1)	Human Health or Environment Threat (Category 2)	Located within Environmental Justice Areas[1] (Category 3)	Standards Exceedances[2] (Categories 4,5,6,7)	Impoundment Category 845.700(g)
Joppa	East Ash Pond	Existing	No	No	No	Yes	5

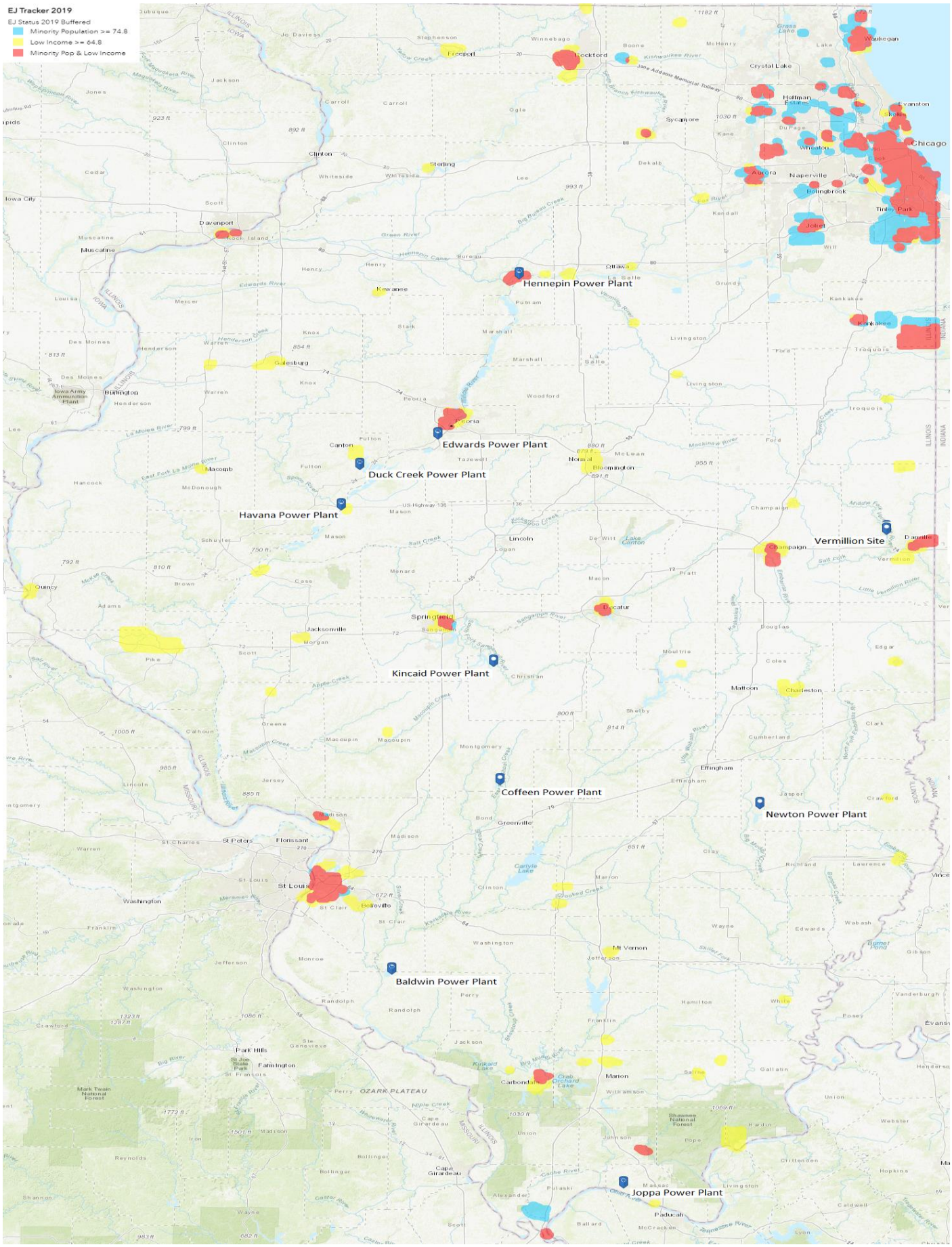
[1] See Attachment 2 Environmental Justice Area Map

[2] Ground water analyses for purposes of categories 4-7, assumptions have been made based on current groundwater data. However, since sampling and analysis is ongoing and subject to IEPA review and approval, IPGC reserves the right to update its category designations for Categories 4-7.

Table 2: Impacts to Potable Water Supply

Site Name	Private and Semi-Private Wells	Non-Community Water Supply (CWS) Wells	Non-CWS Surface Water Intakes	Community Water Supply Wells	CWS Surface Water Intakes
Joppa	**Present, but not at risk** Forty-six (46) water wells were identified and 23 are located potentially downgradient of the site. However, only one (1) well is likely to be present and potentially used for drinking water. Based on Ramboll's review of groundwater data from the eastern portion of the site, it is unlikely that well P018 is at risk from coal ash constituents.	Absent	Absent	**Present, but not at risk** Two CWS wells were identified; however, they are unlikely to be at risk because of their hydrogeologic location relative to the power plant and/or their abandoned status.	Absent

Attachment 2: EJ Mapping Denoting Facilities with Impoundments



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ATTACHMENT J

Post-Closure Care Plan

845.220(d)(5)

July 2022

POST-CLOSURE PLAN FOR EXISTING CCR SURFACE IMPOUNDMENT
40 C.F.R. § 257.104 and 35 I.A.C. 845.780
REV 0 – 10/30/2021

SITE INFORMATION

Site Name / Address	Joppa Power Plant / 2100 Portland Road, Joppa, IL 62953		
Owner Name / Address	Electric Energy, Inc. / 6555 Sierra Drive Irving, Texas 75039		
CCR Unit	East Ash Pond	Closure Method and Final Cover Type	Close In-Place Clayey Soil Cover with Vegetation

POST-CLOSURE PLAN DESCRIPTION

40 C.F.R. § 257.104(c)(1) and 35 I.A.C. 845.780(c)(1) – Length of post-closure care period.	Post-closure care will be conducted for a period of 30 years as required by 40 C.F.R. § 257.104(c)(1) and 35 I.A.C. 845.780(c)(1), except as provided by 40 C.F.R. § 257.104(c)(2) and 35 I.A.C. 845.780(c)(2).
40 C.F.R. § 257.104(c)(2) and 35 I.A.C. 845.780(c)(2) - Circumstances extending the post closure care period.	If at the end of the post-closure care period the CCR unit is operating under assessment monitoring in accordance with §257.95, the post-closure care as described in this plan will continue until returning to detection monitoring in accordance with §257.95. Under 35 I.A.C. 845.780(c)(2), the post-closure care period will be extended until groundwater monitoring data demonstrate that concentrations are below the groundwater protection standards in Section 845.600 and are not increasing for those constituents over background, using the statistical procedures and performance standards in Section 845.640(f) and (g), provided that concentrations have been reduced to the maximum extent feasible and concentrations are protective of human health and the environment.
40 C.F.R. § 257.104(d)(1)(i) and 35 I.A.C. 845.780(d)(1)(A) – A description of the monitoring and maintenance activities required in 40 C.F.R. § 257.104(b) and 35 I.A.C. 845.780(b), and the frequency at which these activities will be performed, to maintain the integrity and effectiveness of the final cover system, maintain the groundwater monitoring system and monitor the groundwater.	Pursuant to § 257.104(b)(1) and 35 I.A.C. 845.780(b)(1), throughout the post-closure care period, periodic visual observations of the final cover system and stormwater management system will be performed at least annually for evidence of settlement, subsidence, erosion, or other damage that may adversely affect the integrity and effectiveness of the final cover system. When practical, visual observations of the final cover will be made concurrent with groundwater monitoring activities. Noted evidence of damage, such as rills, surface cracks and settlement, will be repaired to maintain the integrity and effectiveness of the final cover system. Vegetation will be established and maintained on the final cover system, including storm drainage areas, where appropriate, to provide long-term erosion control. Established vegetation and the slope design of the final cover system will prevent potential erosion and damage that may be caused by run-on and run-off. Repair activities may include, but are not limited to, replacing and compacting soil cover, repairing drainage channels that have been eroded, filling in depressions with soil, regrading, and reseeding areas

	of failed vegetation, as necessary. Pursuant to § 257.104(b)(3) and 35 I.A.C. 845.780(b)(3), the groundwater monitoring system will be maintained, and groundwater will be monitored as required by 40 C.F.R. § 257.90 through 40 C.F.R. § 257.98 and 35 I.A.C. 845.600 through 35 I.A.C. 845.680. Monitoring wells will be inspected during each groundwater sampling event. Monitoring wells and associated instrumentation will be maintained so that they perform to the design specifications throughout the life of the monitoring program. Groundwater monitoring frequency will be at least quarterly, except as provided in 40 C.F.R. § 257.94(d) and 35 I.A.C. 845.650(b)(4).
40 C.F.R. § 257.104(d)(1)(ii) and 35 I.A.C. 845.780(d)(1)(B) – The name, address, telephone number and email address of the person or office to contact about the facility during the post-closure care period.	Electric Energy, Inc. 6555 Sierra Drive Irving, Texas 75039 800.633.4704 ccr@dynegy.com
40 C.F.R. § 257.104(d)(1)(iii) and 35 I.A.C. 845.780(d)(1)(C) – A description of the planned uses of the property during the post-closure period.	The CCR unit is located at an operating electric generation facility. Planned uses of the property during the post-closure period are currentlyunknown, except for post-closure care of the CCR unit. Post-closure use of the property will not disturb the integrity of the final cover system or other components of the containment system, or the function of the monitoring systems unless necessary to comply with the requirements of 40 C.F.R. Part § 257, Subpart D and 35 I.A.C Part 845. Any other disturbance will be conducted following a demonstration that it will not increase the potential threat to human health or the environment, as required by 40 C.F.R. § 257.104(d)(1)(iii) and 35 I.A.C. 845.780 (d)(1)(C). The demonstration will be certified by a qualified professional engineer and submitted to the Illinois Environmental Protection Agency (IEPA). Per 40 C.F.R. § 257.104(d)(1)(iii) notification shall be provided to the State Director that the demonstration has been placed in the operating record and on the owners or operator's publicly accessible internet site. Following closure of the CCR unit, a notation on the deed to the property, or some other instrument that is normally examined during title search, will be recorded in accordance with 40 C.F.R. § 257.102(i) and 35 I.A.C. 845.760(h). The notation will notify potential purchasers of the property that the land has been used as a CCR unit and its use is restricted under the post-closure care requirements in 40 C.F.R. § 257.104(d)(1)(iii) and 35 I.A.C. 845.780(d)(1)(C) or groundwater monitoring requirements per 35 I.A.C. 845.740(b). Within 30 days of recording the deed notation, a notification stating that the notation has been recorded will be submitted to the IEPA and placed in the facility's operating record per 35 I.A.C. 845.760(h)(3). The notification will be placed on the owner or operator's publicly accessible CCR Web site in accordance with 40 C.F.R. § 257.107(i)(9) and 35 I.A.C. 845.810(e) and placed in the facility's operating record as required by 35 I.A.C. 845.800(d)(26) and §257.105(i)(9).

40 C.F.R. § 257.104(d)(3) and 35 I.A.C. 845.780(d)(3) – Amendments to the initial or subsequent written post-closure plan.	Pursuant to 40 C.F.R. § 257.104(d), the initial post closure care plan for the Joppa East Ash Pond was prepared on October 17, 2016. That plan is being amended pursuant to 40 C.F.R. § 257.104(d)(3)(i). This plan also serves as the initial post-closure care plan, prepared in accordance with 35 I.A.C. 845.780(d). Pursuant to § 257.104(d)(3) and 35 I.A.C. 845.780(d)(3), an operating permit modification application to amend the initial or any subsequent written post-closure care plan developed under 35 I.A.C. 845.780 (d)(1) and § 257.104(d)(1) will be submitted to IEPA. The written post-closure care plan will be amended whenever there is a change in the operation of the CCR surface impoundment that would substantially affect the written post-closure care plan in effect; or unanticipated events necessitate a revision of the written post-closure care plan, after post-closure activities have started. The written post-closure care plan will be amended at least 60 days before a planned change in the operation of the facility or CCR surface impoundment, or within 60 days after an unanticipated event requires the need to revise the existing plan. If the plan is revised after post-closure activities have started, a request to modify the operating permit, including an amended written post-closure care plan, will be submitted to the IEPA within 30 days following the triggering event.
40 C.F.R. § 257.104(d)(4) and 35 I.A.C. 845.780(d)(4) – Qualified professional engineering certification.	Certification by a qualified professional engineer will be appended to this plan and any amendment of this plan.
35 I.A.C. 845.780(e) – Termination of post-closure care	Upon completion of the post-closure period, a request to terminate post-closure care will be submitted to the IEPA. The request will include a certification by a qualified professional engineer verifying that post-closure care has been completed in accordance with the post-closure care plan specified in 35 I.A.C. 845.780(d) and the requirements of 35 I.A.C. 845.780.
40 C.F.R. § 257.104(e) and 35 I.A.C. 845.780(f) – Notification of completion of the 40 C.F.R. § 257.104(e) and post-closure care period.	A notification of completion of post-closure care will be prepared and placed in the facility's operating record within 30 days after IEPA approval of the request to terminate post-closure care. The notification will be placed in the facility's operating record in accordance with 35 I.A.C. 845.800(d)(31) and § 257.105(i)(13). The notification will be placed on the owner or operator's publicly accessible CCR Internet site in accordance with the requirements of § 257.107(i)(13) and 35 I.A.C. 845.810(e). The IEPA will be notified when the notification has been placed in the operating record and on the owner or operator's publicly accessible Internet site in accordance with the requirements of § 257.106(i)(13).

Certification Statement 40 C.F.R. § 257.104 (d)(4) and 35 I.A.C. 845.780(d)(4) – Amended/Initial Written Post Closure Plan for a CCR Surface Impoundment

CCR Unit: Electric Energy, Inc.; Joppa Power Plant; East Ash Pond

I, John R. Hesemann, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above referenced CCR Unit, that the information contained in the amended/initial written post closure plan, dated October 30, 2021, meets the requirements of 40 C.F.R. § 257.104 and 35 I.A.C. 845.780.

John R. Hesemann

Printed Name

9/29/2021

Date

Geosyntec
consultants

ATTACHMENT K

Contractor Training Certification

45 ILCS 5/22.59(b)(4)

July 2022

Phil Morris
Electric Energy, Inc.
1500 Eastport Plaza Drive
Collinsville, IL 62234

July 28, 2022

Illinois Environmental Protection Agency
DWPC – Permits MC # 15
ATTN: Part 845 Coal Combustion Residual Rule Submittal
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

Re: 415 ILCS 5/22.59(b)(4) Certification Statement
Joppa Power Plant East Ash Pond (IEPA ID# W1270100004-02)

Dear Mr. Darin LeCrone:

For the above-referenced CCR surface impoundment and in accordance with 415 ILCS 5/22.59(b)(4), Electric Energy, Inc certify that all contractors, subcontractors, and installers utilized to construct, install, modify, or close a CCR surface impoundment will be participants in a training program that is approved by and registered with the US Department of Labor's Employment and Training Administration and that includes instruction in the following: erosion control, environmental remediation, operation of heavy equipment and excavation.

Sincerely,
Electric Energy, Inc.

Phil Morris, P.E.
Senior Director, Environmental