Prepared for

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CCR SURFACE IMPOUNDMENT FINAL CLOSURE PLAN

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

Prepared by

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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 ... 8
      2.1.3. Closure Construction Narrative Sequencing ... 8
   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 ... 19

4. Closure with Final Cover System ... 20
   4.1. Minimization of Post-Closure Infiltration and Releases ... 20
   4.2. Preclusion of Future Impoundment ... 21
   4.3. Provisions for Preventing Instability, Sloughing and Movement ... 22
   4.4. Minimize the Need for Further Maintenance ... 22
   4.5. Be Completed in Shortest Amount of Time ... 23
   4.6. Drainage and Stabilization ... 24
   4.7. Final Cover System ... 24
      4.7.1. Low Permeability Layer - Geomembrane ... 25
      4.7.2. Standards for the Final Protective Layer ... 25
   4.8. Certification ... 27
   4.9. Uses of CCR in Closure ... 28
   4.10. Final Cover System Slopes ... 28

5. Additional Information ... 30

6. Certification from a Qualified Professional Engineer ... 31

7. References ... 32

TABLE OF CONTENTS

TABLES

Table 1 Closure Completion Milestone Schedule
Table 2 CCR Final Closure Plan Revisions

ATTACHMENTS

Attachment A Closure Alternatives Analysis
Attachment B Corrective Measures Assessment
Attachment C Final Closure Plan Drawings and Material Specifications
Attachment D Hydrologic and Hydraulic Design of Stormwater Management System
Attachment E 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.

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.*

Consolidation and 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 CIP was the most appropriate closure method for the EAP. Information developed by Geosyntec to support the Closure Alternatives Analysis is provided as an attachment to the CAA. Geosyntec also prepared a Corrective Measures Assessment (CMA) to support the CAA; the CMA 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

<u>Section 845.720(a)(1):</u> *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 relocating approximately 1.5 million cubic yards (CY) of CCR, up to one foot of underlying soil, and dike materials from an approximately 54-acre closure-by-removal area inside the perimeter dikes to the consolidated footprint within the current EAP dikes. Additionally, CCR from a 32-acre area outside of the perimeter dikes will also be beneficially used for grading and contouring fill as part of the closure in the consolidated footprint. Figures showing the location of these areas is provided within the final closure drawings in **Attachment B**.

During the closure process, we 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 to be Relocated

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

- Approximately 1.2 million CY of CCR will be relocated from a 54-acre area inside the EAP (the closure-by-removal area) into the closure-in-place area.

- Approximately 230,000 CY of CCR will be relocated from a 32-acre area outside of the EAP for beneficial use as grading and contouring fill, to the south and southeast (the Southeast Area) into the closure-in-place area for grading and contouring.
    - 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 B**. CCR in both areas was generated at the JPP and was located into this area between initial commissioning of the JPP in the 1950s and construction of the southern berms of the EAP in the 1970s and 1980s [1].
        - CCR within the Southeast Area – South was located into the area by process and stormwater flows emanating from the EAP, prior to construction of the southern berm and the direction of all process and stormwater flows to NPDES Outfall 001 at the north end of the EAP.
            - Initially, process and stormwater flow from the EAP flowed to the Ohio River via two reinforced concrete pipes (RCP) culverts that penetrated the rail loop. Flows from the EAP formerly carried CCR through these culverts and located the CCR into the area south of the rail loop.
            - When the southern berm and NPDES Outfall 001 were constructed, process and stormwater flow was no longer discharged from the EAP directly through the RCP culverts, and the location of CCR into the Southeast Area – South was ceased. However, CCR located in this area was left in-place.
        - CCR within the Southeast Area – North was located into the original footprint of the EAP, through routine sluicing operations. The EAP previously extended all the way to the current interior limits of the rail loop, prior to construction of the EAP southern berm. When the southern berm was constructed, the footprint of the EAP was reduced. CCR that had been located between the rail loop and the southern berm via previous sluicing is now located outside of the reduced EAP footprint. This CCR was left in-place after the southern berm was construction.
        - An additional intrusive investigation to refine the understanding of the lateral extents, depths, and quantities of CCR in the Southeast Area was

completed in May of 2022. The results of this investigation are currently being processed.

- Approximately 3,000-ft of the existing perimeter dikes will be relocated 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 comingled with CCR will be used for protective cover soil.

CCR relocation in all areas will include excavating both the CCR and up to one foot of underlying native 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 relocated 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 founded on native foundation soils where the CCR has been removed.
    - 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 the proximity of 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 subsurface drainage features to remove liquids wastes prior to installation of the final cover. The 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 to the Settling Lagoon (a non-CCR surface impoundment) for ultimate discharge to the Ohio River at National Pollutant Discharge Elimination System (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.
- 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 CCR.

  - 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 native clay foundation soils 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.

- 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.

    - A 1.5-ft thick protective layer (e.g., protective layer) 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 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.

    - 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.

    - 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. All other vibrating-wire piezometers outside of the consolidated footprint will be abandoned by cutting the readout cable off at the ground surface.

- The alternate final cover system will be based on a demonstration that will be submitted to IEPA, completed pursuant to Section 845.750(c)(2). 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.

    - 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.

    - A stormwater detention pond will be utilized within the closure-by-removal area, within a low area where CCR will be removed. The pond will provide attenuation for stormwater discharge to the southeast area and ultimately the Ohio River.

    - 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.

Permit-level engineering drawings and material specifications for the closure are provided in **Attachment B**.

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 include excavating up to one foot of native underlying 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 soils will be placed beneath the final cover system of the EAP as beneficial fill for contouring and grading. Decontamination will also include a visual inspection of the excavated subgrade to verify that CCR has been removed, and excavation depths will vary, as needed, until CCR has been verified and documented.

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 approximately additional 230,000 cubic yards of CCR located outside of the limits of the EAP embankments (see **Section 2.1**) will be excavated and beneficially used within the EAP as contouring fill to reach final cover system subgrades during closure. Therefore, this inventory will increase to approximately 6,100,000 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, as no CCR will be present in 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 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 CCR from the closure-by-removal portions of the EAP, areas outside of the EAP (the Southeast Area), and 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, 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.

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, 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 • Remove 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)

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 currently 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**.

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 contract with the uppermost aquifer 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 with at least 15 and up to 50 ft of separation above the uppermost aquifer ([2], [6]). 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 and will 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 within the proximity of the uppermost aquifer during post-closure conditions.

  - CCR that is currently (e.g., under pre-closure conditions) expected to be within close proximity to the uppermost aquifer, including CCR within the EAP and in the Southeast Area will be relocated as part of closure. The relocated CCR will be beneficially used for contouring and grading fill under the final cover system within the consolidated-can-capped EAP footprint.

Therefore, vertical infiltration will be minimized and the CCR will be physically isolated from and located above the uppermost aquifer.

4.2. Preclusion of Future Impoundment

<u>Section 845.750(a)(2):</u> *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 D**.

4.3. Provisions for Preventing Instability, Sloughing and Movement

<u>*Section 845.750(a)(3):*</u> *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 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 [7]. Slope stability analyses are provided in **Attachment E**.

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 E**.

4.4. Minimize the Need for Further Maintenance

<u>*Section 845.750(a)(4):*</u> *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 energy dissipation will be placed at each culvert outlet. The erosion control blankets, non-erodible culverts, and riprap 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 D**.

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 1.5 million CY of CCR excavation, placement, and dike construction, and 74 acres of final cover systems), 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. Engineering measures necessary to remove liquid waste that is readily separable under ambient temperature air pressure are being evaluated and are currently expected to include subsurface drainage features and may include sumps, trenches, and/or pumps.

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

<u>Section 845.750(c)(1)(B):</u> *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. A geocomposite drainage layer will be placed on top of the geomembrane, as described in Section 4.7.2.

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:

<u>Section 845.750(c)(2):</u> *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 a demonstration that will be prepared at a later date, 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 will be discussed in a future demonstration. 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 will be accounted for in the design of the final cover system as discussed in **Section 4.10**.

4.8. Certification

<u>Section 845.750(c)(4):</u> *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.

Printed Name

Signature Date

Registration Number State Expiration Date

Affix Seal

4.9. Uses of CCR in Closure

<u>Section 845.750(d):</u> *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 230,000 cubic yards of CCR are estimated to be located outside of the EAP. This CCR was generated at the facility, originally placed within the limits of the EAP prior to being located outside of the EAP by flowing process and stormwater, and will be located at the facility at the time that closure of the EAP is initiated.

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. 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

<u>Section 845.750(d)(4):</u> *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 E**. 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 two 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 [7] 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.

- CCR located outside of the EAP will be excavated and beneficially used for contouring and grading fill 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 of 15 to 50 ft that is approximately 30 ft thick on average beneath the CCR, as shown within the drawings 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] and will provide separation between the CCR and the uppermost aquifer.

- 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 in proximity to the uppermost aquifer during post-closure conditions.

6. 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.

Printed Name

Signature Date

Registration Number State Expiration Date

Affix Seal

7. REFERENCES

[1] AECOM, "History of Construciton, USEPA Final CCR Rule, 40 CFR § 257.73(c), Joppa Power Station, Joppa, Illinois," October 2016.

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

[3] Illinois Department of Natural Resrouces, "Illinois Solar Site Pollinator Habitat Planting Form," 2019.

[4] IngenAE, LLC, "CCR Facility Boundary Exhibit, Luminant Joppa Power Plant," Earth City, MO, September 7, 2021.

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

[6] Ramboll, "Draft Hydrogeologic Updates for Construction Permit, East Ash Pond, Joppa Power Plant, Joppa, IL," 2021.

[7] 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.

[8] Haley & Aldrich, Inc., "Location Restriction Demonstration - Unstable Areas, Joppa Power Station, East Ash Pond, Joppa, Illinois," Cleveland, OH, October 16, 2022.

ATTACHMENT A

Closure Alternatives Analysis

Closure Alternatives Analysis for the East Ash Pond at the Joppa Power Plant, Joppa, Illinois

May 31, 2022

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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 7
    2.1.3 Closure-by-Removal with Off-Site CCR Disposal by Barging 9
  2.2 Long- and Short-Term Effectiveness of the Closure Alternative (IAC Section 845.710(b)(1)) 10
    2.2.1 Magnitude of Reduction of Existing Risks (IAC Section 845.710(b)(1)(A)) 10
    2.2.2 Likelihood of Future Releases of CCR (IAC Section 845.710(b)(1)(B)) 11
    2.2.3 Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (IAC Section 845.710(b)(1)(C)) 12
    2.2.4 Short-Term Risks to the Community or the Environment During Implementation of Closure (IAC Section 845.710(b)(1)(D)) 12
      2.2.4.1 Worker Risks 12
      2.2.4.2 Community Risks 14
      2.2.4.3 Environmental Risks 19
    2.2.5 Time Until Groundwater Protection Standards Are Achieved (IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3)) 21
    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)) 22
    2.2.7 Long-Term Reliability of the Engineering and Institutional Controls (IAC Section 845.710(b)(1)(G)) 22

2.2.8 Potential Need for Future Corrective Action Associated with the Closure (IAC Section 845.710(b)(1)(H)) 22
2.3 Effectiveness of the Closure Alternative in Controlling Future Releases (IAC Section 845.710(b)(2)) 23
2.3.1 Extent to Which Containment Practices Will Reduce Further Releases (IAC Section 845.710(b)(2)(A)) 23
2.3.2 Extent to Which Treatment Technologies May Be Used (IAC Section 845.710(b)(2)(B)) 23
2.4 Ease or Difficulty of Implementing Closure Alternative (IAC Section 845.710(b)(3)) 23
2.4.1 Degree of Difficulty Associated with Constructing the Closure Alternative 23
2.4.2 Expected Operational Reliability of the Closure Alternative 24
2.4.3 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies 24
2.4.4 Availability of Necessary Equipment and Specialists 24
2.4.5 Available Capacity and Location of Needed Treatment, Storage, and Disposal Services 25
2.5 Impact of Closure Alternative on Waters of the State (IAC Section 845.710(d)(4)) 26
2.6 Concerns of Residents Associated with Closure Alternatives (IAC Section 845.710(b)(4)) 26
2.7 Class 4 Cost Estimate (IAC Section 845.710(d)(1)) 27
2.8 Summary 27

References 28

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), 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 consolidating the CCRs in the EAP and CCRs that were disposed of outside 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). 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 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 to add the planned utility-scale battery energy storage facility 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, less traffic-related impacts, and potentially lower impacts to environmental justice [EJ] communities). This conclusion is subject to change as additional data are collected and following the completion of an upcoming public meeting, which will be held in June 2022 pursuant to requirements under IAC Section 845.710(e). Following the public meeting, a final closure decision will be made based on the considerations identified in this report, the results of any additional data that are collected, and any additional considerations that arise during the public meeting. The final closure recommendation will be provided in a Final Closure Plan, which will be submitted to the Illinois Environmental Protection Agency (IEPA) as described under IAC Section 845.720(b) (IEPA, 2021a).

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 that were disposed of outside the EAP would be 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 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 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.	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 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.	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 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.
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 0.99 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.008 worker fatalities and 0.6 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, 0.014 worker fatalities and 1.5 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. Simultaneous with closure activities, the Site would be redeveloped for use in utility-scale battery energy storage. The simultaneous pursuit of two large construction projects may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The CIP scenario would likely result in less traffic congestion – and, hence, a smaller increase in risks to workers – than the two CBR-Offsite scenarios.	An estimated 0.102 worker fatalities and 15.7 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.17 worker fatalities and 8.3 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, 0.27 worker fatalities and 24 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. Simultaneous with closure activities, the Site would be redeveloped for use in utility-scale battery energy storage. The simultaneous pursuit of two large construction projects may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The CIP scenario would likely result in less traffic congestion – and, hence, a smaller increase in risks to workers – than the two CBR-Offsite scenarios.	An estimated 0.082 worker fatalities and 12.6 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.074 worker fatalities and 4.1 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, 0.34 worker fatalities and 17.9 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. Simultaneous with closure activities, the Site would be redeveloped for use in utility-scale battery energy storage. The simultaneous pursuit of two large construction projects may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The CIP scenario would likely result in less traffic congestion – and, hence, a smaller increase in risks to workers – than the two CBR-Offsite scenarios.
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 0.34 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 0.67 fatalities and 19.0 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 Site every 1.7 minutes on average during working hours for approximately 12.9 years (*i.e.*, on 2,230 working 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 0.23 fatalities and 7.0 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 every 1.6 minutes on average during working hours for approximately 13.3 years (*i.e.*, on 2,280 working 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 Joppa Power Plant Site 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 this purpose 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 Joppa Power Plant Site 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 this purpose 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. 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 Joppa Power Plant Site 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 this purpose would occur more rapidly under the CIP scenario than under the two CBR-Offsite scenarios.
▪ *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 similar timeframes for both the CIP and CBR closure scenarios. Specifically, the modeling indicates that GWPSs will be achieved at all well locations in the UA within approximately 24 years after closure under all of the evaluated 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 similar timeframes for both the CIP and CBR closure scenarios. Specifically, the modeling indicates that GWPSs will be achieved at all well locations in the UA within approximately 24 years after closure under all of the evaluated 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 similar timeframes for both the CIP and CBR closure scenarios. Specifically, the modeling indicates that GWPSs will be achieved at all well locations in the UA within approximately 24 years after closure under all of the evaluated 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. Section 3 of this report (Corrective Measures Assessment) presents and evaluates the corrective measures being considered at the Site, consistent with the requirements in IAC Section 845.660.	Corrective action is expected at the Site. Section 3 of this report (Corrective Measures Assessment) presents and evaluates the corrective measures being considered at the Site, consistent with the requirements in IAC Section 845.660.	Corrective action is expected at the Site. Section 3 of this report (Corrective Measures Assessment) presents and evaluates the corrective measures being considered at the Site, consistent with the requirements in IAC Section 845.660.
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 constructed. 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. 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.	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.
▪ *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 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 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 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 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 use in utility-scale battery energy storage.	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. Moreover, under the CBR-Offsite scenarios, the Site could take longer to redevelop for use in utility-scale battery energy storage.	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. Moreover, under the CBR-Offsite scenarios, the Site could take longer to redevelop for use in utility-scale battery energy storage.
Class 4 Cost Estimate (Section 2.7; IAC Section 845.710(d)(1))	A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with AACE classification standards.	A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with AACE classification standards.	A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with AACE classification standards.

Notes:

AACE = Association for the Advancement of Cost Engineering; 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).

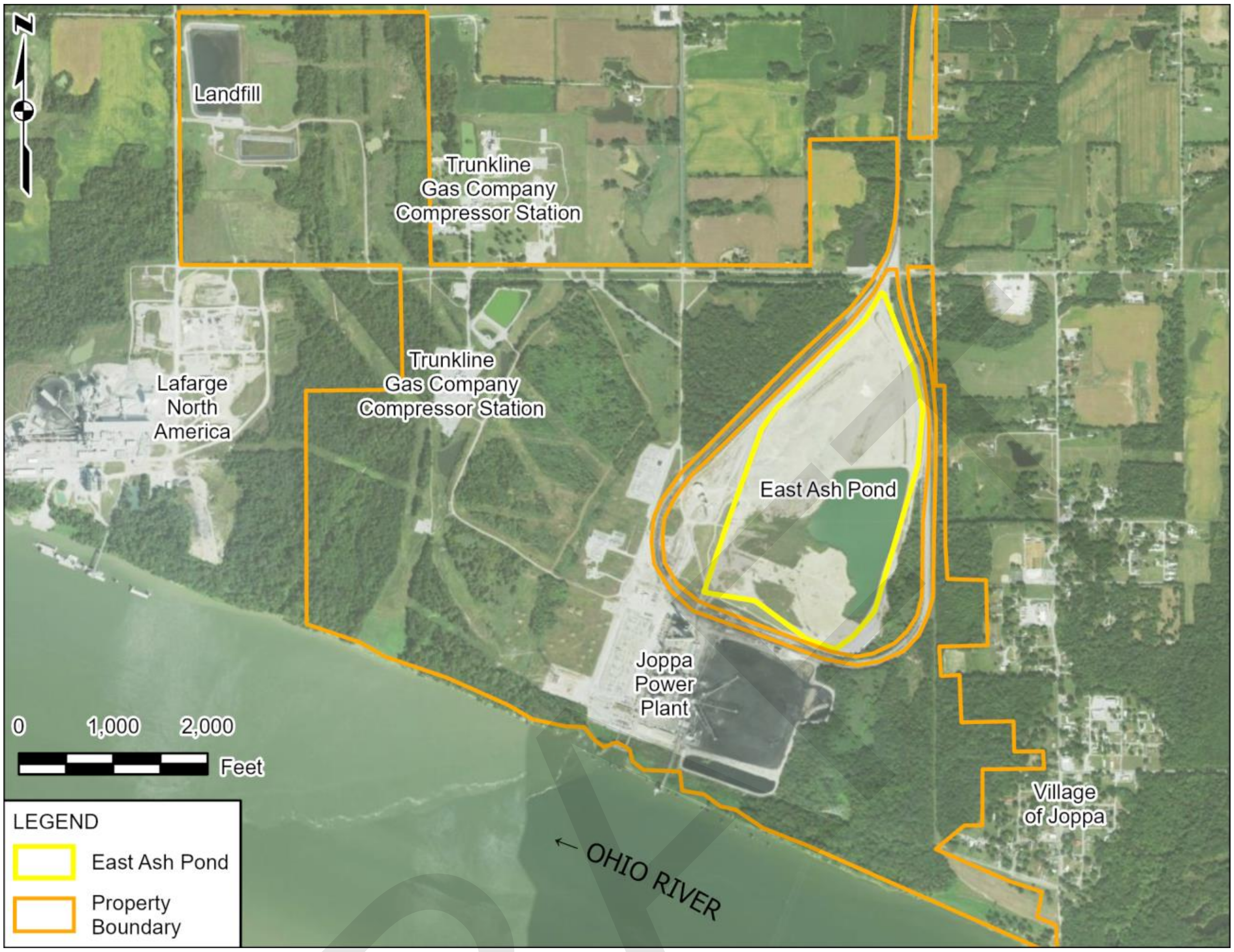

Figure 1.1 Site Location Map. Adapted from Ramboll (2021).

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), 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 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 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 consolidated into one area, then capped with a final cover system. This scenario includes the following work elements (Geosyntec 2022):

- 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. 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 disposed of in a 32-acre outside the EAP into the consolidate-and-cap portion of the EAP.
- 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 will be submitted to IEPA for approval pursuant to IAC Section 845.750(c)(2).
- 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 2022).

- 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)).
- 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 may be considered to facilitate the removal of liquid wastes and the stabilization of wastes. Sumps would be used to collect liquid wastes, which would be managed in accordance with the NPDES permit for the Site (IAC Sections 845.750(b)(1) and 845.750(b)(2)).

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 1,510,000 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 785,000 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 closure activities is approximately 2.2-3.5 years (26-42 months) (Appendix B). 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	1,510,000 CY[a]
Travel Distance for Relocation of CCRs	0.5 mile
Required Volume of Borrow Soil	785,000 CY
Distance to On-Site Borrow Soil Site	0.5 mile
Duration of Construction	2.2-3.5 years
Labor Hours	
Total On-Site Labor	85,600 hours
Total Off-Site Labor	5,040 hours
30% Contingency	27,200 hours
Total Labor Hours:	118,000 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	19,900 miles
Equipment On-Site	543,000 miles
On-Site Haul Trucks (Unloaded + Loaded)	71,500 miles
Labor Mobilization	823,000 miles
Equipment Mobilization (Unloaded + Loaded)	50,400 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:	634,000 miles
Total Off-Site Vehicle and Equipment Travel Miles:	1,190,000 miles
Total Vehicle and Equipment Travel Miles:	1,820,000 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. The preferred landfill for the off-Site disposal of CCRs under this scenario 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 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 6,730,000 CY of CCRs from areas within the EAP and outside EAP would be hauled to an off-Site landfill under this scenario. To backfill 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 closure activities under this closure scenario is approximately 10.3-15.8 years (125-189 months) (Appendix B). 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	6,730,000 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	10.3-15.8 years
Labor Hours	
Total On-Site Labor	1,360,000 hours
Total Off-Site Labor	26,800 hours
30% Contingency	416,000 hours
Total Labor Hours:	1,800,000 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	85,900 miles
Equipment On-Site	2,480,000 miles
On-Site Haul Trucks (Unloaded + Loaded)	208,000 miles
Labor Mobilization	3,120,000 miles
Equipment Mobilization (Unloaded + Loaded)	268,000 miles
Off-Site Haul Trucks (Unloaded + Loaded)	49,100,000 miles
Material Deliveries (Unloaded + Loaded)	200,000 miles
Total On-Site Vehicle and Equipment Travel:	2,770,000 miles
Total Off-Site Vehicle and Equipment Travel:	52,700,000 miles
Total Vehicle and Equipment Travel:	55,500,000 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 (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 6,730,000 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 towing nine barges per trip, with each barge carrying 1,400 CY of CCRs. To backfill 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 closure activities under this closure scenario is approximately 10.7-16.3 years (129-195 months) (Appendix B). 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	6,730,000 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	10.7-16.3 years
Labor Hours	
Total On-Site Labor	1,090,000 hours
Total Off-Site Labor	27,400 hours
30% Contingency	335,000 hours
Total Labor Hours:	1,450,000 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	87,800 miles
Equipment On-Site	2,540,000 miles
On-Site Haul Trucks (Unloaded + Loaded)	208,000 miles
Labor Mobilization	3,190,000 miles
Equipment Mobilization (Unloaded + Loaded)	274,000 miles
Off-Site Haul Trucks (Unloaded + Loaded)	16,400,000 miles
Barge Miles on River (Unloaded + Loaded)	88,700 miles
Material Deliveries (Unloaded + Loaded)	200,000 miles
Total On-Site Vehicle and Equipment Travel:	2,840,000 miles
Total Off-Site Vehicle and Equipment Travel:	20,200,000 miles
Total Vehicle and Equipment Travel:	23,000,000 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 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 exceedance level 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 85,600 on-Site labor hours (Appendix B). The CBR-Offsite-Truck scenario would require approximately 1,360,000 on-Site labor hours, and the CBR-Offsite-Barge scenario would require approximately 1,090,000 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 0.99 worker injuries and 0.006 worker fatalities would occur on Site under the CIP scenario; approximately 15.7 worker injuries and 0.102 worker fatalities would occur on Site under the CBR-Offsite-Truck scenario; and approximately 12.6 worker injuries and 0.0816 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	0.99	0.006
CBR-Offsite-Truck	15.7	0.102
CBR-Offsite-Barge	12.6	0.082

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, 52,700,000 total off-Site vehicle and equipment travel miles would be required; under the CBR-Offsite-Barge scenario, 20,200,000 total off-Site vehicle and equipment travel miles (including 20,100,00 road miles for car and haul truck use, and 88,700 river miles for barge use) would be required (Appendix B). In contrast, under the CIP scenario, only 1,190,000 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 0.55 worker injuries and 0.008 worker fatalities would be expected to occur due to off-Site activities under the CIP scenario; an estimated 8.3 worker injuries and 0.17 worker fatalities would be expected to occur due to off-Site activities under the CBR-Offsite-Truck scenario; and an estimated 4.1 worker injuries and 0.074 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	3.27×10^{-4}	6.3	0.14	2.1	0.048
Labor Mobilization/Demobilization	0.51	0.006	1.9	0.024	2.0	0.025
Equipment Mobilization/ Demobilization	0.0064	0.00015	0.034	0.00078	0.035	0.00079
Material Deliveries	0.026	0.00058	0.026	0.00058	0.026	0.00058
Total:	0.55	0.008	8.3	0.17	4.1	0.074

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), 1.5 worker injuries and 0.014 worker fatalities would be expected to occur under the CIP scenario; 24 worker injuries and 0.27 worker fatalities would be expected to occur under the CBR-Offsite-Truck scenario; and 17.9 worker injuries and 0.34 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 parallel with contractor mobilization and Site preparation activities, the loading terminal on the Joppa Power Plant Site and the unloading terminal at the Port of Cates Landing in Tennessee would require reconstruction and/or modification under the CBR-Offsite-Barge scenario. In addition, concurrently with closure activities under all of the evaluated scenarios, a utility-scale battery energy storage facility would be constructed on the Joppa Power Plant Site. The simultaneous pursuit of closure-related construction, terminal reconstruction/modification, and energy storage facility construction may lead to traffic congestion on Site access roads under the CBR-Offsite-Barge scenario, resulting in greater overall risks to workers than would result from any of these individual construction activities alone. Because the CIP scenario would require less hauling activity (and other forms of ingress and egress to and from the Site) than the two CBR-Offsite scenarios and would also be completed over a shorter time period, the CIP scenario would be expected to result in less congestion on Site access roads during Site redevelopment – and, hence, a smaller increase in the risks to workers – than would occur under the two CBR-Offsite scenarios.

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

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[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).

reported in Appendix B, off-Site vehicle accidents could result in an estimated 0.34 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 19 community injuries and 0.67 community fatalities. Under the CBR-Offsite-Barge scenario, off-Site vehicle accidents could result in an estimated 7 community injuries and 0.23 community fatalities.

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	18.05	0.66	6.02	0.22
Labor Mobilization/Demobilization	0.20	0.0026	0.8	0.010	0.79	0.010
Equipment Mobilization/Demobilization	0.019	0.00067	0.098	0.0036	0.101	0.0036
Material Deliveries	0.07	0.0027	0.073	0.0027	0.07	0.0027
Total:	0.34	0.007	19.0	0.67	7.0	0.23

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. Traffic could potentially cause travel delays on local roads and also cause damage to local roadways. It could also cause delays in the redevelopment of the Site for use in utility-scale battery energy storage.

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 2,230 working days (over the course of 12.9 years) and require approximately 408,000 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 once every 1.7 minutes on average for 12.9 years (on approximately 2,230 working days) under this closure scenario. Similarly, the CBR-Offsite-Barge scenario requires approximately 408,000 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 once every 1.6 minutes on average for 13.3 years (on approximately 2,280 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 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 the former scenarios is expected to be longer (10.3-15.8 years [100-152 months] under the CBR-Offsite-Truck scenario and 10.7-16.3 years [129-195 months] under the CBR-Offsite-Barge scenario) than under the latter scenario (2.2-3.5 years [26-42 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 every 1.7 minutes on average for 10 hours each day over the course of approximately 2,230 working days (12.9 years). The construction schedule for the CBR-Offsite-Barge scenario requires haul trucks to pass a given location every 1.6 minutes on average for 10 hours each day over the course of approximately 2,280 days (13.3 years). 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 (634,000 total on-Site travel miles under the CIP scenario *vs.* 2,770,000 total on-Site travel miles under the CBR-Offsite-Truck scenario *vs.* 2,840,000 total on-Site travel miles under the CBR-Offsite-Barge scenario; 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 (1,190,000 total off-Site travel miles under the CIP scenario *vs.* 52,700,000 total off-Site travel miles under the CBR-Offsite-Truck scenario *vs.* 20,100,000[2] 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 88,700 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 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.

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[2] This value only includes off-Site road miles for car and haul truck 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 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).

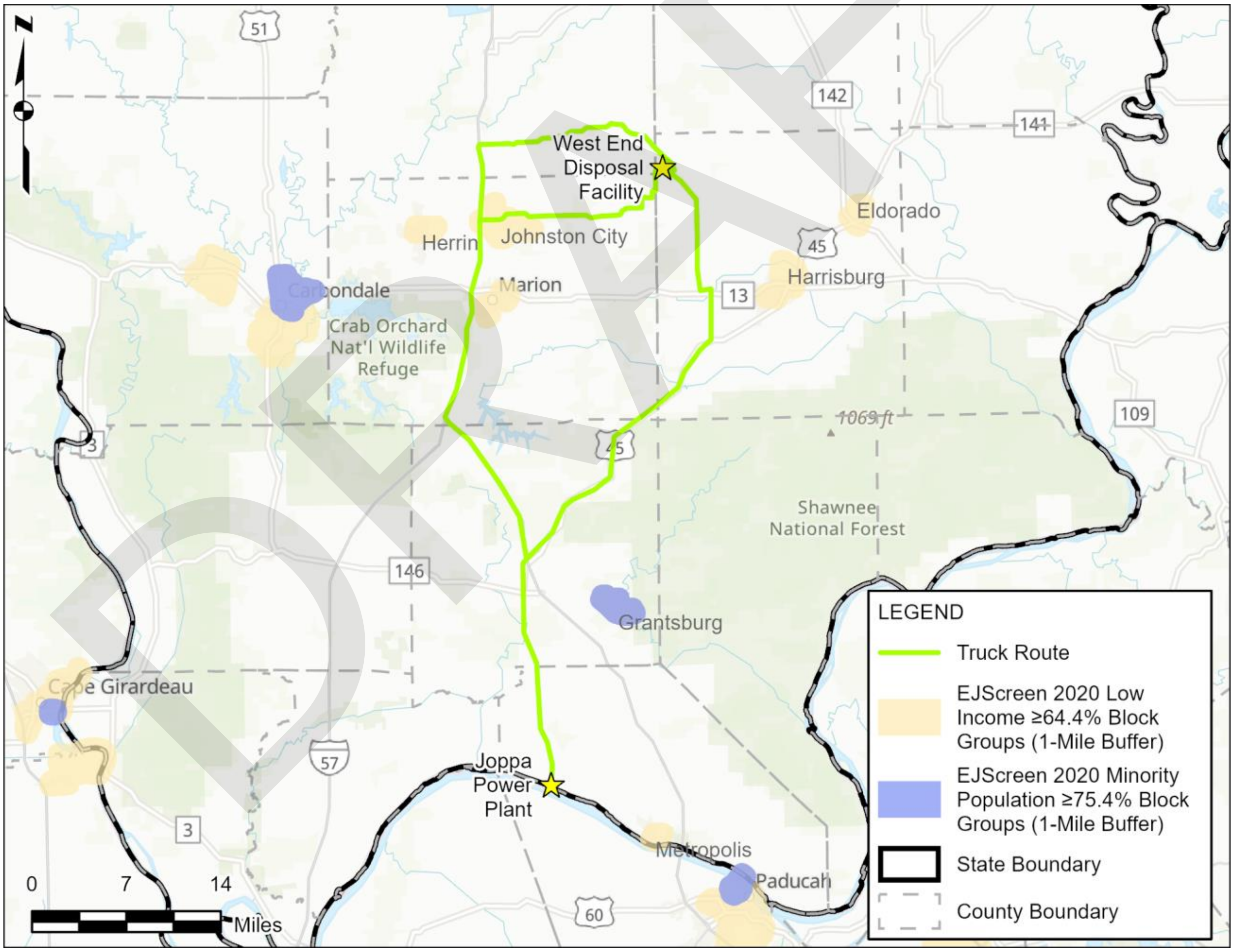

Figure 2.1 Environmental Justice Communities in the Vicinity of the Site and the Off-Site Landfill Under the Closure-by-Removal with Off-Site CCR Disposal by Trucking Scenario. Sources: IEPA (2019); US EPA (2020b); Google LLC (2022).

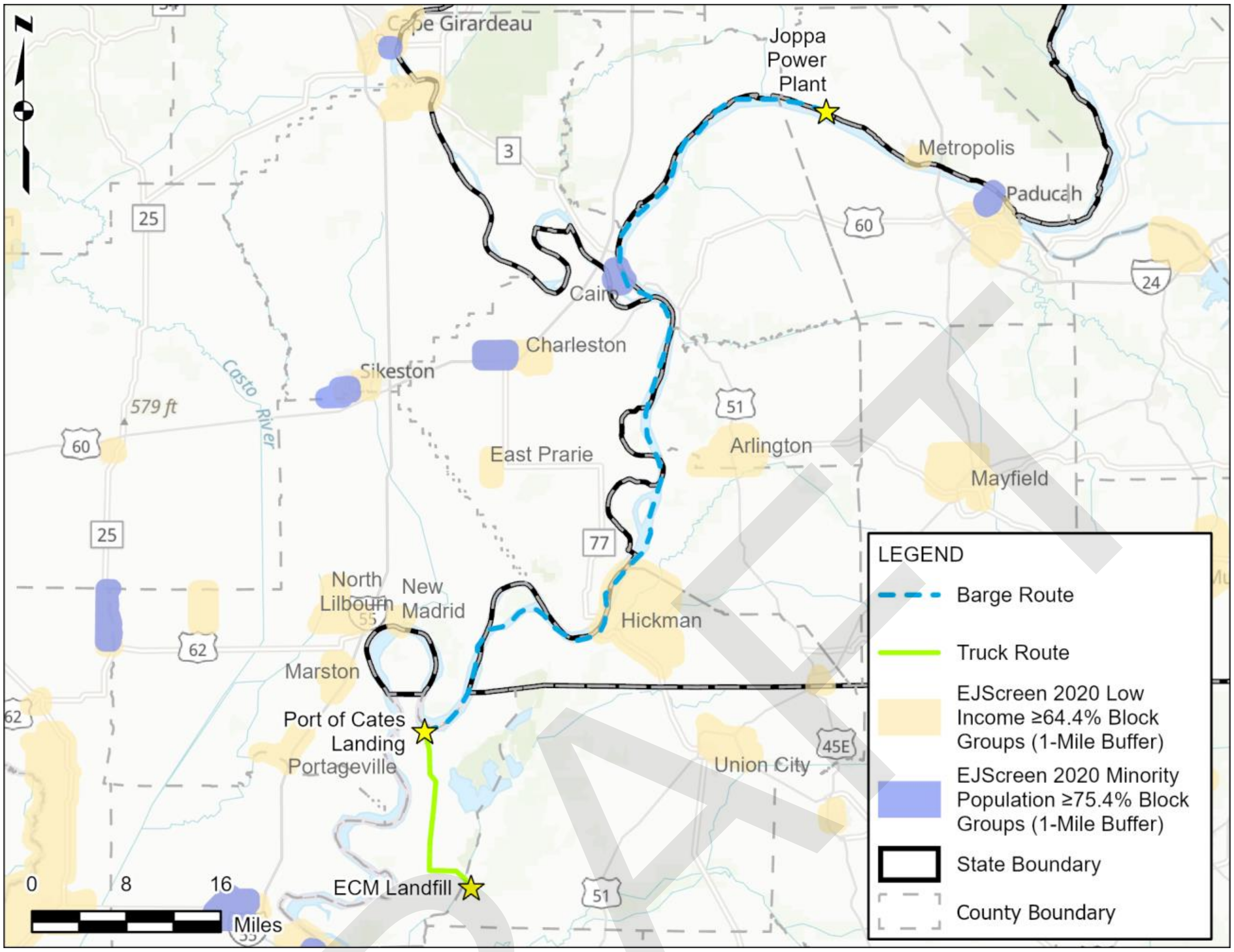

Figure 2.2 Environmental Justice Communities in the Vicinity of the Site and the Off-Site Landfill Under the Closure-by-Removal with Off-Site CCR Disposal by Barging Scenario. Sources: IEPA (2019); US EPA (2020b); Appendix B.

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 (55,500,000 total vehicle and equipment travel miles for the CBR-Offsite-Truck scenario and 23,000,000[3] total vehicle and equipment travel miles for the CBR-Offsite-Barge scenario) are greater than those required under the CIP scenario (1,820,000 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. The proposed battery storage facility at the Joppa Power Plant Site will help the state meet its goals of decarbonizing electricity generation and will improve the overall reliability of the electricity grid. In the short-term, closure activities at the Site may delay and obstruct these redevelopment efforts. The magnitude of expected delays will scale with the expected duration and intensity of construction activities during closure. Because the CIP scenario requires less construction activity than the two CBR-Offsite scenarios and would be completed over a shorter time period, the CIP scenario would be expected to result in fewer delays to the redevelopment of the Site – and, hence, the more rapid realization of grid-scale 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

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[3] This value includes both haul truck miles and barge river miles.

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.*, 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 under the former scenarios (2.2-3.5 years for the CIP scenario *vs.* 10.3-15.8 years for the CBR-Offsite-Truck scenario *vs*. 10.7-16.3 years for the CBR-Offsite-Barge scenario). 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 similar timeframes for both the CIP and CBR closure scenarios. Specifically, the modeling indicates that GWPSs will be achieved at all well locations in the UA within approximately 24 years after closure under all of the evaluated closure scenarios (Ramboll, 2022).

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. Section 3 of this report (Corrective Measures Assessment) evaluates the corrective measures being considered at the Site consistent with the requirements of IAC Section 845.660.

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.

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, 6,730,000 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 for 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 use in utility-scale battery energy storage under the CIP scenario than under the two CBR-Offsite scenarios. Redevelopment of the Site for use in energy storage would bring new jobs to the community and help the state meet its goals of decarbonizing electricity generation.

2.7 Class 4 Cost Estimate (IAC Section 845.710(d)(1))

A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with 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 use in utility-scale battery energy storage 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, less traffic-related impacts, and lower impacts to EJ communities). These conclusions are subject to change as additional data are collected and following the completion of an upcoming public meeting, which will be held in June 2022 pursuant to requirements under IAC Section 845.710(e). Following the public meeting, a final closure decision will be made based on the considerations identified in this report, the results of additional data that are collected, and any additional considerations that arise during the public meeting. The final closure recommendation will be provided in a Final Closure Plan, which will be submitted to IEPA as described under IAC Section 845.720(b) (IEPA, 2021a).

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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

May 31, 2022

GRADIENT

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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 12
      3.2.1.3 Recreational Exposures 12
    3.2.2 Ecological Conceptual Exposure Model 13
  3.3 Identification of Constituents of Interest 13
    3.3.1 Human Health Constituents of Interest 14
    3.3.2 Ecological Constituents of Interest 15
    3.3.3 Surface Water and Sediment Modeling 16
  3.4 Human Health Risk Evaluation 19
    3.4.1 Residents Using Groundwater as Drinking Water 19
    3.4.2 Residents Using Groundwater as an Irrigation Source 21
    3.4.3 Recreators Exposed to Surface Water 22
    3.4.4 Recreators Exposed to Sediment 24
  3.5 Ecological Risk Evaluation 25
    3.5.1 Ecological Receptors Exposed to Surface Water 25
    3.5.2 Ecological Receptors Exposed to Sediment 26
    3.5.3 Ecological Receptors Exposed to Bioaccumulative Constituents of Interest 27
  3.6 Uncertainties and Conservatisms 27

4 Summary and Conclusions 30

References 32

Appendix A Surface Water and Sediment Modeling
Appendix B Screening Benchmarks

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	Wells Within 1,000 meters of the EAP
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
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).

Based on the evaluation presented in this report, an unacceptable risk was identified for the potential residential use of groundwater as 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:

- 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 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 sourthern 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).

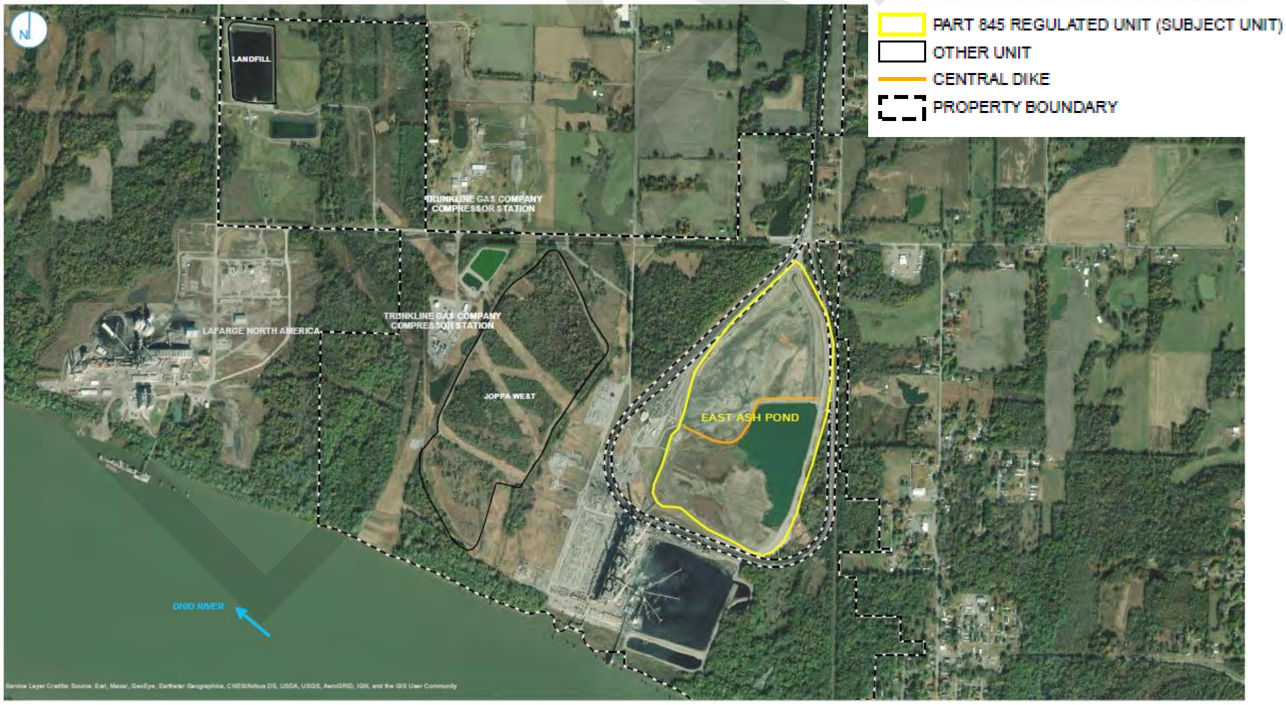

Figure 2.1 Site Location Map. Source: Ramboll (2021).

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

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[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.

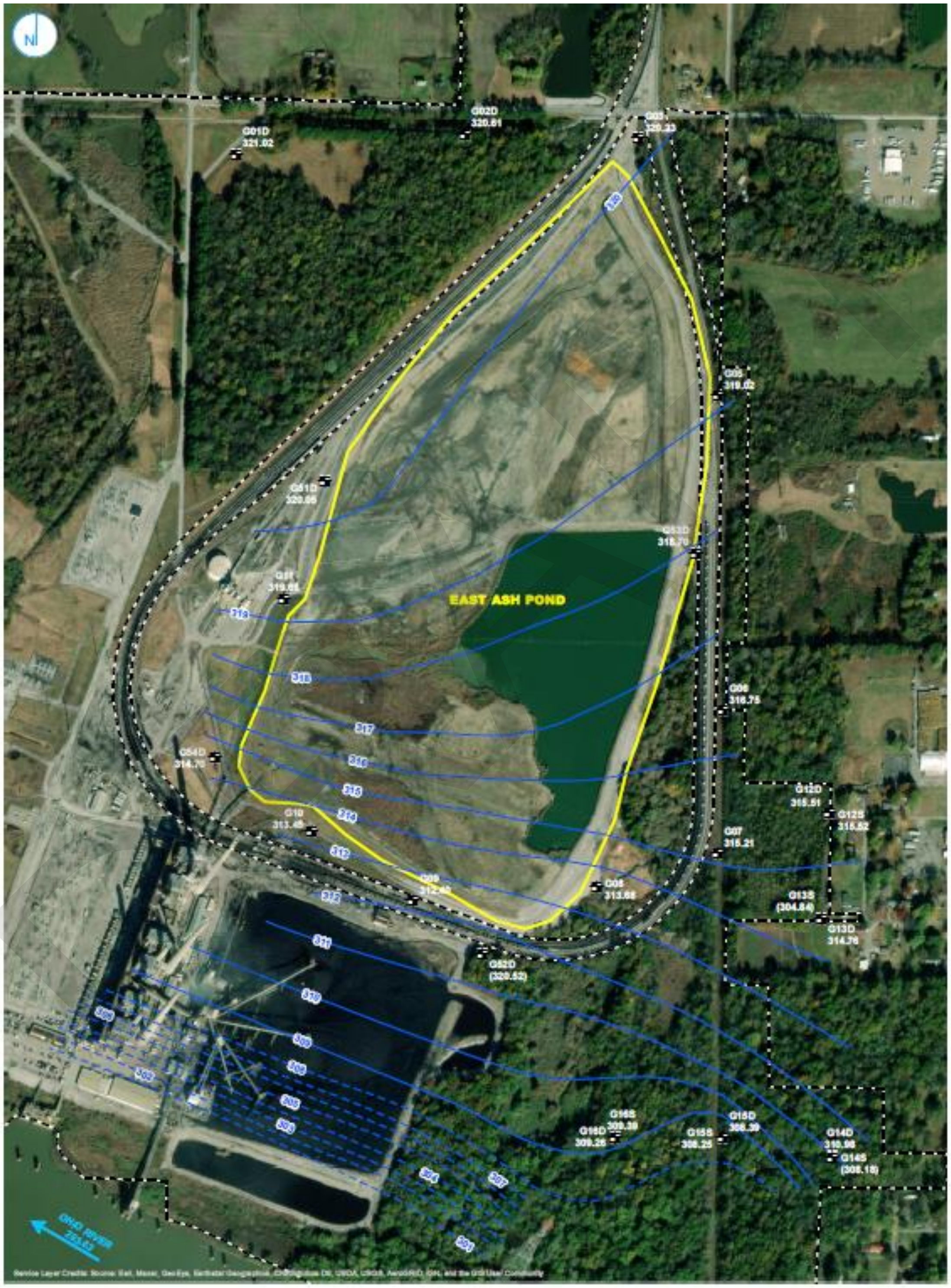

Figure 2.2 Monitoring Well Locations and Groundwater Elevation Contours for the UA.
Source: Ramboll (2022).

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, 2022).
(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, 2022).

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.

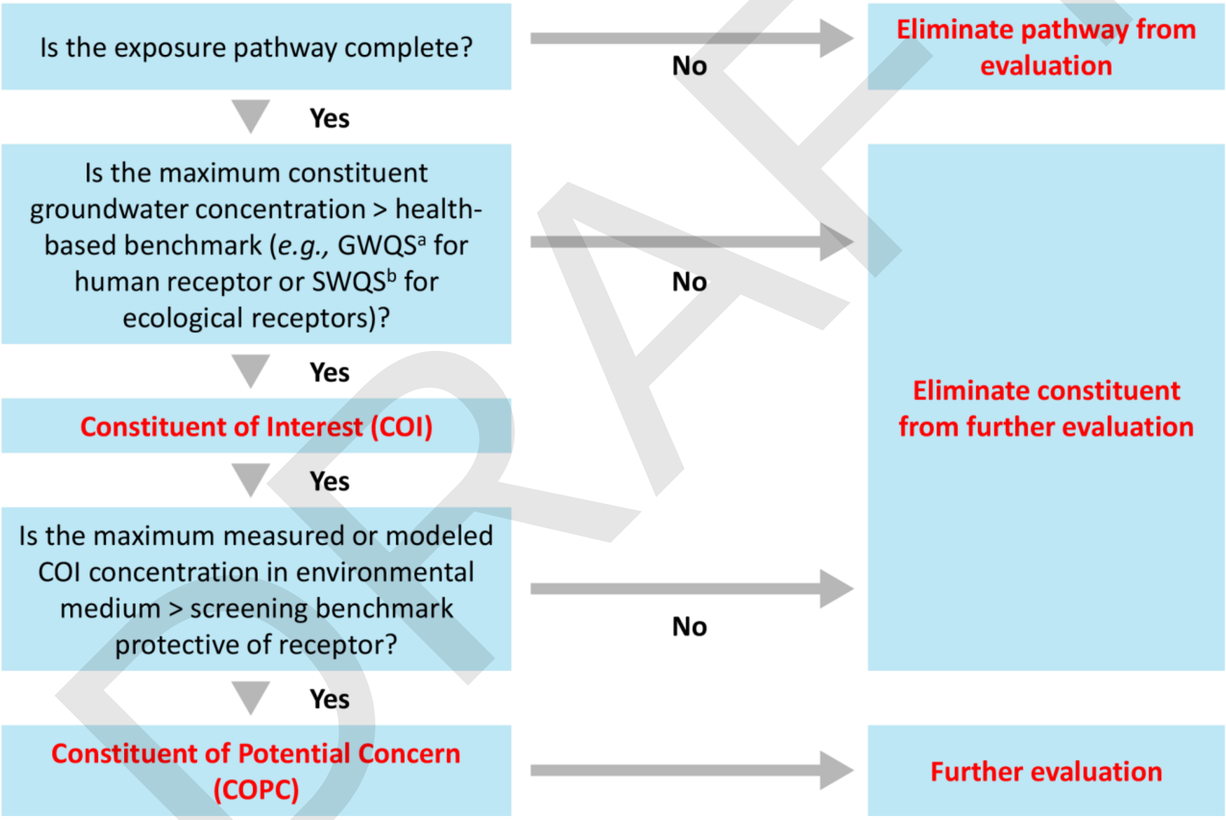

Figure 3.1 Overview of Risk Evaluation Methodology. GWQS = Groundwater Quality Standard; IEPA = Illinois Environmental Protection Agency; SWQS = Surface Water Quality Standard; US EPA = United States Environmental Protection Agency. (a) The IEPA Part 845 GWPS were used to identify COIs. (b) IEPA SWQS 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.

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[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.

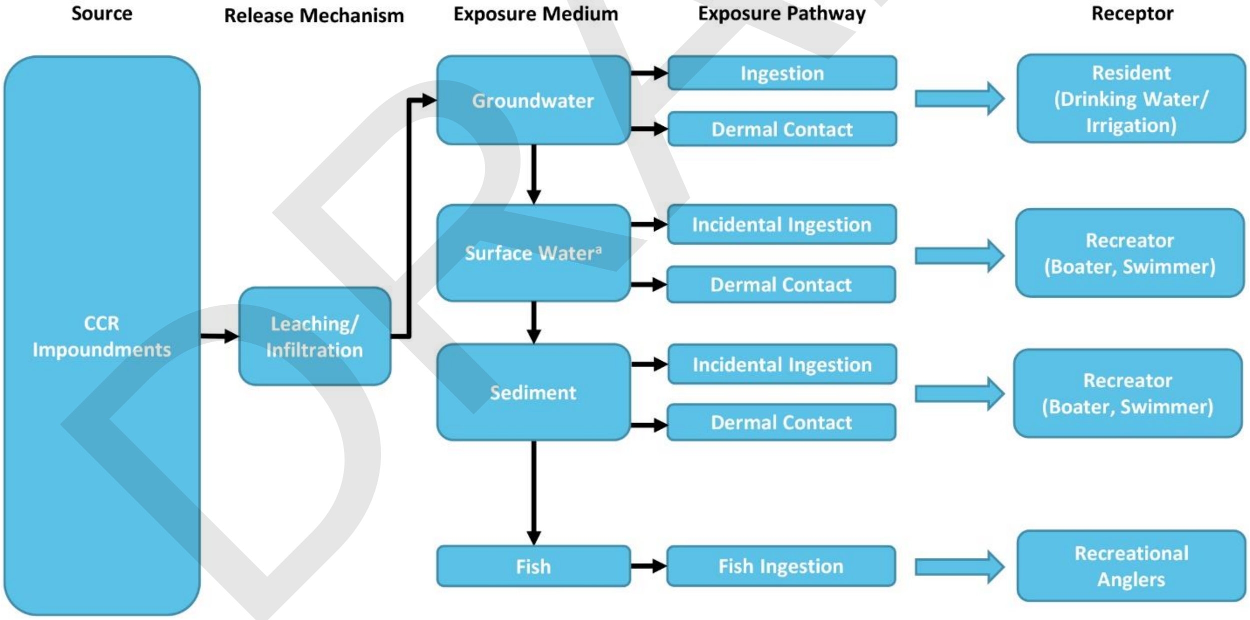

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residual. (a) Surface water is not used as a drinking water source adjacent to the Site.

3.2.1.1 Groundwater as a Drinking Water/Irrigation Source

A receptor survey was performed in 2021 to identify potential users of groundwater in the vicinity of the EAP (Ramboll, 2021). Relying on federal and state databases, Ramboll completed a potable water well survey in 2021 to assess nearby pumping wells, drinking water receptors, and other water users in the vicinity of the EAP (Ramboll, 2021). Specific sources that were used in this survey 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). An additional review of the ILWATER Map identified 17 wells within 1,000 meters of the EAP (Ramboll, 2021). Of the wells identified, six are located hydraulically downgradient of the EAP but on the JPP property (Figure 3.3). Four of the identified wells are located within the Village of Joppa, hydraulically sidegradient of the EAP (121270003100, 121270003000, 121270005100, and 121270005200; Figure 3.3). The other wells that were identified are located upgradient of the EAP (Figure 3.3).

A windshield survey (site visit) was completed in February 2022 to confirm the locations of water wells within the Village of Joppa (Ramboll, 2022). No residential groundwater wells in the Village of Joppa were identified during the windshield survey. Furthermore, during the survey, a resident mentioned that it is unlikely that there are private wells in the area (Ramboll, 2022). Based on the results of the windshield survey and the fact that the Village of Joppa is serviced by a municipal water supply, Gradient believes that it is unlikely that there are any residents in the Village of Joppa that use groundwater from the UA. 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.

A search of the US EPA SDWIS and IEPA DWW databases for drinking water intakes in the vicinity of the EAP identified one public water system (PWS) within 1,000 meters of the EAP. The Joppa PWS well (Water System ID IL1270100) was identified approximately 1,070 meters[7] to the southeast and downgradient of the EAP and provides drinking water supply for 462 residents. This PWS well is screened at a depth of 240 ft with the LAU, separated from the UA by an approximately 14-foot-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 connection between the LAU and the UA, flow would be going from the deeper unit to the shallower unit (Ramboll 2022). Finally, water quality samples collect from the PWS well over the years do not exceed Illinois drinking water standards or show any impact from coal ash-related constituents associated with the EAP (Ramboll, 2022). Thus, we have concluded that there is no plausible mechanism by which the PWS well could be impacted by any potential constituents in groundwater associated with the EAP.

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[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

[7] The coordinates of the Joppa PWS well place it inside the 1,000 meter buffer. However, the field survey found that this well is located 1,070 meters from the EAP.

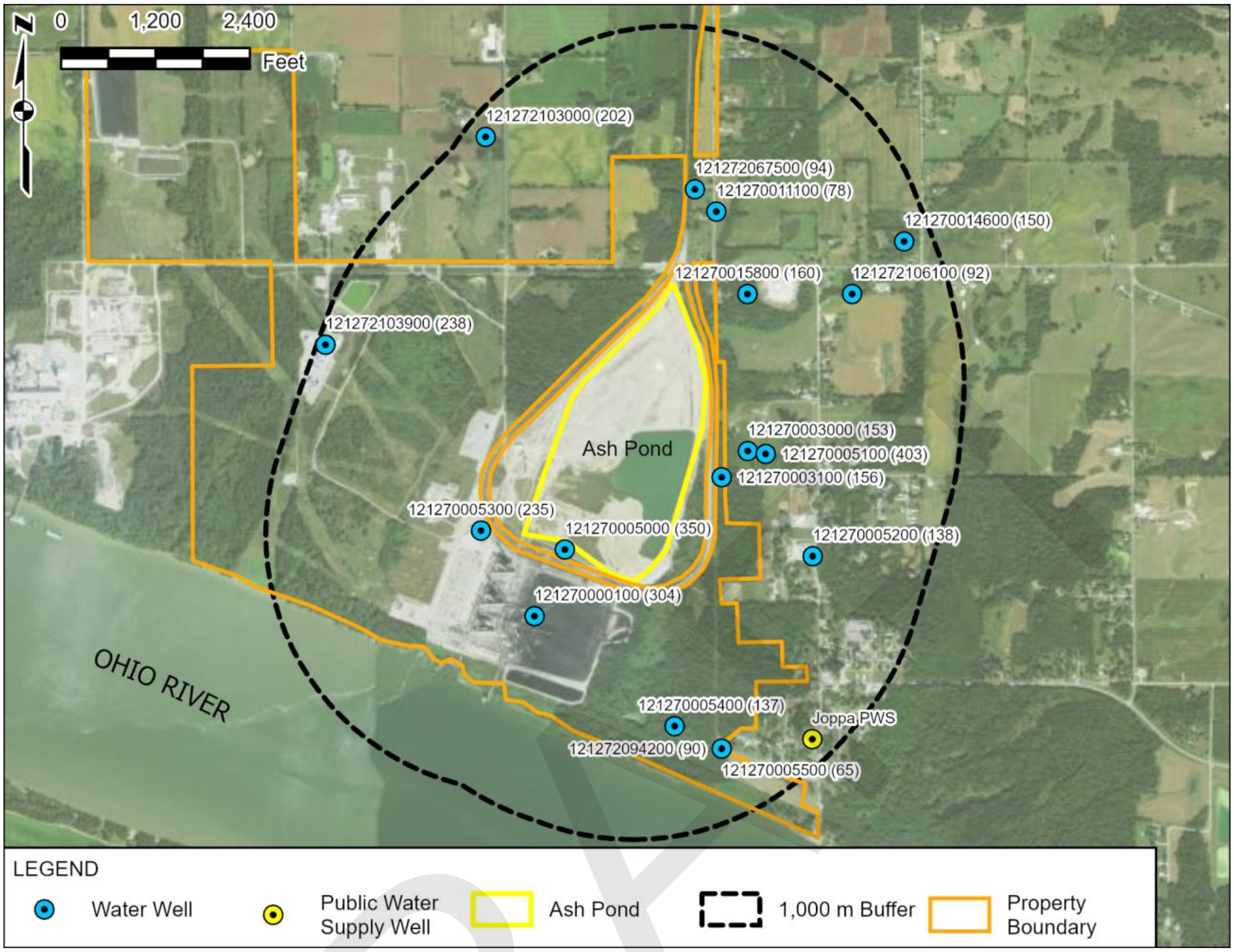

Figure 3.3 Wells Within 1,000 meters of the EAP. Source: Ramboll (2021). Value in parentheses next to the well ID is the well depth in feet.

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).

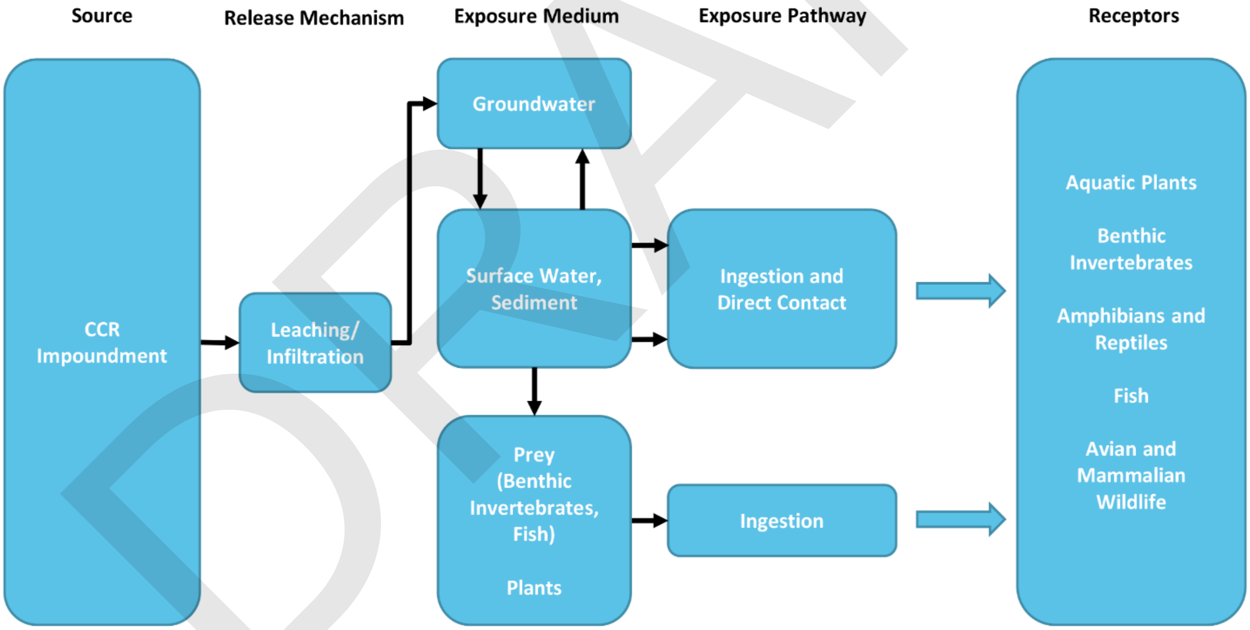

Figure 3.4 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residual.

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).[8]
- 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).

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[8] 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, 2022). 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, 2022).

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).[9]

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.

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[9] 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).[10]
- 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.

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[10] 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).[11] 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.

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[11] 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.

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:

$$\mathrm{Q} = \mathrm{K} \times \mathrm{i} \times \mathrm{A}$$

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:

$$\mathrm{m_c} = \mathrm{C_c} \times \mathrm{Q} \times \mathrm{CF}$$

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):

$$\mathrm{C_{bstot}} = \mathrm{f_{benth}} \times \mathrm{C_{wtot}} \times \frac{\mathrm{d_z}}{\mathrm{d_b}}$$

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:

$$\mathrm{C_{sed\text{-}dw}} = \frac{\mathrm{C_{bstot}}}{\mathrm{bsc}}$$

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):

$$\mathrm{C_{sb}} = \mathrm{C_{dbs}} \times \mathrm{K_{dbs}}$$

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 (mg/kg)	Non-cancer						Non-cancer Benchmark (mg/kg)
						CSF (mg/kg-day)$^{-1}$	Cancer SL (mg/kg)						RfD (mg/kg-day)	Non-cancer SL (mg/kg)					
	Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg		Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg			Fruit-exp	Veg-exp	Fruit-pro	Veg-pro	Root Veg	
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).

$$\text{Benchmark}_{produce\text{-}soil} = \frac{1}{\frac{1}{SL_{fruit}} + \frac{1}{SL_{vegetable}}}$$

$$\text{Cancer } SL_{fruit} = \frac{TR}{\text{Intake} * BCF * CSF} \qquad \text{Non-cancer } SL_{fruit} = \frac{THQ * RfD}{\text{Intake} * BCF * (100/100\text{-}W)}$$

$$\text{Cancer } SL_{vegetable} = \frac{TR}{\text{Intake} * BCF * CSF} \qquad \text{Non-cancer } SL_{vegetable} = \frac{THQ * RfD}{\text{Intake} * BCF * (100/100\text{-}W)}$$

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

		Non-cancer	Cancer		Basis
Intake =	$\frac{IR \times EF \times ED \times CF1 \times CF2 \times TAF}{BW \times AT}$ =	1.5E-03 (Child)	1.3E-04 (Child)	2.6E-04 (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

		Non-cancer	Cancer		Basis
Intake =	$\frac{IR \times EF \times ED \times CF1 \times CF2 \times TAF}{BW \times AT}$ =	1.2E-03 (Child)	1.0E-04 (Child)	2.4E-04 (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

		Non-cancer	Cancer		Basis
Intake =	$\frac{IR \times EF \times ED \times CF1 \times CF2 \times TAF}{BW \times AT}$ =	2.0E-03 (Child)	1.7E-04 (Child)	4.2E-04 (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

		Non-cancer	Cancer		Basis
Intake =	$\frac{IR \times EF \times ED \times CF1 \times CF2 \times TAF}{BW \times AT}$ =	1.2E-03 (Child)	1.0E-04 (Child)	1.8E-04 (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

		Non-cancer	Cancer		Basis
Intake = $\frac{\text{IR x EF x ED x CF1 x CF2 x TAF}}{\text{BW x AT}}$ =		5.4E-04	4.6E-05	1.8E-04	
		(Child)	(Child)	(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) SW-Fish	BAF Basis	MCL (pCi/L)	ADI (pCi/day)	Food Ingestion Slope Factor[d] (risk/pCi)	Human Threshold Criteria 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:

$$\text{HTC} = \frac{\text{ADI}}{\text{W} + (\text{F} \times \text{BCF})}$$

Incidental Consumption of Water Only:

$$\text{HTC} = \frac{\text{ADI}}{\text{W}}$$

Consumption of Fish Only:

$$\text{HTC} = \frac{\text{ADI}}{\text{F} \times \text{BCF}}$$

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:

$$\text{HTC} = \frac{\text{TCR}}{(\text{SF} \times \text{BAF} \times \text{F})}$$

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 $(mg/kg\text{-}day)^{-1}$	Dermal CSF $(mg/kg\text{-}day)^{-1}$	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)

		Non-Cancer		Cancer		
Intake Factor (IF) =	$\frac{IR \times EF \times ED \times CF}{BW \times AT}$ =	7.3E-07	6.8E-08	6.3E-08	2.0E-08	Basis
		Child	Adult	Child	Adult	
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)

		Non-Cancer		Cancer		
Intake Factor (IF) =	$\frac{SA \times AF \times EF \times ED \times CF}{BW \times AT}$ =	2.2E-06	1.2E-06	1.9E-07	3.6E-07	Basis
		Child	Adult	Child	Adult	
SA	Surface Area Exposed to Sediment (cm^2/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/cm^2)	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 B

Supporting Information for the Closure Alternatives Analysis – East Ash Pond at the Joppa Power Plant

Prepared for

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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

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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 CCR impacted areas outside the EAP, contain approximately a combined 6.1 million CY of CCR and impacted soils, 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 and associated right-of-ways (ROWs). Any lateral expansions to the landfill would require the purchase of multiple tracts of land, negotiating with the ROW holder, 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.

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 6.1 million CY of CCR within EAP and impacted soils outside 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 negotiations with the ROW holder and 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 build 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, and challenges involved with constructing over the top of a 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 by the Ohio River Scenic By-way (Portland Road), the BNSF Railway (BNSF) rail spur that surrounds the EAP and is owned by BNSF, and Joppa West.

  - This area is intersected by the plant entrance road, as well as 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 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 6.1 million CY of CCR within the EAP and impacted soils outside the EAP were evaluated for landfills within Illinois, Kentucky, Tennessee, and Missouri, due to JPP's location in southern Illinois near the borders of three 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 found 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 6.1 million CY CCR contained within 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 6.1 million CY of CCR contained in 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 6.1 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 6.1 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 6.1 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 and permitting of the terminal, and construct 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

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.

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 8 to 13 years, the frequency of trucks leaving and entering the port could be as rapid one truck leaving every 2 minutes and one truck returning every 2 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 is a viable option for disposal of CCR and impacted 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. Since the construction of loading/unloading infrastructure is not required, project delays related to coordination with other entities, design, and permitting are unlikely to occur. Therefore, transporting CCR by truck is a viable option for disposal of CCR and impacted soils within the JPP EAP and was evaluated further, as discussed in **Sections 4** and **5**, below.

Transporting CCR by truck will incur significant amounts of additional truck traffic on the public roads between the Site and the chosen 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. Much 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. 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 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, 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.

FIGURES

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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

Site Features and Closure Activities

GLP8025	**APRIL 2022**

Geosyntec consultants

FIGURE 1

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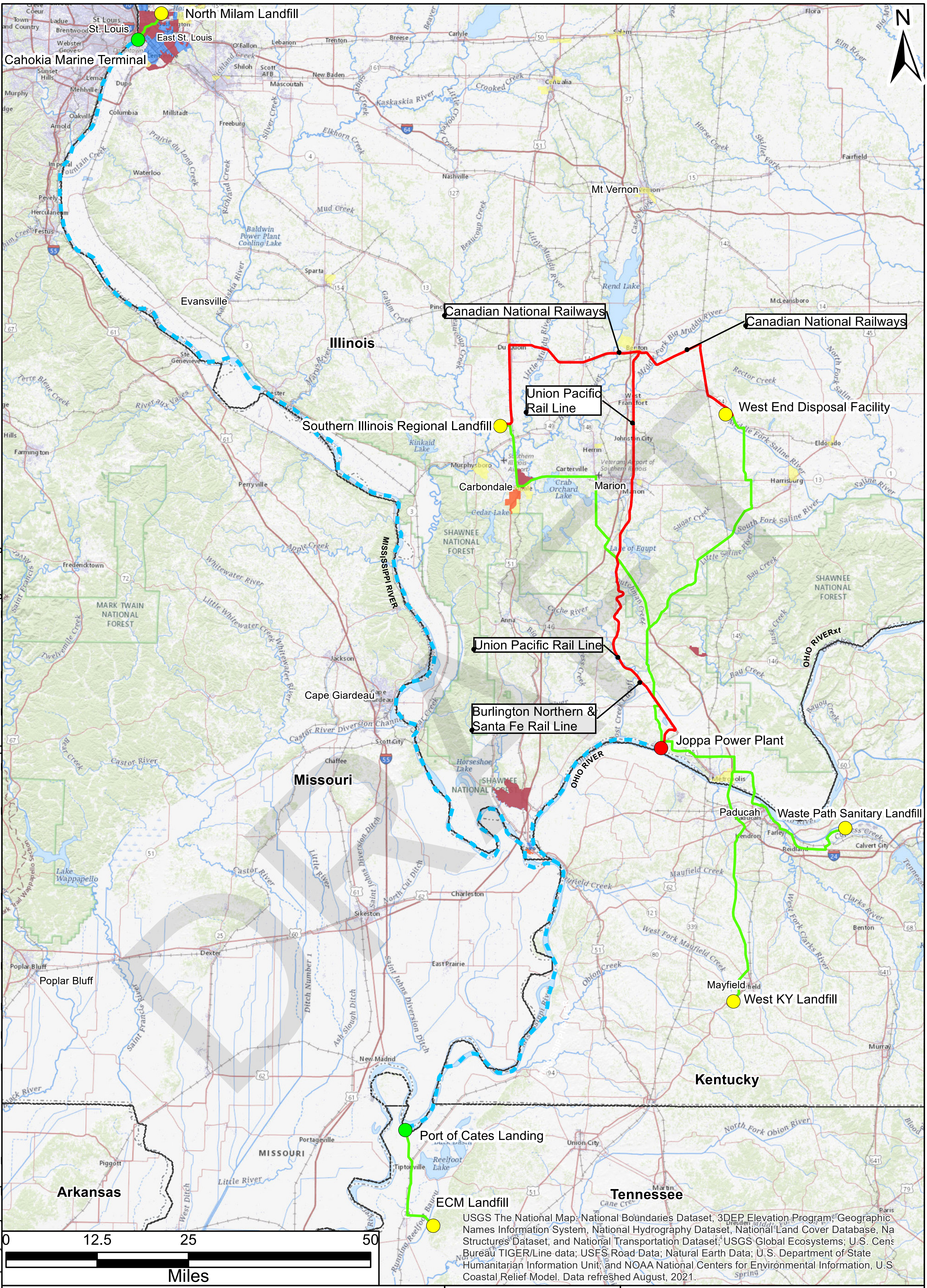

USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, Na Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Cens Bureau TIGER/Line data; USFS Road 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.

Legend

- 🟢 Exsisting Barge Terminal
- 🟡 Potential Offsite Landfill
- 🔴 Joppa Power Plant
- 🟥 Minority Population & Low Income
- 🟦 Minority Population >= 75.4%
- 🟨 Low Income >= 63.4%
- ━ Potential Rail Haul Route
- ╍ Potential Barge Haul Route
- ━ Potential Truck Haul Route

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

Geosyntec consultants

FIGURE 2

GLP8025

APRIL 2022

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TABLES

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.
	10 to 15 years after necessary permits are issued[1]

Site Restoration • Seed and stabilize the EAP. • Complete contractor demobilization.	4 to 8 months after backfill is complete
Timeframe to Complete Closure	June 2034 – July 2040 (12 to 18 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)

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.
	Sub-Items							
	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	-	-	-	-	5,554	1,853	Installation of silt fence, rock check dams, and straw wattles for temporary soil erosion and sediment control during construction.
	Sub-Items							
	Silt Fence	LF	146,880	B62	650	5,423	1,808	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Quantity assumes all silt fence is replaced four 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	32	-	-	-	-	Includes monthly rental for three office trailers, 10 storage trailers, and 8 portable toilets.
	Sub-Items							
	Office Trailer (x2)	MO - in use	32	-	-	-	-	015213200350: Office trailer, furnished, no hookups, 32' x 8', rent per month
	Storage Trailers (x5)	MO - in use	32	-	-	-	-	015213201350: Storage boxes, 40' x 8', rent per month
	Portable Toilet (x8)	MO - in use	32	-	-	-	-	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.
	Sub-Items							
	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.
	Sub-Items							
	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	315	B59	1	2,520	2,520	312323202510: Dust control, heavy; utlizing truck tractor and water tank trailer per RSMeans Crew B59. Quantity is assumed to be 3/4 of working days will need dust control. Daily Output assumed to 1, based on experience.
10	Haul Road Maintenance	DAY	84	B86A	1	672	672	312323202600: Haul road maintenance Quantity is assumed to be 1 day/week.
	SITE PREPARATION ESTIMATED SUBTOTAL					**14,500**	**9,560**	
ITEM NO.	**FREE LIQUIDS REMOVAL, UNWATERING, AND STORMWATER MANAGEMENT**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
11	Free Liquids Removal Subsurface Drainage Features	LF	5,400	-	-	4,234	3,421	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.
	Sub-Items							
	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	850	285	285	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	100	B10I	8	150	100	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 is assumes average of 2 days/week during dike construction and CCR consolidation and 1 day/week for cover construction.
	Sub-Items							
	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	242	B10K	2	1,452	968	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 is assumes average of 3 days/week.
	Sub-Items							
	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	-	-	699	633	Assume 3 are constructed throughout the construction life of project. Each assumed to be 2 acres and 5 ft deep.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	53,240	B14A	3230	198	132	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 and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	53,240	B34G	850	501	501	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
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					**7,000**	**5,300**	
ITEM NO.	**EAST ASH POND CLOSURE**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
16	Demolish and Dispose of Facilities at North End of EAP in EAP	LS	1	B14A	1.0	12	8	Crew and Daily Output based on experience.
17	Excavation and Placement of CCR + 1 ft overdig within Consolidation Area	CY - in place	1,187,600	-	-	31,638	25,023	Quantity based on surface to surface calculation performed in AutoCAD. Quantity excavated in Detention Basin Construction subtracted.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	1,253,120	B14A	3230	4,656	3,104	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 and Dumping within EAP for Moisture Conditioning	CY - as excavated	1,253,120	B34G	850	11,794	11,794	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	1,306,360	B10B	3230	4,853	3,236	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Spreading Lifts	CY - as excavated	1,306,360	B10B	3230	4,853	3,236	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	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
18	Demolish/Excavate and Dispose of DMM	CY	13,350	-	-	738	654	Demolish/Excavate DMM in southeast corner of EAP. Material to be buried in EAP.
	Sub-Items							
	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	850	151	151	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 (assume 20% fluff factor from ground to excavated).
	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	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
19	Excavation and Placement of CCR and Impacted Soils Outside of EAP	CY - in place	233,181	-	-	6,774	5,321	Quantity within rail loop based on surfaces (Top and Bottom of CCR - Southeast) developed by Geosyntec plus one foot of overdig. Quantity outside of rail loop assumed to be 5 ft thick over entire valley floor.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	256,500	B14A	3230	953	635	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 and Dumping in EAP for Moisture Conditioning	CY - as excavated	256,500	B34G	850	2,414	2,414	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	256,500	B10B	3230	953	635	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Spreading Lifts	CY - as excavated	256,500	B10B	3230	953	635	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Finish Grading Surface	SY	314,900	B10W	8900	425	283	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	233,181	B10F	2600	1,076	717	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
20	Removal and Stockpiling of Dike Riprap for Onsite Use	CY - in place	12,600	-	-	212	181	Remove existing riprap facing on EAP dikes and stockpile onsite for future use.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	12,600	B14A	3230	47	31	312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 C.Y. bucket, 95% fill factor
	Hauling of Material to Onsite Stockpile	CY - as excavated	12,600	B34G	850	119	119	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	12,600	B10B	3230	47	31	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
21	Contruct New Soil Containment Berm	CY - in place	375,700	-	-	8,802	7,164	Construct compacted soil berm along proposed alignment for the reduced EAP footprint.
	Sub-Items							
	Excavation and Loading of Material from Onsite Source	CY - as excavated	413,270	B14A	3230	1,535	1,024	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	413,270	B34G	850	3,890	3,890	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	413,270	B10B	3230	1,535	1,024	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Finish Grading Surface	SY	79,711	B10W	8900	107	72	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	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)
22	Contruct Geosynthetic Cover	SF - in place	2,834,100	-	-	1,561	260	Install geomembrane and geotextile cushion.
	Sub-Items							
	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	313219161550: Geotextile soil stabilization; non-woven 120 lb. tensile strength. Daily output edited based on experience.
23	Install Anchor Trench	LF	9,500	-	-	635	425	Install anchor trench for anchoring geosynthetics.
	Sub-Items							
	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
24	Placement of Onsite Protective Cover Soil	CY - in place	157,450	-	-	3,342	2,771	Place 18 inches of cover soil over geotextile cushion. Material assumed to come from onsite borrow/clean existing dike fill.
	Sub-Items							
	Excavation and Loading of Material from Onsite Source	CY - as excavated	173,195	B14A	3230	643	429	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	173,195	B34G	850	1,630	1,630	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	173,195	B10B	3230	643	429	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Finish Grading Surface	SY	314,900	B10W	8900	425	283	312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience.
25	Placement of Onsite Vegetative Soil	CY - in place	52,483	-	-	1,397	1,112	Place 6 inches of vegetative soil. Material assumed to come from onsite borrow.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	57,732	B14A	3230	214	143	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	57,732	B34G	850	543	543	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	57,732	B10B	3230	214	143	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Finish Grading Surface	SY	314,900	B10W	8900	425	283	312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience.
26	Reconstruct Creek Channel	CY - in place	33,800	-	-	824	666	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.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	37,180	B14A	3230	138	92	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	37,180	B34G	850	350	350	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	37,180	B10B	3230	138	92	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Finish Grading Surface	SY	31,200	B10W	8900	42	28	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	33,800	B10F	2600	156	104	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
27	Regrade Consolidated Area	CY - in place	117,000	-	-	3,011	2,355	Regrade/place fill, in consolidated area to promote drainage to creek channel.
	Sub-Items							
	Excavation and Loading of Material from Onsite Source	CY - as excavated	128,700	B14A	3230	478	319	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	128,700	B34G	986	1,044	1,044	312323206130: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 15 MPH, cycle 2000 ft
	Spreading of Material for Regrading /Drainage	CY - as excavated	128,700	B10B	3230	478	319	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Finish Grading Surface	SY	349,000	B10W	8900	471	314	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	117,000	B10F	2600	540	360	312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
	EAST ASH POND CLOSURE ESTIMATED SUBTOTAL					**#REF!**	**#REF!**	

Table 3 - Material Quantity Estimate - CIP (2 of 2)

ITEM NO.	SITE RESTORATION	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
28	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.
	Sub-Items							
	Purchasing of Material	CY	2,667	-	-	-	-	
	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
29	Install Stormwater Chute Culverts	EA	20	-	-	434	130	Install HDPE culverts to carry stormwater through dike.
	Sub-Items							
	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
30	Install Stormwater Catch Basins	EA	20	-	-	189	74	Install catch basins, or drop inlets, to collect and transmit stormwater.
	Sub-Items							
	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
31	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.
	Sub-Items							
	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.
32	Placement of Erosion Control Blankets (ECBs)	SF - in place	835,000	ECB	22500	891	297	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.
33	Straw Wattle Ditch Checks	LF - in place	17,252	A2	1000	414	138	312514160705: Sediment Log, Filter Sock, 9". Quantity assumed 3/acre (based on experience) for entire disturbed area and each being 30 ft long.
34	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.
35	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.
	Sub-Items							
	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.
36	Seed, Mulch, and Maintain Vegetated Surfaces	AC	192	-	-	2,349	2,349	Includes soil ammendments, upland seeding, and wetland planting for all disturbed areas.
	Sub-Items							
	Lime	MSF	8,350	B66	700	95	95	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader.
	Fertilizer	MSF	8,350	B66	700	95	95	329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader.
	Wetland Mix	MSF	2,020	B66	26	622	622	Daily output and crew based on experience. Quantity assumes 40% of disturbed area outside of EAP.
	Grassland Mix	MSF	4,310	B66	52	663	663	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quanity assumes entire final cover surface and 20% of disturbed areas outside of EAP. .
	Pollinator Mix	MSF	2,020	B66	26	622	622	Daily output, crew based on experience. Quantity assumes 40% of disturbed area outside of EAP.
	Mulch	MSF	8,350	B65	530	252	252	329113160350: Mulching, Hay, 1" deep, power mulcher, large
	SITE RESTORATION ESTIMATED SUBTOTAL					**5,170**	**3,710**	

ITEM NO.	ENGINEERING AND CONSTRUCTION SUPPORT TASKS	Units	Quantity	Crew	Output	Labor Hours	Equipment Hours	Notes
37	Engineering Support and CQA During Construction	LS	1	Eng	60 hrs/week	5,040	1,680	Crew and Output based on experience.
	ENGINEERING AND PERMITTING ESTIMATED SUBTOTAL					**5,040**	**1,680**	

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)

					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	5,423	1,808
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	2,520	2,520
B86A	Operator x1	8	Grader, 30,000 lbs	8	672	672
B10K	Operator x1 Laborer x0.5	12	Centr. Water Pump, 6"	8	1,512	1,008
B14A	Operator x1 Laborer x0.5	12	Hyd. Excavator, 4.5 C.Y.	8	8,875	5,916
1 Clab	Laborer x1	8	None	0	Not Used	Not Used
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	15,136	10,090
B12F	Operator (crane) x 1 Laborer x 1	16	Hyd. Excavator, 0.75 C.Y.	8	74	37
B6	Laborer x 2 Operator (light) x 1	24	Backhoe Loader, 48 H.P.	8	Not Used	Not Used
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	534	178
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	2,097	2,097
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	252	252
A1F	Laborer x 1	8	Rammer/Tamper, Gas, 8"	8	49	49
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	22,721	22,721
ECB	Laborer x3	24	Tractor	8	957	319
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	5,040	1,680
B10F	Operator (med) x1 Laborer x0.5	12	Tandem Roller, 10, Ton	8	9,155	6,103
B10I	Operator (med) x1 Laborer x0.5	12	Diaphragm Water Pump, 4"	8	150	100
B34C	Truck Driver (heavy) x 1	8	Truck Tractor, 6x4, 380 H.P. x 1 Dump Trailer, 16.5 CY x 1	8	4,272	4,272
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	1,894	1,263
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**	90,500	65,700

Table 4 - Labor, Equipment, and Mileage Estimate - CIP (2 of 2)

Item	Quantity	Assumptions
Labor Total Hours	90,600	Per projected subtotal in cost estimate (Does not include contingency)
Duration of Onsite Construction in Days	420	Per Construction Schedule
Average Daily Crew Size	28	10 hour days (5 days per week)
Daily Labor Mobilization Miles	823,200	Average of 70 miles round trip per day
Vehicles Miles Onsite	19,866	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	25,200	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	25,200	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Daily Equipment Miles Onsite	543,480	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	35,763	34 CY Off Road Dump Truck 1 mile round trip per load
Onsite Haul Truck Miles - Loaded	35,763	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)

QUANTITY, LABOR, AND EQUIPMENT HOURS ESTIMATE
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CLOSURE-BY-REMOVAL OF EAST ASH POND - TRANSPORTATION WITH BARGES AND TRUCKS

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.
	Sub-Items							
	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	-	-	-	-	26,845	8,950	Installation of silt fence, rock check dams, and straw wattles for temporary soil erosion and sediment control during construction.
	Sub-Items							
	Silt Fence	LF	723,520	B62	650	26,715	8,905	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Quantity assumes all silt fence is replaced four 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 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	160	-	-	-	-	Includes monthly rental of three office trailers, 10 storage trailers, and 8 portable toilets.
	Sub-Items							
	Office Trailer (x3)	MO - in use	160	-	-	-	-	015213200350: Office trailer, furnished, no hookups, 32' x 8', rent per month
	Storage Trailers (x10)	MO - in use	160	-	-	-	-	015213201350: Storage boxes, 40' x 8', rent per month
	Portable Toilet (x8)	MO - in use	160	-	-	-	-	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.
	Sub-Items							
	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	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	-	-	2,829	1,834	Construction of a new access road to the west of the rail spur from Portland Rd. to the SE Area.
	Sub-Items							
	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	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	1,710	B59	1	13,680	13,680	312323202510: Dust control, heavy; utlizing truck tractor and water tank trailer per RSMeans Crew B59. Quantity is assumed to be 3/4 of working days will need dust control. Daily Output assumed to 1, based on experience.
10	Haul Road Maintenance	DAY	456	B86A	1	3,648	3,648	312323202600: Haul road maintenance Quantity is assumed to be 1 day/week.
	SITE PREPARATION ESTIMATED SUBTOTAL					**51,260**	**31,100**	
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	#REF!	B10K	4	4,104	2,739	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 is assumes average of 3 days/week.
	Sub-Items							
	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	-	-	1,398	1,266	Assume 6 are constructed throughout the construction life of project. Each assumed to be 2 acres and 5 ft deep.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	106,480	B14A	3230	396	264	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 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					**6,700**	**4,600**	
ITEM NO.	**EAST ASH POND CLOSURE**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
14	Demolish and Dispose of Facilities at North End of EAP in Receiving Landfill	LS	1	B14A	1.0	12	8	Crew and Daily Output based on experience.
15	Excavation of CCR + 1 ft overdig within EAP Boundaries	CY - in place	5,869,600	-	-	968,914	851,746	Quantity based on surface to surface calculation performed in AutoCAD. Quantity excavated in Detention Basin Construction subtracted.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	6,350,080	B14A	3230	23,592	15,728	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 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	6,456,560	B10B	3230	99,947	15,991	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	1,936,968	B45	1888	16,415	8,207	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	2,700	Barge	5130	194,399	194,399	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. Assumes 45 barges (four sets of nine barges).
	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 Tipping Total Volume	TON	7,427,286	-	-	-	-	
16	Excavation of CCR and Impacted Soils Outside of EAP	CY - in place	233,181	-	-	38,459	33,800	Quantity within rail loop based on surfaces (Top and Bottom of CCR - Southeast) developed by Geosyntec plus one foot of overdig. Quantity outside of rail loop assumed to be 5 ft thick over entire valley floor.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	256,500	B14A	3230	953	635	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 and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	256,500	B34G	850	2,414	2,414	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	256,500	B10B	3230	3,971	635	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	76,950	B45	1888	652	326	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	256,500	B14K	5130	600	400	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	107	Barge	5130	7,704	7,704	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. Assumes 45 barges (four sets of nine barges).
	Unloading Material from Barge onto Trucks	CY - as excavated	256,500	B14C	5510	559	372	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	128,250	B10L	5510	279	186	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	256,500	B14K	5130	600	400	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	256,500	B34C	99	20,727	20,727	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 Tipping Fee	TON	294,333	-	-	-	-	
17	Removal and Stockpiling of Dike Riprap for Onsite Use	CY - in place	38,300	-	-	2,418	762	Remove existing riprap facing on EAP dikes and stockpile onsite for future use.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	38,300	B14A	3230	142	95	312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 C.Y. bucket, 95% 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
18	Movement of Dike Fill for Regrading/Drainage	CY - in place	331,700	-	-	13,648	7,102	Excavation of clean dike fill and placement of fill in CBR EAP to promote drainage towards the creek channel/Ohio River.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	364,870	B14A	3230	1,356	904	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	3230	5,648	904	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)
19	Reconstruct Creek Channel	CY - in place	47,850	-	-	1,799	939	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.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	52,635	B14A	3230	196	130	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	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	3230	815	130	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					**1,025,250**	**894,360**	
ITEM NO.	**SITE RESTORATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
20	Placement of Erosion Control Blankets (ECBs)	SF - in place	840,800	ECB	22500	897	299	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.
21	Straw Wattle Ditch Checks	LF - in place	17,372	A2	1000	417	139	312514160705: Sediment Log, Filter Sock, 9". Quantity assumed 3/acre (based on experience) for entire disturbed area and each being 30 ft long.
22	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.
23	Place Rip Rap and Geotextile Along Creek Channel and Around Culvert Entry/Exit.	CY - in place	19,150	-	-	742	381	Quantity assumes half of rip rap excavated from dike face is used.
	Sub-Items							
	Loading of Stockpiled Material	CY - as excavated	19,150	B14A	3230	71	47	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	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.
24	Seed, Mulch, and Maintain Vegetated Surfaces	AC	193	-	-	2,774	2,774	Includes soil ammendments, upland seeding, and wetland planting for all disturbed areas.
	Sub-Items							
	Lime	MSF	8,408	B66	700	96	96	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader.
	Fertilizer	MSF	8,408	B66	700	96	96	329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader.
	Wetland Mix	MSF	3,363	B66	26	1,035	1,035	Daily output and crew based on experience. Quantity assumes 40% of disturbed area outside of EAP.
	Grassland Mix	MSF	1,682	B66	52	259	259	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quanity assumes entire final cover surface and 20% of disturbed areas outside of EAP. .
	Pollinator Mix	MSF	3,363	B66	26	1,035	1,035	Daily output and crew based on experience. Quantity assumes 40% of disturbed area outside of EAP.
	Mulch	MSF	8,408	B65	530	254	254	329113160350: Mulching, Hay, 1" deep, power mulcher, large
	SITE RESTORATION ESTIMATED SUBTOTAL					**4,920**	**3,620**	
ITEM NO.	**ENGINEERING AND CONSTRUCTION SUPPORT TASKS**	**Units**	**Quantity**	**Crew**	**Output**	**Labor Hours**	**Equipment Hours**	**Notes**
25	Engineering Support and CQA During Construction	LS	1	Eng	60 hrs/week	27,360	9,120	Crew and and Output based on experience.
	ENGINEERING AND CONSTRUCTION SUPPORT ESTIMATED SUBTOTAL					**27,360**	**9,120**	

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)

					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	26,715	8,905
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	13,680	13,680
B86A	Operator x1	8	Grader, 30,000 lbs	8	3,648	3,648
B10K	Operator x1 Laborer x0.5	12	Centr. Water Pump, 6"	8	4,104	2,736
B14A	Operator x1 Laborer x0.5	12	Hyd. Excavator, 4.5 C.Y.	8	26,717	17,811
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	113,598	18,176
Barge	Tug Captain x 1 Mates, Engineers, & Seamen x 5	72	Diesel Tugboat, 6,000 HP	12	202,103	202,103
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	7,327	4,885
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	537	179
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	2,521	2,521
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	254	254
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	67,652	67,652
ECB	Laborer x3	24	Tractor	8	983	328
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	27,360	9,120
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	15,741	10,494
B34C	Truck Driver (heavy) x 1	8	Truck Tractor, 6x4, 380 H.P. x 1 Dump Trailer, 16.5 CY x 1	8	545,561	545,561
B14C	Operator (crane) x 1 Laborer x 0.5	12	Hyd. Excavator, 7 C.Y.	8	14,655	9,770
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	17,067	8,534
Note: Blue crew names were created by Geosyntec based on experience (not pulled from RSMeans).				**Totals**	1,099,700	932,300

Table 6 - Labor, Equipment, and Mileage Estimate
CBR-Offsite-Barge Transportation
(2 of 2)

Item	Quantity	Assumptions
Labor Total Hours	1,115,500	Per projected subtotal in cost estimate (Does not include contingency)
Duration of Onsite Construction in Days	2,280	Per Construction Schedule
Average Daily Crew Size	20	10 hour days (5 days per week)
Daily Labor Mobilization Miles	3,192,000	Average of 70 miles round trip per day
Vehicles Miles Onsite	87,780	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	136,800	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	136,800	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Daily Equipment Miles Onsite	2,539,920	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	104,140	34 CY Off Road Dump Truck 1 mile round trip per load
Onsite Haul Truck Miles - Loaded	104,140	34 CY Off Road Dump Truck 1 mile round trip per load
Tugboat Miles on River - Unloaded	44,340	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	44,340	9 barges per trip 162 mile cycle (increased by 2.5% to account for maneuvering, rearranging, etc. at docks)
Offsite Haul Truck Miles - Unloaded	8,188,048	16.5 CY Dump Truck 40 mi cycle for exported CCR
Offsite Haul Truck Miles - Loaded	8,188,048	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)

QUANTITY, LABOR, AND EQUIPMENT HOURS ESTIMATE
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CLOSURE-BY-REMOVAL OF EAST ASH POND WITH TRUCKS

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.
	Sub-Items							
	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	-	-	-	-	26,845	8,950	Installation of silt fence, rock check dams, and straw wattles for temporary soil erosion and sediment control during construction.
	Sub-Items							
	Silt Fence	LF	723,520	B62	650	26,715	8,905	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Quantity assumes all silt fence is replaced four 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	32	-	-	-	-	Includes monthly rental for three office trailers, 10 storage trailers, and 8 portable toilets.
	Sub-Items							
	Office Trailer (x3)	MO - in use	160	-	-	-	-	015213200350: Office trailer, furnished, no hookups, 32' x 8', rent per month
	Storage Trailers (x10)	MO - in use	160	-	-	-	-	015213201350: Storage boxes, 40' x 8', per month.
	Portable Toilet (x8)	MO - in use	160	-	-	-	-	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.
	Sub-Items							
	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	-	-	2,829	1,834	Construction of a new access road to the west of the rail spur from Portland Rd. to the SE Area.
	Sub-Items							
	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	1,710	B59	1	13,680	13,680	312323202510: Dust control, heavy; utlizing truck tractor and water tank trailer per RSMeans Crew B59. Quantity is assumed to be 3/4 of working days will need dust control. Daily Output assumed to 1, based on experience.
10	Haul Road Maintenance	DAY	456	B86A	1	3,648	3,648	312323202600: Haul road maintenance Quantity is assumed to be 1 day/week.
	SITE PREPARATION ESTIMATED SUBTOTAL					**51,260**	**31,100**	
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	1,368	B10K	4	4,104	2,736	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 is assumes average of 3 days/week.
	Sub-Items							
	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	-	-	1,398	1,266	Assume 6 are constructed throughout the construction life of project. Each assumed to be 2 acres and 5 ft deep.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	106,480	B14A	3230	396	264	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 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					**6,700**	**4,600**	
ITEM NO.	**EAST ASH POND CLOSURE**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
14	Relocation of Power Lines	LS	4					Price to be per provided by client.
15	Demolish and Dispose of Facilities at North End of EAP in Receiving Landfill	LS	1	B14A	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	-	-	1,237,094	1,207,980	Quantity based on surface to surface calculation performed in AutoCAD. Quantity excavated in Detention Basin Construction subtracted.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	6,350,080	B14A	3230	23,592	15,728	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 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	6,456,560	B10B	3230	23,987	15,991	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	1,936,968	B45	1888	16,415	8,207	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 Tipping Quantity	TON	7,427,286	-	-	-	-	
17	Excavation of CCR and Impacted Soils Outside of EAP	CY - in place	233,181	-	-	49,079	47,918	Quantity within rail loop based on surfaces (Top and Bottom of CCR - Southeast) developed by Geosyntec plus one foot of overdig. Quantity outside of rail loop assumed to be 5 ft thick over entire valley floor.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	256,500	B14A	3230	953	635	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 and Dumping Onsite of Material for Moisture Conditioning	CY - as excavated	256,500	B34G	850	2,414	2,414	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	256,500	B10B	3230	953	635	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	76,950	B45	1888	652	326	312323239000: Water, 3000 gal. truck, 3 mile haul. Assume 30% of volume will need to be wetted.
	Loading of Material	CY - as excavated	256,500	B14K	5130	600	400	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	256,500	B34C	47	43,507	43,507	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 Tipping Fee	TON	294,333	-	-	-	-	Price per West End Disposal Facility located in Thompsonville IL (cannot have dust).
18	Removal and Stockpiling of Dike Riprap for Onsite Use	CY - in place	38,300	-	-	962	762	Remove existing riprap facing on EAP dikes and stockpile onsite for future use.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	38,300	B14A	3230	142	95	312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 C.Y. bucket, 95% 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	-	-	9,355	7,102	Excavation of clean dike fill and placement of fill in CBR EAP to promote drainage towards the creek channel/Ohio River.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	364,870	B14A	3230	1,356	904	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	3230	1,356	904	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	-	-	1,180	939	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.
	Sub-Items							
	Excavation and Loading of Material	CY - as excavated	52,635	B14A	3230	196	130	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	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	3230	196	130	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					**1,297,670**	**1,264,700**	
ITEM NO.	**SITE RESTORATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
21	Placement of Erosion Control Blankets (ECBs)	SF - in place	840,800	ECB	22500	897	299	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.
22	Straw Wattle Ditch Checks	LF - in place	17,372	A2	1000	417	139	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	-	-	742	381	Quantity assumes half of rip rap excavated from dike face is used.
	Sub-Items							
	Loading of Stockpiled Material	CY - as excavated	19,150	B14A	3230	71	47	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	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	193	-	-	2,774	2,774	Includes soil ammendments, upland seeding, and wetland planting for all disturbed areas.
	Sub-Items							
	Lime	MSF	8,408	B66	700	96	96	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader.
	Fertilizer	MSF	8,408	B66	700	96	96	329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader.
	Wetland Mix	MSF	3,363	B66	26	1,035	1,035	Daily output and crew based on experience. Quantity assumes 40% of disturbed area outside of EAP.
	Grassland Mix	MSF	1,682	B66	52	259	259	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quanity assumes entire final cover surface and 20% of disturbed areas outside of EAP. .
	Pollinator Mix	MSF	3,363	B66	26	1,035	1,035	Daily output and crew based on experience. Quantity assumes 40% of disturbed area outside of EAP.
	Mulch	MSF	8,408	B65	530	254	254	329113160350: Mulching, Hay, 1" deep, power mulcher, large
	SITE RESTORATION ESTIMATED SUBTOTAL					**4,920**	**3,620**	
ITEM NO.	**ENGINEERING AND CONSTRUCTION SUPPORT TASKS**	**Units**	**Quantity**	**Crew**	**Output**	**Labor Hours**	**Equipment Hours**	**Notes**
26	Final Closure Design and Bid Support	LS	1	-	-	-	-	
27	Engineering Support and CQA During Construction	LS	1	Eng	60 hrs/week	26,760	8,920	Crew and Output based on experience.
	ENGINEERING AND PERMITTING ESTIMATED SUBTOTAL					**26,760**	**8,920**	

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 (1 of 2)

					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	25,911	8,637
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	13,380	13,380
B86A	Operator x1	8	Grader, 30,000 lbs	8	3,568	3,568
B10K	Operator x1 Laborer x0.5	12	Centr. Water Pump, 6"	8	4,014	2,676
B14A	Operator x1 Laborer x0.5	12	Hyd. Excavator, 4.5 C.Y.	8	26,717	17,811
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	27,264	18,176
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	537	179
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	1,486	1,486
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	254	254
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	Not Used	Not Used
B34G	Truck Driver x1	8	Dump Truck, Off Hwy., 50 ton	8	67,652	67,652
ECB	Laborer x3	24	Tractor	8	983	328
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	26,760	8,920
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	15,741	10,494
B34C	Truck Driver (heavy) x 1	8	Truck Tractor, 6x4, 380 H.P. x 1 Dump Trailer, 16.5 CY x 1	8	1,143,165	1,143,165
B14B	Operator (crane) x 1 Laborer x 0.5	12	Hyd. Excavator, 6 C.Y.	8	Not Used	Not Used
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	17,067	8,534
Note: Blue crew names were created by Geosyntec based on experience (not pulled from RSMeans).				**Totals**	1,383,700	1,310,900

Table 8 - Labor, Equipment, and Mileage Estimate - CBR-Offsite-Truck (2 of

Item	Quantity	Assumptions
Labor Total Hours	1,385,000	Per projected subtotal in cost estimate (Does not include contingency)
Duration of Onsite Construction in Days	2,230	Per Construction Schedule
Average Daily Crew Size	20	10 hour days (5 days per week)
Daily Labor Mobilization Miles	3,122,000	Average of 70 miles round trip per day
Vehicles Miles Onsite	85,855	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	133,800	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	133,800	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Daily Equipment Miles Onsite	2,484,220	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	104,140	34 CY Off Road Dump Truck 1 mile round trip per load
Onsite Haul Truck Miles - Loaded	104,140	34 CY Off Road Dump Truck 1 mile round trip per load
Offsite Haul Truck Miles - Unloaded	24,564,144	16.5 CY Dump Truck 120 mi cycle for exported CCR
Offsite Haul Truck Miles - Loaded	24,564,144	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

ATTACHMENT B

Corrective Measures Assessment

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
May 27, 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-foot 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 (*i.e.*, 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 EAP and CCRs located in an approximately 32-acre area outside of the EAP would be consolidated into one approximately 74-acre area area, then capped with a geomembrane and soil final cover system. 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 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. To date, municipal or private groundwater wells which extract groundwater from the UAU and thus have the potential to be impacted have not 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 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. To date, municipal or private groundwater wells which extract groundwater from the UAU and thus have the potential to be impacted have not 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 the primary source (CCR) has been capped and dewatered. 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.

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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

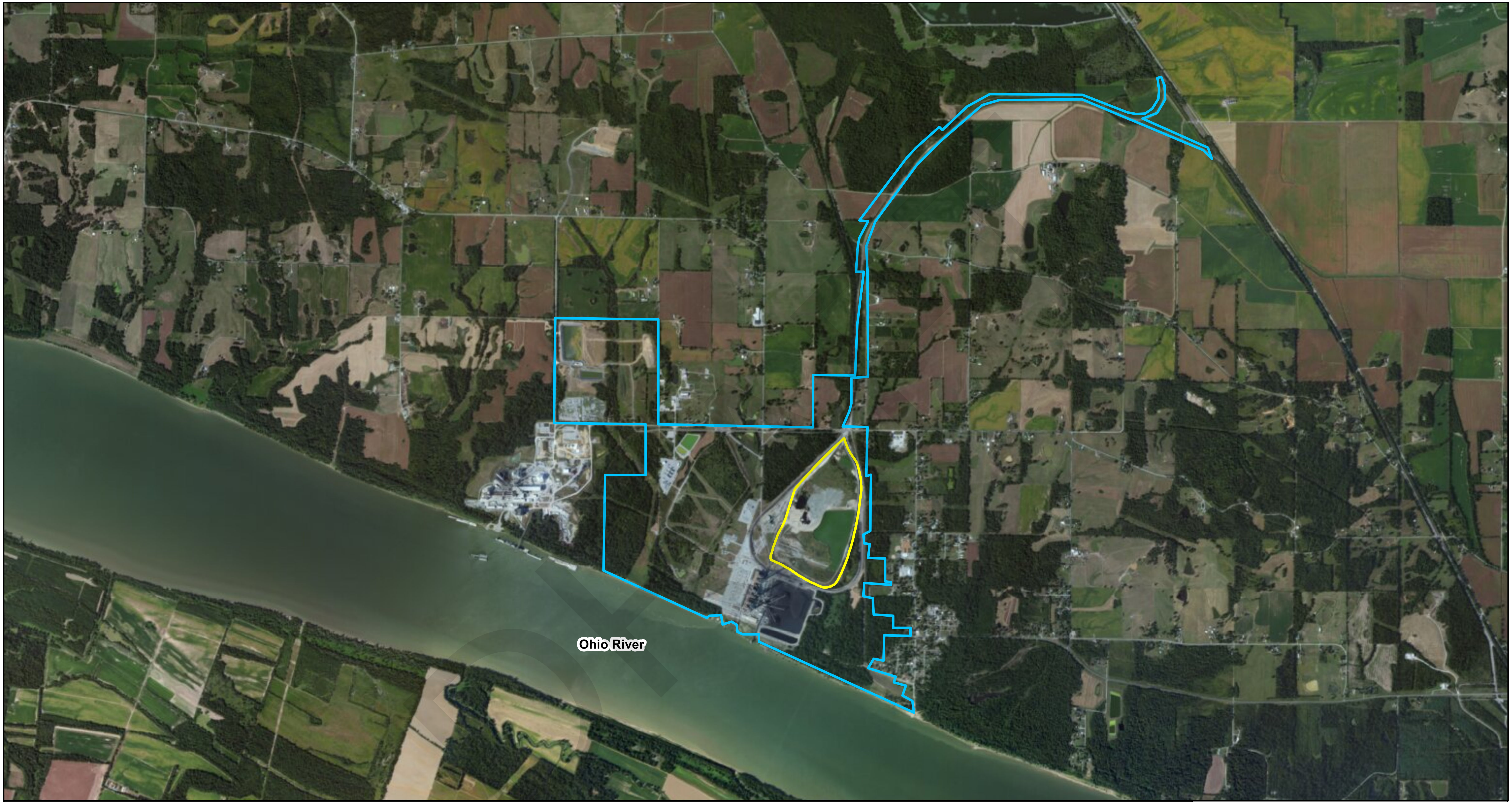
Evaluation Factor (Report Section; Part 845 Section)	**Corrective Measures Alternative**					
	MNA	**GE**	**GCT**	**CW**	**PRB**	**WT**
Reliability - Potential Need for Replacement of the Corrective Measure (Section 2.2.5; IAC Section 845.660(c)(1))	Without the installation, operation, and maintenance 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



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

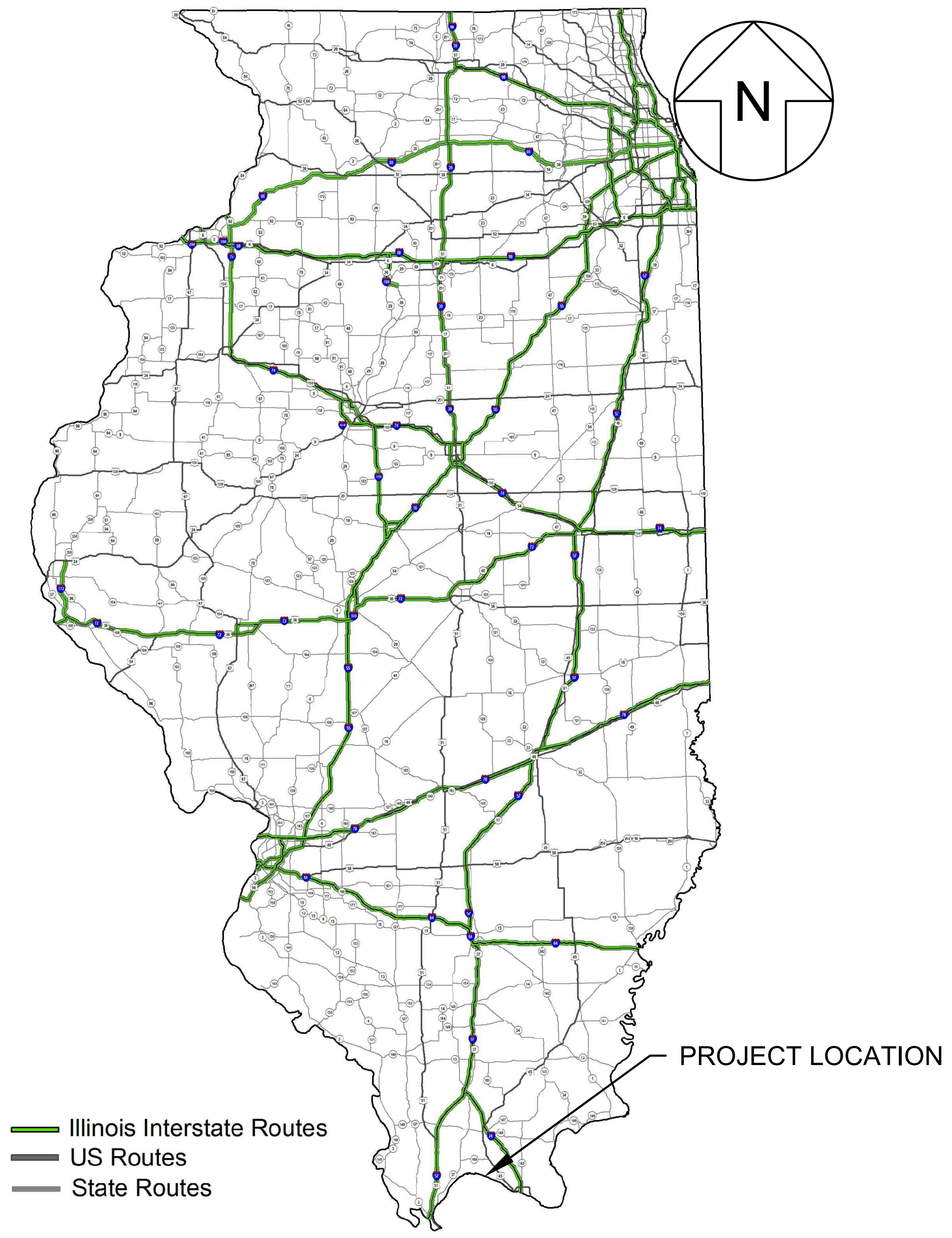
Figure 1

\\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

ATTACHMENT C

Final Closure Plan Drawings and Material Specifications

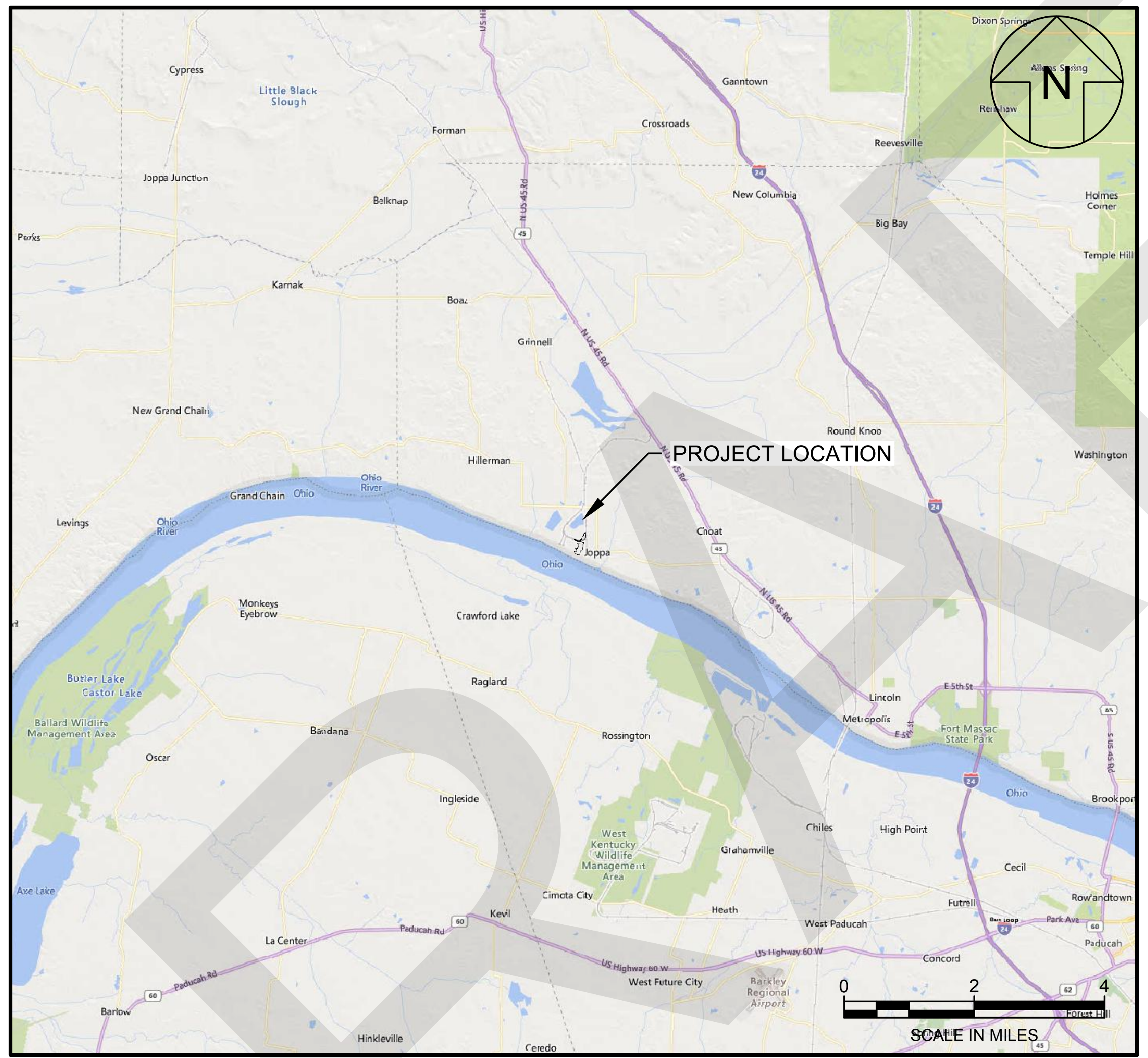
ELECTRIC ENERGY INCORPORATED
JOPPA POWER PLANT
JOPPA, ILLINOIS
EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS
PROJECT NO. GLP8025
MAY 2022



SOURCE: IDOT

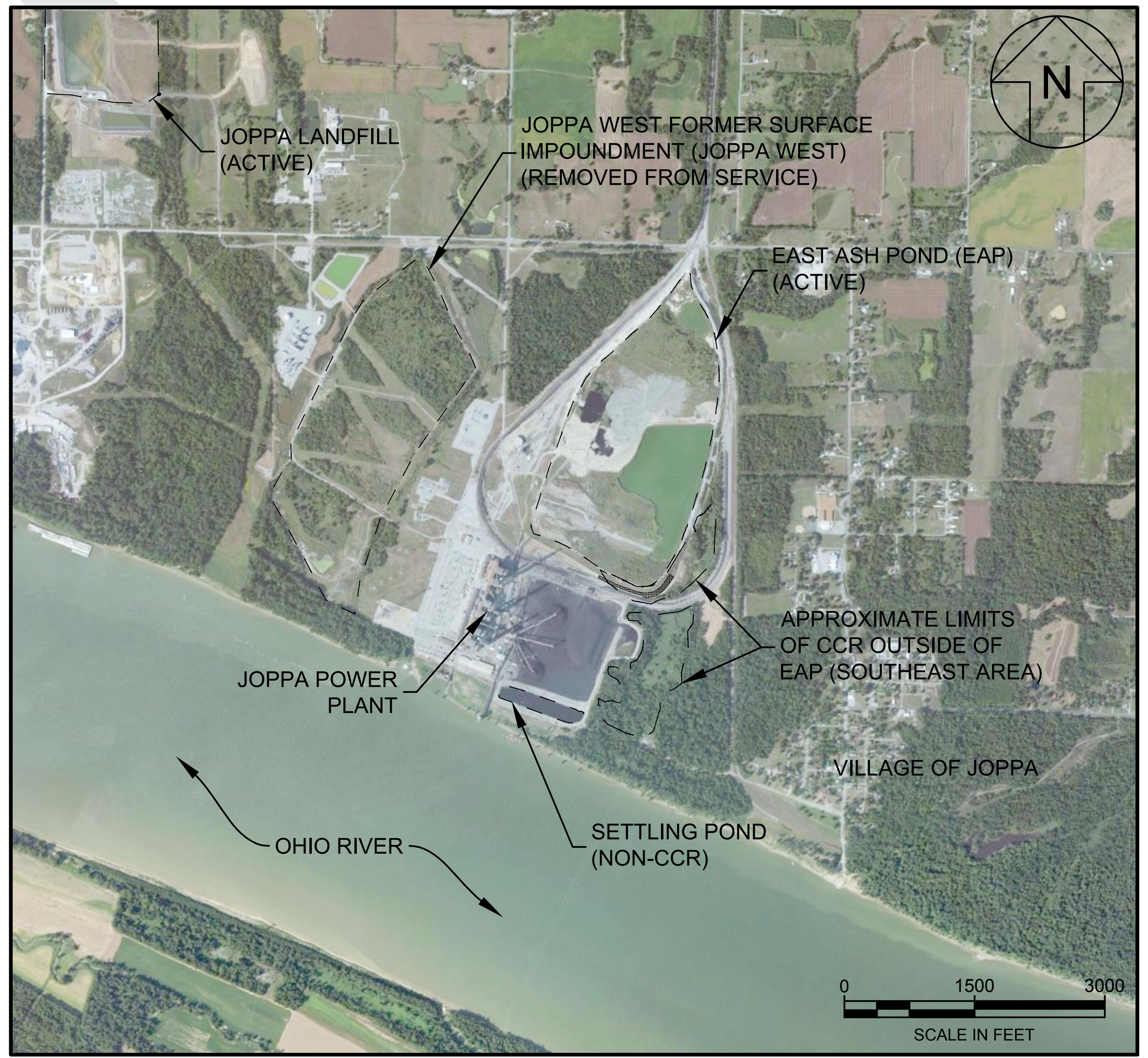
STATE MAP

NOT TO SCALE



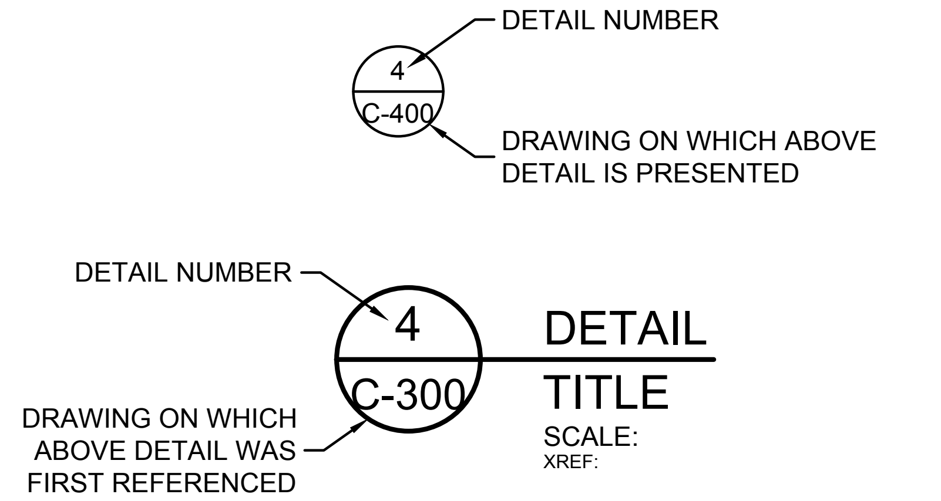
SOURCE: BING MAPS

LOCATION MAP



SOURCE: GOOGLE EARTH PRO

SITE MAP



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

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REV	DATE	DESCRIPTION	DRN	APP
A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC

Geosyntec consultants

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CHESTERFIELD, MO 63005 USA
TELEPHONE: 636-812-0800

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE: COVER SHEET AND LOCATION MAP

PROJECT: EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

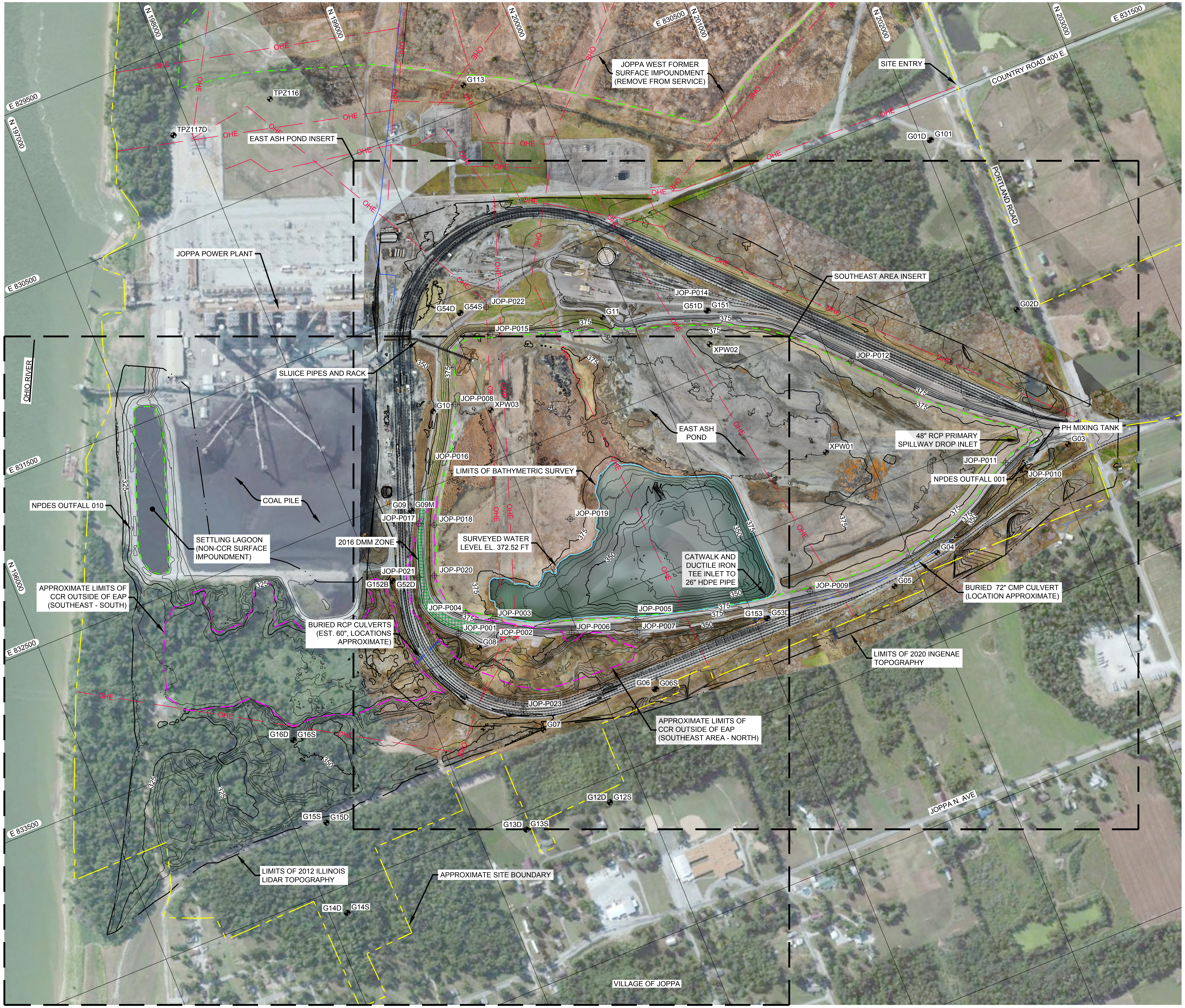
SITE: JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	MAY 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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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.

0 300 600
SCALE IN FEET

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REV	DATE	DESCRIPTION	DRN	APP
A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC

Geosyntec consultants

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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:	MAY 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		

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, AND OTHER FEATURES SHOWN ON THIS SHEET.

0 200 400
SCALE IN FEET

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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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DESIGN BY:	LPC	DATE:	MAY 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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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, AND OTHER FEATURES SHOWN ON THIS SHEET.

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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

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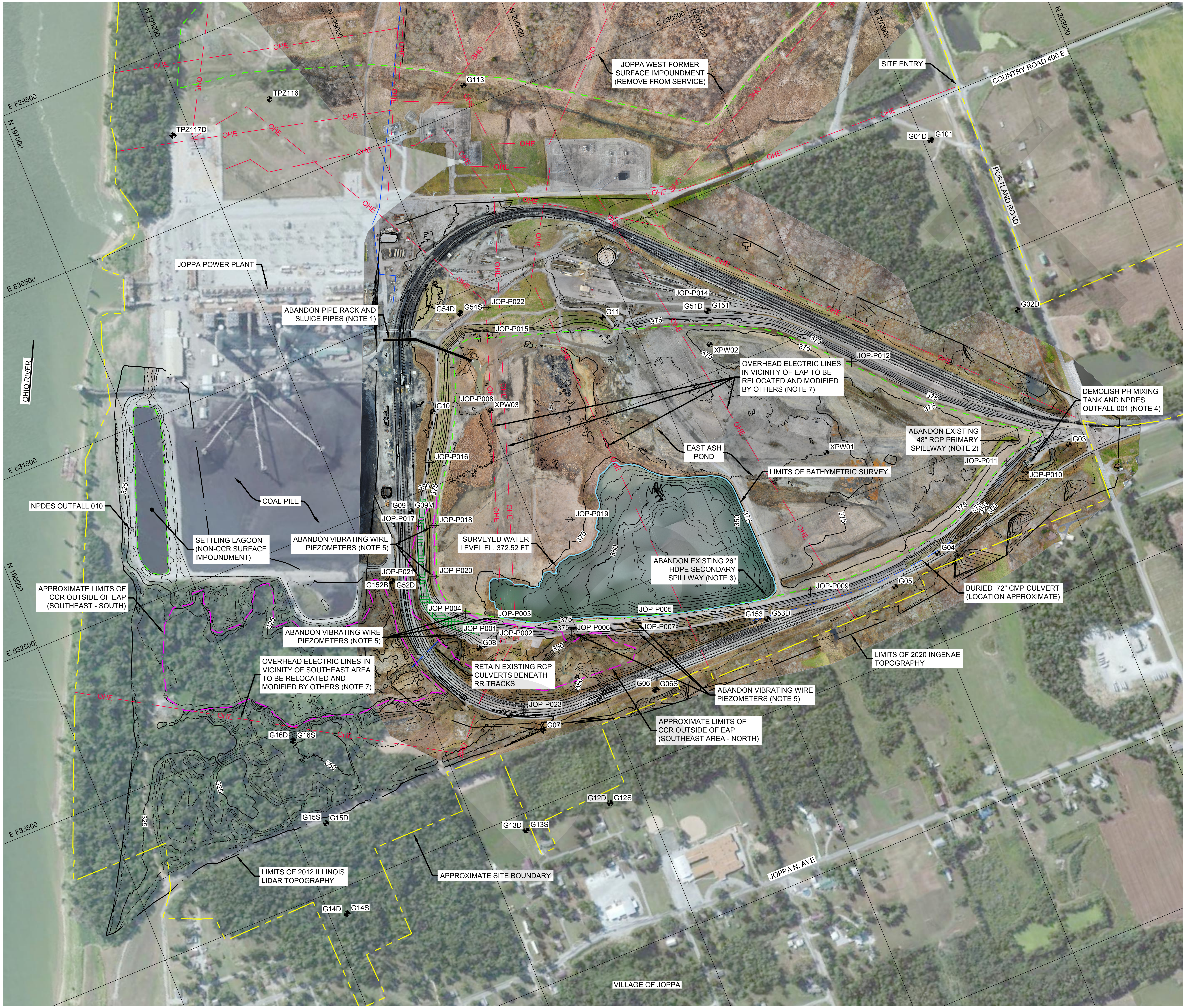
DESIGN BY:	LPC	DATE:	MAY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 G-130
REVIEWED BY:	JPS	DRAWING NO.:	G-130
APPROVED BY:	LPC		



LEGEND

——— 350 ———	EXISTING GROUND SURFACE ELEVATION (MAJOR) (5-FT INTERVAL)
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——— – ———	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, BURIED CULVERTS, AND LIMITS FOR THE EAP.

0 300 600
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC

Geosyntec consultants

1 MCBRIDE AND SON CENTER DRIVE,
SUITE 202
CHESTERFIELD, MO 63005 USA
TELEPHONE: 636-812-0800

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

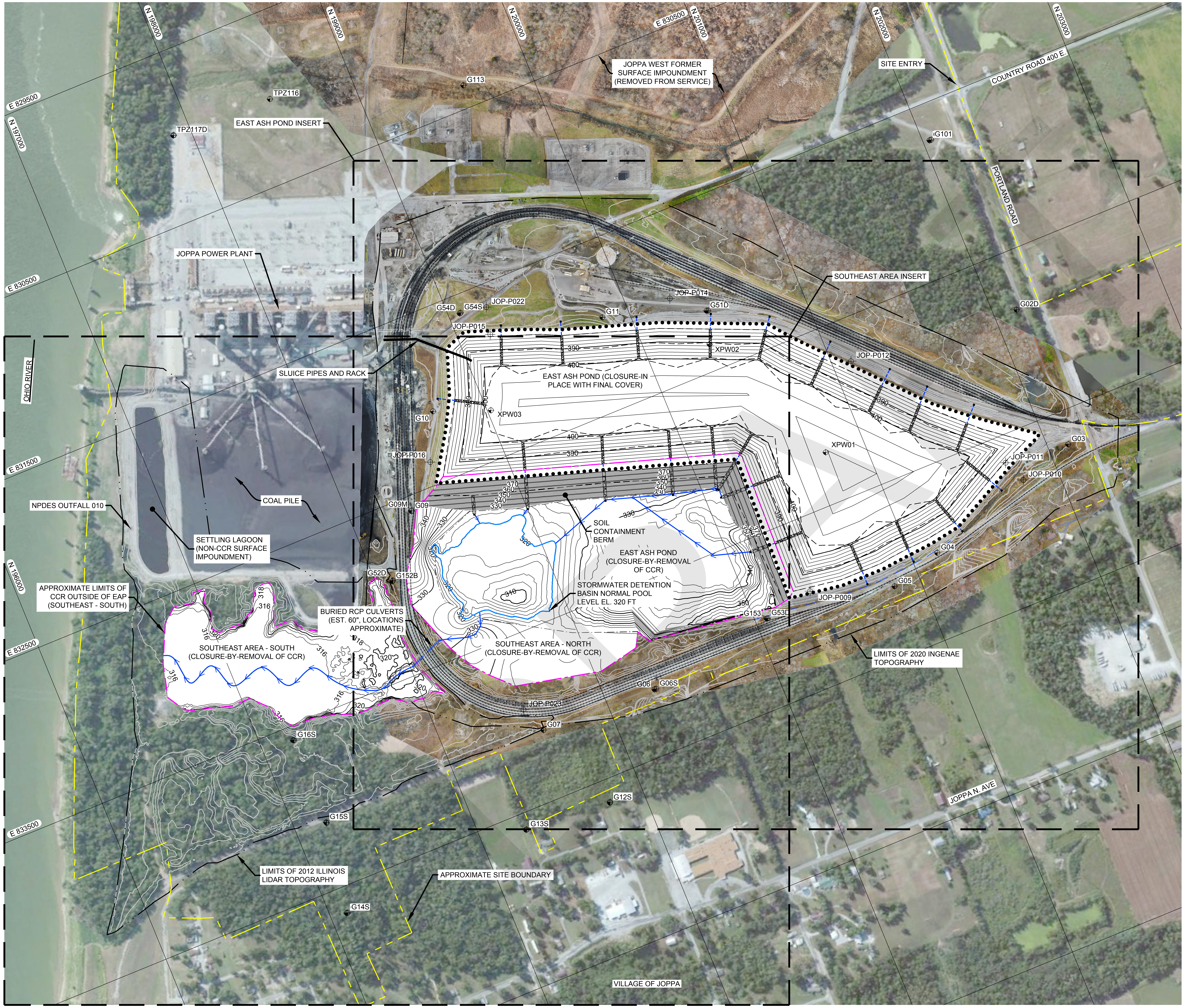
THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

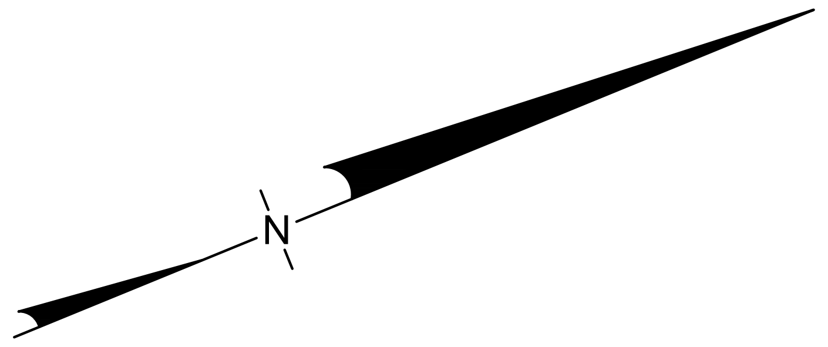
DATE

DESIGN BY:	LPC	DATE:	MAY 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		

DRAFT - NOT FOR CONSTRUCTION



DRAFT - NOT FOR CONSTRUCTION



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.
2. EXISTING AND RELOCATED UTILITY ALIGNMENTS ARE NOTE SHOWN ON THIS SHEET. SEE SHEET G-110 AND G-130 FOR UTILITY INFORMATION.

0 300 600
SCALE IN FEET

A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC
REV	DATE	DESCRIPTION	DRN	APP

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SUITE 202
CHESTERFIELD, MO 63005 USA
TELEPHONE: 636-812-0800

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

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SIGNATURE

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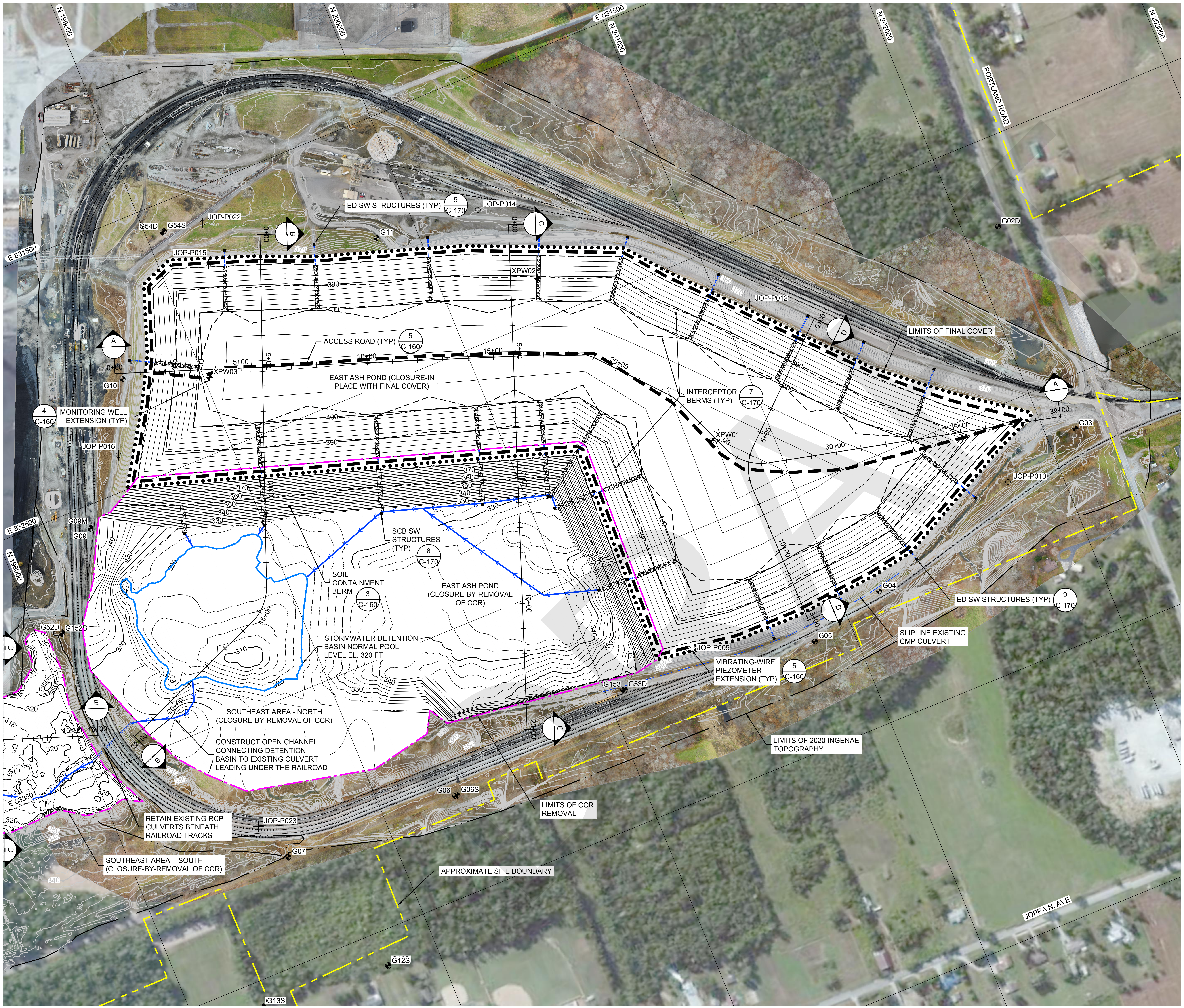
DESIGN BY:	LPC	DATE:	MAY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-110
REVIEWED BY:	JPS	DRAWING NO.:	C-110
APPROVED BY:	LPC		



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
▬ ▬ ▬	ACCESS ROAD
- - - -	INTERCEPTOR BERM
▨	ROCK CHUTE
- - - -	PROPSED CULVERT
→	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 AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
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. ACTUAL GRADES MAY VARY BASED ON OBSERVATIONS PERFORMED DURING CCR EXCAVATION.
5. 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

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A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC

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CHESTERFIELD, MO 63005 USA
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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:	MAY 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		

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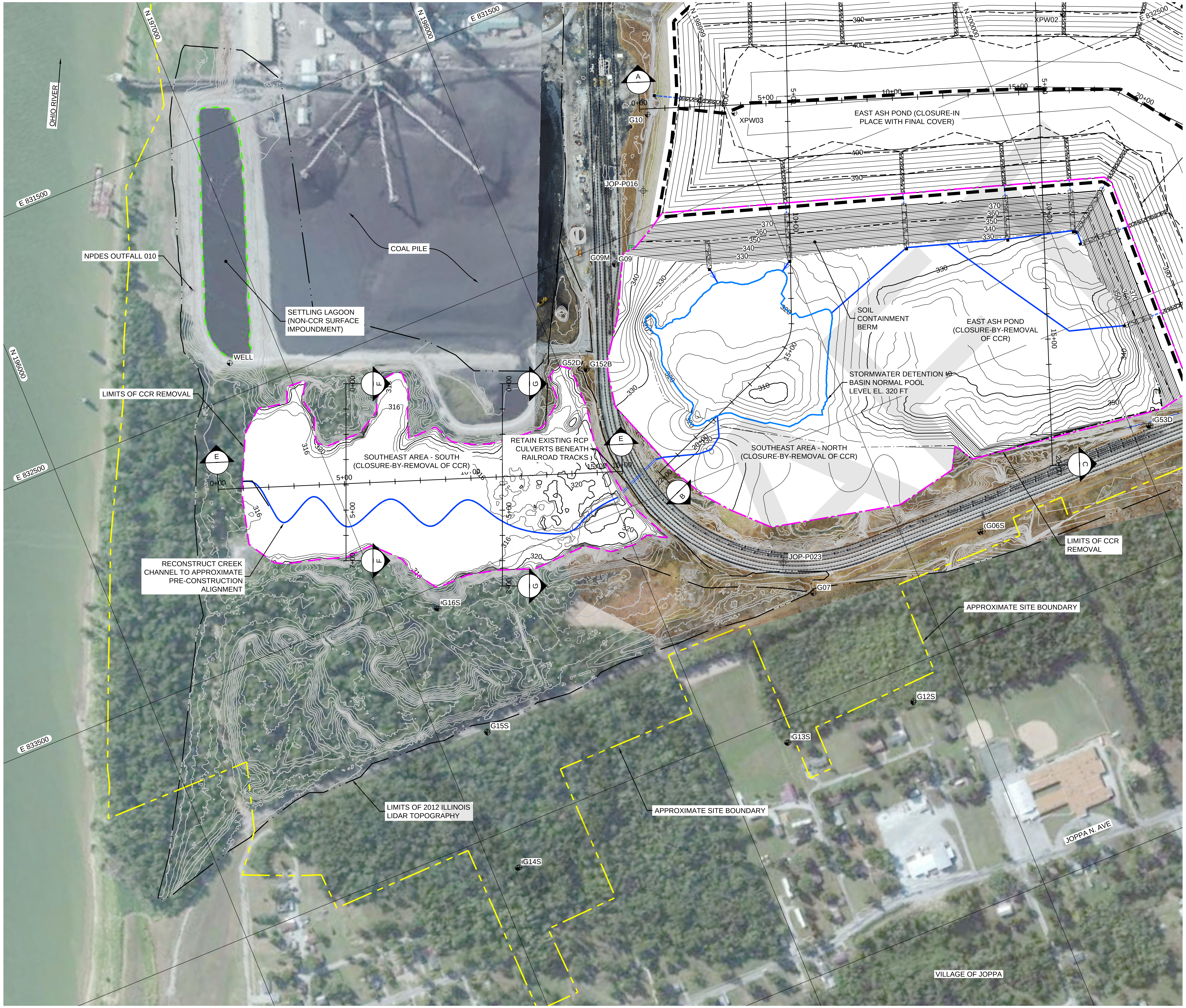

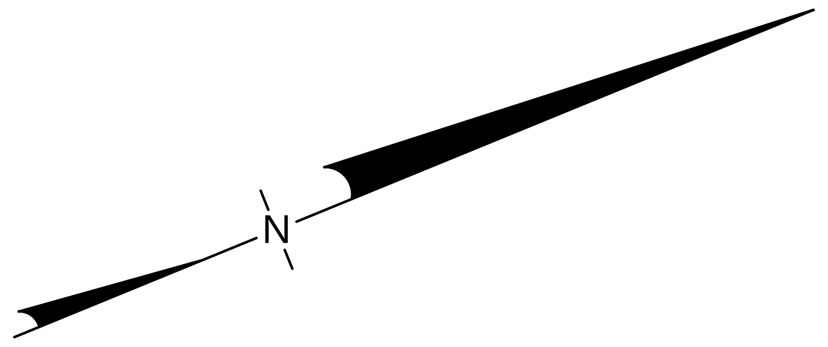

LEGEND

— 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
▬ ▬ ▬	ACCESS ROAD
- - - -	INTERCEPTOR BERM
▨	ROCK CHUTE
=====	PROPSED 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 AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
2. EXISTING AND RELOCATED UTILITY ALIGNMENTS ARE NOTE 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 REFINE AT A LATER PHASE OF DESIGN.

0 200 400
SCALE IN FEET

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REV	DATE	DESCRIPTION	DRN	APP
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Geosyntec consultants
1 MCBRIDE AND SON CENTER DRIVE,
SUITE 202
CHESTERFIELD, MO 63005 USA
TELEPHONE: 636-812-0800

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

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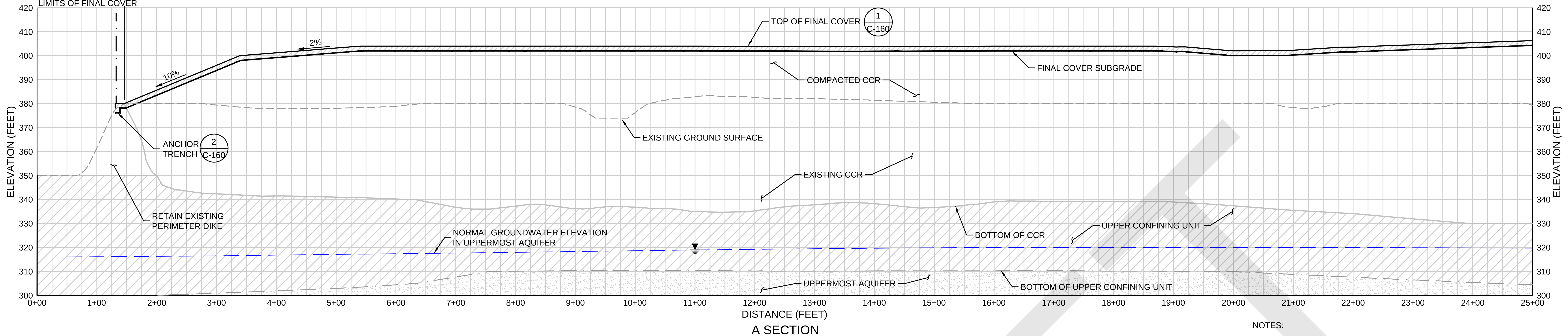
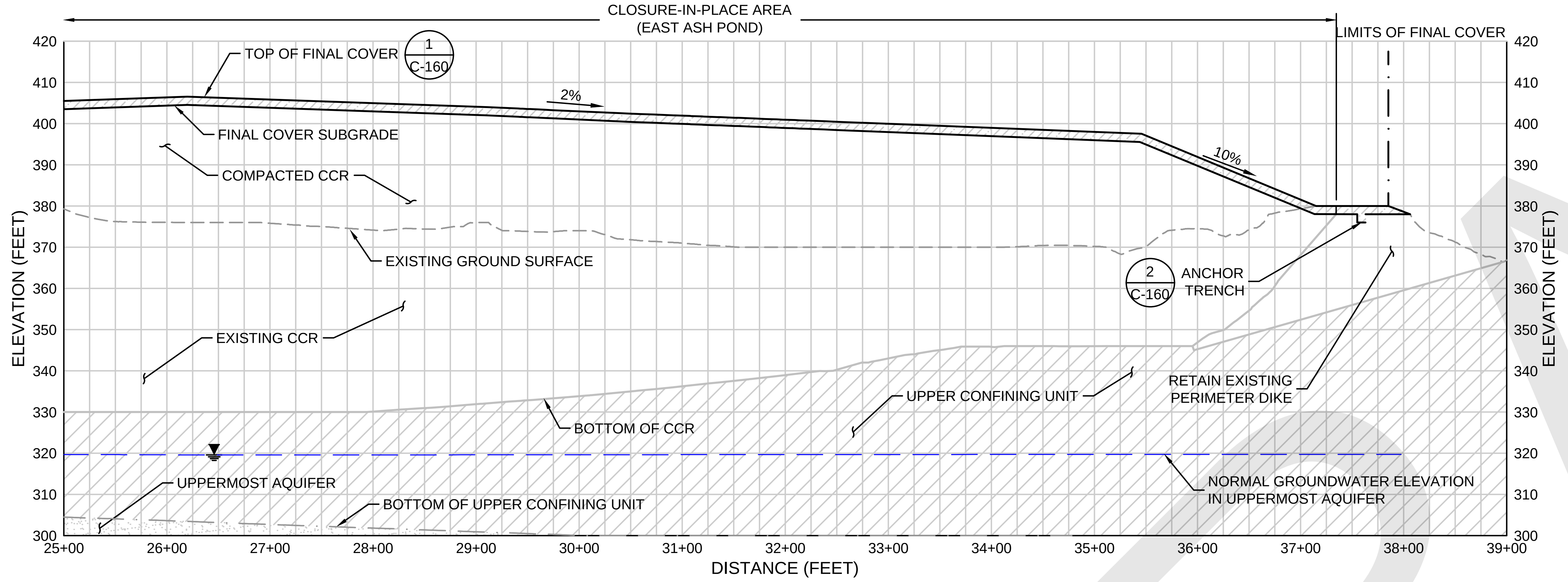
SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	MAY 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'

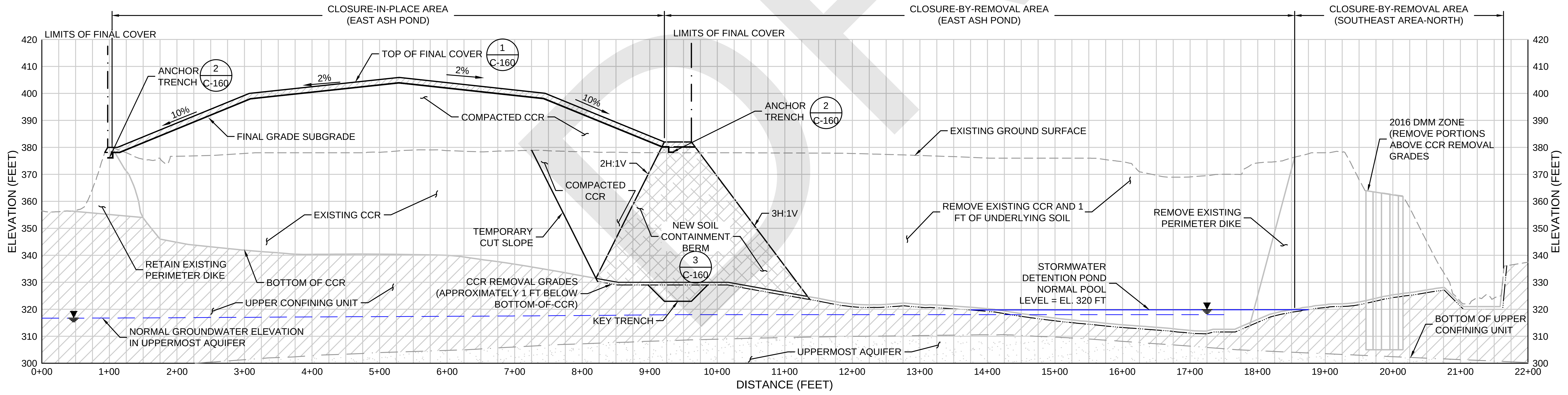
NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING COORDINATE SYSTEMS AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
2. THE BOTTOM OF CCR WITHIN THE EAP WAS TAKEN FROM THE GEOSYNTEC DRAWING TITLED "ESTIMATED BOTTOM OF CCR ELEVATION, POND INTERIOR, EAST ASH POND, JOPPA POWER PLANT, JOPPA, ILLINOIS", DATED FEBRUARY 16, 2022. THE DRAWING WAS DEVELOPED USING AVAILABLE EXPLORATION, HISTORICAL TOPOGRAPHIC, AND RECENT TOPOGRAPHIC DATA. THE BOTTOM OF CCR SHOULD BE CONSIDERED APPROXIMATE, DUE TO LIMITED RECENT INVESTIGATION DATA.
3. THE BOTTOM OF CCR FOR THE SOUTHEAST AREA WAS TAKEN FROM THE GEOSYNTEC DRAWING TITLED "JOPPA POWER PLANT, EAST ASH POND, NORTH EXTERIOR AND SOUTH EXTERIOR, BOTTOM OF CCR SURFACE", DATED APRIL 2022. THE DRAWING WAS DEVELOPED USING LIMITED SITE EXPLORATION DATA AND AN ASSUMED CCR THICKNESS OF 4 FT, AND SHOULD BE CONSIDERED APPROXIMATE. INVESTIGATIONS ARE UNDERWAY TO FURTHER EVALUATE THE BOTTOM OF CCR IN THE SOUTHEAST AREA AND THIS SURFACE WILL BE UPDATED AT A LATER DATE BASED ON THE RESULTS OF THOSE INVESTIGATIONS.
4. 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.
5. 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.
6. 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.
7. 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



B SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'

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REV	DATE	DESCRIPTION	DRN	APP
A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC

Geosyntec consultants
1 MCBRIDE AND SON CENTER DRIVE, SUITE 202
CHESTERFIELD, MO 63005 USA
TELEPHONE: 636-812-0800

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE:
SECTIONS - 1 OF 2

PROJECT:
EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

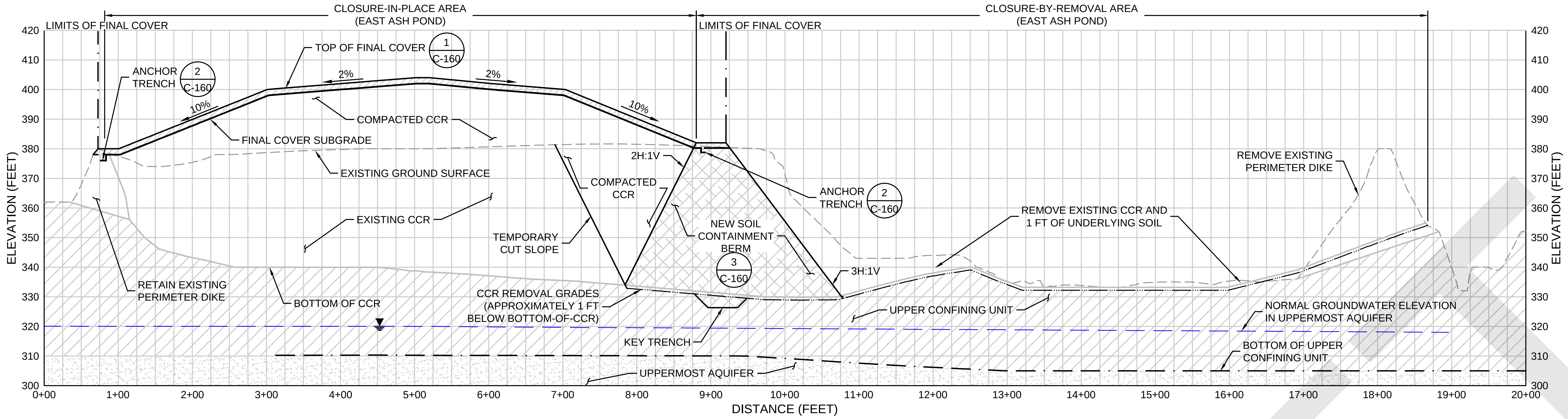
SITE:
JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

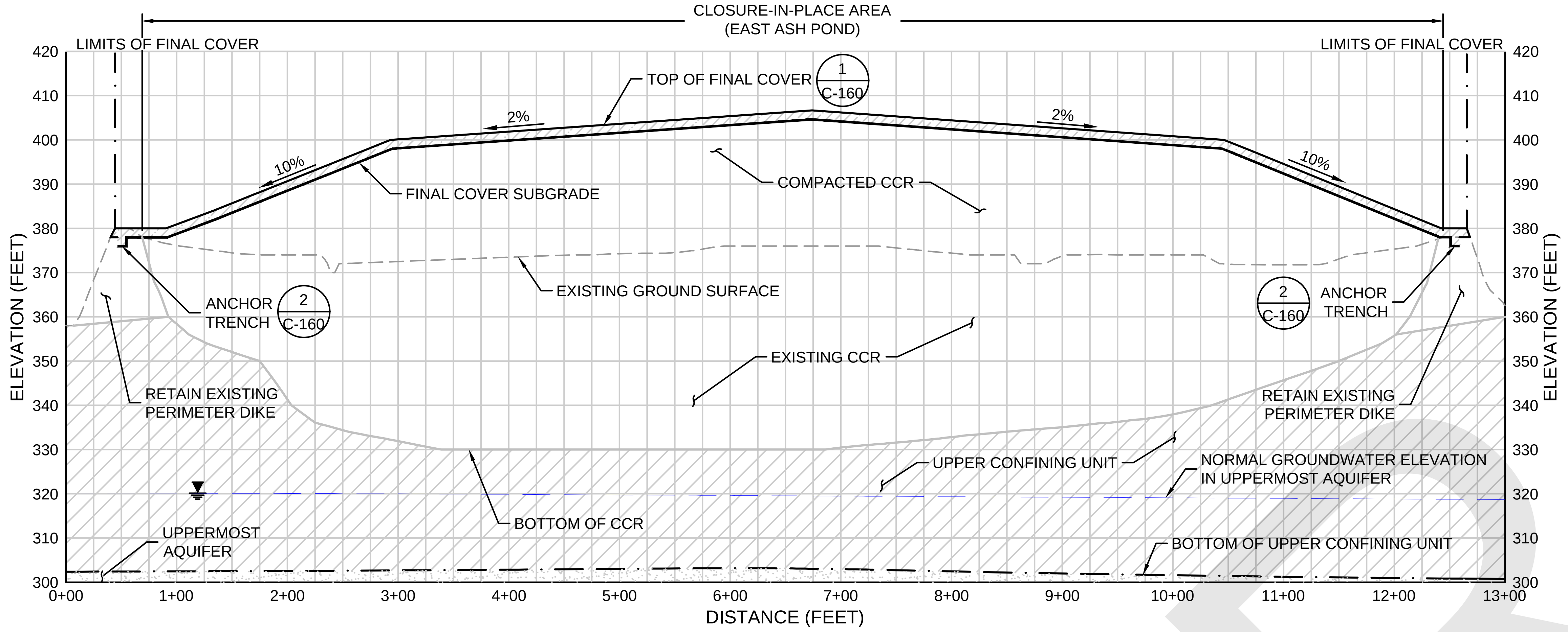
SIGNATURE

DATE

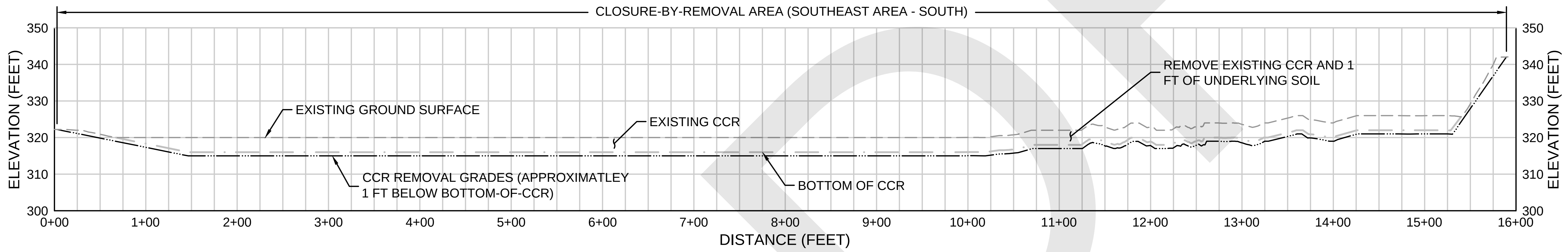
DESIGN BY:	LPC	DATE:	MAY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-140
REVIEWED BY:	JPS	DRAWING NO.:	
APPROVED BY:	LPC		C-140



C SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



D SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



E SECTION
HORIZONTAL: 1" =100'
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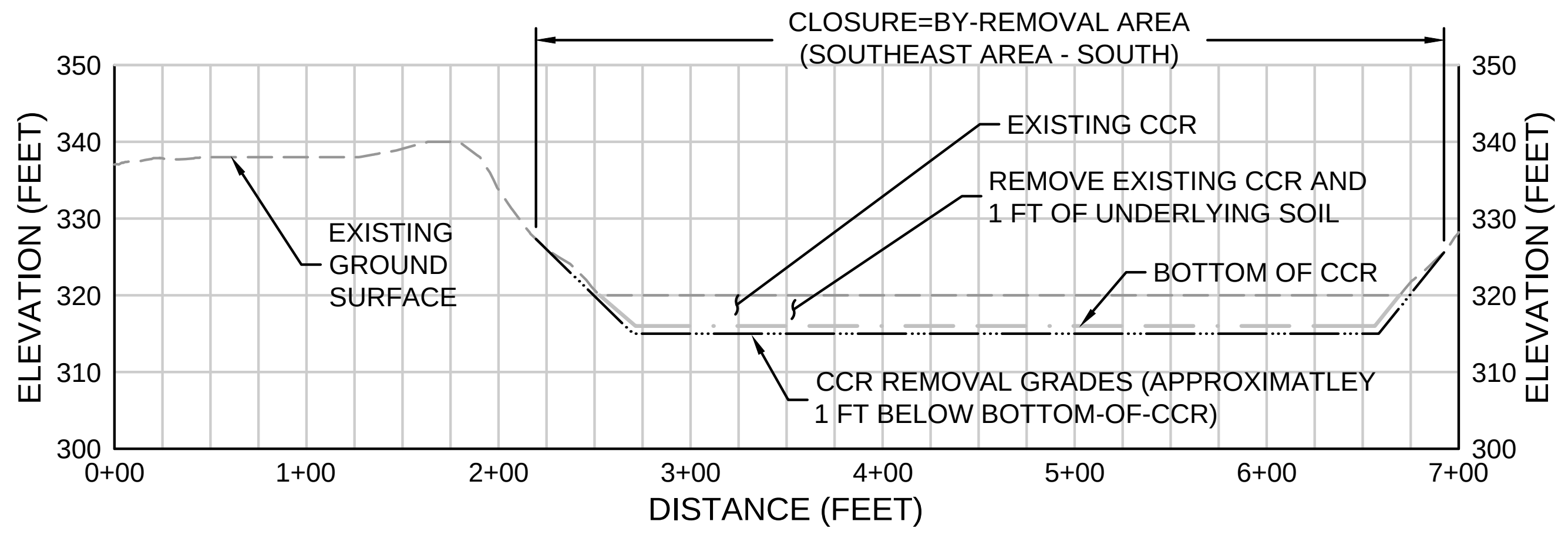
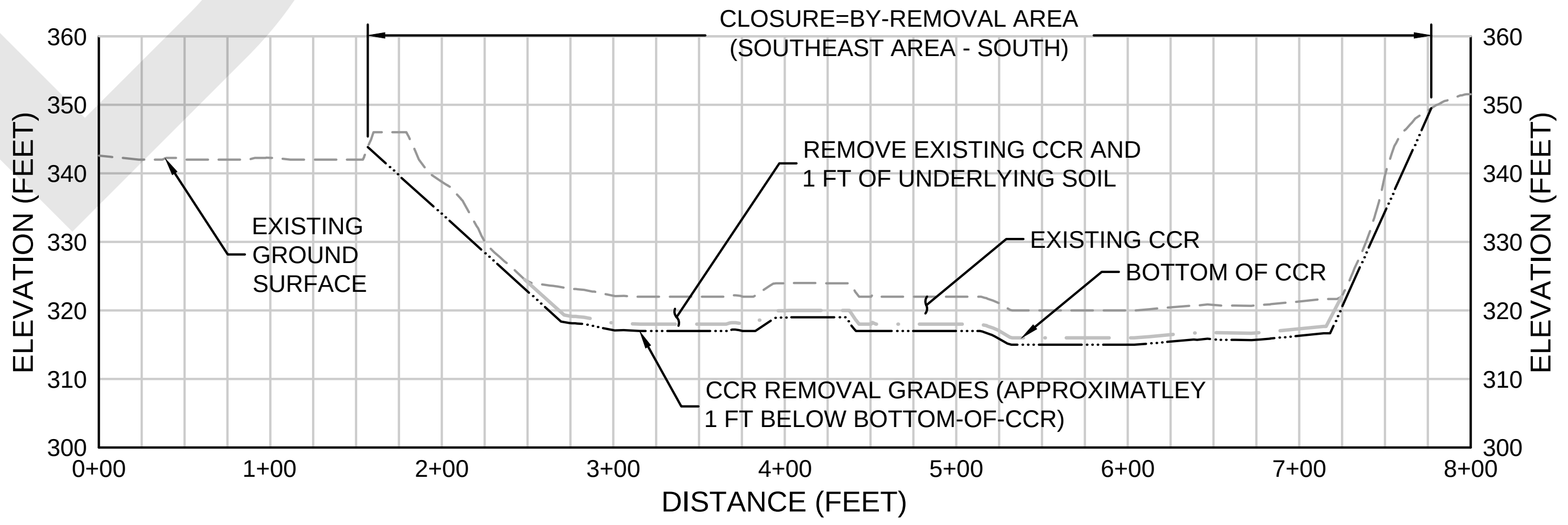


F SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'



G SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING COORDINATE SYSTEM AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
2. THE BOTTOM OF CCR WITHIN THE EAP WAS TAKEN FROM THE GEOSYNTEC DRAWING TITLED "ESTIMATED BOTTOM OF CCR ELEVATION, POND INTERIOR, EAST ASH POND, JOPPA POWER PLANT, JOPPA, ILLINOIS", DATED FEBRUARY 16, 2022. THE DRAWING WAS DEVELOPED USING AVAILABLE EXPLORATION, HISTORICAL TOPOGRAPHIC AND RECENT TOPOGRAPHIC DATA. THE BOTTOM OF CCR SHOULD BE CONSIDERED APPROXIMATE, DUE TO LIMITED RECENT INVESTIGATION DATA.
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4. 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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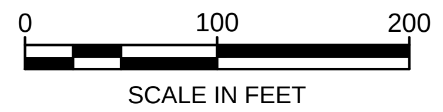
LEGEND

━━━	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



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1 MCBRIDE AND SON CENTER DRIVE,
SUITE 202
CHESTERFIELD, MO 63005 USA
TELEPHONE: 636-812-0800

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE:
SECTIONS - 2 OF 2

PROJECT:
EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

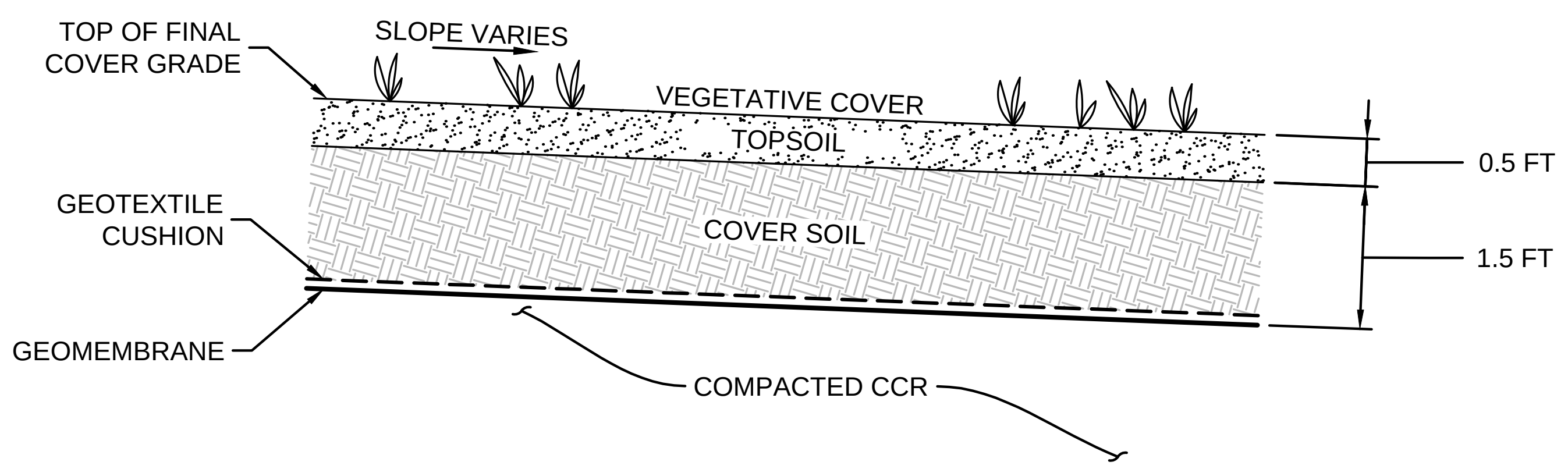
SITE:
JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

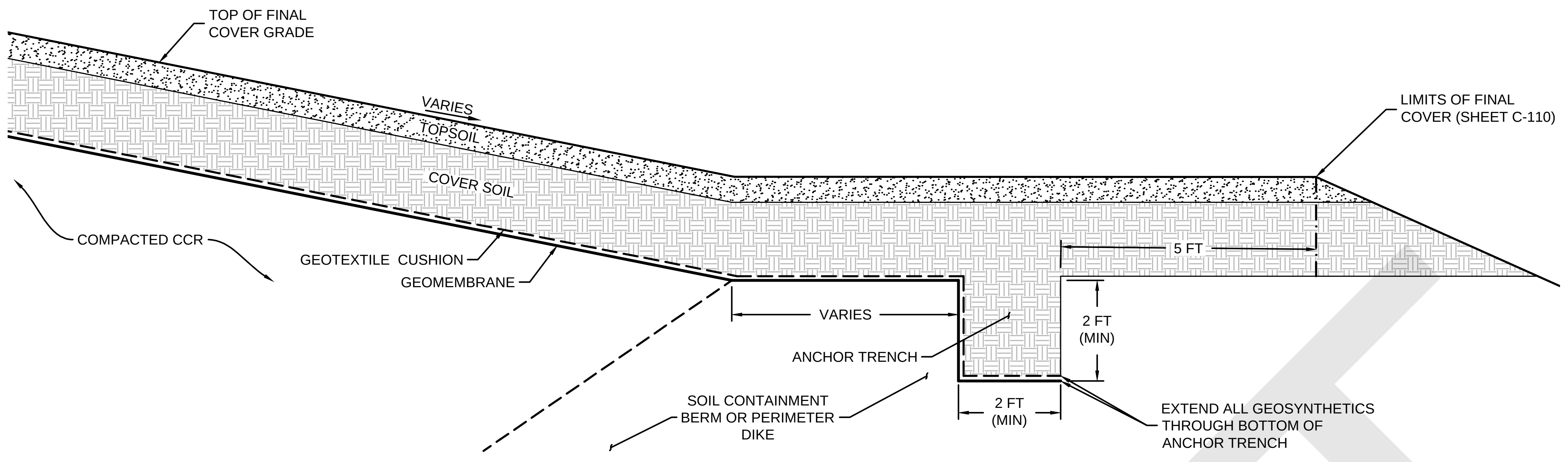
SIGNATURE

DATE

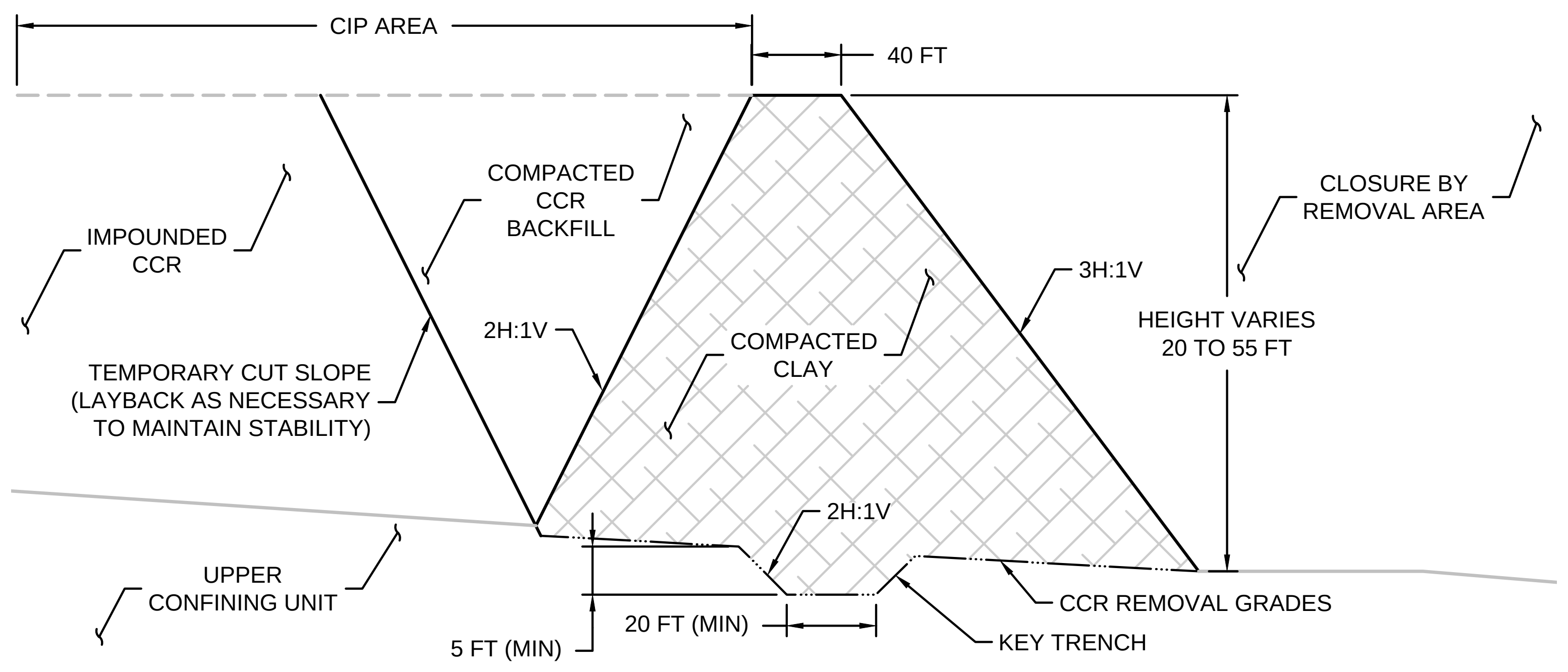
DESIGN BY:	LPC	DATE:	MAY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-150
REVIEWED BY:	JPS	DRAWING NO.:	C-150
APPROVED BY:	LPC		



1 C-140,C-150 DETAIL
FINAL COVER
SCALE: N.T.S



2 C-140,C-150 DETAIL
ANCHOR TRENCH
SCALE: N.T.S



3 C-140,C-150 DETAIL
SOIL CONTAINMENT BERM AND KEY TRENCH
SCALE: N.T.S

CM

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.

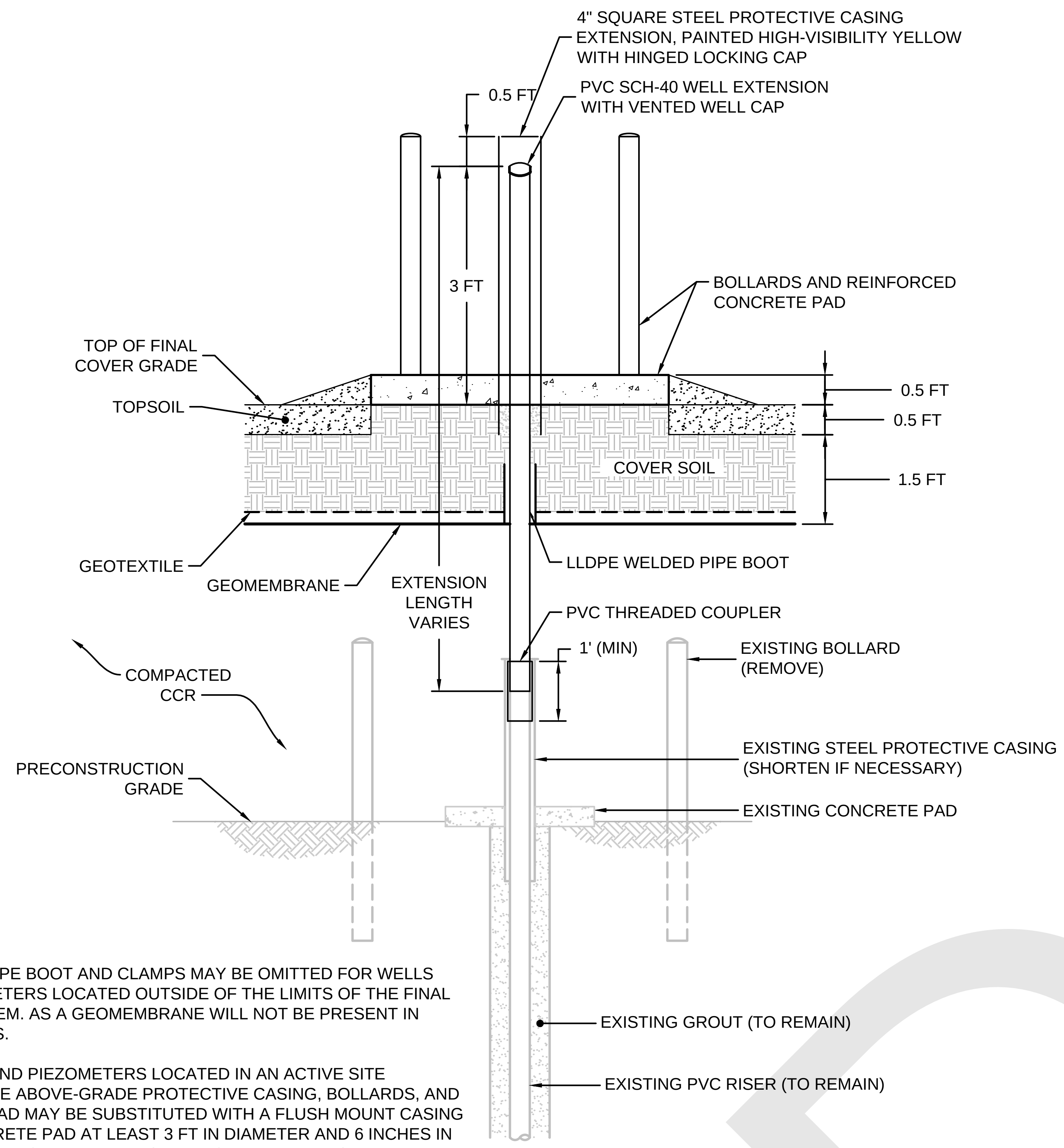
2. TOPSOIL
TOPSOIL IS TO CONSIST OF A NATURAL SOIL MATERIAL THAT IS RELATIVELY HOMOGENOUS, FREE OF DEBRIS, FOREIGN OBJECTS, AND LARGE ROCK FRAGMENTS. THE TOPSOIL IS TO:
-BE CLASSIFIED AS SC, CL, ML, OR OL (PER ASTM D2487), AND
-BE FERTILIZED, AS NECESSARY BASED ON AGRONOMIC TESTING, TO SUPPORT VEGETATION 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 $1x10^{-6}$CMPER 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. GEOTEXTILE
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/YD2 (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.

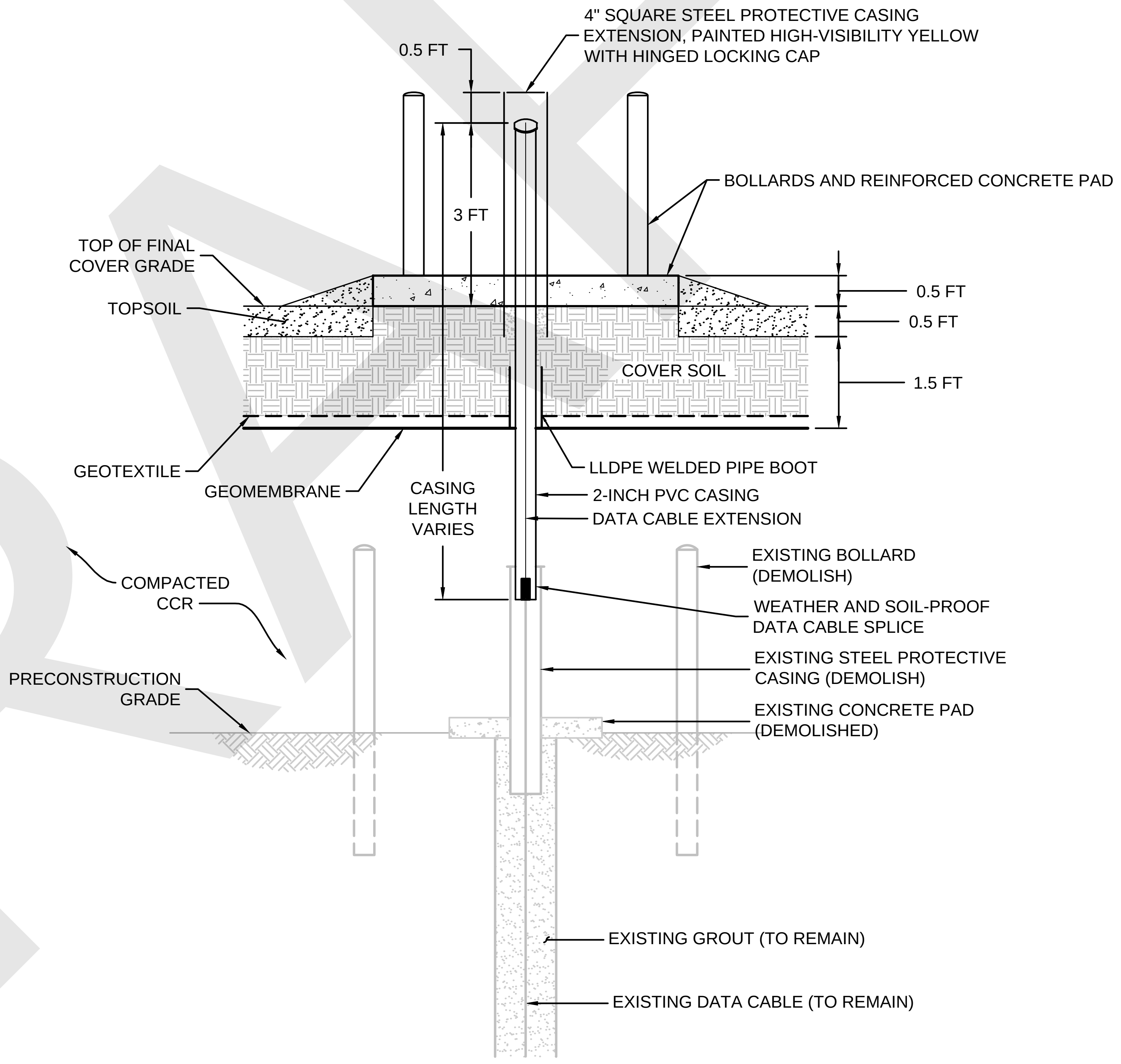
6. GEOMEMBRANE
THE GEOMEMBRANE IS TO CONSIST OF A LINEAR, LOW-DENSITY POLYETHYLENE (LLDPE) MATERIAL, TEXTURED ON BOTH SIDES, MANUFACTURED IN ACCORDANCE WITH THE LATEST VERSION OF GEOSYNTHETIC INSTITUTE GM17 STANDARD SPECIFICATION, AND WITH THE FOLLOWING REQUIREMENTS:
-MINIMUM NOMINAL HEIGHT OF 40 MIL (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.



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.

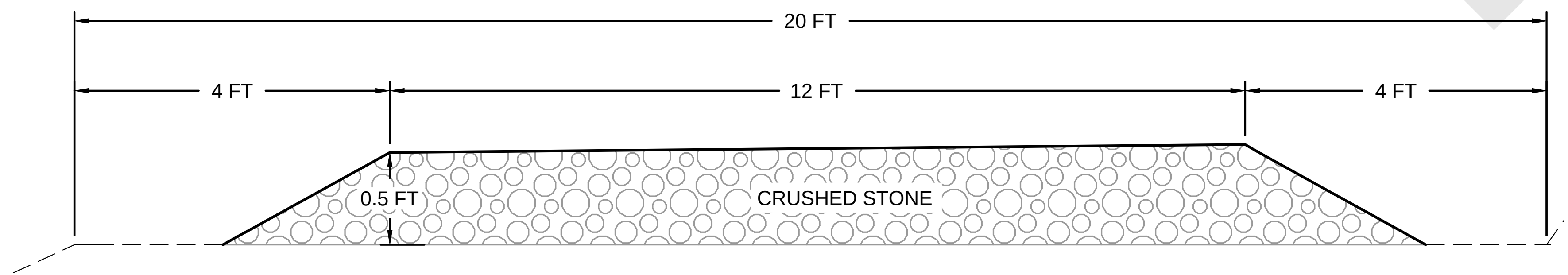
4 C-120 DETAIL
STANDPIPE PIEZOMETER AND MONITORING WELL EXTENSION
SCALE: N.T.S



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 C-120 DETAIL
VIBRATING WIRE PIEZOMETER EXTENSION
SCALE: N.T.S



6 C-120 DETAIL
ACCESS ROAD
SCALE: N.T.S

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REV	DATE	DESCRIPTION	DRN	APP
A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC

Geosyntec consultants
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CHESTERFIELD, MO 63005 USA
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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

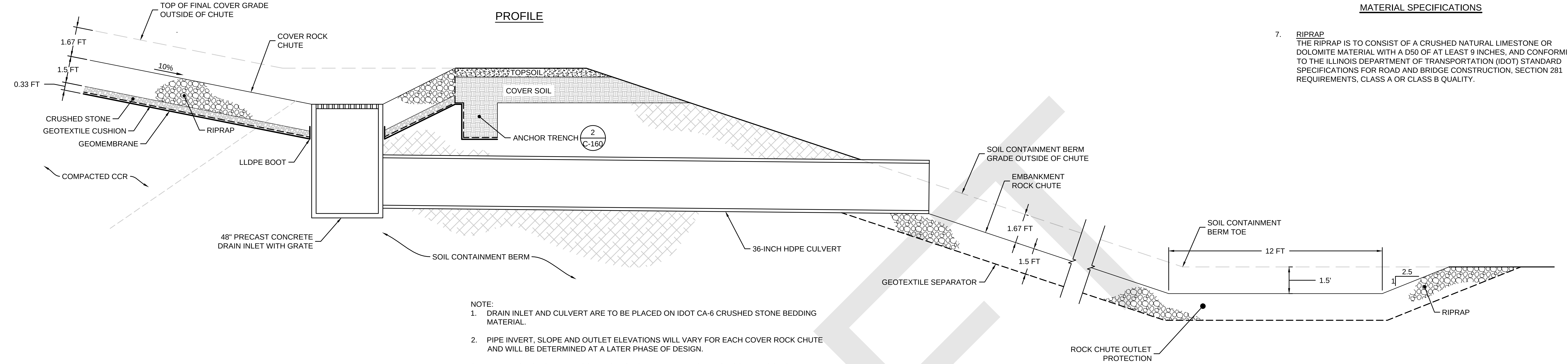
THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	MAY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-160
REVIEWED BY:	JPS	DRAWING NO.:	C-160
APPROVED BY:	LPC		

PROFILE

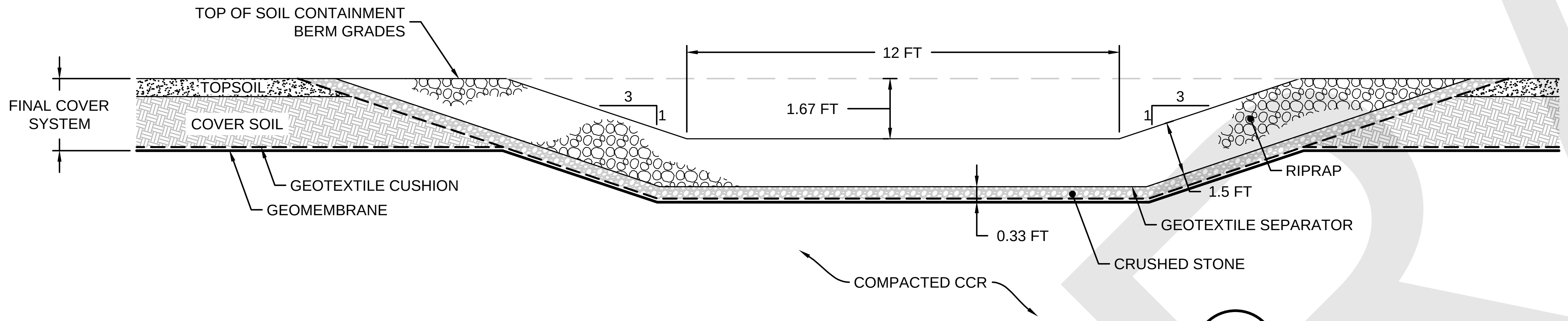


NOTE:
1. DRAIN INLET AND CULVERT ARE TO BE PLACED ON IDOT CA-6 CRUSHED STONE BEDDING MATERIAL.
2. PIPE INVERT, SLOPE AND OUTLET ELEVATIONS WILL VARY FOR EACH COVER ROCK CHUTE AND WILL BE DETERMINED AT A LATER PHASE OF DESIGN.
3. ELEVATION OF OUTLET ROCK PROTECTION WILL VARY FOR EACH COVER ROCK CHUTE 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.

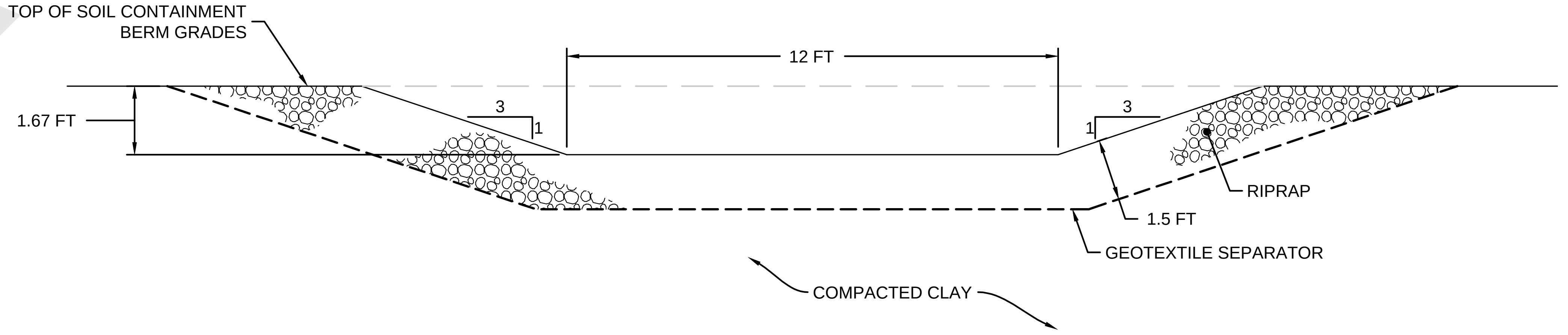
MATERIAL SPECIFICATIONS

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.

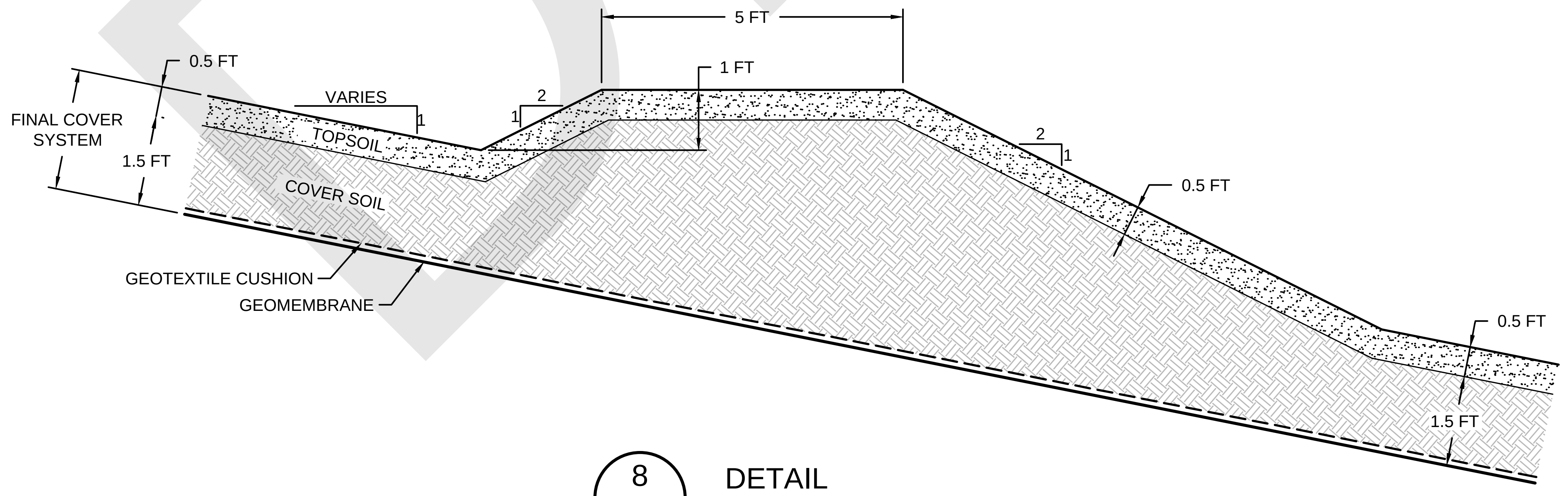
CROSS SECTION
COVER ROCK CHUTE



CROSS SECTION
EMBANKMENT ROCK CHUTE



7
C-170
DETAIL
SOIL CONTAINMENT BERM CULVERT AND CHUTES
SCALE: 1" = 2'



8
C-170
DETAIL
INTERCEPTOR BERM
SCALE: 1" = 2'

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A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC

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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

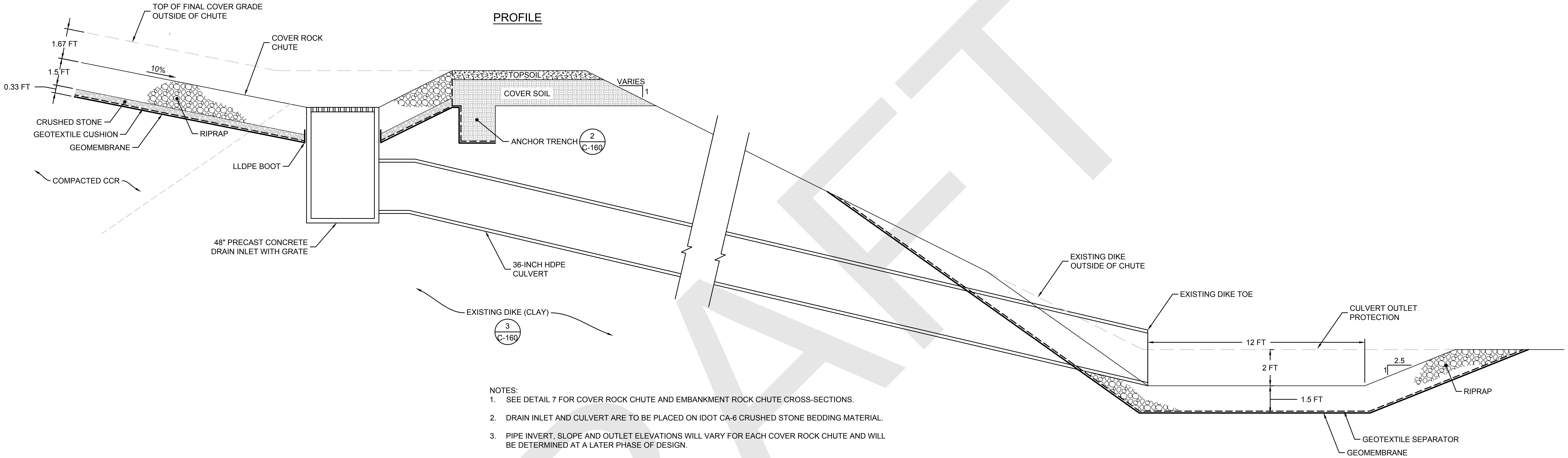
SITE:
JOPPA POWER PLANT
JOPPA, ILLINOIS

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	MAY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-170
REVIEWED BY:	JPS	DRAWING NO.:	C-170
APPROVED BY:	LPC		



NOTES:

1. SEE DETAIL 7 FOR COVER ROCK CHUTE AND EMBANKMENT ROCK CHUTE CROSS-SECTIONS.
2. DRAIN INLET AND CULVERT 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'

DRAFT - NOT FOR CONSTRUCTION

A	5/12/2022	DRAFT FOR EEI REVIEW	DW/SRN	LPC
REV	DATE	DESCRIPTION	DRN	APP

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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

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	MAY 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		

ATTACHMENT D

Hydrologic and Hydraulic Design of Stormwater Management System

Geosyntec
consultants

COMPUTATION COVER SHEET

Client: Electric Energy, Inc. (EEI) Project: **Joppa East Ash Pond (EAP) Closure Plan** Project/ Proposal No.: **GL8025**

Task No. **02**

Title of Computations **Cover System Hydrologic and Hydraulic Calculation Package**

Computations by:
Signature
Printed Name Priya Iyengar. P.E.
Title Project Engineer
Date 04-08-2022

Assumptions and Procedures Checked by:
(Senior reviewer)
Signature
Printed Name Matthew Bardol, P.E.
Title Senior Principal
Date 04-26-2022

Computations Checked by:
Signature
Printed Name Patrick VanDeWiele, P.E.
Title Project Engineer
Date 04-12-2022

Computations backchecked by:
(originator)
Signature
Printed Name Priya Iyengar, P.E.
Title Professional
Date 04-24-2022

Approved by:
(pm or designate)
Signature
Printed Name Lucas Carr, P.E.
Title Senior Engineer
Date XX-XX-2022

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

TABLE OF CONTENTS

1. INTRODUCTION 3

2. DESIGN BASIS 3

3. ASSUMPTIONS AND DATA INPUT 4

3.1 Summary of Survey Data and Site Improvement Data 4
3.2 Hydrology Inputs 4
  3.2.1 Rainfall Depth and Distribution 4
  3.2.2 Curve Number 4
  3.2.3 Sub-catchments 4
  3.2.4 Time of Concentration 5
3.3 Hydraulic Inputs 6
  3.3.1 Interceptor Berms 6
  3.3.2 Rock Chutes 7
  3.3.3 Culverts 7

4. RESULTS 7

4.1 Time of Concentration 7
4.2 Interceptor Berm Design 7
4.3 Rock Chute Design 9
4.4 Culvert Design 10

5. CONCLUSION 11

6. REFERENCES 12

7. APPENDICES 13

7.1 Appendix A – NOAA Atlas 14, Volume 2, Version 3 13
7.2 Appendix B – Drainage Maps 13
7.3 Appendix C – Sub-catchment Summary 13
7.4 Appendix D – Interceptor Berm Hydraulic Analysis 13
7.5 Appendix E – Rock Chute Analysis 13
7.6 Appendix F – Culvert Crossing Analysis 13

Written by: **PI** Date: **04/08/2022** DD MM YY Reviewed by: **PV** Date: **04/08/2022** DD MM YY

Client: **EEI** Prj. **Joppa EAP Closure Plan** Prj. No.: **GLP8025** Task No.: **02**

LIST OF TABLES

TABLE 3: CRITICAL PARAMETERS FOR THE INTERCEPT BERMS......8
TABLE 4: ROCK CHUTE DESIGN PARAMETERS......9

LIST OF FIGURES

FIGURE 1. EXCERPT TABLE 8-11 FROM CHAPTER 8 OF THE NRCS ENGINEERING HANDBOOK......9
FIGURE 2: EXCERPT FROM FHWA, 2006......10

1. INTRODUCTION

This calculation package provides documentation of the hydrologic and hydraulic (H&H) analysis of approximately 78 acres of the cover system designed for the Joppa East Ash Pond Coal Combustion Residue impoundment. The H&H design and analysis is based on the 30% cover system design plans dated April 2022.

The H&H analysis evaluates the performance of the cover's proposed drainage features for the 100-year, 24-hour Soil Conservation Service (SCS) Type II storm event in accordance with the CCR Rule (USEPA, 2015) and the Illinois Part 845 Rule (IEPA, 2021).

Stormwater design features include interceptor berms, rock chutes, culverts and riprap aprons. Design approach and methodology are summarized below:

- HEC-HMS 4.9 (USACE, 2021) is a hydrologic modelling system that was used to analyze and estimate peak runoff rate from delineated drainage areas, for the determined design storm event.
- A Manning's spreadsheet calculation (NEH, 2010) was performed for the hydraulic conveyance analysis of the interceptor berms.
- The National Resource Conservation Service (NRCS) Design of Rock Chutes Spreadsheet calculator (Robinson et al., 1998) was utilized to design the rock down chutes.
- The Federal Highway Administration (FHWA) HY-8 7.7 Culvert Analysis Program (FHWA, 2021) was used to analyze culvert design elements. Design of riprap apron was performed for culvert outlet protection (FHWA, 2006).

2. DESIGN BASIS

The proposed stormwater features were designed to safely convey the 100-year design storm per IL Part 845.510. The SCS Type-II rainfall distribution was used for the hydrologic design event. The SCS Type-II distribution is 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).

3. ASSUMPTIONS AND DATA INPUT

The following section presents a summary of the assumptions and inputs associated with the H&H analysis and design of stormwater features.

3.1 Summary of Survey Data and Site Improvement Data

Site topographic surveys of existing (pre-closure) conditions were performed by IngenAE, LLC in December 2020, which were prepared and provided to Dynegy as a drawing set (IngenAE, May 2021). Site improvements are based on the conceptual closure design for the Joppa East Ash Pond prepared by Geosyntec Consultants.

3.2 Hydrology Inputs

The following design assumptions and hydrologic parameters were used to perform the hydrologic analysis.

3.2.1 Rainfall Depth and Distribution

Rainfall depths were based on NOAA Atlas 14 (NOAA, 2006) Point Precipitation Frequency Estimates, as shown in **Appendix A**. The Type II SCS 100-year, 24-hour event of 7.43 inches was used to size the proposed stormwater features.

3.2.2 Curve Number

Curve number (CN) was determined from TR-55 manual (USDA, 1986) and assumed soil conditions based on soil maps and knowledge of the site. A single curve number was used to represent the final cover system. 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. The following assumed conditions were used in determining the curve number based on those conditions:

- Post-development Areas (CN=78)
- Cover Type – Meadow
- Hydrologic Condition – Fair
- Hydrologic Soil Group – D

3.2.3 Sub-catchments

The total cover system area of approximately 78 acres was divided into 21 drainage areas ranging from 0.0019 square miles to a maximum of 0.0068 square miles. The delineation was based on 30% cover system design plans dated April 2022. The drainage map and associated drainage parameters are presented in Table 1 and Figure 1 of **Appendix B**. Drainage Area 14 is the largest area and is used as the critical drainage area as presented in Table 2 and Figure 2 of Appendix B. Supporting calculations use drainage area 14 as a reference area for the design of stormwater conveyance features, even for smaller tributary areas.

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 watershed or drainage area to a point of interest. Factors affecting T_c include surface roughness, channel shape, flow patterns, and slope. For this analysis the calculation of T_c evaluates the impact of three different types of stormwater runoff flow:

- **Sheet flow** – flow over plane surfaces; this represents the runoff over the cover 2% and 10% slopes prior to being collected by the Intercept Berms. NEH allows up to 100 feet for sheet flow length, therefore sheet flow length was kept at or less than 100 feet for calculating sheet flow travel time.

  Note: travel velocities are lower for "sheet flow" compared to "concentrated flow". Therefore a shorter sheet flow travel length results in a shorter overall travel time thus creating a higher peak discharge in the runoff hydrograph which is utilized in the design of the stormwater management features for a more conservative design;
- **Shallow concentrated flow** – After a distance less than 100 feet, sheet flow will begin to concentrate, but not necessarily be defined in a specific channel. Shallow concentrated flow was utilized to calculate travel time up to the top (upstream) of the first intercept berms; and,
- **Channel flow** – flow that is confined to a defined channel section. Channel flow was utilized to iteratively calculate travel time within the interceptor berm. It was assumed that travel time within the rock chute was considered negligible and not included (conservative approach).

The T_c value for a drainage area 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);

n = Manning's roughness coefficient (dimensionless);

L = length of flow (ft.);

P_2 = rainfall from a 2-year, 24-hour storm (in.);

s = Bed or surface slope in the flow direction (ft/ft); and

V = velocity (ft/sec) obtained from equations provided within *Table 15-3* of the *SCS NEH Part 630*

Table 3-1 from *TR-55* provides Manning's "n" for sheet flow for ten (10) different surfaces ranging from concrete surfaces to woods-dense underbrush. *Table 15-3* of the *SCS NEH Part 630* provides average velocity equations for shallow concentrated flow over seven (7) different types of surfaces. A sheet flow Manning's n of 0.15 was selected from *Table 3-1* for "Short Grass Prairie".

The SCS UH Method utilizes a Lag Time calculated from the T_c value. A Lag Time value equal to 60% of the T_c value ($0.6^* T_c$) was utilized in the HEC-HMS model.

3.3 Hydraulic Inputs

The following section summarizes the design assumptions and hydraulic parameters used to perform the hydraulic analysis. The HEC-HMS model peak discharges from the design storm event for the largest delineated sub-catchment (i.e. critical sub-catchment) were utilized in designing the following stormwater features (intercept berms, rock chutes and culverts).

3.3.1 Interceptor Berms

The location, length and longitudinal slope of the interceptor berms were based on the 30% grading plans. The interceptor berms were designed as V-ditches with varying side slopes and a consistent longitudinal slope of 1% as described in the results section.

According to Manning's n for Channels (Chow, 1959), a manning's roughness coefficient of 0.03 was used for excavated earthen channels with short grass and few weeds. The maximum height needed for the intercept berms to convey design storm events surface without overtopping was calculated using the Manning's n spreadsheet.

3.3.2 Rock Chutes

Rock chutes were designed to collect discharge from the interceptor berms and safely convey flow down the 10% slope of the closure and on the 33% slope of the embankment. The hydraulic performance of the rock chutes was designed as a trapezoidal channel to match the proposed grades as follows:

- 10% cover slope. A trapezoidal channel with 10-foot bottom width, 3H:1V side slopes and a longitudinal slope of 10H:1V..
- 33% embankment slope. A trapezoidal channel with 12-foot bottom width, 3H:1V side slopes and a longitude slope of 3H:1V.

The Design of Rock Chutes Spreadsheet calculator (Robinson et al., 1998) was utilized to calculate the minimum chute depth, along with the riprap lining minimum D50 and layer thickness.

3.3.3 Culverts

Culverts were designed to collect discharge from the Rock Chutes and safely convey the flow under the embankments and dikes of the post-closure EAP. HY-8 (FHA, 2019), a hydraulic computation model built by Federal Highway Administration for roadway crossings was utilized to size the culvert. Sizing parameters were based on the design flow of 27.6 cfs for a 100-year event from the critical sub-catchment of 4.36 acres and 30% grading plans.

4. RESULTS

4.1 Time of Concentration

The Tc for the area tributary to the first interceptor berm presented in Figure 2 of Appendix B was approximately 15 minutes with a Lag Time of approximately 9 minutes. Sub-catchment peak flow summary is presented in **Appendix C**.

4.2 Interceptor Berm Design

Interceptor berms were designed to convey the 100-year, 24-hour event. The design of interceptor berms on the 2% and 10% cover slope was based on the 0.0068 square mile critical sub-catchment. The design of interceptor berms on the 33% embankment slope was based on the 0.0028square mile critical sub-catchment as presented in Figure 3 of Appendix B.

Peak discharge outputs from the delineated critical sub-catchments were taken from the HEC-HMS model based on the proposed stormwater drainage features and are shown in **Table 3**.

Additionally, the velocities and depths associated with the peak 100-year, 24-hour storm flows were calculated from a Manning's spreadsheet calculation as shown in Appendix D. The spreadsheet calculation sheets for the interceptor berms are shown in **Appendix D**.

Table 1: Critical parameters for the Intercept Berms

	Peak Flow (CFS)	Max Velocity (ft/s)	Max Flow Depth (ft)
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

Using guidance from Chapter 8 of the Natural Resources Conservation Services (NRCS) Engineering Handbook (NRCS, 2007), temporary erosion control blanket and permanent grass cover is anticipated to provide the necessary protection to prevent erosion from the 100-year, 24-hour peak discharge. Using the maximum velocities of ~1.8 ft/s for the 100-year storm event and Table 8-11 from Chapter 8, table shown below in Figure 1, the berms can use "Jute net" or "Straw with net" as a temporary erosion control product.

An erosion control blanket (ECB) will be used to stabilize the swales until grass is established. An ECB such as "straw with net" has an allowable velocity of 3 ft/s. Grass vegetation is anticipated to establish through the temporary erosion control product on the interceptor berms and has a recommended allowable velocity of 5 to 8 ft/s dependent on grass type – e.g., bermudagrass versus Kentucky bluegrass per Table 8-11 for Chapter 8 (see **Figure 1**).

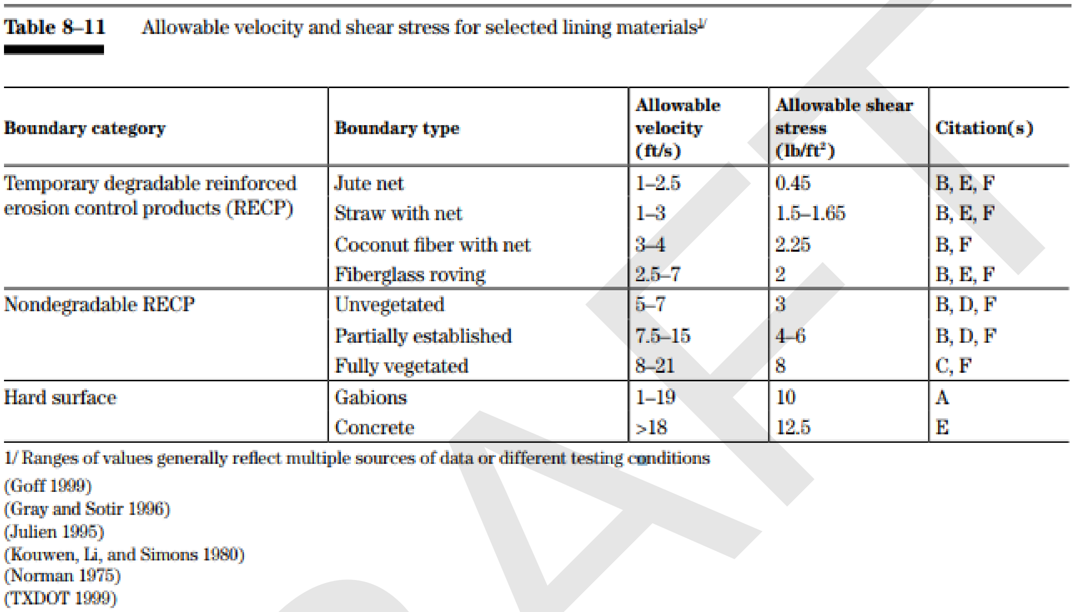

Table 8–11 Allowable velocity and shear stress for selected lining materials[1/]

Boundary category	Boundary type	Allowable velocity (ft/s)	Allowable shear stress (lb/ft^2)	Citation(s)
Temporary degradable reinforced erosion control products (RECP)	Jute net	1–2.5	0.45	B, E, F
	Straw with net	1–3	1.5–1.65	B, E, F
	Coconut fiber with net	3–4	2.25	B, F
	Fiberglass roving	2.5–7	2	B, E, F
Nondegradable RECP	Unvegetated	5–7	3	B, D, F
	Partially established	7.5–15	4–6	B, D, F
	Fully vegetated	8–21	8	C, F
Hard surface	Gabions	1–19	10	A
	Concrete	>18	12.5	E

1/ Ranges of values generally reflect multiple sources of data or different testing conditions

(Goff 1999)
(Gray and Sotir 1996)
(Julien 1995)
(Kouwen, Li, and Simons 1980)
(Norman 1975)
(TXDOT 1999)

Figure 1. Excerpt Table 8-11 from Chapter 8 of the NRCS Engineering Handbook

4.3 Rock Chute Design

The rock chutes were designed using the Design of Rock Chutes spreadsheet developed by the NRCS (Robinson et al., 1998). Peak flows from critical sub-catchments for the 100-year, 24-hour event were used to design the channel geometry and rock-armor sizing (Appendix E). A summary of the design elements are presented in **Table 4**.

Table 2: Rock Chute Design Parameters

Description	Peak Flow (CFS)	Channel Bottom Width (ft)	D50 (inches)
On 10% Cover Slope	27.6	10	6
On 33% Embankment Slope	38.1	12	9

Based on the calculations presented in **Appendix E**, the rock chutes shall consist of an outlet apron no less than 10-feet long and an inlet apron no less than 10-feet long. **Appendix E** presents a plan sheet of the rock chute design.

4.4 Culvert Design

Two culvert crossings were designed—one to convey design peak flow from a rock chute on the 10% cover slope to the rock chute on the 33% embankment slope, second to convey design peak flows from a rock chute on the 10% cover all the way down on the 50% embankment slope. In both cases, a 3-foot diameter corrugated HDPE pipe is designed to safely convey the design peak flow of 27.6 cfs which is a 100-year peak flow from the critical sub-catchment, and a maximum flow of 35 cfs. **Appendix F** presents a profile view of the proposed culvert crossing.

For culvert outlet protection a peak discharge of 27.6 cfs was used to size the geometry of Riprap Apron at locations presented in Figure 4 of Appendix B. A D50 of 5.94 inches was calculated based on the culvert diameter of 3-foot and a tailwater depth of 0.4 ft. Based on Table 10.1 in figure 2, Apron length and depth shall be no less than 12 feet and 2 feet respectively.

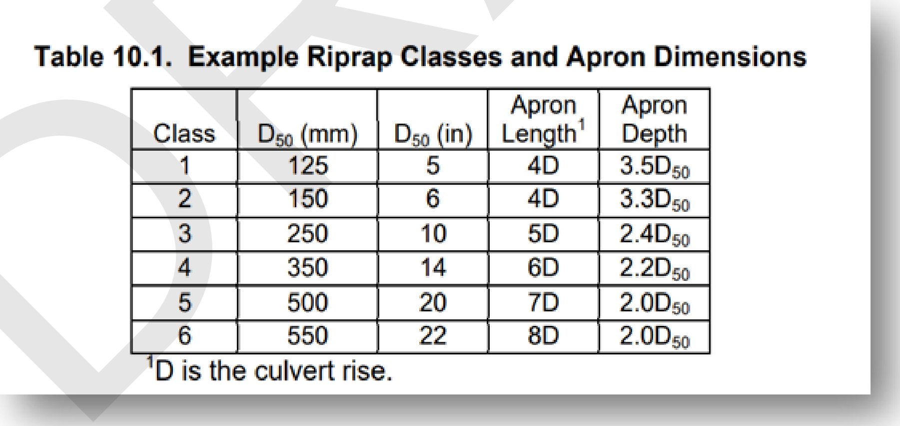

Table 10.1. Example Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
1	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	250	10	5D	$2.4D_{50}$
4	350	14	6D	$2.2D_{50}$
5	500	20	7D	$2.0D_{50}$
6	550	22	8D	$2.0D_{50}$

[1] D is the culvert rise.

Figure 2: Excerpt from FHWA, 2006

5. CONCLUSION

The design of the stormwater management features for the closure cover system presented in this report are based on the 30% design plans dated XX, 2022. These plans are identified as "not for construction." The design of the stormwater management features shall be reviewed based on the final construction plans.

The design of the three stormwater management features are summarized below:

1. The V-ditch interceptor berms are designed with a longitudinal slope of 1% and varying side slopes to match the proposed grading plan. The berm can safely convey the 100-year event with a maximum flow depth of ~0.8 feet. According to Table 8-11 in Chapter 8 of the NRCS Engineering Handbook, the max velocities of ~2.5 ft/s for the 100-year storm event in the interceptor berms are low enough to be supported by temporary erosion control blanket and grass cover
2. The rock chute on the cover and embankment slopes should be constructed with a riprap gradation with a D_{50} of 6 inches and 9 inches and minimum bed thickness of 12 inches and 18 inches respectively. The rock chutes shall include an inlet and outlet apron with a minimum length of 10 feet.
3. The culverts through the embankment shall consist of corrugated HDPE pipe with a minimum diameter of 3-feet. At the discharge outlet of each culvert shall be a riprap apron with minimum D50 of 6 inches and minimum depth of 2 feet. The riprap aprons shall extend 12feet downstream of the culvert end.

6. REFERENCES

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7. APPENDICES

7.1 Appendix A – NOAA Atlas 14, Volume 2, Version 3

7.2 Appendix B – Drainage Maps

7.3 Appendix C – Sub-catchment Summary and Stormwater Features

7.4 Appendix D – Interceptor Berm Hydraulic Analysis

7.5 Appendix E – Rock Chute Analysis

7.6 Appendix F – Culvert Crossing Analysis

APPENDIX A

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).

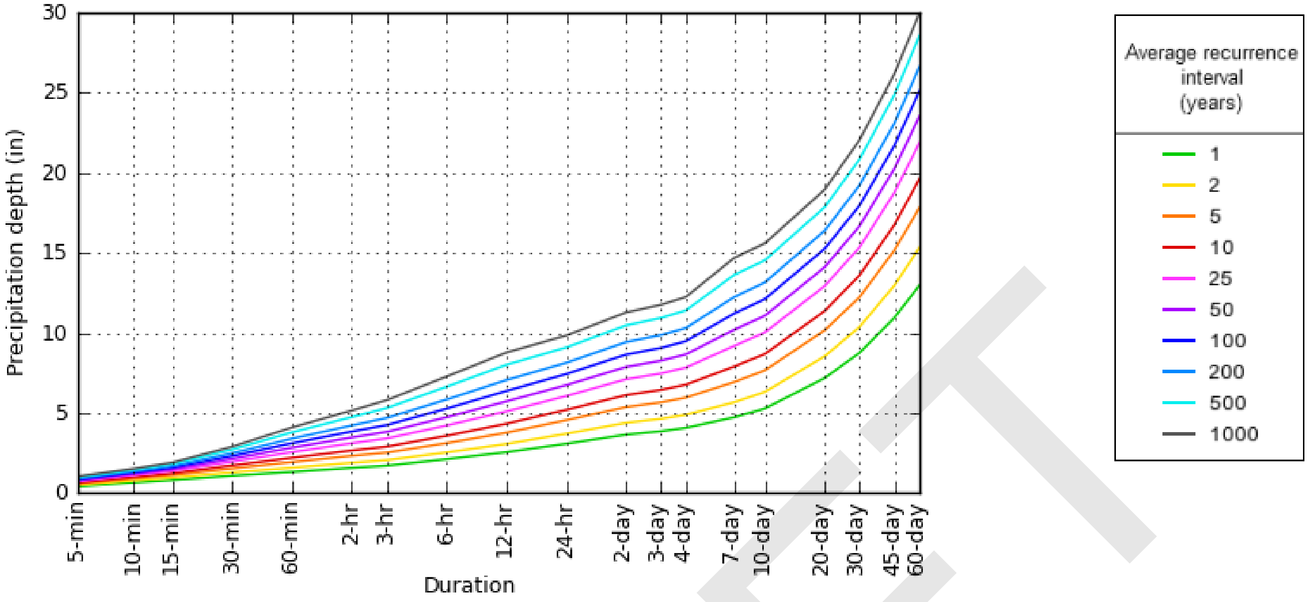
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

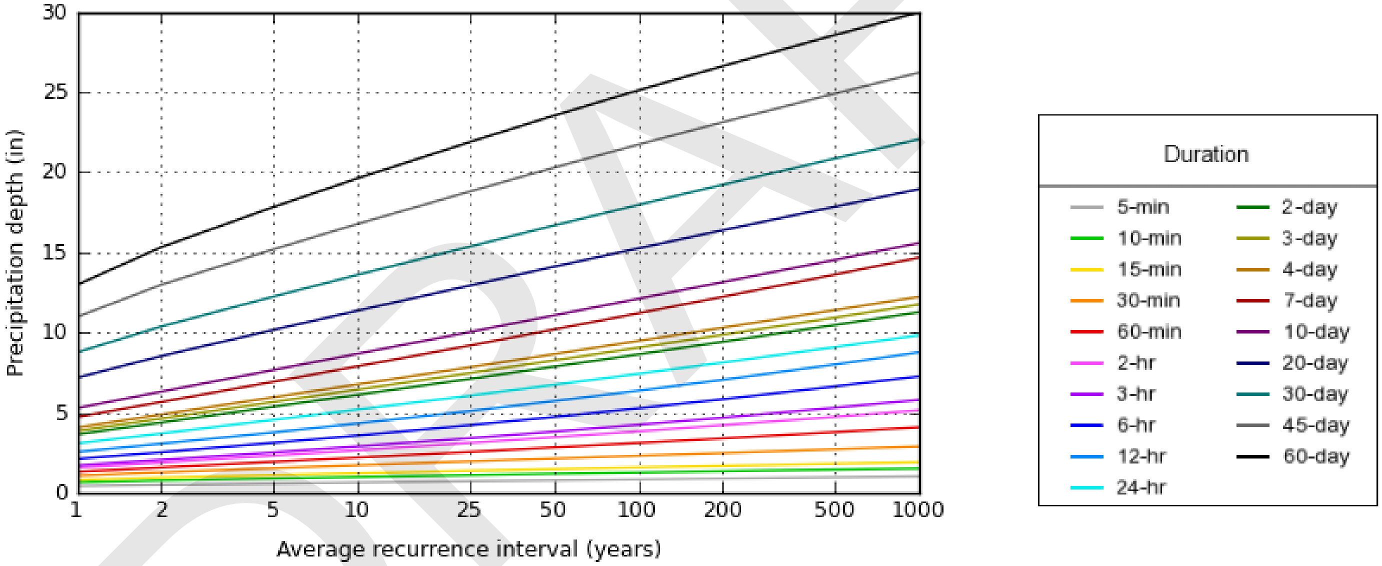
Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 37.1518°, Longitude: -88.7312°



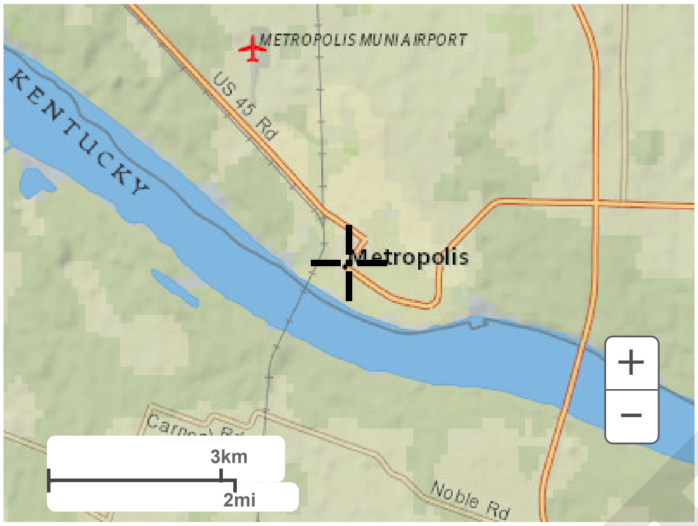


NOAA Atlas 14, Volume 2, Version 3 Created (GMT): Tue Mar 22 21:06:47 2022

Back to Top

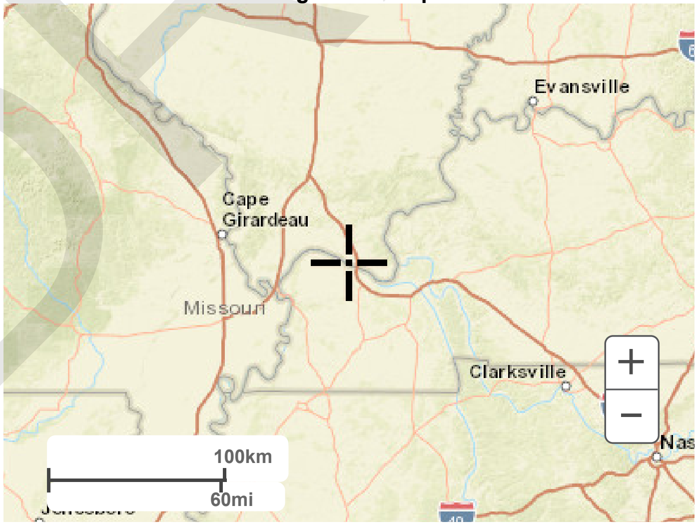
Maps & aerials

Small scale terrain

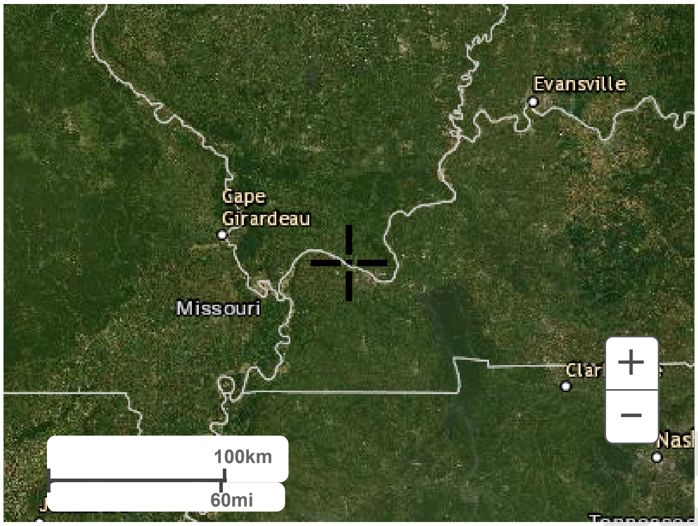


Large scale terrain

Large scale map



Large scale aerial



Back to Top

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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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APPENDIX B

Drainage Maps

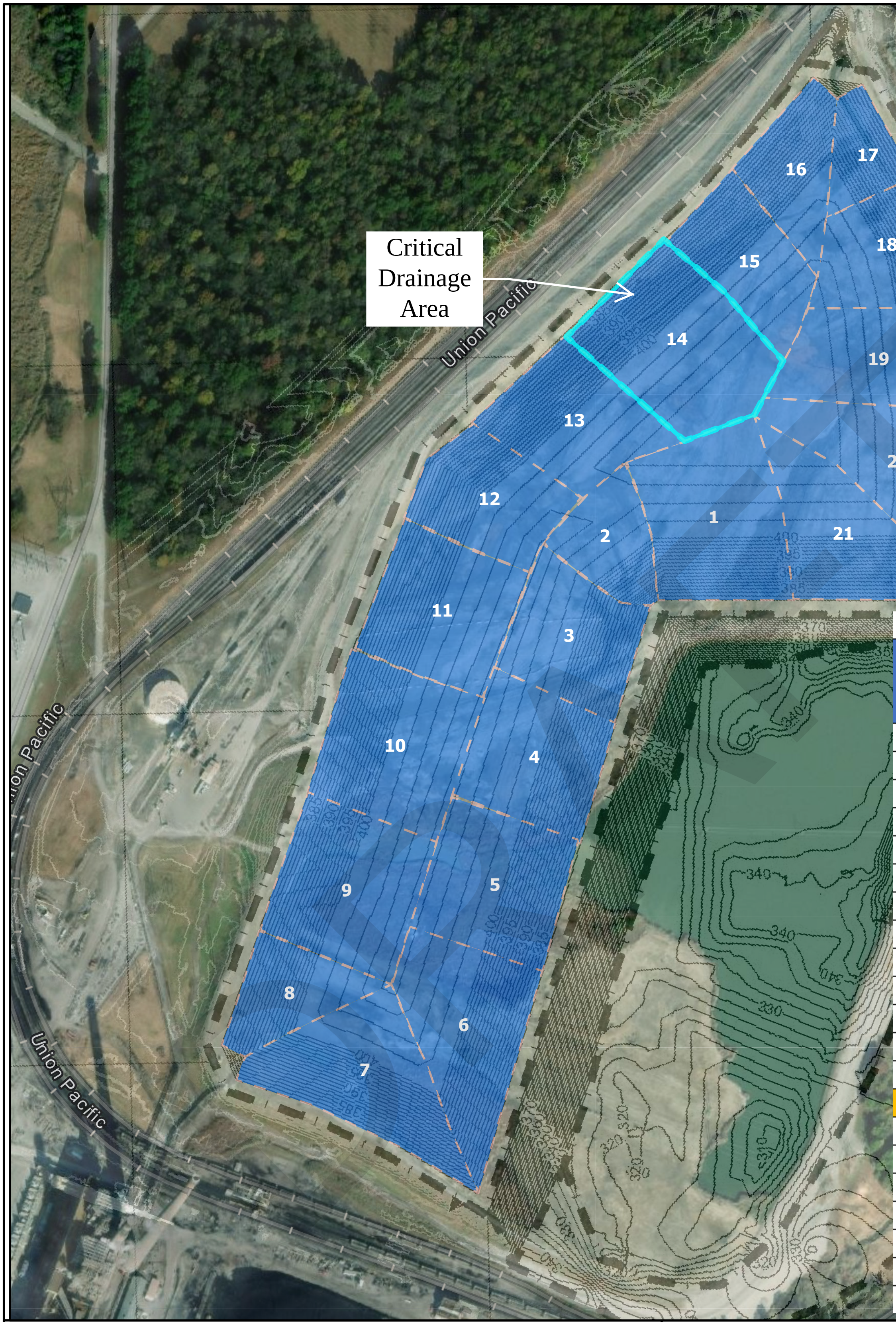
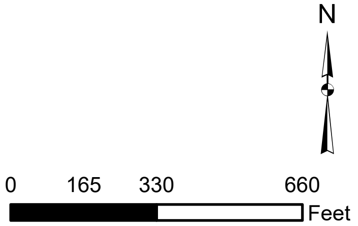


Table 1

Drainage Area Number Identifier	Area (Square Miles)
1	0.0065
2	0.0027
3	0.0044
4	0.0051
5	0.0054
6	0.0059
7	0.0059
8	0.0029
9	0.0060
10	0.0060
11	0.0053
12	0.0042
13	0.0048
14	0.0068
15	0.0038
16	0.0031
17	0.0019
18	0.0042
19	0.0050
20	0.0060
21	0.0051

Legend

🟦 Cover Drainage Area



Drainage Areas

(Joppa, IL)

Geosyntec consultants

Joppa EAP Closure | April 2022

Figure 1

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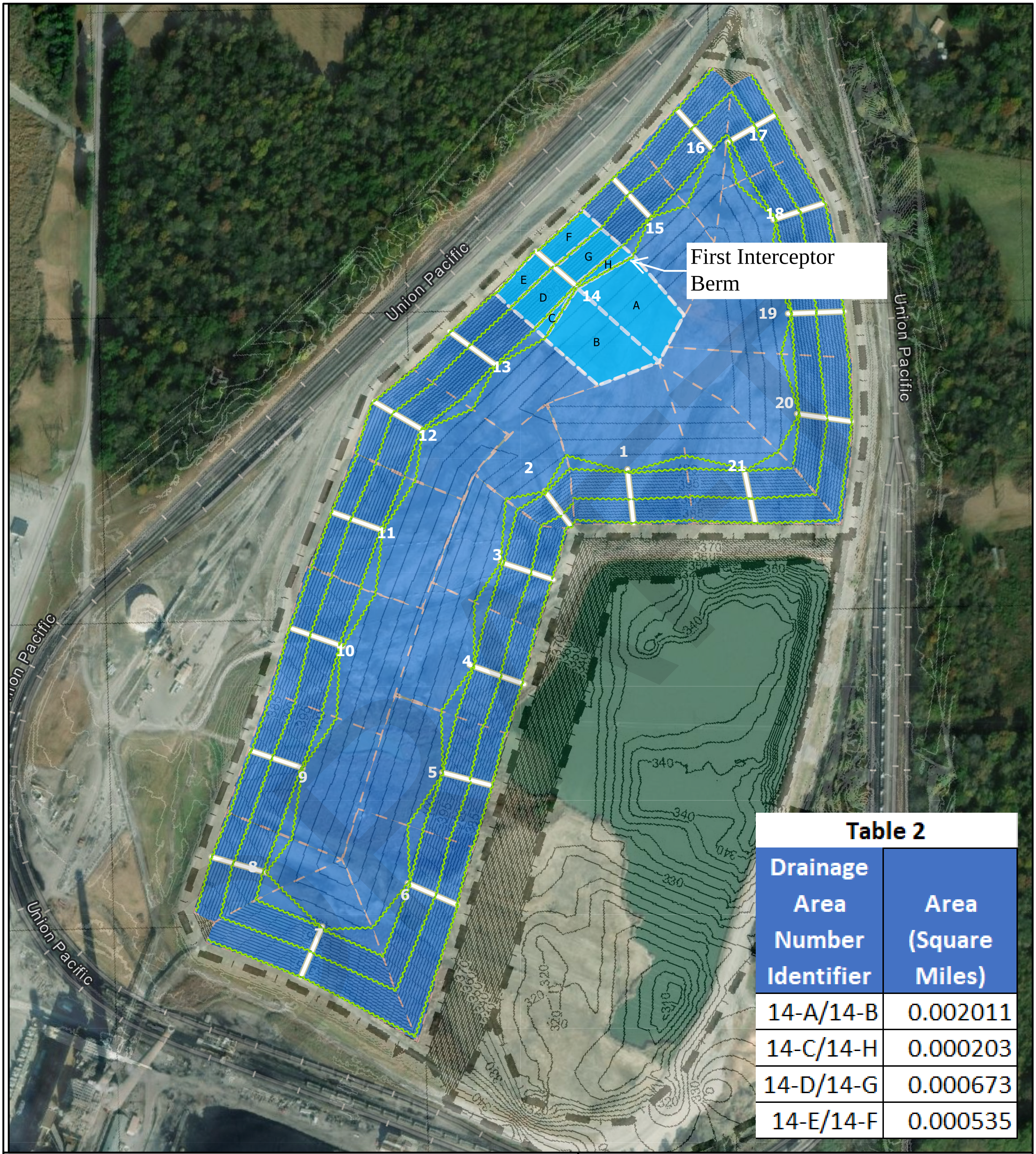

Table 2

Drainage Area Number Identifier	Area (Square Miles)
14-A/14-B	0.002011
14-C/14-H	0.000203
14-D/14-G	0.000673
14-E/14-F	0.000535

Legend

- Interceptor Berm
- Cover Rock Chute
- Critical Drainage Area
- Cover Drainage Area

N

0 165 330 660 Feet

Critical Drainage Area

(Joppa, IL)

Geosyntec consultants

Figure

1

Joppa EAP Closure | April 2022

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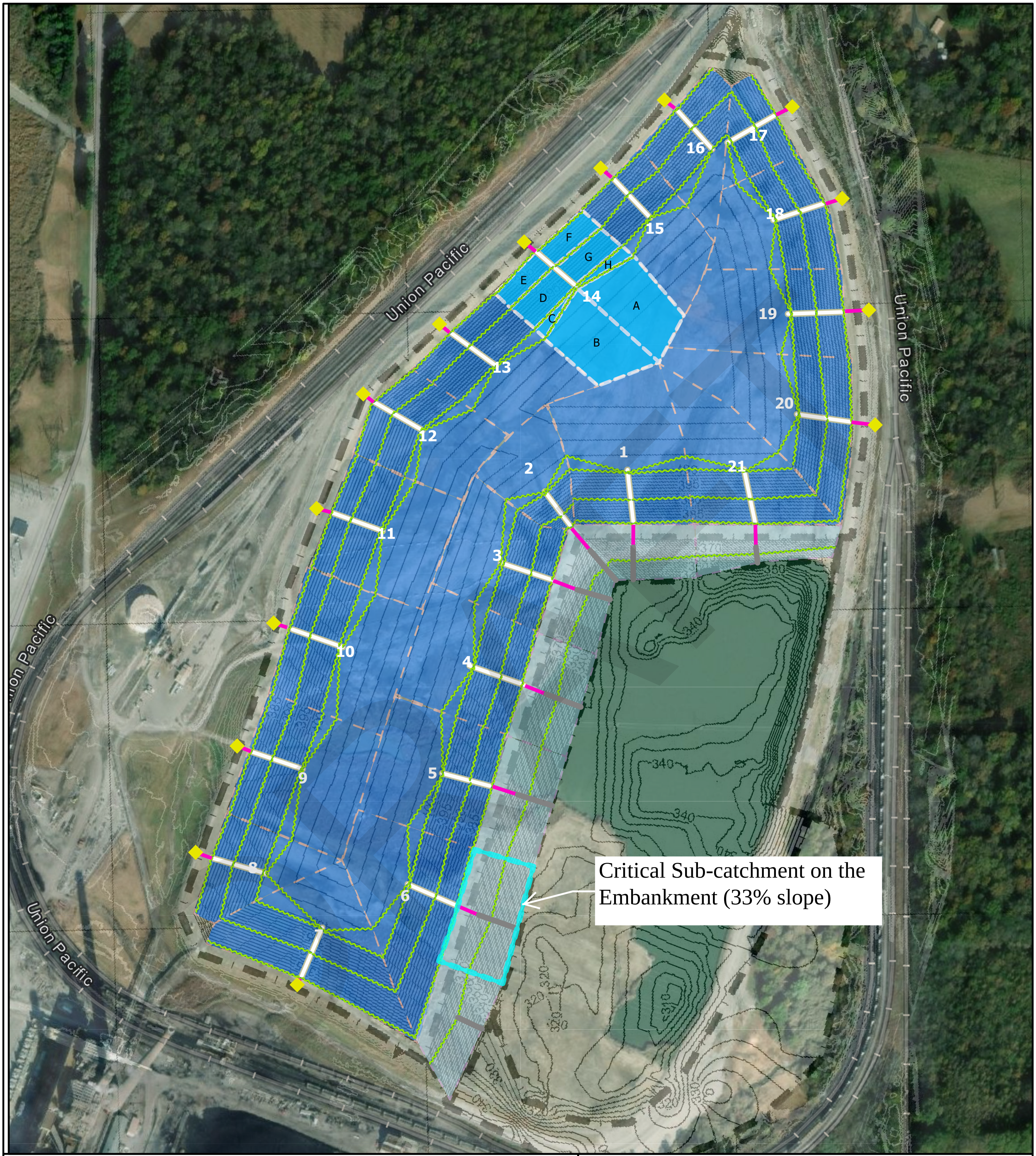

Critical Sub-catchment on the Embankment (33% slope)

Legend

- 🟥 Culvert Crossing
- ▨ Interceptor Berm
- ▭ Cover Rock Chute
- 🟦 Critical Drainage Area
- 🟦 Cover Drainage Area
- ◆ Riprap Apron

N

0 165 330 660 Feet

Critical Drainage Area

(Joppa, IL)

Geosyntec consultants

Joppa EAP Closure | April 2022

Figure

3

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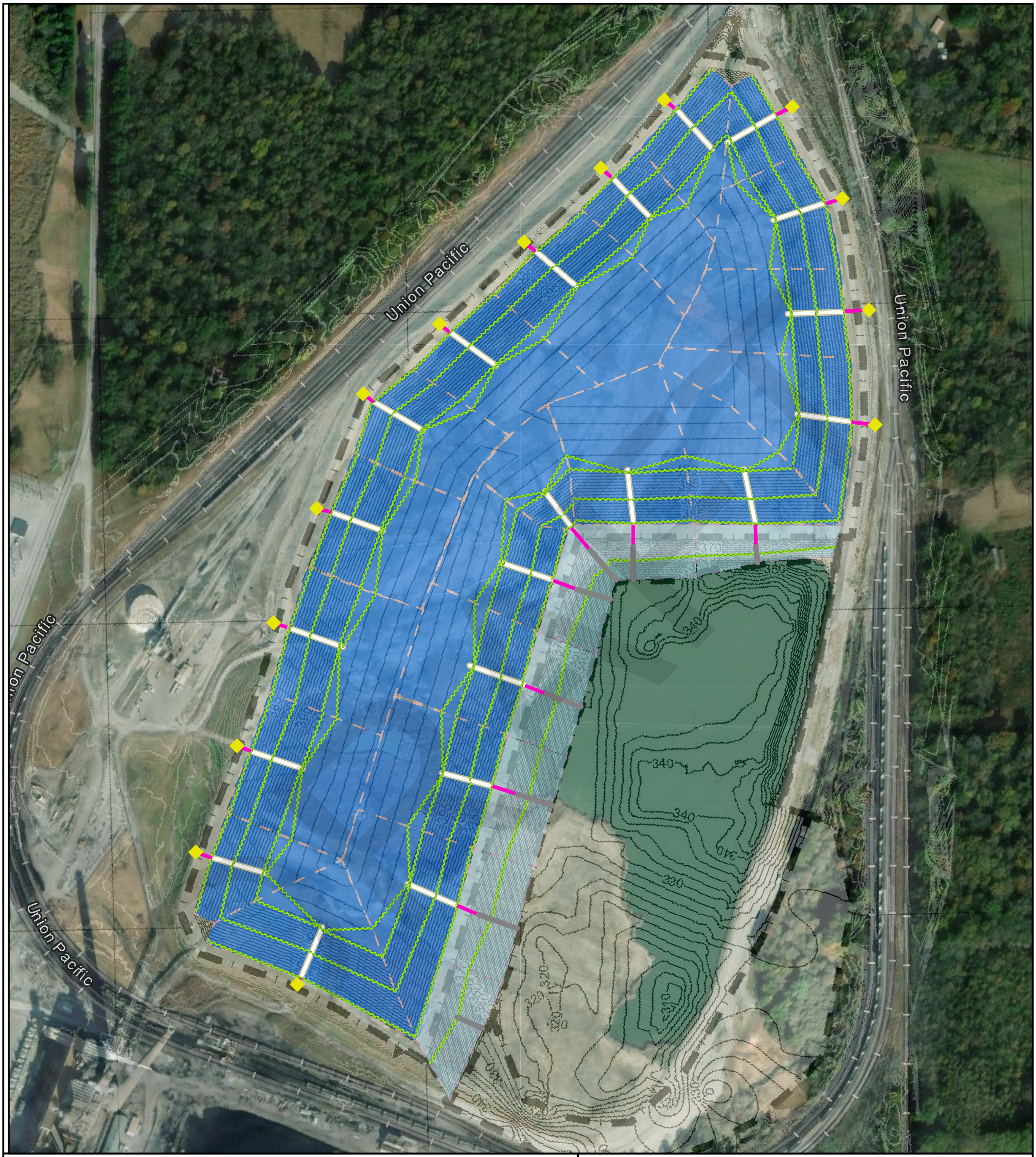
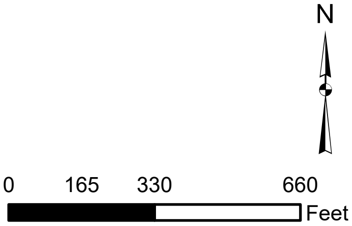


Legend

- ▬ Embk Rock Chute
- ▬ Culvert Crossing
- ┅ Interceptor Berm
- ▭ Cover Rock Chute
- ▨ Embk Drainage Area
- ▨ Cover Drainage Area
- ◆ Riprap Apron



Stormwater Features

(Joppa, IL)

Geosyntec
consultants

Joppa EAP Closure	April 2022	**Figure** 4

APPENDIX C

Sub-catchment Summary and Stormwater Features

Appendix C – Sub-catchment and Stormwater Feature Summary

Table 1: Peak Discharge from Delineated sub-catchments

Stormwater Feature Description	Tributary Drainage Area/Sub-catchment (Square Miles)	Peak Discharge (Cubic Feet Per Second) From HEC-HMS
Cover (2% slope) Interceptor Berm	0.0020	8.5
Cover (10% slope) Interceptor Berm	0.0006	3.4
Cover (10% slope) Rock Chute	0.0068	27.6
Embankment (33% slope) Interceptor Berm	0.0007	3.6
Embankment (33% slope) Rock Chute	0.0029	38.5*

*Peak discharge includes flows from cover rock chute upslope.

Written by:	LH	Date:	09/22/21 DD MM YY	Reviewed by:	PVW	Date:	9/23/21 DD MM YY
Client:	Vistra	Project:	Hennepin Closure Plan	Project No.:	GLP8026	Task No.:	A/03

APPENDIX D

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	

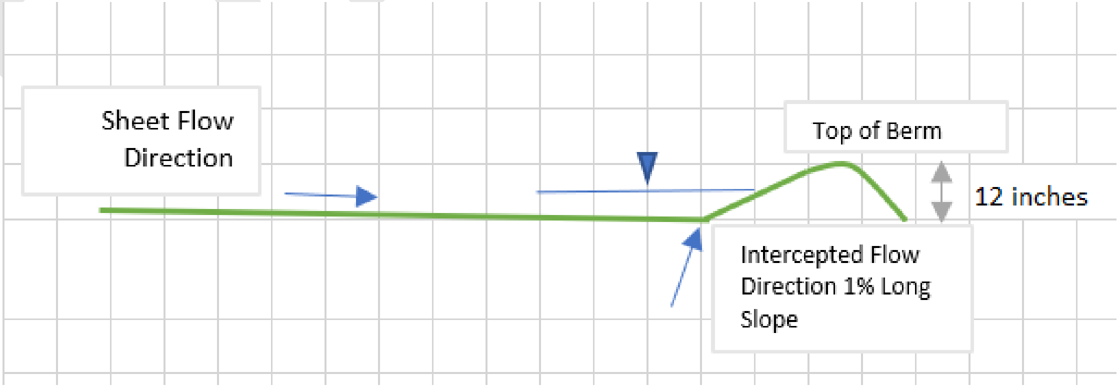
Depth of Flow	Top Width	Area of Flow	Wetted Perimeter	Hydraulic Radius	Channel Slope	Average Velocity	Discharge (Flow Rate)	Avg. Tractive Stress	Comments
Y	T	A	P	R=A/P		V	Q=AV	to	
ft	ft	ft2	ft	ft	ft/ft	ft/s	ft3/s	lb./ft2	
0.01	0.52	0.00	0.52	0.00	0.010	0.14	0.00	0.00	
0.05	2.64	0.07	2.66	0.03	0.010	0.43	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



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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 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		

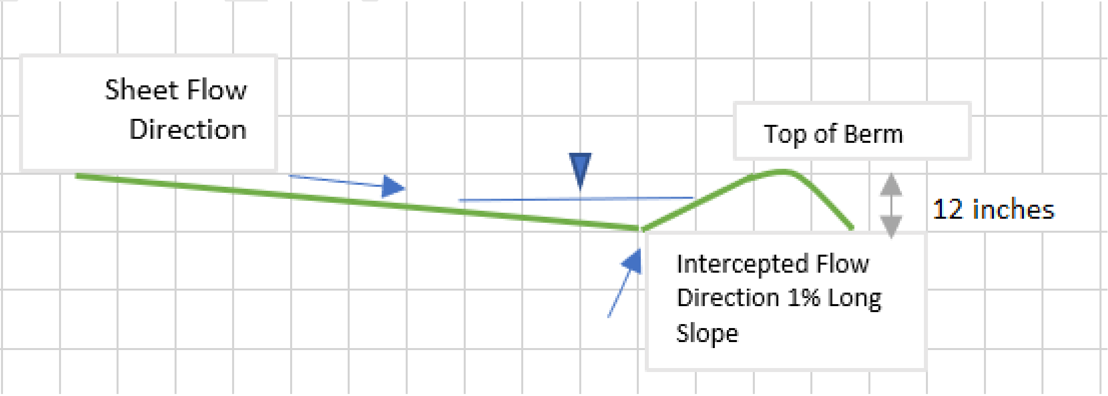
V-Ditch Design Parameters

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 Y ft	Top Width T ft	Area of Flow A ft2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Channel Slope ft/ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft3/s	Avg. Tractive Stress to lb./ft2	Comments
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

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 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		

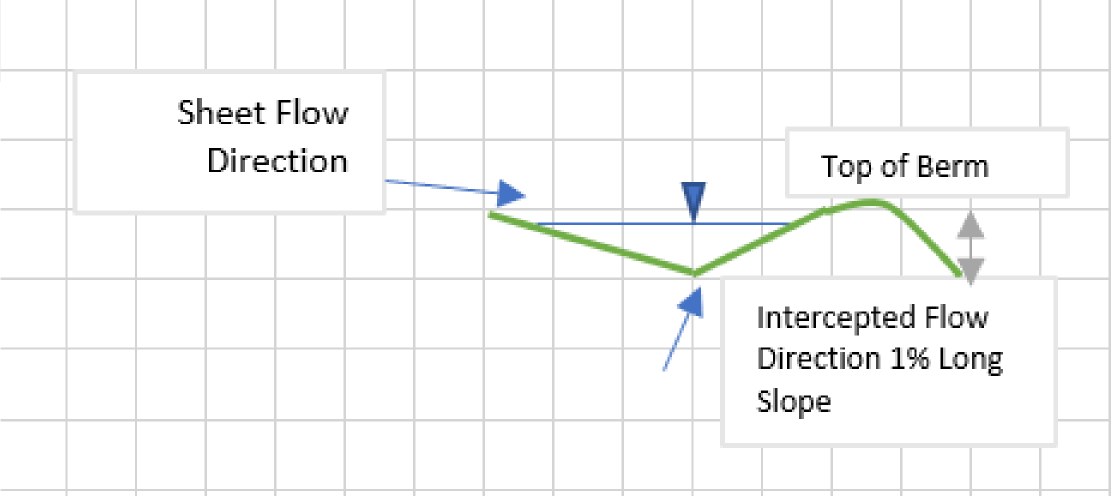
V-Ditch Design Parameters

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 Y ft	Top Width T ft	Area of Flow A ft2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Channel Slope ft/ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft3/s	Avg. Tractive Stress to lb./ft2	Comments
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 E

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

D_{50} dia. = 6.0 in.
$\text{Rock}_{\text{chute}}$ thickness = 12.0in
Inlet apron length = 10 ft.
Outlet apron length = 10 ft.
Radius = 17 ft
Will bedding be used? No

Rock Gradation Envelope

% Passing	*Diameter, in. (weight, lbs.)*
D_{100}--------	9 - 12 (52 - 122)
D_{85}--------	8 - 11 (34 - 89)
D_{50}--------	6 - 9 (15 - 52)
D_{10}--------	5 - 8 (8 - 34)

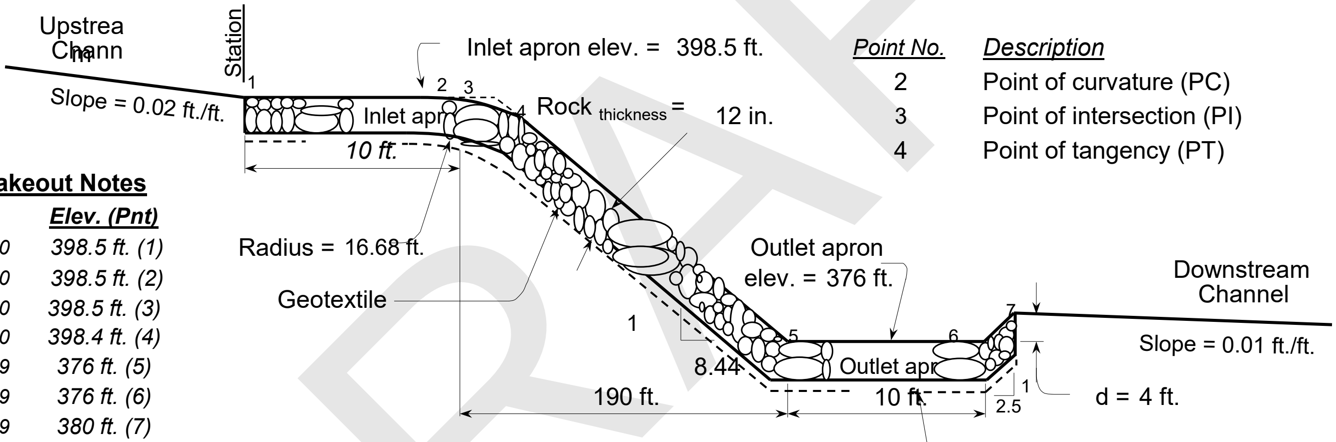
Coefficient of Uniformity, $(D_{60})/(D_{10}) < 1.7$

Quantities [a]

Rock = 154 yd^3
Geotextile (WCS-13)[b] = 542 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.*

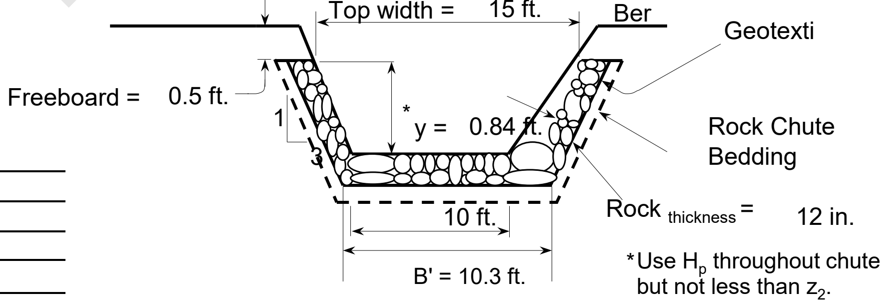


Point No.	*Description*
2	Point of curvature (PC)
3	Point of intersection (PI)
4	Point of tangency (PT)

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



*Use H_p throughout chute but not less than z_2.

Rock Chute Cross Section

Notes:
Rock gradation envelope is 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.
$\text{Rock}_{\text{chute}}$ thickness = 18.0in
Inlet apron length = 12 ft.
Outlet apron length = 12 ft.
Radius = 25 ft
Will bedding be used? No

Rock Gradation Envelope

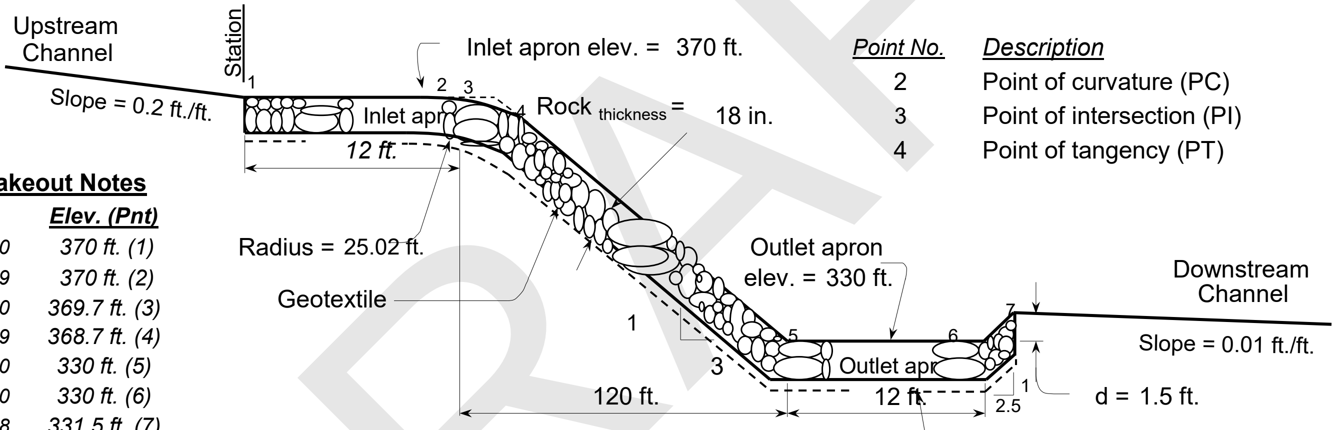
% Passing	*Diameter, in. (weight, lbs.)*
D_{100}--------	14 - 18 (174 - 413)
D_{85}--------	12 - 16 (113 - 301)
D_{50}--------	9 - 14 (52 - 174)
D_{10}--------	7 - 12 (26 - 113)

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.*

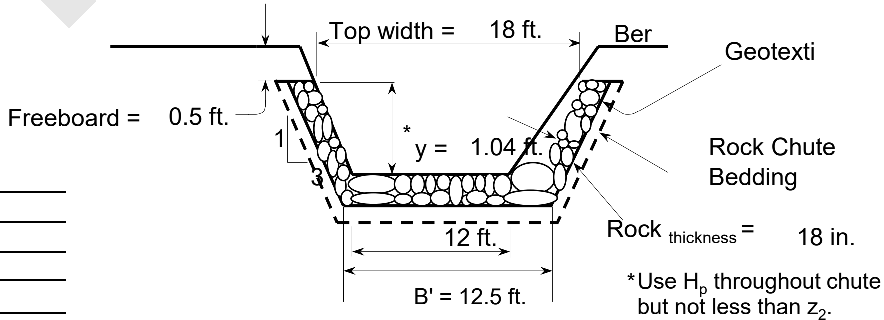


Point No.	*Description*
2	Point of curvature (PC)
3	Point of intersection (PI)
4	Point of tangency (PT)

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)*

Profile Along Centerline of Rock Chute



*Use H_p throughout chute but not less than z_2.

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 F

Culvert Crossing Analysis

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 13.70 cfs

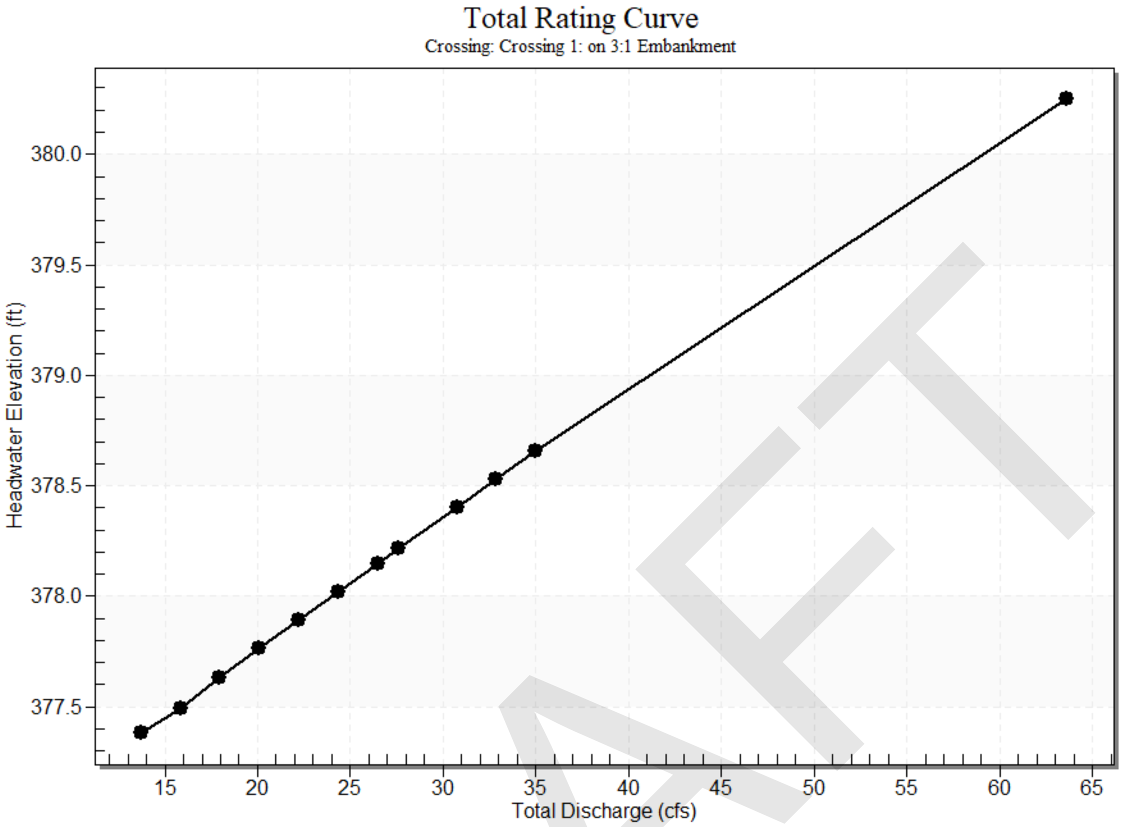
Design Flow: 27.60 cfs

Maximum Flow: 35.00 cfs

Table 1 - Summary of Culvert Flows at Crossing: Crossing 1: on 3:1 Embankment

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
377.38	13.70	13.70	0.00	1
377.49	15.83	15.83	0.00	1
377.63	17.96	17.96	0.00	1
377.76	20.09	20.09	0.00	1
377.89	22.22	22.22	0.00	1
378.02	24.35	24.35	0.00	1
378.15	26.48	26.48	0.00	1
378.21	27.60	27.60	0.00	1
378.40	30.74	30.74	0.00	1
378.53	32.87	32.87	0.00	1
378.66	35.00	35.00	0.00	1
380.00	54.10	54.10	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 1: on 3:1 Embankment



Culvert Data: Culvert 1

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
13.70 cfs	13.70 cfs	377.38	1.38	0.0*	1-S2n	0.59	1.18	0.61	0.29	13.20	4.39
15.83 cfs	15.83 cfs	377.49	1.49	0.0*	1-S2n	0.63	1.27	0.66	0.31	13.70	4.63
17.96 cfs	17.96 cfs	377.63	1.63	0.0*	1-S2n	0.67	1.36	0.70	0.34	14.22	4.84
20.09 cfs	20.09 cfs	377.76	1.76	0.0*	1-S2n	0.71	1.44	0.71	0.36	15.61	5.04

22.22 cfs	22.22 cfs	377.89	1.89	0.0*	1-S2n	0.75	1.52	0.78	0.38	15.29	5.22
24.35 cfs	24.35 cfs	378.02	2.02	0.0*	1-S2n	0.79	1.59	0.82	0.40	15.46	5.40
26.48 cfs	26.48 cfs	378.15	2.15	0.0*	1-S2n	0.82	1.66	0.86	0.42	15.85	5.56
27.60 cfs	27.60 cfs	378.21	2.21	0.0*	1-S2n	0.84	1.70	0.88	0.43	15.94	5.64
30.74 cfs	30.74 cfs	378.40	2.40	0.0*	1-S2n	0.89	1.80	0.93	0.46	16.35	5.85
32.87 cfs	32.87 cfs	378.53	2.53	0.0*	1-S2n	0.92	1.86	0.97	0.48	16.72	5.99
35.00 cfs	35.00 cfs	378.66	2.66	0.0*	1-S2n	0.95	1.92	1.01	0.50	16.83	6.12

* Full Flow Headwater elevation is below inlet invert.

Culvert Barrel Data

Culvert Barrel Type Straight Culvert

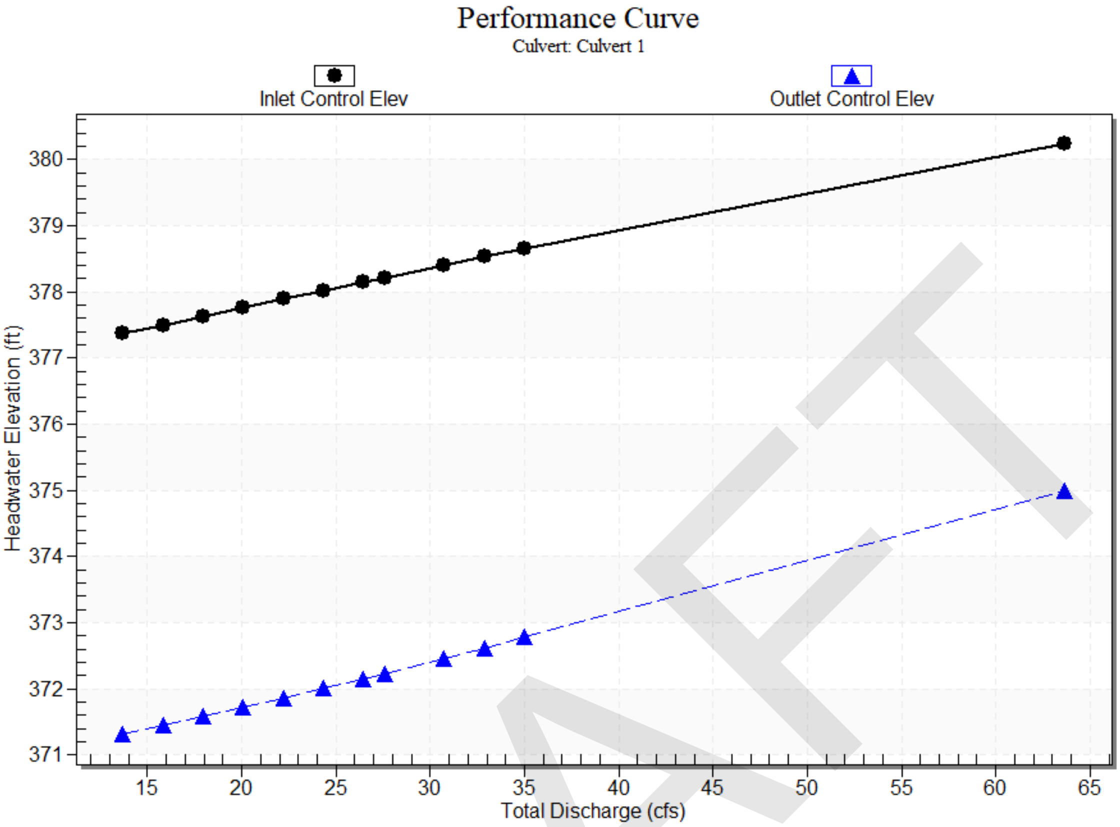
Inlet Elevation (invert): 376.00 ft,

Outlet Elevation (invert): 370.00 ft

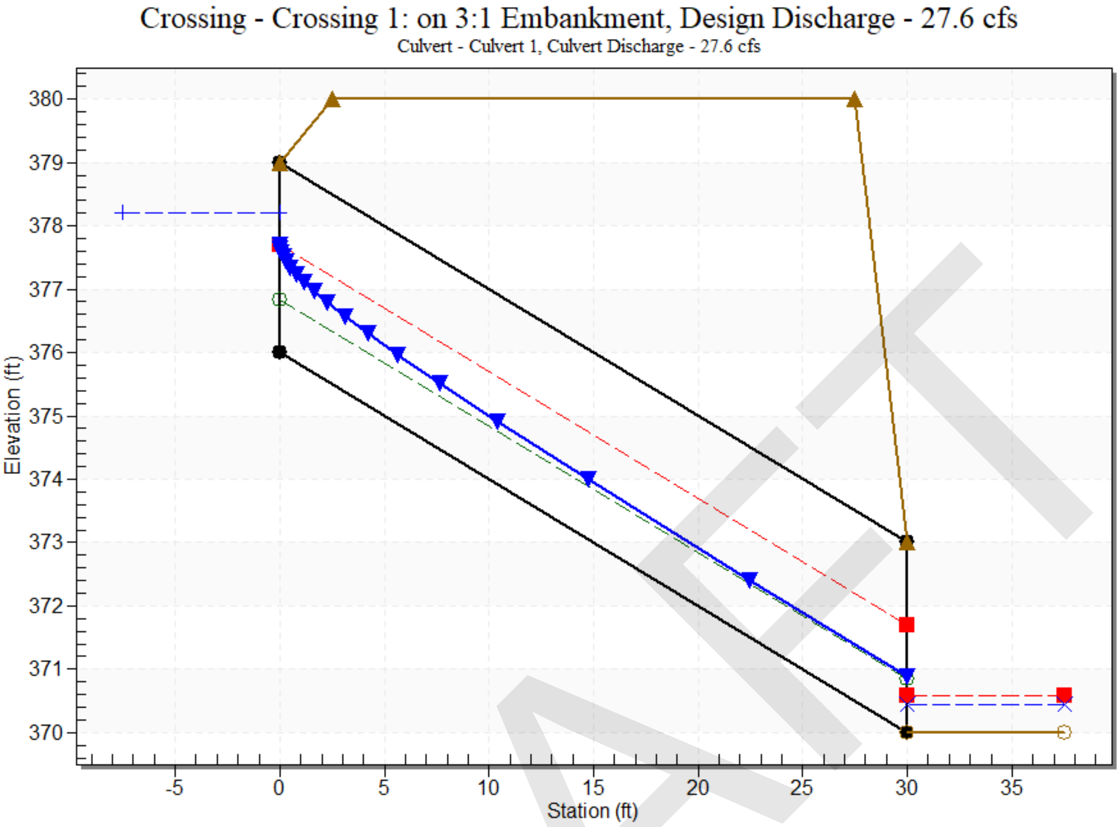
Culvert Length: 30.59 ft,

Culvert Slope: 0.2000

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 376.00 ft

Outlet Station: 30.00 ft

Outlet Elevation: 370.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Corrugated PE

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Tailwater Data for Crossing: Crossing 1: on 3:1 Embankment

Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 1: on 3:1 Embankment)

Flow (cfs)	Water Surface Elev (ft)	Velocity (ft/s)	Depth (ft)	Shear (psf)	Froude Number
13.70	370.29	0.29	4.39	5.91	1.50
15.83	370.31	0.31	4.63	6.44	1.52
17.96	370.34	0.34	4.84	6.94	1.54
20.09	370.36	0.36	5.04	7.41	1.55
22.22	370.38	0.38	5.22	7.86	1.57
24.35	370.40	0.40	5.40	8.29	1.58
26.48	370.42	0.42	5.56	8.71	1.59
27.60	370.43	0.43	5.64	8.92	1.59
30.74	370.46	0.46	5.85	9.50	1.61
32.87	370.48	0.48	5.99	9.87	1.62
35.00	370.50	0.50	6.12	10.24	1.63

Tailwater Channel Data - Crossing 1: on 3:1 Embankment

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 3.00 (_:1)

Channel Slope: 0.3300

Channel Manning's n: 0.0800

Channel Invert Elevation: 370.00 ft

Roadway Data for Crossing: Crossing 1: on 3:1 Embankment

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 380.00 ft

Roadway Surface: Gravel

Roadway Top Width: 25.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 13.40 cfs

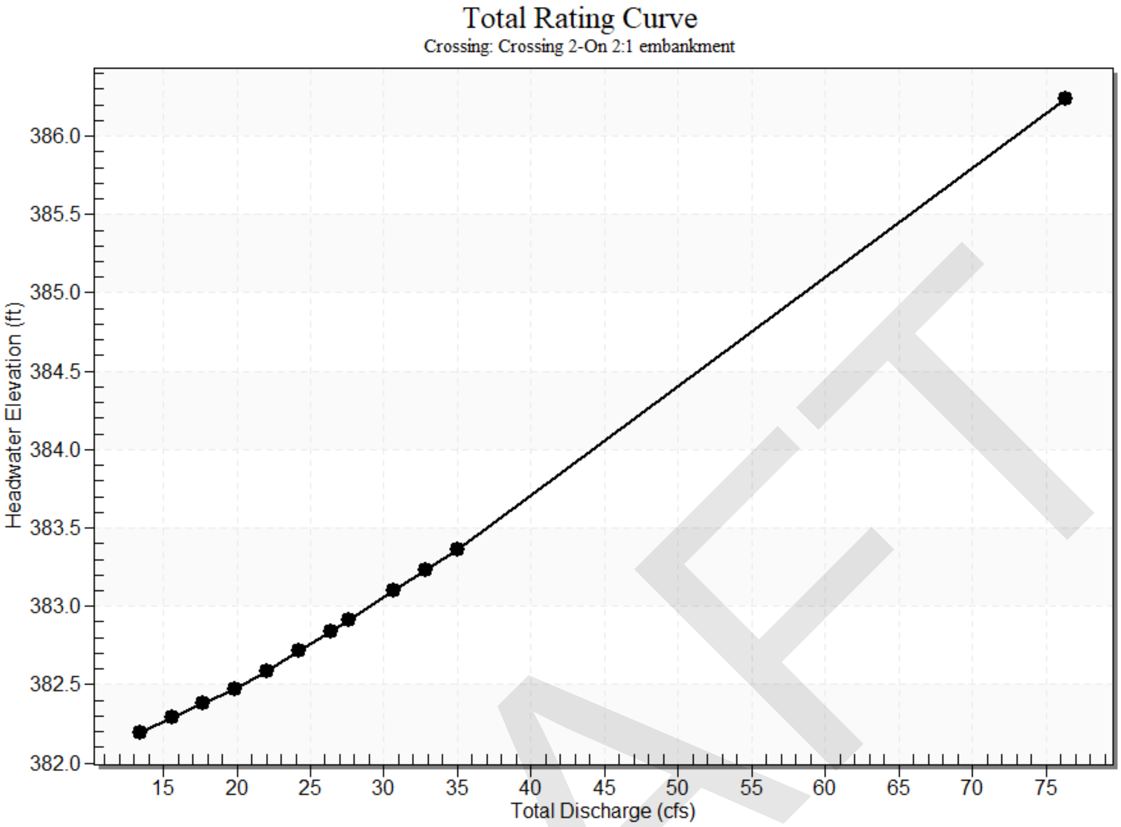
Design Flow: 27.60 cfs

Maximum Flow: 35.00 cfs

Table 4 - Summary of Culvert Flows at Crossing: Crossing 2-On 2:1 embankment

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
382.19	13.40	13.40	0.00	1
382.29	15.56	15.56	0.00	1
382.38	17.72	17.72	0.00	1
382.47	19.88	19.88	0.00	1
382.58	22.04	22.04	0.00	1
382.71	24.20	24.20	0.00	1
382.84	26.36	26.36	0.00	1
382.91	27.60	27.60	0.00	1
383.10	30.68	30.68	0.00	1
383.23	32.84	32.84	0.00	1
383.36	35.00	35.00	0.00	1
386.00	68.14	68.14	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 2-On 2:1 embankment



Culvert Data: Culvert 1

Table 5 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
13.40 cfs	13.40 cfs	382.19	1.19	0.0*	1-S2n	0.49	1.16	0.49	0.26	17.73	5.17
15.56 cfs	15.56 cfs	382.29	1.29	0.0*	1-S2n	0.53	1.26	0.56	0.28	17.13	5.47
17.72 cfs	17.72 cfs	382.38	1.38	0.0*	1-S2n	0.56	1.35	0.59	0.31	17.94	5.76
19.88 cfs	19.88 cfs	382.47	1.47	0.0*	1-S2n	0.60	1.43	0.63	0.33	18.60	6.02

22.04 cfs	22.04 cfs	382.58	1.58	0.0*	1-S2n	0.63	1.51	0.66	0.35	19.20	6.26
24.20 cfs	24.20 cfs	382.71	1.71	0.0*	1-S2n	0.66	1.59	0.66	0.37	21.08	6.49
26.36 cfs	26.36 cfs	382.84	1.84	0.0*	1-S2n	0.69	1.66	0.69	0.39	21.59	6.70
27.60 cfs	27.60 cfs	382.91	1.91	0.0*	1-S2n	0.70	1.70	0.74	0.40	20.44	6.82
30.68 cfs	30.68 cfs	383.10	2.10	0.0*	1-S2n	0.74	1.80	0.78	0.43	21.02	7.10
32.84 cfs	32.84 cfs	383.23	2.23	0.0*	1-S2n	0.77	1.86	0.81	0.45	21.46	7.29
35.00 cfs	35.00 cfs	383.36	2.36	0.0*	1-S2n	0.79	1.92	0.83	0.47	21.86	7.47

* Full Flow Headwater elevation is below inlet invert.

Culvert Barrel Data

Culvert Barrel Type Straight Culvert

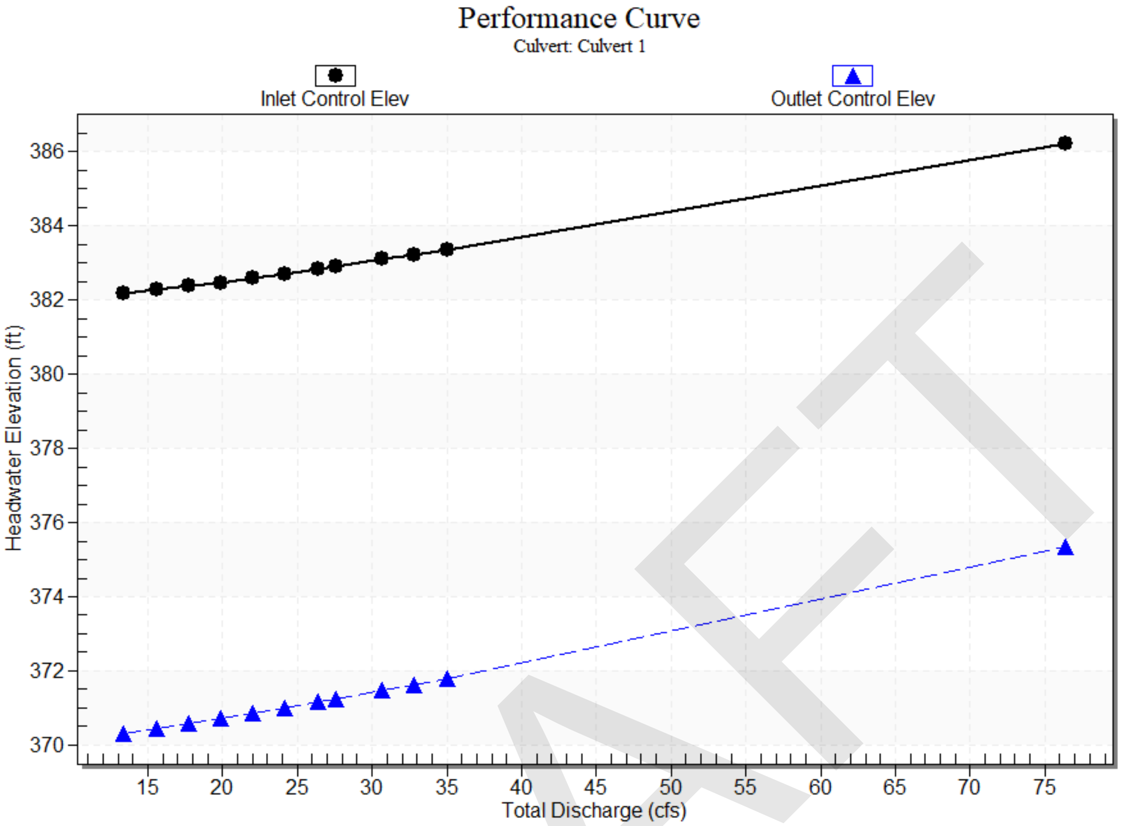
Inlet Elevation (invert): 381.00 ft,

Outlet Elevation (invert): 369.00 ft

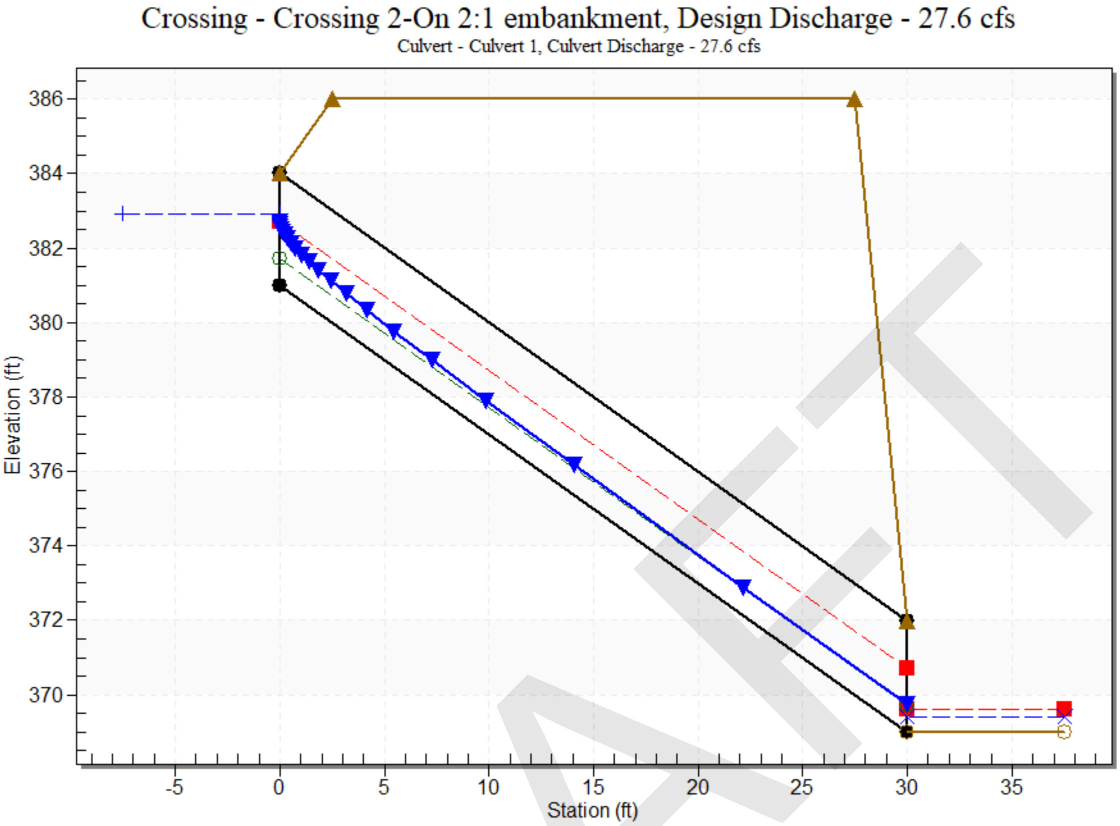
Culvert Length: 32.31 ft,

Culvert Slope: 0.4000

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 381.00 ft

Outlet Station: 30.00 ft

Outlet Elevation: 369.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Corrugated PE

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Tailwater Data for Crossing: Crossing 2-On 2:1 embankment

Table 6 - Downstream Channel Rating Curve (Crossing: Crossing 2-On 2:1 embankment)

Flow (cfs)	Water Surface Elev (ft)	Velocity (ft/s)	Depth (ft)	Shear (psf)	Froude Number
13.40	369.26	0.26	5.17	8.09	1.79
15.56	369.28	0.28	5.47	8.87	1.81
17.72	369.31	0.31	5.76	9.61	1.83
19.88	369.33	0.33	6.02	10.31	1.84
22.04	369.35	0.35	6.26	10.98	1.86
24.20	369.37	0.37	6.49	11.64	1.87
26.36	369.39	0.39	6.70	12.27	1.88
27.60	369.40	0.40	6.82	12.62	1.89
30.68	369.43	0.43	7.10	13.48	1.90
32.84	369.45	0.45	7.29	14.06	1.91
35.00	369.47	0.47	7.47	14.63	1.92

Tailwater Channel Data - Crossing 2-On 2:1 embankment

Tailwater Channel Option: Rectangular Channel

Bottom Width: 10.00 ft

Channel Slope: 0.5000

Channel Manning's n: 0.0800

Channel Invert Elevation: 369.00 ft

Roadway Data for Crossing: Crossing 2-On 2:1 embankment

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 386.00 ft

Roadway Surface: Gravel

Roadway Top Width: 25.00 ft

ATTACHMENT E

Geotechnical Design of Slopes and Final Cover System

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**

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Date 04-25-2022

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
2022 Geosyntec Investigation 7

3- Summary of Subsurface Conditions 8

Embankment Fill 9
CCR 9
Foundation Clay 9
Foundations Sand 9
Soft Clay/Miscellaneous Fill 9

4- Design Geotechnical Strength and Unit Weight Parameters 9

Drained Shear Strength 11
Undrained Shear Strength 13
Unit Weight 16

5- Consolidation characterization 19

6- Groundwater Conditions 20

7- Seismic Assessments 22

Site Seismic Hazard Assessment 22
Liquefaction Triggering Analysis 23
Pseudostatic Seismic Analysis 23

8- Global Slope Stability 23

Selected Cross-sections 25
Results 27

9- Veneer Cover Stability 27

10- Settlement Analyses 31

11- Conclusions 31

12- References 31

LIST OF ATTACHMENTS

Attachment A – 2016 AECOM Geotechnical Report

Attachment B – Excerpts from 2021 Geosyntec Investigation

Attachment C – Excerpts from 2022 Geosyntec Investigation

Attachment D – Summary of 2022 Geosyntec Subsurface Characterization

Attachment E – AECOM Seicmic Hazard Assessment

Attachment F – EAP Subsurface Layer Interface Maps

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 performed to support 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) include:

(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) Global slope stability analyses considering post-closure conditions for static and seismic conditions; and

(iv) Cover system veneer stability analyses.

The following analyses will be provided in a subsequent revision to this draft package:

(i) Liquefaction screening analyses for the CCR and subsurface soils, and

(ii) Settlement analyses for post-closure conditions.

2- SUMMARY OF SUBSURFACE INVESTIGATIONS

2015 AECOM Investigation

A subsurface investigation program was performed by AECOM at the EAP and adjacent CCR surface impoundments in August of 2015 [1] to be used for evaluating 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 (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 and the results from a sampling and testing program performed by Geotechnology in 2010. CPT and Boring locations by this investigation are shown on **Figure 1**.

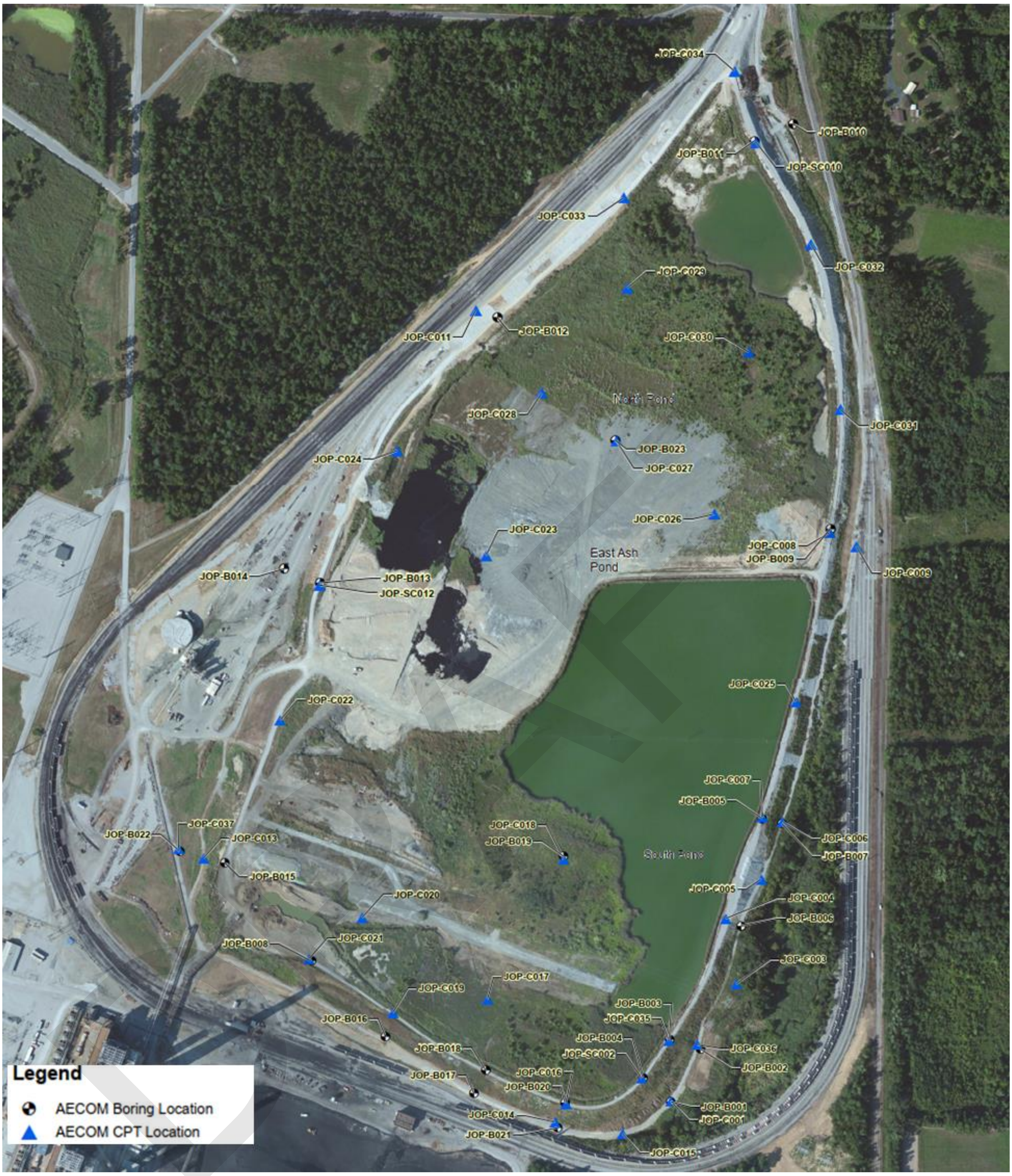

Figure 1 – 2015 AECOM Subsurface Investigation Locations

[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 [2] to resolve data gaps to 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 ten well borings outside the EAP, as shown in **Figure 2**.

The hollow-stem auger borings were advanced to between 17 and 20 ft below grade and the sonic borings were advanced to 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 the following laboratory tests were performed:

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, is provided in **Attachment B**.

Figure 2 – 2021 Geosyntec Subsurface Investigation Locations[1]

2022 Geosyntec Investigation

An investigation for CCR delineation in the southeast of East Ash Pond was completed by Geosyntec in March of 2022 to evaluate the lateral and vertical extents of CCR located outside of the EAP perimeter embankments. The investigation program included

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[1] The 2021 Geosyntec investigation also included monitoring wells installed around the perimeter of the EAP. These monitoring wells did not include conducting in-situ geotechnical tests or laboratory tests for were not used for contouring the groundwater flow and are therefore not discussed further in this report.

advancing five hand auger borings within the exterior of the EAP, as shown in **Figure 3**. Boring logs are provided in **Attachment C**.

This investigation will be expanded to use direct push technique (DPT) sampling at a later date. This draft package will be updated to discuss the results of this investigation, at that time.

Figure 3 – 2022 Geosyntec Subsurface Investigation Locations

3- SUMMARY OF SUBSURFACE CONDITIONS

AECOM [1] and Geosyntec [2] 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 to be 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 showed the soil to be 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 gravel content. Samples obtained from the field investigation showed samples to be 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 done by this package due to removal of 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 Sands. 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 [3]).
    - 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 peak 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. For undrained conditions, τ_{ff} was used directly as undrained shear strength. For drained conditions τ_{ff} was utilized along with effective stresses normal to the failure plane at failure, σ'_n .
    - 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 [4]).
    - A total of six tests were performed on samples of Foundation Clay.
    - 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 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 [5]).
    - 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 [6]).
    - 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 [7]).
    - 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 D.**

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_{ff}, 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 Clays, and CCR, respectively.

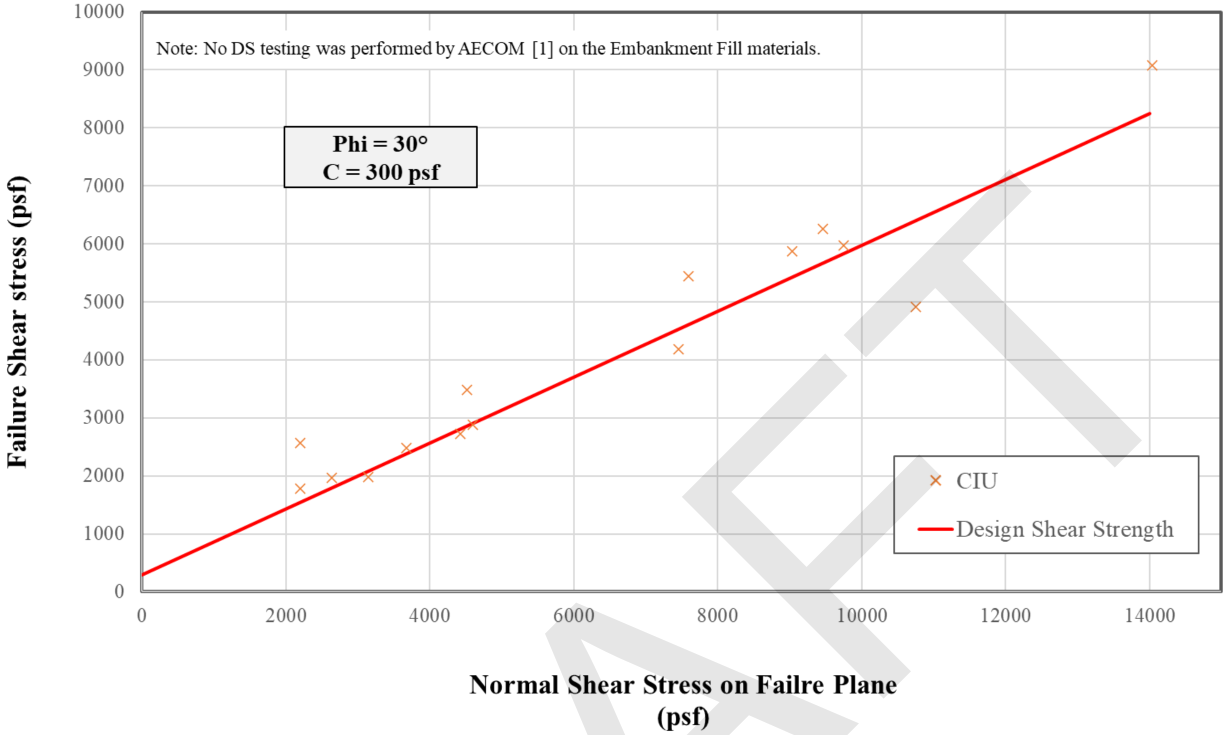


Figure 4. Drained Strength Data and Design Envelope for Embankment Fill

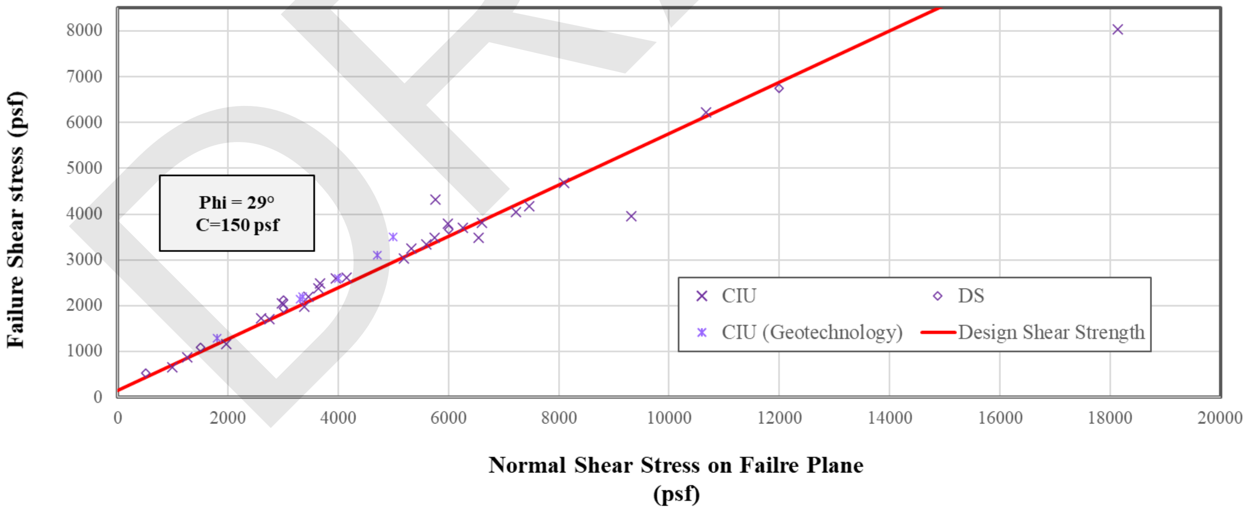


Figure 5. Drained Strength Data and Design Envelope for Foundation Clays

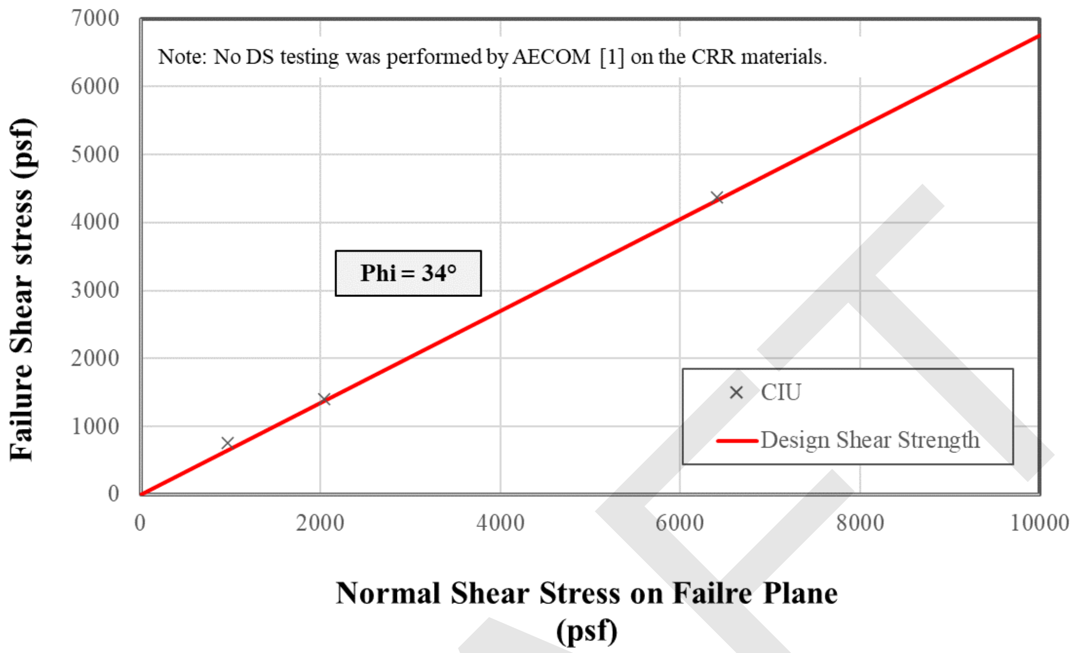


Figure 6. Drained Strength Data and Design Envelope for CCR

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 above one-third of the plotted points and below two-thirds of the plotted points. For the Embankment Fill material, a uniform shear strength vs. elevation was assigned, as the data did not indicate significant variations in strength vs. depth. For the Foundation Clay a variable shear strength envelope was utilized, where a uniform shear strength was assigned above El. 340 ft, and a shear strength that increased 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 strength tests, shown in **Figure 9**, indicate that the CCR undrained shear strength ratio graph, Su/σ'_{3c}, results in a 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.

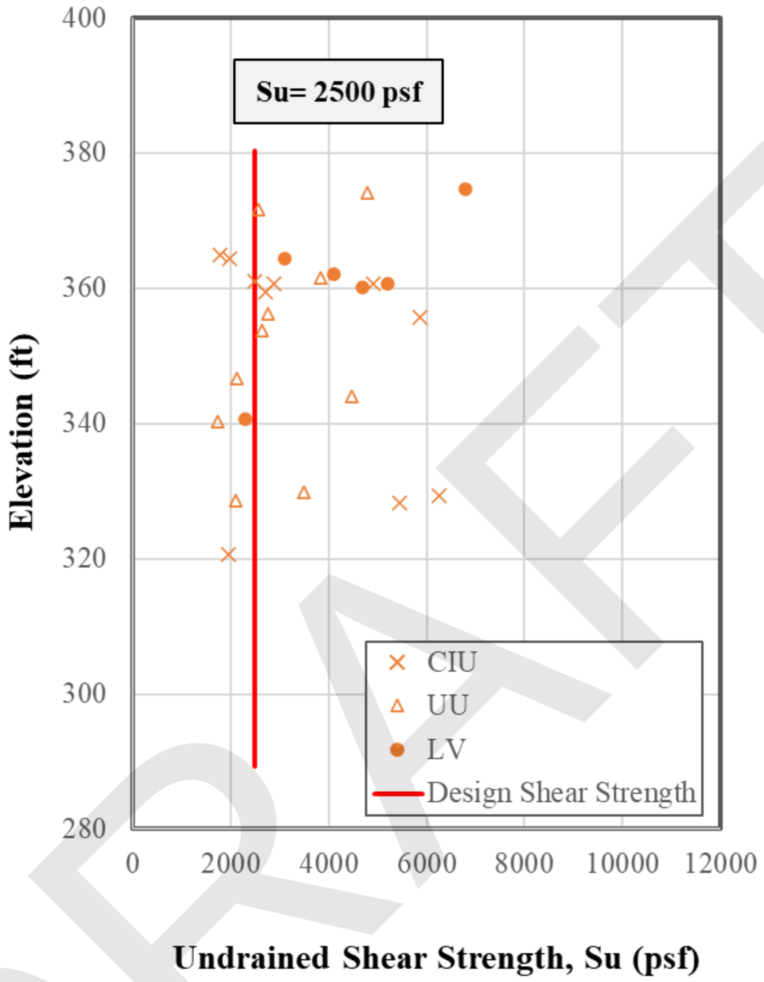
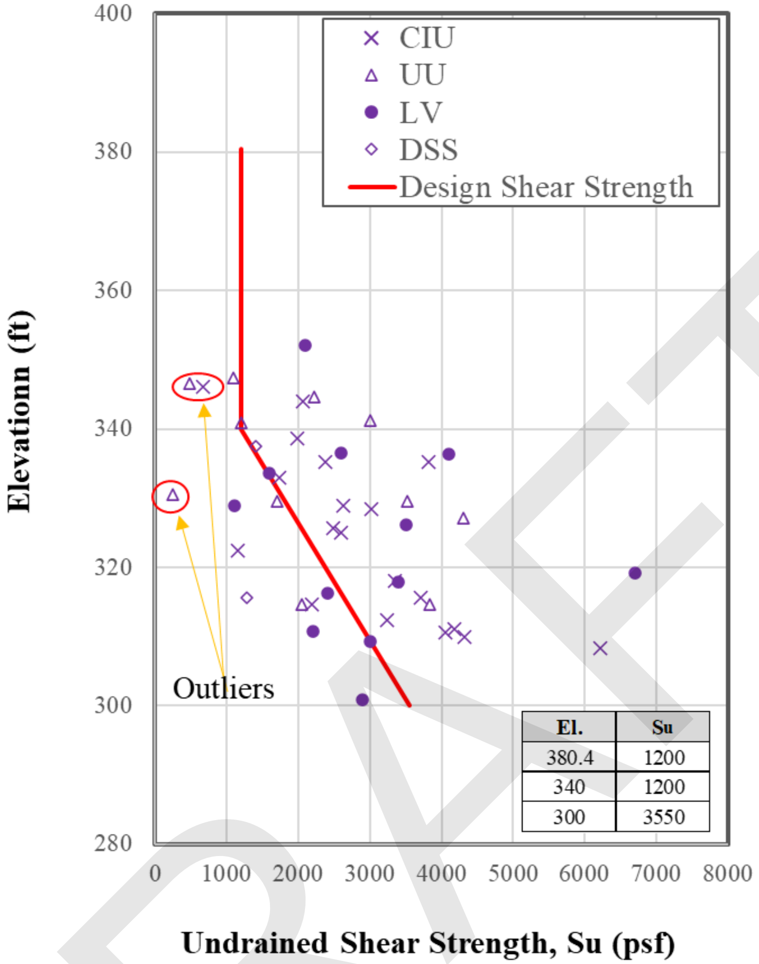


Figure 7. Undrained Strength Data and Design Envelope for Embankment Fill



El.	Su
380.4	1200
340	1200
300	3550

Figure 8. Undrained Strength Data and Design Envelope for Foundation Clay

(Note: S_u is capped at 3,550 psf below El. 300 ft)

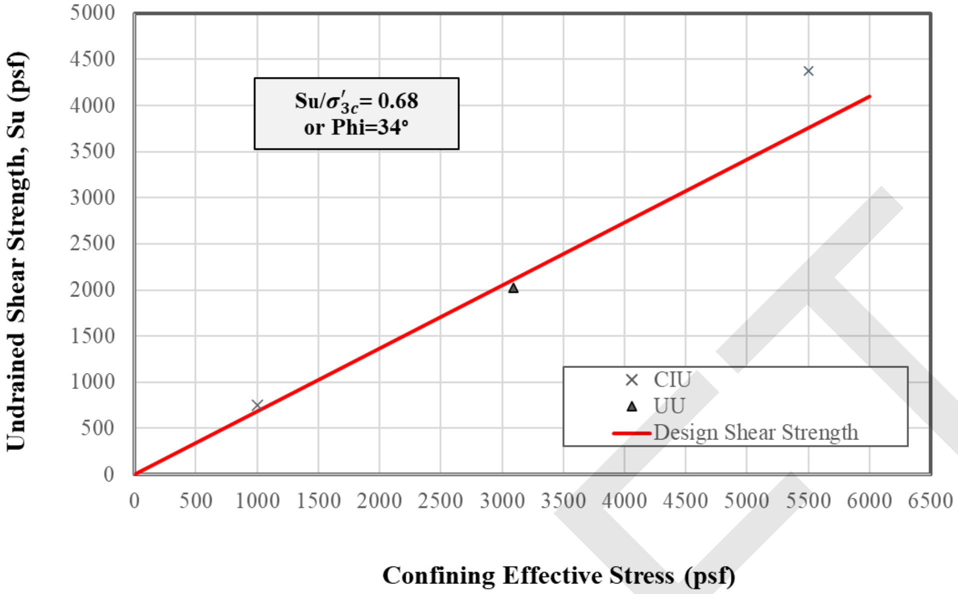


Figure 9. Undrained Strength Data and Envelope for CCR

Design geotechnical materials for the final covers were also selected based on Geosyntec's experience.

Unit Weight

A total of 169 measurements from AECOM [1] report were utilized to develop design total unit weights, γ_t, for Embankment Fill, Foundation Clay, and CCR materials. This was performed by plotting the unit weight values versus sample elevations. The geometric mean of the measured values for these layers were calculated as shown in **Figure 10** through **12.**

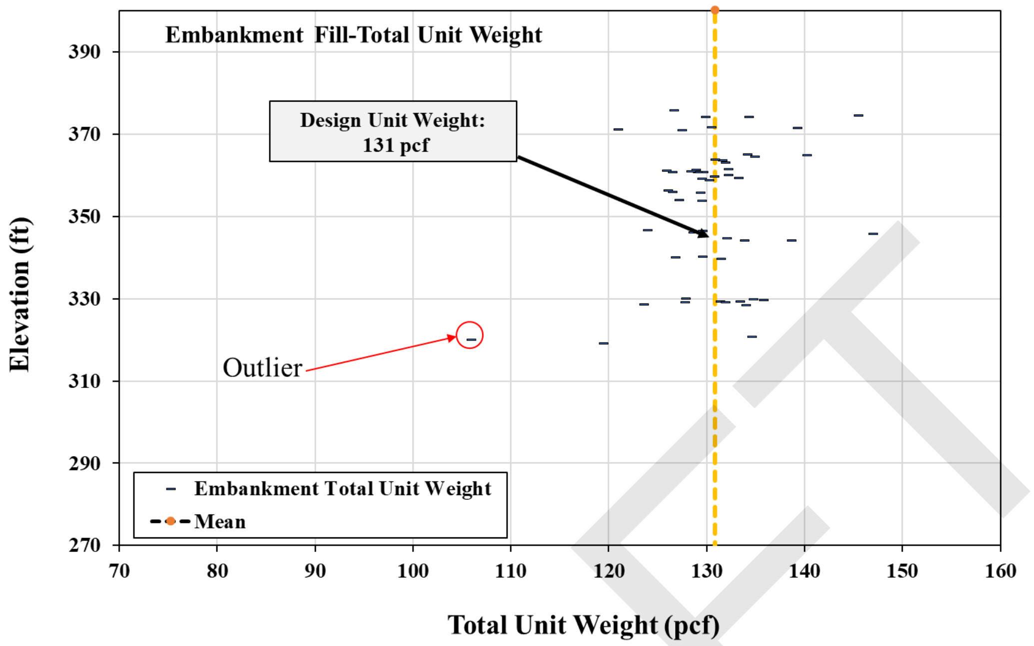


Figure 10. Embankment Fill Design Total Unit Weight

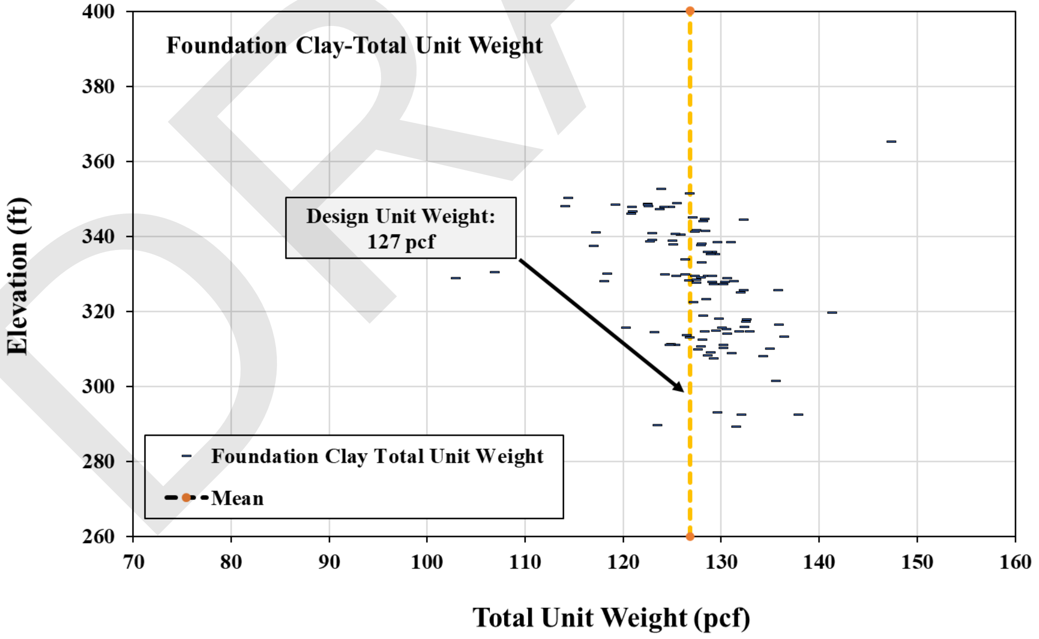


Figure 11. Foundation Clay Design Total Unit Weight

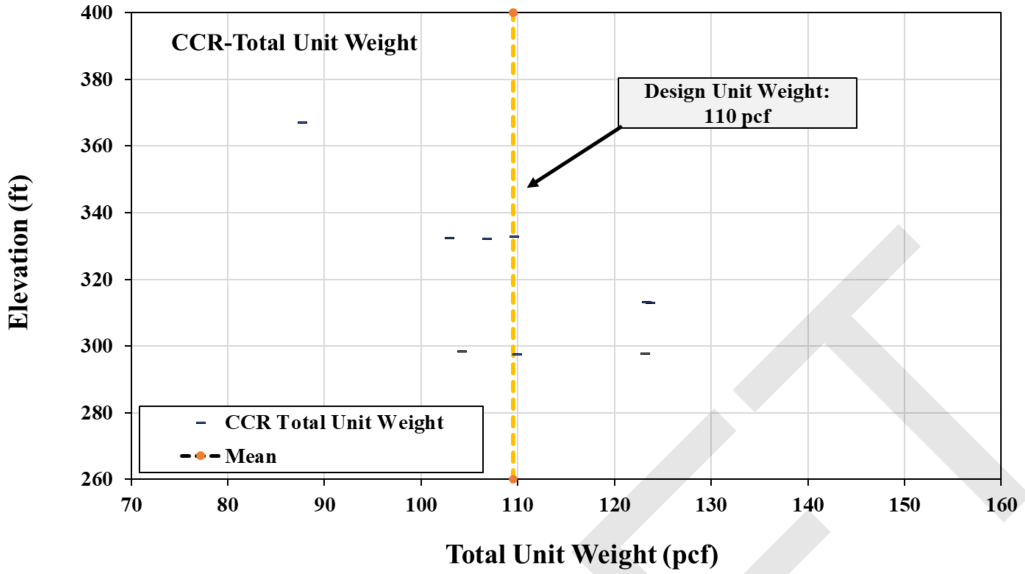


Figure 12. CCR Design Total Unit Weight

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: Friction Angle (ϕ', deg)	Drained Shear Strength: Cohesion (c', psf)	Undrained Shear Strength (Su, psf)
Embankment Fill (Includes New Soil Containment Berm)	131	30	300	2,500
Foundation Clays	127	29	150	Bi-linear envelope: Elevation >= 340: 1200 psf Elevation <340: 1200psf + 58.75 psf/ft <= 3550 psf
Foundation Sands[1]	130	0	35	Assumed drained under each evaluated loading condition.
CCR[2]	110	34	0	
Final Cover System[3]	110	27	0	

[1] Foundation Sands 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

5- CONSOLIDATION CHARACTERIZATION

The results of one-dimensional consolidation tests reported by AECOM [1] were used to estimate the compressibility parameters of clays in the foundation materials. The compressibility of the CCR and underlying foundation sands were not assessed as the concern in this regard was due mainly to the post-construction settlement in the clay layers that might affect the final cover system grades. In Geosyntec's experience, settlement in the CCR and the underlying foundation sands will occur nearly immediately while fill is being placed.

The foundation soils will experience consolidation. The compression ratio ($C_{c\varepsilon}$), recompression ratio ($C_{r\varepsilon}$), and the coefficient of consolidation (c_v) were estimated by the testing laboratory for each consolidation test. **Table 2** summarizes the obtained values and average design parameters for the consolidation parameters of foundation clays.

Table 2. Summary of Consolidation Testing and Design Parameters of Foundation Clays

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 OCR shown in **Table 2**, an OCR profile was developed and is provided in **Figure 13** for the site to address the observed variability in this parameter.

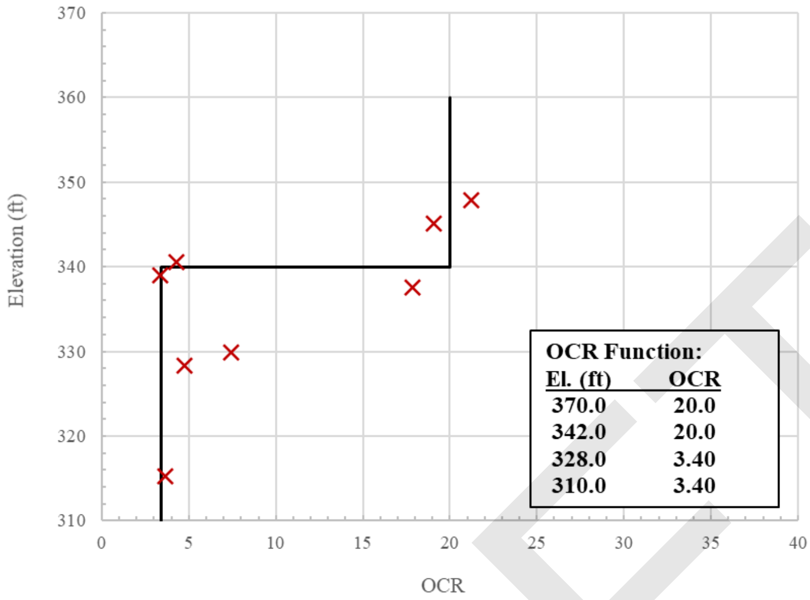


Figure 13. Over-Consolidation Ratio Profile for Foundation Clays

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 3**.

The data indicates that groundwater levels in the CCR retained within the EAP typically vary between El. 355 ft and El. 374.5 ft. For geotechnical analyses, the piezometric data was used to select a water level within the impounded CCR. To encompass the most critical scenario, the highest groundwater water levels recorded by the related piezometers during the monitoring period were chosen for slope stability analyses.

The water level within the embankment was then assumed to be linearly decrease to the embankment toe elevation, and then follow the ground surface beyond the embankment toe.

Actual water levels within the EAP are expected decrease during closure due to dewatering and due to a reduction in infiltration caused by installation of the final cover system and the removal of free liquids within the CCR. Therefore, the selected groundwater conditions are conservative. These groundwater conditions will be updated to represent estimated post-closure conditions once post-closure groundwater predictive modeling performed by others is completed.

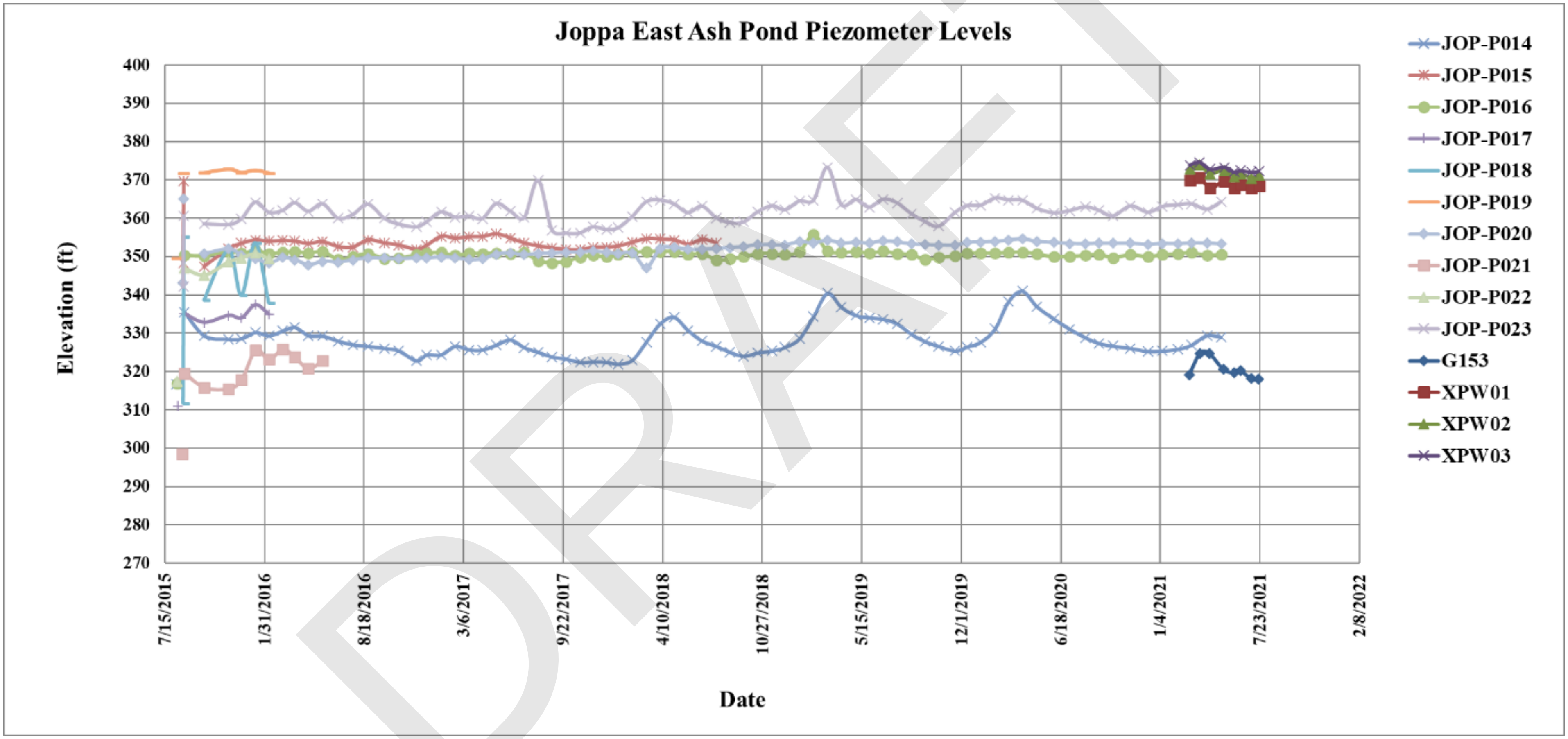


Figure 14. EAP Piezometer Data

7- 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 [8] for the 2% probability of exceedance in 50-years earthquake event (e.g., 2,475-year return period). 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 a input) for the site. The UHSs for the top-of-rock and top-of-soil are shown in **Figure 15**.

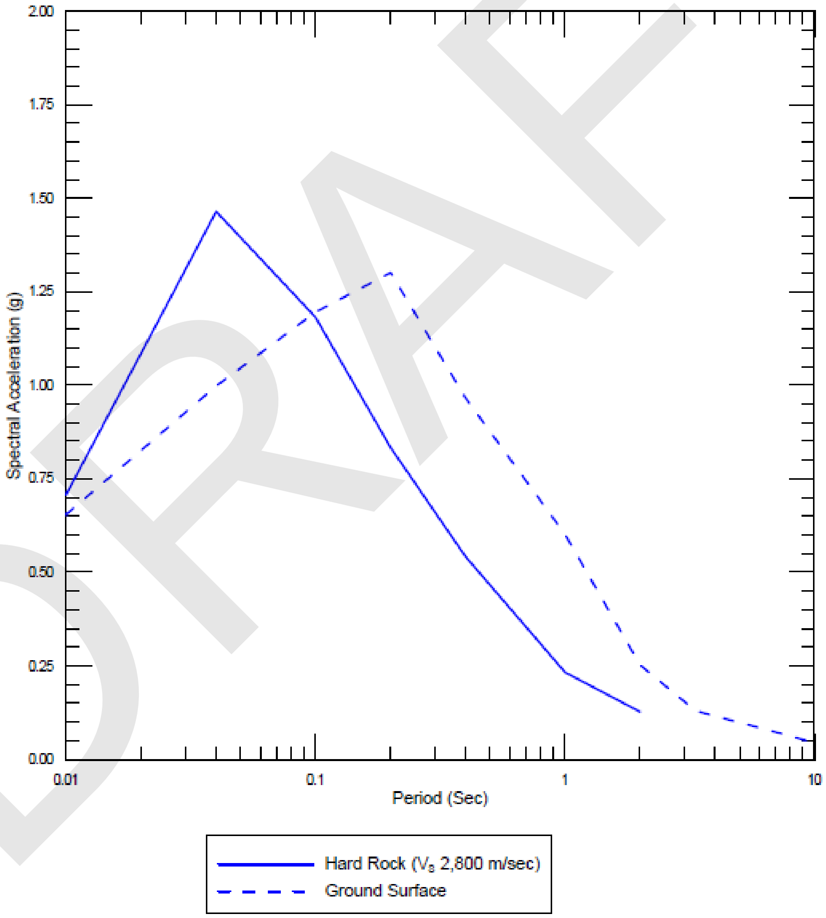


Figure 15. Horizontal Mean UHS on Hard Rock and Ground Surface, AECOM [8]

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 deep dense to very dense foundation sands. Essentially, 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 by AECOM.

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) [9] which was also utilized by Geosyntec here in the post-earthquake loading condition of slope stability analyses.

Geosyntec will perform a supplemental liquefaction triggering analysis for EAP for post-closure conditions in a subsequent revision to this draft package to independently verify AECOM's conclusions.

Pseudostatic Seismic Analysis

Geosyntec selected the pseudostatic seismic coefficient for slope stability analysis using the Bray and Macedo [10] 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, 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 **Attachment E**.

8- 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 [11], 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 [12]. Evaluated circular slip surface defined using the entry-exist method, with each critical slip surface being optimized into a non-circular slip surface. Factors of safety were calculated for the following loading conditions:

> <u>End-of-Construction Static Conditions</u>: This loading condition corresponds to the stability of the post-closure EAP dikes immediately after construction of the

closure is completed. Peak undrained material properties are used for all cohesive materials, as pore pressures induced by construction may not yet have dissipated. Peak drained material properties are used for all free-draining materials, as these materials are assumed to dissipate pore pressures concurrently with loading. The minimum acceptable FoS for this loading condition is 1.30, per the USEPA CCR Rule [13] and the Illinois Part 845 Rule [14].

<u>Long-Term Static Conditions</u>: 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 material properties, representing effective stress conditions, are used for all materials, as this condition corresponds to static conditions without the application of pore-pressure inducing loads. The minimum acceptable FoS for this loading condition is 1.50, per the USEPA CCR Rule [13] and the Illinois Part 845 Rule [14].

<u>Pseudostatic Seismic Conditions</u>: This loading condition corresponds to the stability of the EAP dikes under short-term seismic shaking conditions. This loading condition assumed peak drained strengths in all free-draining materials (CCR and Foundation Sand) and peak undrained 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 [13] and the Illinois Part 845 Rule [14].

<u>Post-Earthquake Conditions</u>: 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 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 [13] and the Illinois Part 845 Rule [14], 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 [13] and the Illinois Part 845 Rule [14] 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 [13], [14]) were not evaluated as closure of the EAP will remove the ability of the EAP to retain water. Therefore, this loading condition will not be appliable 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. Plan-view drawings of these surfaces are provided in **Attachment F**.

Selected Cross-sections

Four cross-sections (A, B, C, and D) were selected based on critical surface geometry and subsurface conditions (**Figure 15**). 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.
- A height of 24 ft of consolidated CCR will be retained behind the dike at this section.
- The Foundation Clay has a thickness of approximately 27 ft.

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.
- A depth of 26 ft of consolidated CCR will be retained behind the dike at this section.
- Th Foundation Clay has a maximum thickness of 36 ft; this is the thickest along the proposed new soil containment berm.

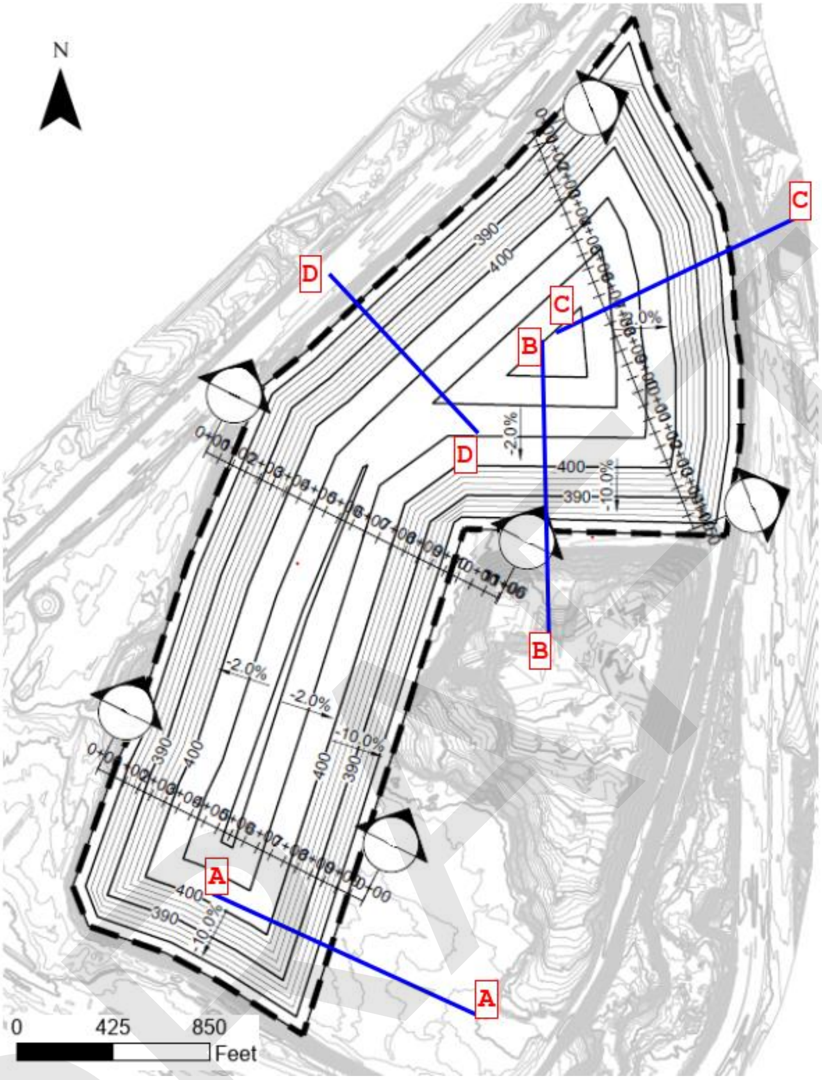


Figure 15. Post-closure Condition Cross-section Locations for Slope Stability Analysis

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
- A height of 26 ft of consolidated CCR will be retained behind the dike at this section.
- The Foundation Clay has a maximum thickness of 43 ft; this is the thickest along the existing perimeter dike.

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
- A height of 24 ft of consolidated CCR is present at the location of this section.
- The Foundation Clay has a maximum thickness of 40 ft.

Results

The results of each of the design scenarios is presented in **Table 3**. 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 3. 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	1.75	2.04	1.84	1.86	PASS

9- 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 geomembrane low permeability 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 [15]. 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 4** and shown in plan in **Figure 16**.

Table 4 – 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

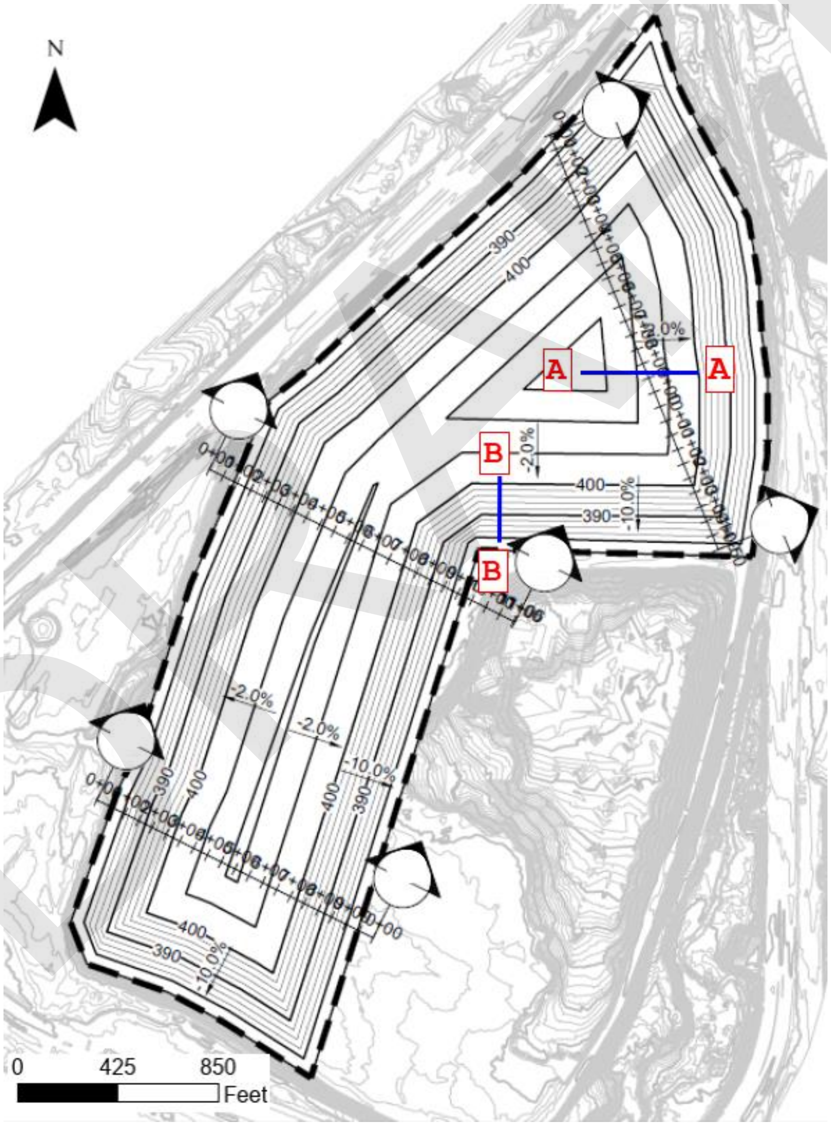


Figure 4 – Veneer Stability Slope Locations

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 [16]. Similar materials will be utilized for the final cover system at the JOP EAP; therefore, it is appropriate to use this data for the veneer stability assessment. 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 5** and laboratory testing sheets are provided in **Attachment H**.

Table 5 – 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 Skaps Nonwoven Geotextile GE116 Skaps 40 mil LLDPE Textured Geomembrane CCR	27.8	81	17.1	0
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:

> <u>Normal Static Conditions</u>: 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 [17]. Peak interface shear strength data was used for this condition.
>
> <u>Saturated Conditions</u>: 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) [18], 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 [18]. 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 [13] and Illinois Part 845 [14] 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 6.** Each calculated factor of safety exceeds minimum acceptable values. Calculation output data is provided in **Attachment I**.

Table 6 – 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

10- SETTLEMENT ANALYSES

[Settlement analyses for post-closure conditions will be provided in a subsequent revision to this draft package.]

11- 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 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.

12- REFERENCES

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ATTACHMENT A

2016 AECOM Geotechnical Report

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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,

Victor Modeer

Ronald H. Hager

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Senior Project Manager
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Ron Hager
Program Manager
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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	$\alpha > 5^\circ$: 33 deg $-5^\circ \le \alpha \le 5^\circ$: 29 deg $\alpha < -5^\circ$: 33 deg
Foundation Sand	130	0	35
Ash	106	0	$\alpha > 5^\circ$: 33 deg $-5^\circ \le \alpha \le 5^\circ$: 29 deg $\alpha < -5^\circ$: 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	$\sigma'_{fc} < 0.5$ 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	$S_u/\sigma'_{fc} = 0.41$ $c_o = 700$ psf	
Foundation Sand	128	Drained Strength Use (See Table 10)	Drained Strength Use (See Table 10)
Ash	106	$S_u/\sigma'_{fc} = 0.44$	$S_u/\sigma'_{vc} = 0.07$[2]
Soft Clay (Miscellaneous Fill)[3]	125	$S_u/\sigma'_{fc} = 0.25$, min Su = 500 psf	$S_u/\sigma'_{fc} = 0.18$, 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

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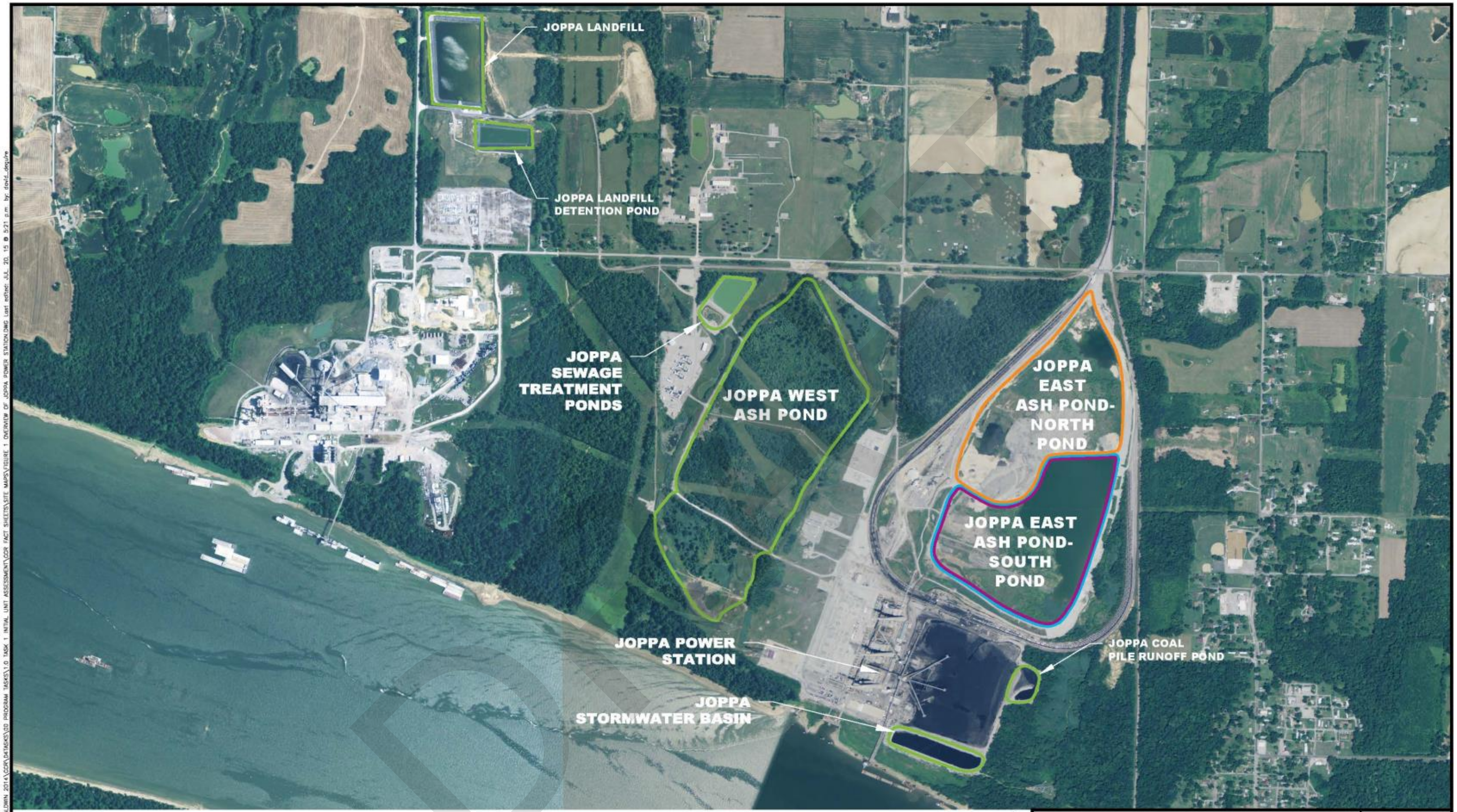
Weaver Consultants Group, “Joppa 2015 Aerial Topography”, December 2015

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

File: P:\PROJECTS\GEOTECH\DYNEGY - BALDWIN 2014\CCR\DATASKS\00 PROGRAM TASKS\1.0 TASK 1 INITIAL UNIT ASSESSMENT\CCR FACT SHEETS\SITE MAPS\FIGURE 1 OVERVIEW OF JOPPA POWER STATION.DWG Last edited: JUL. 20, 15 @ 5:21 p.m. by: david_deguire

PRIVILEGED & CONFIDENTIAL - ATTORNEY CLIENT PRIVILEGED

Legend

◐ AECOM Boring Location

▲ AECOM CPT Location

Figure A - 2
Exploration Locations - North Pond
Joppa Power Station
Massac County, Illinois

DYNEGY

AECOM

Q:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - North.mxd

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Legend

— Cross Sections

◐ AECOM Boring Location

▲ AECOM CPT Location

N W E S

250 0 250 500 Feet

Figure A - 3

Cross Section Locations - North Pond

Joppa Power Station

Massac County, Illinois

DYNEGY

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

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Legend

◐ AECOM Vibrating-Wire Piezometer Location

N W E S

250 0 250 500 Feet

Figure A - 4
Piezometer Locations - North Pond
Joppa Power Station
Massac County, Illinois

DYNEGY

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

Figure A - 5

Exploration Locations - South Pond

Joppa Power Station

Massac County, Illinois

DYNEGY

AECOM

Legend 2015 Explorations

◐ AECOM Boring Location

▲ AECOM CPT Location

Legend 2016 Explorations

🟥 Mud hole for liquefaction

● Direct Push hole

Figure A - 6
2016 Exploration Locations - South Pond
Joppa Power Station
Massac County, Illinois

DYNEGY

AECOM

Q:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Boring_Locations - South.mxd

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

250 0 250 500

Feet

Figure A - 7

Cross Section Locations - South Pond

Joppa Power Station

Massac County, Illinois

DYNEGY

AECOM

Figure A - 8
Piezometer 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

Legend

◕ AECOM Vibrating-Wire Piezometer Location

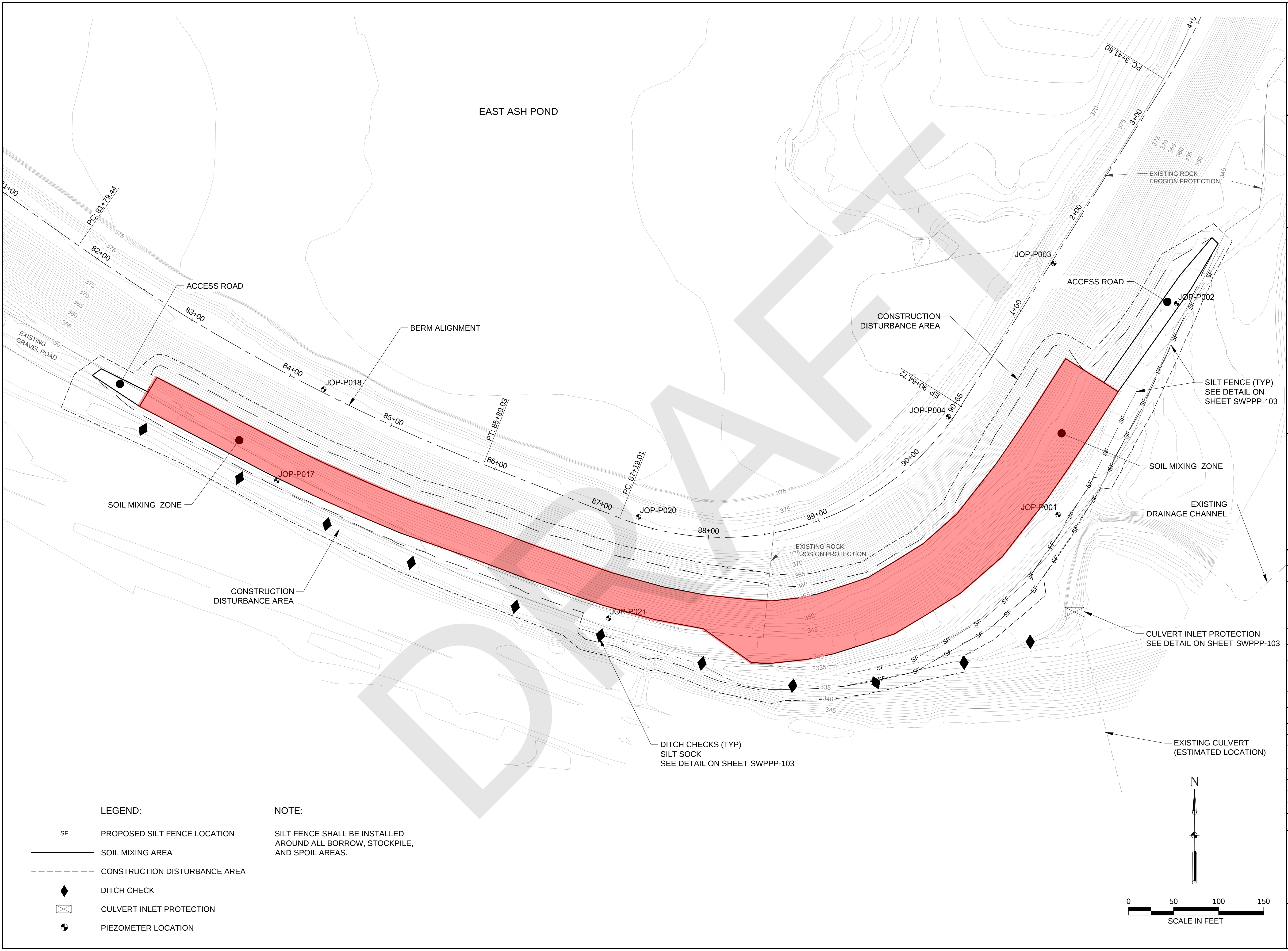
N
W E
S

250 0 250 500
Feet

DYNEGY

AECOM

Q:\Projects\DOE\0 Projects\Dynegy\Joppa\09_Data\GIS\Maps\Joppa_Piezometer_Locations - South.mxd



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.

AECOM

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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

ATTACHMENT B

BORING LOGS

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B001

Sheet 1 of 2

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	SAMPLES 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
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 19.4 21.1	131.4 127.8 123.6	34	17			2.1	*P200 = 80.4*
	5														
327.6	6.0						[ASH] SILT (ML), dark gray, very loose, moist to saturated								
			S-2	1 0 0	100			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						[FOUNDATION] Lean CLAY with Sand (CL), tan/brown, very soft								
315			S-4	1 0 0	78			23.4		27	9				*P200 = 84.6*
	20														
310							light gray, stiff, with varying sand								
			S-5	2 4 9	100										
	25														
305			ST-3	P											*Shelby pushed 9", showed dent*
	30														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B001

Sheet 2 of 2

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					▨									
300			S-6	6 7 5	100	▨		21.3							*P200 = 81.8*
	35					▨									
295			S-7	3 4 6	100	▨									
	40					▨									
290			ST-4	P		▨	290.1 — 43.5 Clayey SAND (SC)	14.6 13.6	123.5 131.5	29	17				*P200 = 38.5* *Shelby pushed 14"*
	45					░	288.9 — 44.8 Poorly Graded SAND (SP), gray and tan, subangular	14.5							
285			S-8		100	░		16.5							*P200 = 2.8*
	50						283.6 — 50.0 End of Boring at 50 ft								*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

Sheet 1 of 3

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	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	MATERIAL DESCRIPTION (Elevation (feet) 350.1; Depth (feet) 0.0)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
350	0				[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*
		S-A	2 2 4	33									
		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												
					with trace fine black sand								
		S-3	3 4 5	89		20.1		28	15				
325	25												
					stiff								
		S-4	4 5 7	78									
	30												

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B002

Sheet 2 of 3

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
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	17.9							*P200 = 56.7*
	65					▥	285.1 Sandy SILT (ML), gray, medium stiff — 65.0								

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B002

Sheet 3 of 3

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
285						End of Boring at 65 ft								*End 8/18/15 at 2:00 PM*
280	70													
275	75													
270	80													
265	85													
260	90													
255	95													
	100													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B003

Sheet 1 of 4

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	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
379.8	0.0						[CREST WEARING SURFACE] Crushed stone, sand and gravel								*Start 8/17/15*
378.8	1.0					▨	[EMBANKMENT] Lean CLAY with Sand (CL), brown/gray, stiff, dry to moist, varying sand content								
			ST-1	P	75			15.9 15.6 17.2	126.7	41	24				*P200 = 82.0*
375	5														
			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 16.2 16.1 14.7	129.7 126.5						*P200 = 85.7* *LV Su=4.7 ksf*
360	20														
			S-3	4 6 8	33										
355	25														
			S-4	3 3 6	67			17.4							*P200 = 87.6*
350	30														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B003

Sheet 2 of 4

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
	30														
345	35		ST-3	P	83			12.7 24.7 18.0 16.2	147.0	38	19				*P200 = 96.2*
							with gray mottling, trace sand and gravel								
340	40		S-5	4 5 10	78			17.4							
335.8	44.0														
335	45		S-6	2 2 3	11		[FOUNDATION] Lean CLAY (CL), brown/gray with gray mottling, stiff, trace sand and gravel								*Piece of wood blocked opening of split spoon*
330	50		S-7	4 5 8	100			20.6							*Pushed Shelby 24", no recovery. Recovered with split spoon.*
			ST-4	P	67			23.1	102.9	34	17				*P200 = 95.2* *End 8/17/15.* *Start 8/18/15 with mud rotary.*
325	55		S-8	3 3 2	100										
320	60		S-9	2 2 2	100			28.2		41	25				
315	65		S-10	3 5 6	100		stiff								

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B003

Sheet 3 of 4

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
		▨ S-11	3 5 7	100	▨		23.2							*P200 = 91.8*
310	70				▨									
		▨ S-12	4 3 9		▨									
305	75				▨									
					▨	gray								
		▨ S-13	6 9 8		▨	very stiff								
300	80				▨									
		▨ S-14	4 5 6		▨	stiff	21.7		37	21				
295	85				▨									
		▨ S-15	9 11 12		▨	very stiff	20.6							*P200 = 96.5*
290	90				▨									
		▨ S-16	5 6 9		▨									
285	95				▨									
		▨ S-17	6 6 11		▨									
280	100													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B003

Sheet 4 of 4

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
		S-18			▨		21.0		36	21				
275	105				▨									
		S-19	6 6 6		▨		20.2							*P200 = 96.8*
270	110					269.8 End of Boring at 110 ft 110.0								*End 8/18/15*
265	115													
260	120													
255	125													
250	130													
245	135													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Sheet 1 of 4

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	SAMPLES 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						379.0 / 0.0 [CREST WEARING SURFACE]								*Start 8/10/15*
							378.0 Gray to dark gray, crusher STONE, angular 1.0								
							[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				

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													
330		ST-10	P	100			16.0 15.7 15.9 16.2	127.9 134.8 133.4	34	18			3.6	*P200 = 83.8* *End 8/10/15 at 5:00 PM* *Start 8/11/15 at 7:30 AM with Mud Rotary*
	50													
325		S-11	2 6 8	92		325.5 / 53.5 Sandy Lean CLAY (CL), stiff, and trace dark gray fine sand or ash	17.0		31	18				*P200 = 69.3*
	55													
320		ST-12	P	100		321.0 / 58.0 Lean CLAY with Sand (CL), orange brown, medium stiff, moist	19.9 57.9 29.0	134.6 106.0 119.5	37	23				*P200 = 81.5*
	60													
315		S-13	2 3 4			314.5 / 64.5 [ASH]	25.7		24	5				*P200 = 76.9*
	65													

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

Sheet 3 of 4

Elevation (feet)	Depth (feet)	Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	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
310.0	69.0												
310	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	28.2 21.3 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												
295	85	S-17	2 4 7	100									
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		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												
	95				Poorly Graded SAND (SP), brown to gray brown, very dense, wet, medium to coarse sand								
280	100	S-20	16 29 27	61									

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B004

Sheet 4 of 4

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES 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		▨	S-21	17 29 29	33	░	more coarse sand and gravel								
	105					░									*Grinding, rattling, shaking of drill rig*
						░	with 6" layer of brown to orange brown, fine to medium sand								
270		▨	S-22	28 50/5"	73	░									
	110					░									
265		▨	S-23	15 23 30	67	░									
	115					░									
260		▨	S-24	22 25 23	56	░									
	120						259.0 — 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

AECOM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Sheet 1 of 4

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	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
379.9	0					[CREST WEARING SURFACE] Gray to dark gray, crushed rock, stone								*Start 8/9/15*
378.9	1.0					[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													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Sheet 2 of 4

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					▨									
		☰	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					▨									
		☰	ST-10	P	100	▨	with sand	22.2 22.1 20.8 20.9 20.6	129.1 129.4	39	25				*LV Su=4.1 ksf* *P200 = 81.2*
335	45					▨									
		▨	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														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Sheet 3 of 4

Elevation (feet)	Depth (feet)	Samples: Type	Samples: 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
310	70	▨	S-15	3 7 9	100	▨	with sand	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	░									
290.9	89.0					░	[FOUNDATION] Poorly graded SAND (SP), gray to gray brown, dense, wet								
290	90	▨	S-19	12 9 17	100	░									
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

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B005

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES 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
															PM
275	105														
270	110														
265	115														
260	120														
255	125														
250	130														
245	135														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B006

Sheet 1 of 2

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 (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
357.1	0.0					[FILL] Silty SAND (SM), dark gray, loose, moist, little to no plasticity								*Start 8/18/15 at 4:15 PM*
		▨	S-1	2 4 5	44									
		▤												*Pushed Shelby 24", no recovery.*
352.2	4.9					[FOUNDATION] Lean CLAY (CL), burnt orange/brown, stiff, moist								
		▨	S-2	3 5 6	67		25.2							*P200 = 98.3*
		▤	ST-1	P	100		26.1 26.2 26.5	114.1	33	10				
														End 8/18/15 at 5:30 PM *Start 8/19/15 at 7:30 AM*
		▨	S-3	2 7 5	78									
		▨	S-4	2 5 8	78		18.9		39	24				
		▨	S-5	3 4 5	67									
		▤	ST-2	P	100		19.4 18.7 18.0	118.1	39	26				*P200 = 85.7*

Elevation scale (feet): 355, 350, 345, 340, 335, 330

Depth scale (feet): 0, 5, 10, 15, 20, 25, 30

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B006

Sheet 2 of 2

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					▨				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						End of Boring at 40 ft	317.1	40.0								*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

Sheet 1 of 2

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	SAMPLES 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
347.6	0 / 0.0						[FILL] Silty SAND with Gravel (SM)								*Start 8/11/15 at 10:35 AM*
346.6	1.0						[FOUNDATION] Lean CLAY (CL), gray with orange staining, stiff, moist, bits of root (wet)								
345			S-1	2 3 4	83										
	5		ST-1	P	100										*Pushed Shelby 20"*
340			S-2	2 4 6	72			20.0		40	24				
	10		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*
335															
	15		S-3	2 5 6	83		with sand	18.3		36	22				*P200 = 84.9*
330															
	20		S-4	2 5 7	83										
325															
	25		S-5	2 4 7	83			18.5		38	24				*P200 = 73.5*
320															
	30		ST-3	P	100		less sand	18.0 16.8	128.2 129.8	37	22				*LV Su=6.7 ksf* *Pushed Shelby 20"*

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B007

Sheet 2 of 2

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	MATERIAL DESCRIPTION	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								
	35		S-6	4 6 7	100		17.6		37	25				*P200 = 84.1*
310														
	40		S-7	0 2 4	100									
305														
303.6	44.0 ▽					[FOUNDATION] Silty SAND (SM), gray, medium dense, wet, band of rust at 6" of split spoon								
	45		S-8	8 8 16	56		15.6		18	2				*P200 = 23.8* *Water observed on outside of split spoon*
300														
			S-9		100	no rust								*Attempted Shelby tube, recovered sample with split spoon* *End 8/11/15 at 1:45 PM*
297.6	50.0					End of Boring at 50 ft								
295	55													
290	60													
285	65													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Sheet 1 of 3

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] Crushed stone, gray to dark gray								*Start 8/19/15 at 2:50 PM*
							379.4 / 1.0 [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 20.0	139.3						
370	10														
			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														
			ST-2	P	100			18.4 17.6 18.8	127.2 129.5	41	23			2.7	*P200 = 91.2*
			S-5	5 7 13	44			17.3		41	23				*P200 = 93.5 Sand looks to be coal sand < 8%*
	30														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Sheet 2 of 3

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES 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														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B008

Sheet 3 of 3

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
315						▨				19.6 19.3							*P200 = 92.6* *P200 = 93.5*
								312.4	68.0								
		▨	S-11	11 17 12	44	▨	[FOUNDATION] Silty SAND (SM), gray/beige, medium dense, low plasticity			18.3							*P200 = 89.7*
310	70																
		▨	S-12	8 11 18	50	▨											
305	75																
								303.4	77.0								
		▤	ST-6	P		▨	Silty, clayey, SAND (SC-SM), gray/beige, low plasticity			17.3 16.3 16.8 15.1 14.2	135.6	21	6				*Pushed Shelby 20"* *LV Su=2.9 ksf* *P200 = 36.2* *End 8/20/15 at 10:45 AM*
300	80						End of Boring at 80 ft	300.4	80.0								
295	85																
290	90																
285	95																
	100																

Project: Dynegy

Project Location: **Joppa Power Station, Massac County, IL**

Project Number: **60428794**

Log of Boring JOP-B009

Sheet 1 of 3

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 (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
378.8	0.0				[CREST WEARING SURFACE] Stone or crushed rock, gray to dark gray								*Start 8/7/15*
377.8	1.0				[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				Lean CLAY with Sand (CL), orange brown, stiff, moist								
365		ST-3	P	100		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

Sheet 2 of 3

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES 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	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														
330		▤	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*
	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														
315		▤	ST-14	P	100			18.5 18.4 18.9	129.5 128.3					3.8	
	65														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B009

Sheet 3 of 3

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	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		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*
	70												
305		S-16	2 3 22	100									
	75				304.3 / 74.5 Silty SAND (SM), gray and brownish orange to orange, dense								
300		S-17	11 14 21	78		20.7		NP	NP				*P200 = 23.7*
	80				298.8 / 80.0 End of Boring at 80 ft								*End 8/8/2015 at 2:30 PM*
295													
	85												
290													
	90												
285													
	95												
280													
	100												

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B010

Sheet 1 of 2

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	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	0					350.0 / 0.0 [FOUNDATION] Lean CLAY (CL), yellow, stiff, medium plasticity, with pockets of beige sand								*Start 8/6/15*
		ST-1	P				20.7 20.2 19.8 18.1 18.0	122.5 122.5 119.2 122.5 122.6 124.8	37	22				*P200 = 88.6*
						346.5 / 3.5 Lean CLAY with Sand (CL), stiff, medium plasticity								*P200 = 82.6*
		S-1	2 5 5	89			18.5		38	23				
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 Lean CLAY (CL), yellow, very stiff, pockets of sand more apparent less sand								*P200 = 87.6*
		S-3	3 7 12	50			15.2							
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 Sandy Lean CLAY (CL), stiff								*P200 = 52.9*
		S-6	1 3 9	100			17.6		26	16				
320	30													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B010

Sheet 2 of 2

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
320	30					▨									
315	35	▤	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*
310	40	▨	S-7	1 2 5	100	▨									
						▨	∇								
305	45	▨	S-8	3 6 8	100	▨	Layer of silty sand, 6" thick								
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														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B011

Sheet 1 of 3

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 (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
380.0	0.0				[CREST WEARING SURFACE] Crushed rock surface, gray to dark gray								*Start 8/6/15*
379.2	0.8				[EMBANKMENT] Lean CLAY with Sand (CL), brown to orange brown, soft, dry to moist								
375	5	S-1	1 1 2	67									
372.0	8.0	ST-2	P	75	Lean CLAY with Sand (CL), gray brown to dark brown, moist, contains organic matter								
370	10												
367.0	13.0	S-3	1 4 8	56	Lean CLAY with Sand (CL), orange brown to brown, stiff, moist to dry, contains pockets of gray sand	16.0		34	18				*P200 = 83.6*
365	15												
360	20	S-4	5 7 4	22	with gravel, dry								*Rough drilling*
357.0	23.0	ST-5	P	100	Lean CLAY (CL), gray brown, firm, moist	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												
350.0	30.0	S-6	2 4 4	44	with sand	18.5							*P200 = 84.1*

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	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					▨									
						▨	326.5 — 53.5								
		▨	S-11	3 4 5	33	▨	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					▨									
						▨	316.5 — 63.5								
		▨	S-13	2 4 4	100	▩	Clayey SAND (SC), brown to brown orange, loose, with dark orange clayey sand pockets, moist								
315	65														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B011

Sheet 3 of 3

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
310	70	ST-14	P	100	▨		20.2 17.4 16.8 16.6 16.4	125.3 130.2	34	23				*LV Su=2.2 ksf* *P200 = 45.3*
305	75	S-15	3 5 8	100	▨									
303.8	76.2				▒	Poorly Graded SAND with Silt (SP-SM), gray to brown gray, very dense, wet								
300	80	S-16	22 28 30		▒									
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

Sheet 1 of 3

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	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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
	0					379.6		0.0								
						379.1	[CREST WEARING SURFACE] Crushed rock or stone, gray to dark gray	0.5								*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															
355		S-5	4 5 7	39					15.3							*P200 = 78.6*
	25															
						351.1		28.5								
350		S-6	5 8 13	78			Lean CLAY (CL), brown to orange brown, very stiff, moist		17.0		38	20				*P200 = 91.7*
	30															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B012

Sheet 2 of 3

Elevation (feet)	Depth (feet)	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
349.1	30.5	S-7	2 4 2	11	▨	[FOUNDATION] Lean CLAY (CL), gray brown to brown gray, firm, moist, organics/roots present								*Poor recovery. Tip was soft.*
		ST-8	P	100	▨		27.3 28.7 28.8 29.4 29.1	121.0 120.8	40	21			0.5	*P200 = 98.2*
345.6	34.0				▨	Lean CLAY (CL), gray brown to brown, stiff, moist, becomes brown with frequent gray to light gray sand lenses								
		S-9	8 8 6	100	▨		26.1		33	12				*P200 = 95.9*
		ST-10	P	100	▨									
	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*
331.1	48.5	S-12	5 5 6	100	▨	Sandy Lean CLAY (CL), gray brown to gray, stiff, moist	21.7							*P200 = 69.3*
	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*
321.6	58.0	S-14	8 11 24	100	▦	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*
316.6	63.0	S-15	3 4 5	100	▨	Lean CLAY with Sand (CL), brown orange to brown and gray, stiff, moist								

Elevation scale: 345, 340, 335, 330, 325, 320, 315

Depth scale: 30, 35, 40, 45, 50, 55, 60, 65

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B012

Sheet 3 of 3

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES 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														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Sheet 1 of 3

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	SAMPLES 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						379.3 / 0.0 [CREST WEARING SURFACE] Crushed rock or stone, gray to dark gray 378.3 / 1.0								*Start 8/21/15 at 12:30 PM*
							[EMBANKMENT] Sandy Lean CLAY with sand (CL), brown to orange brown, stiff, moist								
375	5		S-1	3 6 7	33										
370	10		S-2	3 5 10	39			14.7							*P200 = 67.8*
365	15		ST-1	P	100			15.9 16.1 15.8 15.4	147.4						
							with light gray stones/gravel 360.3 / 19.0								*Lots of chatter on augers*
360	20		S-3	50/2"	0		[EMBANKMENT] Lean CLAY (CL), very stiff, brown to orange-brown, moist 357.3 / 22.0								*Could not auger with center punch HSA. Only pulled 4 1/4 plugs of light, gray stones*
							[FOUNDATION] Lean CLAY (CL), stiff, gray, moist								
355	25		S-4	1 3 6	72			23.1							*P200 = 95.8*
350	30		ST-2	P	100			21.6 21.1 21.9 19.9	114.4	33	13				

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Sheet 2 of 3

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														
345	35	▨	S-5	2 5 5	78	▨		20.8		38	21				
340	40	▨	S-6	4 5 7	89	▨	gray with orange streaking								
		▤	ST-3	P	100	▨		18.9 20.5 20.7 19.9	125.1	35	19				
335	45	▨	S-7	3 4 5	100	▨		19.8							*P200 = 85.4*
330	50	▨	S-8	2 4 5	100	▨									
325	55	▨	S-9	12 25 42	78	▨	with sand and gravel	12.7		27	16				
320	60	▨	S-10	2 2 5	100	▨		19.5		37	24				
316.8	62.5					▨	Sandy Lean CLAY (CL), gray with orange/rust streaks, stiff, moist								
315	65	▨	S-11	5 5 6	100	▨									

AECOM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B013

Sheet 3 of 3

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
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*
300.3	79.0	▨	S-14	9 27	100	░	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														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B014

Sheet 1 of 2

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 (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
361.8	0.0					[FILL] Clayey SAND with Gravel (SP), brown to dark gray, loose								*Start 8/7/15*
		▨	S-1	6 5 3	11									
358.8	3.0					[FOUNDATION] Lean CLAY (CL), burnt orange/yellow, stiff, sand is vertical vein and beige in color								
		▤	ST-1	P	80									*Pushed Shelby 20"*
		▨	S-2	2 4 5	78		23.4		31	9				*P200 = 96.8*
		▤	ST-2	P	100		23.3 20.8 20.7 20.8 21.5	123.9 126.8	33	13				*Pushed Shelby 20"* *LV Su=2.1 ksf* *P200 = 91.8*
		▨	S-3	2 5 5	67									
		▨	S-4	2 4 5	89		20.1		47	33				*P200 = 88.8*
339.8	22.0					Lean CLAY with Sand (CL), burnt orange/yellow, stiff, moist								
		▨	S-5	3 5 7	78									
		▨	S-6	2 4 5	100	mostly beige	20.8		39	24				*P200 = 85.0*

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B014

Sheet 2 of 2

Elevation (feet)	Depth (feet)	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
329.8	32.0						Clayey SAND (SC), gray with orange mottling, stiff, moist, noticeable flakes of rust, in various states of decomposition								
			ST-3	P	100			14.9 13.8 14.1 14.9 17.4 16.1	126.7 130.4 130.2	26	15			4.3	*Pushed Shelby 20", crumpled at tip. Inverted for wax plug.* *P200 = 45.2*
			S-7	4 4 4	100										
318.8	43.0						Sandy Lean CLAY (CL), gray with orange mottling, moist, with flakes of rust								
			ST-4	P	100			17.2 18.8 17.6 17.9 16.7	132.6 132.5	33	21				*Pushed Shelby 20"* *LV Su=3.4 ksf* *P200 = 63.7*
			S-8	5 6 7	100			16.2		26	15				*P200 = 54.6*
311.8	50.0						End of Boring at 50 ft								*End 8/7/15*

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Sheet 1 of 3

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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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
380	0						380.3	[FILL] Poorly Grades SAND with Silt (SP-SM)	0.0								*Start 8/20/15 at 1:15 PM*
			S-1	3 7 7	33												
375	5																
							373.3	[EMBANKMENT] Lean CLAY (CL), orange brown to brown, stiff, moist, contains some silt and sand	7.0								
			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																
							351.8	[FOUNDATION] Lean CLAY (CL), burnt orange/gray, very stiff, moist	28.5								
			S-5	4 8 9	33												
	30																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Sheet 2 of 3

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					reddish brown								
		S-6	1 4 6	89		stiff	8.5		33	13				
345	35													
		S-7	2 3 4	89		firm, gray with orange vertical streaking	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													
						316.8 ― 63.5								
		S-12	3 6 7	100		Silty SAND (SM), beige, medium dense, saturated	17.2							*P200 = 48.4*
	65													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B015

Sheet 3 of 3

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
315														
314.8	65.5				▨	[FOUNDATION] Sandy Lean CLAY (CL), gray with burnt orange vertical streaking, stiff								
		ST-4		100	▨		22.4 19.9 21.4 21.5	124.9 124.7						P200 = 91.0
310	70				▨									
					▨	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				
300.3	80.0					End of Boring at 80 ft								End 8/7/15
300	80													
295	85													
290	90													
285	95													
	100													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B016

Sheet 1 of 2

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	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
352.1	0.0						[FILL] Crushed stone and gravel with silt and sand								*Start 8/9/15 at 12:10 PM*
351.1	1.0					▨	Lean CLAY (CL), blue green, stiff, moist, some organic material								
		▨	S-1	3 4 6	33	▨									
348.1	4.0	☰	ST-1	P	80	▨	[FOUNDATION] Lean CLAY (CL), blue green, stiff, moist	25.2 25.8 25.8 26.6	120.9 124.2 123.7	33	12			1.1	*Pushed Shelby 20"* *P200 = 98.3*
		▨	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"*
		▨	S-3	1 6 6	50	▨	wet								
		▨	S-4	3 6 7	50	▨		21.1		30	14				*P200 = 90.0*
		☰	ST-3	P		▨	gray	23.0 19.7 19.5 19.2 19.1 17.6 18.2	127.5 131.3 129.1 127.5 129.2	35	20				*LV Su=1.1 ksf* *P200 = 98.8* *Pushed Shelby 20"*
		▨	S-5	1 5 5	67	▨		21.3		40	26				*P200 = 97.0*

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

Sheet 2 of 2

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				▨									
320					▨									
	35	ST-4	P		▨		21.0 20.1 18.0 18.1	134.3 129.2	27	10				*Pushed Shelby 20"* *P200 = 88.1*
315					▨									
	40	S-6	2 3 3	100	▨	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													

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	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	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*
		ST-2	P	90	339.2 / 8.0 [FOUNDATION] Sandy Lean CLAY (CL), yellow brown, very soft, moist	22.5 17.1	123.0 129.6	33	16				*Pushed Shelby 20" P200 = 67.1*
335	10												
		S-3	WOR	89		23.7		38	20				*P200 = 94.7*
330	15				reduced sand content								
					329.2 / 18.0 Sandy Lean CLAY (CL), brown, firm, moist								
		S-4	4 6 8	100									
325	20												
		ST-3	P	80	reduced sand content	17.9 21.4 20.3 21.3	128.5 127.2	34	20				*Pushed Shelby 20"* *P200 = 93.3*
320	25												
	30	S-5	2 2 6	100		19.5		35	23				*P200 = 60.4*

AECOM

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-B017

Sheet 2 of 2

Elevation (feet)	Depth (feet)	Samples: Type	Samples: 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
	30					▨									
315						▨	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*
	35					▨									
310						▨	∇								*Water returned to surface*
		▨	S-6	2 4 5	100	▨									
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														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Sheet 1 of 3

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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
378.6	0.0					[CREST WEARING SURFACE] Crushed stone, sand, silt, gray to dark gray								*Start 8/20/15*
377.6	1.0					[EMBANKMENT] Lean CLAY (CL), brown/gray with gray mottling, stiff								
		▤	ST-1	P			14.6 15.1	145.5						
		▨		3 4 6										*No recovery*
		▨	S-1	3 5 6	78		14.0		38	25				
		▨												*No recovery*
		▨	S-2	2 5 8	72									
		▤	ST-2	P	71		15.4 14.7 15.0	130.8						*P200 = 90.6*
		▨	S-3	4 7 9	89									
														End 8/20/15 *Start 8/21/15*
		▨	S-4	3 5 7	94		15.2		37	24				

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Sheet 2 of 3

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES 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							less sand								
			S-8	1 2 4	100										
	65														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B018

Sheet 3 of 3

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															
	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			19.5		NP	NP				
298.6	80.0						End of Boring at 80 ft								End 8/21/15
295	85														
290	90														
285	95														
280	100														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Sheet 1 of 3

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) 376.1 / Depth (feet) 0.0)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
375	0					[ASH] Sandy SILT to SILT (ML), gray to dark gray, very loose, wet, non-plastic								*Start 8/8/15 at 10:44 AM*
		S-1	1 0 1	100			48.2		NP	NP				*P200 = 51.4*
370	5					∇								*Observed water*
									NP	NP				*P200 = 94.5*
		ST-1	P	10			106.0	87.7						*Pushed Shelby 20"*
365	10													
		S-2	0 1 1	100			102.0		NP	NP				
360	15													
		S-3	WOR	100										
355	20													
		S-4	WOR	100										*Switch to mud rotary*
350	25													
		S-5	WOR	100			43.4							*P200 = 97.6*
	30													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Sheet 2 of 3

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	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														
	35	▨	S-6											*Pushed Shelby 20". Sample fell out of tube, recovered with split spoon*
340														
	40	▨	S-7	WOR	100		36.8		NP	NP				*P200 = 70.8*
335														
	45	▤	ST-2	P	50		41.8 46.0 54.5	109.6 102.9 106.8	NP	NP				*P200 = 83.5* *Pushed Shelby 20"*
330														
	50	▨	S-8	WR	100									
325						325.1 / 51.0 [FOUNDATION] Sandy Lean CLAY (CL), yellow, stiff, wet								
	55	▨	S-9	10 5 4	100		18.9							*Driller reports drilling getting harder* *P200 = 64.2*
320														
		▤	S-10											*Pushed Shelby 20". Sample fell out of tube at surface. Bagged and labeled.*
	60	▨	S-11	2 3 4	33		17.7		24	13				*P200 = 61.1*
315														
		▤	ST-3	P	75	vibrant orange, moist/saturated, medium sand								*Pushed Shelby 20"*
						312.1 / 64.0 Silty SAND (SM), gray, dense, wet								
	65	▨	S-12	10 15 20										

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B019

Sheet 3 of 3

Elevation (feet)	Depth (feet)	Samples: Type Number	Samples: Sampling Resist. OR Core RQD (%)	Samples: Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
		S-13	15 19 17	28									
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*
299.1	77.0				Poorly-Graded SAND with Clay (SP-SC), yellow, very dense, medium to coarse sand, angular								*Shelby tube will not advance. Retrieve sample with split spoon. Drilling mud possibly not allocating sample to enter split spoon. Check valve working correctly.*
		S-15	17 28 21	56									
		S-16	14 26 30	28		13.3		33	16				*End 8/8/15 at 5:20 PM* *P200 = 7.6* *Start 8/9/15 at 7:20 AM* *15ft of hole collapsed over again. Redrill.*
		S-17	24 24 23	33									
		S-18	11 10 11	33									
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*
276.1	100.0												

End of Boring at 100 ft

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Sheet 1 of 4

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 (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
378.1	0.0				[CREST WEARING SURFACE] Crushed stone with Gravel and Sand, gray to dark gray								*Start 8/19/15*
377.1	1.0				[EMBANKMENT] Lean CLAY (CL), brown/gray, moist, stiff								
		ST-1	P	50		16.5 15.3 15.8	134.3 129.9	35	19			4.8	*LV Su=6.8 ksf*
		S-1	3 4 6	72									
		S-2	2 3 4	72		16.2		36	21				
		ST-2	P	79	with gray mottles	15.7 13.7 15.3	129.5 130.3						*P200 = 97.8*
		S-3	2 5 8	94									
		S-4	3 4 12	89		14.3							*P200 = 95.6*

Elevation (feet): 375, 370, 365, 360, 355, 350

Depth (feet): 0, 5, 10, 15, 20, 25, 30

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Sheet 2 of 4

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					▨									
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				
	50														*Switch to mud rotary at 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															
							gray to dark gray								
		▨	S-9	4 5 7	100		313.6 64.5 [FOUNDATION]	20.9		36	23				*Bottom 4" appears to be ash*
	65														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Sheet 3 of 4

Elevation (feet)	Depth (feet)	SAMPLES Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	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 18.2	128.9 128.6						
	70	S-10	2 3 6	100		22.8		41	29				*P200 = 82.9*
305					305.1 — 73.0 Clayey SAND with Gravel (SC), gray, dense								
		S-11	15 21 12	67	303.7 — 74.5 Poorly-Graded SAND with Gravel (SP), dense, brown/gray, moist								
	75												
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

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B020

Sheet 4 of 4

Elevation (feet)	Depth (feet)	SAMPLES			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
		Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)										
														End 8/20/15
275														
	105													
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

Sheet 1 of 2

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	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					▨	Elevation (feet) 344.0, Depth (feet) 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	▨									
340	5	▤	ST-1	P	100	▨		19.5 16.6 15.0	129.6 126.8 131.5	39	26				*LV Su=2.3 ksf*
		▨	S-2	1 1 1	67	▥	338.0 — 6.0 [ASH] SILT (ML), gray, soft to medium stiff, wet, low plasticity ▽ 6" layer of clay at 6'	23.7		42	26				
335	10	▨	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*
330	15	▤	ST-2	P	100	▨	330.5 — 13.5 [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*
325	20	▨	S-4	2 4 4	100	▨									
320	25	▨	S-5	0 1 5	89	▨		21.0							*P200 = 90.7*
315	30	▨	S-6	2 1 3	100	▨									

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B021

Sheet 2 of 2

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES 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 Poorly-Graded SAND with Silt (SP-SM), beige, loose, wet								
295			S-9	1 2 4	44			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	SAMPLES 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
353.4	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		351.9 / 1.5 [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*
345			ST-2	P				22.4 20.8 21.5 21.3 21.7 21.4	127.1 128.3 132.2 128.2	35	17			2.3	*P200 = 93.7*
	10														
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 19.3 18.9 19.5	127.3 129.1 130.6	38	24			1.8	*Pushed Shelby 20"* *P200 = 92.4*
	25														
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

Sheet 2 of 2

Elevation (feet)	Depth (feet)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	MATERIAL DESCRIPTION	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					▨											
320						▨											
		▨	S-6	2 3 5	100	▨		beige, with more fine sand									
	35					▨											
315						▨											
		☰	ST-4	P		▨	314.1		39.3	14.9 18.0	131.8 123.2	23	9			2.2	*P200 = 71.0* *Pushed Shelby 15"*
						░	313.4	Silty SAND (SM), beige, bottom of ST.	40.0								
	40							End of Boring at 40 ft									*End 8/8/15 at 8:45 AM*
310																	
	45																
305																	
	50																
300																	
	55																
295																	
	60																
290																	
	65																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023

Sheet 1 of 3

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 Elevation (feet) 341.5 Depth (feet) 0.0	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	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*
340															
		▨	S-1	1 2 1	11										
	5														
335															
		▨	S-2	2 0 1	11										
	10														
330															
							∇								
		▨	S-3					26.6		NP	NP				*Pushed Shelby 20", no recovery. Sample recovered with split spoon.* *P200 = 94.5*
	15														
325															
		▨	S-4	1 0 1	100										
	20														
320															
		▨	S-5	WOR	67			31.3							*P200 = 57.4*
	25														
315															
		▨	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

Sheet 2 of 3

Depth (feet)	Type / Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	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	S-7	WOR	11									*16"/18" drilling mud*
40	S-8	WOR	11		37.6		NP	NP				*P200 = 97.3* *16"/18" driling mud*
				300.5 — 41.0 Mixed Lean CLAY (CL) and Silt (ML), gray, moist								
45	ST-1	P	100		57.5 27.1	104.2 109.9 123.2	32	10				*Pushed Shelby 5"* *P200 = 93.0*
50	ST-2	P	93	292.5 — 49.0 [FOUNDATION] Clayey SAND (SC), yellow-orange loose	20.5 20.9 19.9 13.6 18.1	129.6 137.9 132.1	35	21			2.2	*Pushed Shelby 21"* *P200 = 74.0*
55	S-9	3 4 4	100	some coarse sand, rounded to subrounded	17.4		22	12				*P200 = 49.7*
60	S-10	4 3 4	100									
65	S-11	4 4 4	100	with moist to wet, pockets of poorly-graded sand	19.9							*P200 = 49.7*

Elevation (feet): 310, 305, 300, 295, 290, 285, 280

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B023

Sheet 3 of 3

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
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*
		▨	S-13	2 2 4	100	mostly clay	24.5							*P200 = 93.1*
264.5	77.0					Clayey SAND (SC), yellow-orange, medium dense, moist								
		▨	S-14	8 8 9	100		16.7							*P200 = 37.5*
258.5	83.0					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'*
		▨	S-15	8 50/5"	0									
		▨	S-16	22 22 12	33									
						with less silt								
		▨	S-17	11 13 20	11									*16"/18" drilling mud*
		▨	S-18	20 40 50/5"	88									*End 8/9/15 at 10:15 AM*
241.5	100.0													

End of Boring at 100 ft

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	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
380	0					Elevation (feet) 380.4 Depth (feet) 0.0 [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										
365	15					Saturated								
		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													

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B024

Sheet 1 of 3

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	SAMPLES 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														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B024

Sheet 2 of 3

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															
					▨	Lean CLAY with Sand (CL), brown, stiff, moist	42.0								
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			
					▨	[FOUNDATION] Lean CLAY with Sand, gray, stiff, moist to saturated 12-inch layer of soft, saturated	57.0								
	▨	S-4	WOH/12" 4 7	100								0.25 0.25 1 1			
60	▨	S-5	4 5 10 12	100								2.5 2.5 3 3			
65															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B024

Sheet 3 of 3

Depth (feet)	SAMPLES Type	SAMPLES 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-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					2.5 2.5 2.5 2.5			
						End of Boring at 97 ft									*End 3/19/16*
100															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B025

Sheet 1 of 3

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	SAMPLES 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						[FILL] Base Course GRAVEL (GP)	0.0 1.0								*Start 3/22/16*
					▨	[EMBANKMENT] Lean CLAY with Sand (CL), brown to orange-brown, moist									
5															
10															
15															
20															
25															
30															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B025

Sheet 2 of 3

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	▨	S-1	8 9 13 12	83	▨	35.0 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 gray clay with ash								
55	▨	S-9	WOH/12" 4 5	100	▨									
	▨	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														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B025

Sheet 3 of 3

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																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B026

Sheet 1 of 3

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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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
0							[FILL] Base Course GRAVEL (GP)	0.0								*Start 3/21/16*
							[EMBANKMENT] Lean CLAY with Sand (CL), brown, some Silt, stiff, moist	1.0								
5																
10																
15																
20																
25																
30																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B026

Sheet 2 of 3

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					1 1.5			
					▥	[ASH] FLYASH (ML), gray, stiff, saturated		62.0								
	▨	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,										

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B026

Sheet 3 of 3

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-11	2 4 5 8	83	░	saturated		65.5					n/a 3 3 3.5			
				▨	Lean CLAY with Silt (CL), brown, stiff, moist										
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															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B027

Sheet 1 of 3

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)	SAMPLES Type Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	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				[FILL] Base Course GRAVEL (GP)		0.0 1.0								*Start 3/23/16 at 8:35 AM*
				[FILL] Silty SAND (SM), brown, medium dense, moist		3.5								
	S-1	3 7 9 6	100	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								
	S-3	3 5 10 11	71	[ASH] FLYASH with Clay, no to low plasticity FLYASH with no clay										
10	S-4	4 4 3 WOH	67											
	S-5	WOH 1 2 4	75	becomes wet		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			24.5					>4.5			*Shelby tube 22-24,Driller noted soft layer and hit stiff layer right at bottom.*
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														

AECOM

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B027

Sheet 2 of 3

Depth (feet)	Samples: Type	Samples: 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-11	4 10 8 12	100	▨										
	▨	S-12			▨	fine sand									
35	▨	S-13	5 5 5 11	88	▨	gray mottled with brown, low plasticity, moist	35.0								
	▨	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	░	Fine SAND with trace Clay (SP), gray mottled with orange, medium dense	46.0								
	▨	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		░										
55						End of Boring at 54.5 ft	54.5								
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

Sheet 3 of 3

Depth (feet)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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
70																
75																
80																
85																
90																
95																*End 3/23/16 at 3:00 PM*
100																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028

Sheet 1 of 3

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	SAMPLES 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
0							[CREST WEARING SURFACE] Crushed STONE with Sand (GP), gray, dense, moist	0.0								
							[EMBANKMENT] Lean CLAY (CL), brown, stiff, moist, some Silt and trace Fine Sand	1.0								
5																
10																
15																
20																
25																
30																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028

Sheet 2 of 3

Depth (feet)	SAMPLES Type	SAMPLES 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															
35															
40															
45															
						gray, very stiff, moist									
50															
						brown and gray									
55		S-1	n/a n/a n/a n/a	66								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			62.0					1.5 1.5 1.5 1.5			
						[FOUNDATION] Lean CLAY (CL-OL), dark gray, stiff, moist	62.5								
		S-4	1 4 5 6	100		Silty Clay with trace decomposed organics (CL-ML), gray, loose, saturated						1 1 1.25 1.5			
65															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B028

Sheet 3 of 3

Depth (feet)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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
	▨	S-5	woh/24"	83	▨								0.25 0.25 0.25 0.25			
	▨	S-6	woh 3 2 2	100	░		Fine Silty SAND (SM), gray, loose, saturated	68.0								
70	▨	S-7	2 2 3 3	100	░								1.5			
					▨		Lean CLAY with Fine Sand (CL), gray, firm, moist	71.5								
	▨	S-8	5 7 7 7	100	▨								2.5 2.5 2.5 2.5			
75					▨											
80	▨	S-9	3 4 5 7	100	▨								2 2 2 2			
					░		Fine Silty SAND (SM), brown, medium dense, saturated	83.0								
85	▨	S-10	7 8 9 8	100	░											
							End of Boring at 87 ft	87.0								
90																
95																
100																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B029

Sheet 1 of 2

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)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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
0							[CREST WEARING SURFACE] Crushed STONE (Pavement) (GP), gray, medium dense, moist	0.0 1.0								
							[FILL] SAND with Silt (SP), brown, trace clay, medium dense, moist	2.0								
	▨	S-1	3 4 4 4	75			Lean CLAY with Silt to some Silt (CL), brown, stiff, moist	6.5					1.5 2 2.5			
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

Sheet 2 of 2

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			
						Fine SAND with trace course to medium Sand (SP), brown, medium dense, wet		36.5								
40	▨	S-12	3 7 9 11	92		trace gravel										
						dense										
45	▨	S-13	15 19 22 18	83		very dense										
						End of Boring at 47 ft		47.0								
50																
55																
60																
65																

AECOM

Project: Dynegy	# Log of Boring JOP-B030
Project Location: Joppa Power Station, Massac County, IL	Sheet 1 of 3
Project Number: 60428794	

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	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**
0							[TEMPORARY ACCESS RAMP] Crushed STONE (GP), gray, medium dense, moist	0.0								
							[BOTTOM ASH] Poorly Graded SAND (SP), medium dense, moist	3.0								
5							[ASH] SILT with some Clay (ML), gray, loose, moist	5.0								
10							very loose and saturated									
15																
20		S-1	WOR/24"	100												
		S-2	WOH/12" WOH 1	54									<0.25 0.25			
							[EMBANKMENT] Lean CLAY with Silt (CL), brown, soft, wet	23.5								
25		S-3	4 6 5 8	63			firm, moist stiff						2.5 2.5 3			
		S-4	3 5 8 11	71									2 2.5 2.75			
30																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B030

Sheet 2 of 3

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-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	▨	[ASH] SILT (ML), dark gray, loose, saturated		51.0					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																

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-B030

Sheet 3 of 3

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			
						[FOUNDATION] Lean CLAY (CL), light gray, soft, moist										
70		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				83.0					3.5 3.5 3.5 4			
						Fine Silty SAND (SM), brown, medium dense, moist										
85		S-24	5 4 6 7	83				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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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
0								0.0								
							[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/15/16 at 3:50 PM*
		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		S-2		98			[ASH] SILT (ML), gray, moist to wet, non-plastic									
10		S-3		100			6" layer of Sand									
15		S-4		100												
		S-5		100				19.0								
20							[FOUNDATION] Lean CLAY with Ash (CL), gray, soft, moist to wet, medium plasticity									
		S-6		100				23.0								
							Fine to Medium SAND (SP), gray, loose, moist	24.0								
25							End of Boring at 24 ft									*End 3/15/16 at 4:50 PM*
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

Sheet 1 of 2

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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Elevation (feet) / Depth (feet) 0.0	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0						[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/17/16 at 10:45 AM*
		S-1		100		Sandy SILT (ML), brown, firm, low plasticity, moist	3.5								
						Silty SAND and fine Gravel (SM), grey, loose	4.5								
5		S-2		75		Fine GRAVEL with Silt and Fine Sand (GM), loose, moist to wet	6.0								
						Organic CLAY (OL), brown and dark grey, traces of wood and coal, firm, medium plasticity, moist	8.0								
10		S-3		100		[FOUNDATION] Silty Lean CLAY (CL), gray and orange to brown, traces of coal, firm to stiff, trace iron stain, medium plasticity, moist									
						6" organic lean clay, dark grey to grey, becomes stiff									
		S-4		100											
15															
		S-5		100											
20															
		S-6		100											
25						6" silty clay, low to medium plasticity, moist									
		S-7		100		grey with iron staining									
						soft									
		S-8		100											
30															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D006

Sheet 2 of 2

Depth (feet)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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		100			3" seam of fine to medium sand light gray with iron staining, stiff, low to medium plasticity									
		S-9		100			stiff, medium plasticity, moist									
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		S-11		100			becomes very soft to firm, low to medium plasticity									
45		S-12		100			soft to firm									
							Fine SAND (SP), light gray with orange-brown spotting, dense	47.5								
50							End of Boring at 50.7 ft	50.7								*Refusal at 50.7ft. End 3/18/16 at 10:30 AM*
55																
60																
65																

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	SAMPLES 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 [RAILROAD] Lean CLAY (CL), soft, moist, gray and orange-brown, medium plasticity								*Start 3/20/16 at 11:00 AM*
	▼	S-1		94	▨									
					▨	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														

AECOM

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	SAMPLES 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								*Start 3/18/16*
						[FILL] Base Course GRAVEL (GP)	0.5								
		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									
						[FOUNDATION] Lean CLAY (CL), gray and orange-ish brown, medium plasticity	8.0								
10		S-3		100											
						more silt, low to medium plasticity, gray with iron staining									
		S-4		100											
15						medium plasticity									
		S-5		100											
20						very stiff									
		S-6		92											
25						frim to very stiff, low to medium plasticity wet									
		S-7		100											
30															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D008

Sheet 2 of 2

Depth (feet)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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						very stiff									
		S-8		100		6" pocket of grayish brown dense fine to medium grained sand									End 3/18/16 at 5:55 PM Start 3/19/16 at 7:20 AM
35						soft zones									
		S-9		83											
40															
		S-10		100		Fine Silty SAND (SM), gray, dense	42.0								
45						very loose									Driller noted very soft layer
		S-11		0											
		S-12		80											
50						dense, pockets of very stiff clayey silt, medium dense									Refusal at 50.5ft.
		S-13		100		brown and gray									
55						End of Boring at 54.7 ft	54.7								End 3/19/16 at 10:45 AM
60															
65															

Elevation (feet)

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Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D009

Sheet 1 of 2

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	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								
		S-1		63		[FILL] Base Course GRAVEL (GP)	0.5								*Start 3/20/16 at 1:00 PM*
						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	11.8								
10		S-3		75											
		S-4		75		[ASH] SILT (ML), dark grey, soft, wet, no plasticity	18.8								
15		S-5		100											
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															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D009

Sheet 2 of 2

Depth (feet)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION Elevation (feet)	MATERIAL DESCRIPTION	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		100	▨		low to medium plasticity, gray to gray and orange-brown									
		S-9		71	▨		very stiff									
							Fine to Medium SAND (SP), brown, very dense, moist	34.5								
35							End of Boring at 31.1 ft	35.4								*First Refusal at 35.1ft.* *Second Refusal at 35.4ft.* *End 3/20/16*
40																
45																
50																
55																
60																
65																

Project: Dynegy	# Log of Boring JOP-D010
Project Location: Joppa Power Station, Massac County, IL	Sheet 1 of 2
Project Number: 60428794	

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) 0.0)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
0						[FILL] Base Course GRAVEL (GP) 1.0								*Start 3/19/16 at 11:55 AM*
		S-1		85		[RAILROAD EMBANKMENT] Lean CLAY with Ash (CL), gray, stiff, low plasticity, iron staining								
5		S-2		75		low to medium plasticity clayey silt firm, medium plasticity								*Driller noted soft layer*
						stiff								
10		S-3		100										
		S-4		100										
15														
		S-5		100		orange-brown, gray layers								
20						very stiff, gray and orange-brown								*Driller noted hand push*
25		S-6		94		18" layer, organic clay, dark brown, medium stiff, moist								
		S-7		88		very stiff, moist, gray and orange-brown, silty clay								
30														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D010

Sheet 2 of 2

Depth (feet)	SAMPLES				Graphic Symbol	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
	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)												
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*

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	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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
0		S-1		88		[FILL] Base Course GRAVEL (GP)	0.0–0.5								*Start 3/15/16 at 3:00 PM*
						[ASH] SILT with Sand (ML), gray, non-plastic	0.5–1.0								
						[FILL] Lean CLAY (CL), moist, orange-brown, trace fine sand, stiff	1.0–8.0								
5		S-2		85											
						End of Boring at 8 ft	8.0								*End 3/15/16 at 3:30 PM*
10															
15															
20															
25															
30															

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	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						[FILL] Base Course GRAVEL and Sand (GP)		0.0								*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		0.5								
5		S-2		65		Silty Lean CLAY (CL-ML), brown, firm, medium plasticity, moist		3.0								
10		S-3		58		[FOUNDATION] Lean CLAY with Sand (CL), orange-brown to gray, stiff, medium plasticity		8.0								
						End of Boring at 12 ft		12.0								*End 3/16/16 at 9:50 AM*
15																
20																
25																
30																

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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	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	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					[FILL] Base Course GRAVEL (GP)		0.0 0.5								*Start 3/16/16 10:05 AM*
		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-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															

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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 (%)	REMARKS
0					*Start 3/16/16 at 10:45 AM*
0–4		S-1		75	
4–8		S-2		58	
8–12		S-3		83	
12–16		S-4		100	
16–20		S-5		100	
20–24		S-6		100	
24					*End 3/16/16 at 3:00 PM*

Depth (feet)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)
0.0–0.5	[FILL] Base Course GRAVEL (GP)							
0.5–3.0	Sandy SILT (ML), brown, firm, low plasticity							
3.0–4.0	[ASH] SILT with Sand (ML), stiff, no to low plasticity, moist							
4.0–10.0	[FILL] Lean CLAY (CL), firm, medium plasticity, moist							
10.0–19.5	[ASH] SILT with Sand (ML), gray, soft, no plasticity, wet, 2" layer of medium sand							
19.5–24.0	Lean CLAY with Ash (CL) gray, soft, medium plastiticy, wet							
24.0	End of Boring at 24 ft							

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						[FILL] Base Course GRAVEL (GP)		0.0 0.5								*Start 3/16/16 at 3:05 PM*
		S-1		73		[FILL] Lean CLAY (CL), brown, stiff, medium plasticity, moist to wet, trace fine sand										
						firm										
5																
		S-2		79		[ASH] SILT with Sand (ML), gray, soft, wet, traces of fine sand		6.0								
10		S-3		83												
		S-4		83												
15																
		S-5		100												
						Lean CLAY with Ash (CL), gray, soft, medium plasticity, wet		19.0								
20																
		S-6		100		Fine SAND with ash (SM), gray, loose, wet		22.0								
						End of Boring at 24 ft		24.0								*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	SAMPLES 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		S-1		65		[FILL] Sandy SILT (ML), brown, soft to medium stiff, trace gravel		0.0								*Start 3/16/16 at 4:45 PM*
5		S-2		54	▨	[FILL] Lean CLAY (CL) with silt, brown, medium stiff, wet, trace wood, fine gravel		4.0								
10		S-3		100	▨	[FOUNDATION] Lean CLAY (CL), brown, stiff		8.0								
						End of Boring at 12 ft		12.0								
15																
20																
25																*End 3/16/16 at 5:15 PM*
30																

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	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
0								0.0								*Start 3/17/16 at 7:55 AM*
							[FILL] Base Course GRAVEL (GP)	0.5								
		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												
15		S-4		100				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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	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					[FILL] Silty SAND (SM) with gravel		0.0								*Start 3/17/16 at 9:15 AM*
		S-1		100	[FILL] Sandy SILT (ML), brown, medium stiff, moist, low plasticity		1.5								
5		S-2		75	[FILL] Lean CLAY (CL), gray to dark gray, medium stiff, moist, medium plasticity, trace coal		4.0								
					[FILL] Sandy SILT (ML), brown, sotf to medium stiff, moist to wet, medium plasticity		5.0								
10		S-3		100	[FOUNDATION] Silty lean CLAY (CL), gray to orangish brown, medium stiff, moist, medium plasticity		9.0								
					stiff, with iron stains										
15		S-4		100											
					End of Boring at 16 ft		16.0								*End 3/17/16 at 10:15 AM*
20															
25															
30															

AECOM

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											
10		S-3		63			10.0								
						[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															

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D021

Sheet 1 of 2

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	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					[FILL] Base Course GRAVEL (GP)	0.0								*Start 3/19/19 at 3:45 PM*
	S-1		75		[RAILROAD EMBANKMENT] Lean CLAY with Ash (CL), gray and orange-brown, stiff, no to low plasticity, moist	1.5								
5														
	S-2		100		Silty CLAY (CL-ML), orange-brown and gray, stiff, low to medium plasticity, moist gray	5.5								
														Driller noted soft layer
10	S-3		83		brown and gray, medium plasticity									
														End 3/19/16 at 5:50 PM *Start 3/20/16 at 7:30 AM*
					trace silt, brown, very stiff									
	S-4		63											
15														
					[FOUNDATION] Lean CLAY (CL), gray and green-gray, very stiff, medium to high plasticity, moist, traces of coal	16.0								
	S-5		75											
20														
	S-6		75		wet ▽									
25					ranges from brown to green-gray									
	S-7		79											
	S-8		62		orange-brown and gray, silty									
30														

Project: Dynegy

Project Location: Joppa Power Station, Massac County, IL

Project Number: 60428794

Log of Boring JOP-D021

Sheet 2 of 2

Depth (feet)	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	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								
							End of Boring at 31.1 ft									*Refusal at 31.1ft.* *End 3/20/16 at 10:15 AM*
35																
40																
45																
50																
55																
60																
65																

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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet): NOT SURVEYED)	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0	☒	HA-1			▨	[FILL] CLAY (CL), dark brown, soft, moist, with silt and decomposed organics brown, with sand	0.0								
		☒	HA-2			▨										
	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	SAMPLES 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
	0						NOT SURVEYED		0.0								
								[FILL] CLAY (CL), dark brown, soft, moist, with silt and decomposed organics ∇	0.5								
		☒	HA-1			▨		[FILL] SAND (SC), brown, loose, saturated, with clay and silt 3" layer of medium dense, saturated crushed stone	3.5								
		☒	HA-2			▨		[FILL] CLAY (CL), brown, soft, saturated, with silt and sand	5.0								
	5	☒	HA-3			✱		[ASH] FLY ASH, gray, loose, saturated	6.5								
								End of Boring at 6.5 ft									
	10																
	15																
	20																
	25																
	30																

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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) NOT SURVEYED; Depth (feet) 0.0)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	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														

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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet): NOT SURVEYED; Depth (feet): 0.0)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	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	SAMPLES Number	SAMPLES Sampling Resist. OR Core RQD (%)	SAMPLES Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) NOT SURVEYED; Depth (feet) 0.0)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					▨	[FILL] CLAY (CL), dark brown, soft, moist, with silt and decomposed organics ∇ brown, medium stiff, trace sand								
		☒	HA-1				2.0								
							[ASH] FLY ASH, gray, very loose, saturated								
		☒	HA-2				4.0								
							End of Boring at 4 ft								
	5	☒	HA-3												
	10														
	15														
	20														
	25														
	30														

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: 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	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:

$$\text{Linear, } P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$$

$$\text{Polynomial, } P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$$

*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.

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: 1520001

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	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

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520002

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	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.

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: 1520003

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	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

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:

$$\text{Linear, } P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$$

$$\text{Polynomial, } P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$$

*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.

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: 1520005

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	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.

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: 1520006

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	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.

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.

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

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: 1520660

Temperature: 23.10 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 991.3 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	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.

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:

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.

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: 1520835

Temperature: 22.90 °C

Calibration Instruction: VW Pressure Transducers

Barometric Pressure: 995.7 mbar

Cable Length: 70 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	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.

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: 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	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.

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.

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: 1520838

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	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.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Serial Number: 1520839

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	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:

$$\text{Linear, } P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$$

$$\text{Polynomial, } P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$$

*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.

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: 1520840

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	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

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:

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.

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

Date of Calibration: July 27, 2015

This calibration has been verified/validated as of 07/31/2015

Serial Number: 1520844

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	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.

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:

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.

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.

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.

ATTACHMENT D

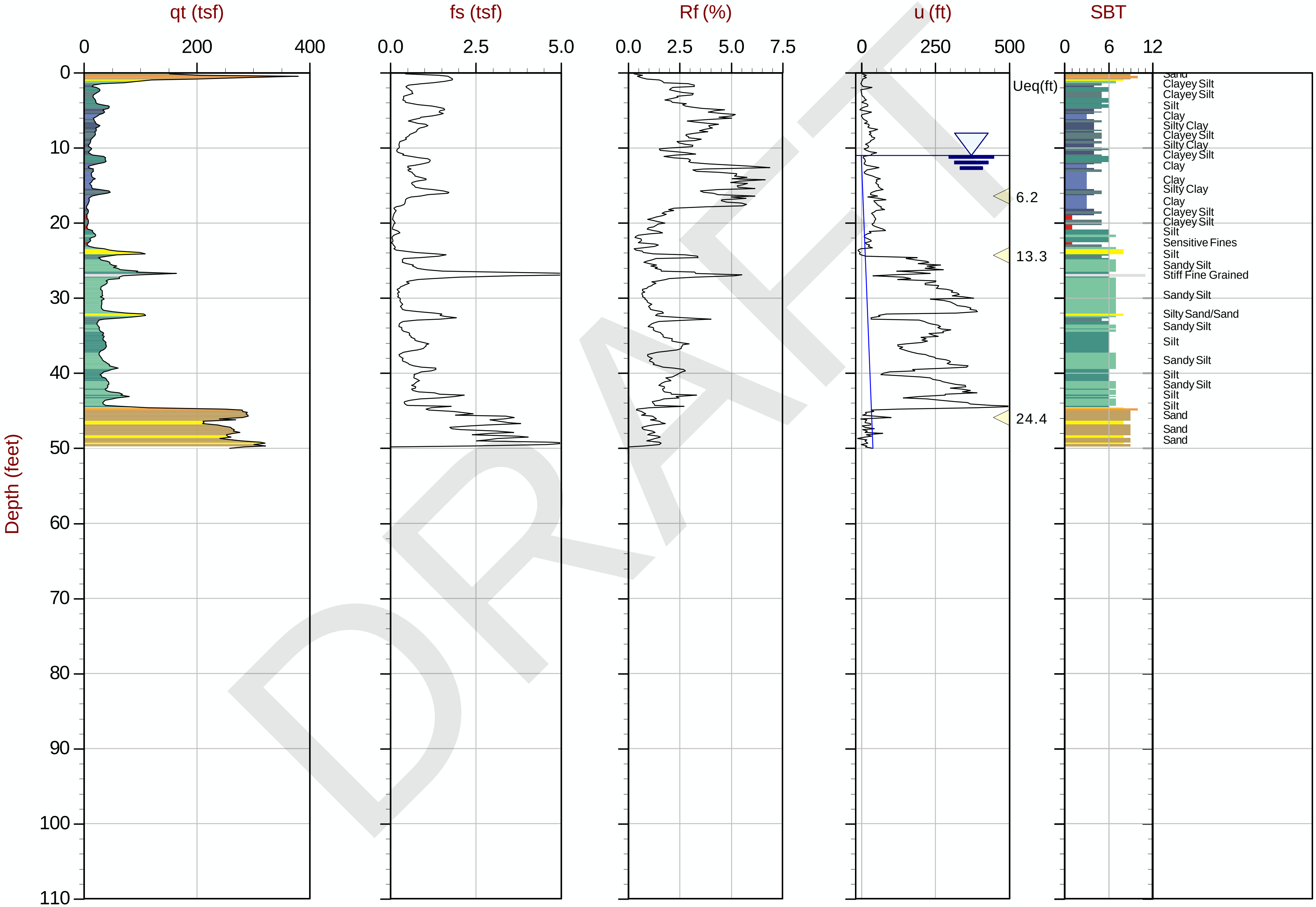
CONE PENETROMETER TESTS (CPT) DATA REPORT

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

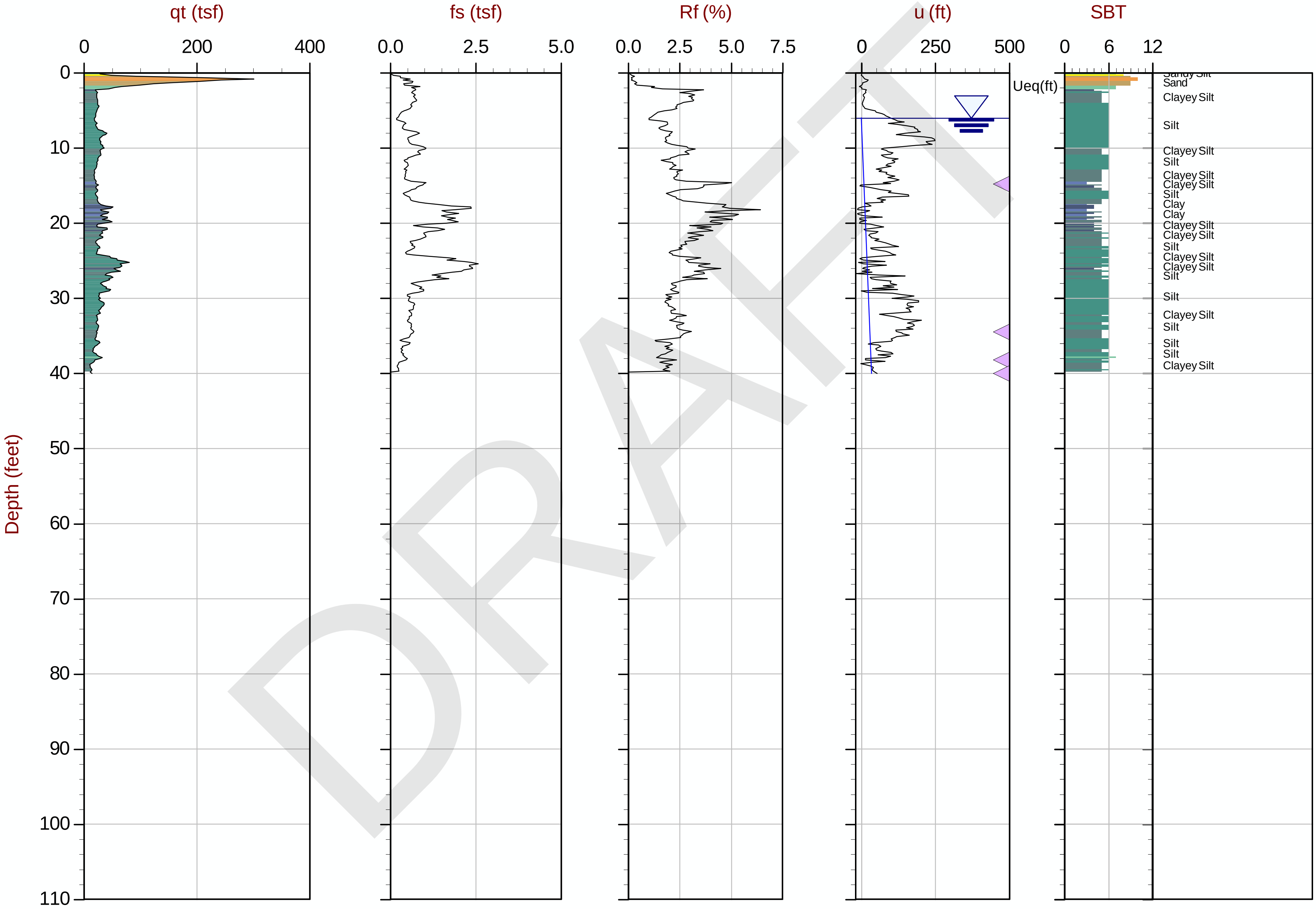
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

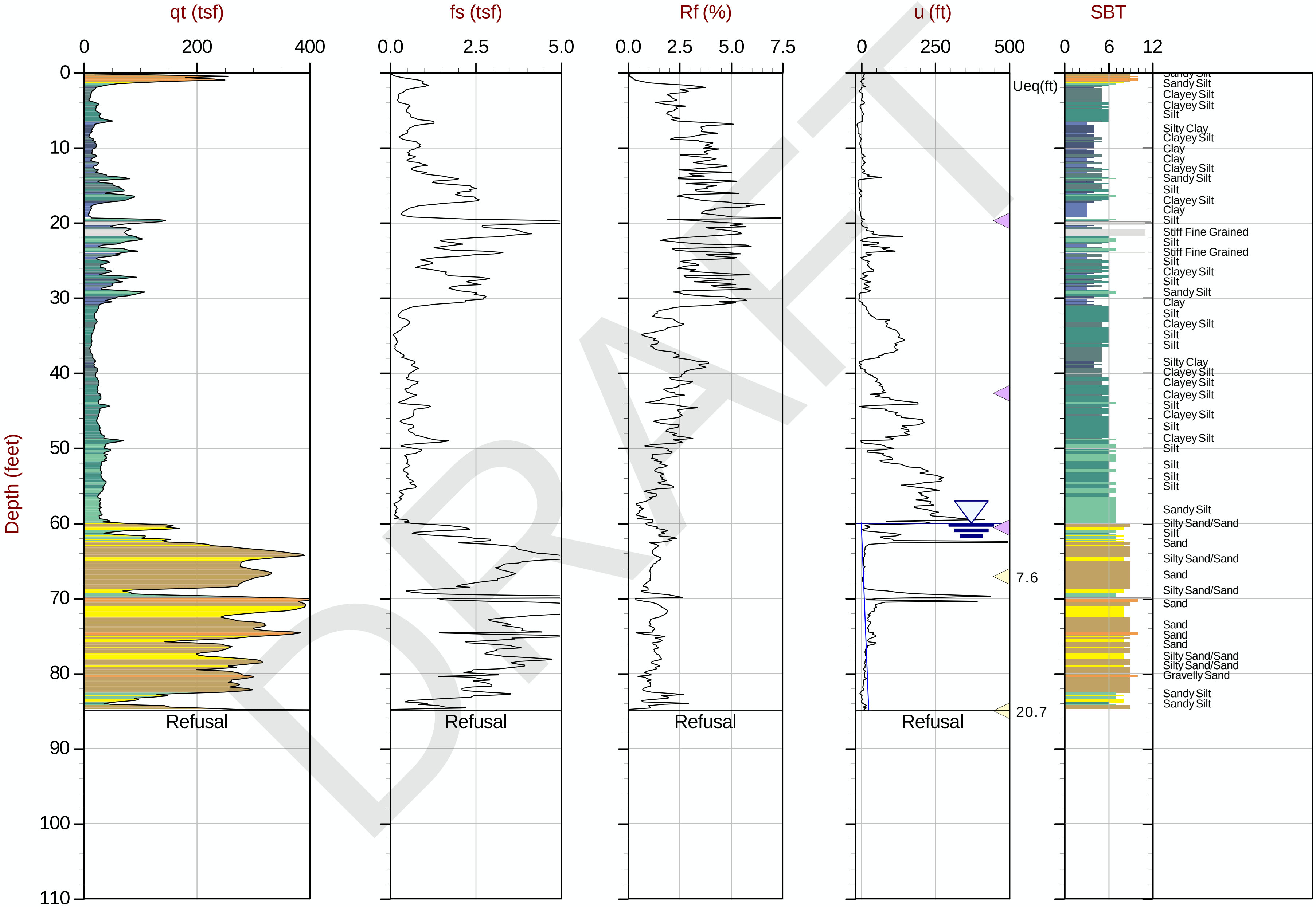
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

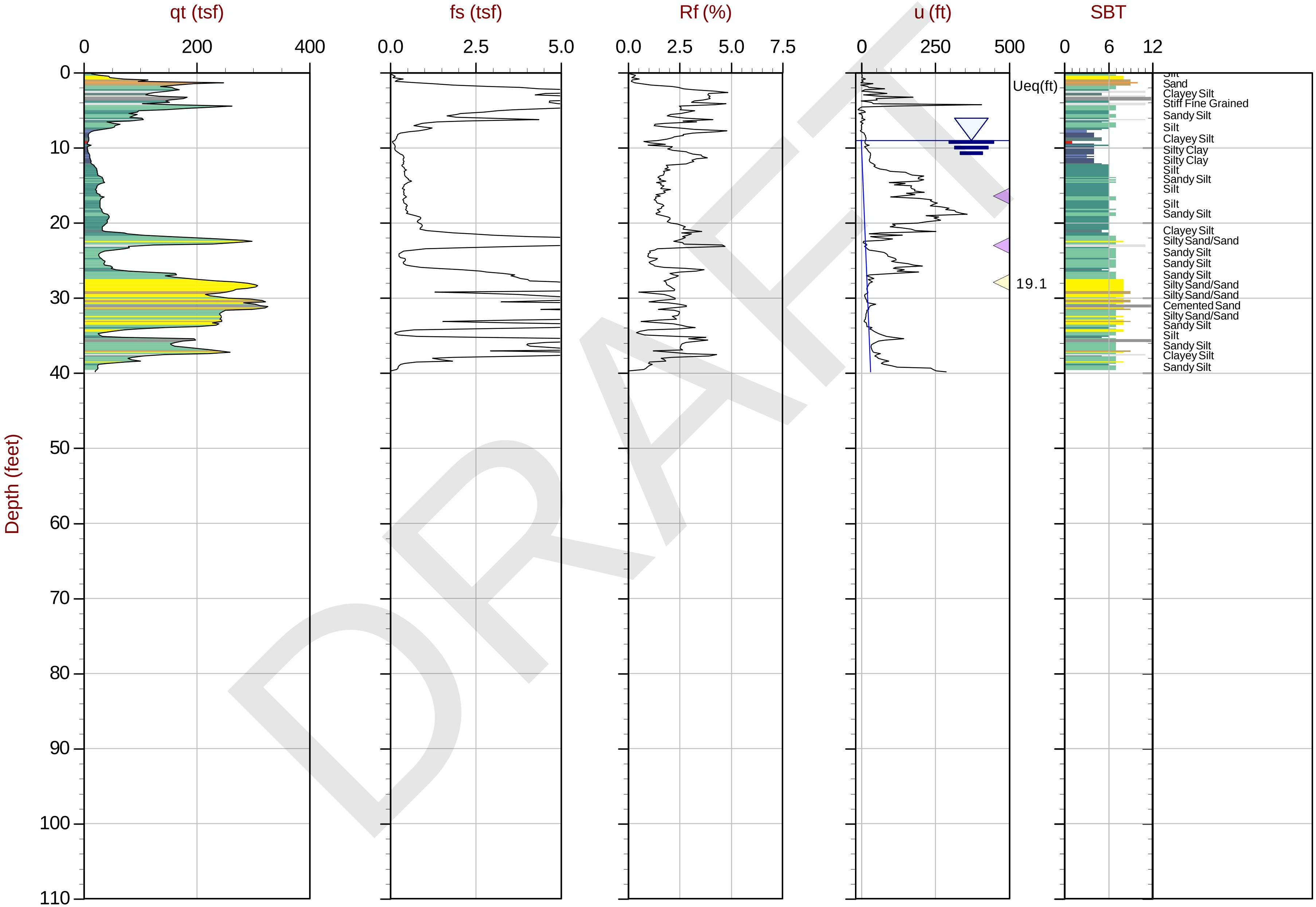
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

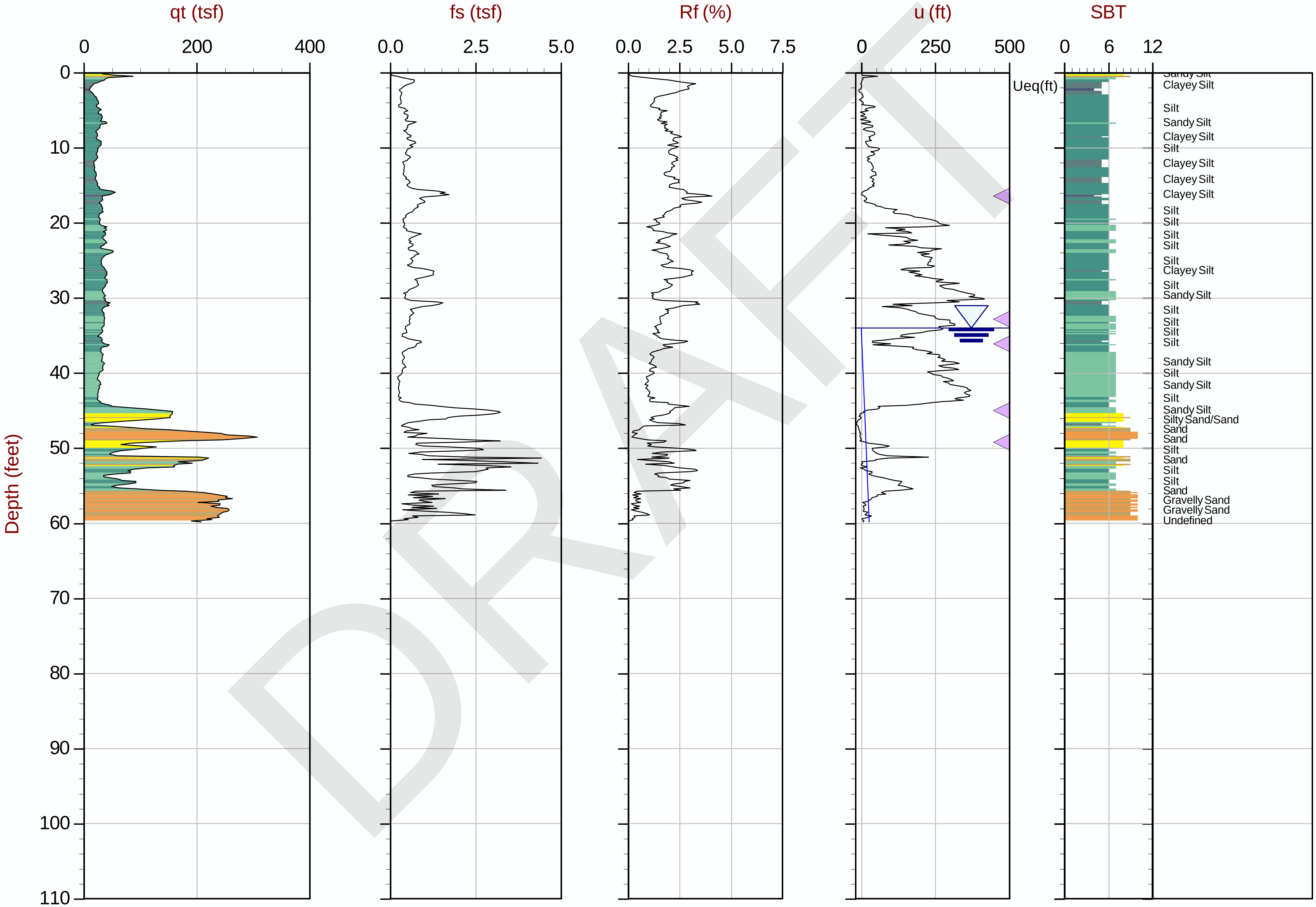
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

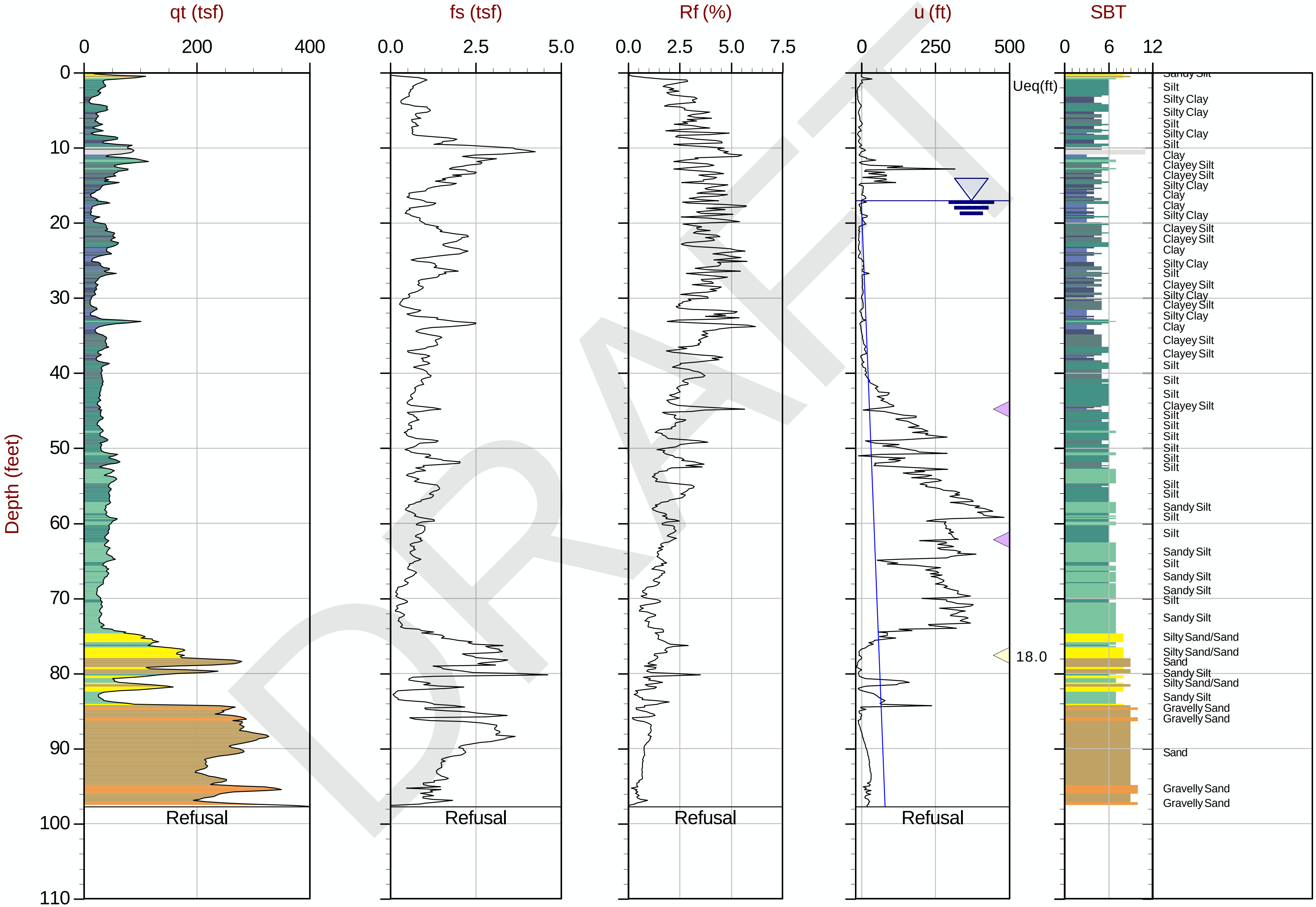
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

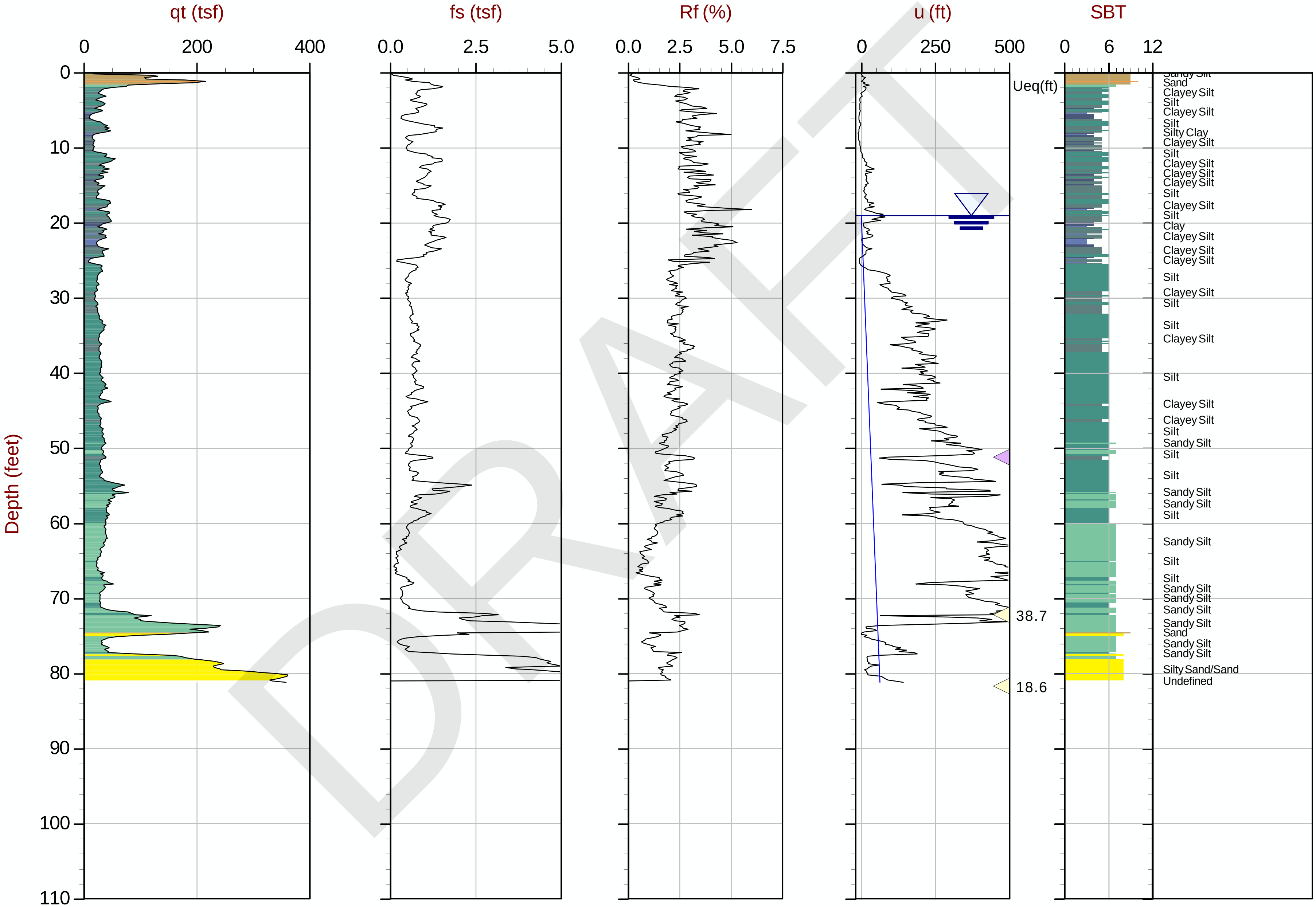
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

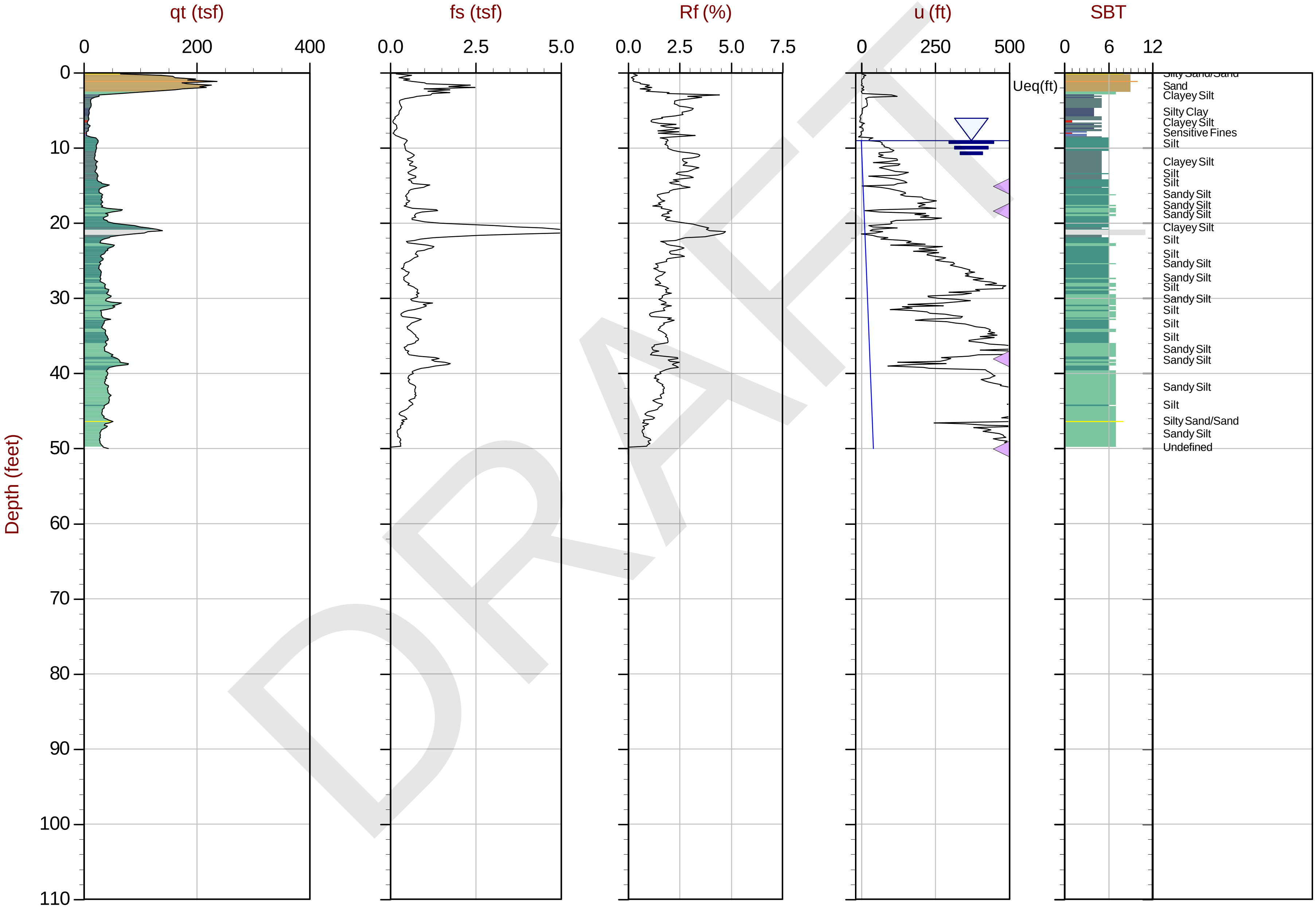
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

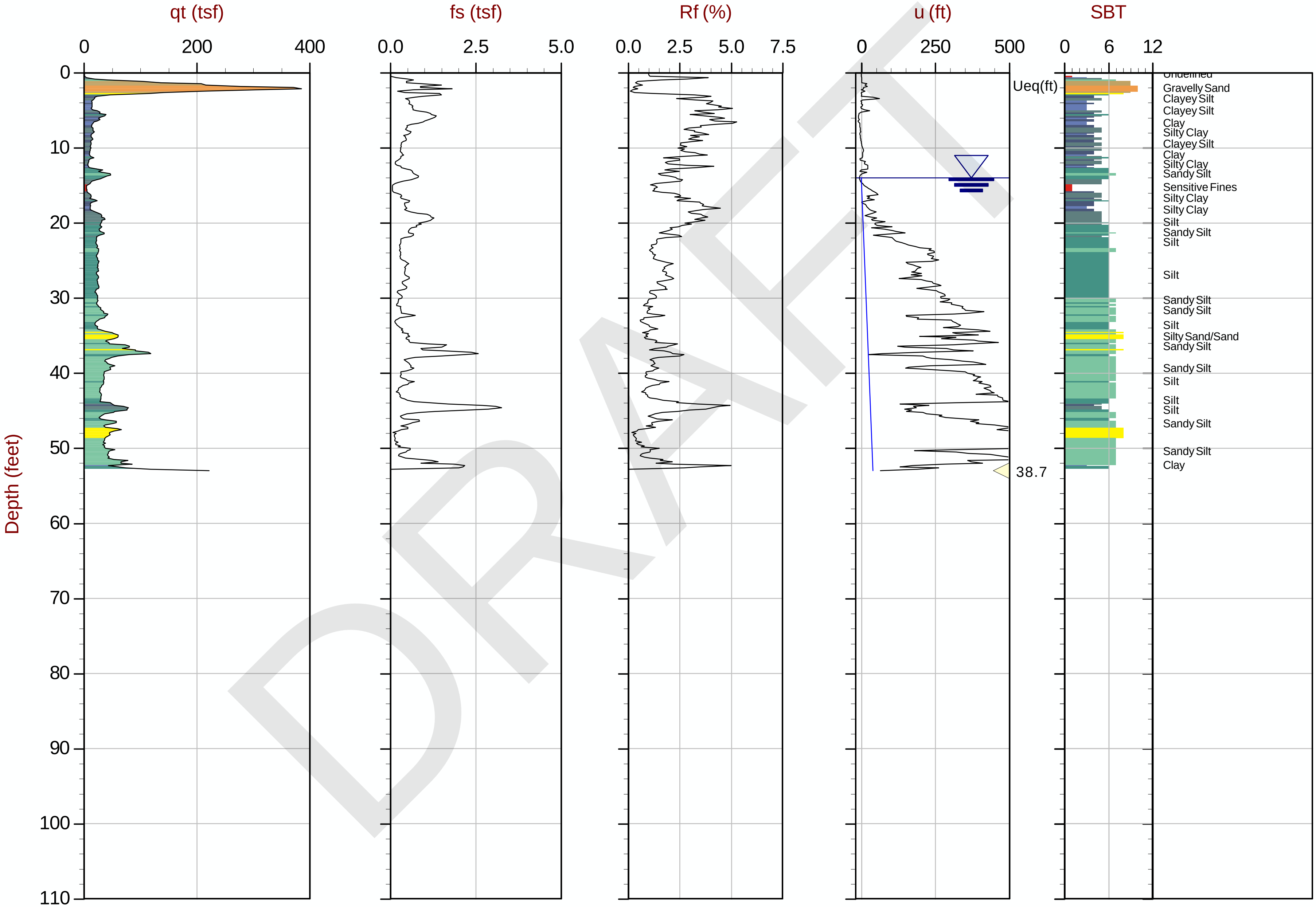
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

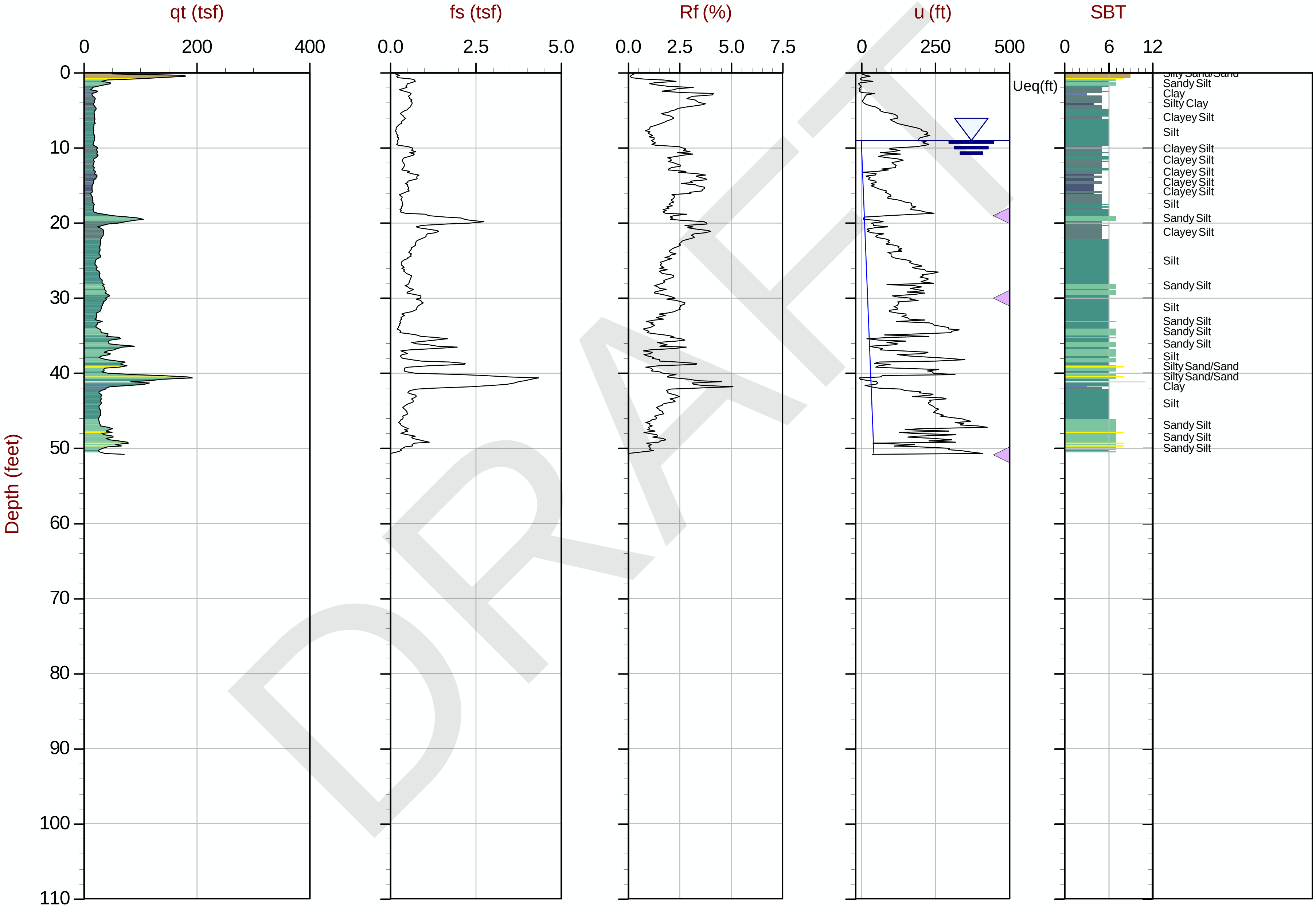
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

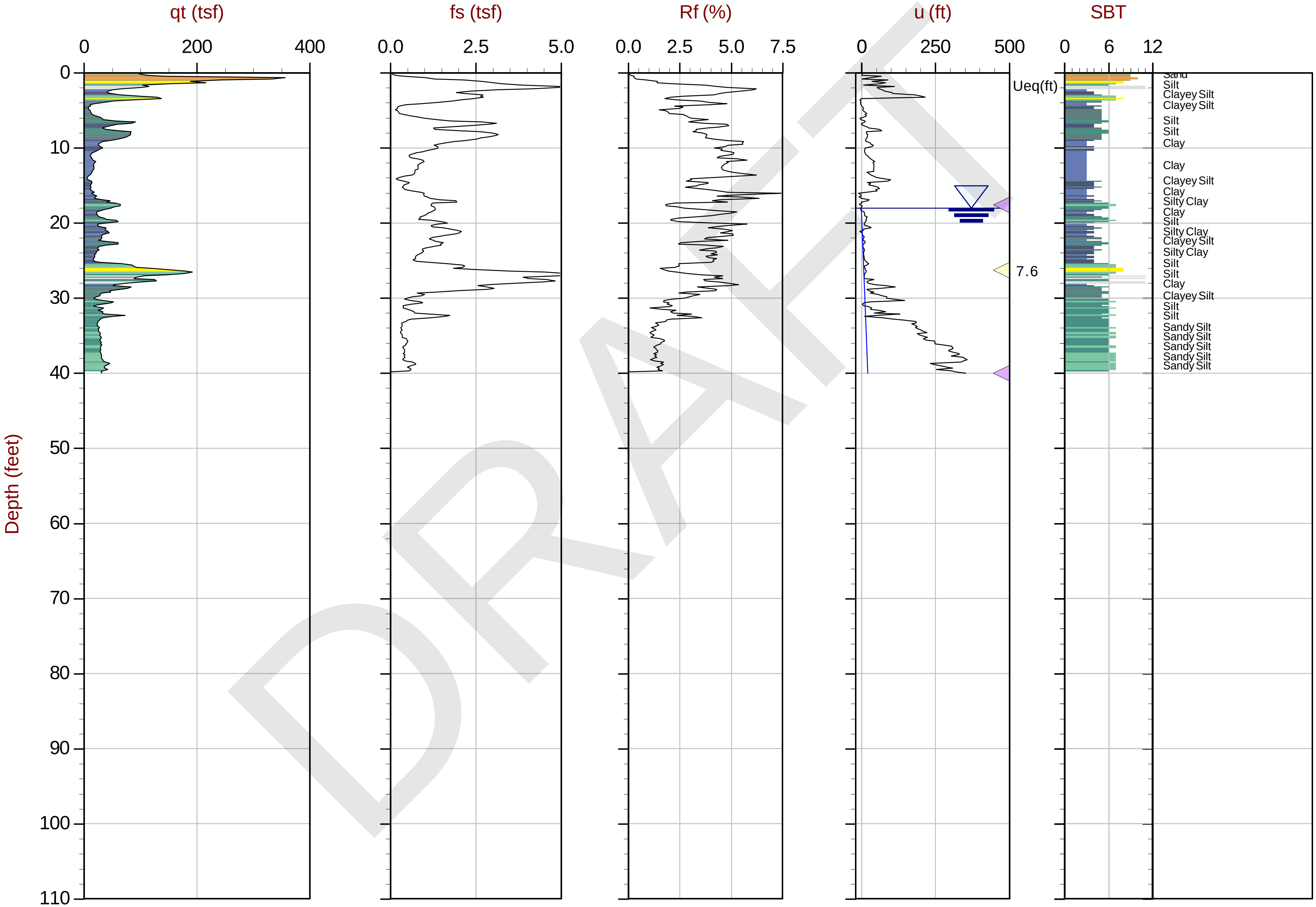
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

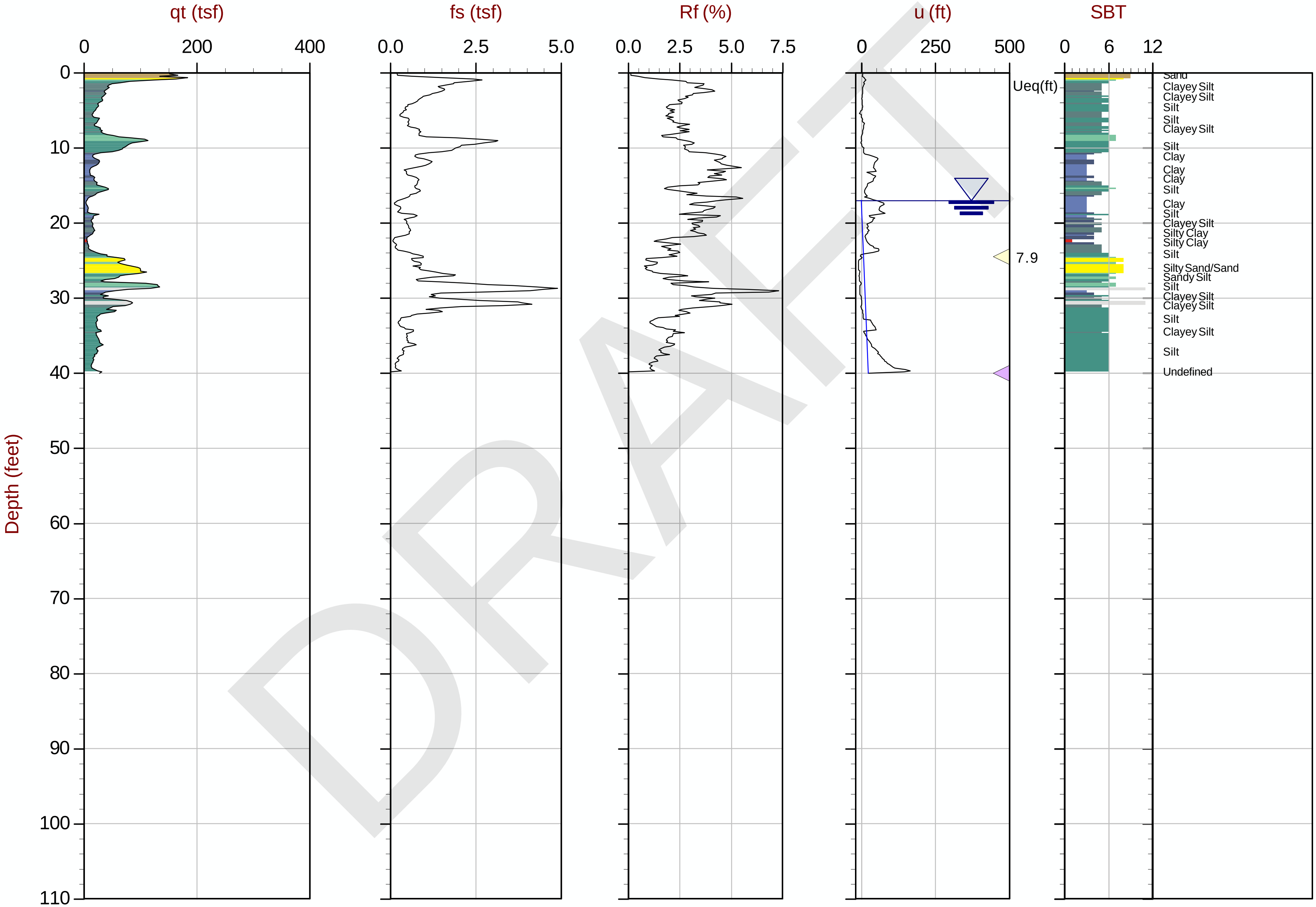
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

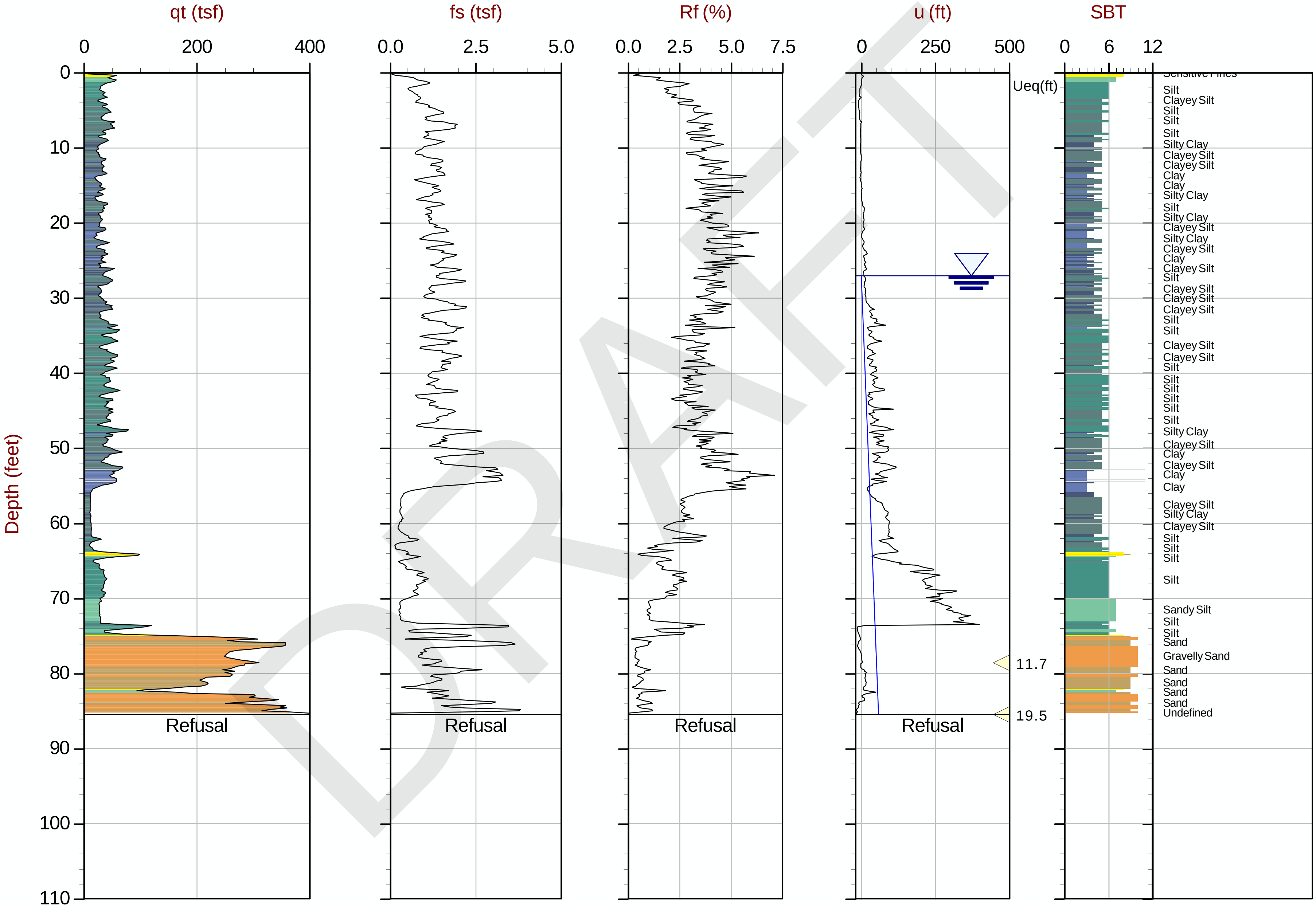
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

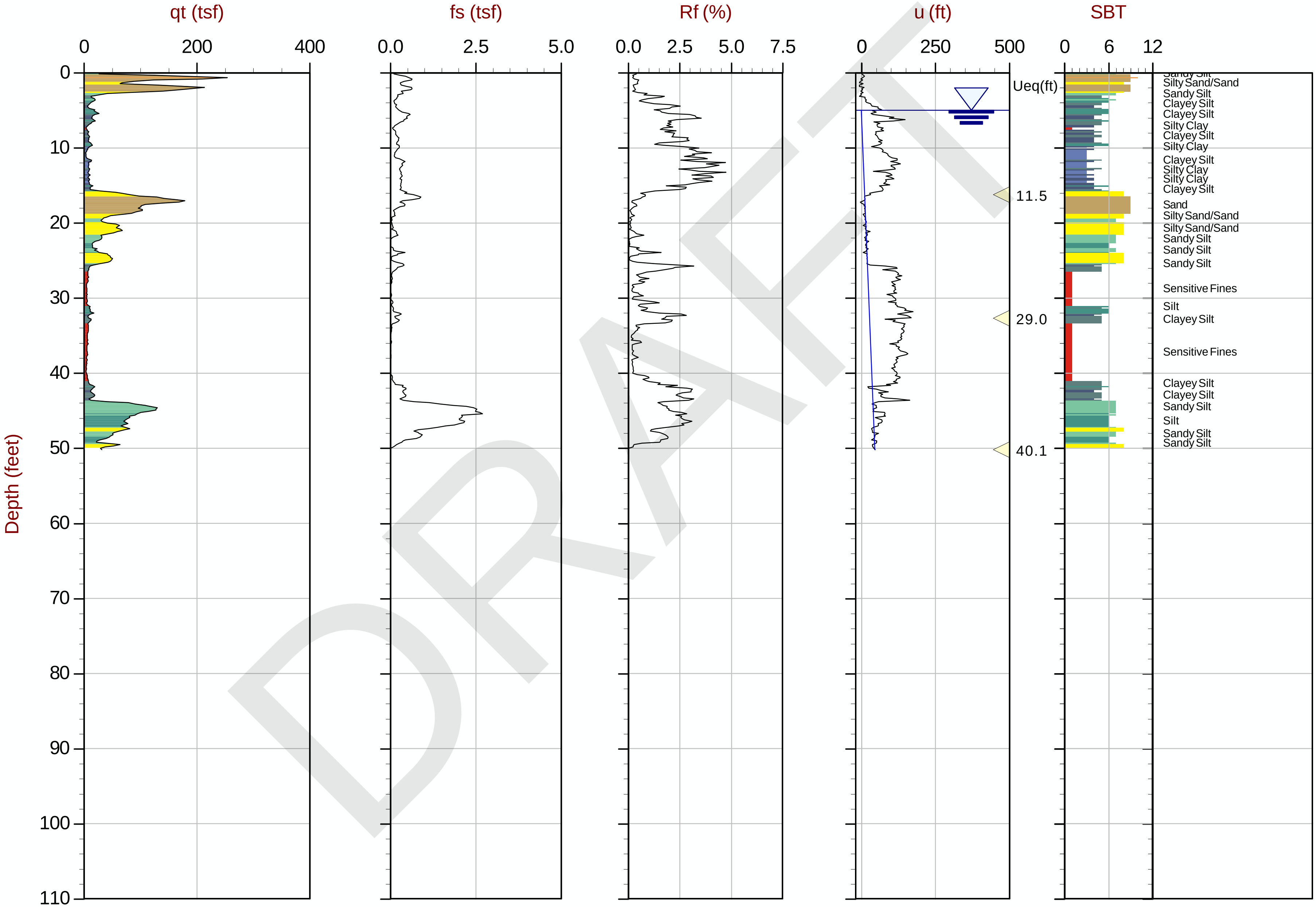
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

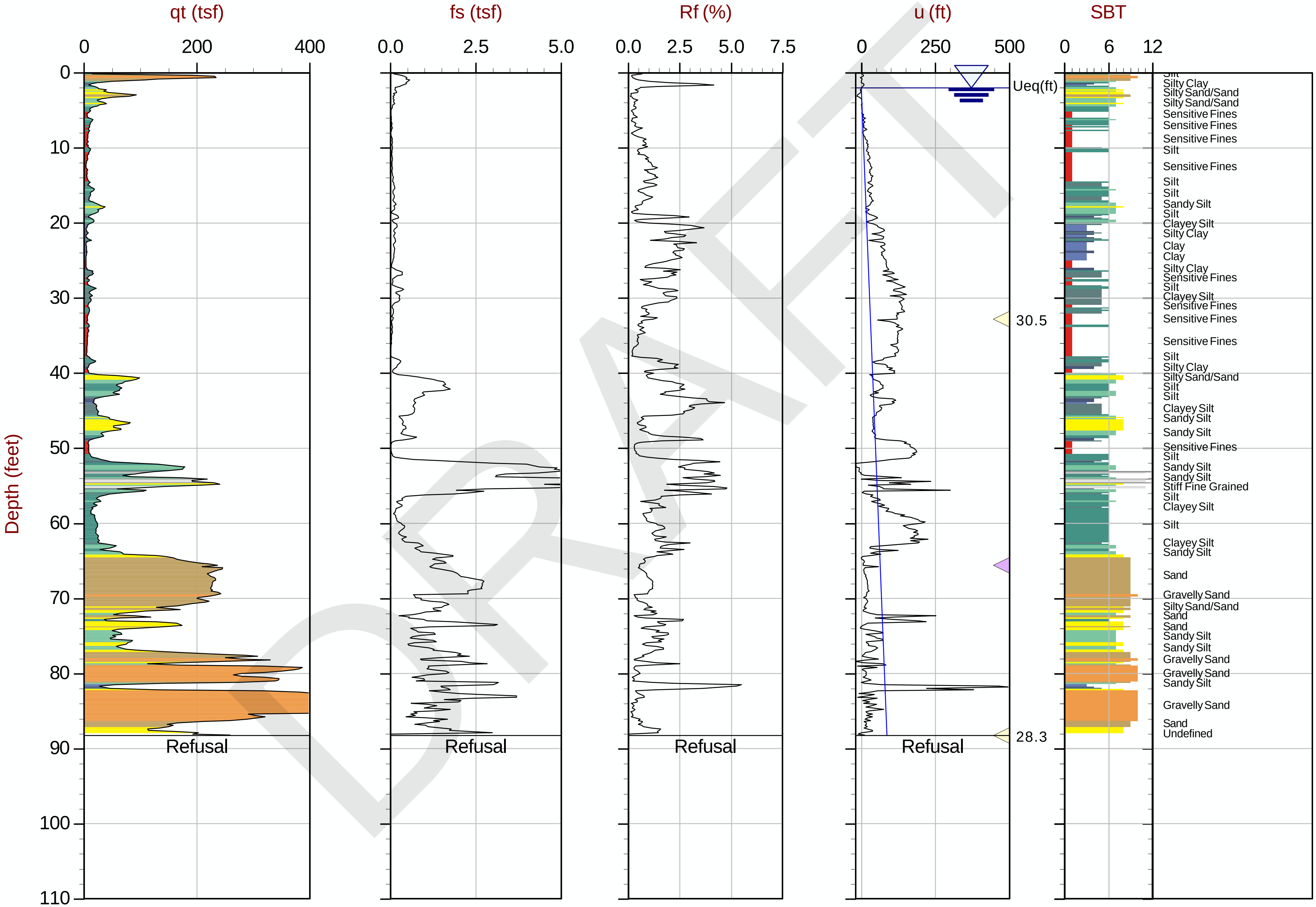
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

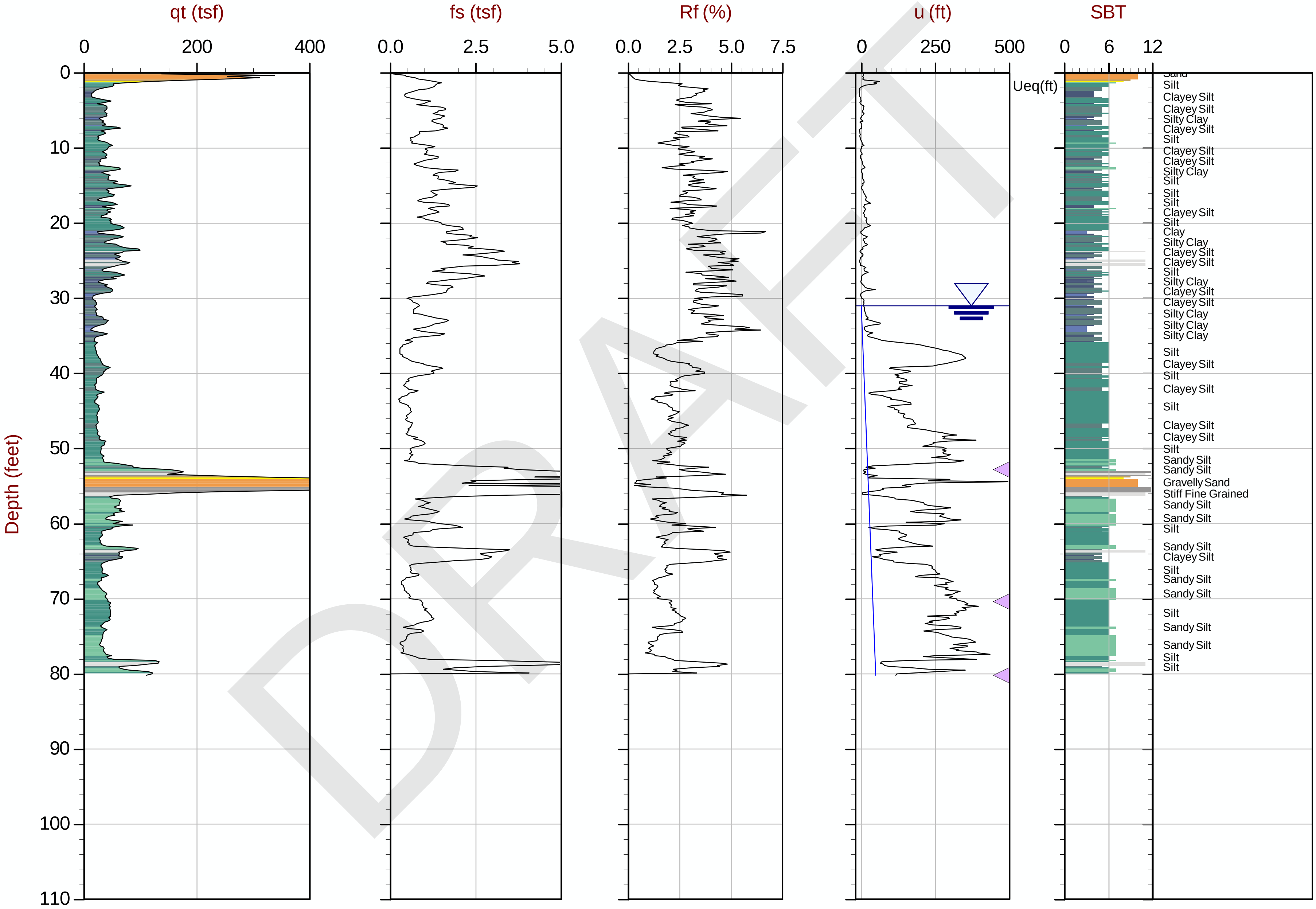
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

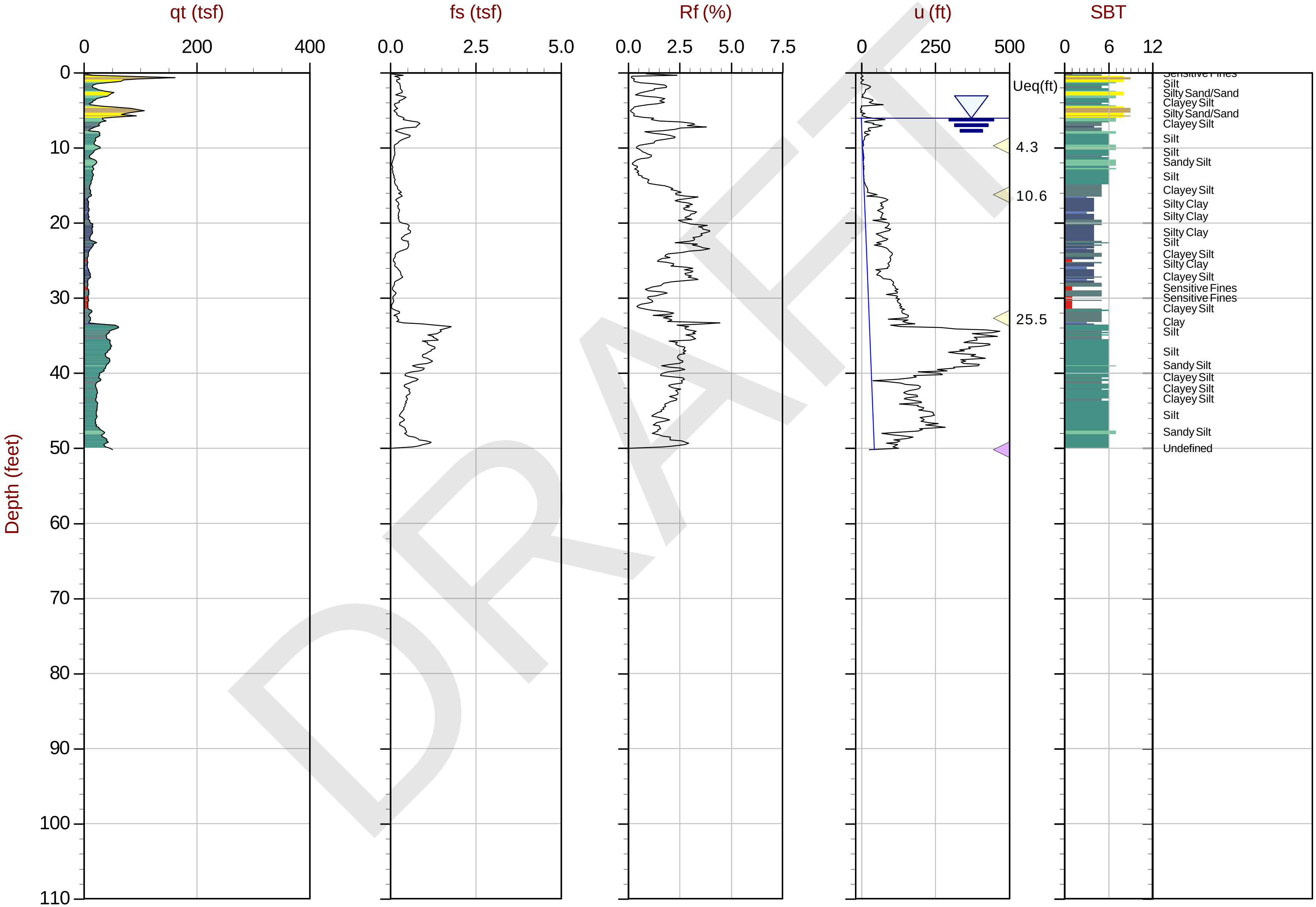
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

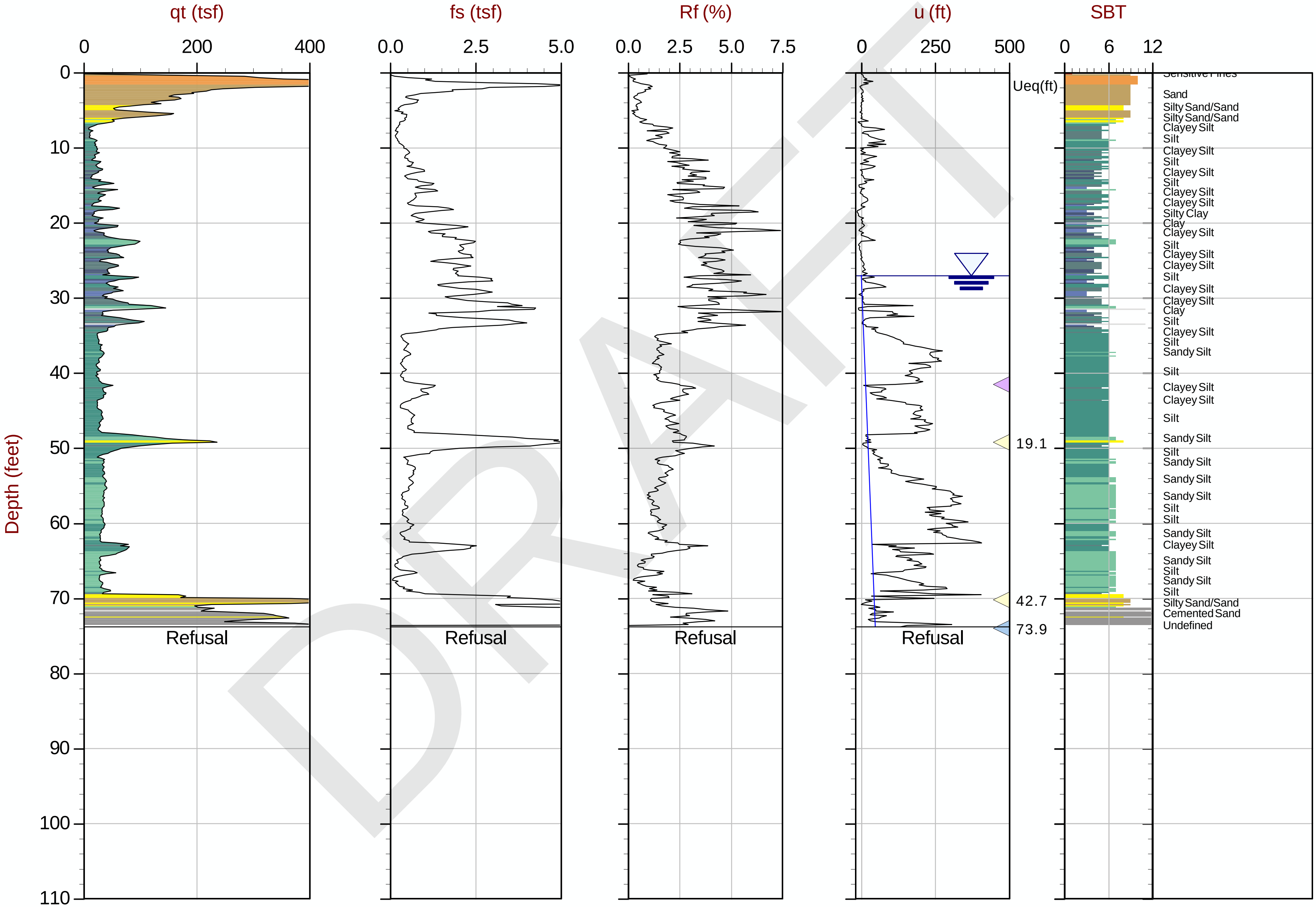
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

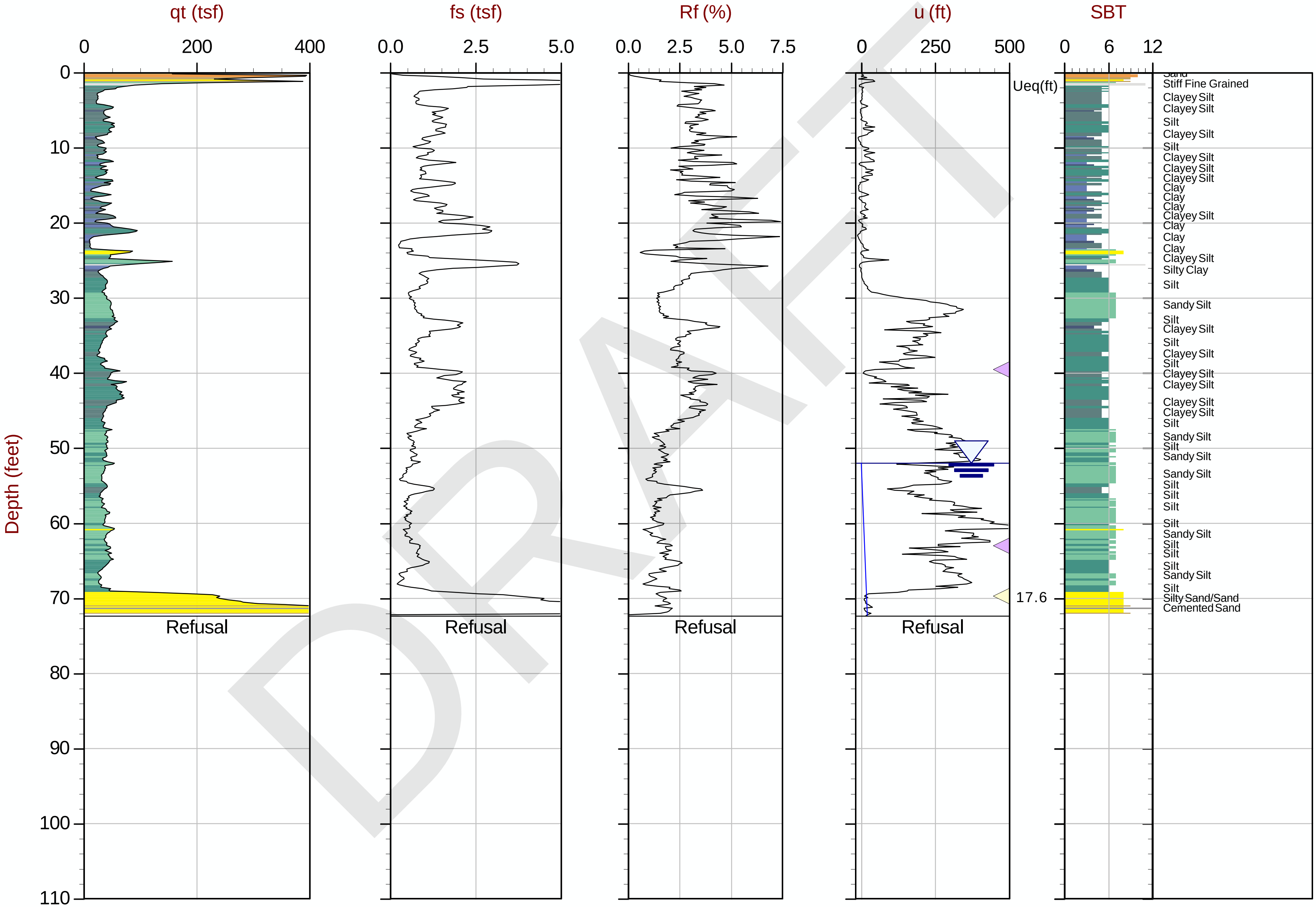
△ Dissipation, equilibrium not achieved

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

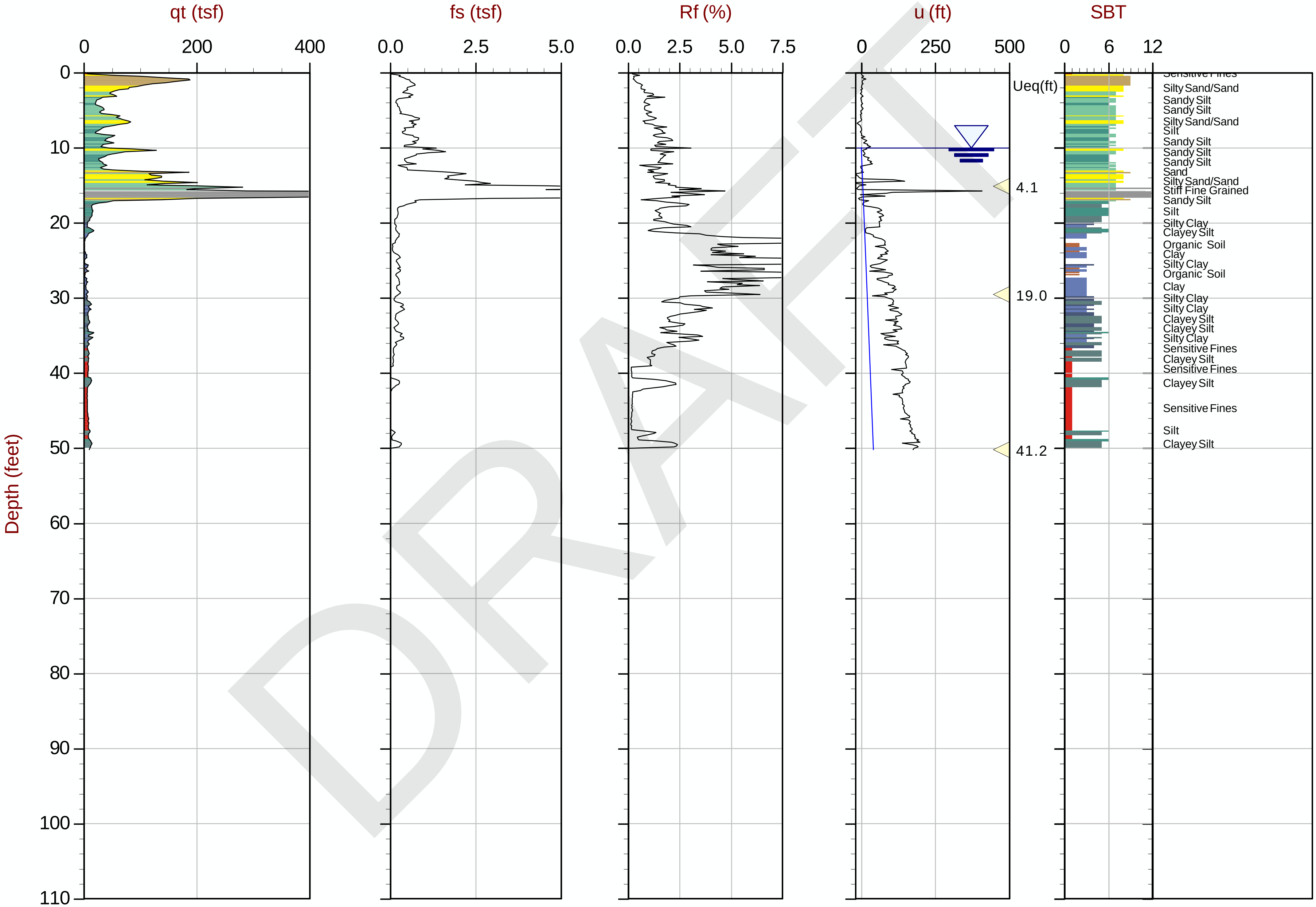
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

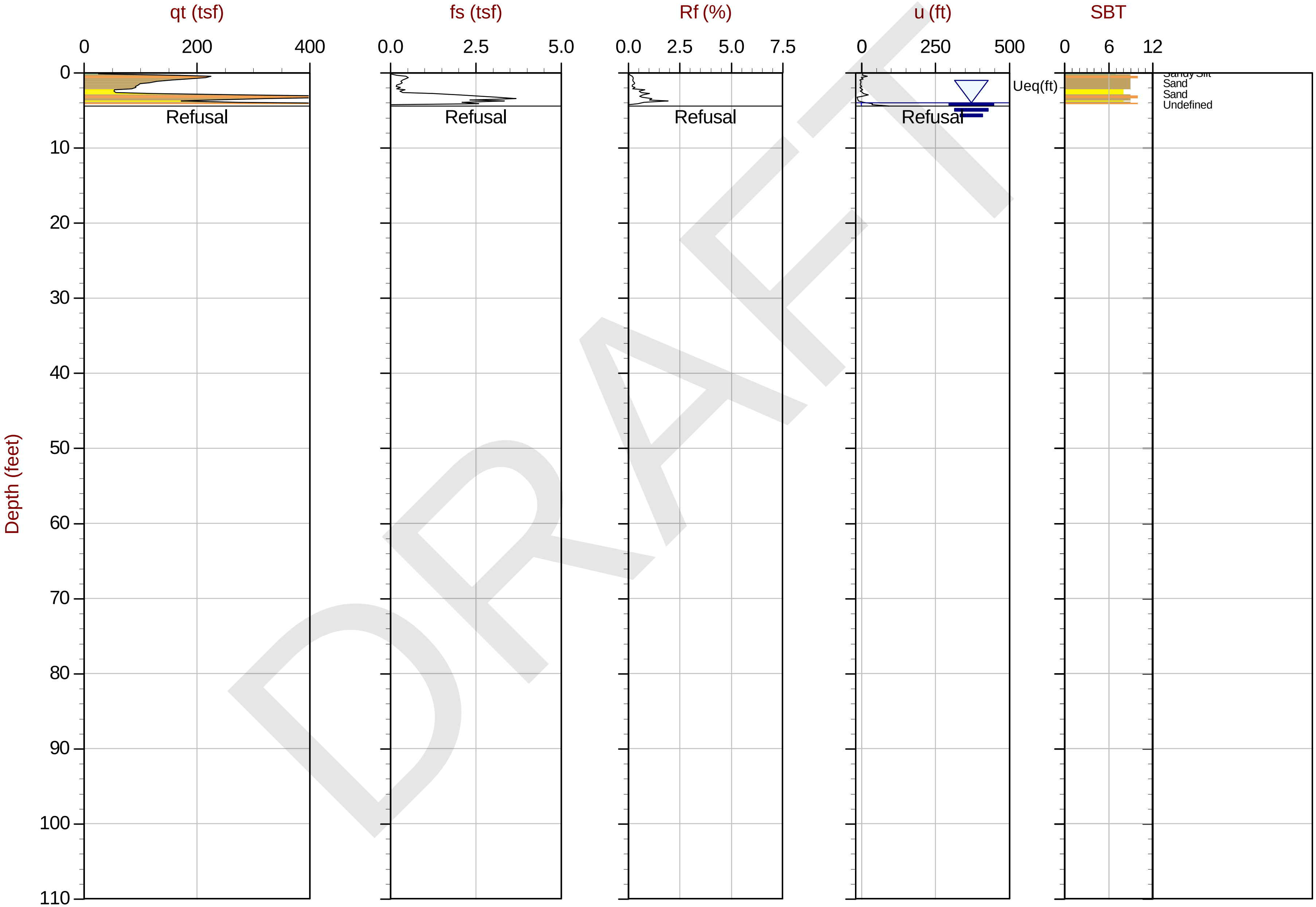
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

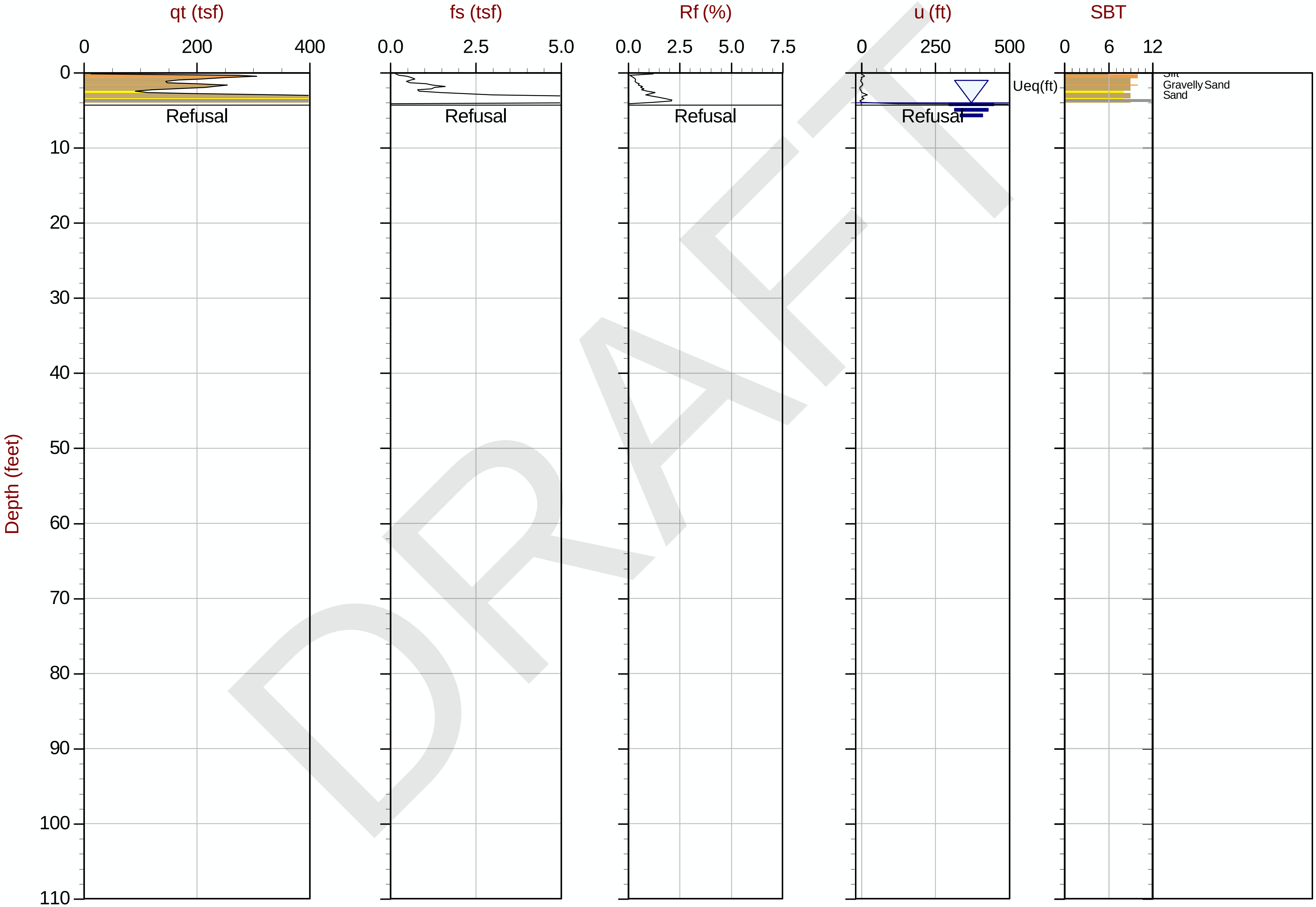
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

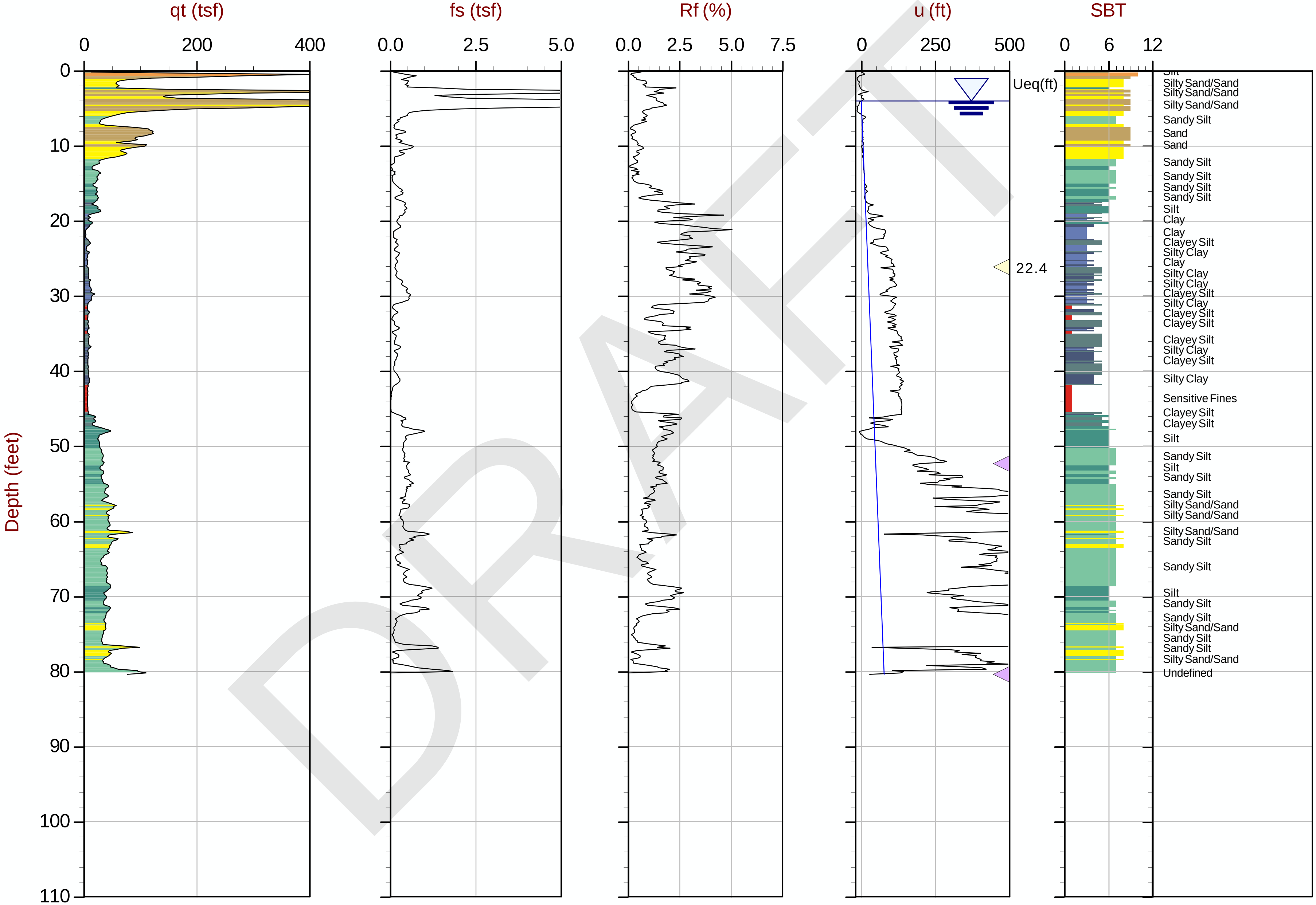
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

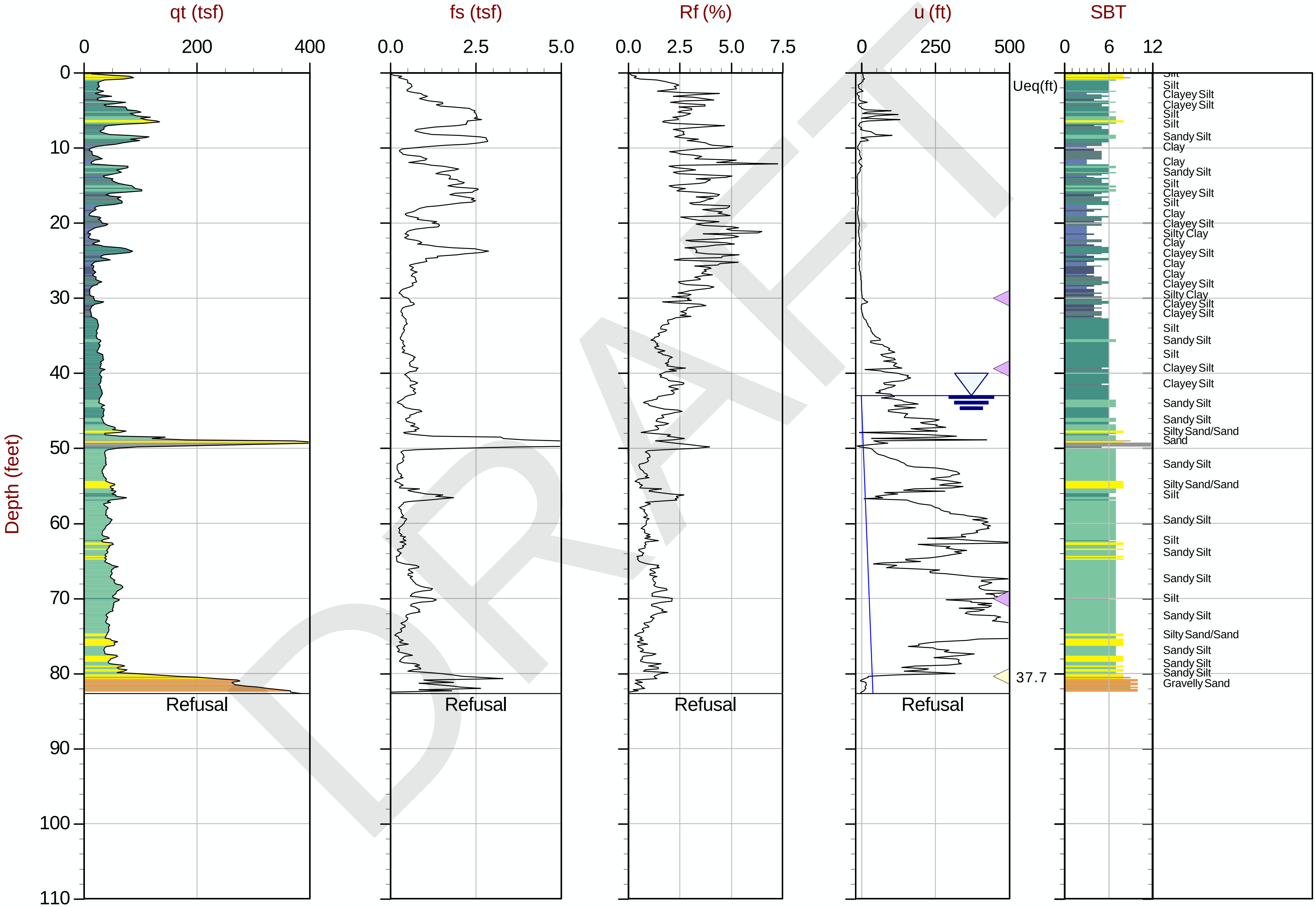
△ Dissipation, equilibrium not achieved

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

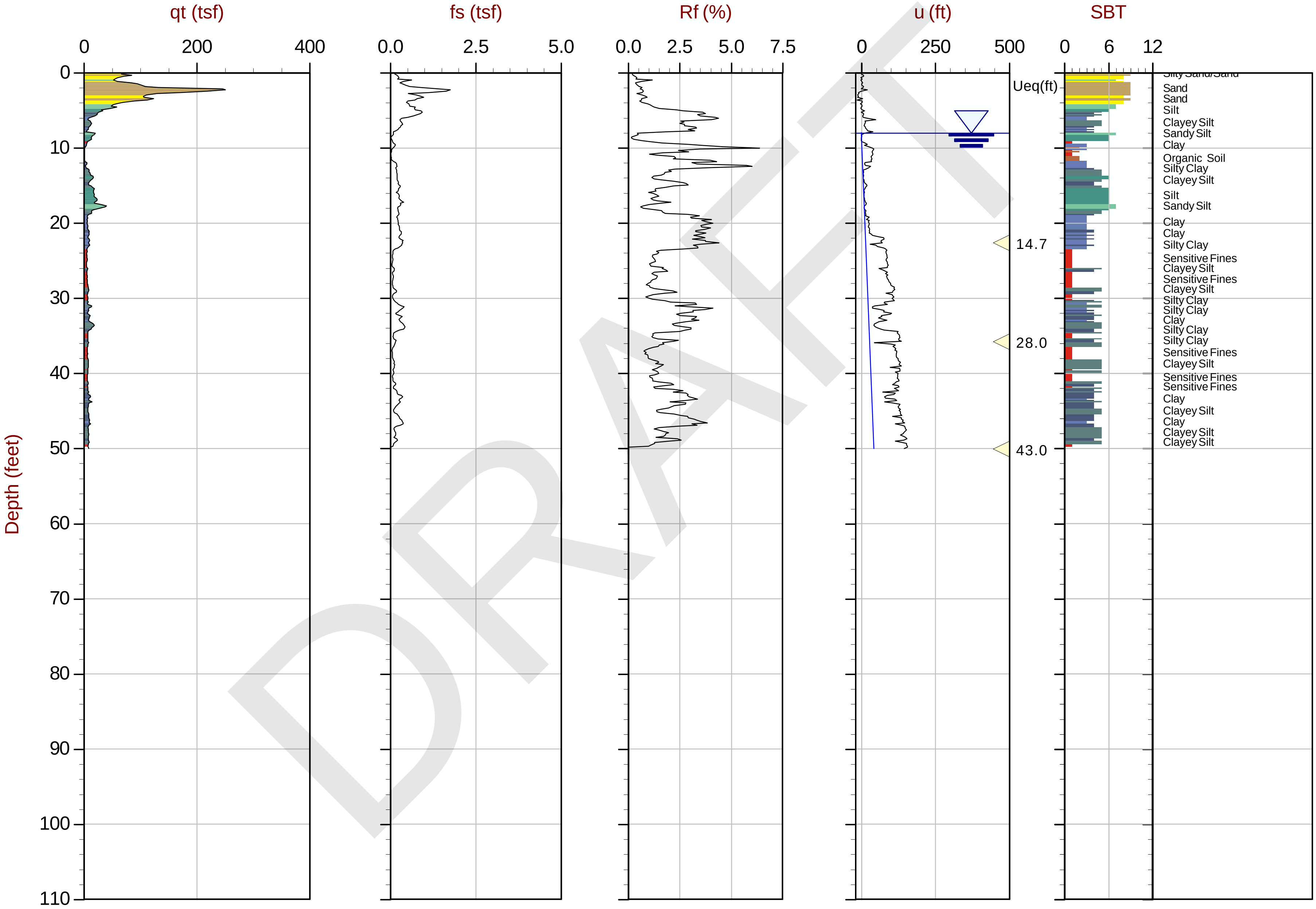
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

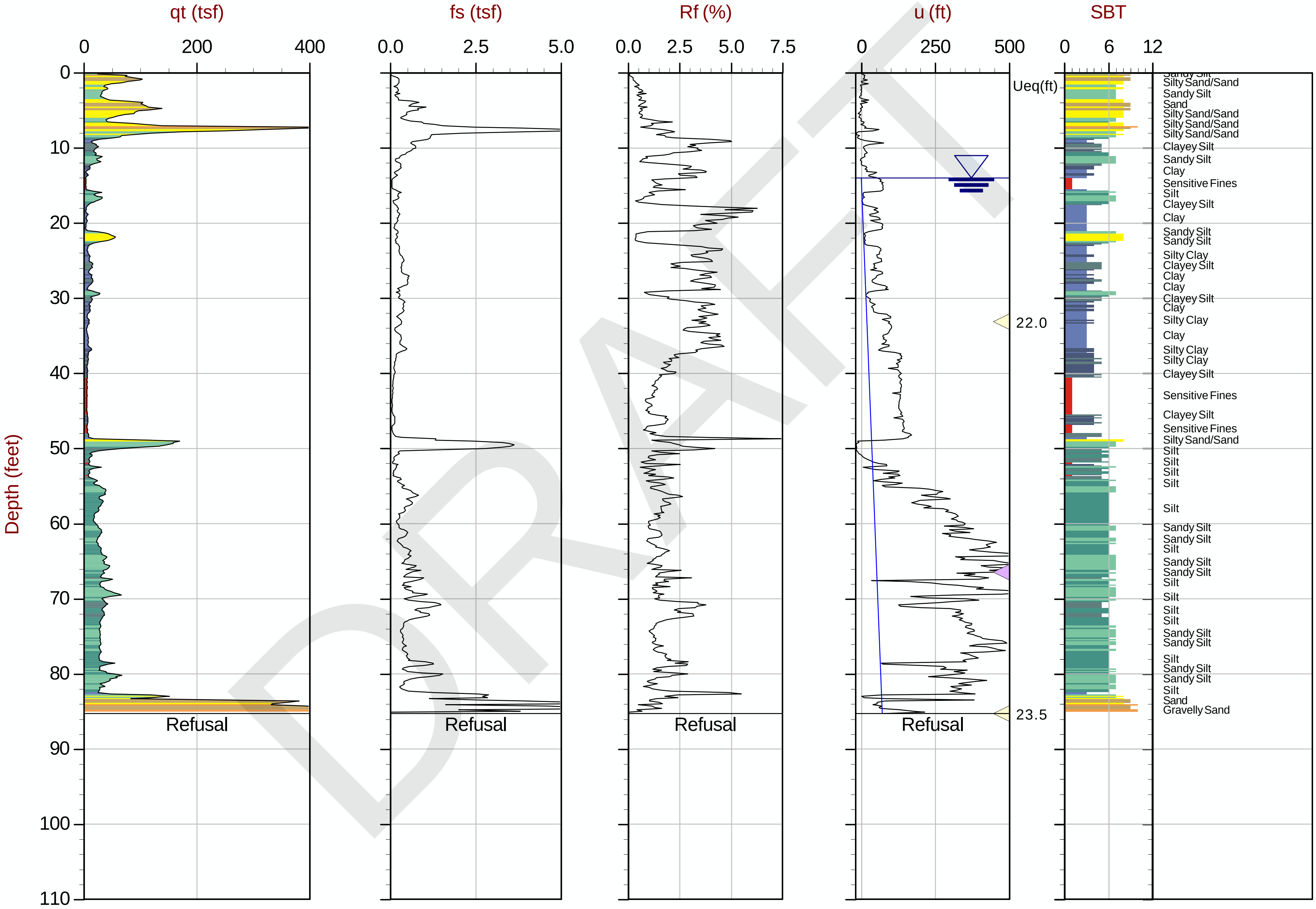
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

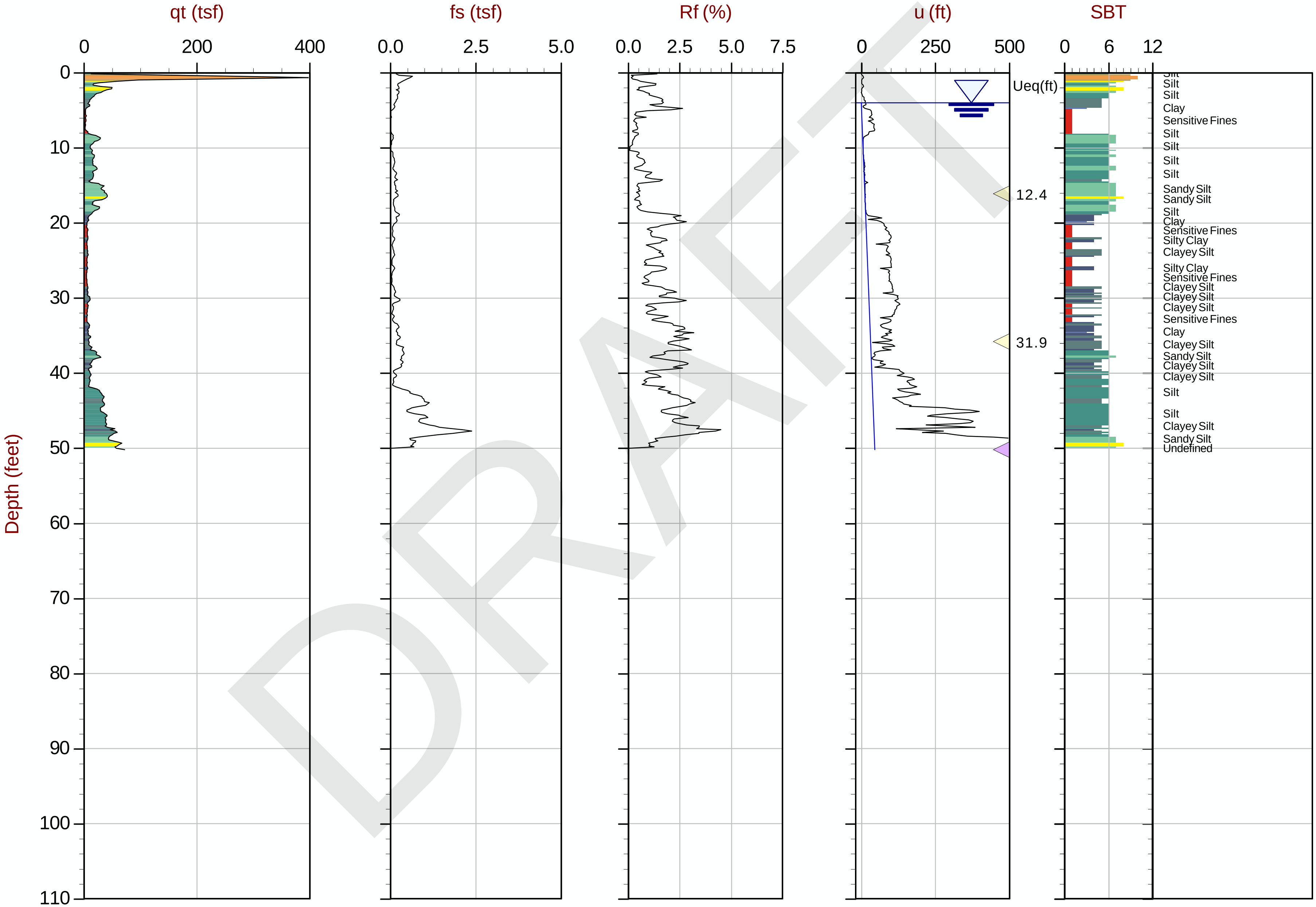
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

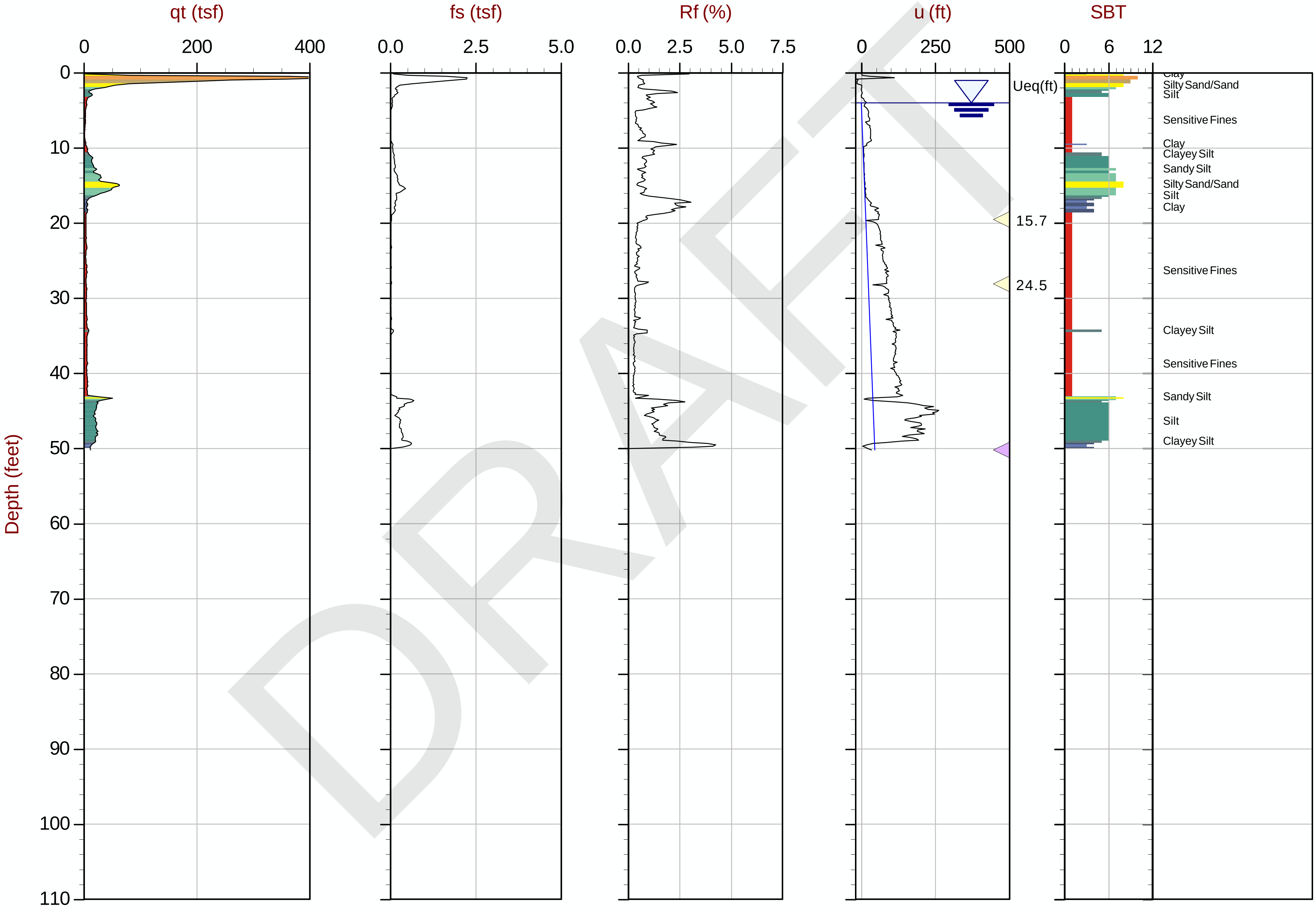
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

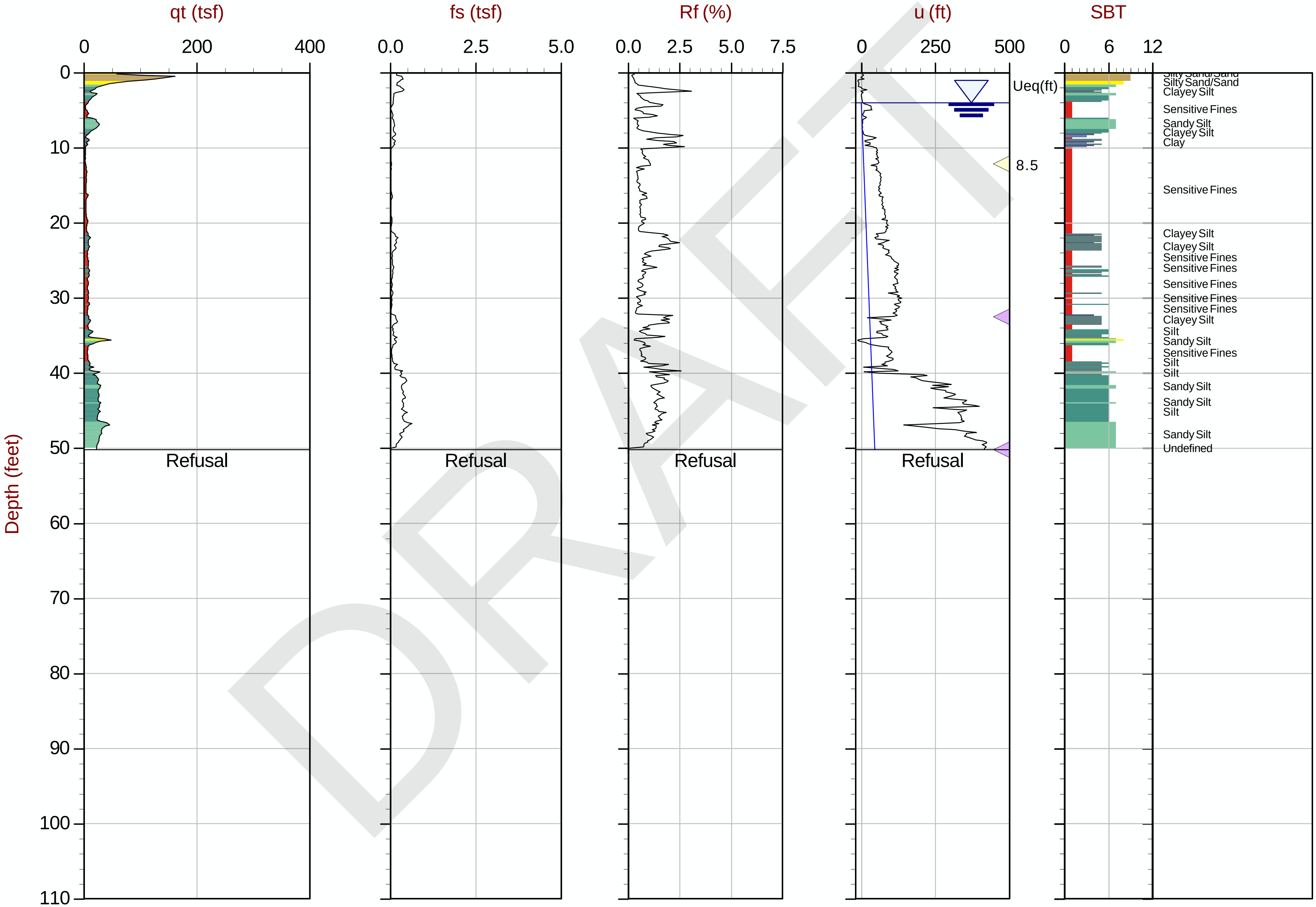
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

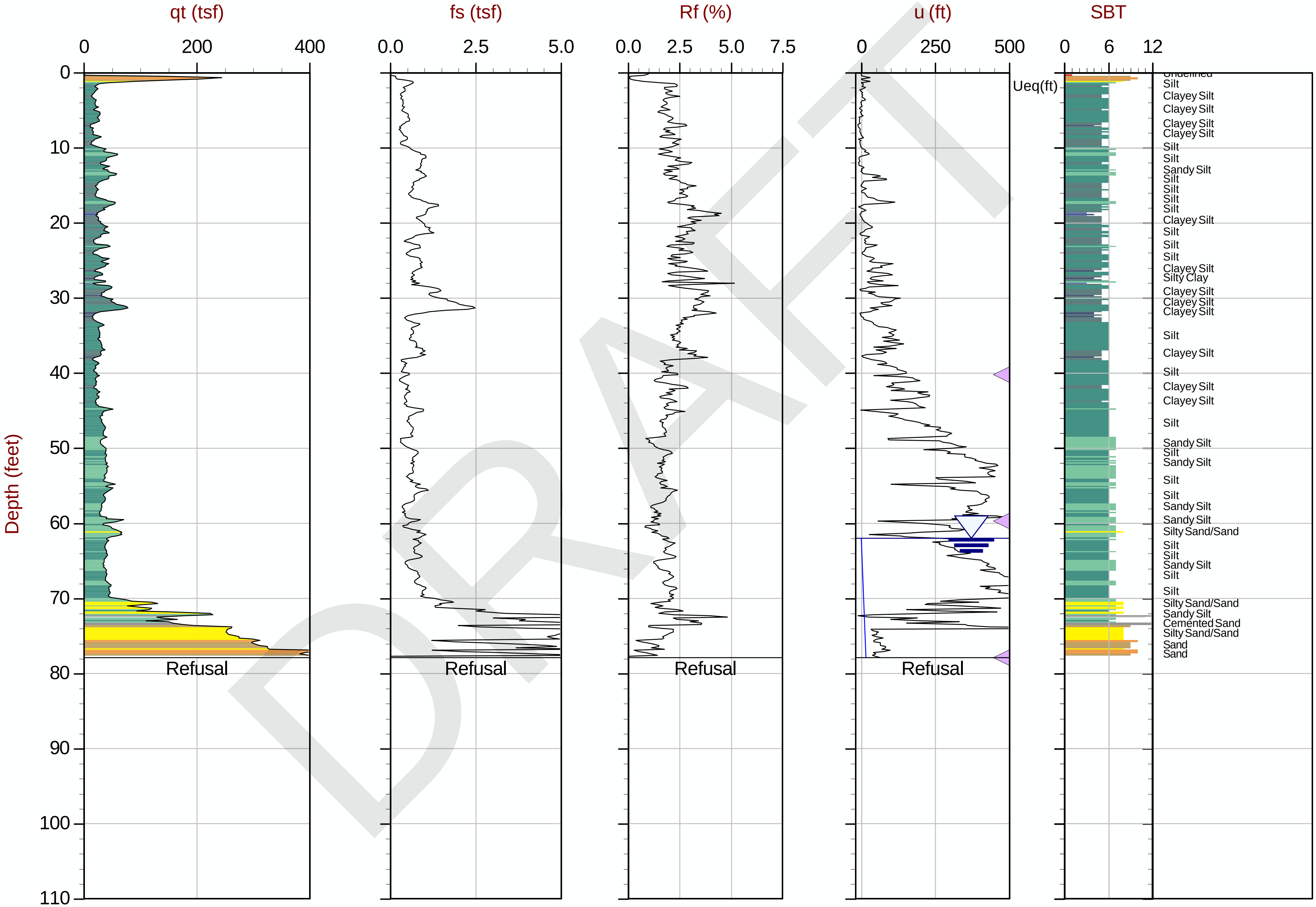
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

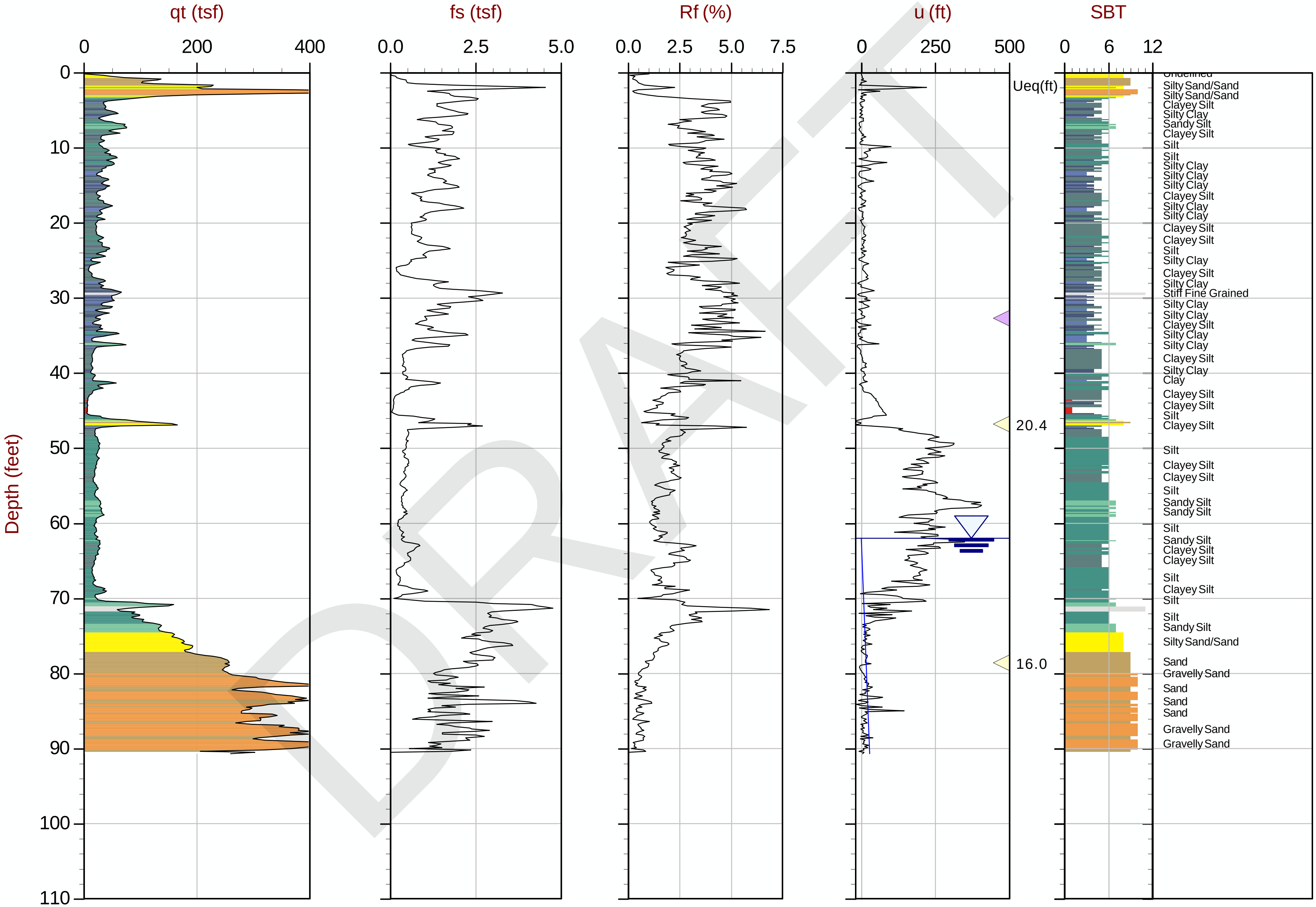
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

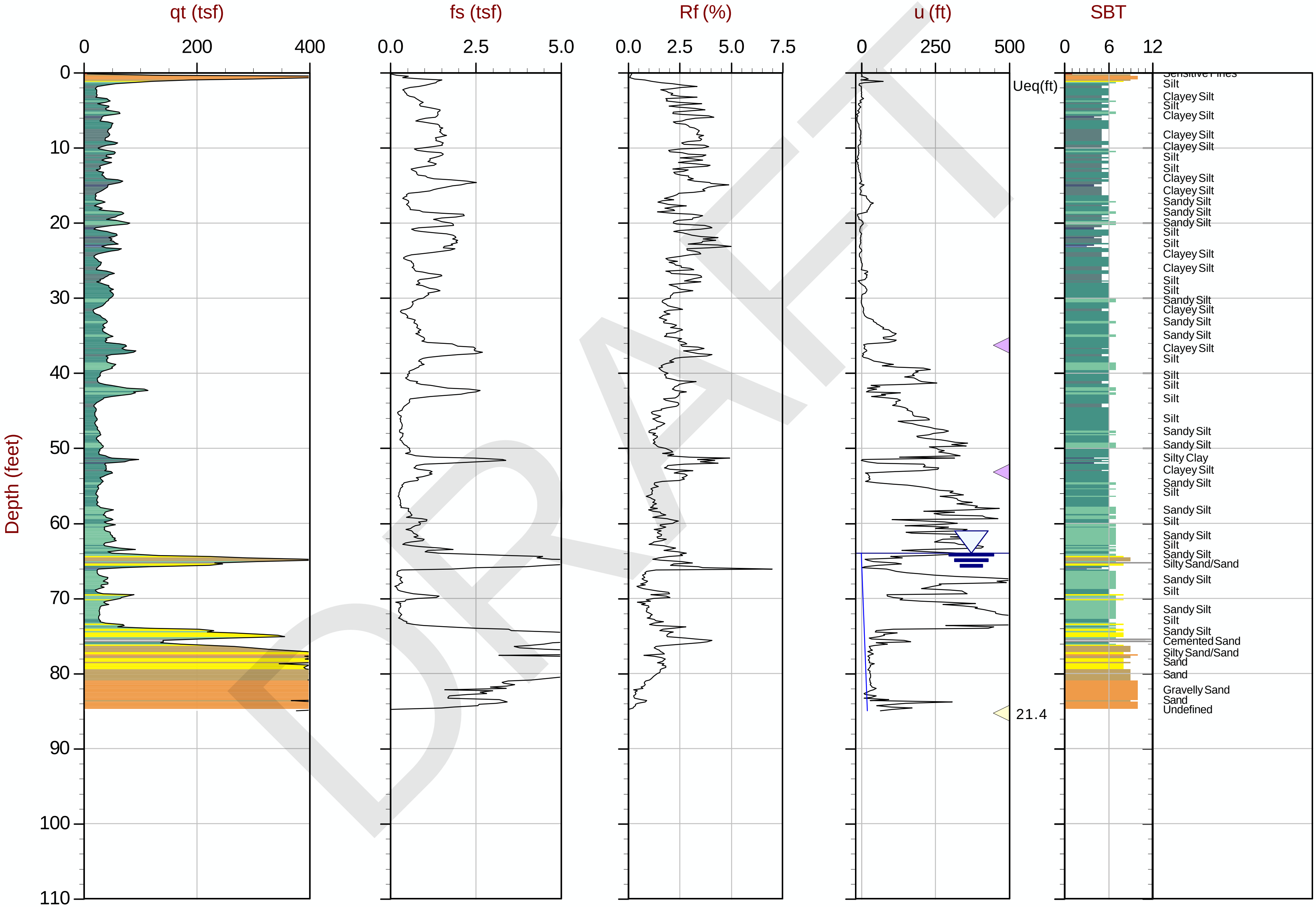
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

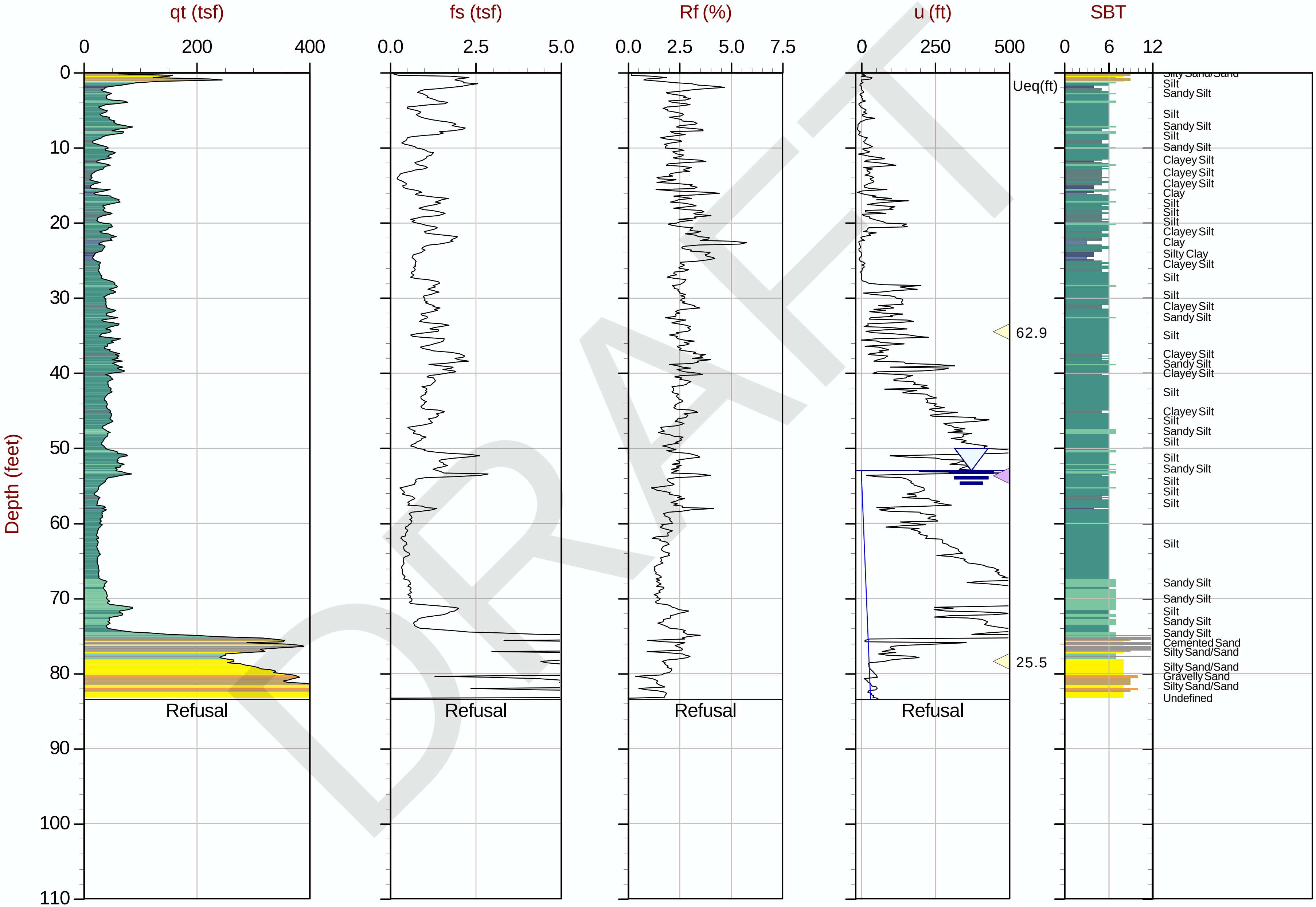
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

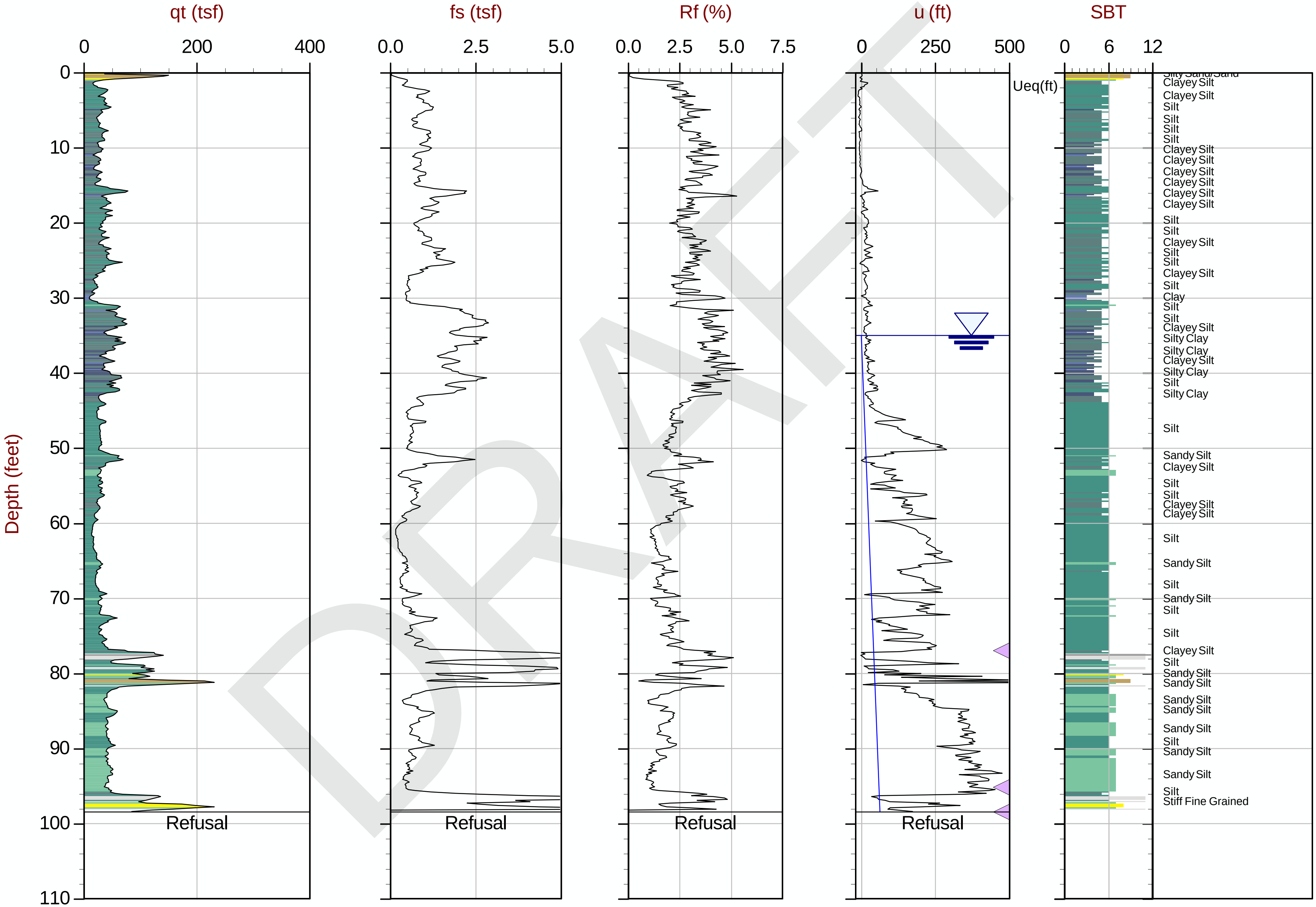
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

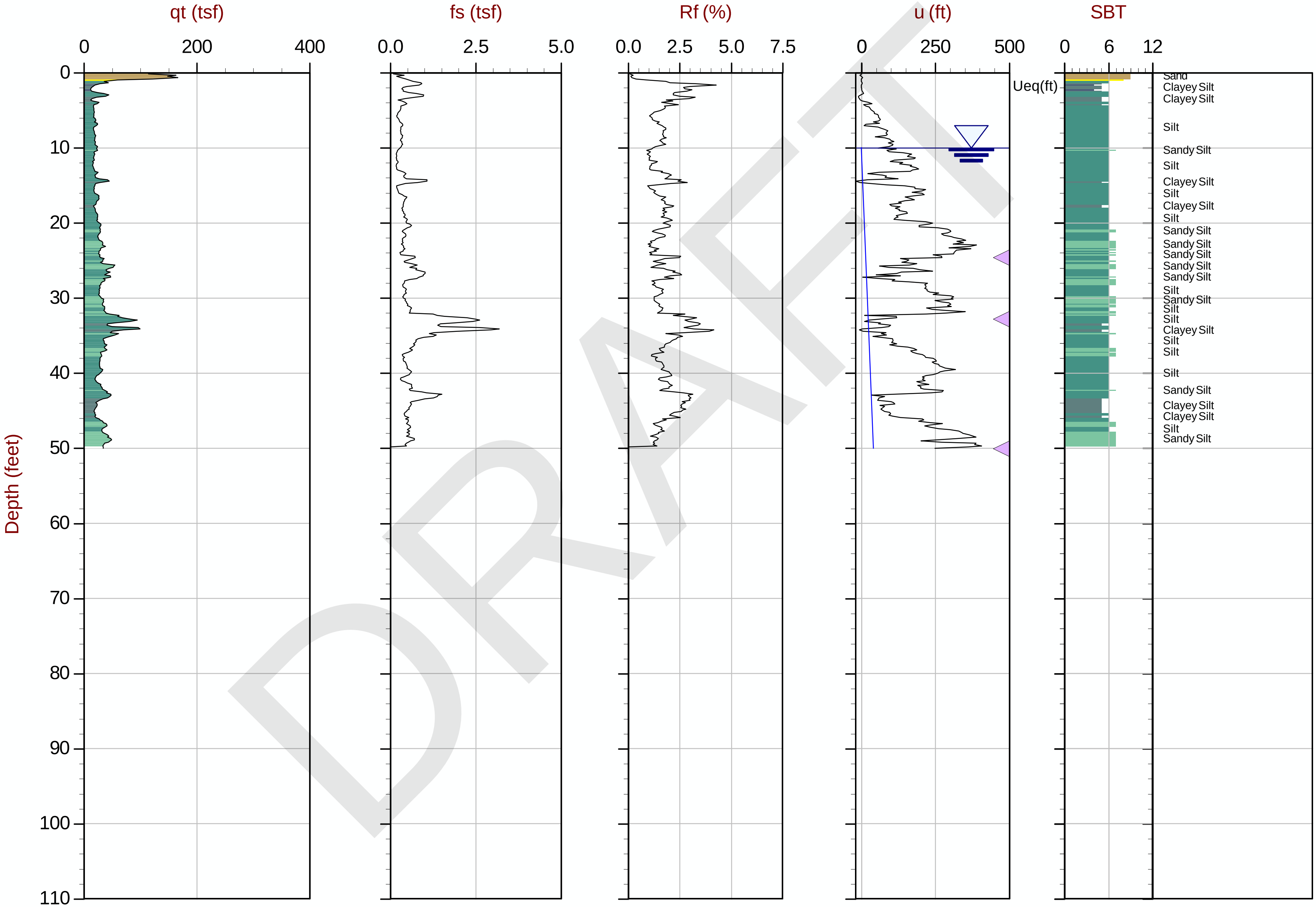
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

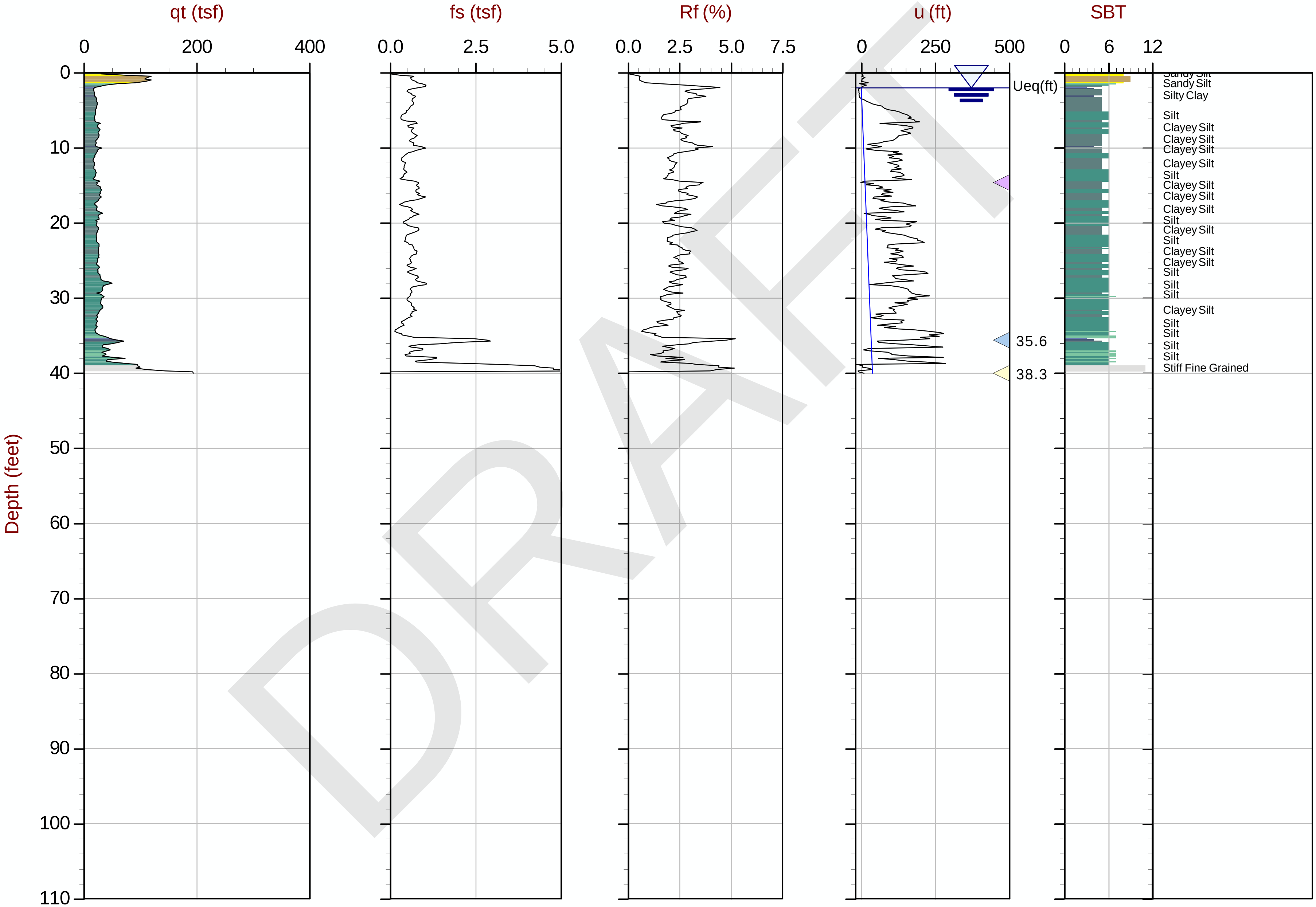
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

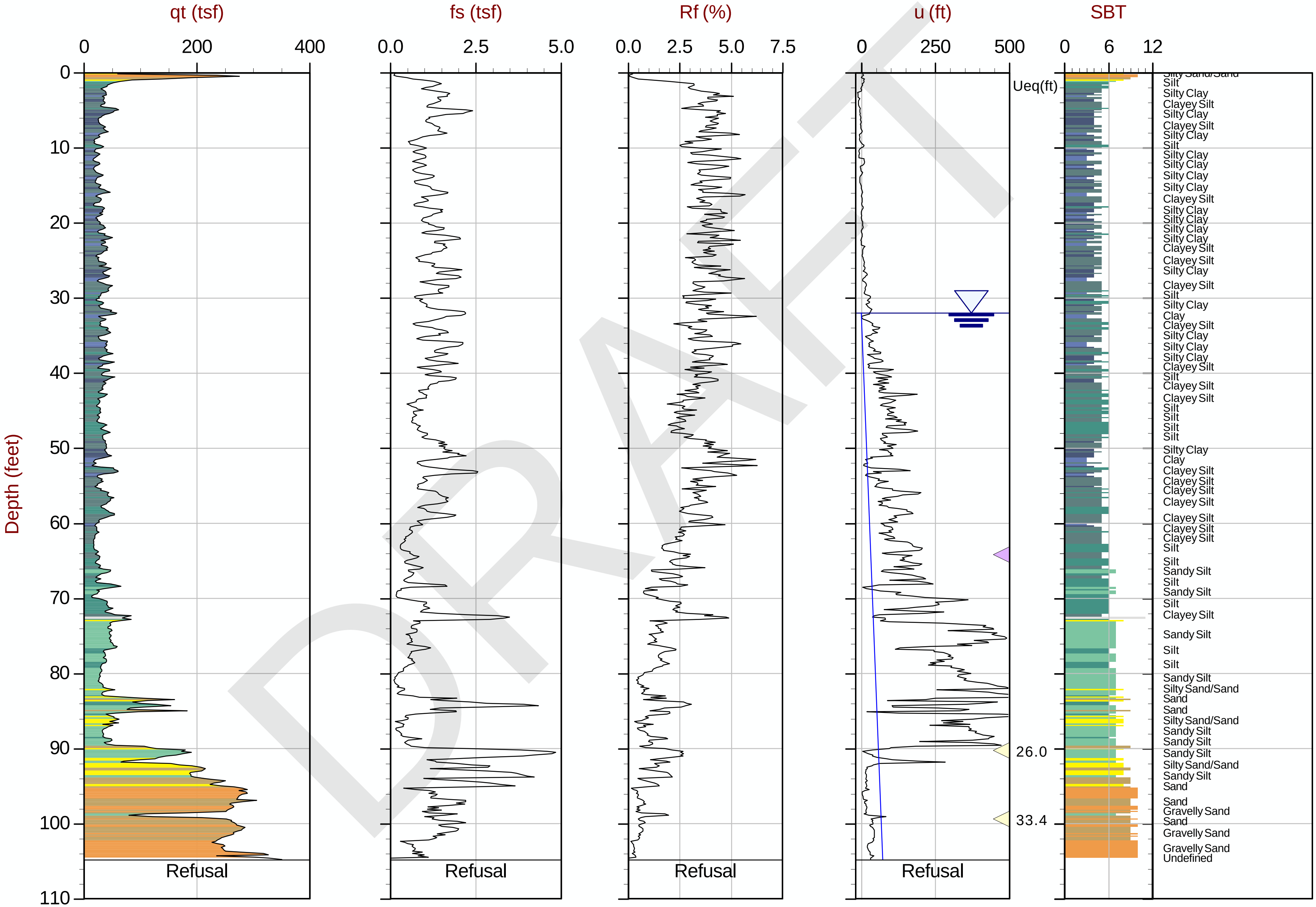
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

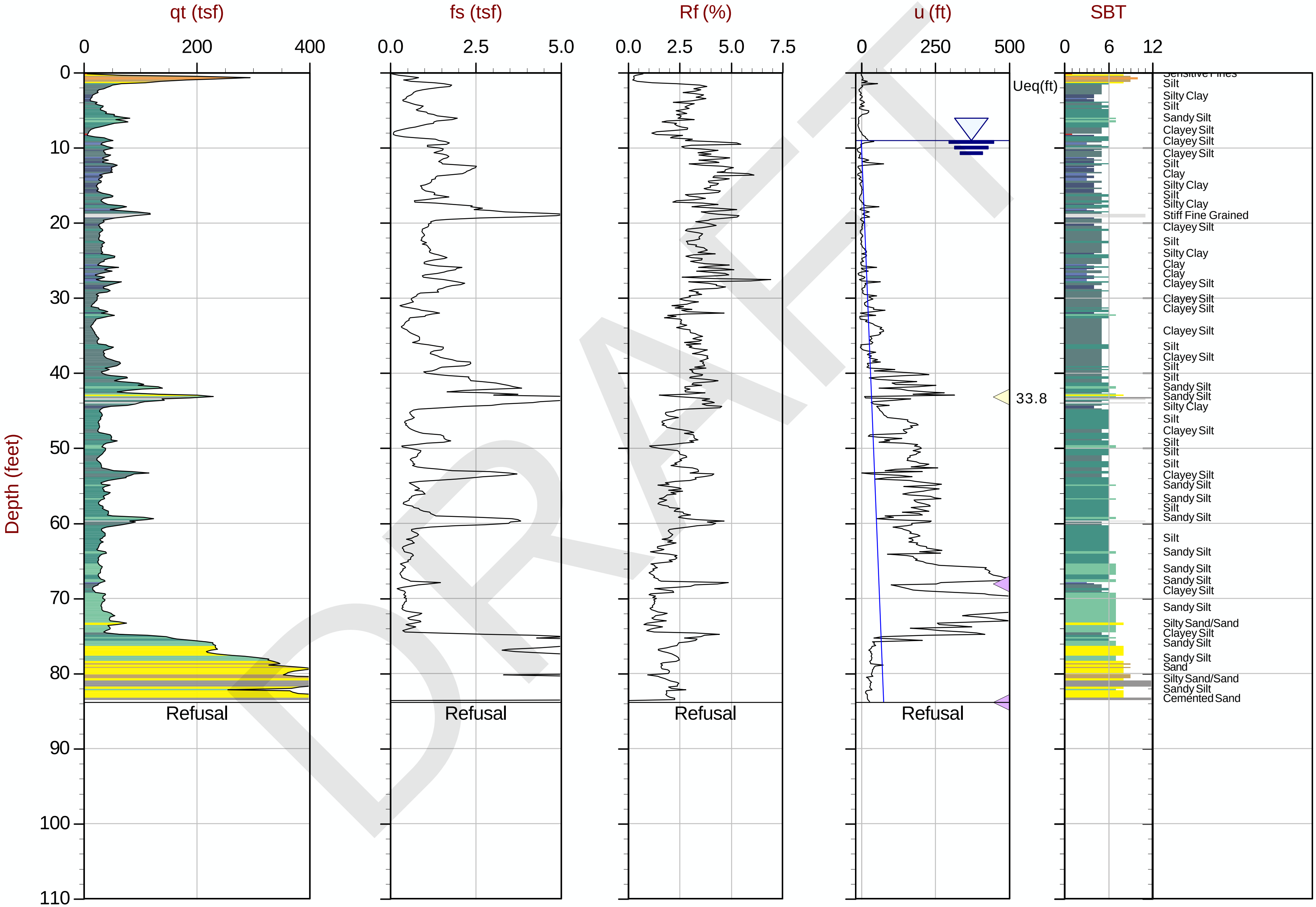
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

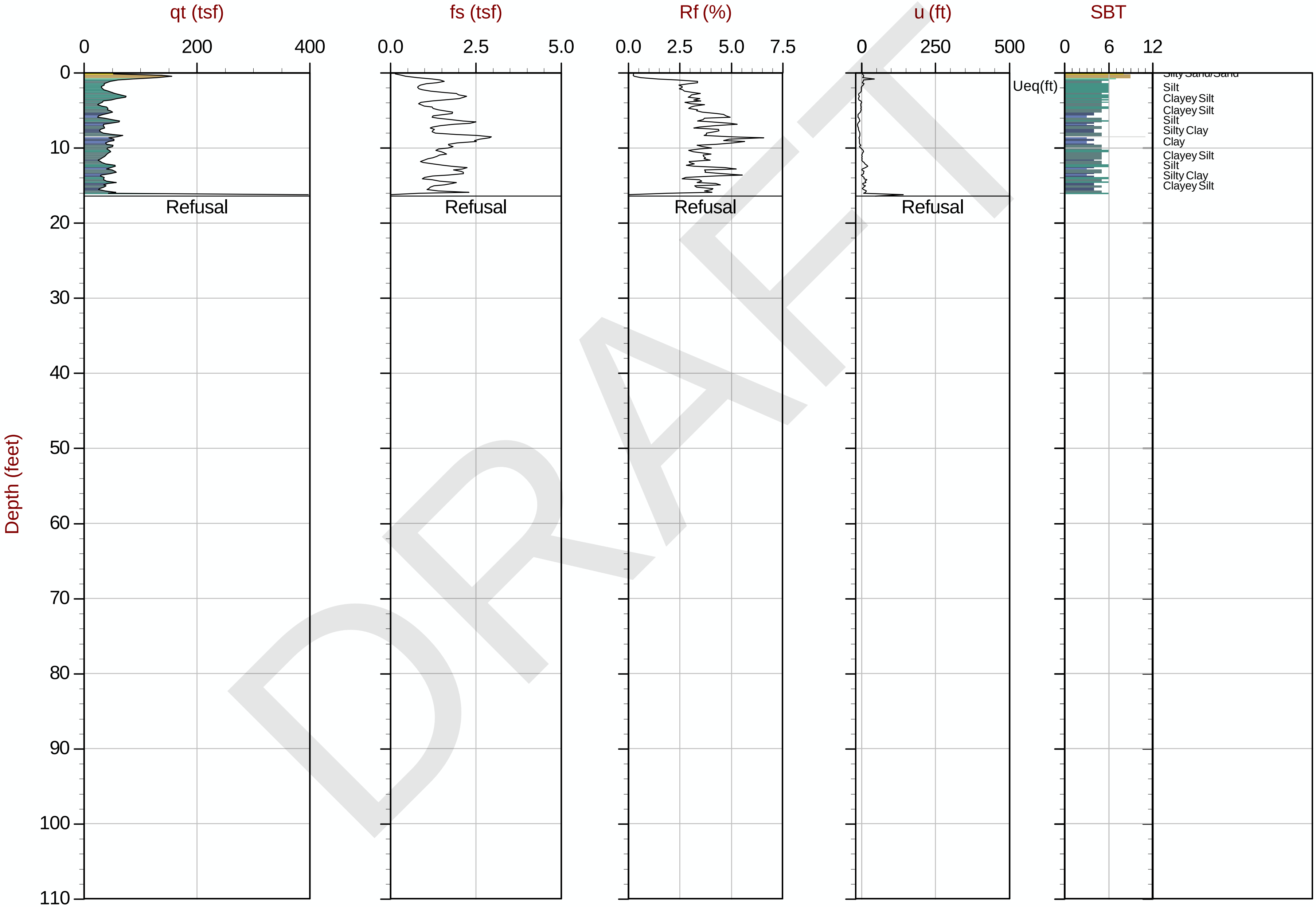
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

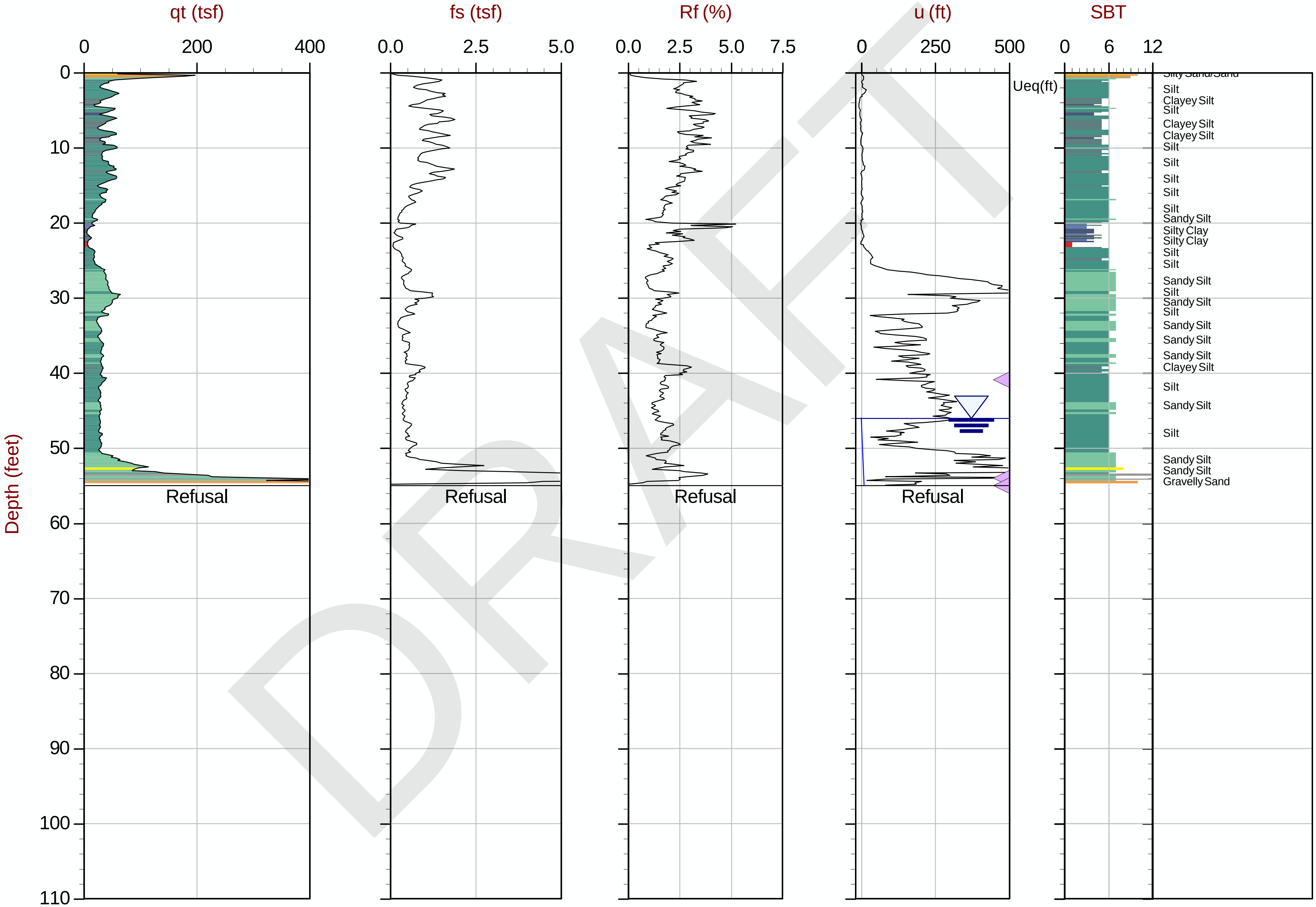
△ Dissipation, equilibrium not achieved

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

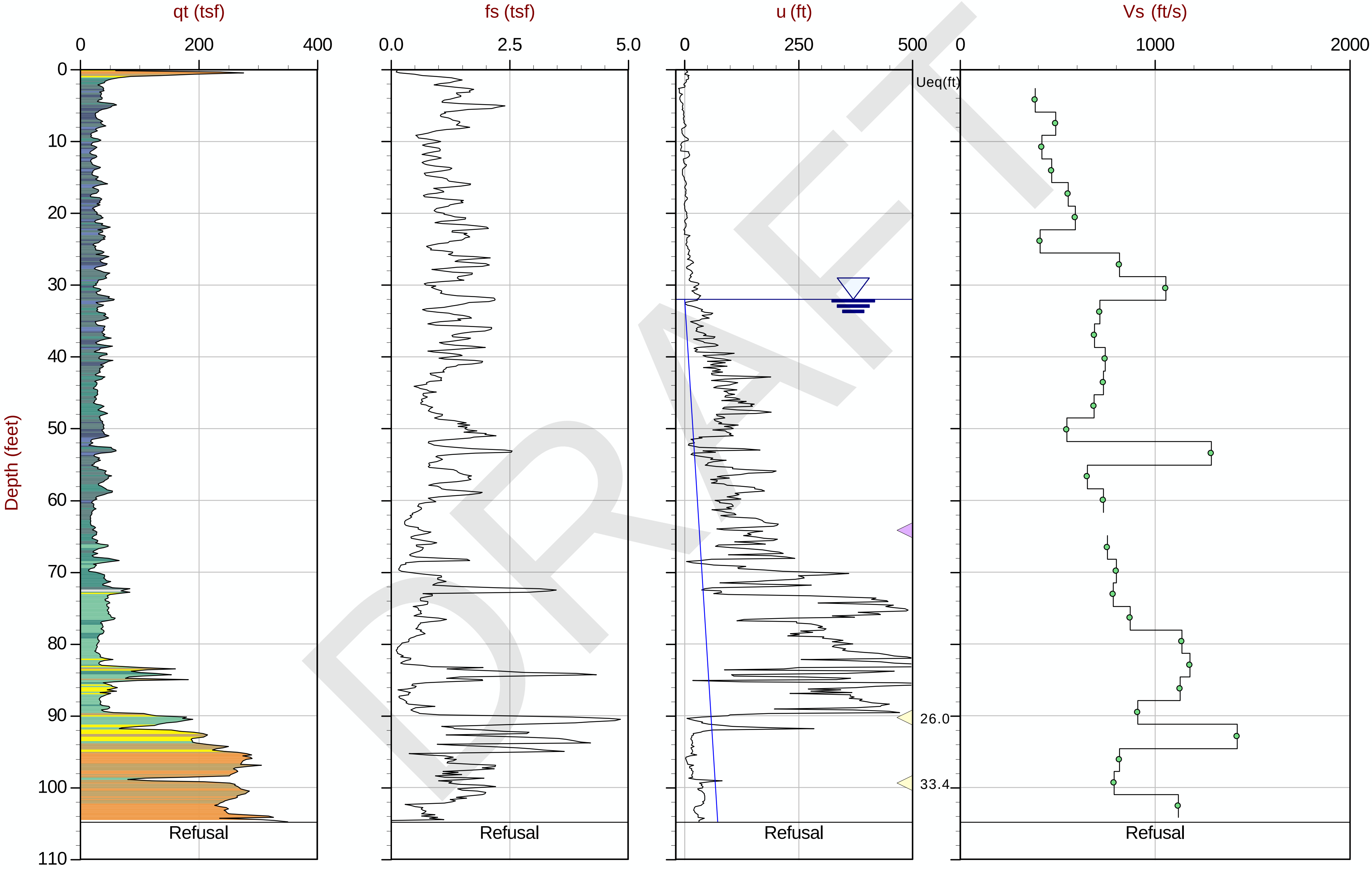
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

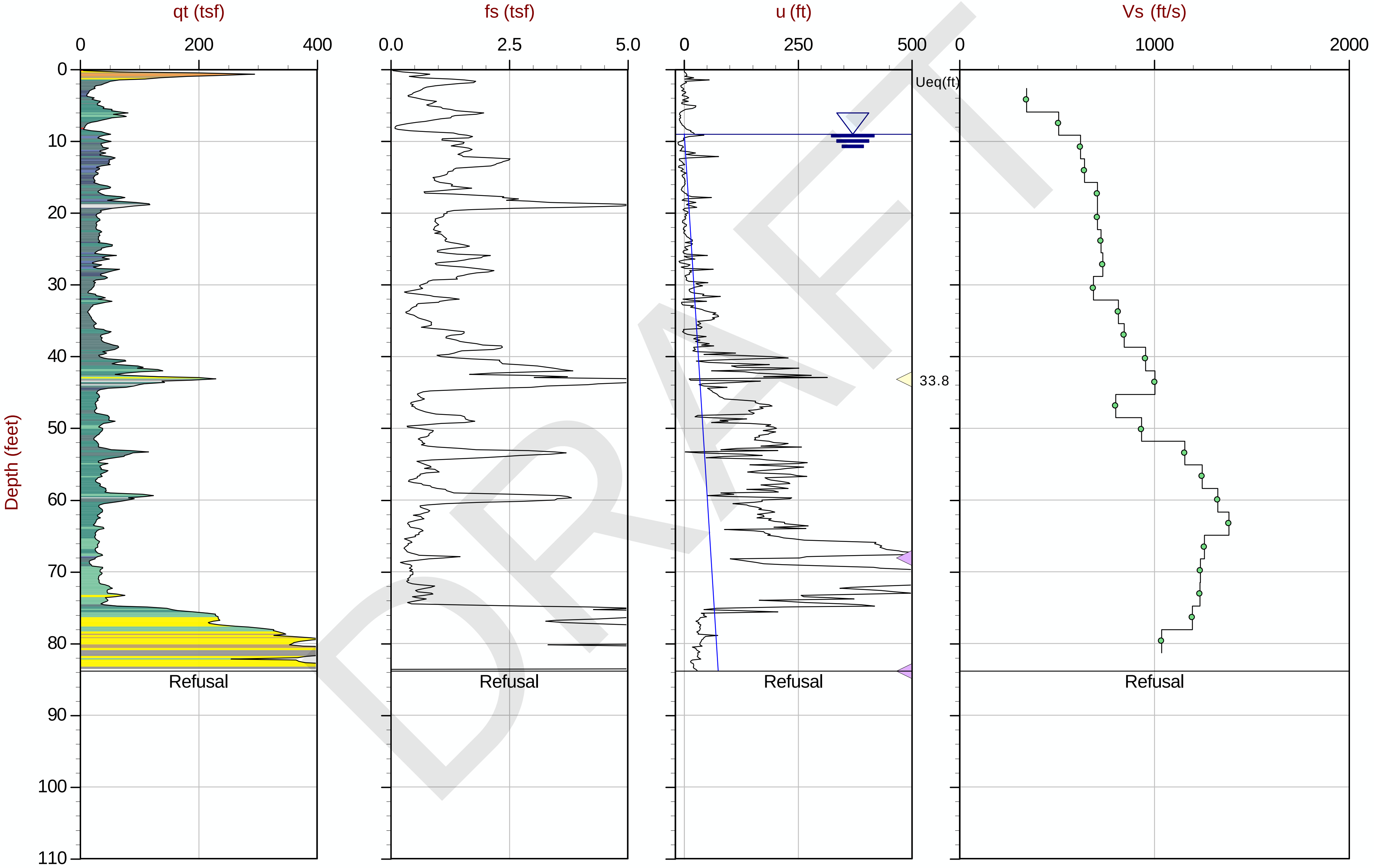
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

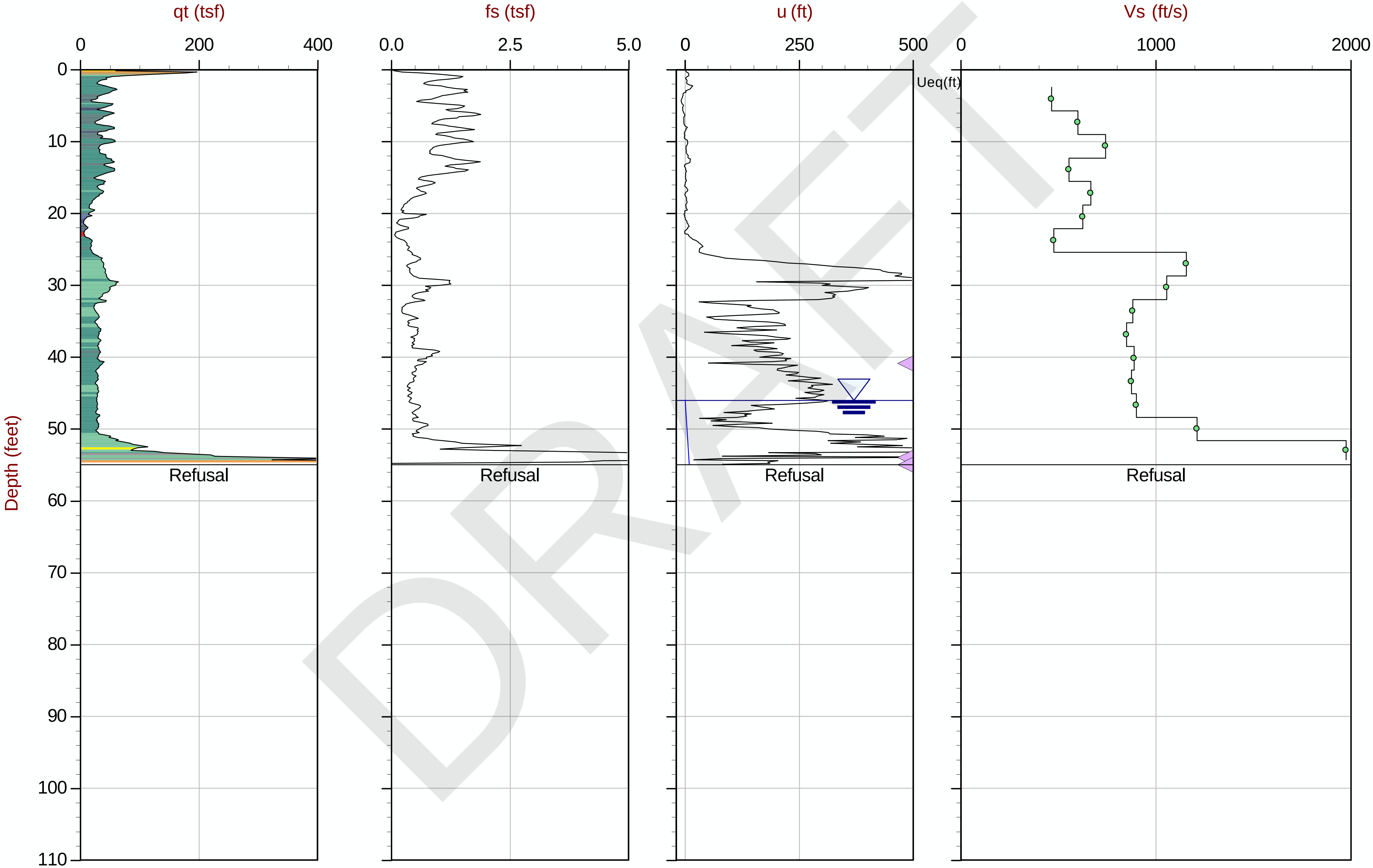
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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

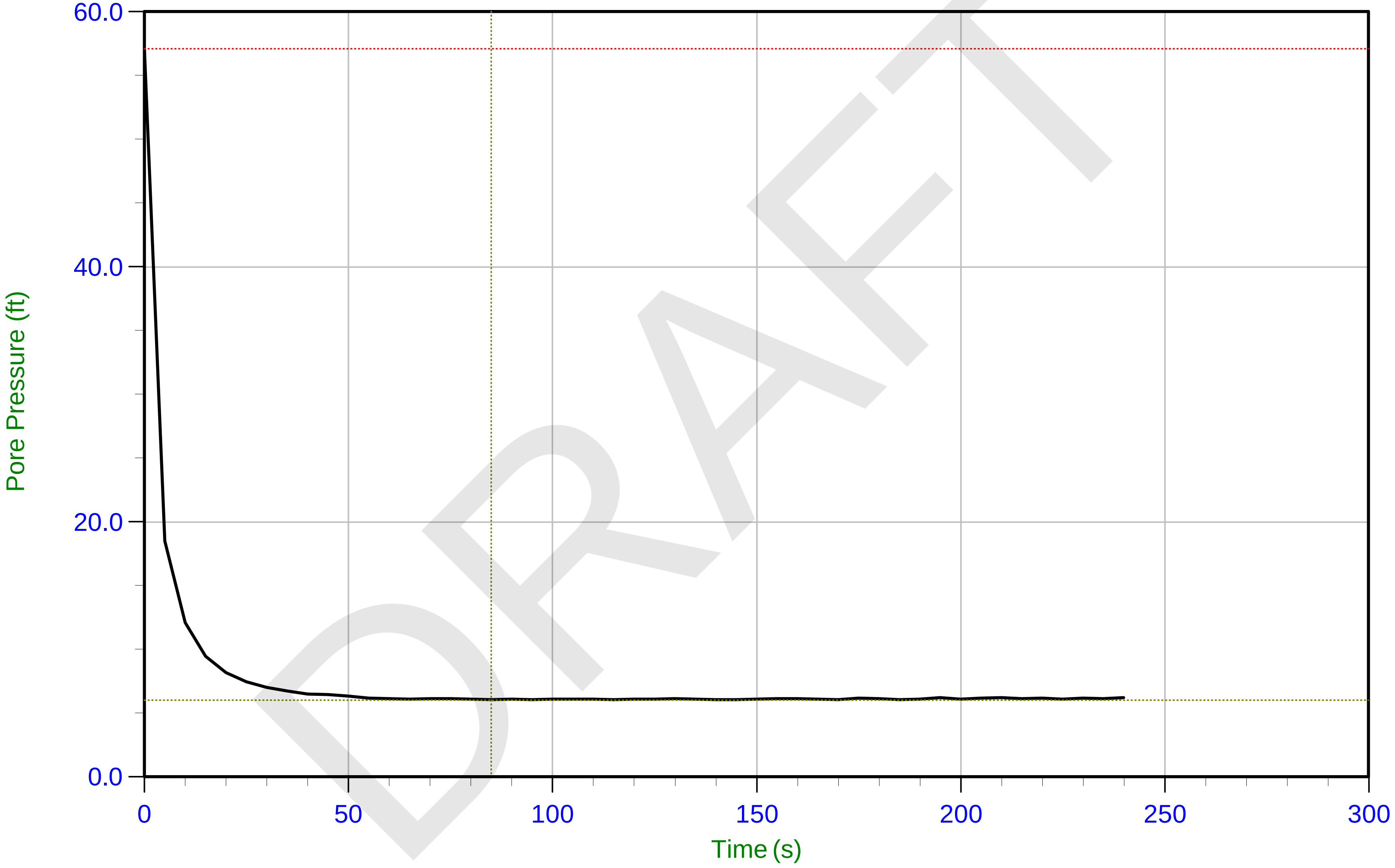
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

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_CPJOP-C001.PPD
Depth: 5.000 m / 16.404 ft
Duration: 240.0 s

U Min: 6.0 ft
U Max: 57.1 ft

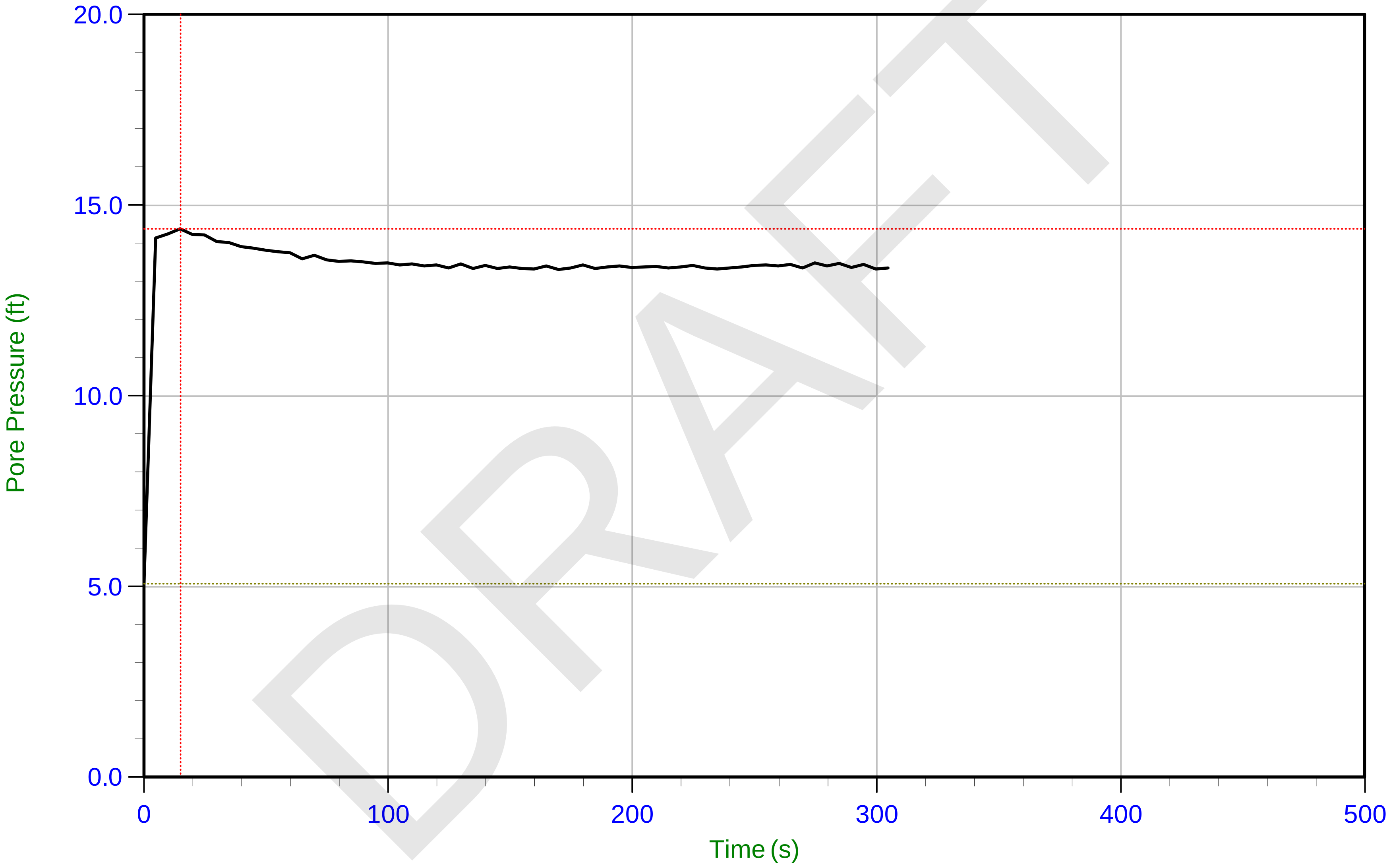
WT: 3.112 m / 10.210 ft
Ueq: 6.2 ft

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_CPJOP-C001.PPD
Depth: 7.400 m / 24.278 ft
Duration: 305.0 s

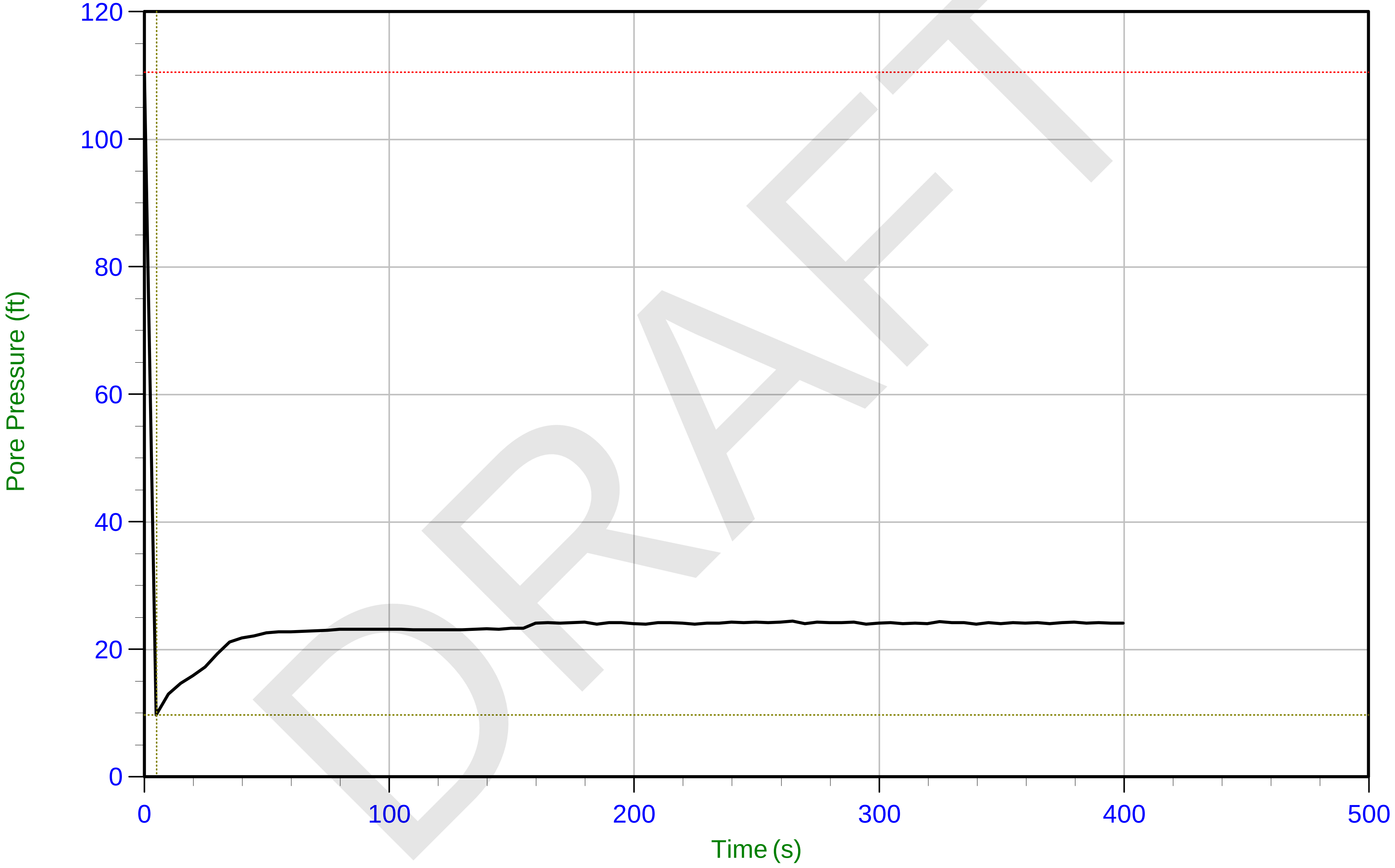
U Min: 5.1 ft
U Max: 14.4 ft

WT: 3.329 m / 10.922 ft
Ueq: 13.4 ft

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

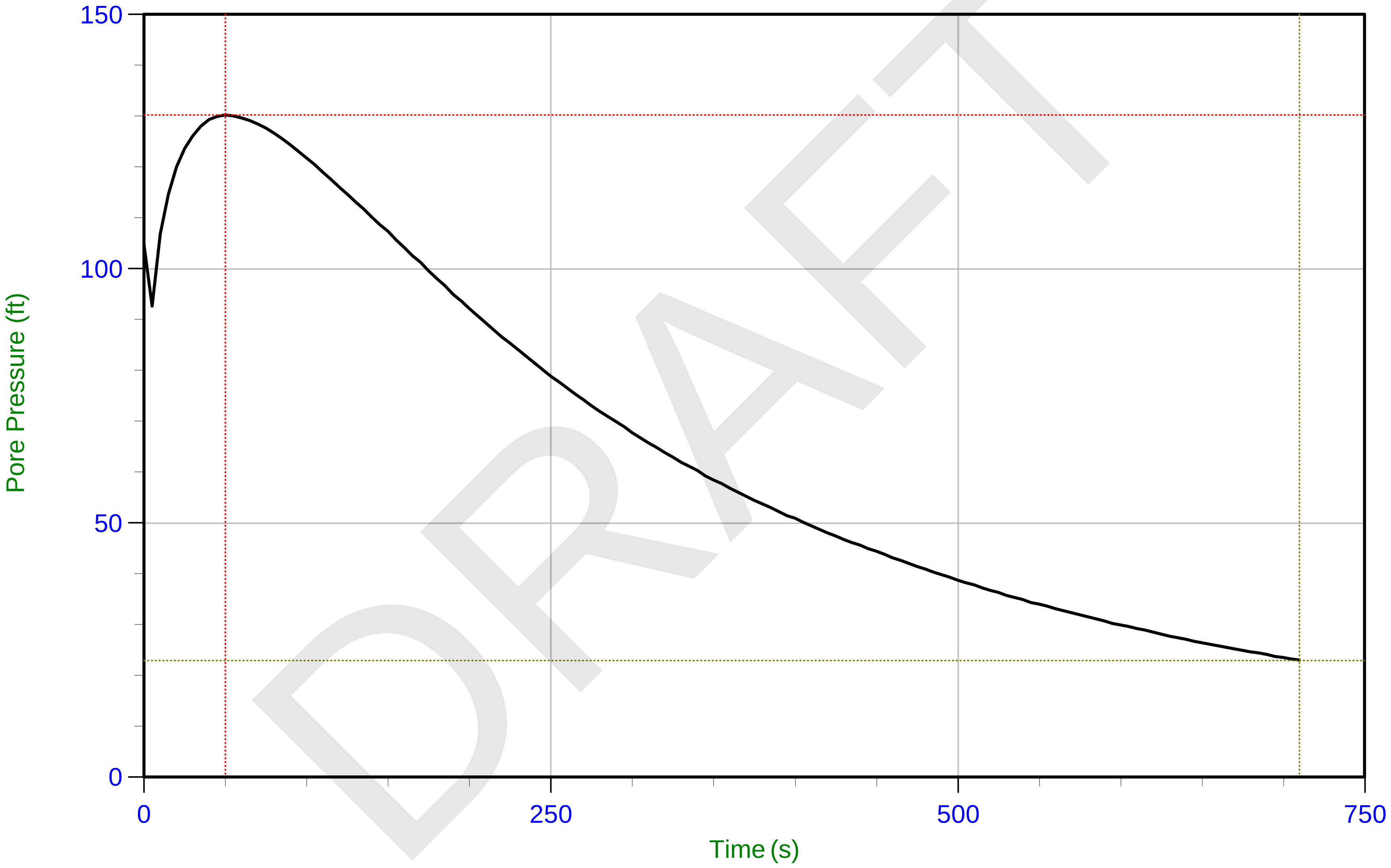
U Min: 9.7 ft
U Max: 110.6 ft

WT: 6.567 m / 21.545 ft
Ueq: 24.4 ft

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:

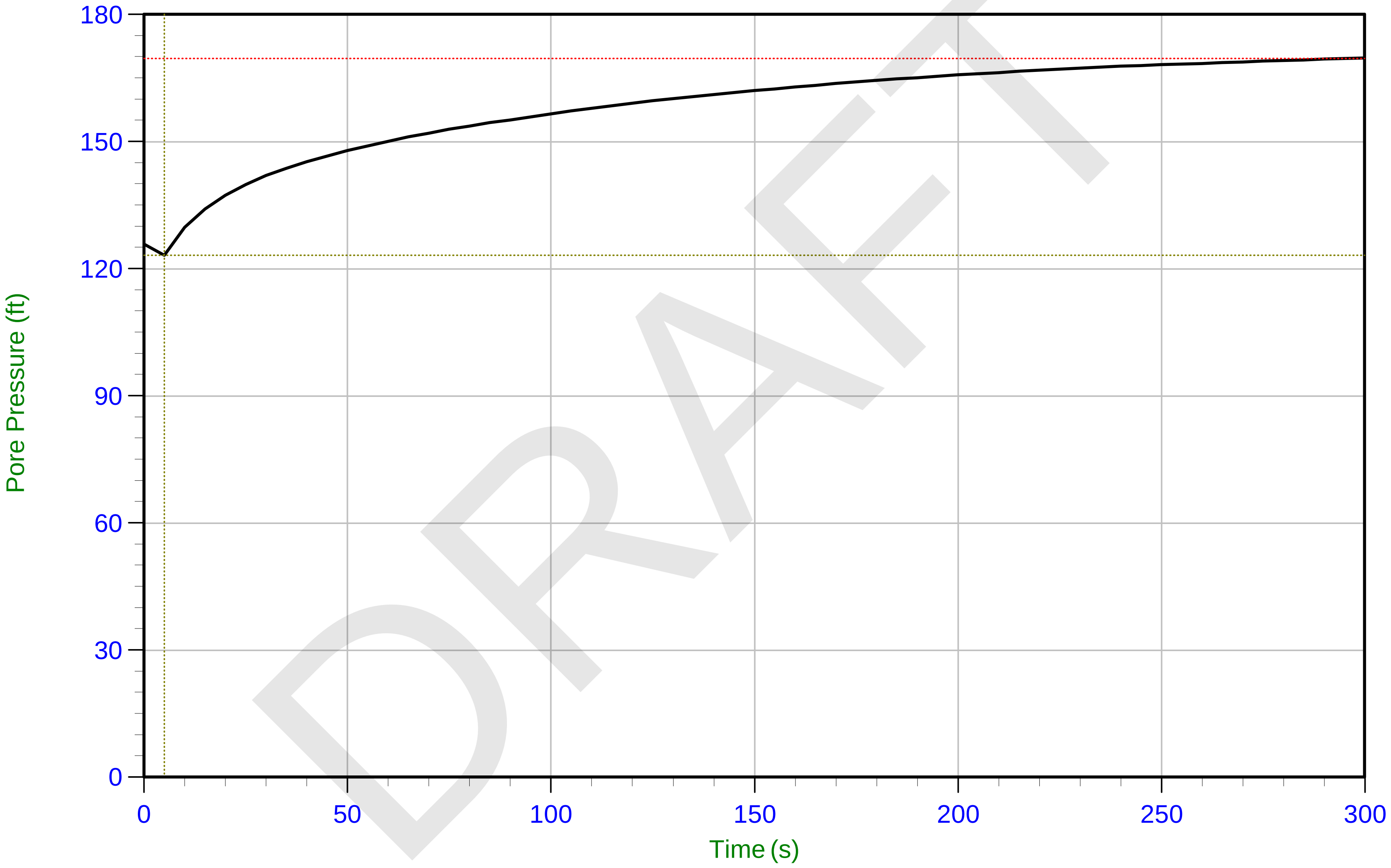
Filename: 15-54071_CP JOP-C003.PPD
Depth: 4.500 m / 14.764 ft
Duration: 710.0 s

U Min: 23.0 ft
U Max: 130.3 ft

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

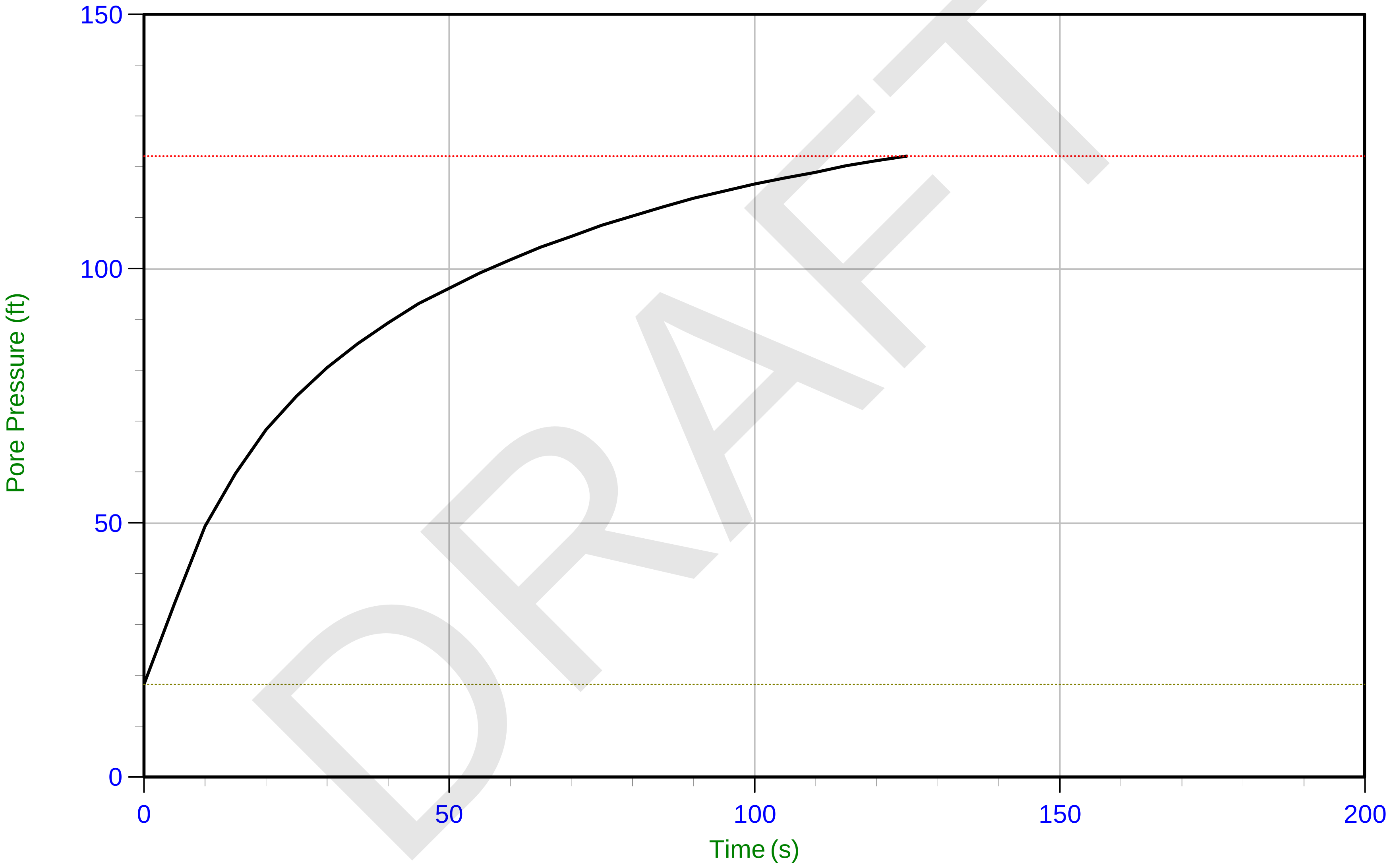
U Min: 123.2 ft
U Max: 169.7 ft

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

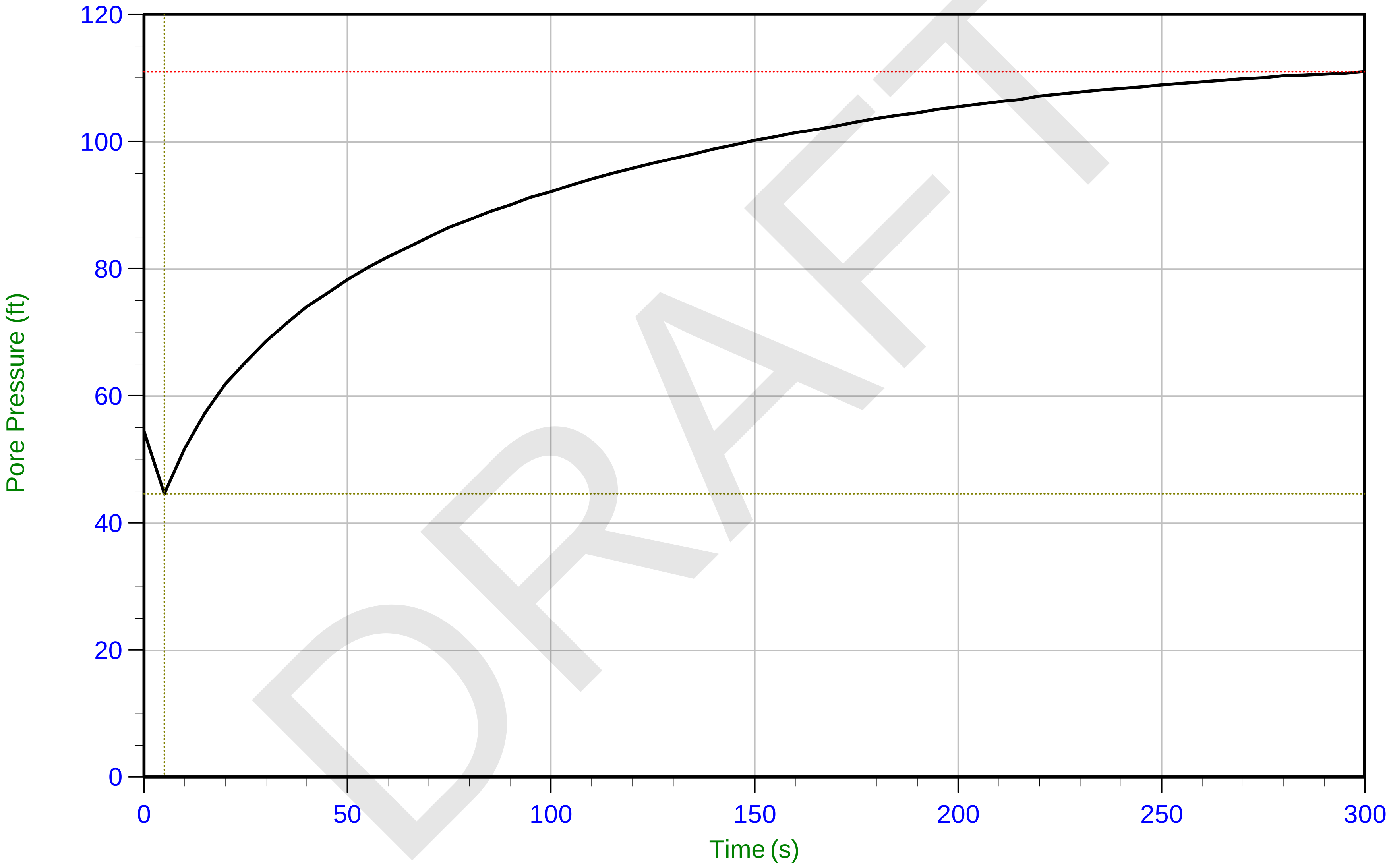
U Min: 18.3 ft
U Max: 122.2 ft

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

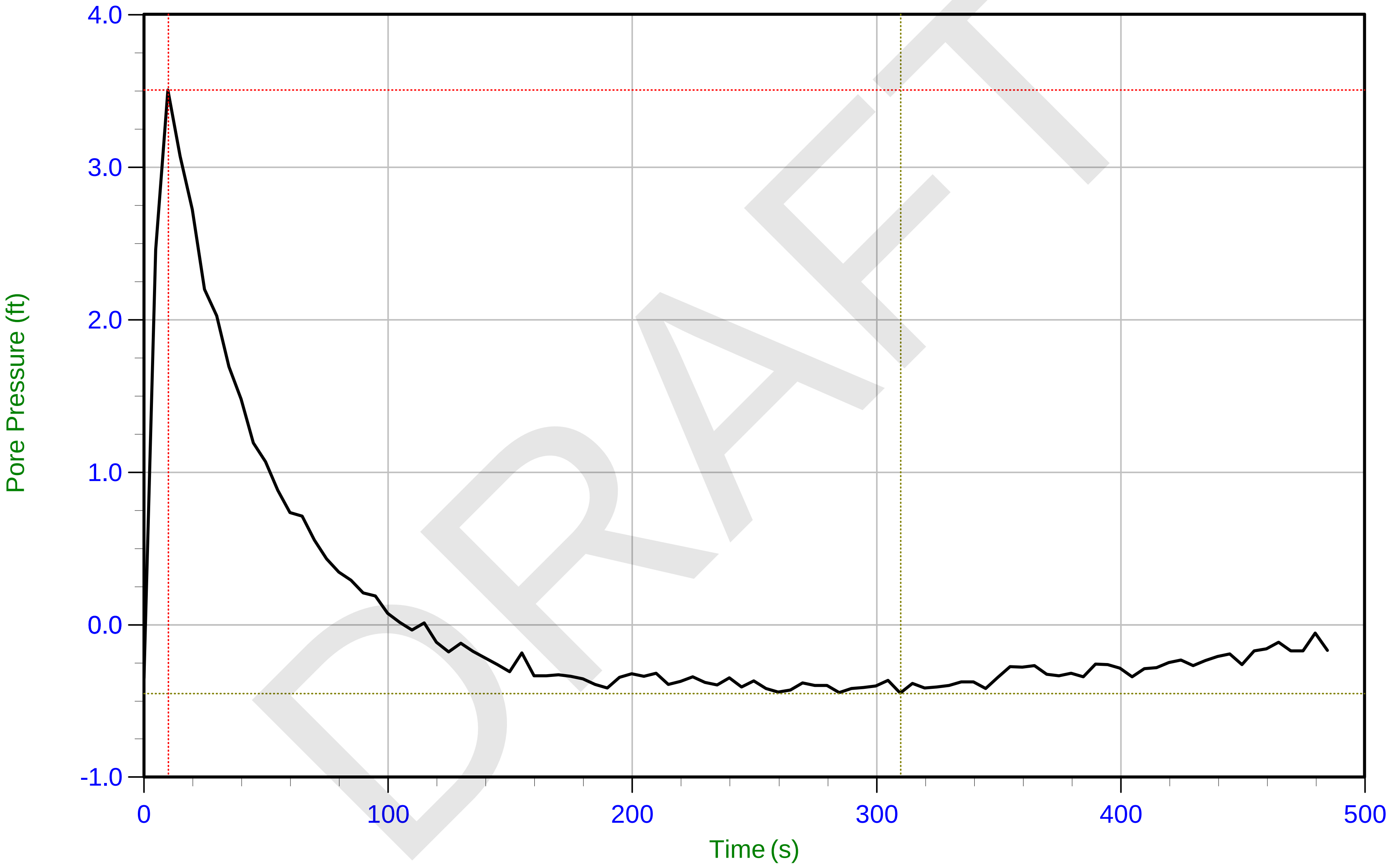


Trace Summary:

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

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

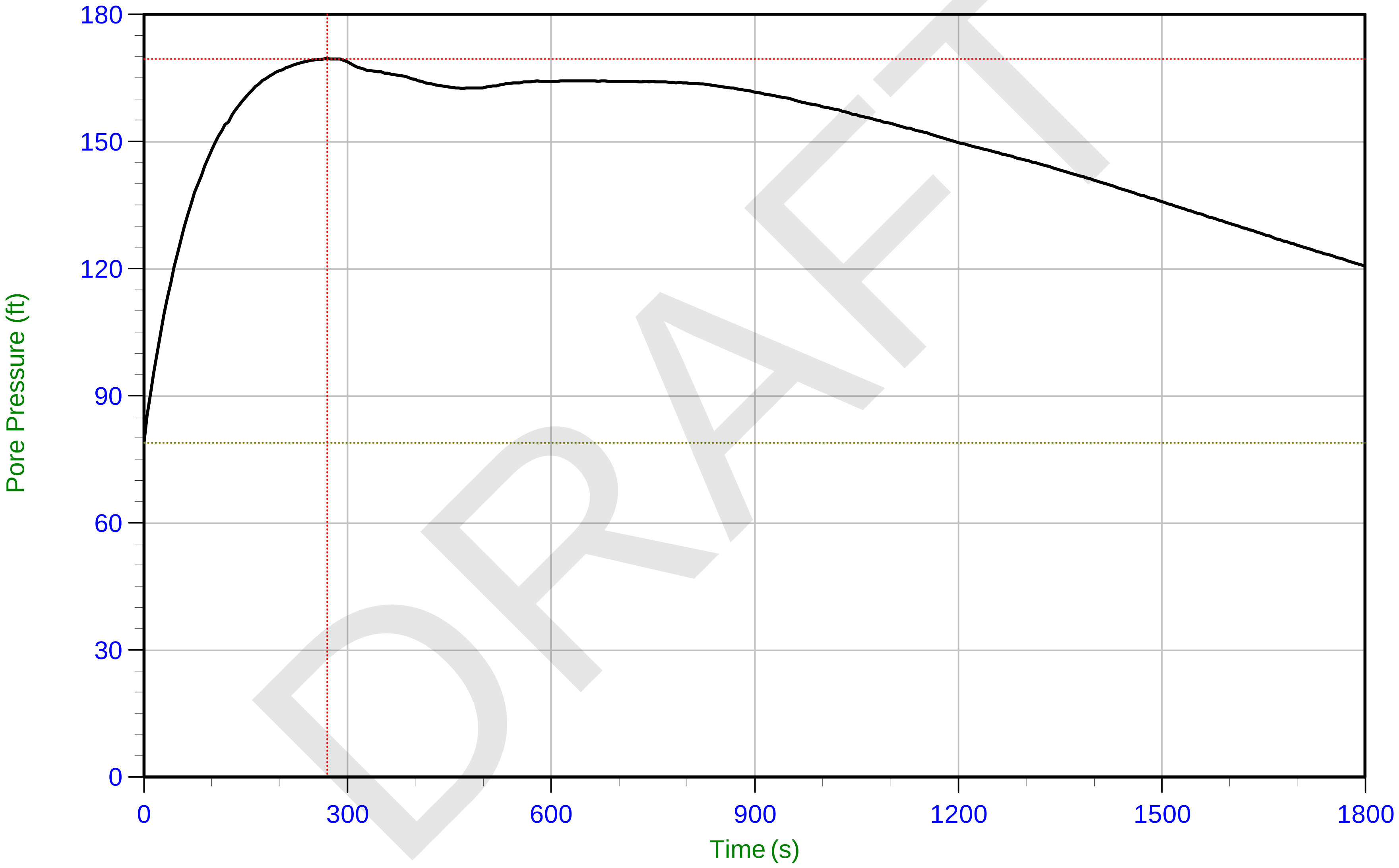
U Min: -0.4 ft
U Max: 3.5 ft

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:

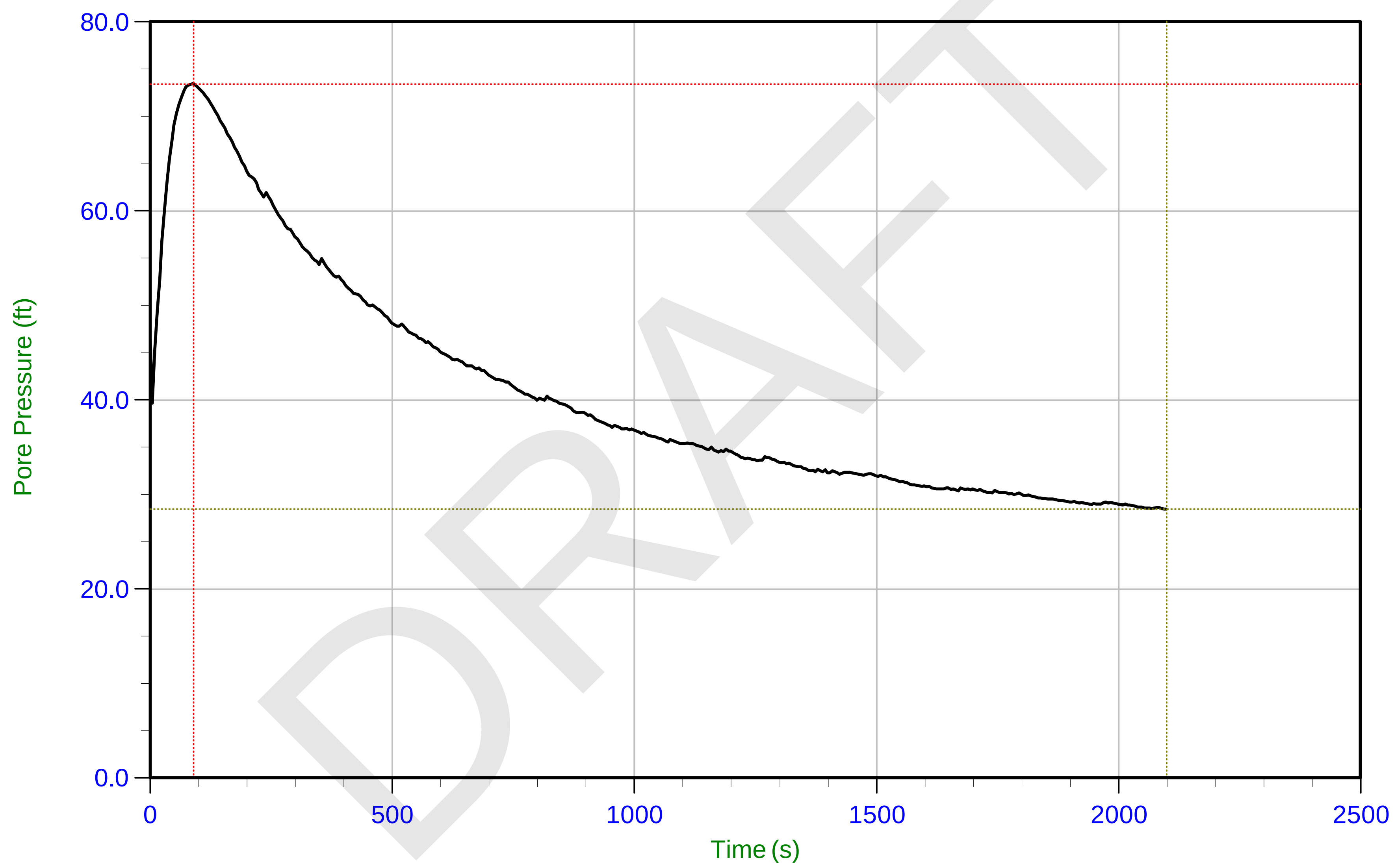
Filename: 15-54071_CP JOP-C004.PPD
Depth: 13.000 m / 42.650 ft
Duration: 1800.0 s

U Min: 79.0 ft
U Max: 169.6 ft

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

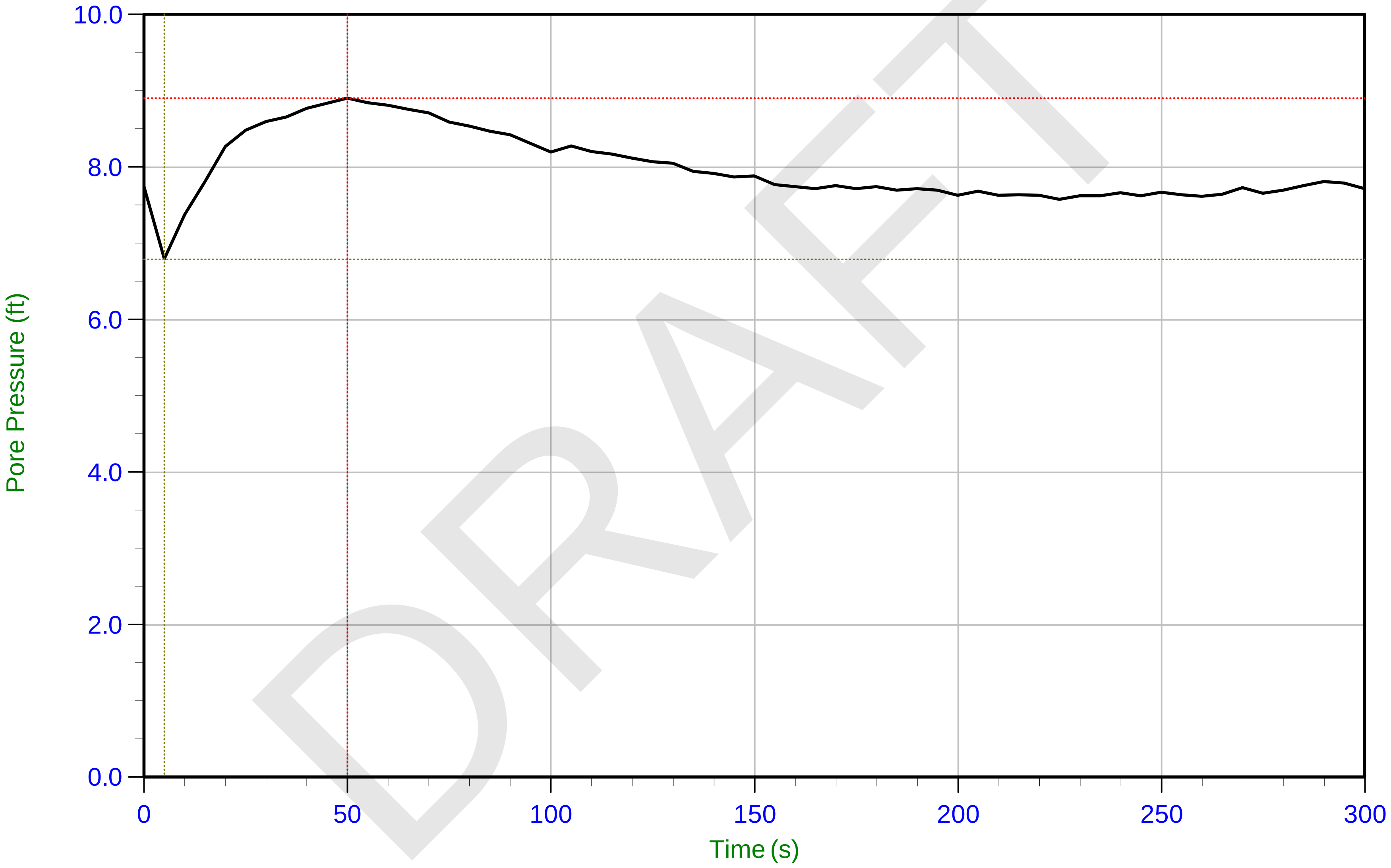
U Min: 28.5 ft
U Max: 73.5 ft

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



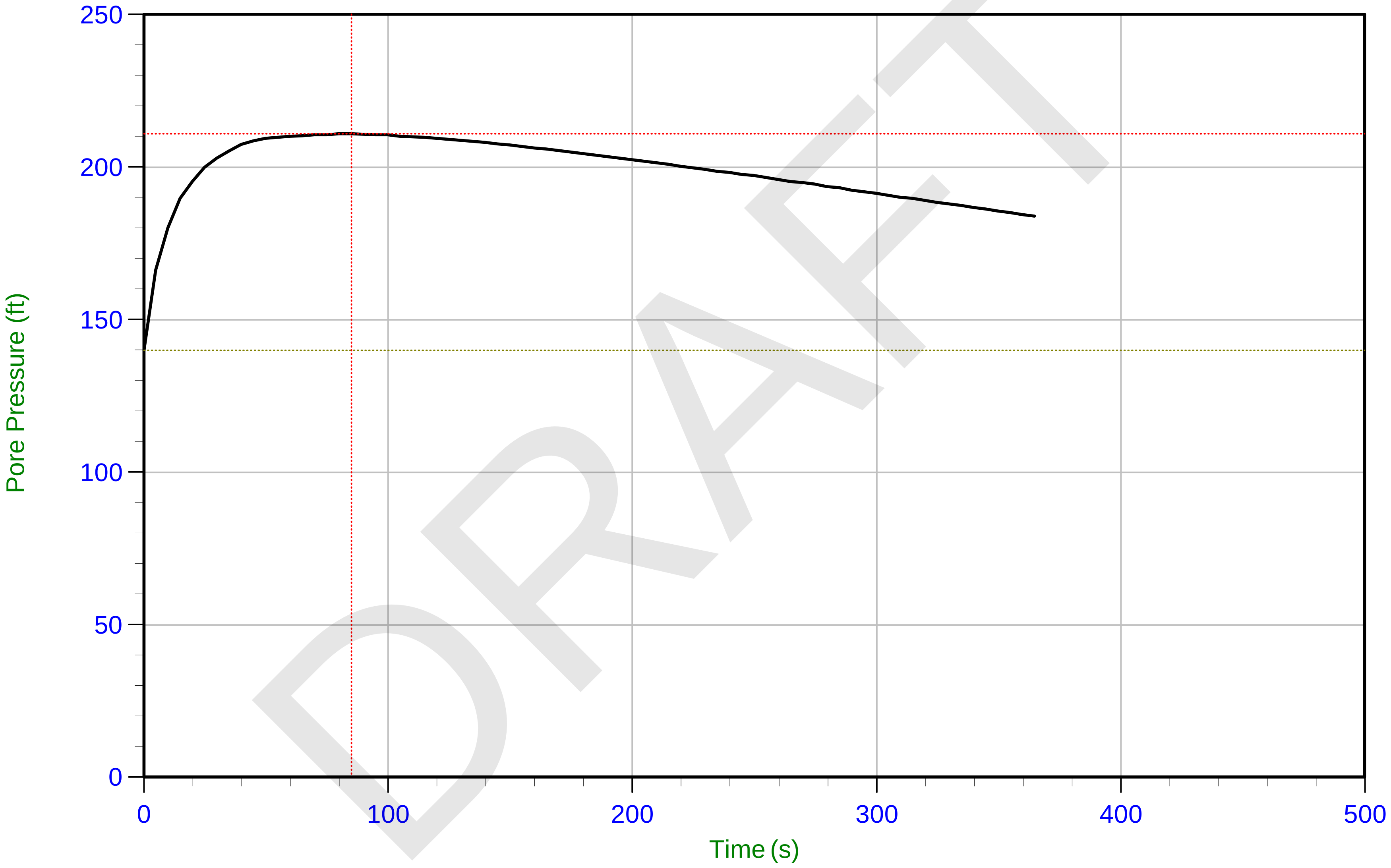
Trace Summary:

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

AECOM	Job No: 15-54071	Sounding: JOP-C005
	Date: 08/20/2015 10:29	Cone: 392:T1500F15U500
	Site: Dynegy Joppa, I	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

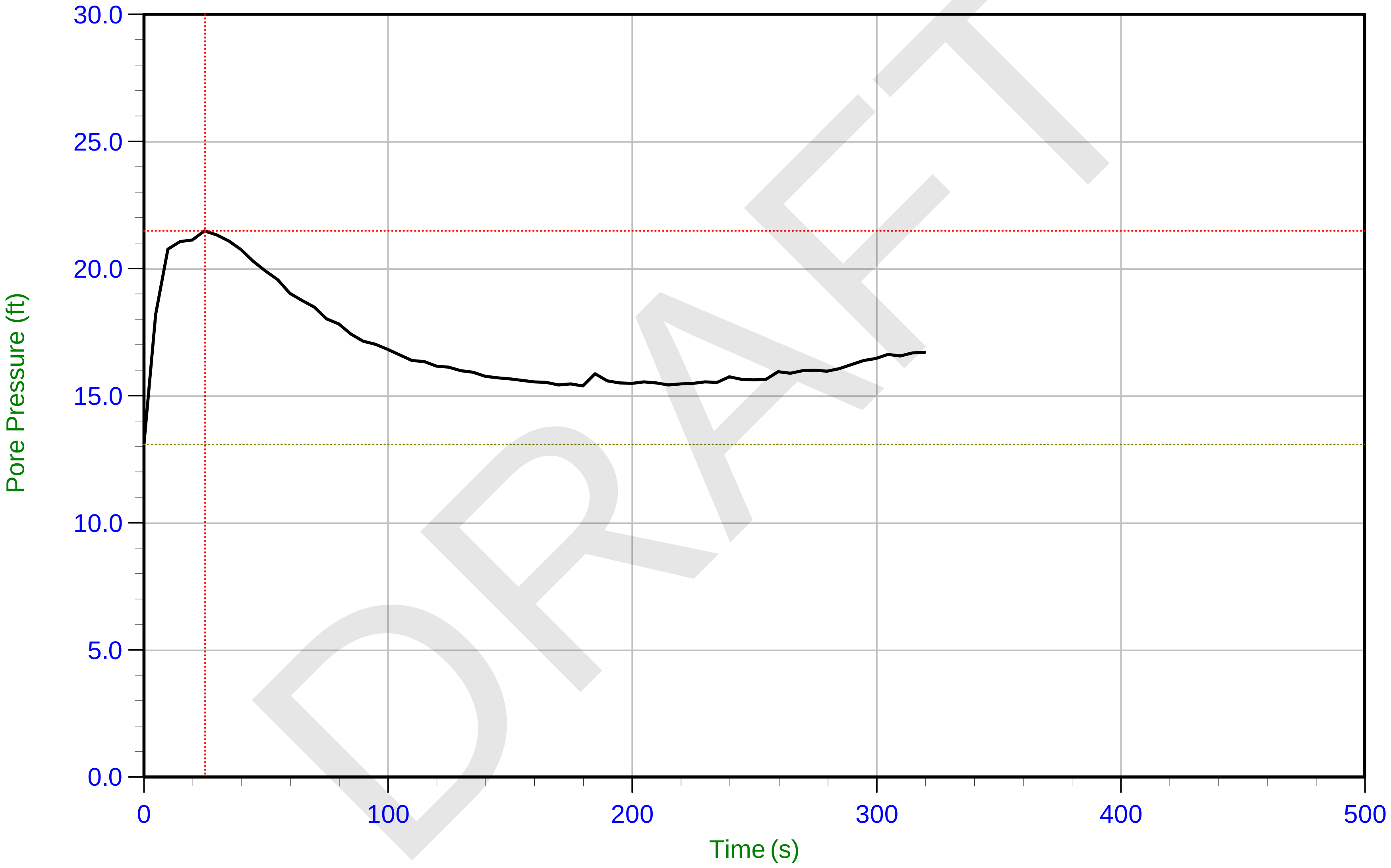
U Min: 140.0 ft
U Max: 210.9 ft

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:

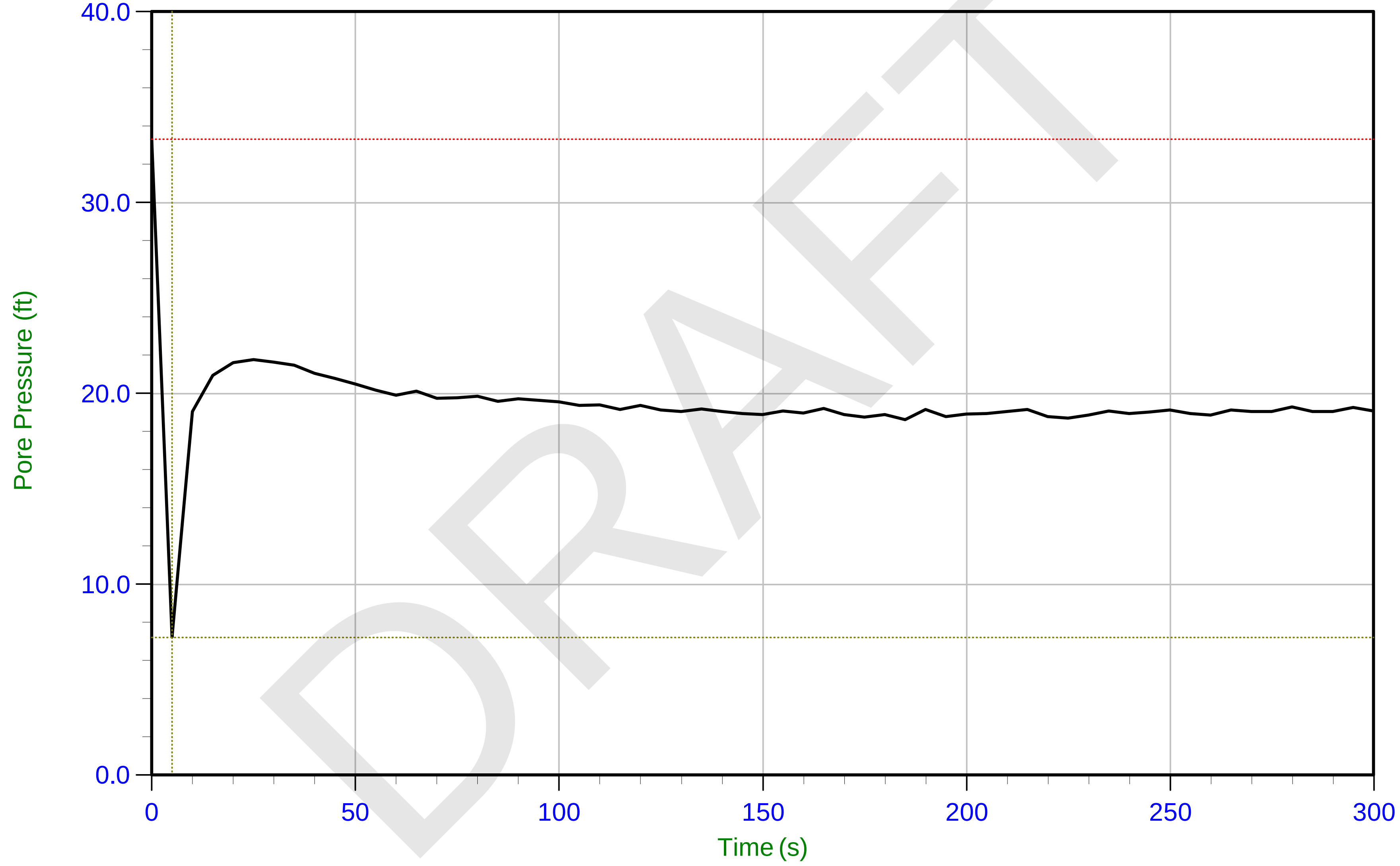
Filename: 15-54071_CP JOP-C005.PPD
Depth: 7.000 m / 22.966 ft
Duration: 320.0 s

U Min: 13.1 ft
U Max: 21.5 ft

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

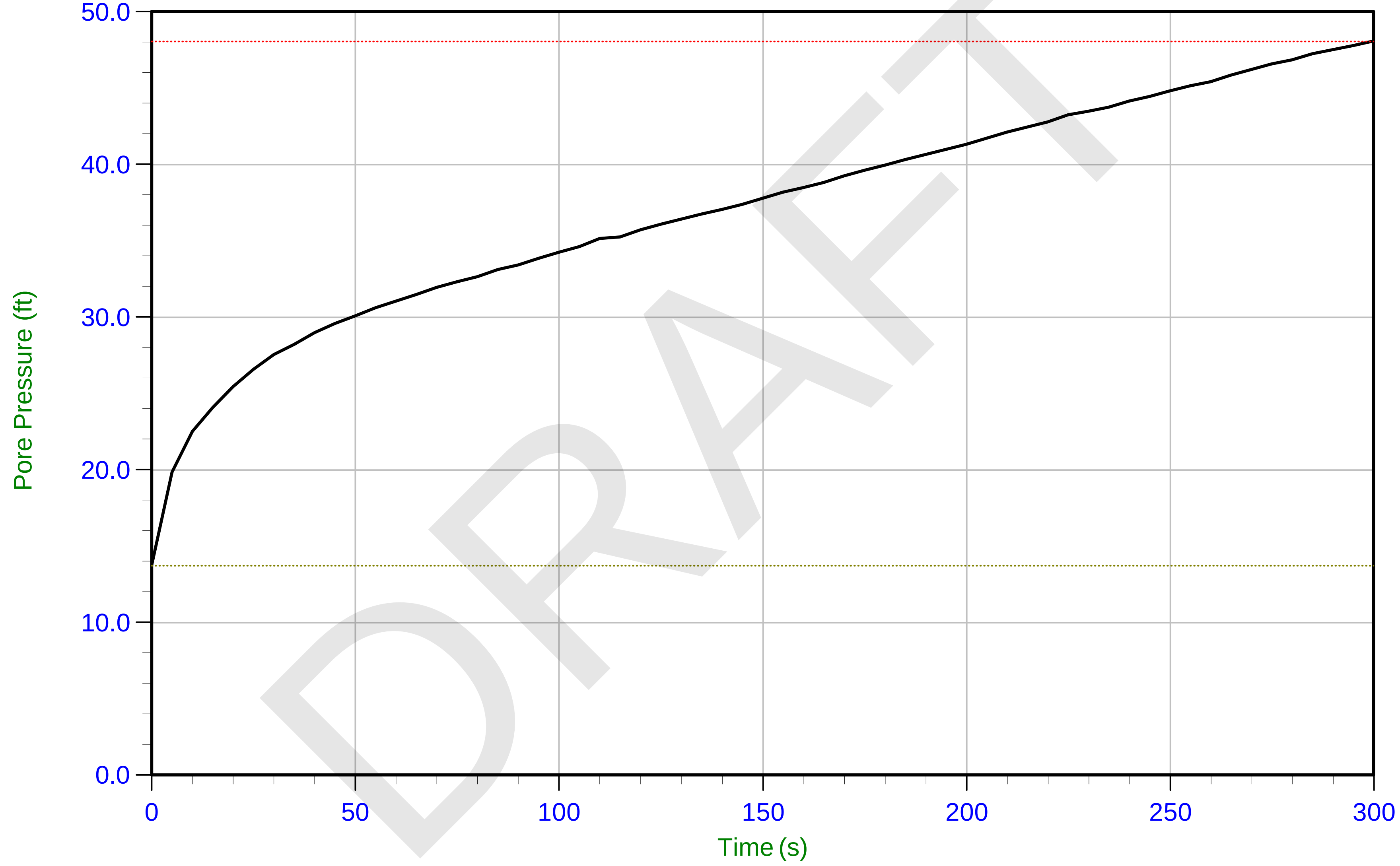
WT: 2.679 m / 8.790 ft
Ueq: 19.1 ft

ConeTec

AECOM

Job No: 15-54071
Date: 08/20/2015 08:24
Site: Dynegy Joppa, I

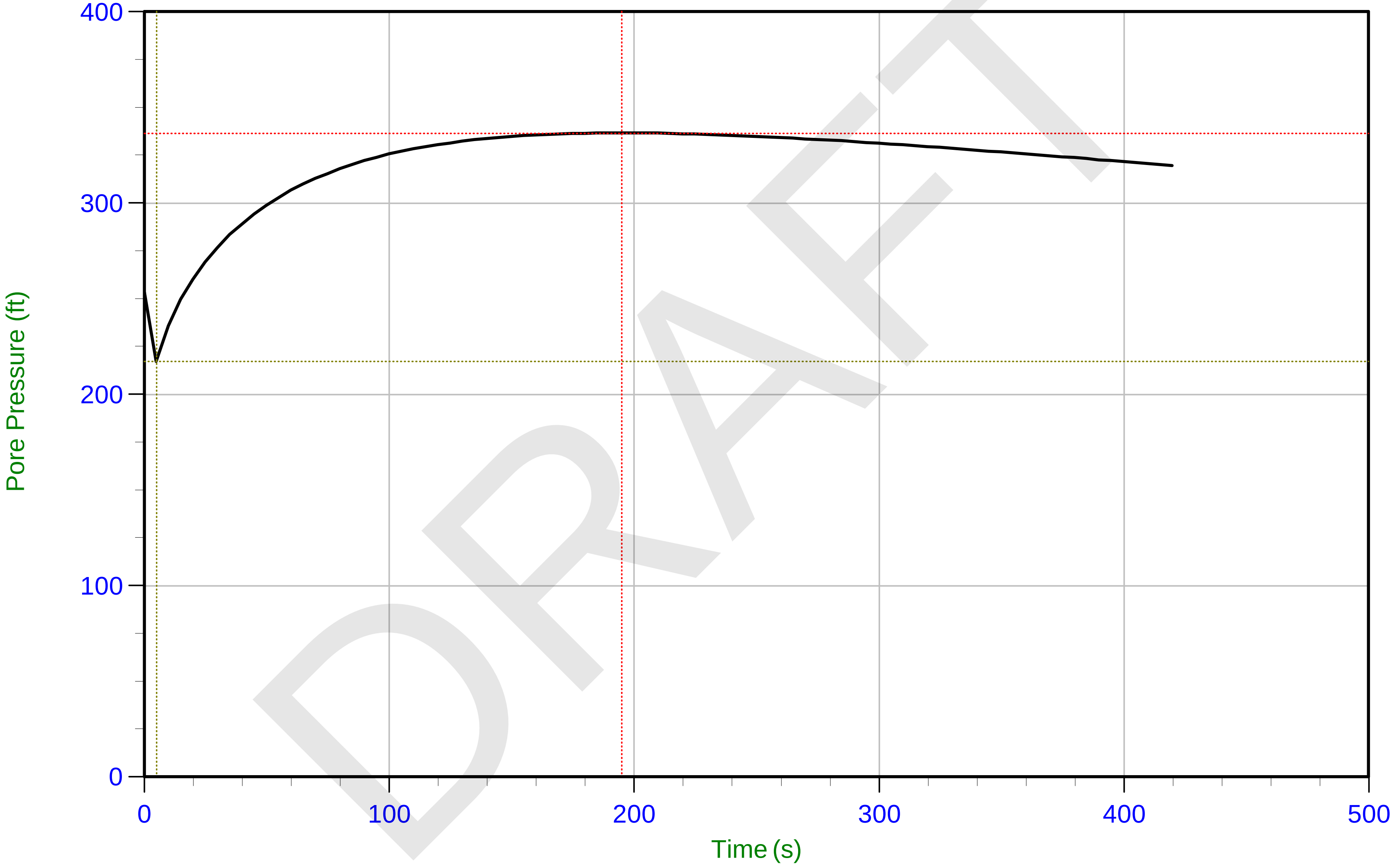
Sounding: JOP-C006
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-54071_CP JOP-C006.PPD
Depth: 5.000 m / 16.404 ft
Duration: 300.0 s

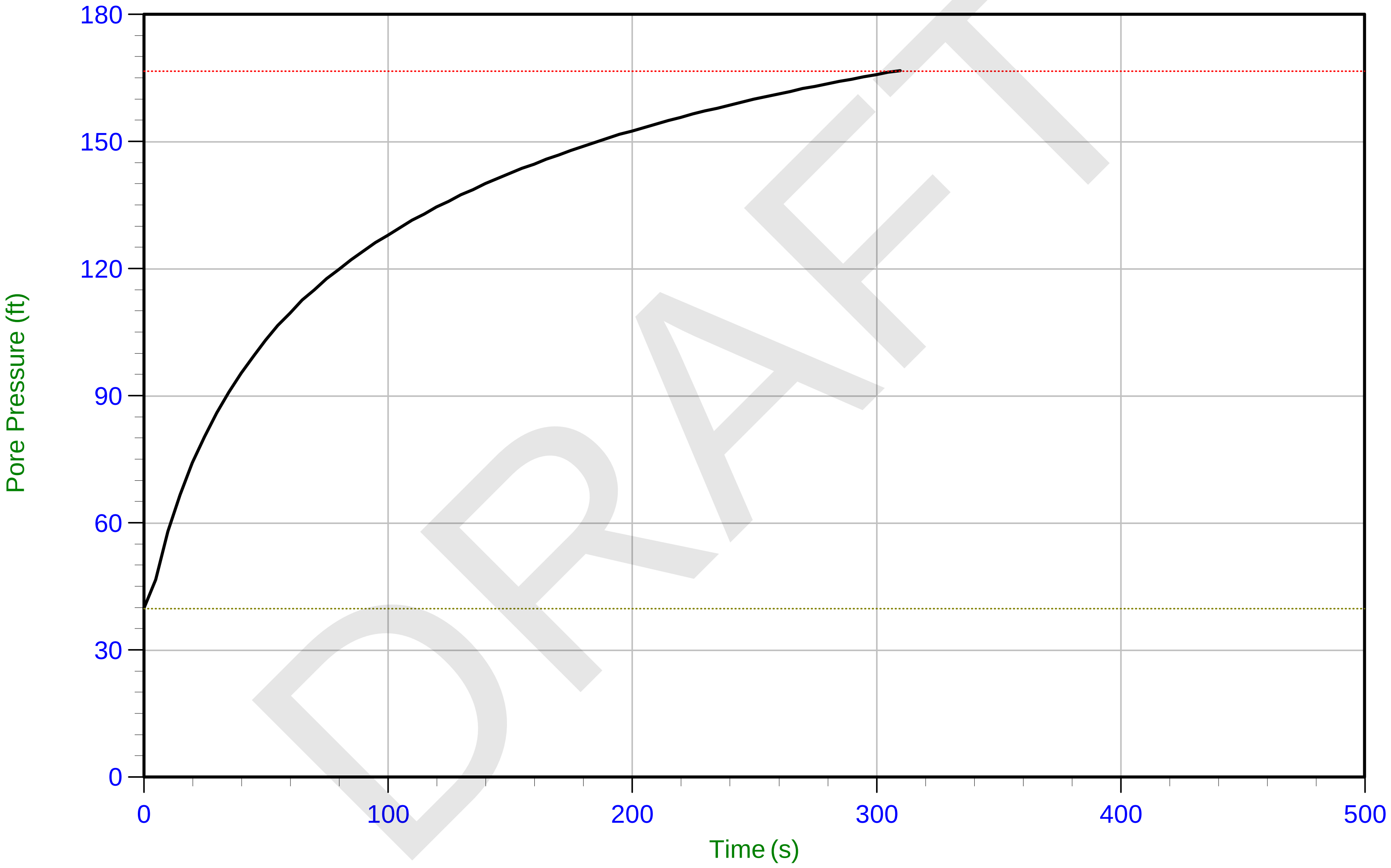
U Min: 13.7 ft
U Max: 48.1 ft



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



Trace Summary:

Filename: 15-54071_CP JOP-C006.PPD
Depth: 11.000 m / 36.089 ft
Duration: 310.0 s

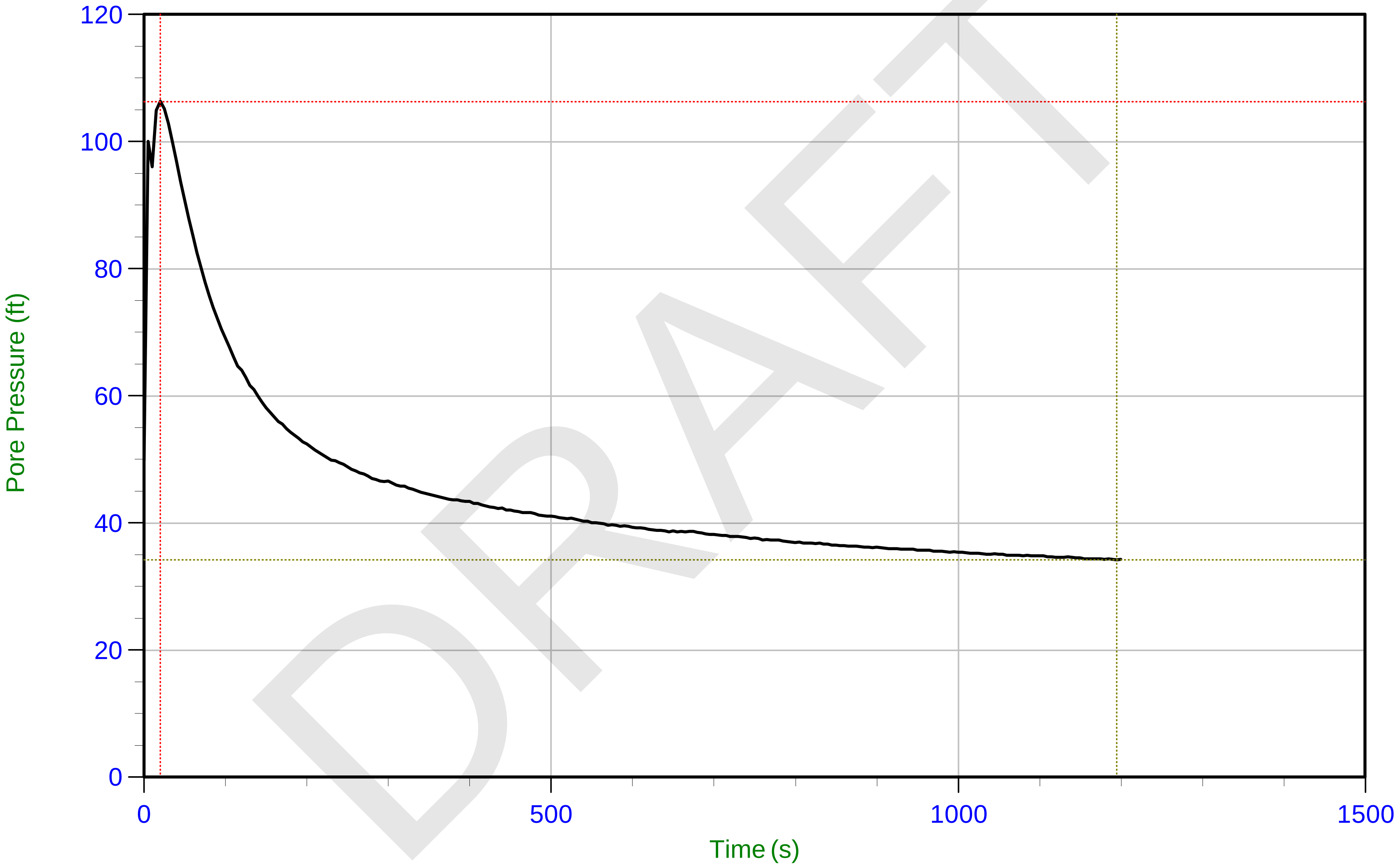
U Min: 39.9 ft
U Max: 166.7 ft

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

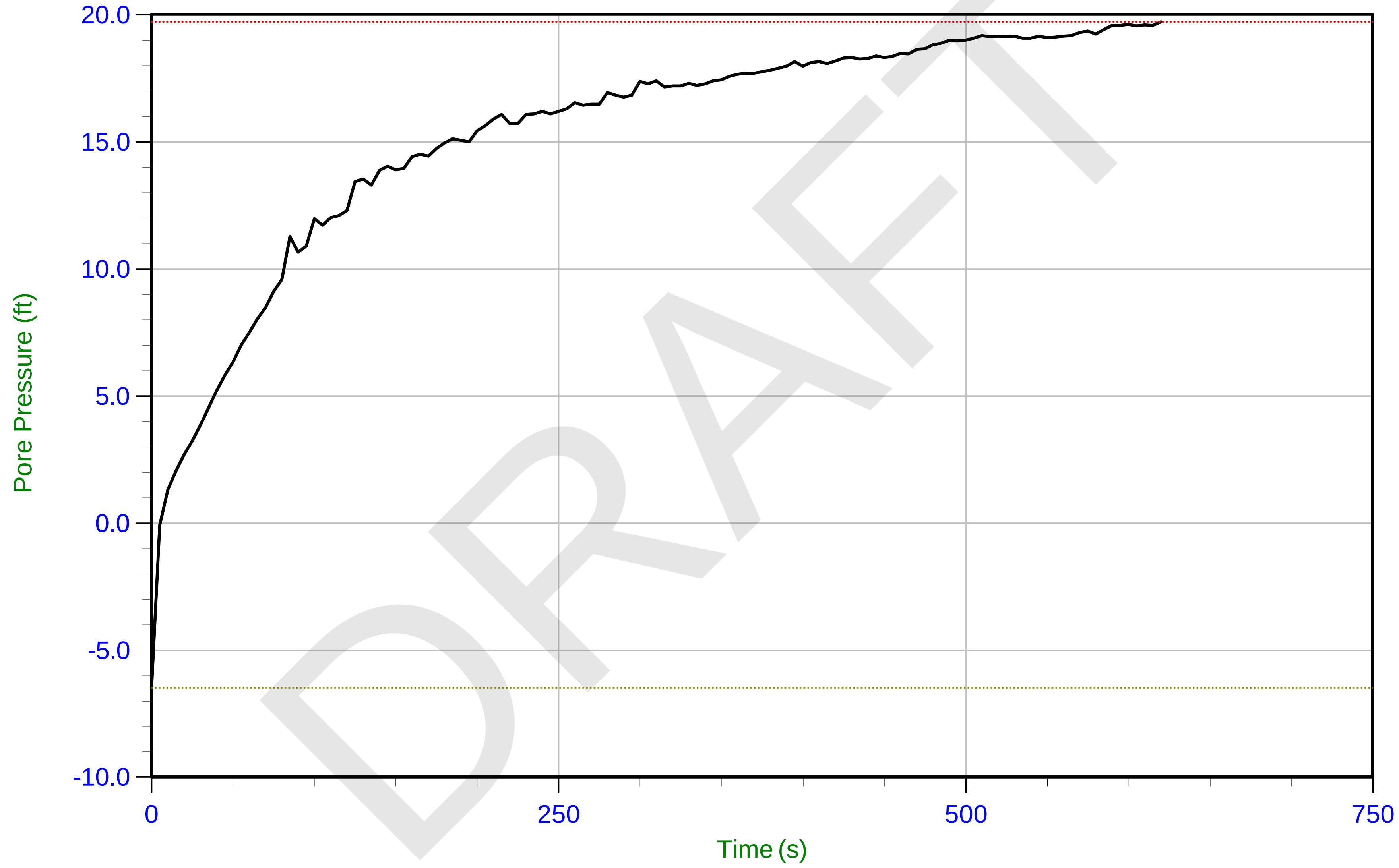
U Min: 34.2 ft
U Max: 106.3 ft

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

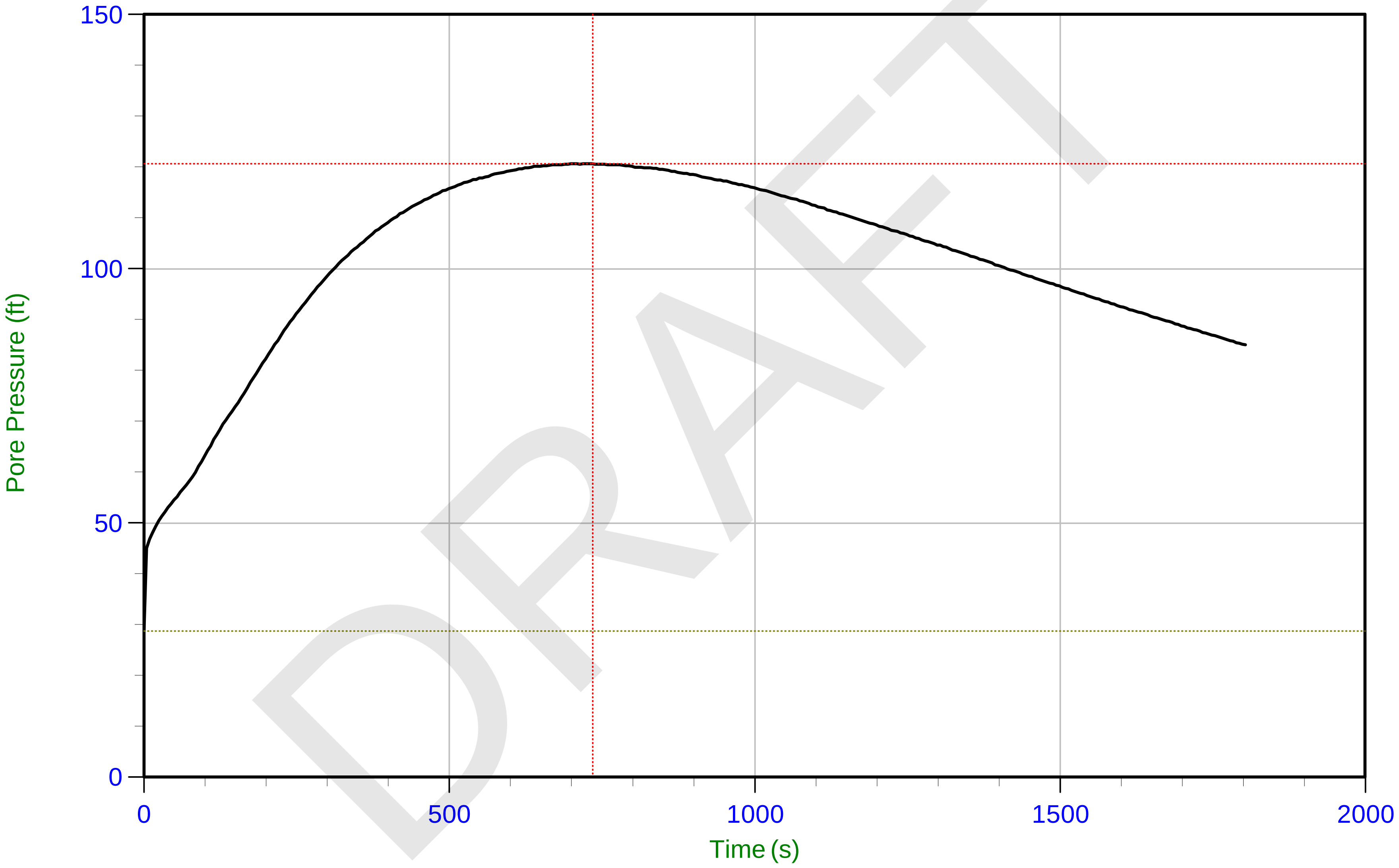
U Min: -6.5 ft
U Max: 19.7 ft

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

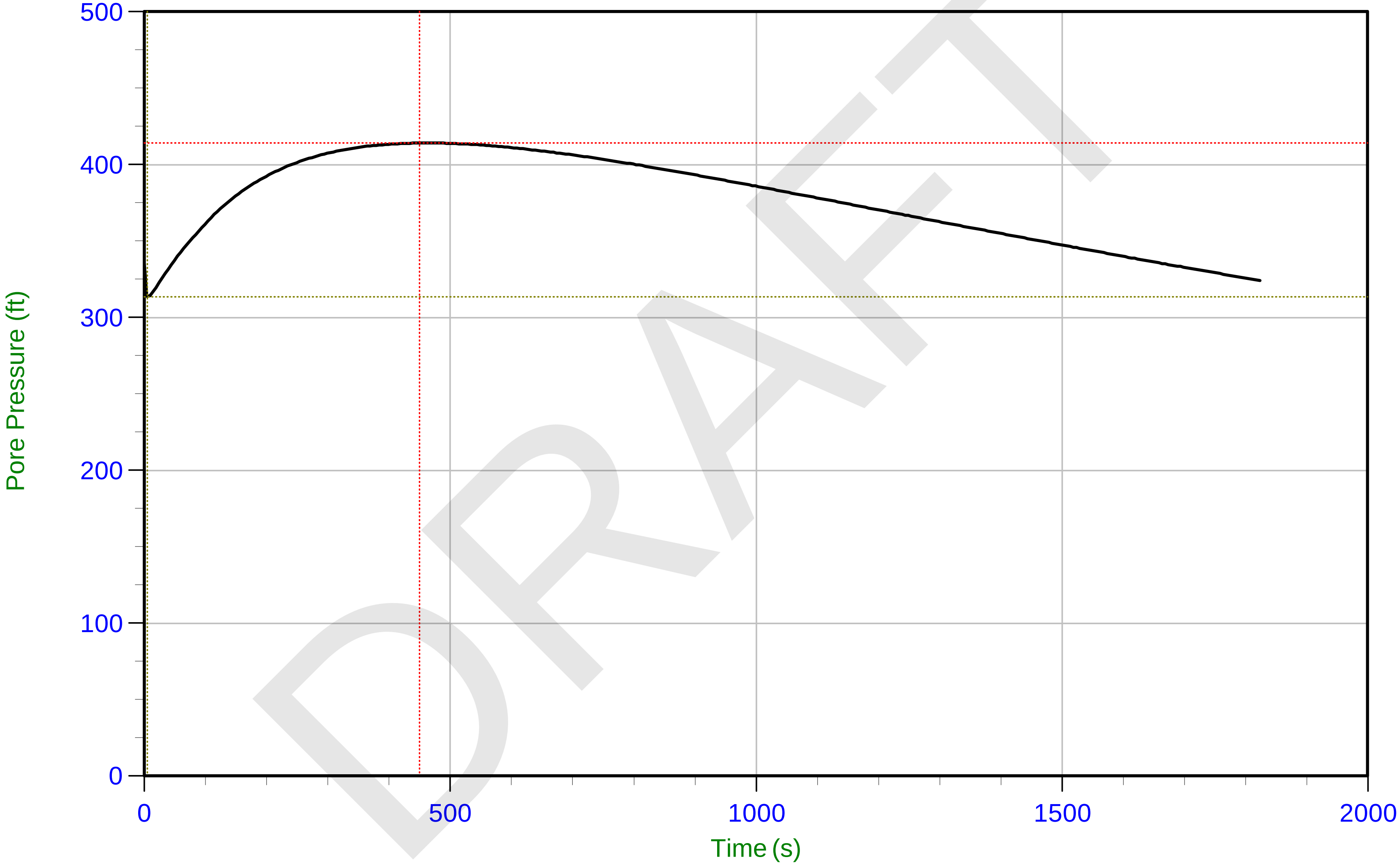
U Min: 28.8 ft
U Max: 120.7 ft

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:

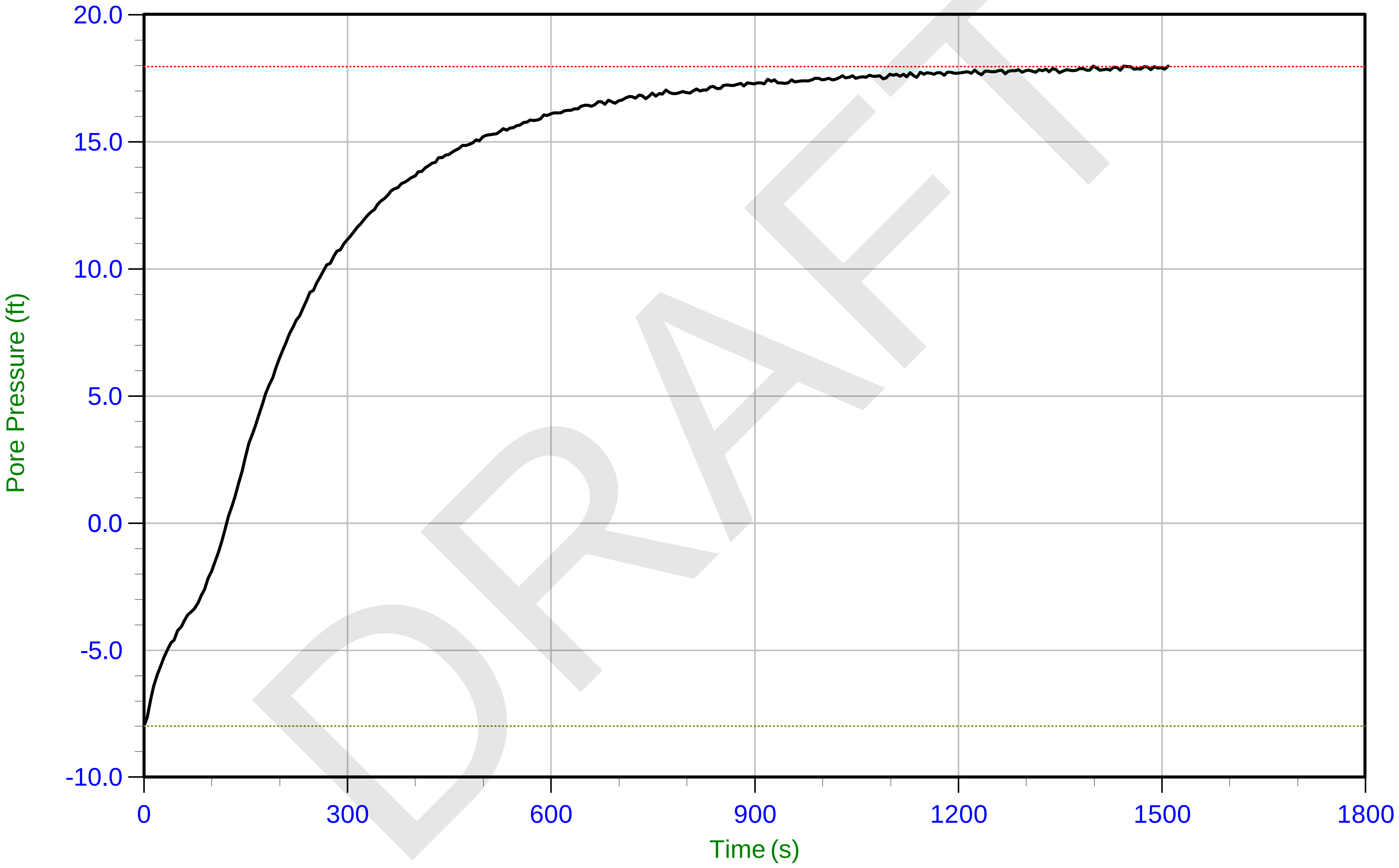
Filename: 15-54071_CP JOP-C007.PPD
Depth: 18.950 m / 62.171 ft
Duration: 1825.0 s

U Min: 313.7 ft
U Max: 414.2 ft

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



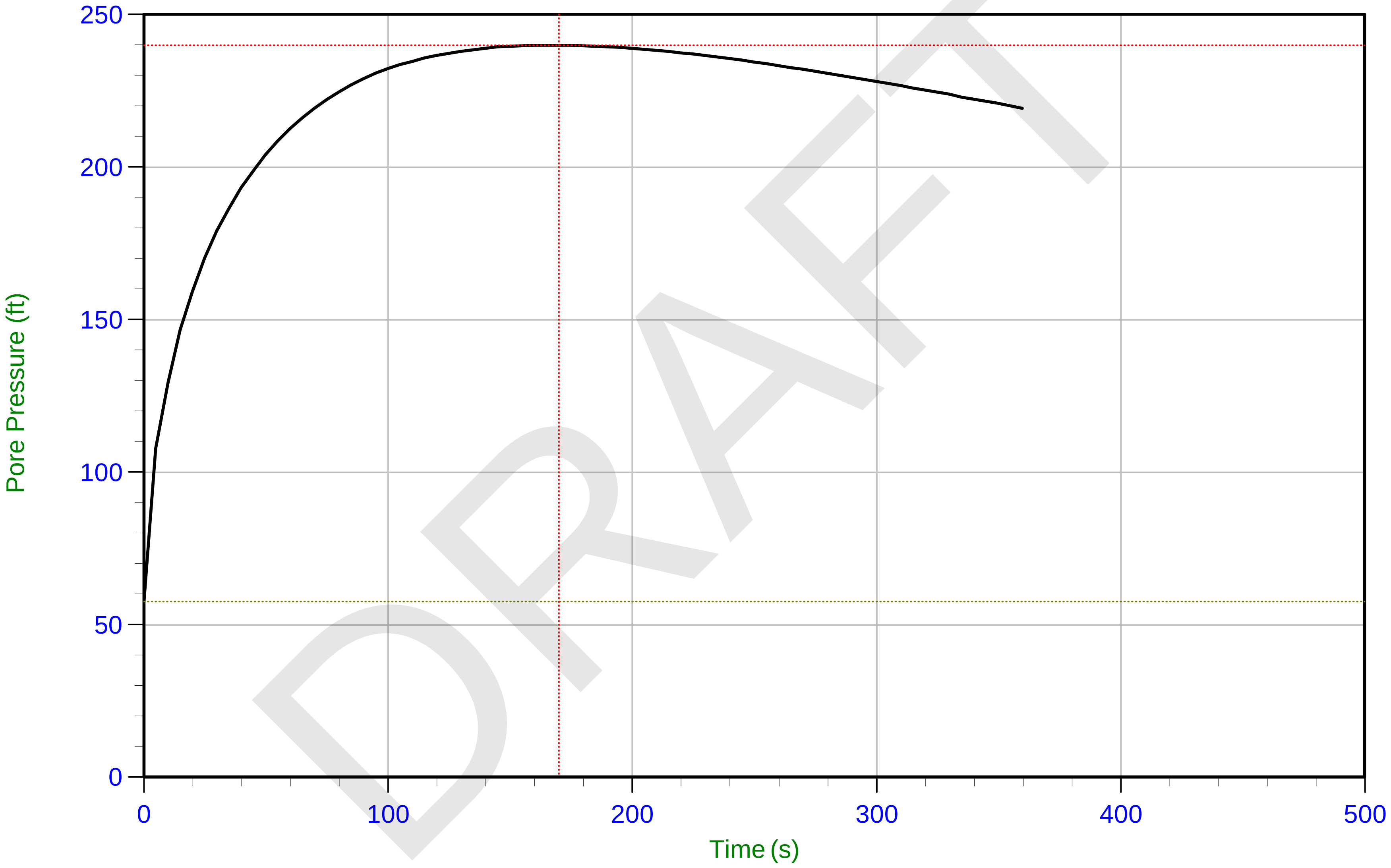
Trace Summary:

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

AECOM	Job No: 15-54071	Sounding: JOP-C008
	Date: 08/12/2015 08:08	Cone: 184:T1500F15U500
	Site: Dynegy Joppa IL	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

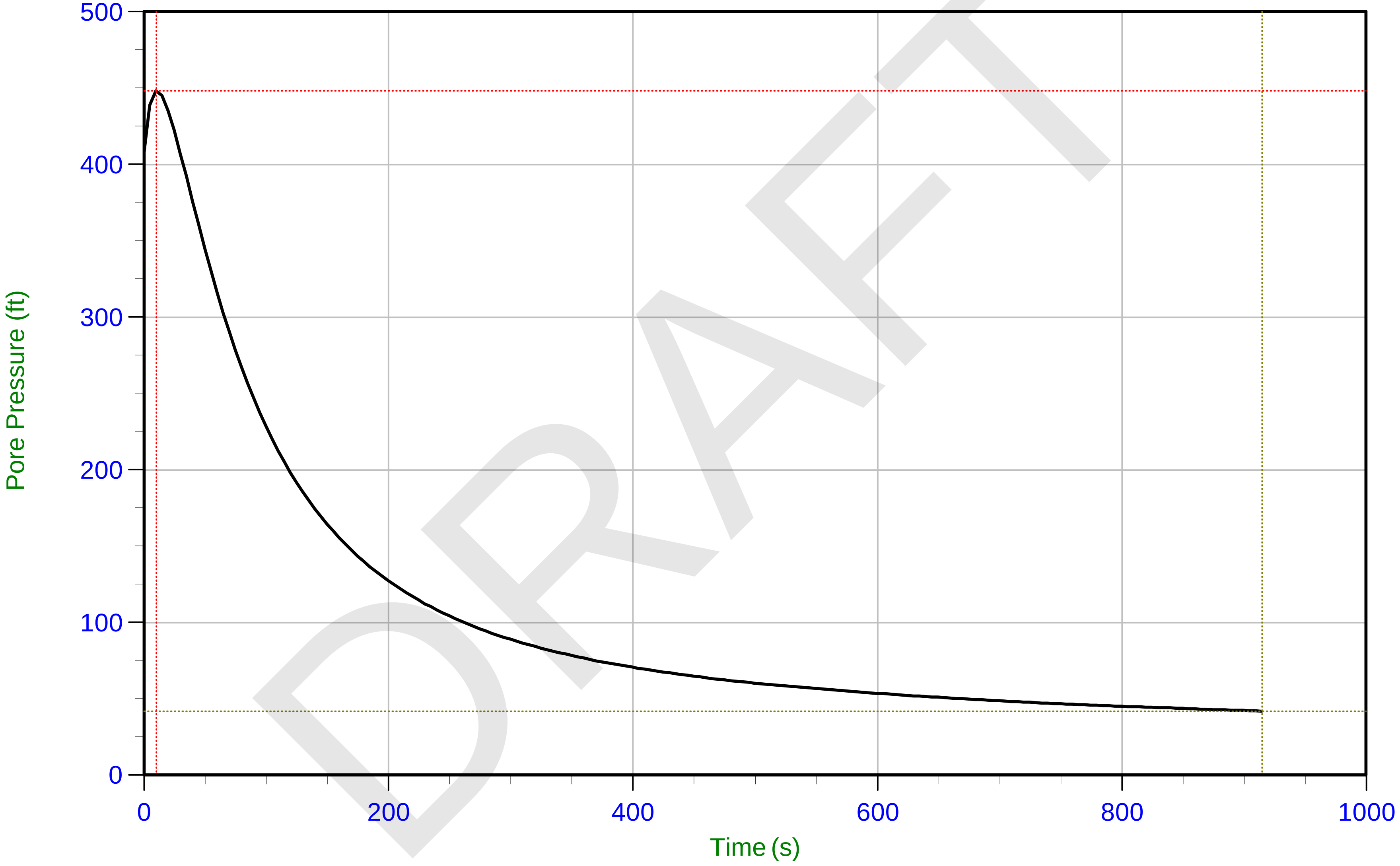
U Min: 57.6 ft
U Max: 240.0 ft

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

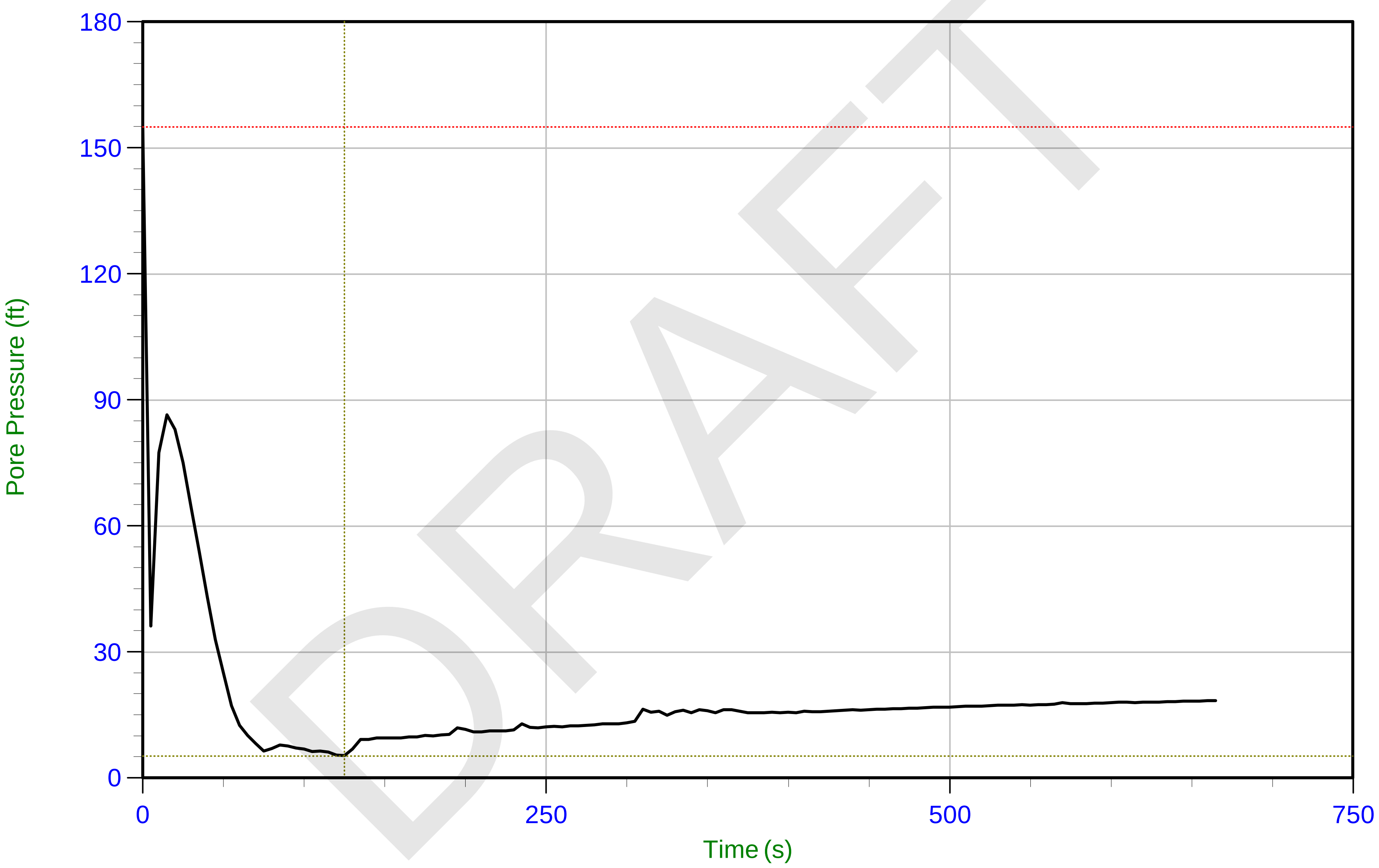
WT: 10.201 m / 33.467 ft
Ueq: 38.7 ft

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



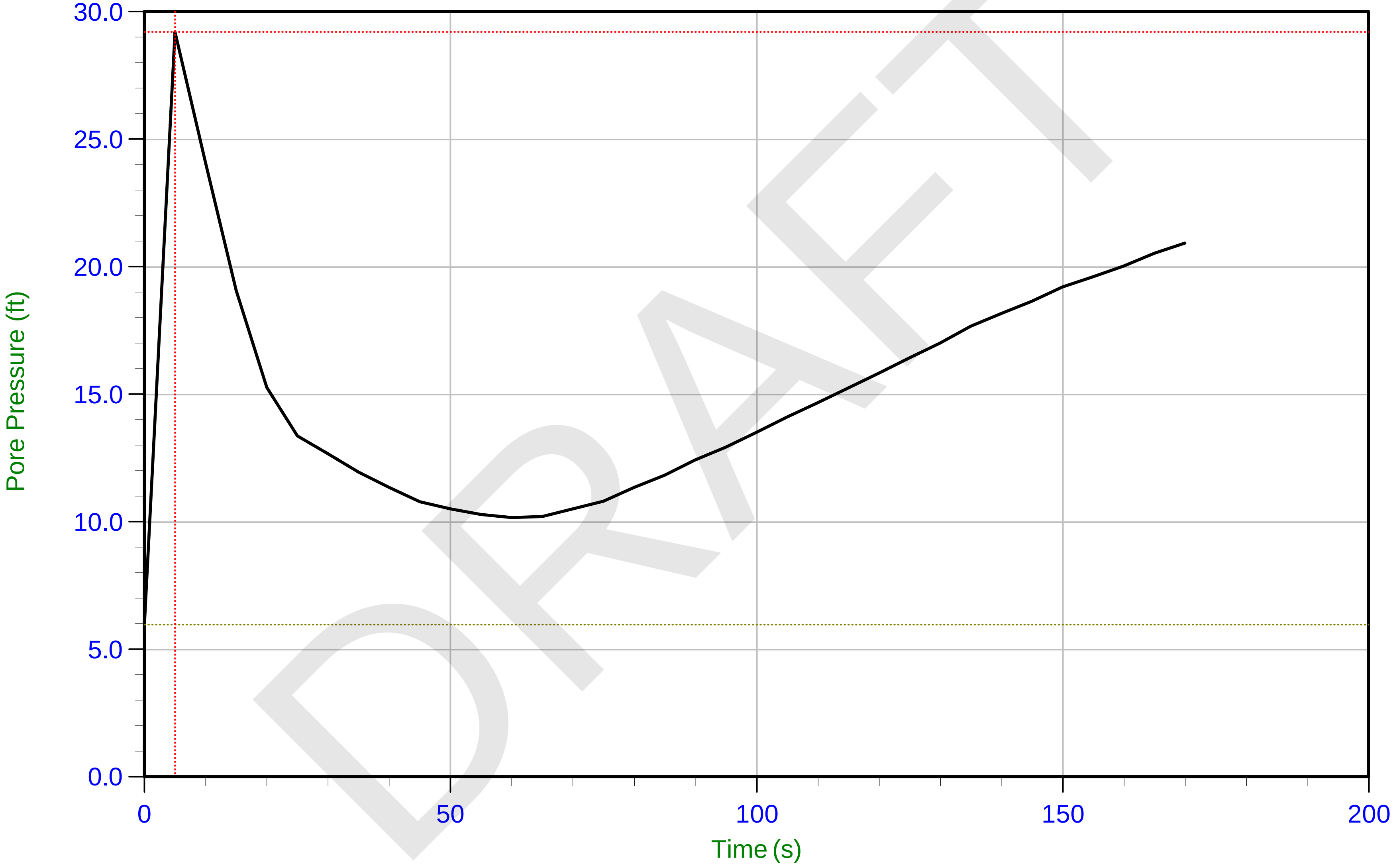
Trace Summary:

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:

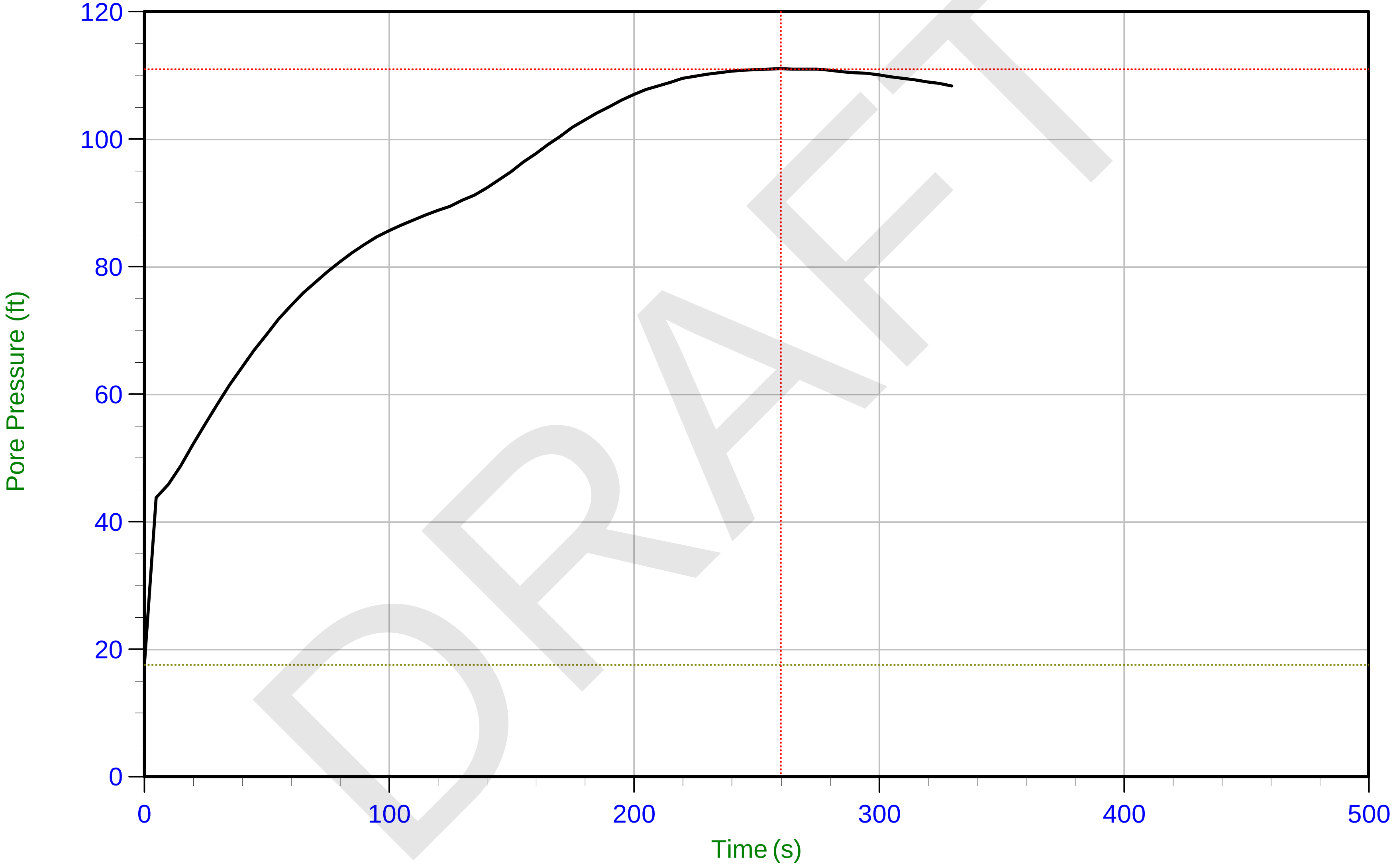
Filename: 15-54071_CP JOP-C009.PPD
Depth: 4.600 m / 15.092 ft
Duration: 170.0 s
U Min: 6.0 ft
U Max: 29.2 ft

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

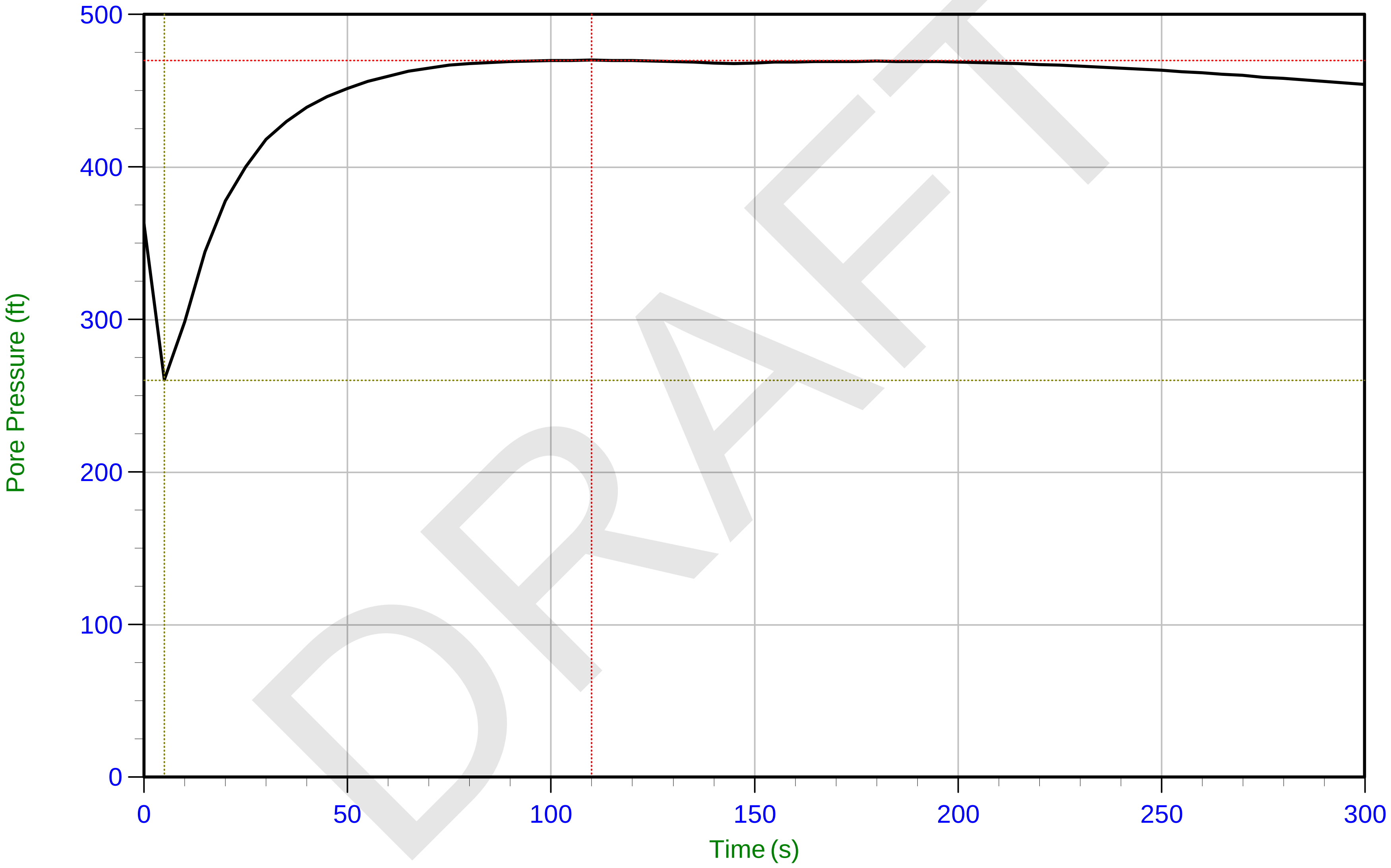
U Min: 17.6 ft
U Max: 111.1 ft

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

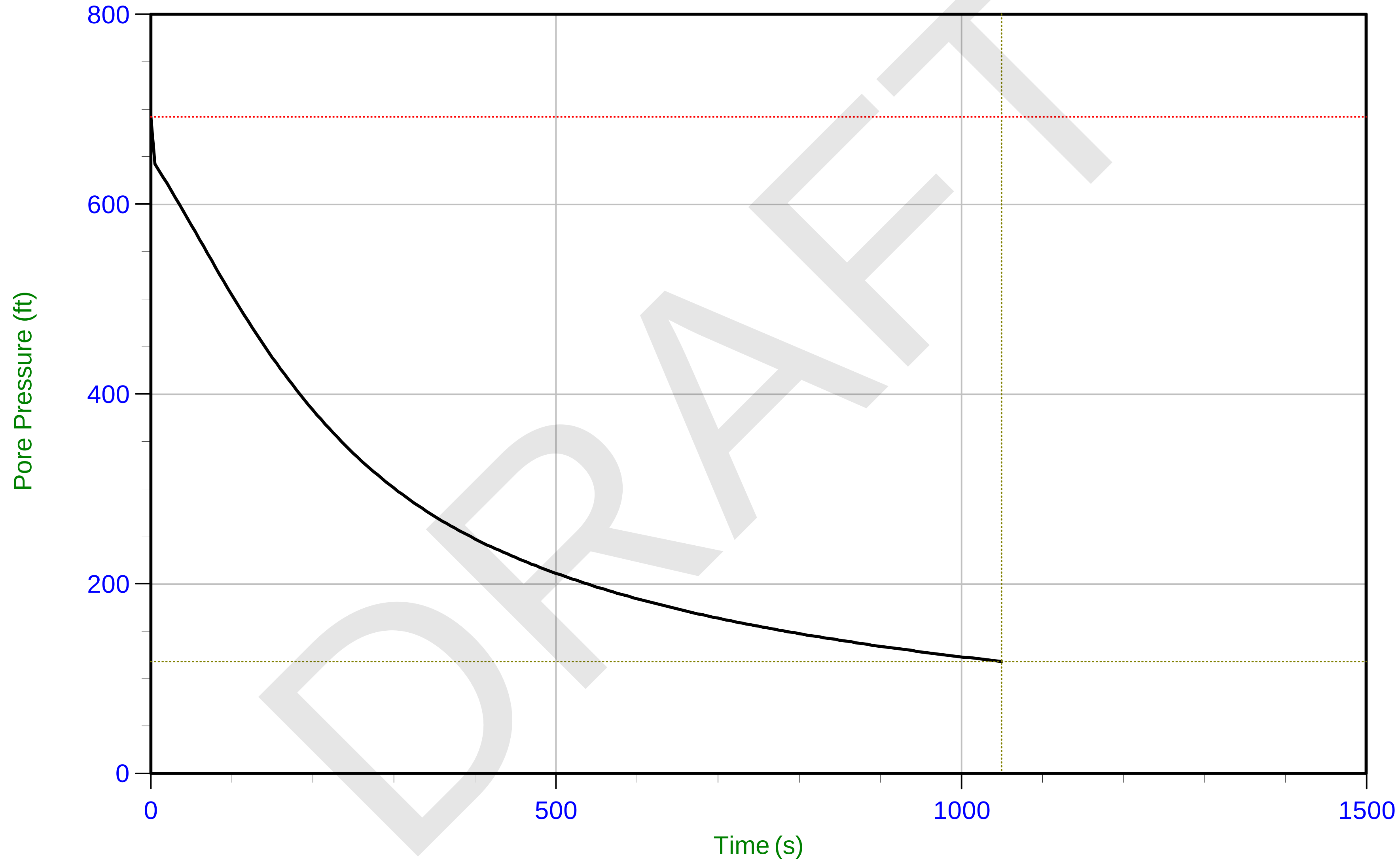
U Min: 260.5 ft
U Max: 470.1 ft

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

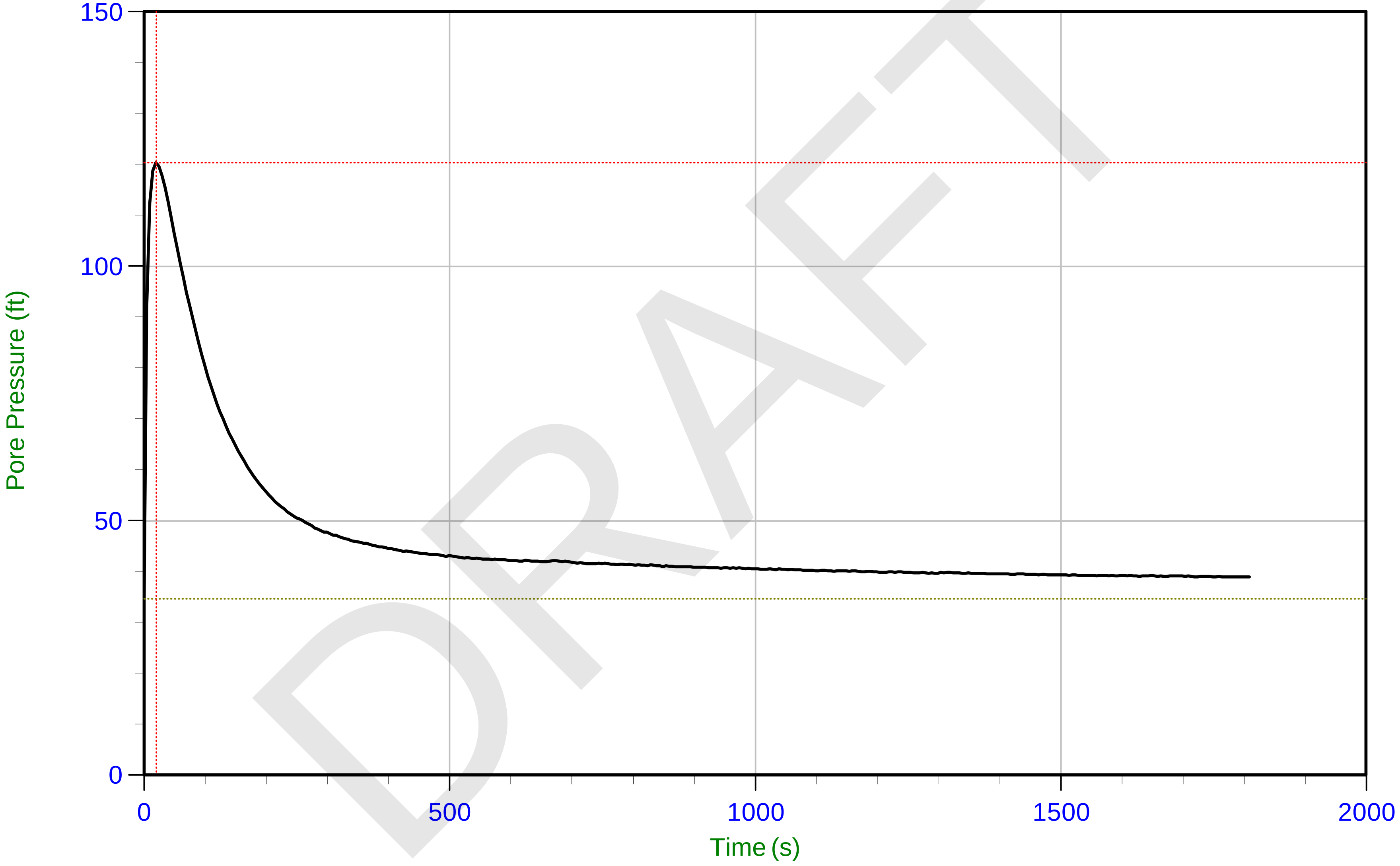


Trace Summary:

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

AECOM	Job No: 15-54071	Sounding: JOP-C011
	Date: 08/09/2015 07:40	Cone: 349:T1500F15U500
	Site: Dynegy Joppa IL	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

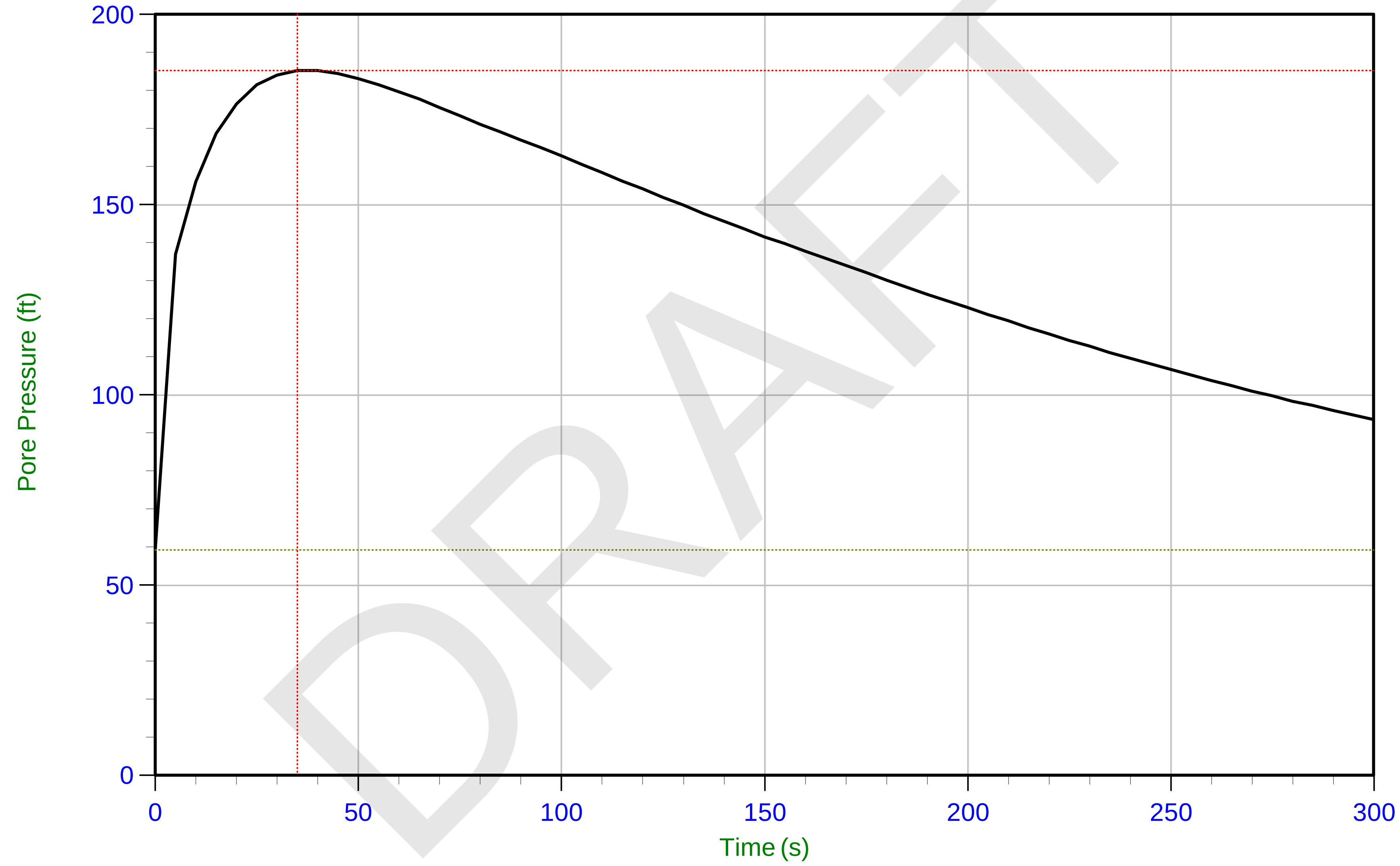
WT: 4.204 m / 13.792 ft
Ueq: 39.2 ft

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

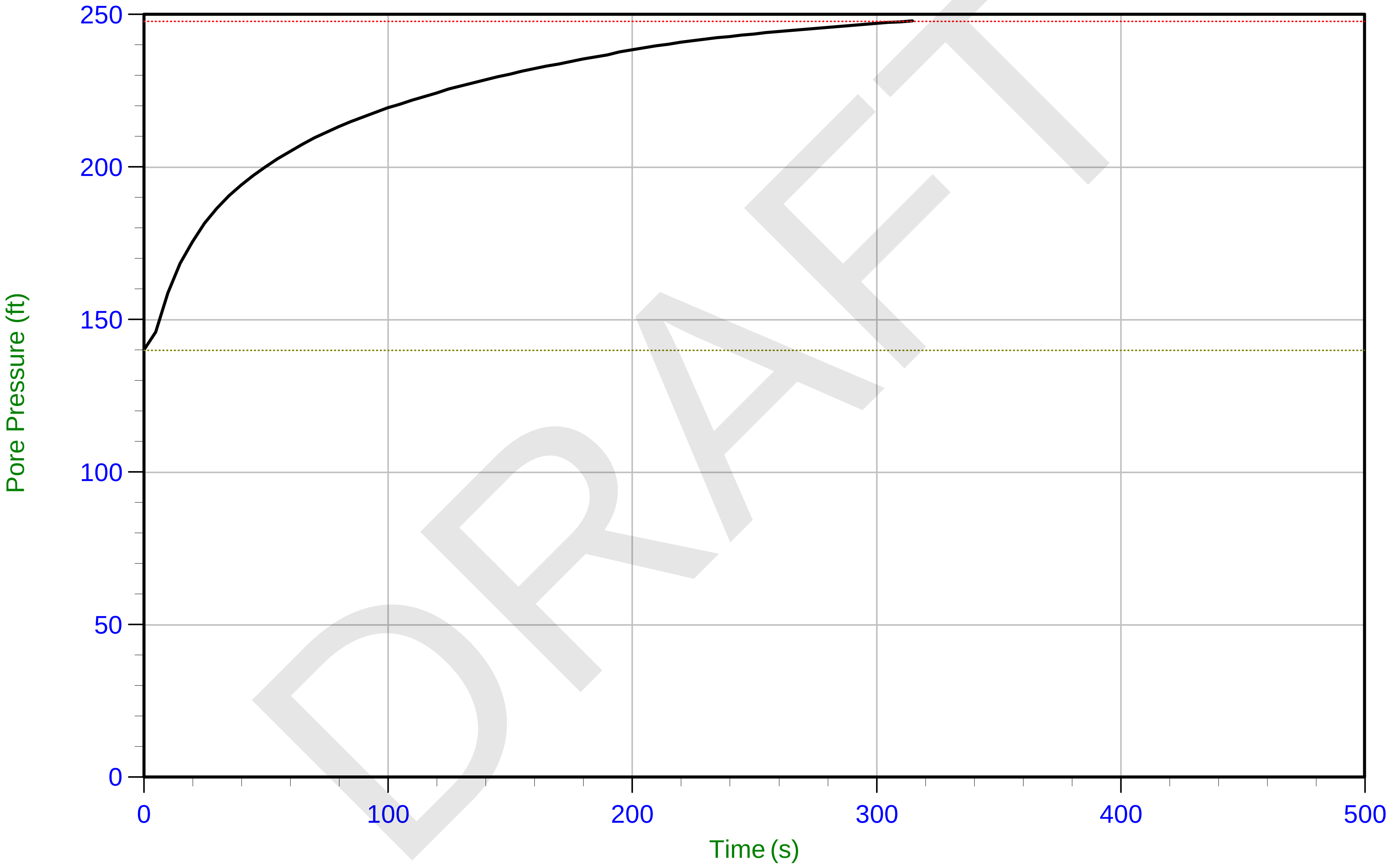
U Min: 59.3 ft
U Max: 185.3 ft

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

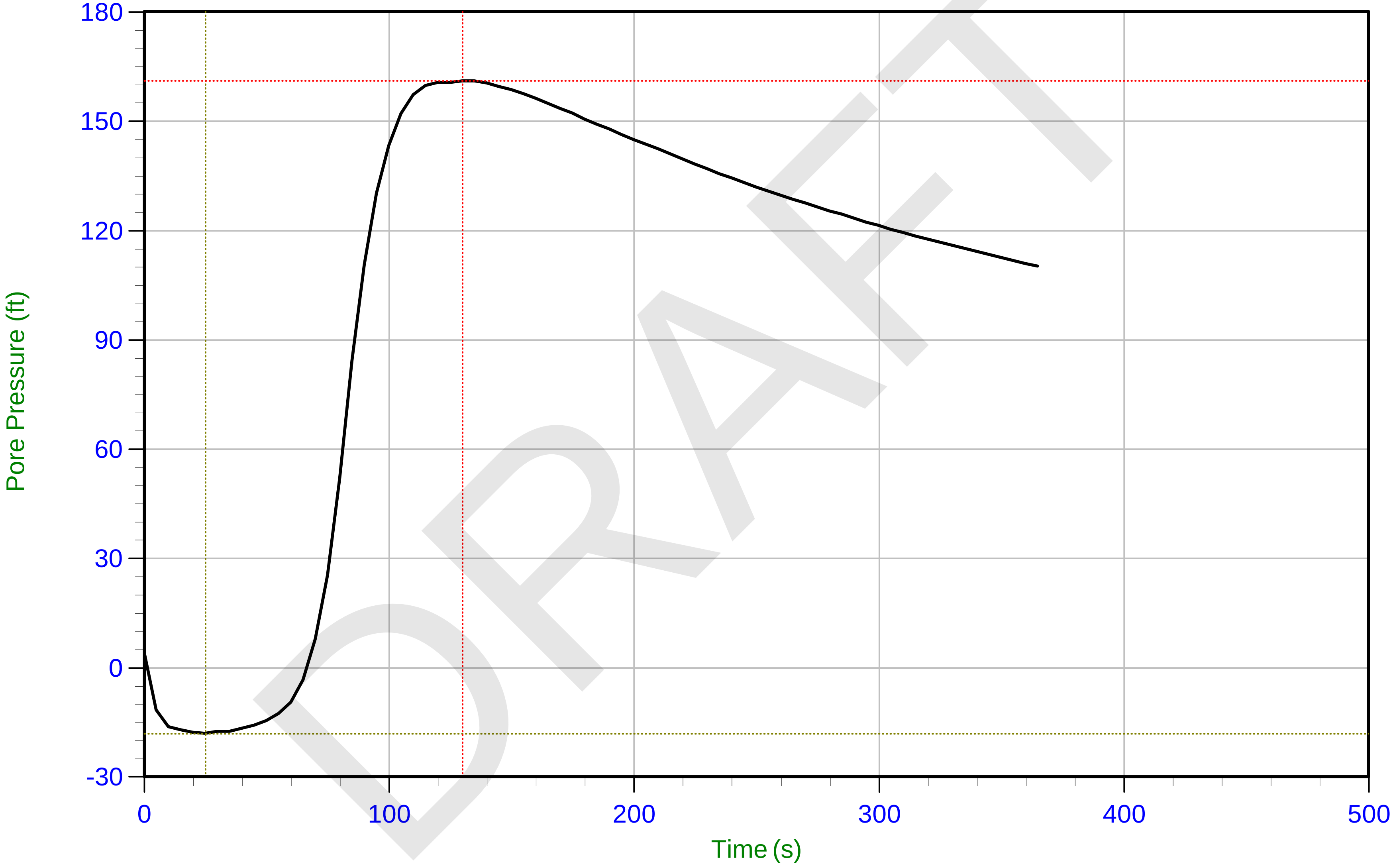
U Min: 140.0 ft
U Max: 247.9 ft

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

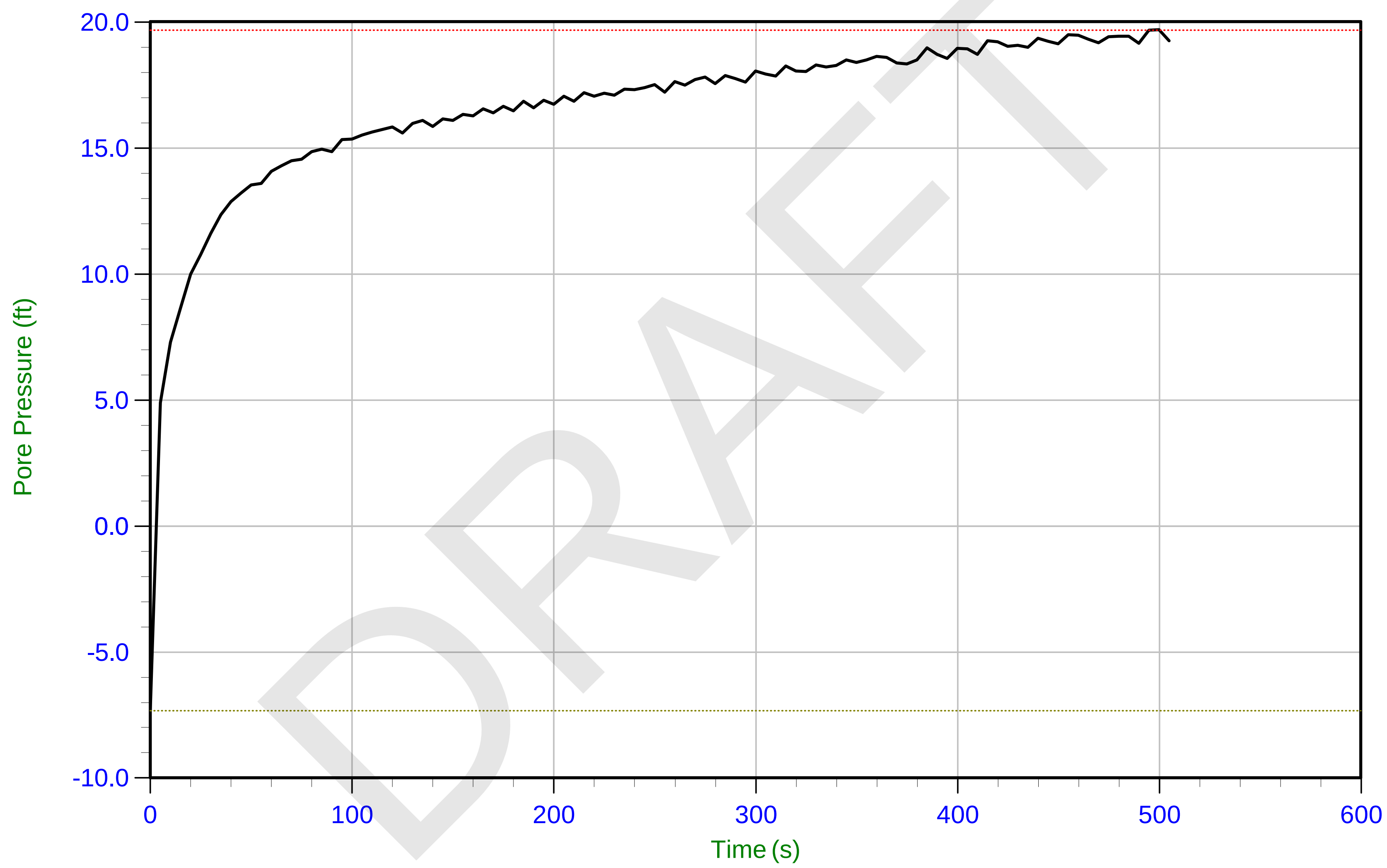
U Min: -18.1 ft
U Max: 161.1 ft

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_CPJOP-C014.PPD
Depth: 5.350 m / 17.552 ft
Duration: 505.0 s

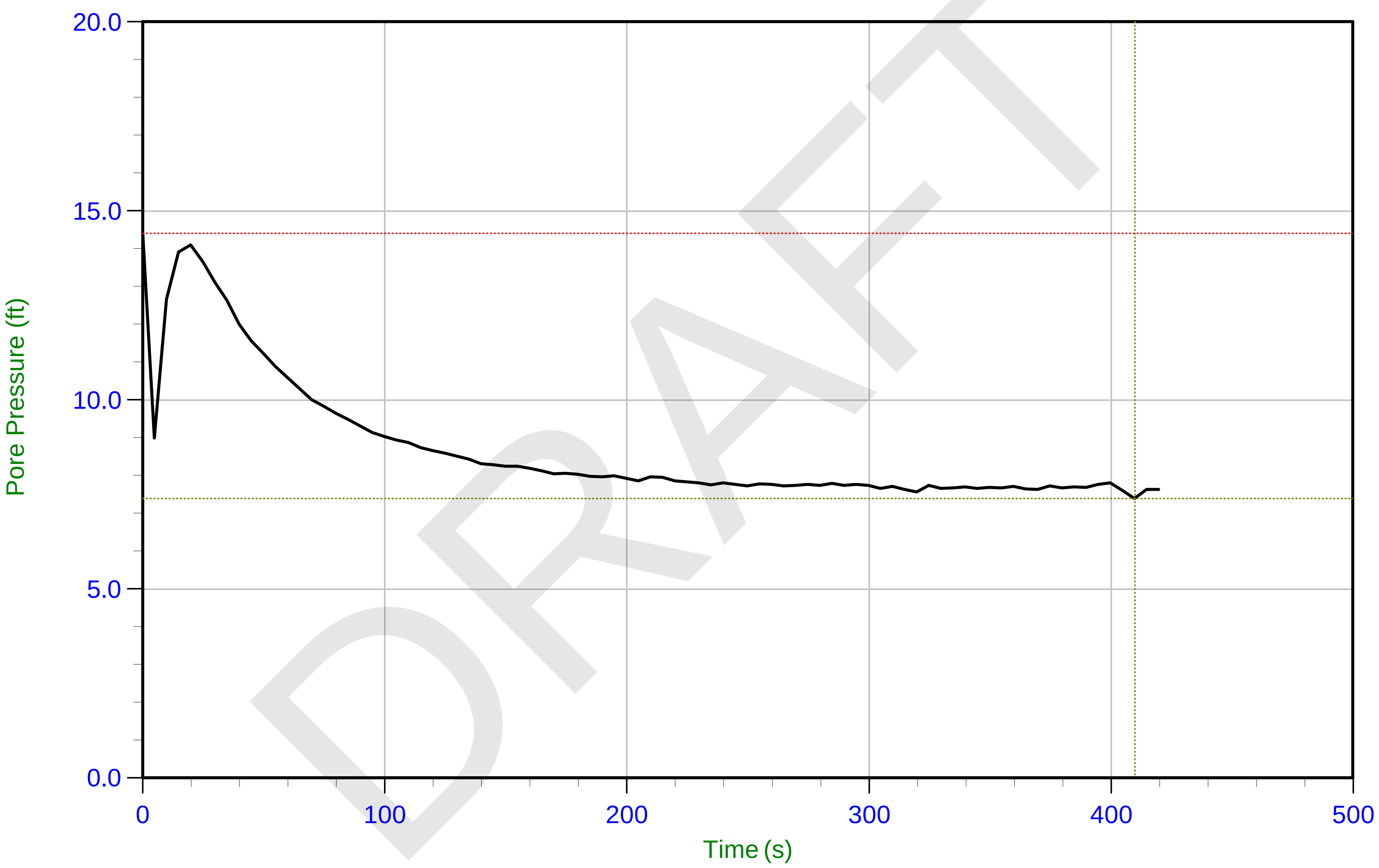
U Min: -7.3 ft
U Max: 19.7 ft

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

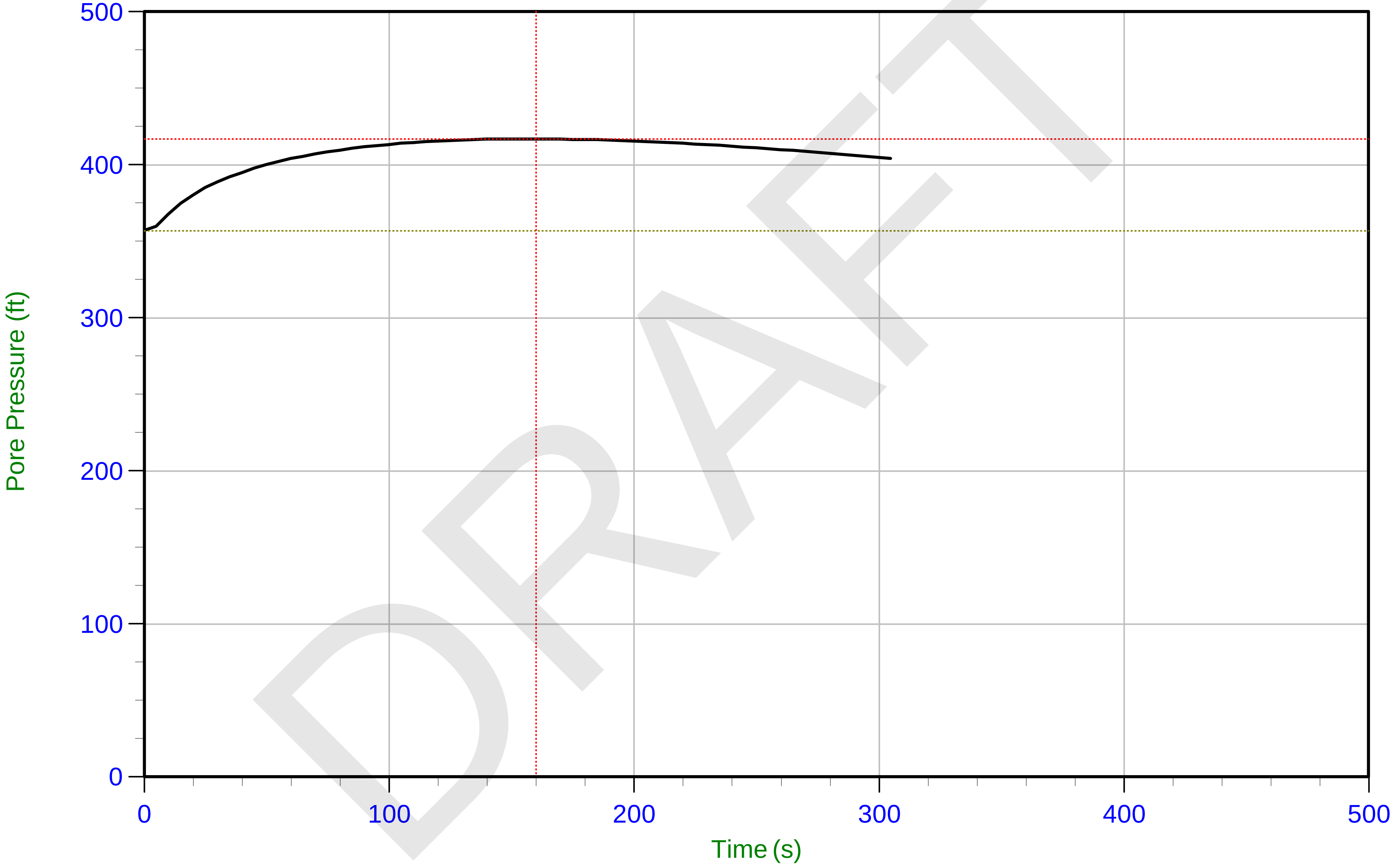
U Min: 7.4 ft
U Max: 14.4 ft

WT: 5.680 m / 18.635 ft
Ueq: 7.6 ft

AECOM

Job No: 15-54071
Date: 08/12/2015 11:56
Site: Dynegy Joppa, I

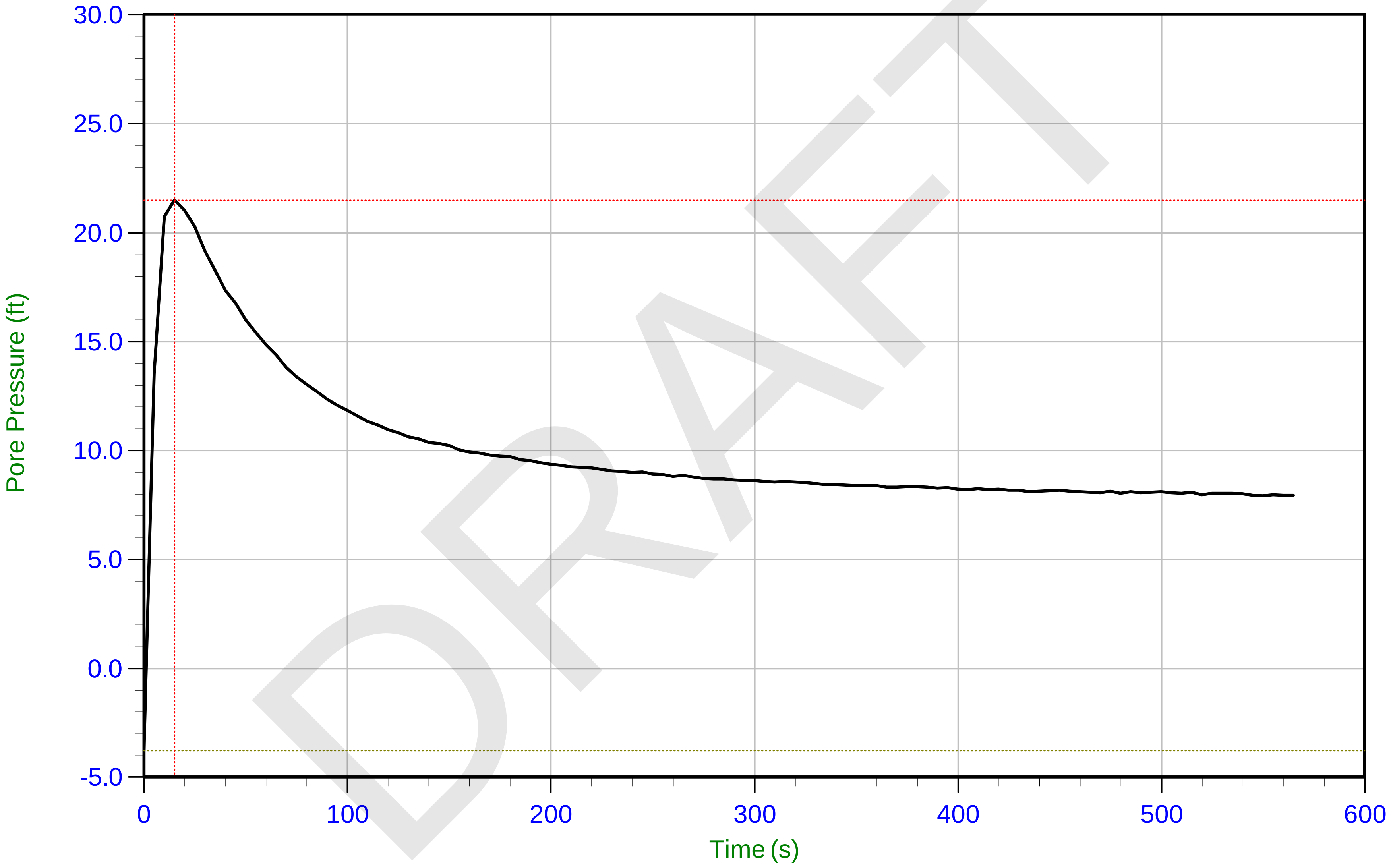
Sounding: JOP-C014
Cone: 392:T1500F15U500
Cone Area: 15 sq cm



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



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

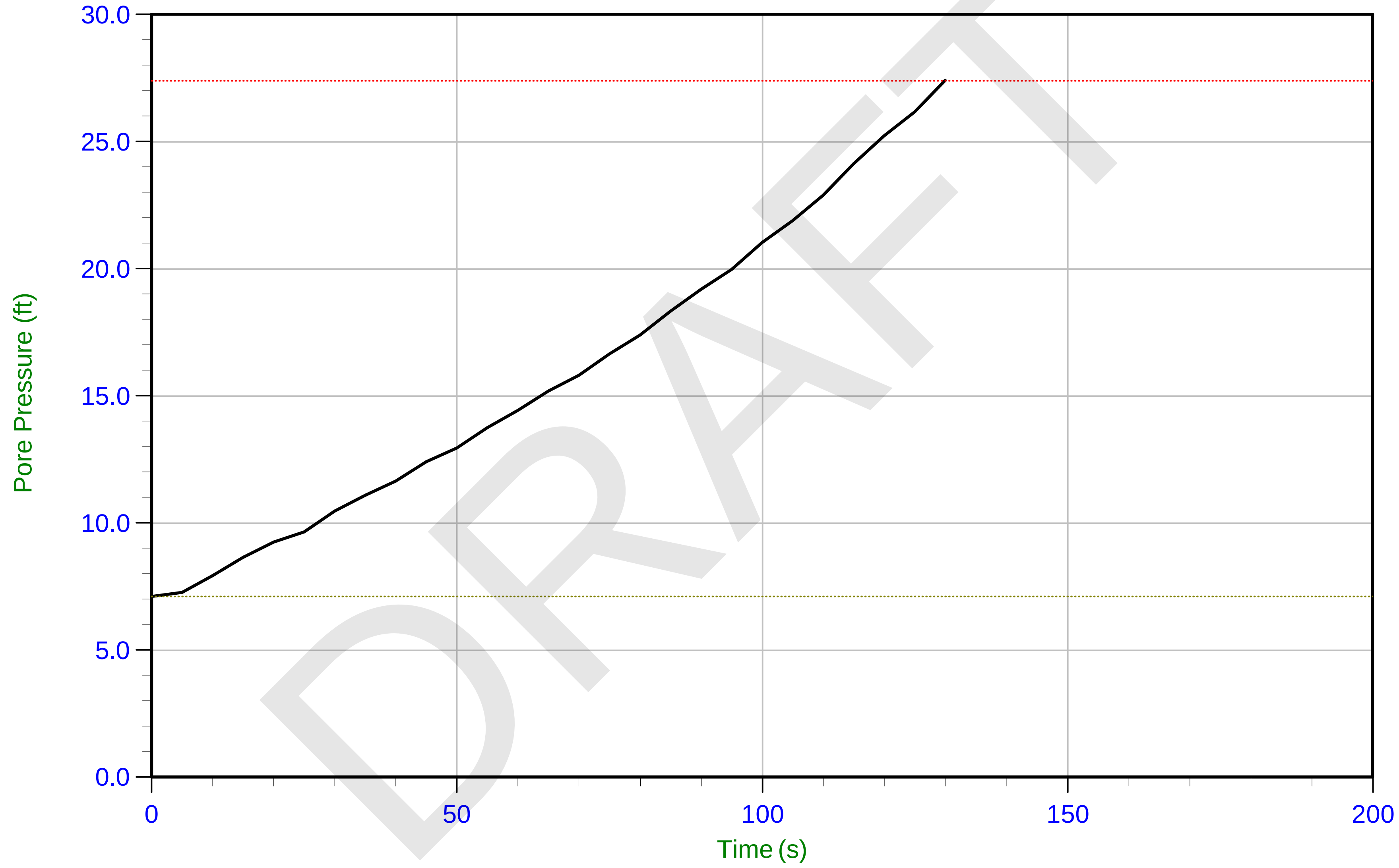
WT: 5.051 m / 16.571 ft
Ueq: 7.9 ft

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

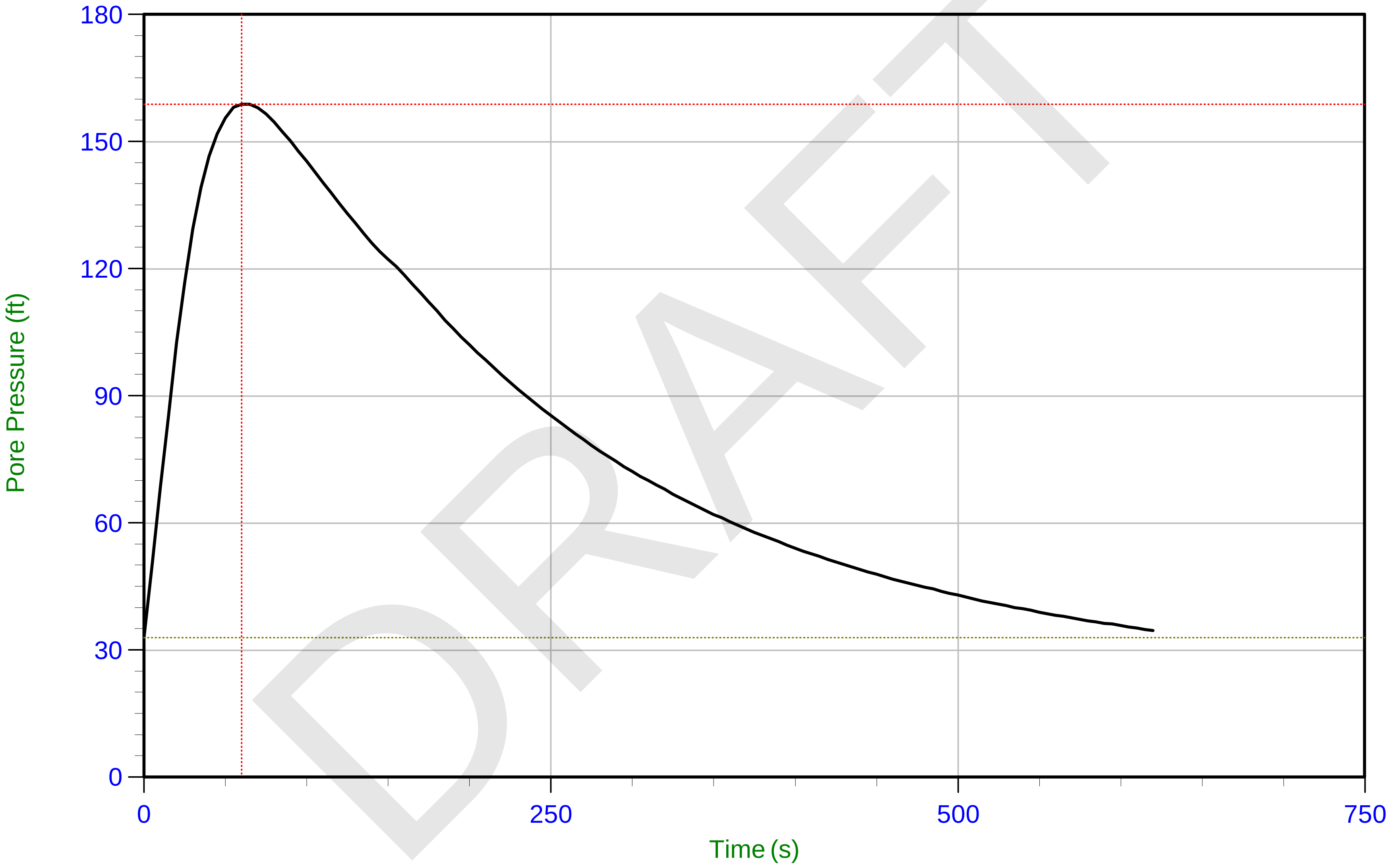


Trace Summary:

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

AECOM	Job No: 15-54071	Sounding: JOP-C015
	Date: 08/12/2015 13:57	Cone: 392:T1500F15U500
	Site: Dynegy Joppa, I	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

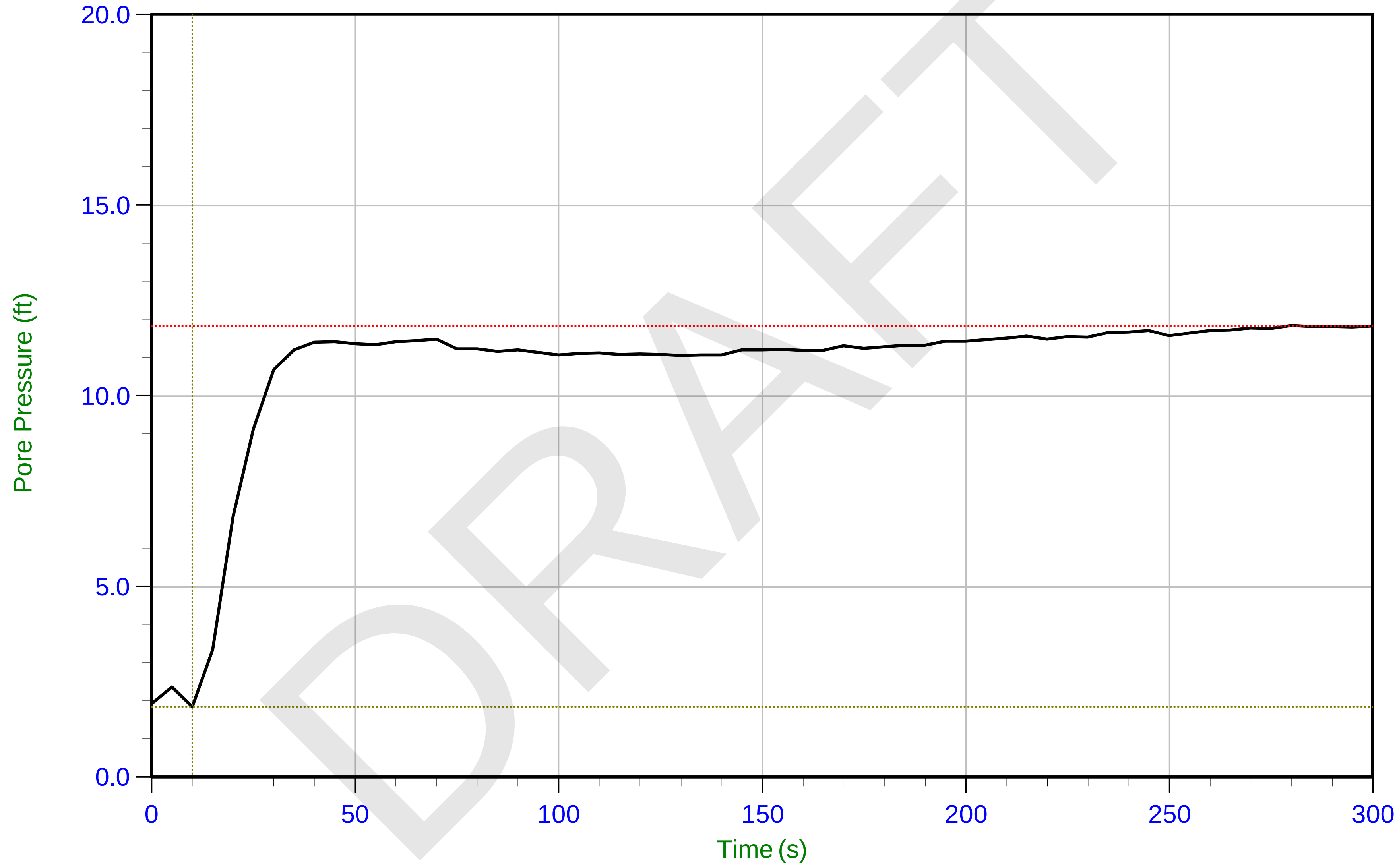
U Min: 33.0 ft
U Max: 158.9 ft

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

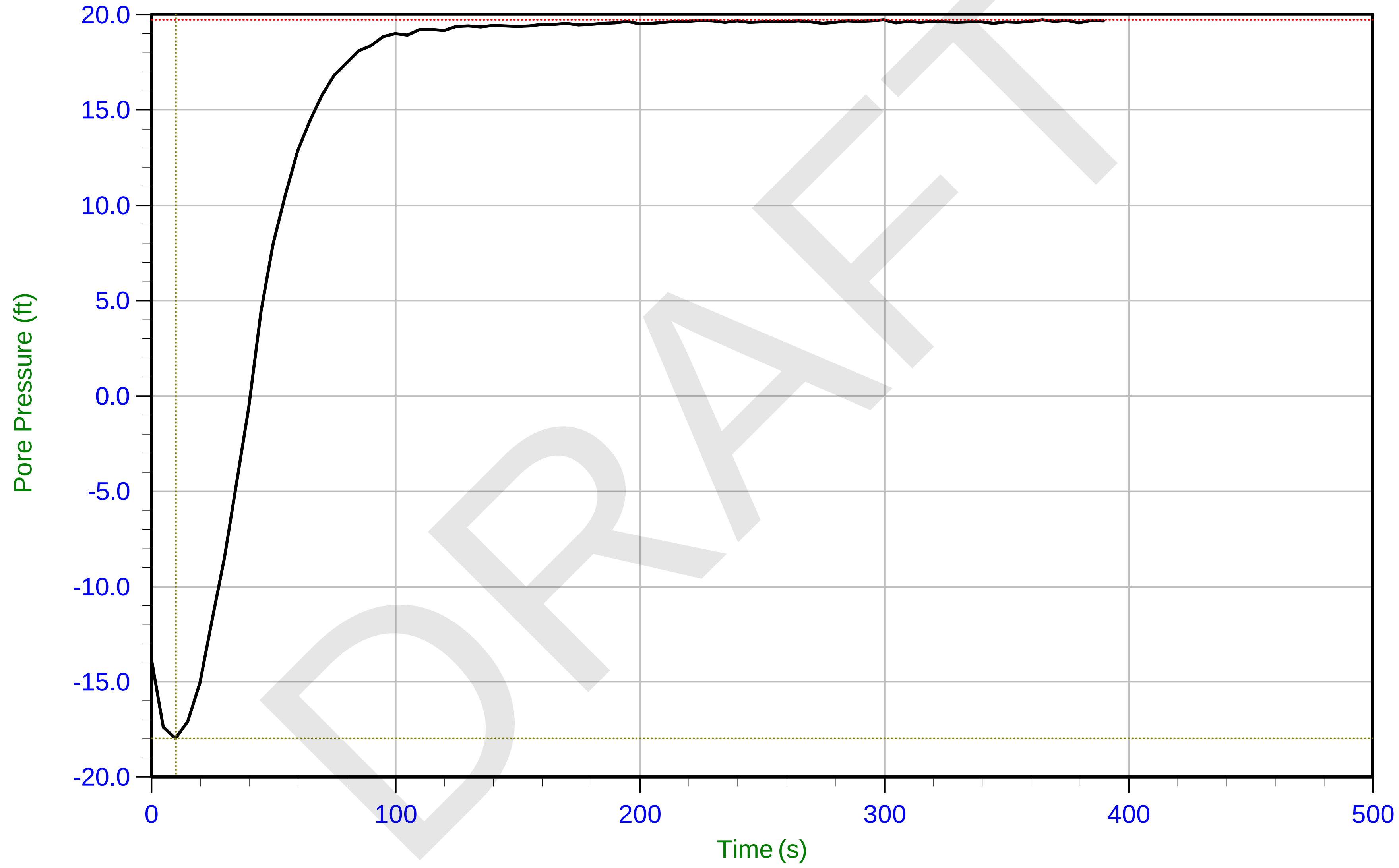
WT: 20.351 m / 66.769 ft
Ueq: 11.8 ft

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

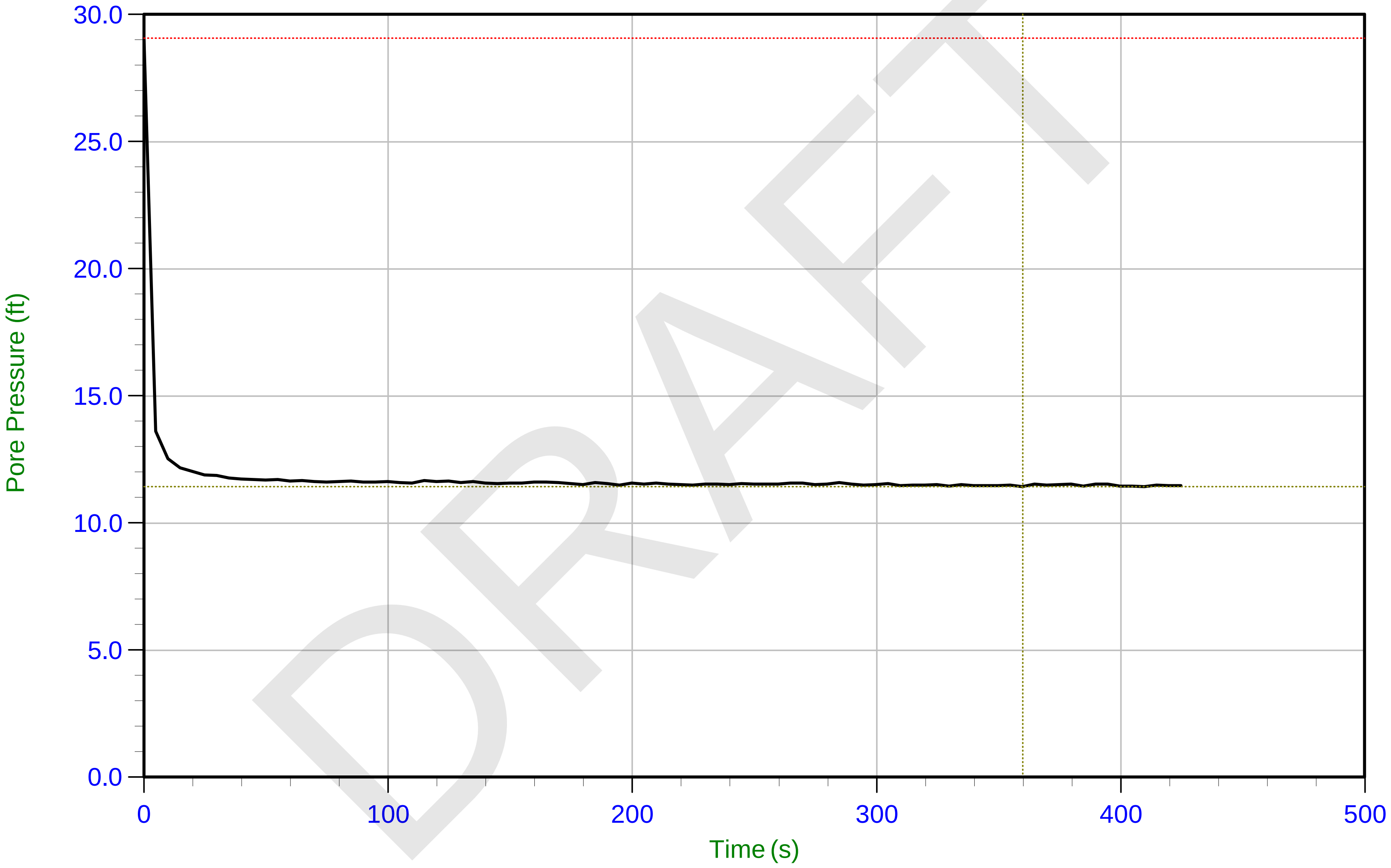
WT: 20.111 m / 65.981 ft
Ueq: 19.5 ft

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

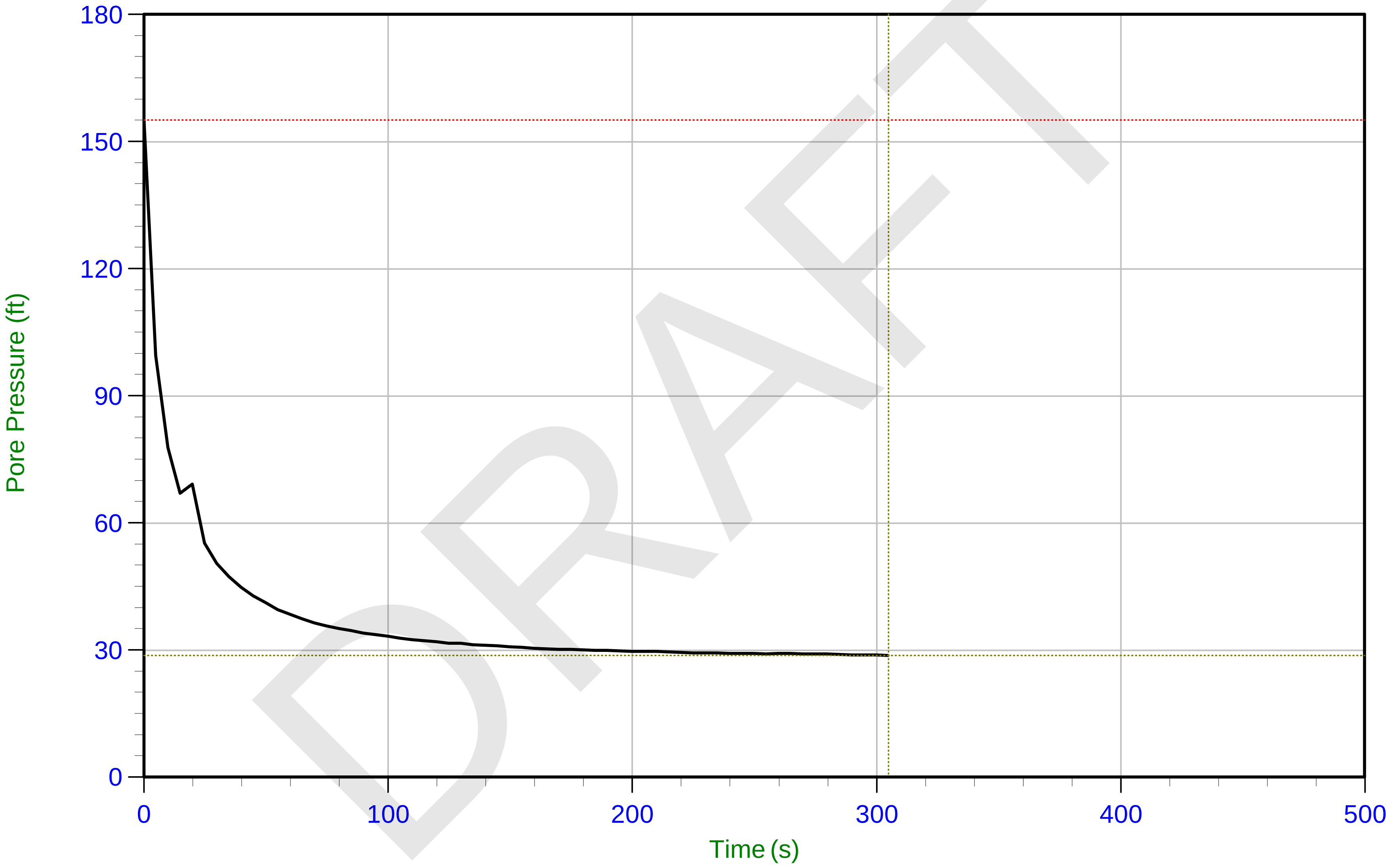


Trace Summary:

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



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

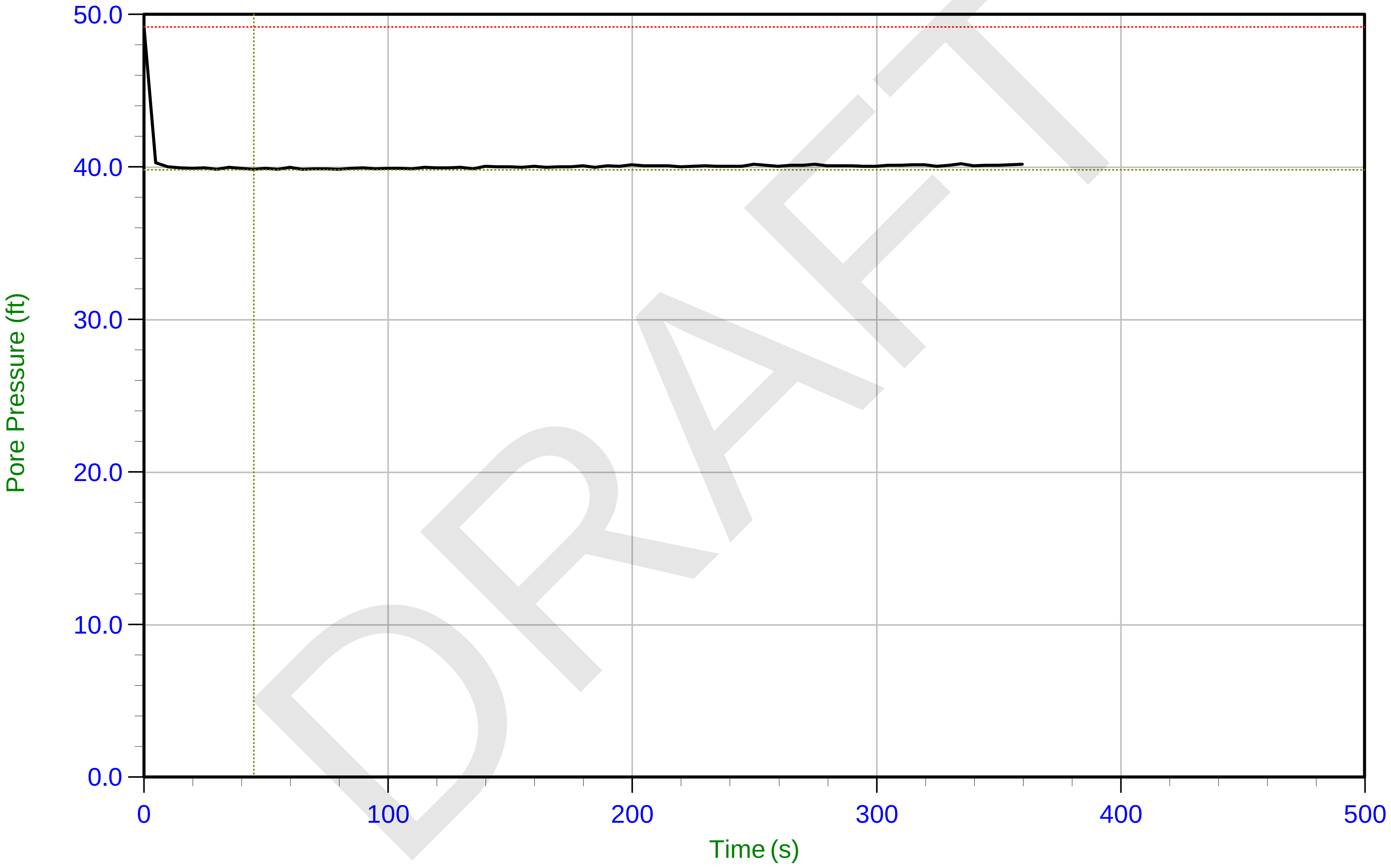
WT: 1.101 m / 3.612 ft
Ueq: 29.0 ft

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

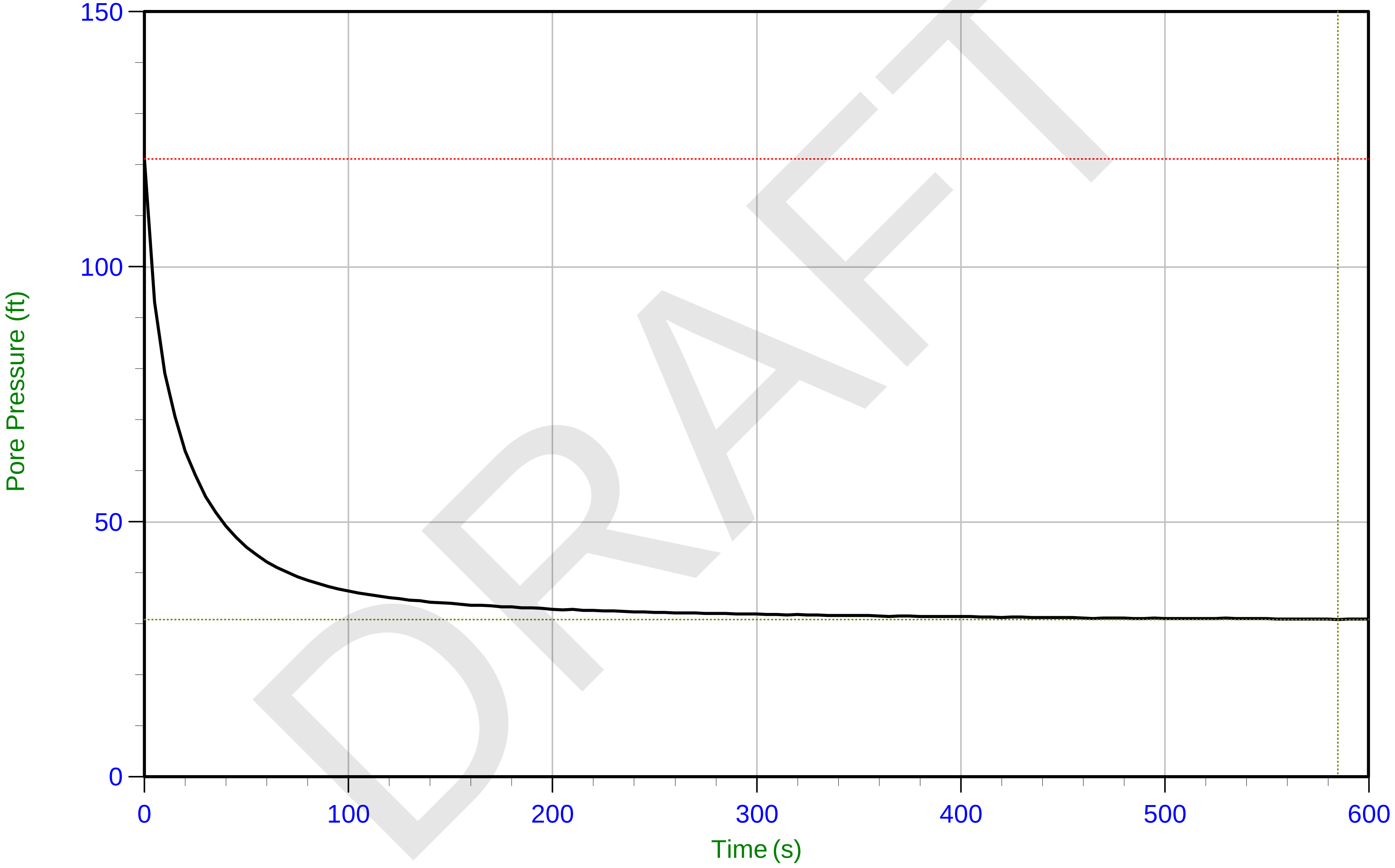
WT: 3.059 m / 10.035 ft
Ueq: 40.2 ft

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

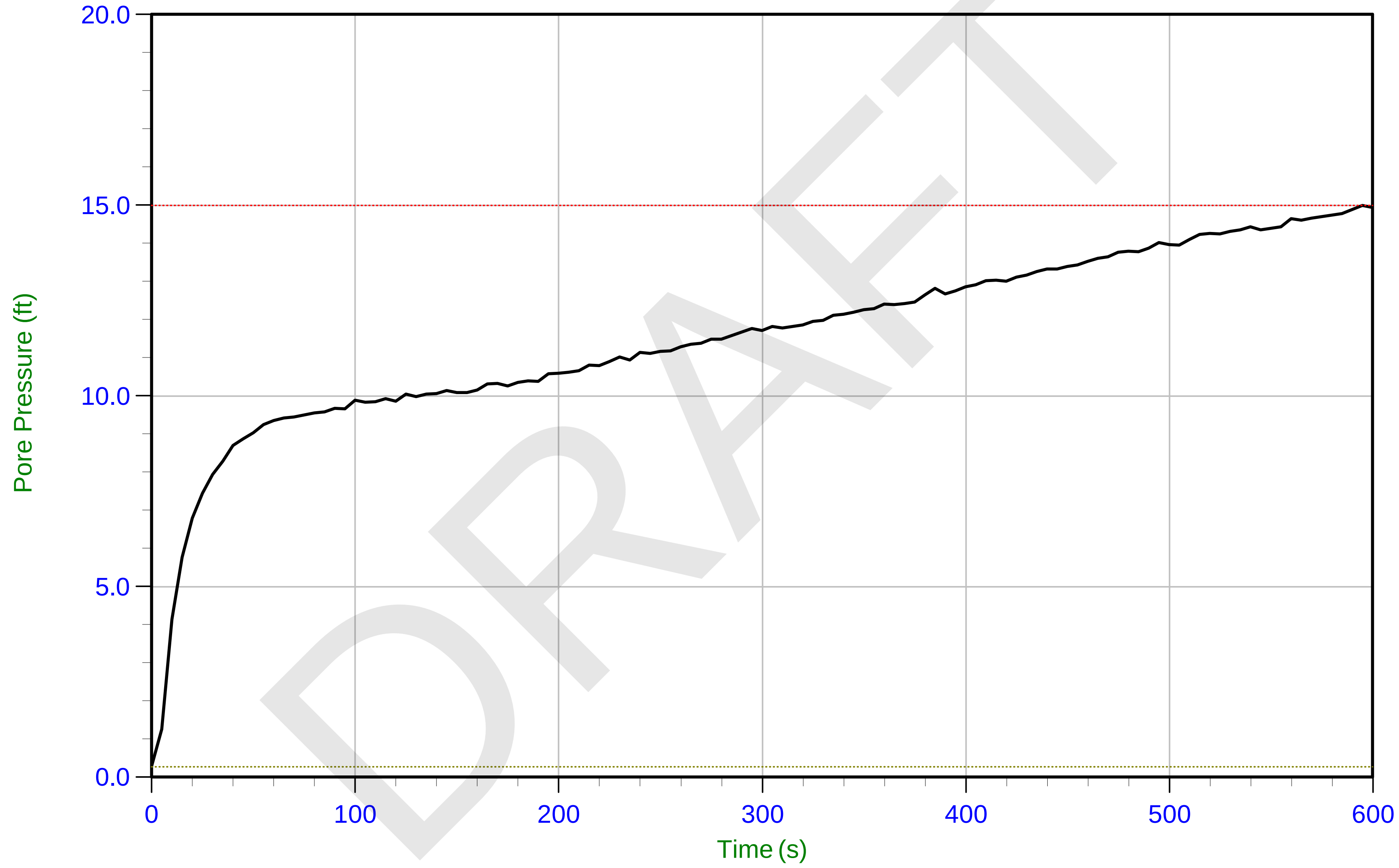
WT: 0.709 m / 2.324 ft
Ueq: 30.5 ft

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

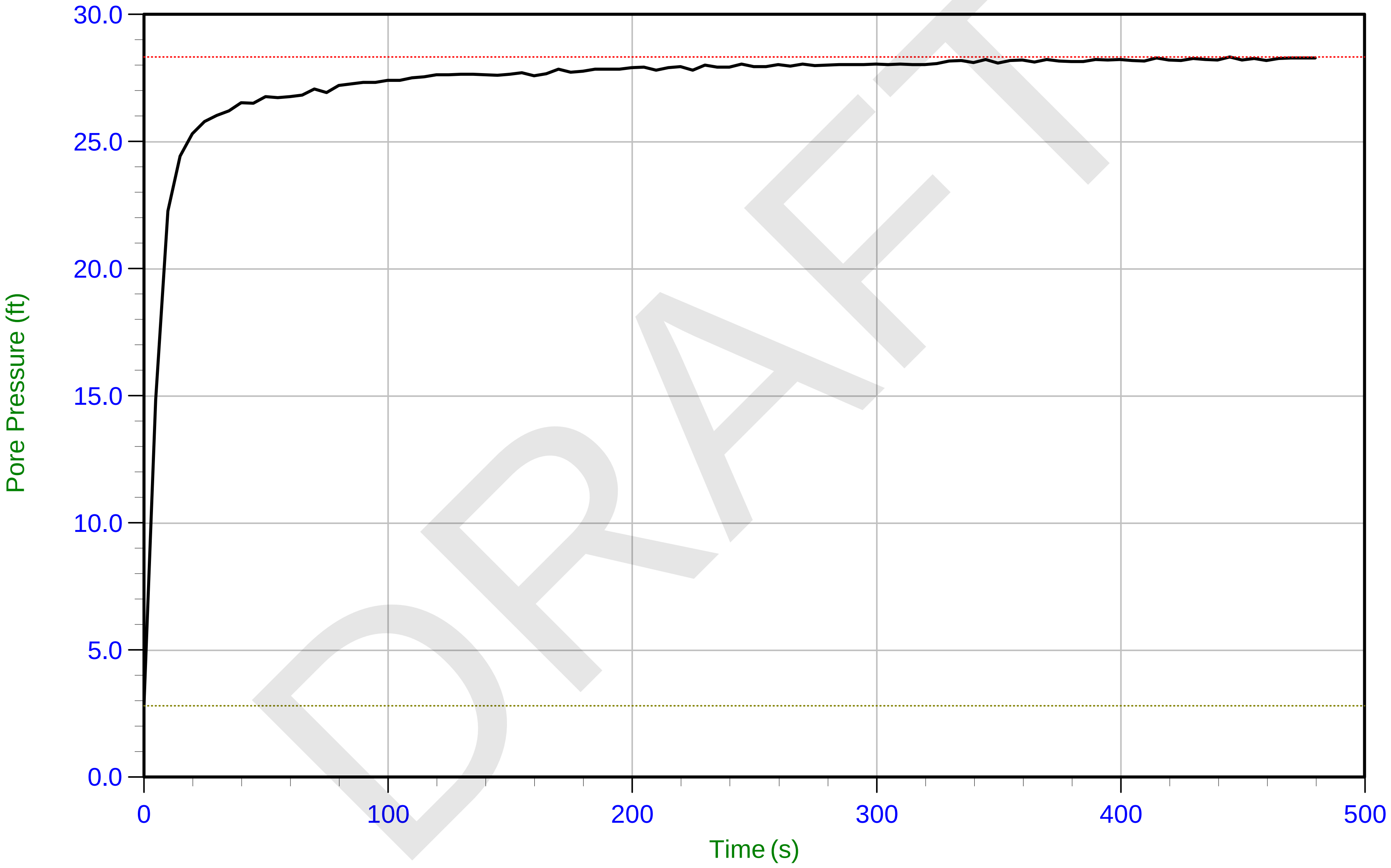
U Min: 0.3 ft
U Max: 15.0 ft

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

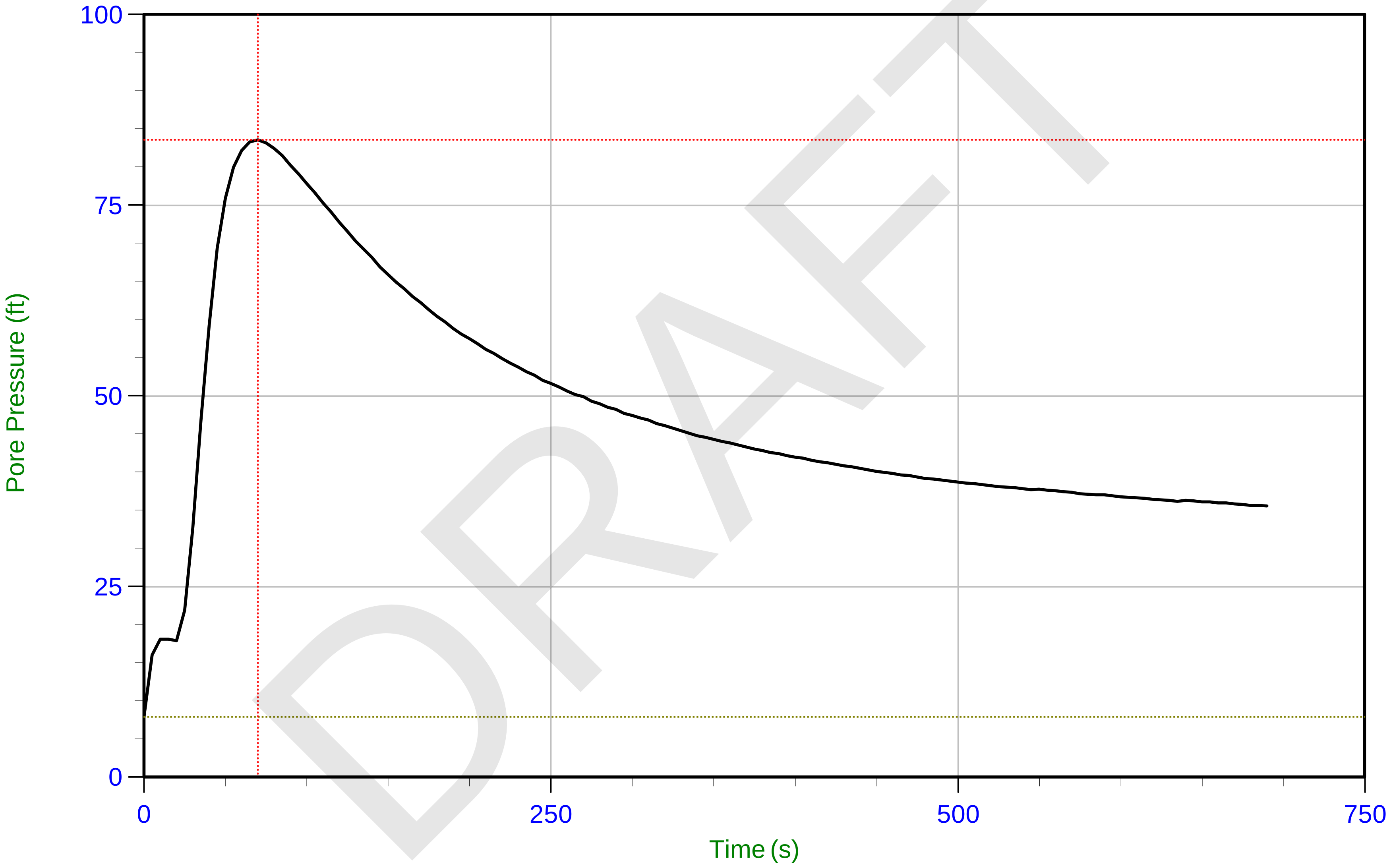


Trace Summary:

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



Trace Summary:

Filename: 15-54071_CP JOP-C019.PPD
Depth: 16.100 m / 52.821 ft
Duration: 690.0 s

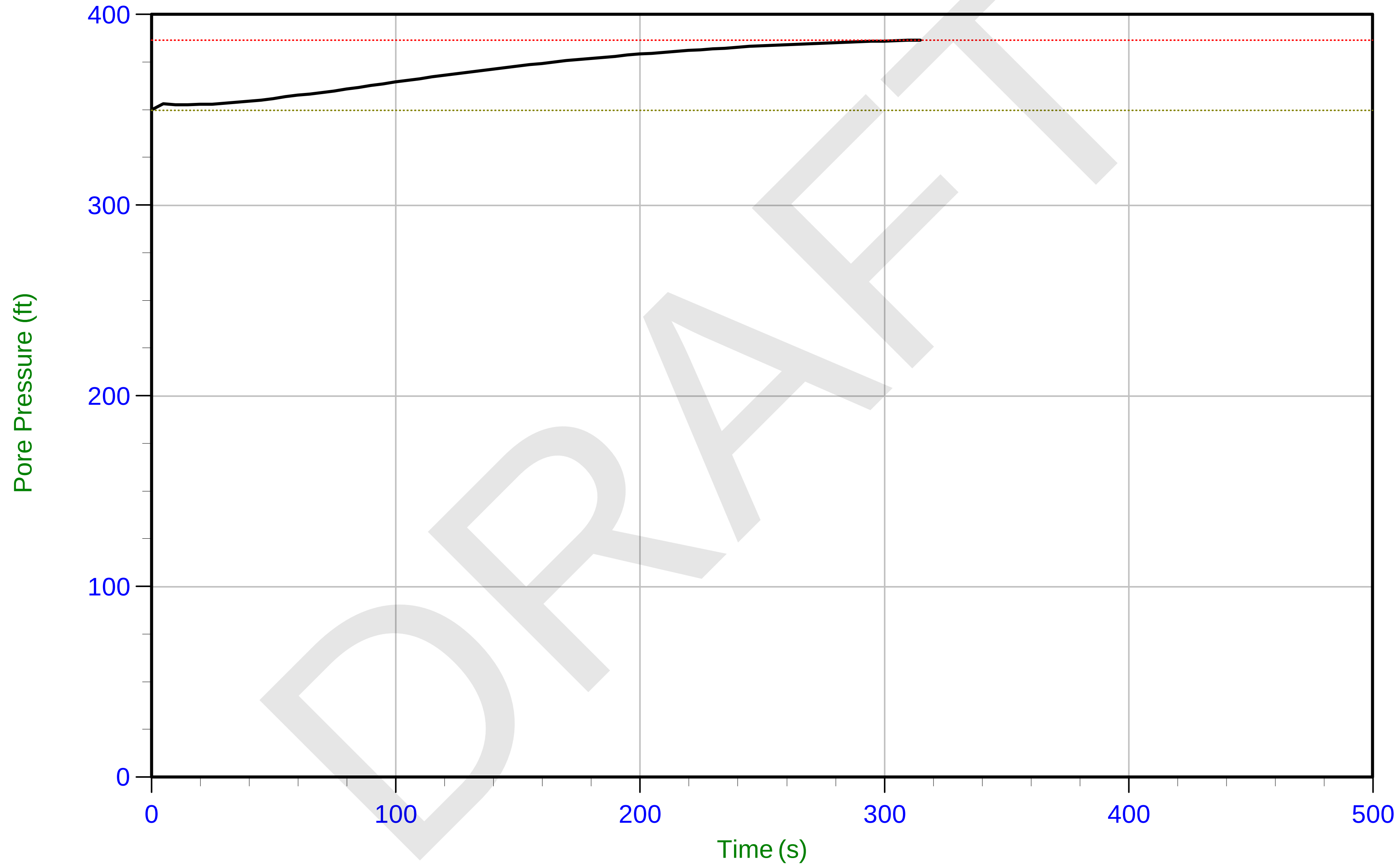
U Min: 7.9 ft
U Max: 83.6 ft

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



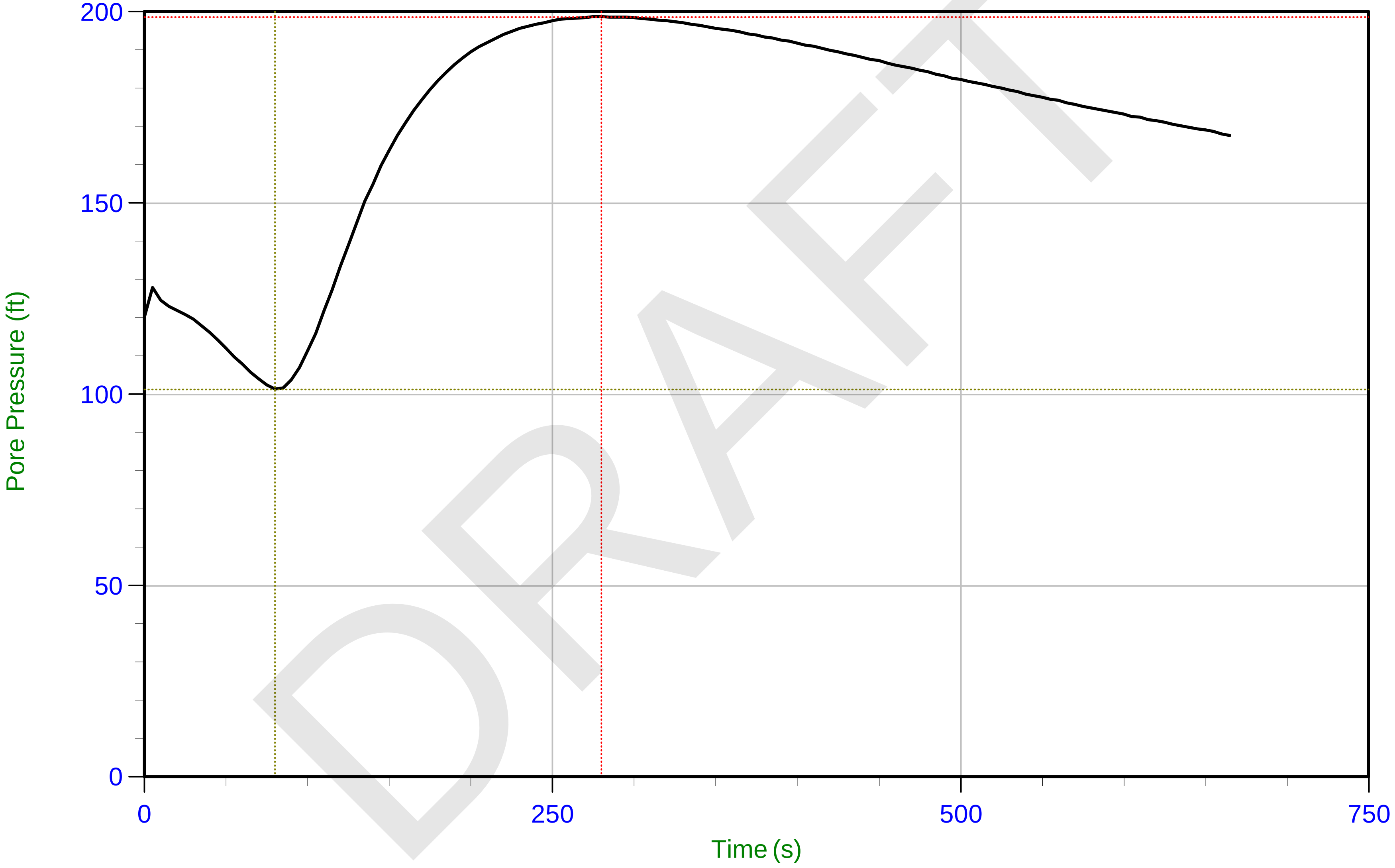
Trace Summary:
Filename: 15-54071_CP JOP-C019.PPD
Depth: 21.450 m / 70.373 ft
Duration: 315.0 s
U Min: 349.9 ft
U Max: 386.6 ft

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:

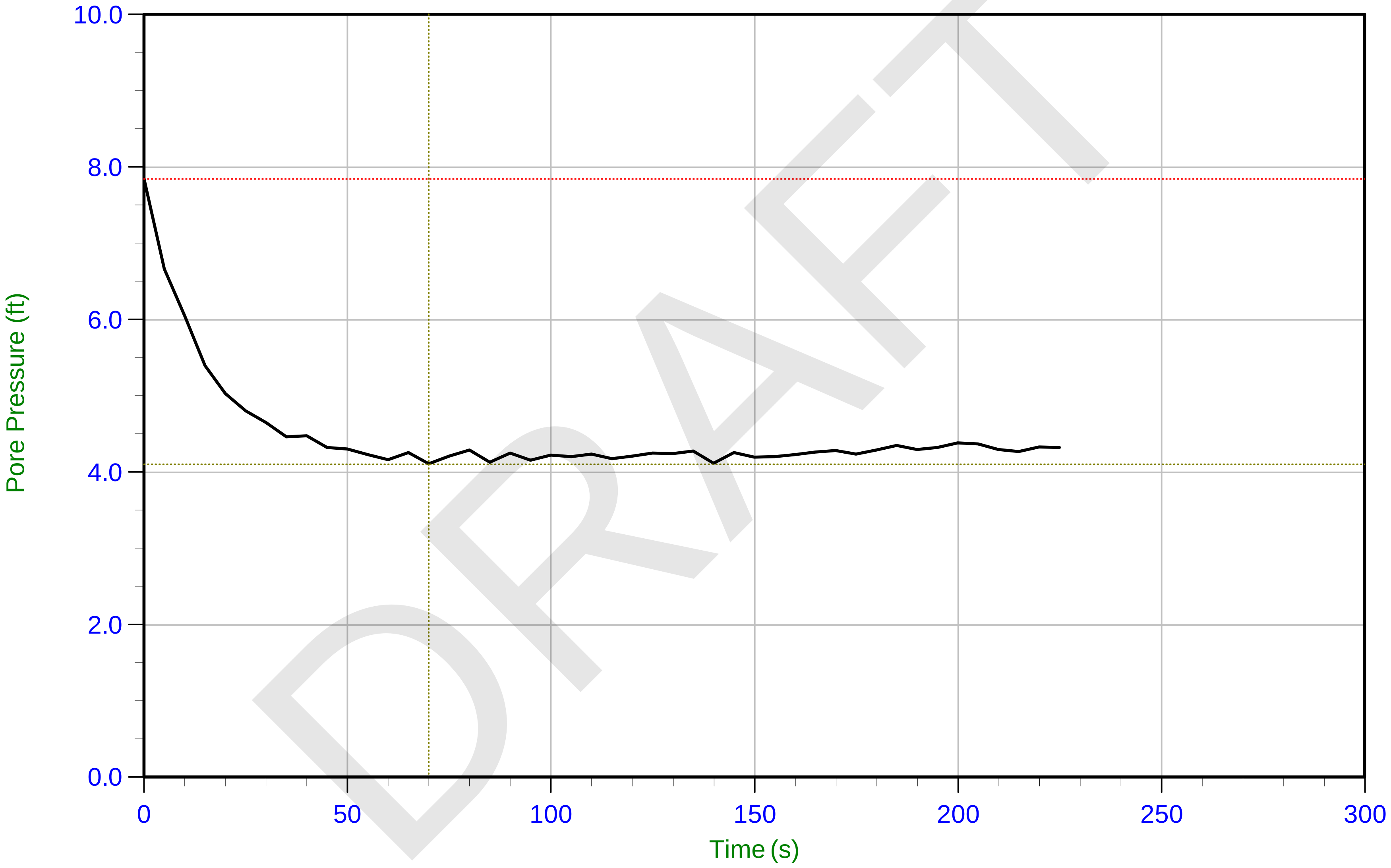
Filename: 15-54071_CP JOP-C019.PPD
Depth: 24.450 m / 80.216 ft
Duration: 665.0 s

U Min: 101.4 ft
U Max: 198.7 ft

CONETEC

AECOM

Job No:	15-54071	Sounding:	JOP-C020
Date:	08/19/2015 14:21	Cone:	349:T1500F15U500
Site:	Dynegy Joppa IL	Cone Area:	15 sq cm



Trace Summary:

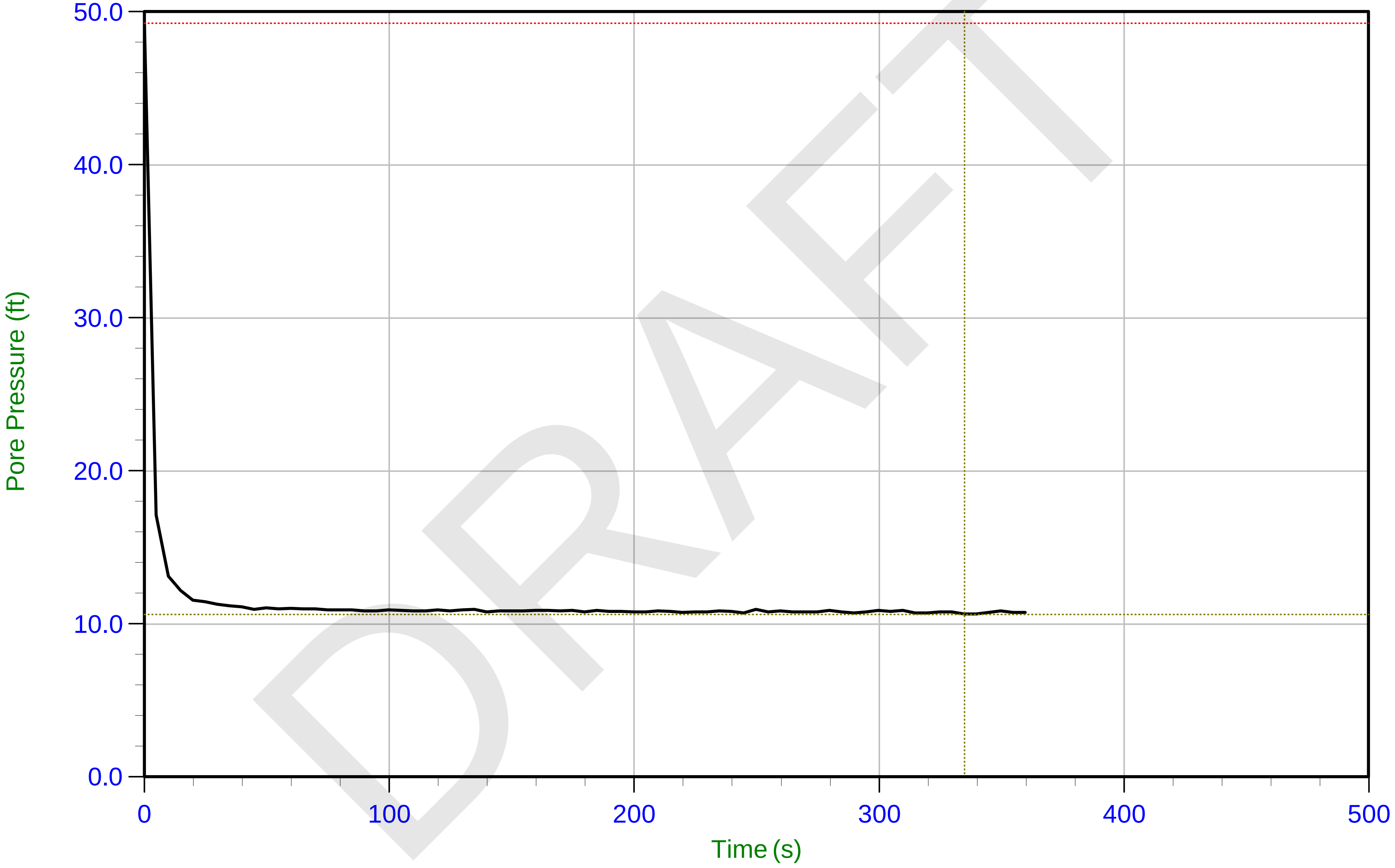
Filename: 15-54071_CP JOP-C020.PPD
Depth: 2.950 m / 9.678 ft
Duration: 225.0 s
U Min: 4.1 ft
U Max: 7.8 ft
WT: 1.632 m / 5.356 ft
Ueq: 4.3 ft

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

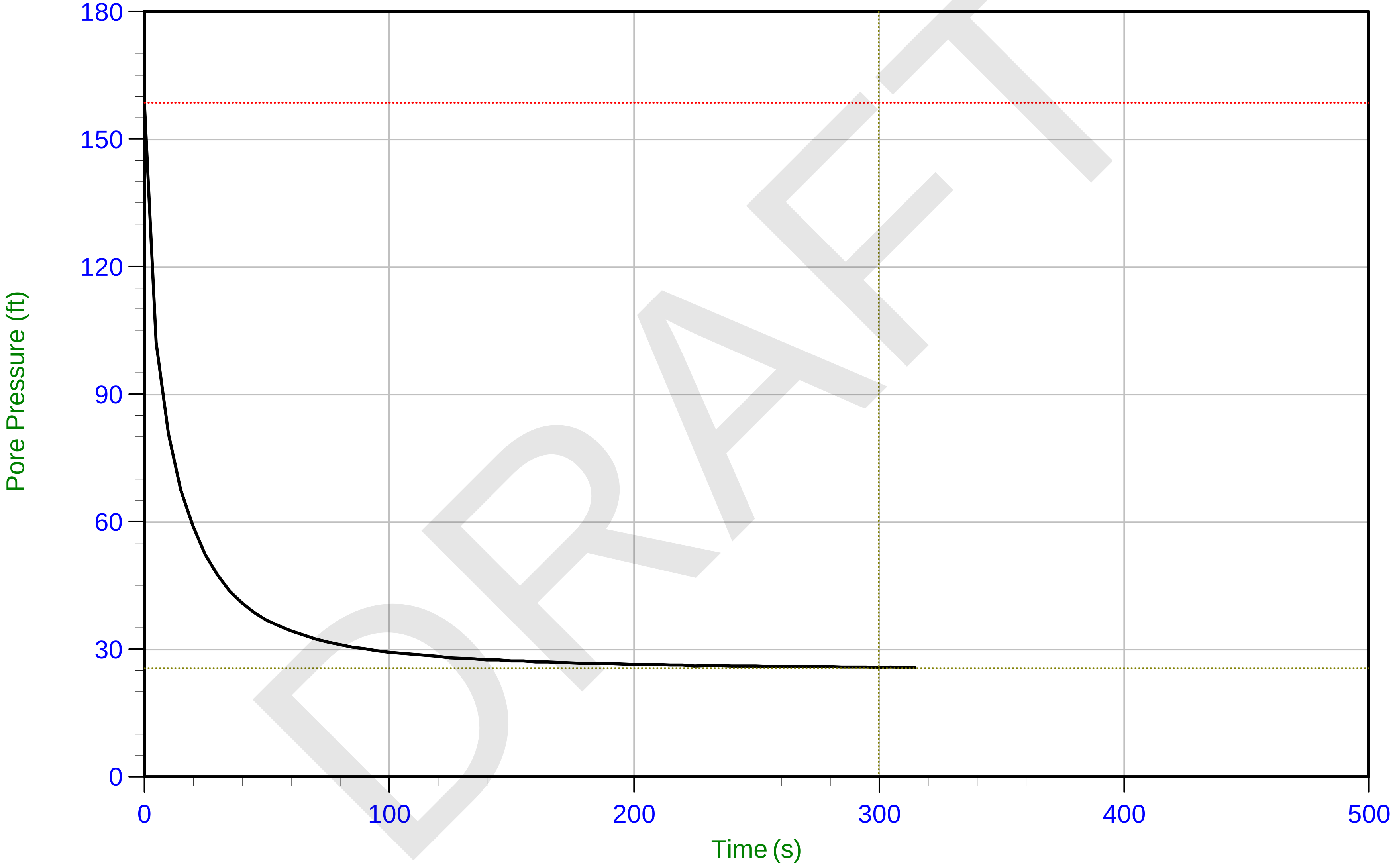
WT: 1.705 m / 5.595 ft
Ueq: 10.6 ft

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

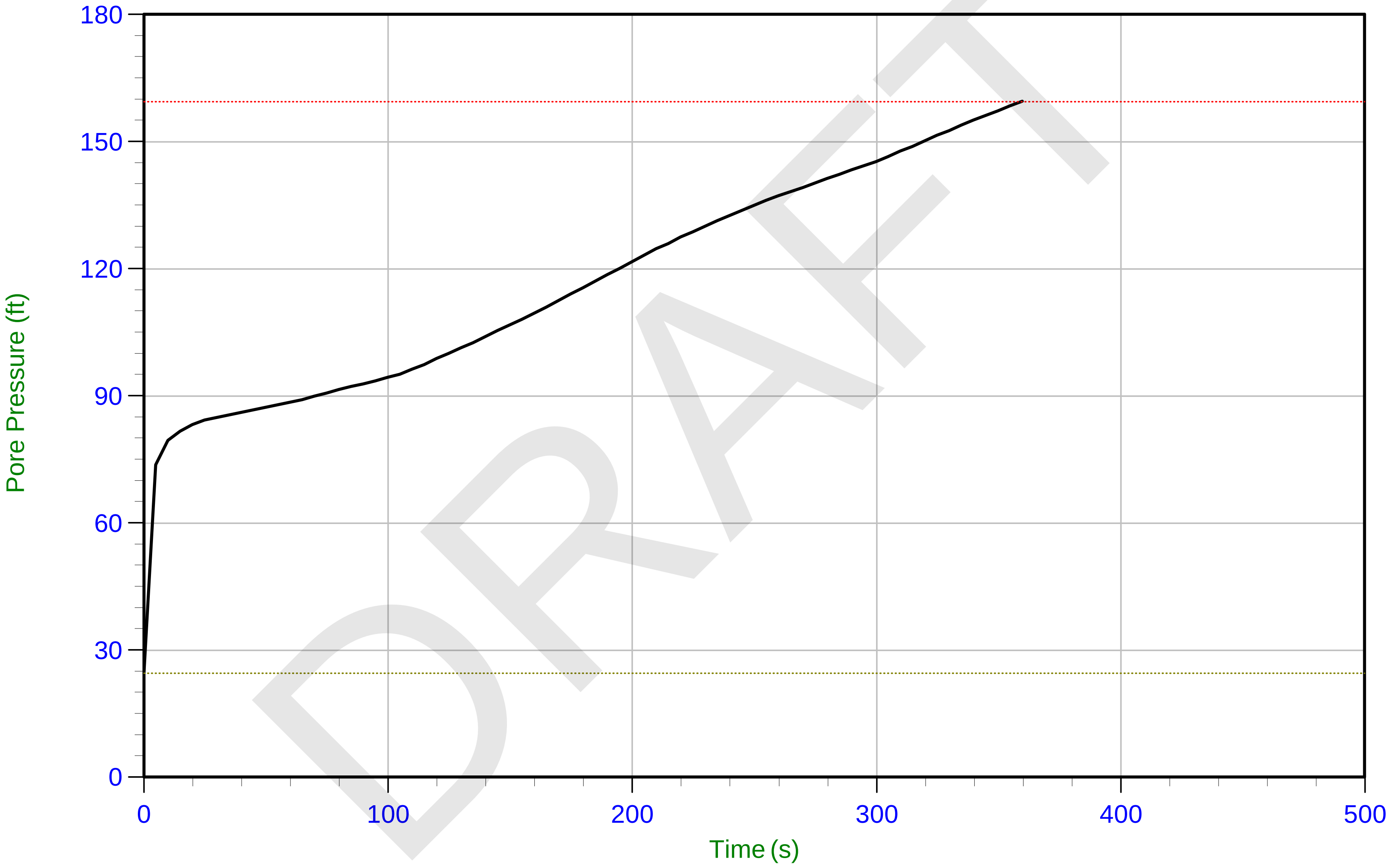
WT: 2.163 m / 7.096 ft
Ueq: 25.5 ft

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

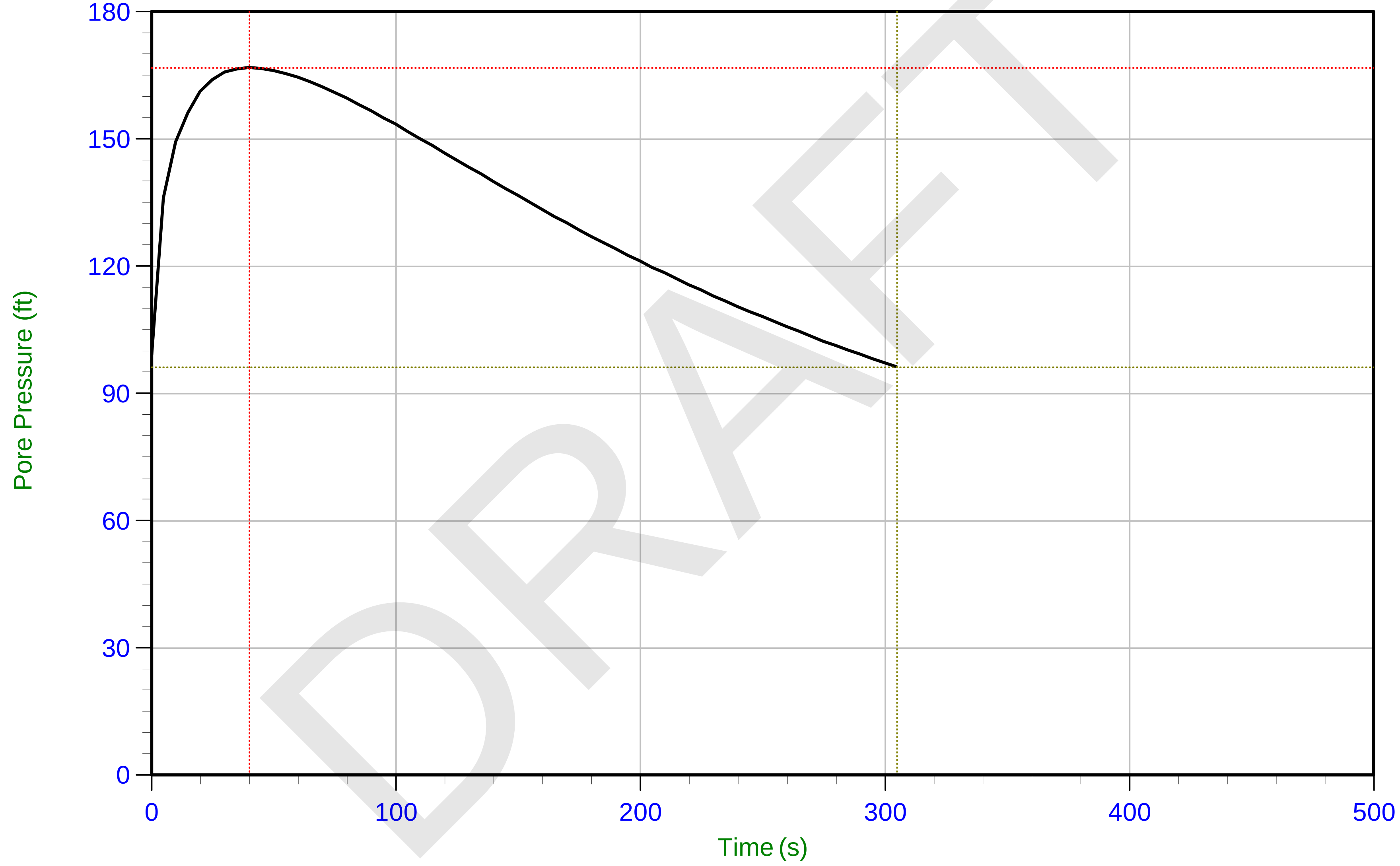
U Min: 24.6 ft
U Max: 159.5 ft

ConeTec

AECOM

Job No: 15-54071
Date: 08/09/2015 09:29
Site: Dynegy Joppa IL

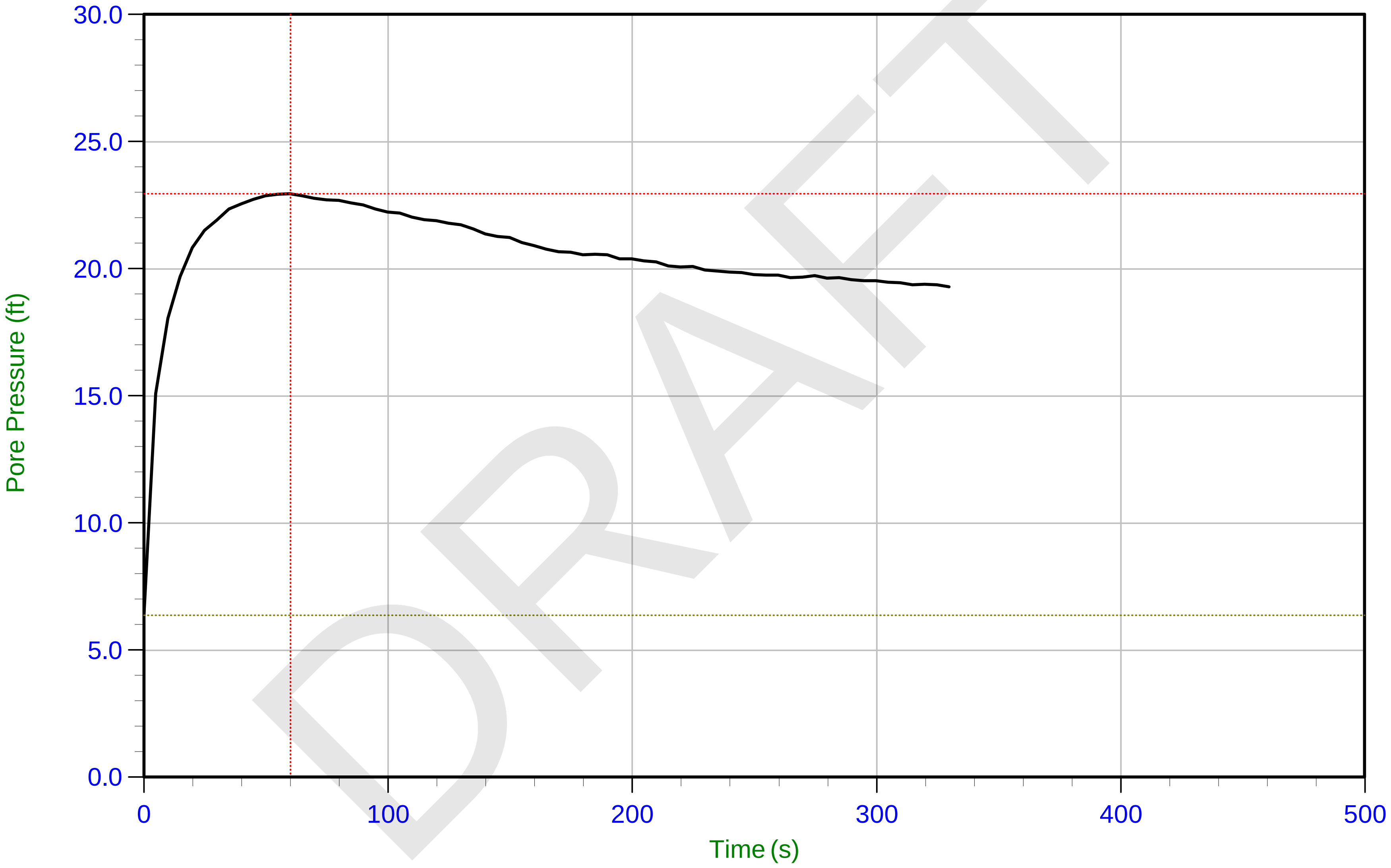
Sounding: JOP-C021
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



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

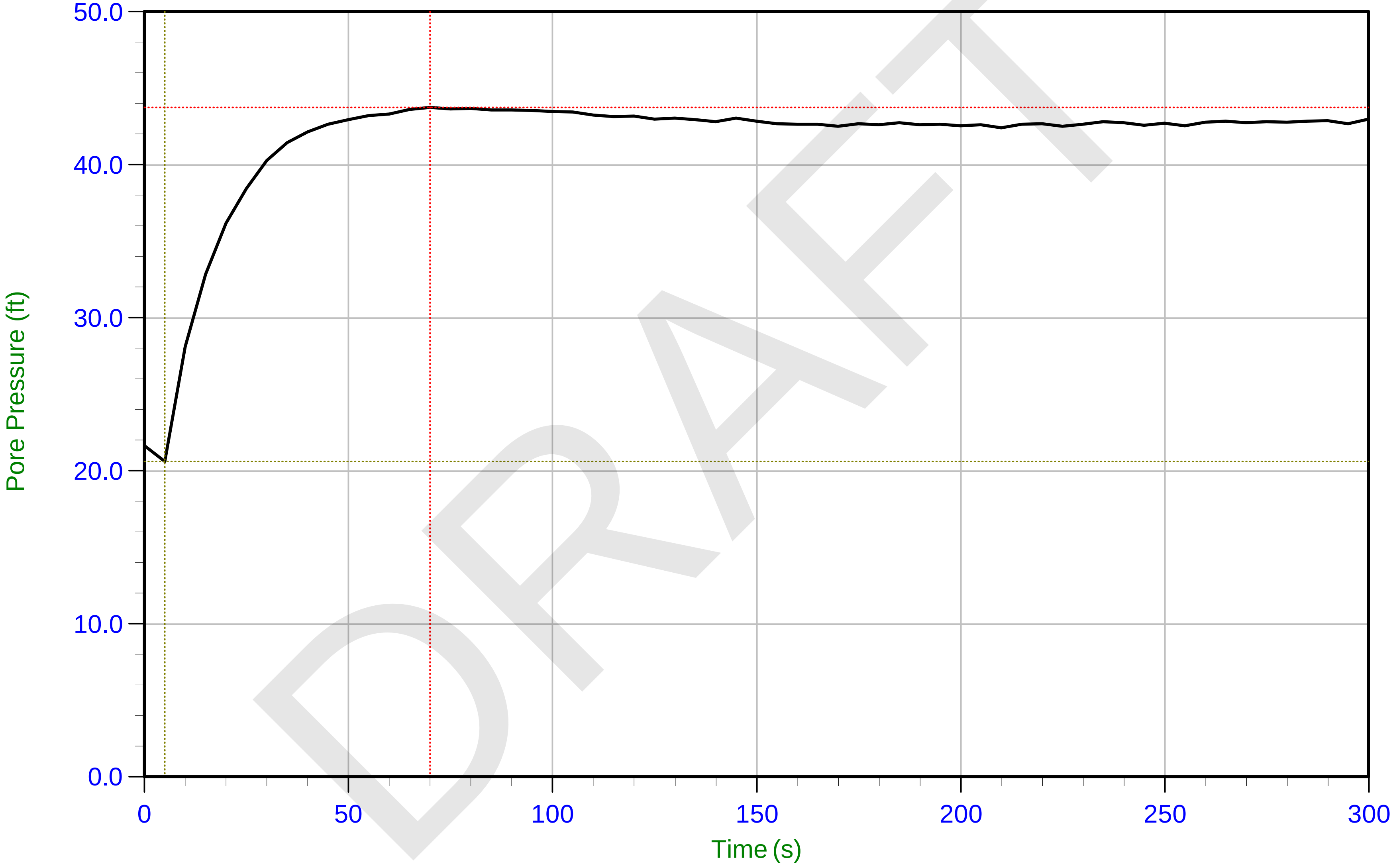


Trace Summary:

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



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

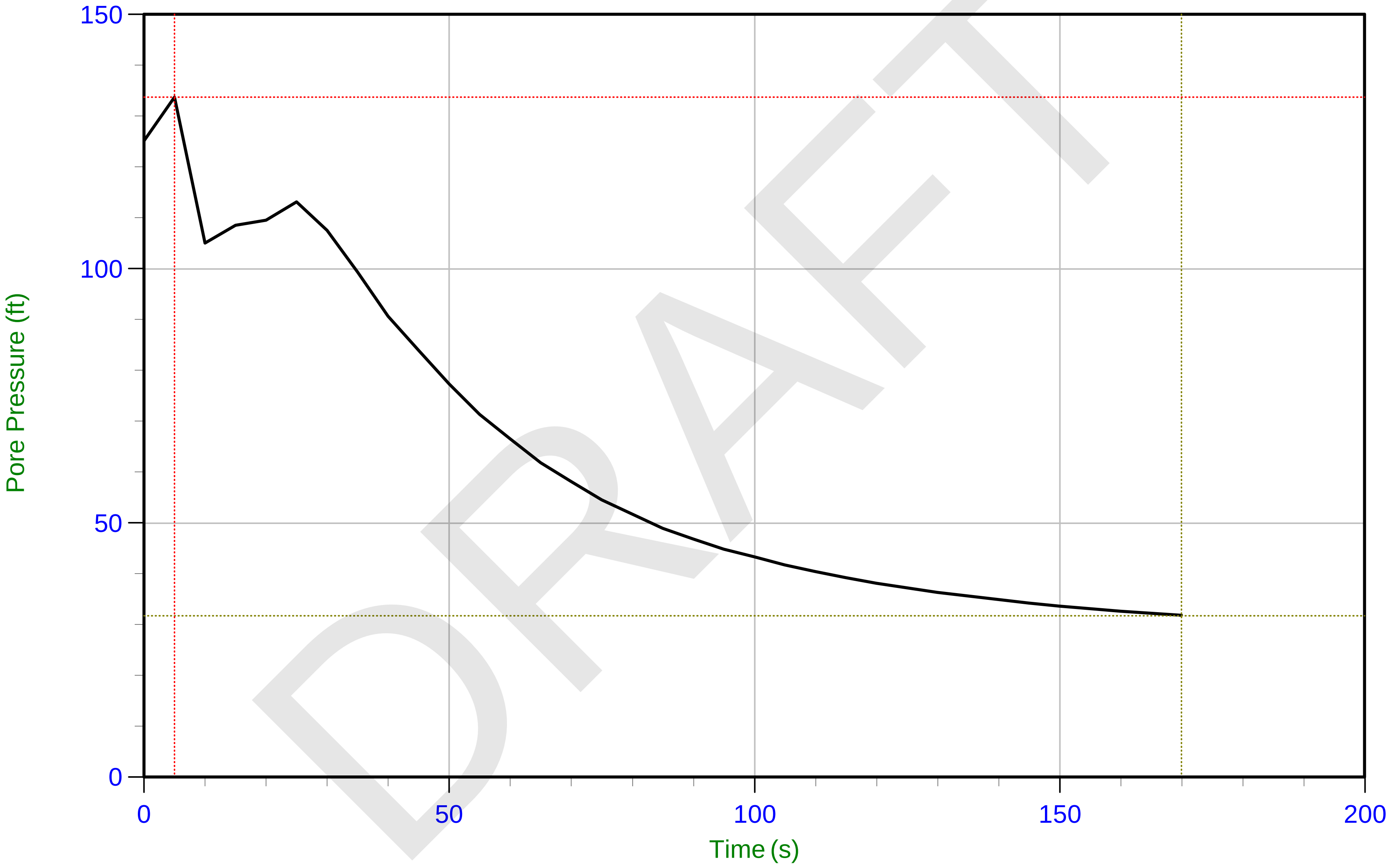
WT: 8.372 m / 27.468 ft
Ueq: 42.7 ft

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

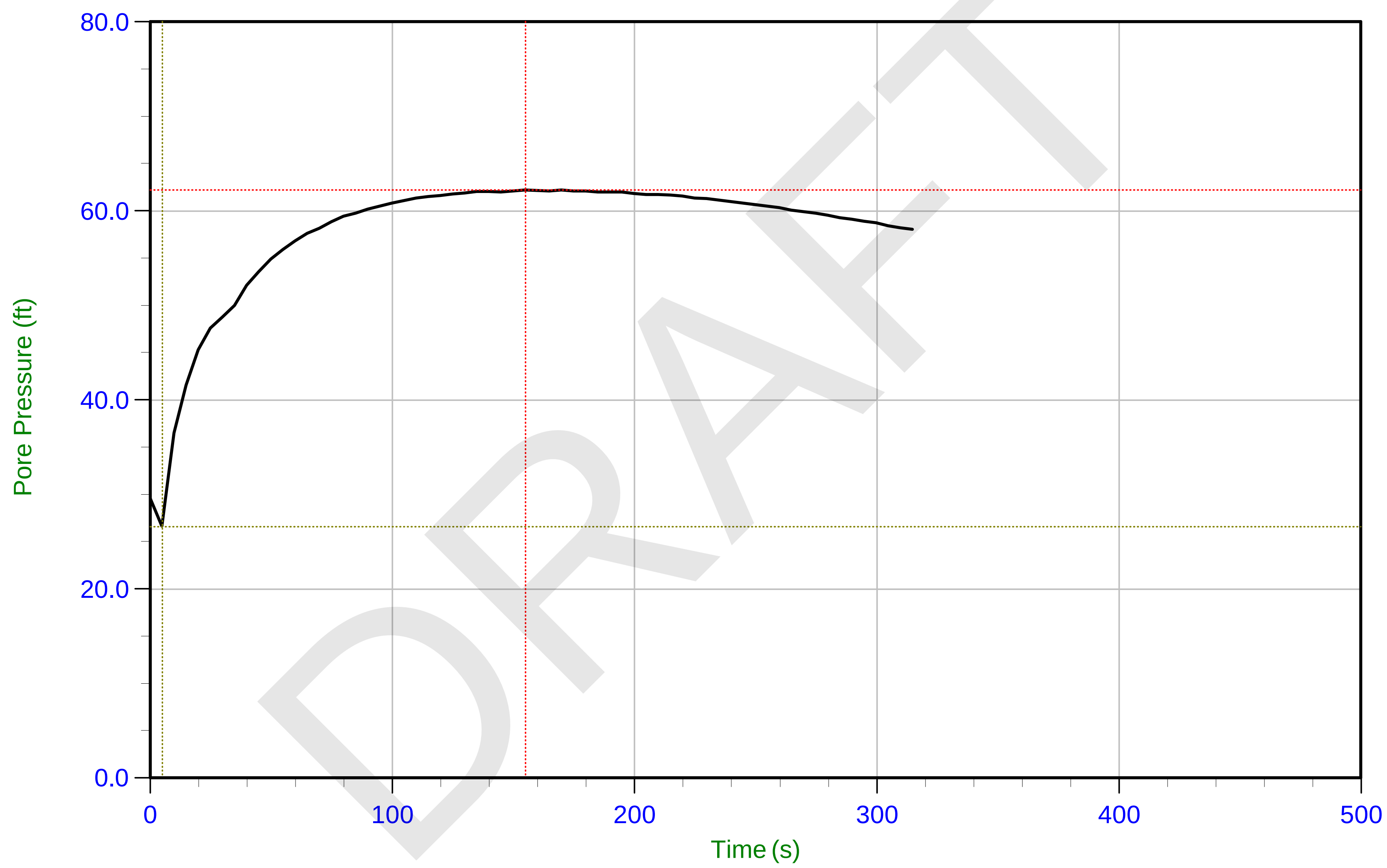
WT: 60.960 m / 200.000 ft
Ueq: -126.0 ft

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

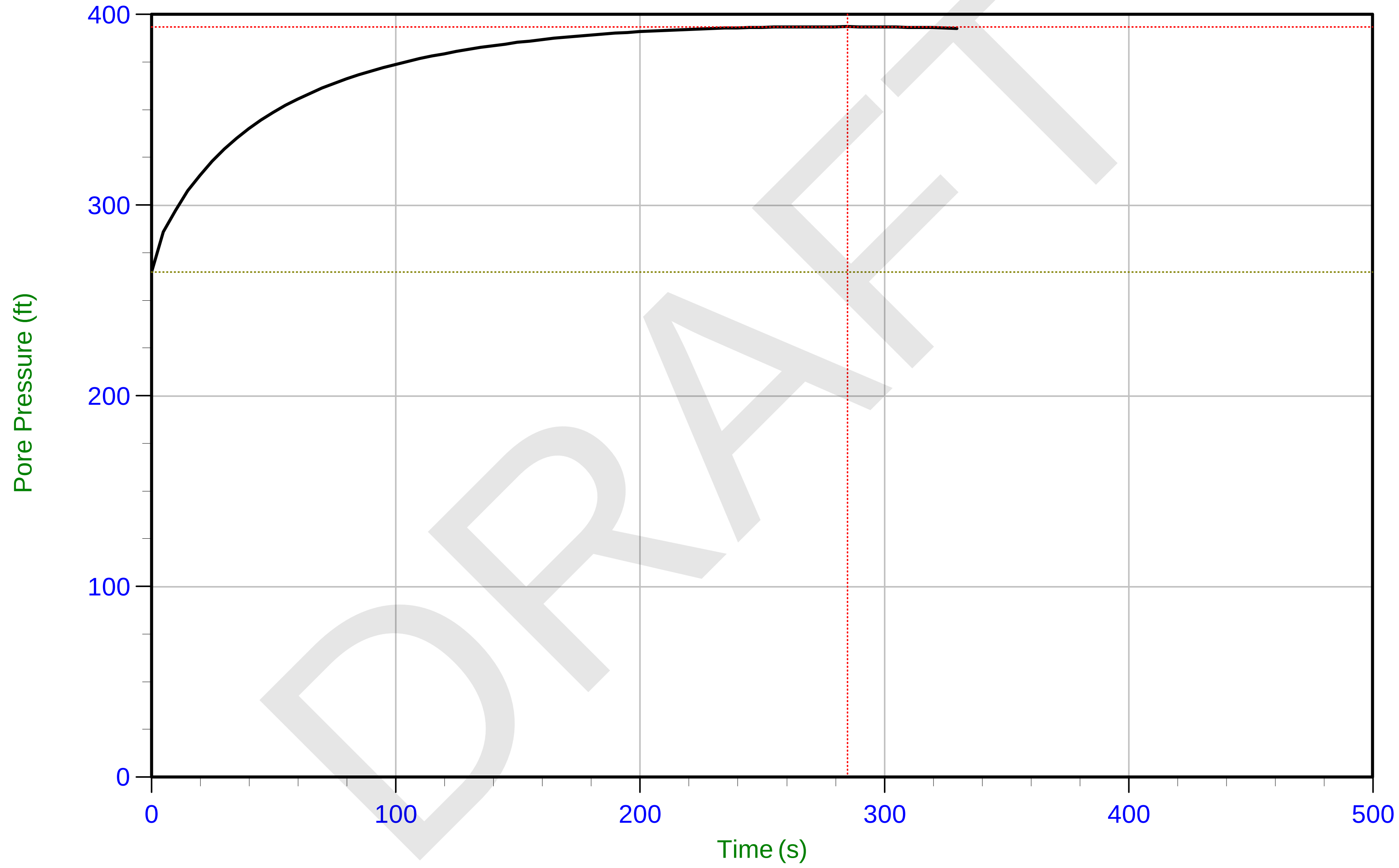
U Min: 26.6 ft
U Max: 62.2 ft

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



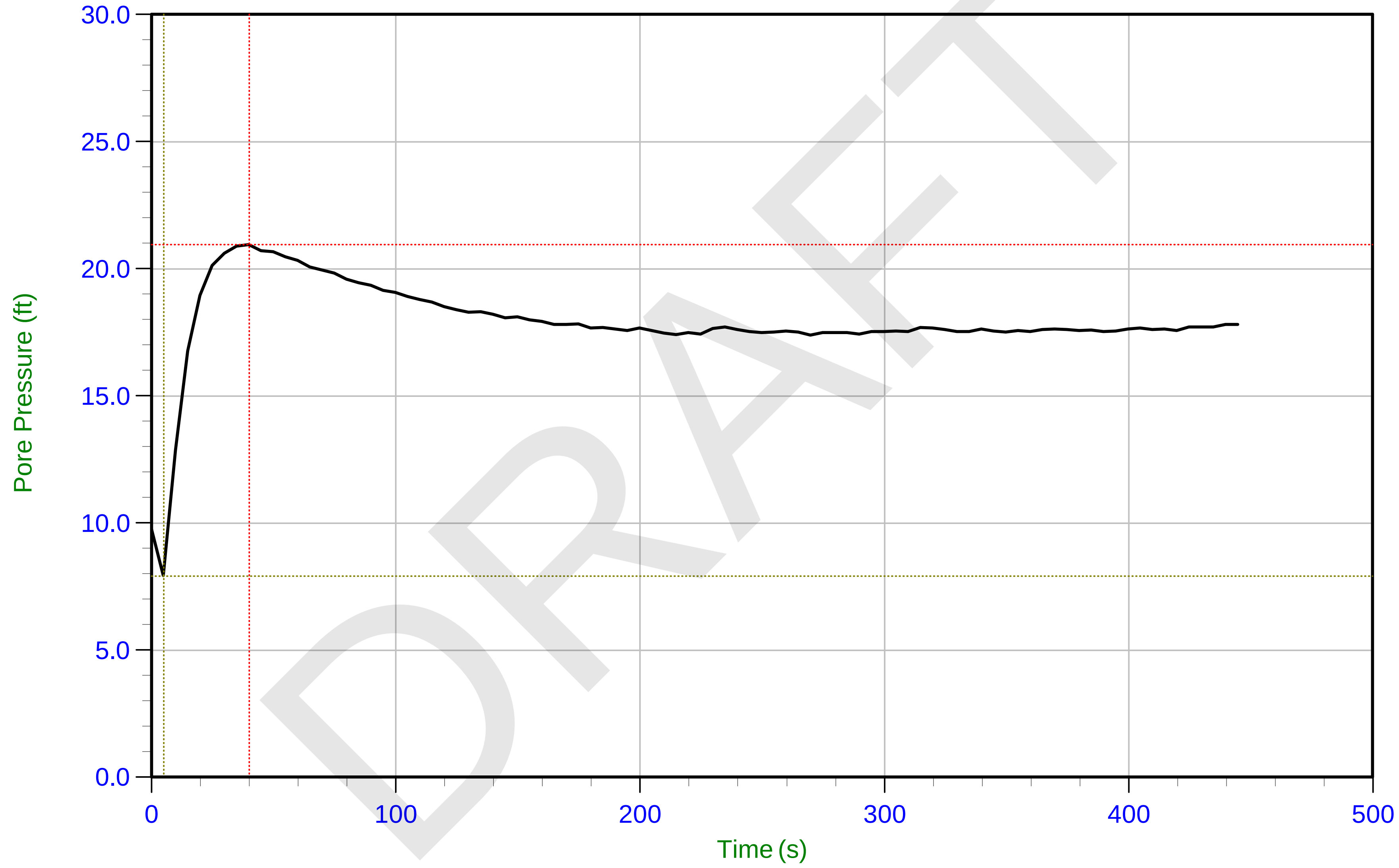
Trace Summary:
Filename: 15-54071_CP JOP-C022.PPD
Depth: 19.200 m / 62.991 ft
Duration: 330.0 s
U Min: 265.0 ft
U Max: 393.6 ft

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

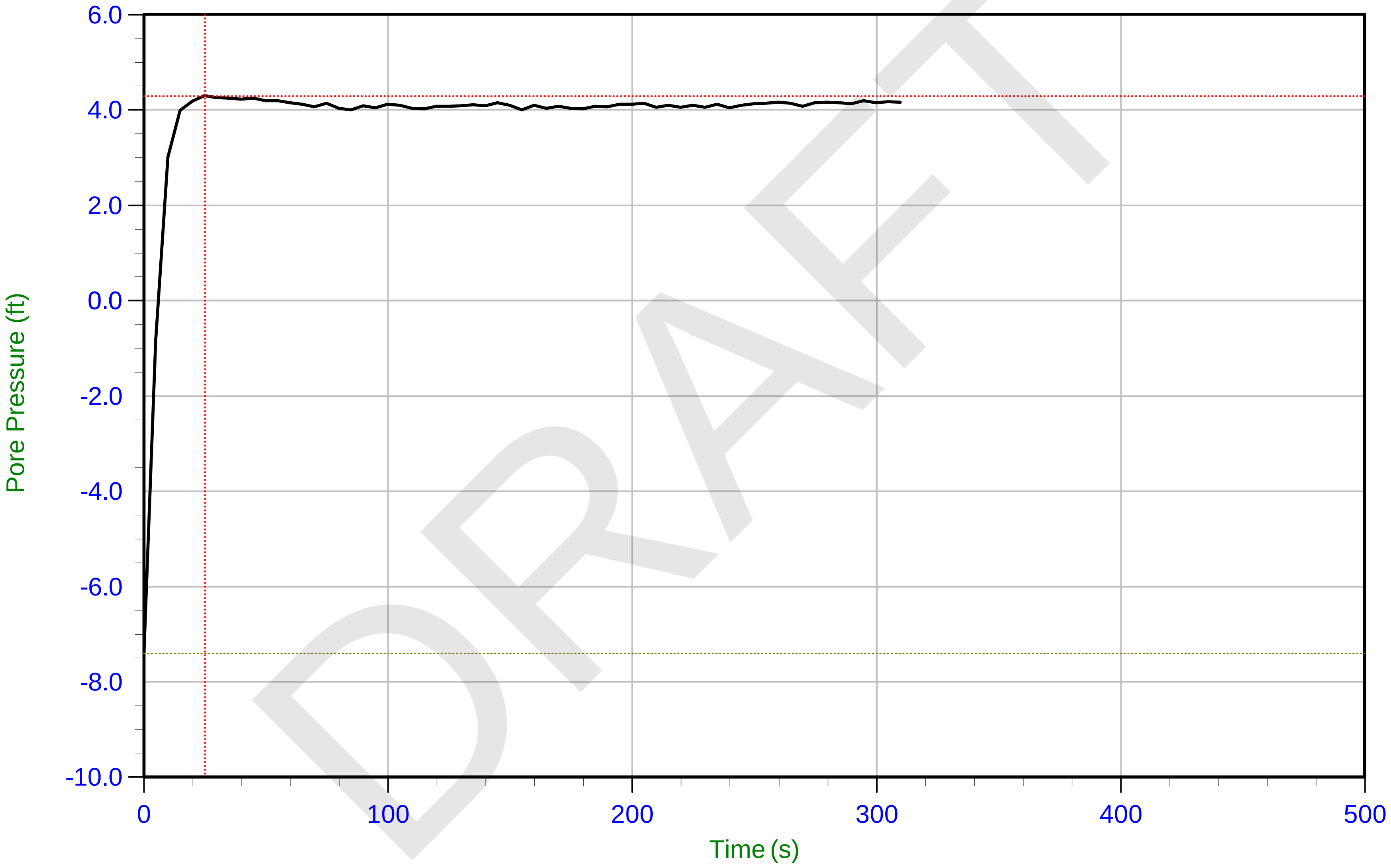


Trace Summary:

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



Trace Summary:

Filename: 15-54071_CP JOP-C023.PPD
Depth: 4.600 m / 15.092 ft
Duration: 310.0 s

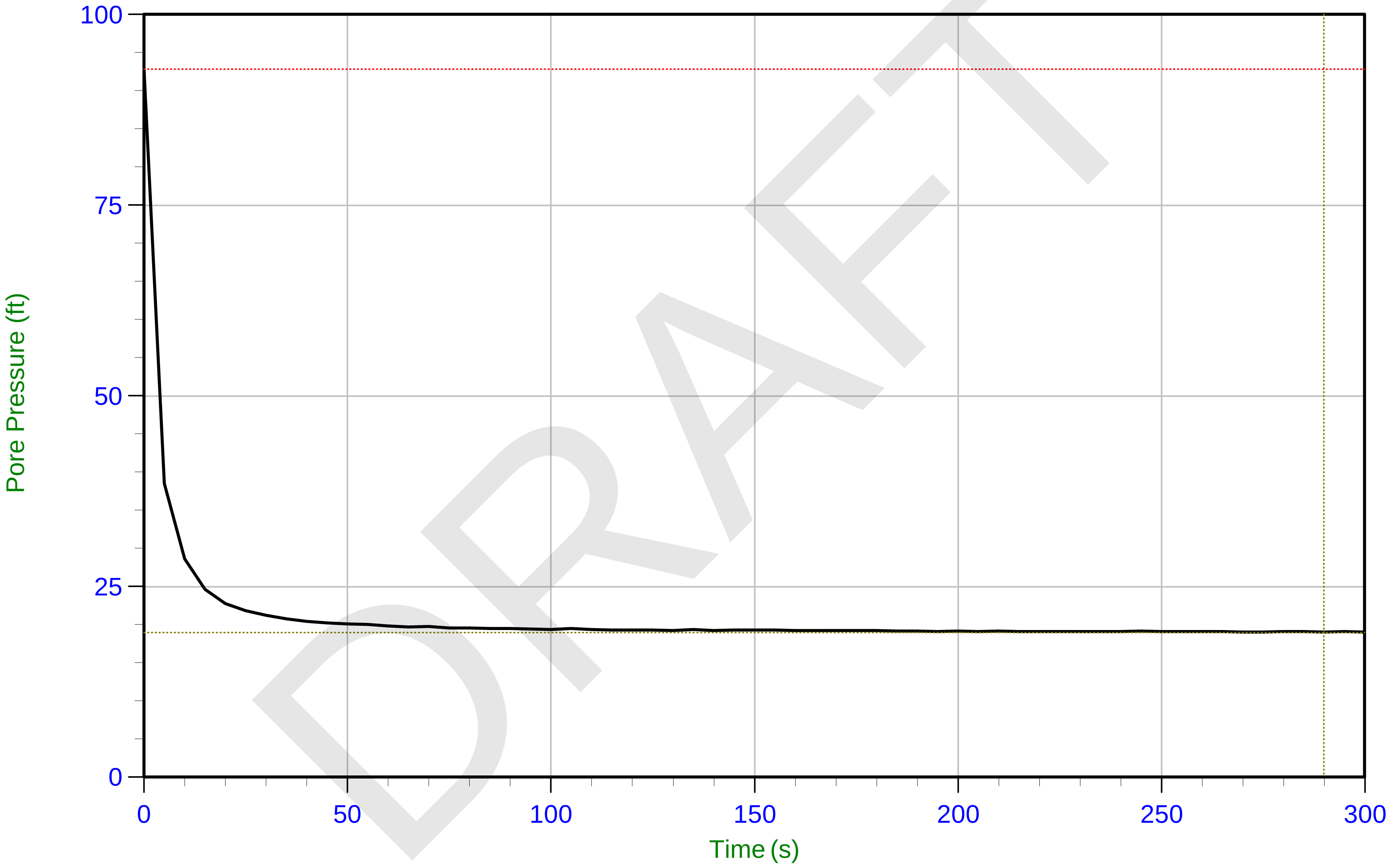
U Min: -7.4 ft
U Max: 4.3 ft

WT: 3.338 m / 10.950 ft
Ueq: 4.1 ft

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

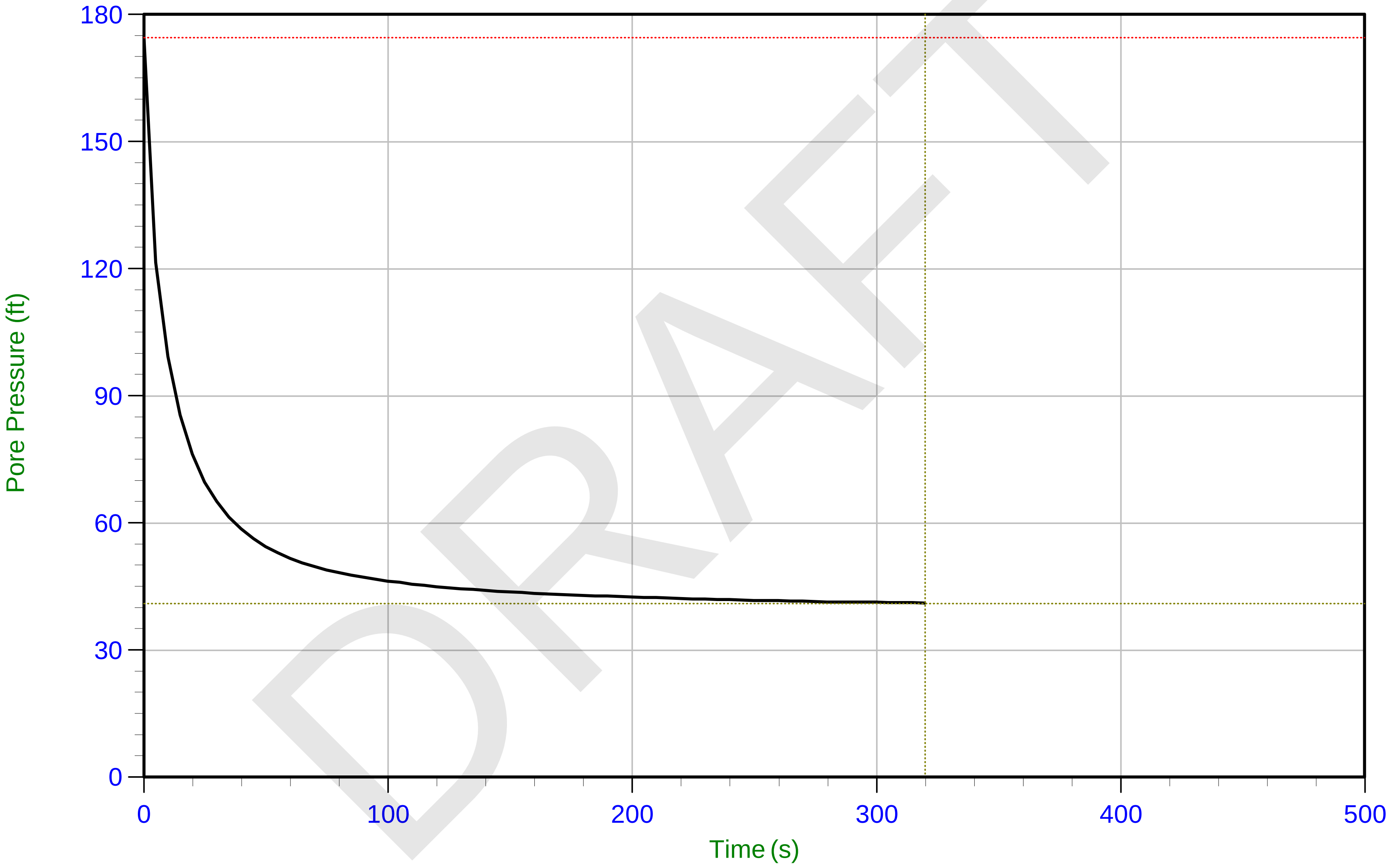
WT: 3.199 m / 10.495 ft
Ueq: 19.0 ft

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



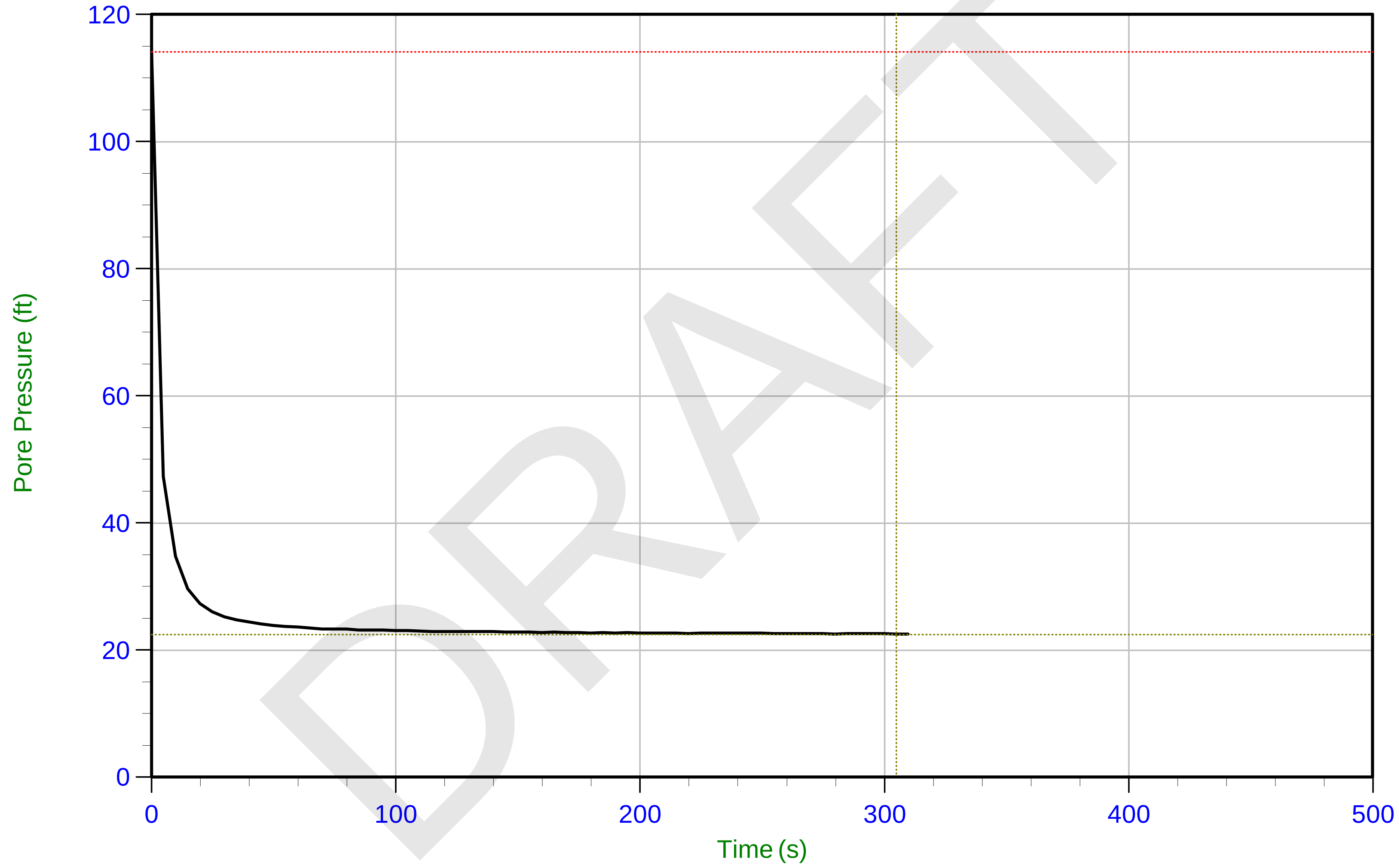
Trace Summary:

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

AECOM	Job No: 15-54071	Sounding: JOP-C024B
	Date: 08/19/2015 11:08	Cone: 349:T1500F15U500
	Site: Dynegy Joppa IL	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

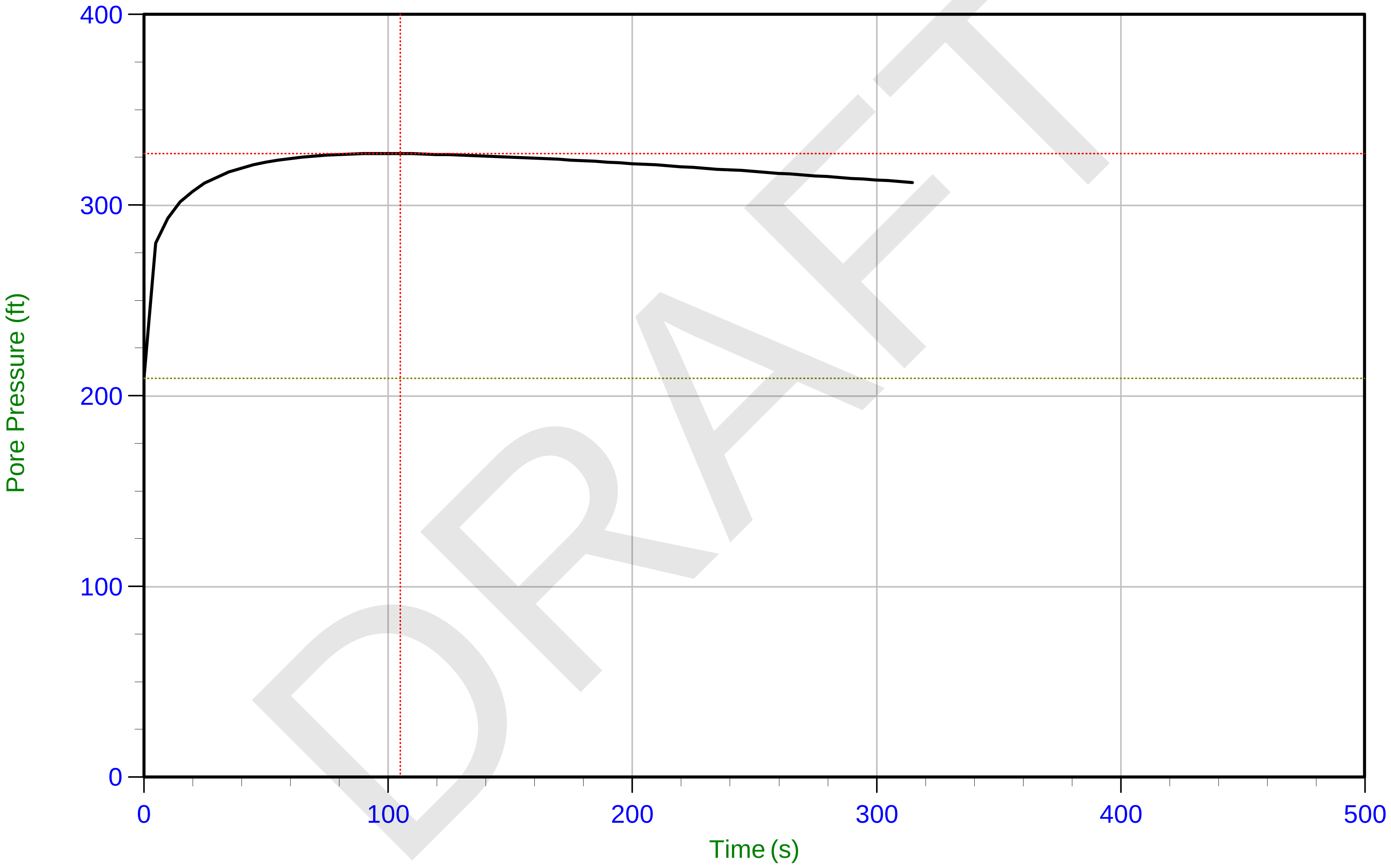
U Min: 22.5 ft
U Max: 114.2 ft

WT: 1.107 m / 3.631 ft
Ueq: 22.5 ft

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:

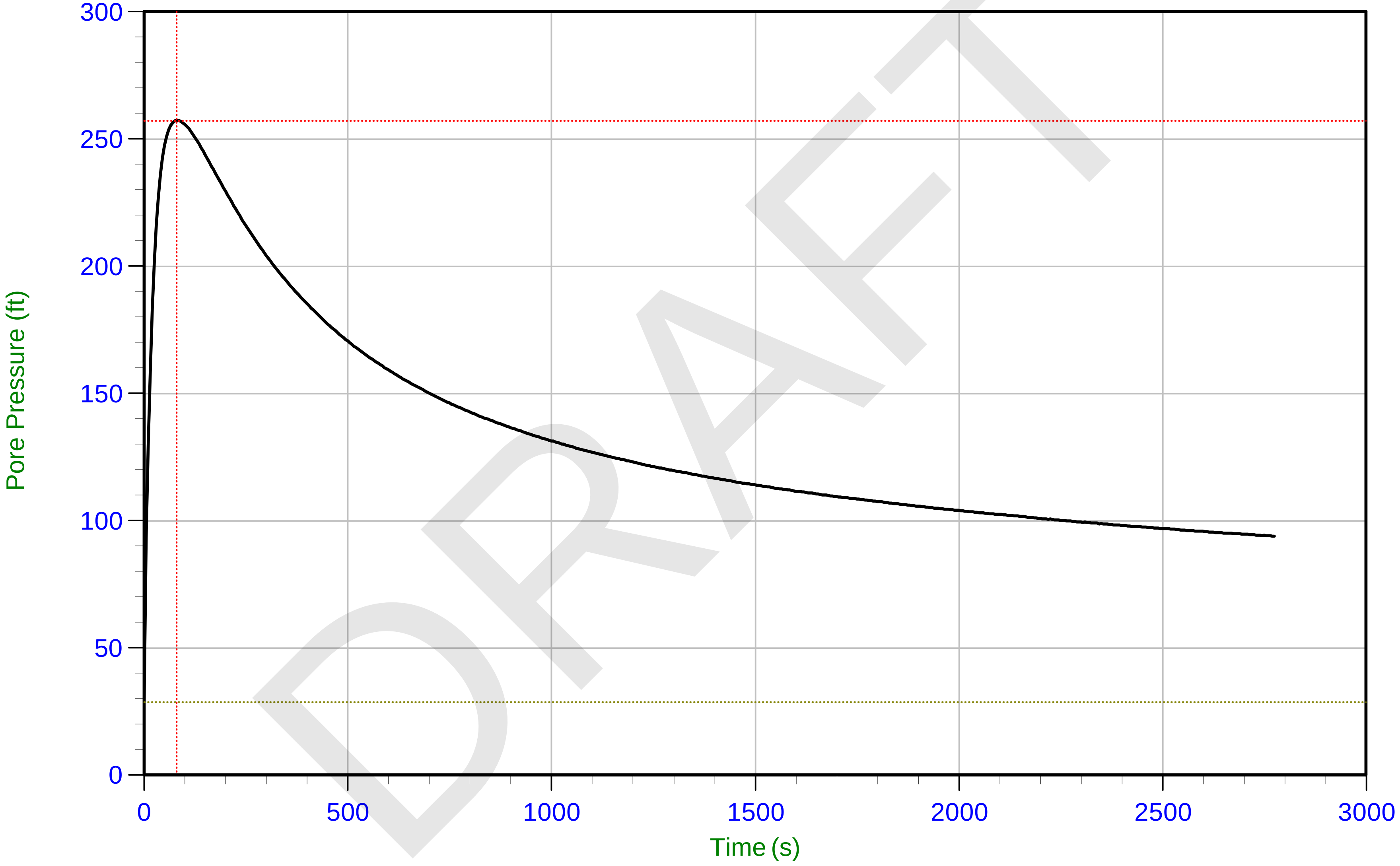
Filename: 15-54071_CP JOP-C024B.PPD
Depth: 15.950 m / 52.329 ft
Duration: 315.0 s

U Min: 209.3 ft
U Max: 327.1 ft

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:

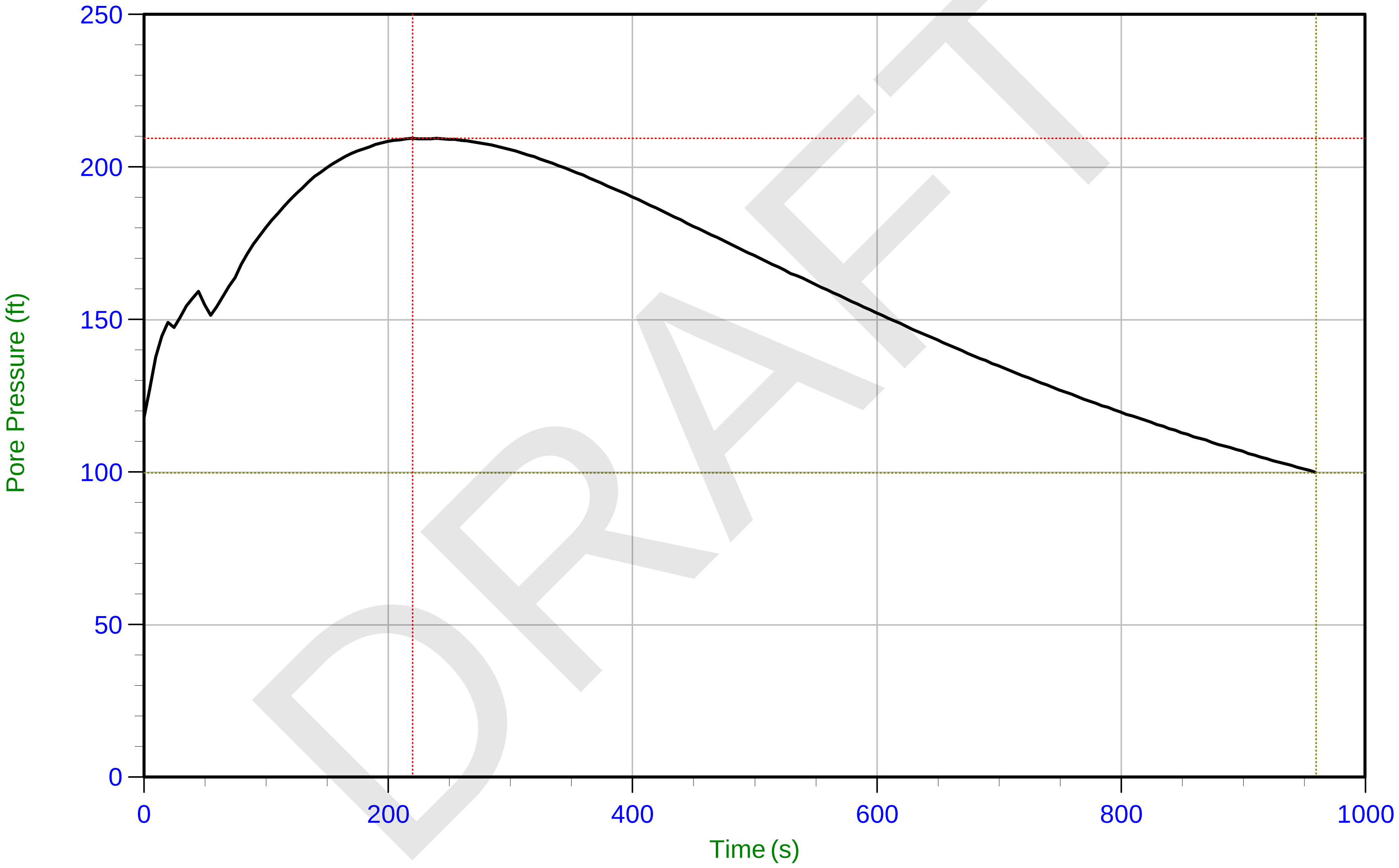
Filename: 15-54071_CPJOP-C024B.PPD
Depth: 24.500 m / 80.380 ft
Duration: 2775.0 s

U Min: 28.8 ft
U Max: 257.3 ft

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

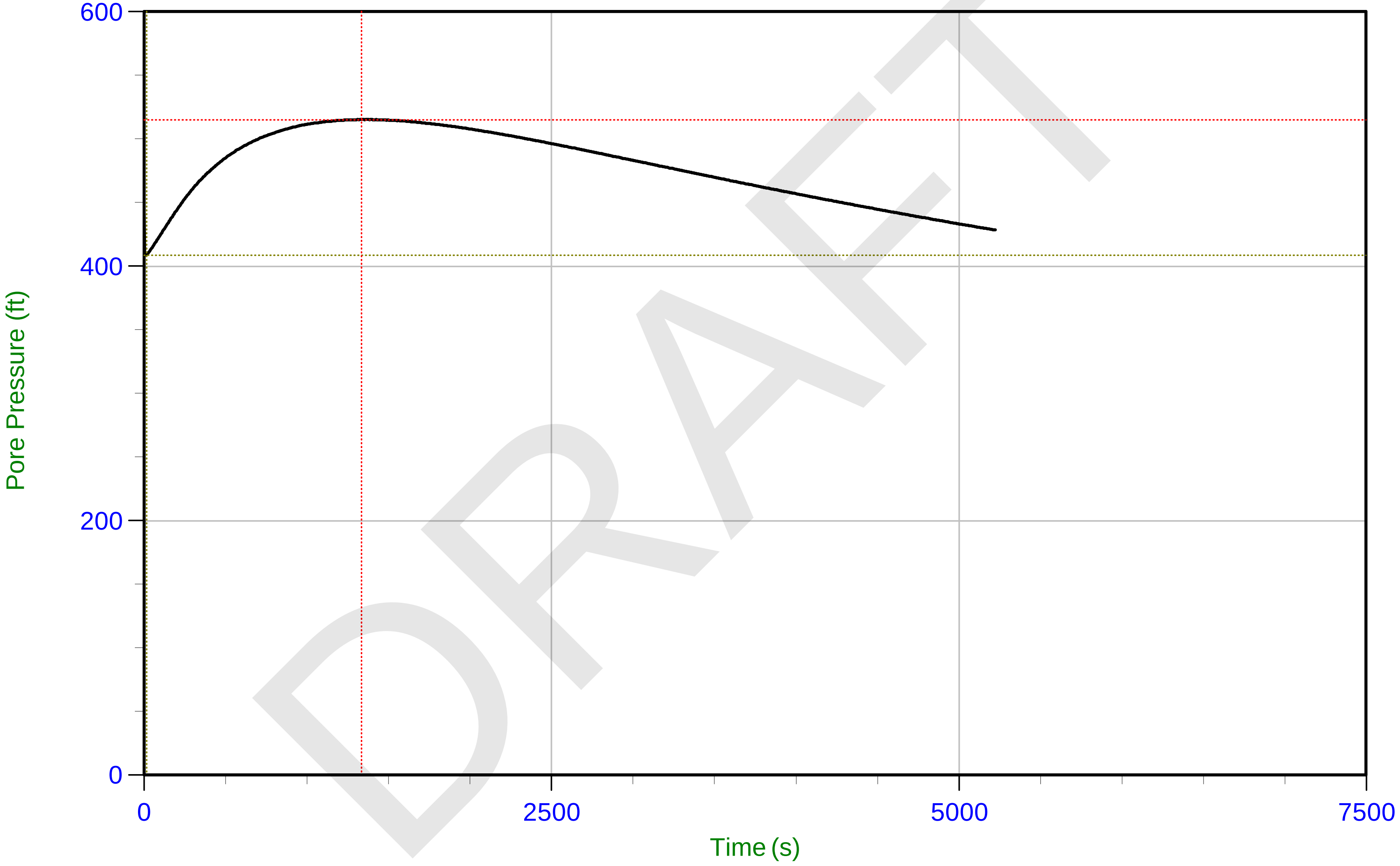
U Min: 99.9 ft
U Max: 209.5 ft

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

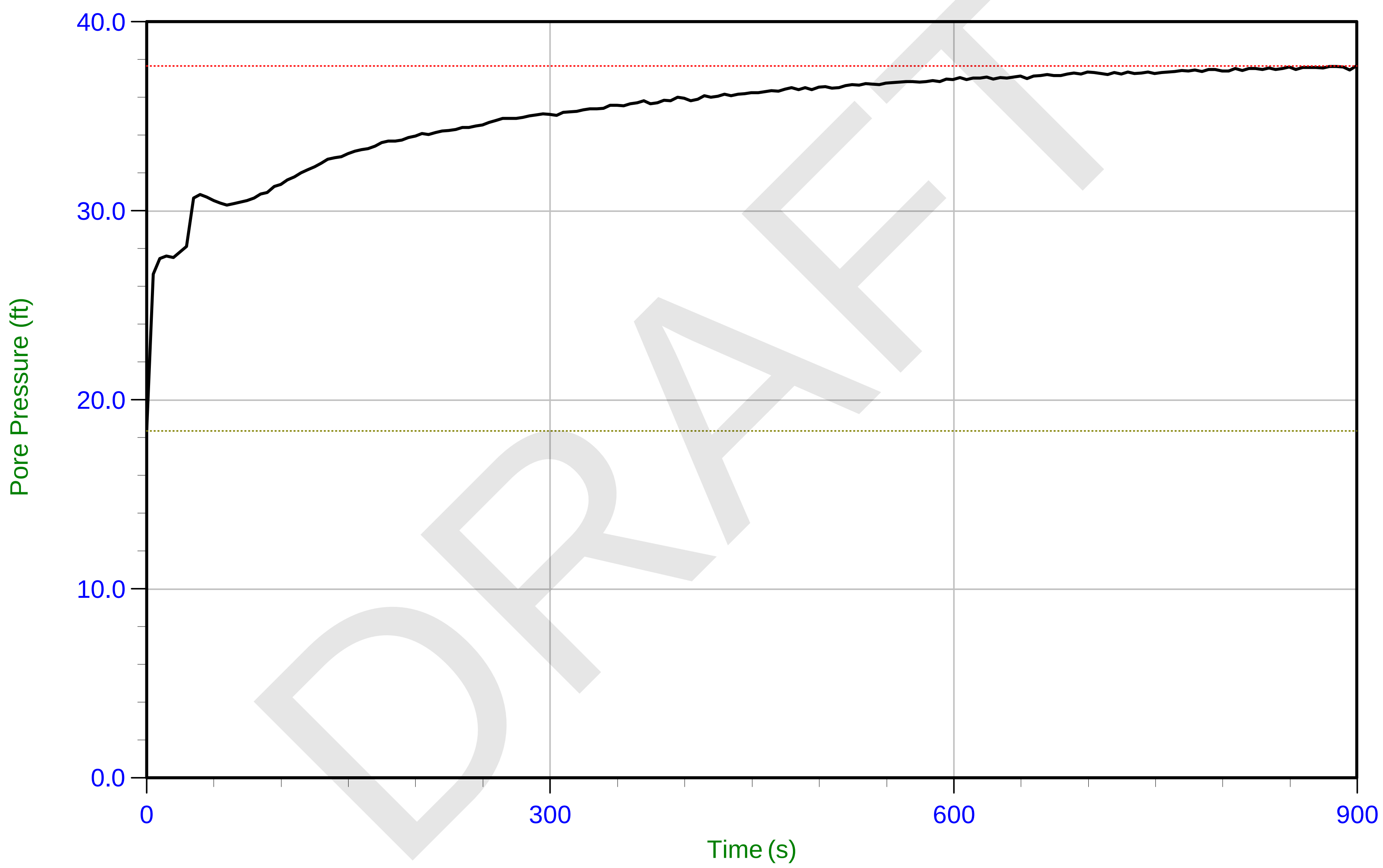
U Min: 408.9 ft
U Max: 515.3 ft

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

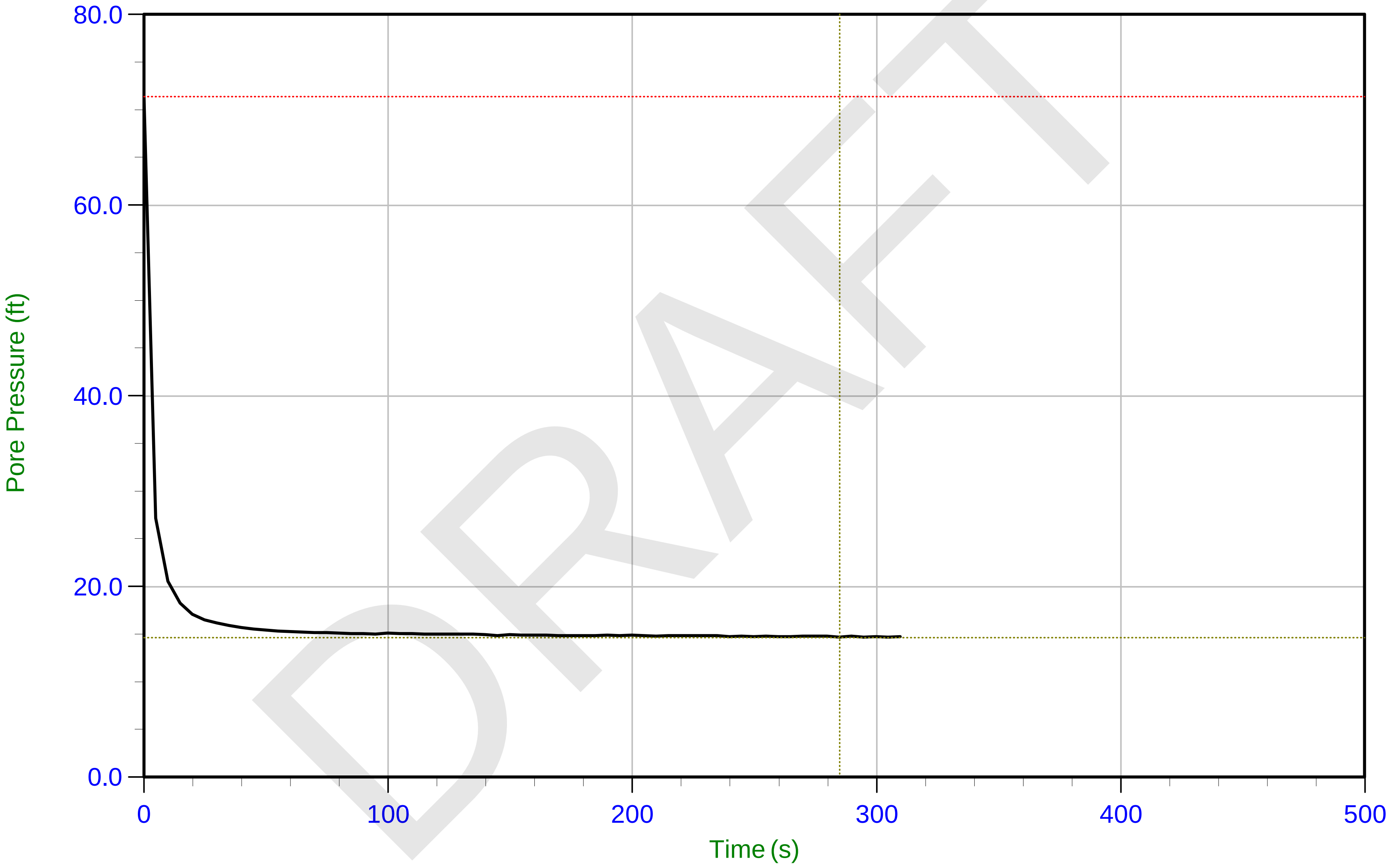
U Min: 18.4 ft
U Max: 37.7 ft

WT: 13.016 m / 42.703 ft
Ueq: 37.7 ft

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

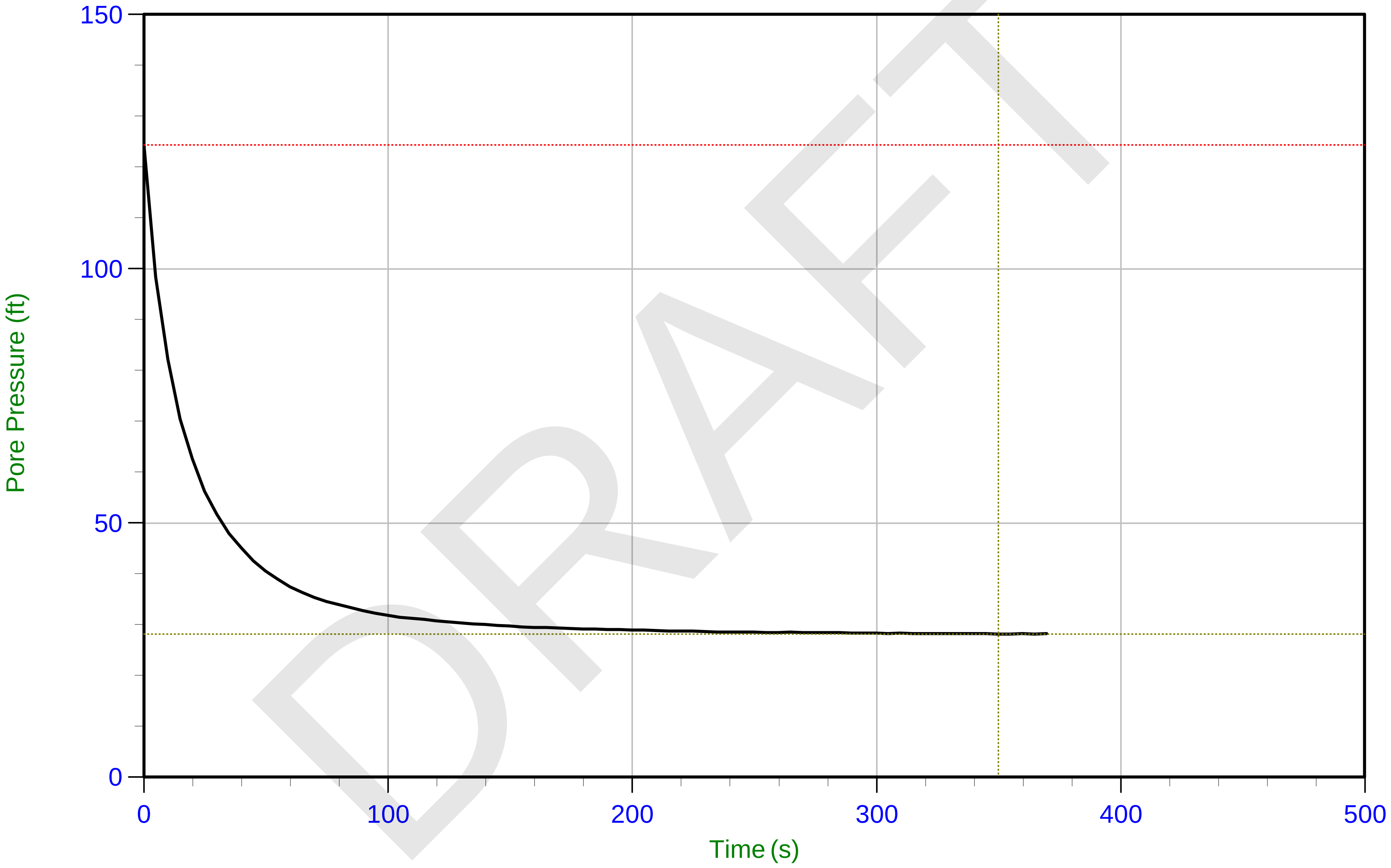
WT: 2.416 m / 7.926 ft
Ueq: 14.7 ft

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

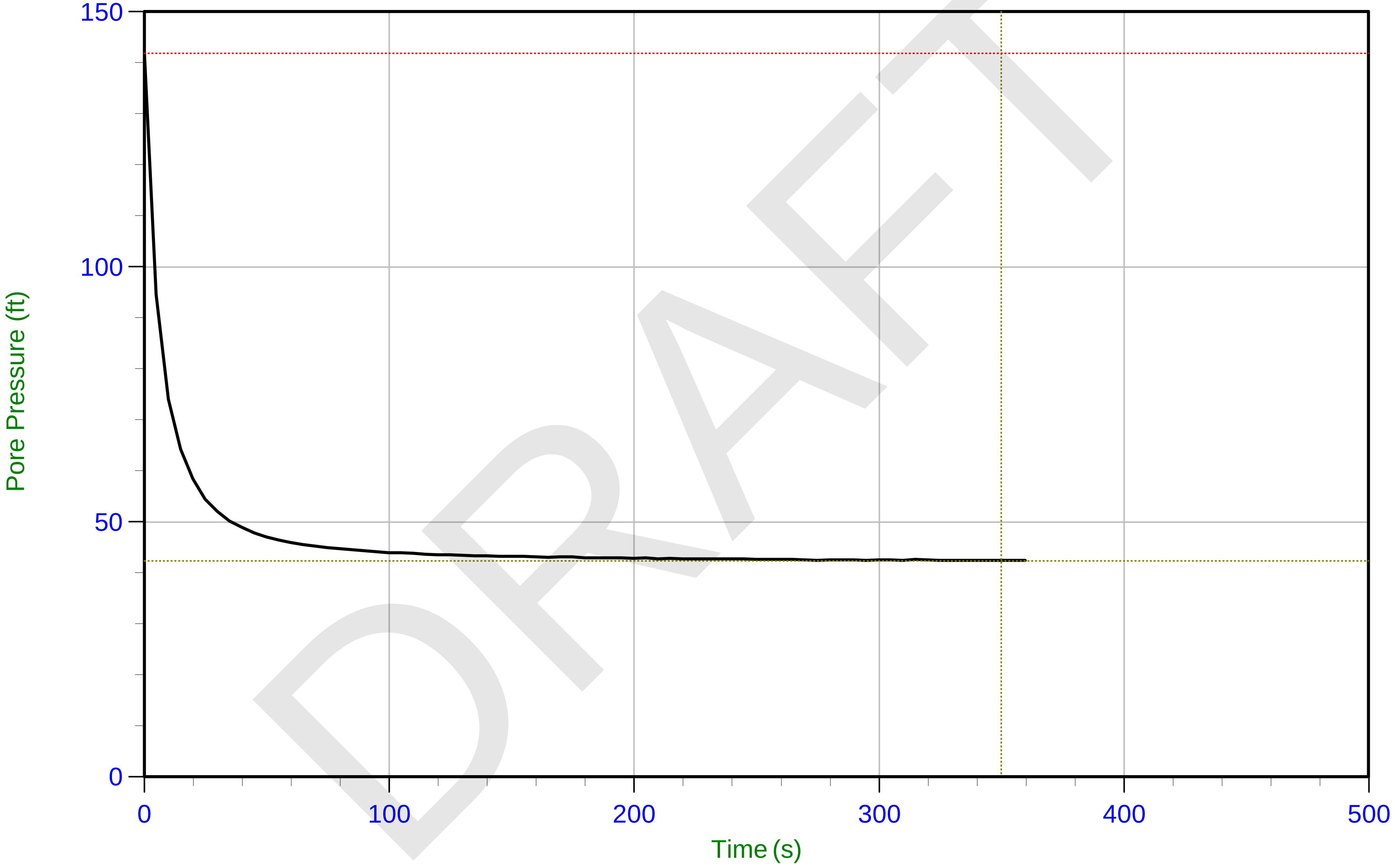
WT: 2.346 m / 7.697 ft
Ueq: 28.1 ft

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

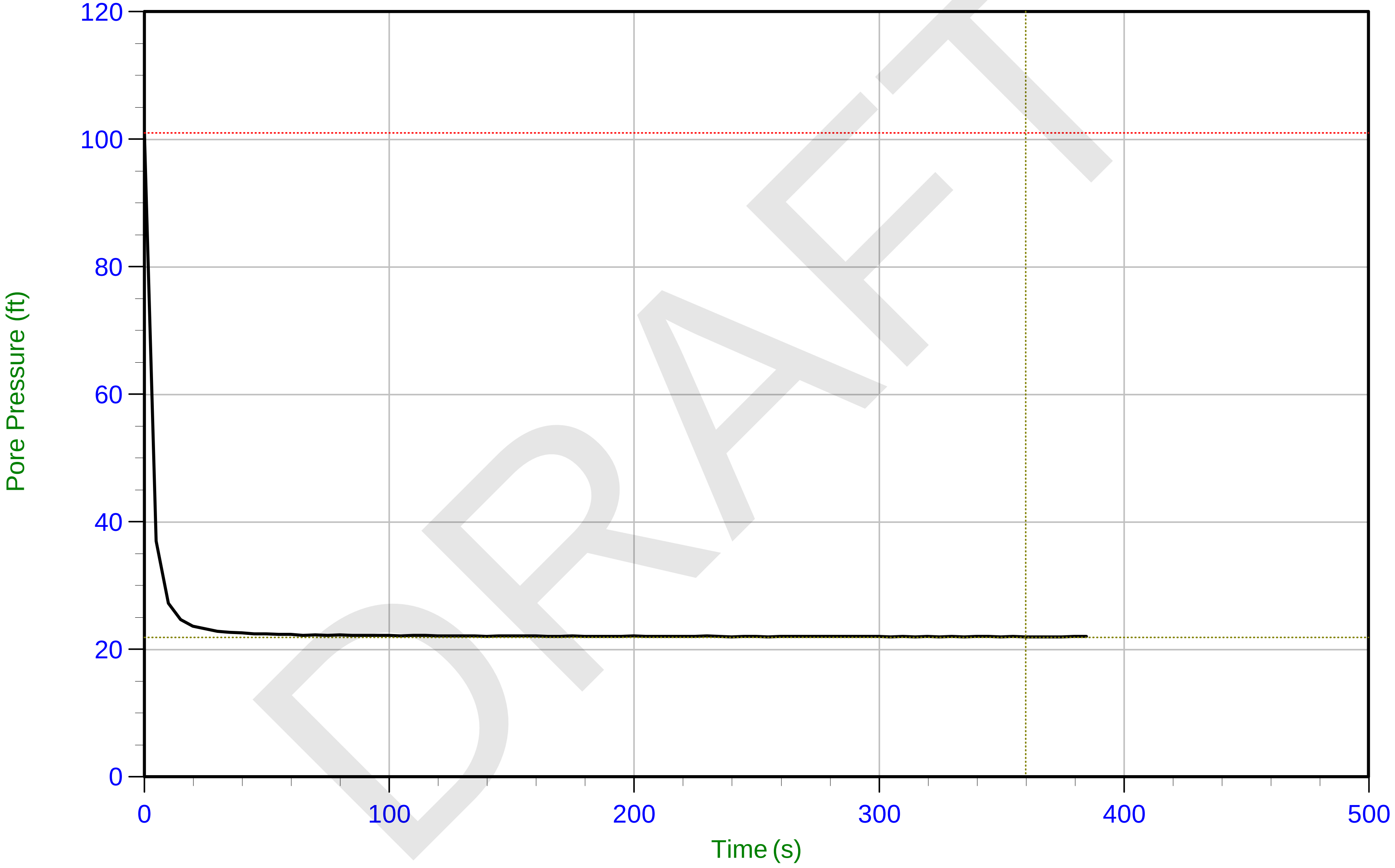
WT: 2.124 m / 6.968 ft
Ueq: 43.1 ft

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

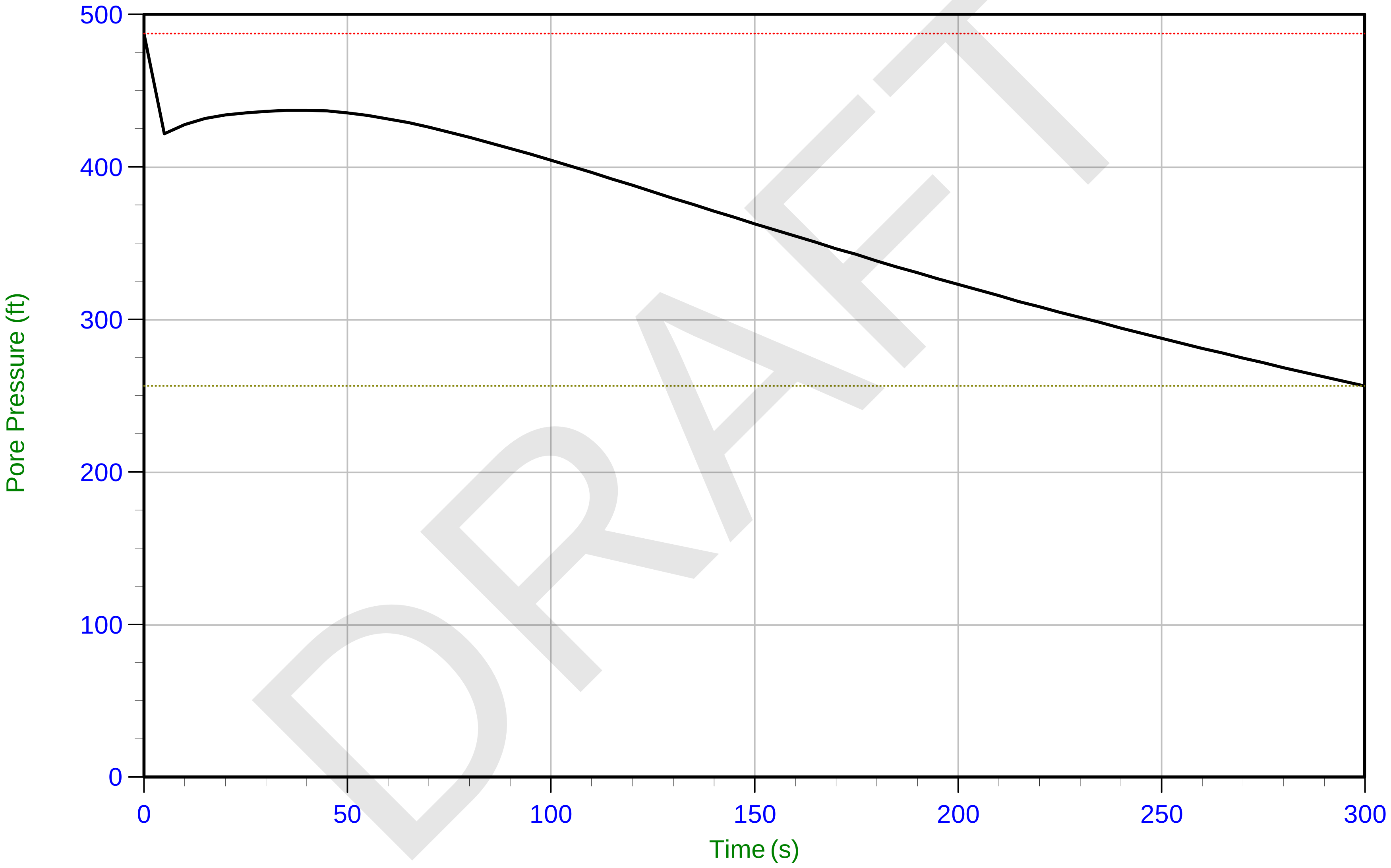
U Min: 21.9 ft
U Max: 101.1 ft

WT: 3.375 m / 11.072 ft
Ueq: 22.1 ft

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

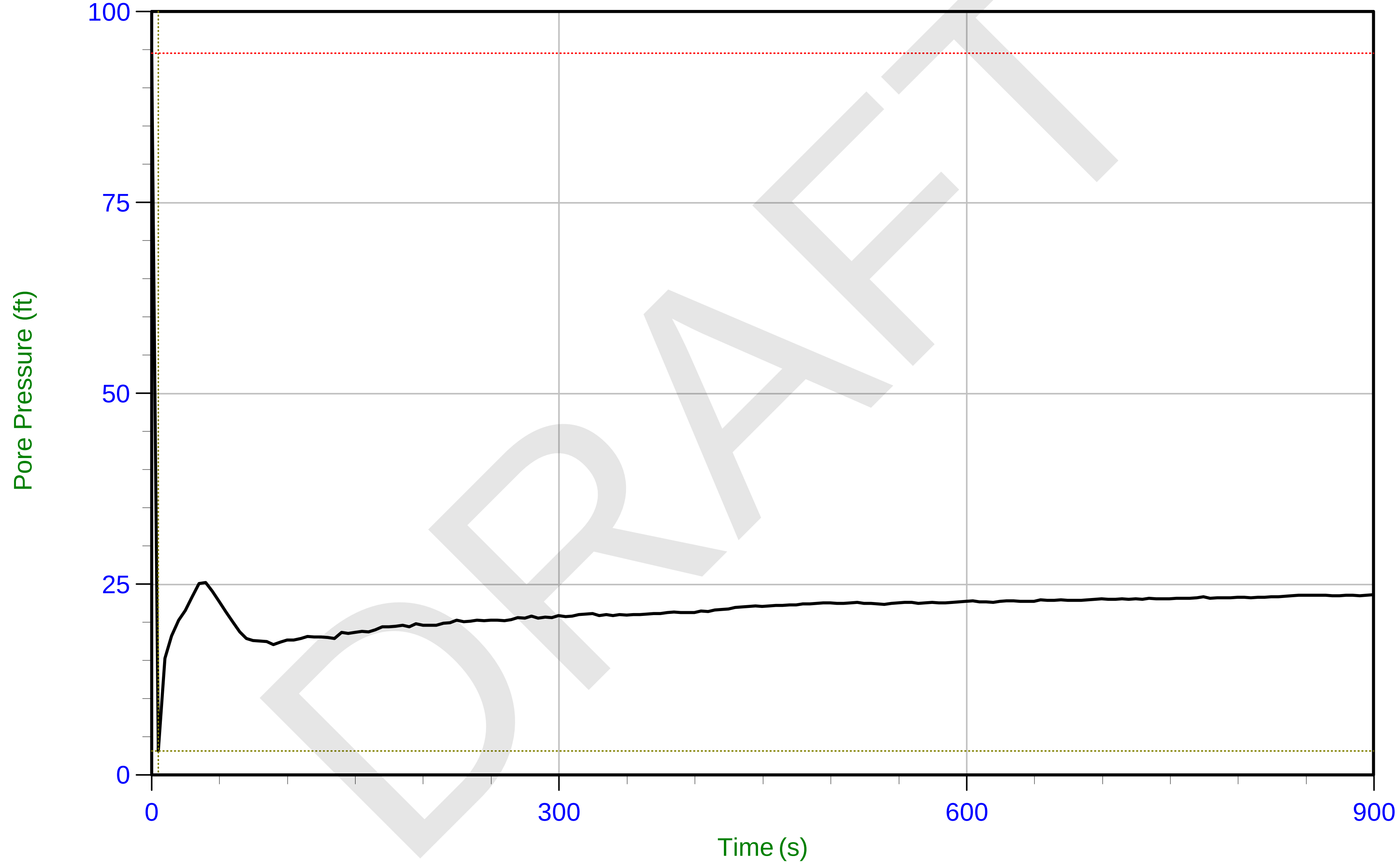
U Min: 256.7 ft
U Max: 487.5 ft

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

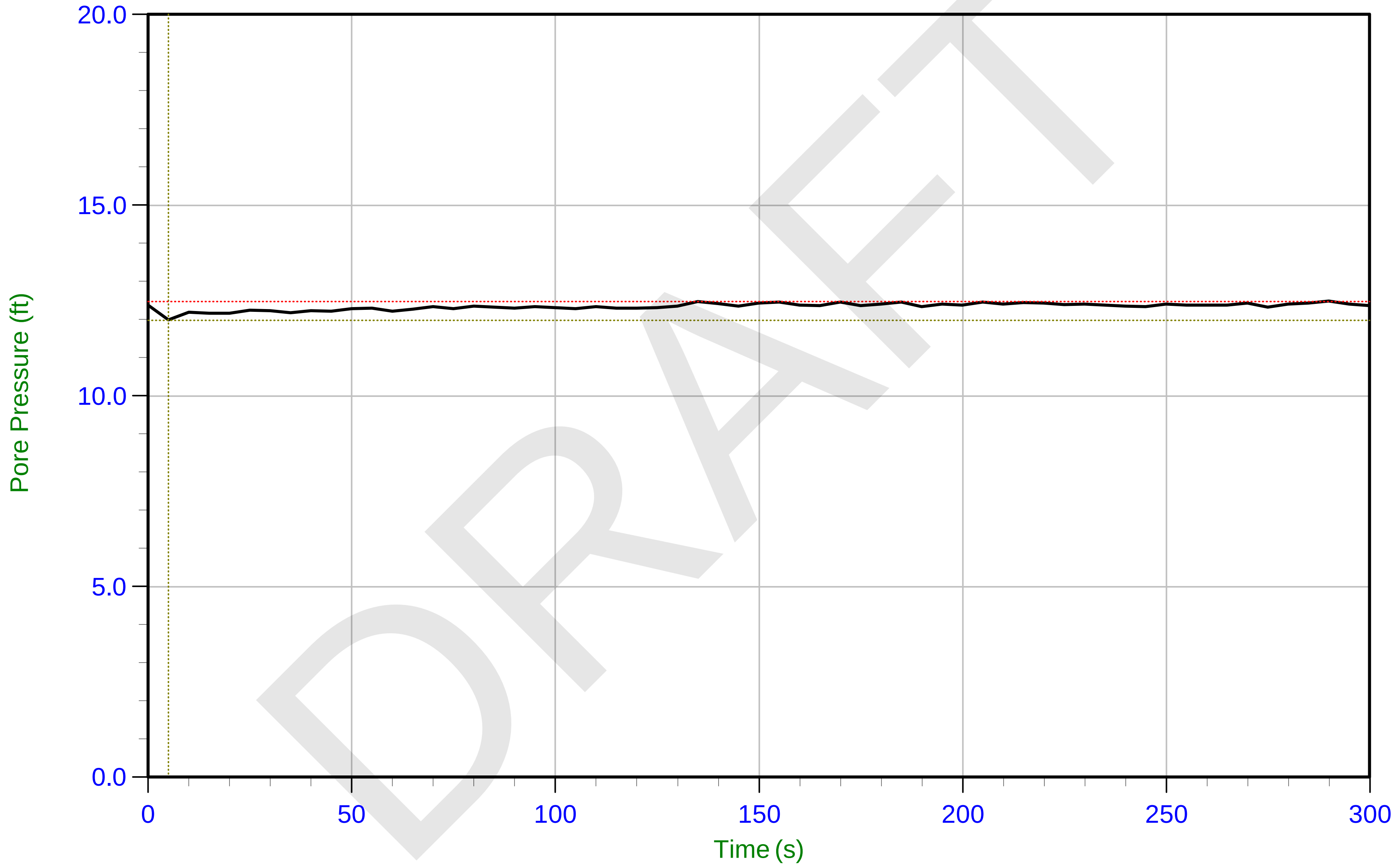
WT: 18.822 m / 61.753 ft
Ueq: 23.5 ft

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

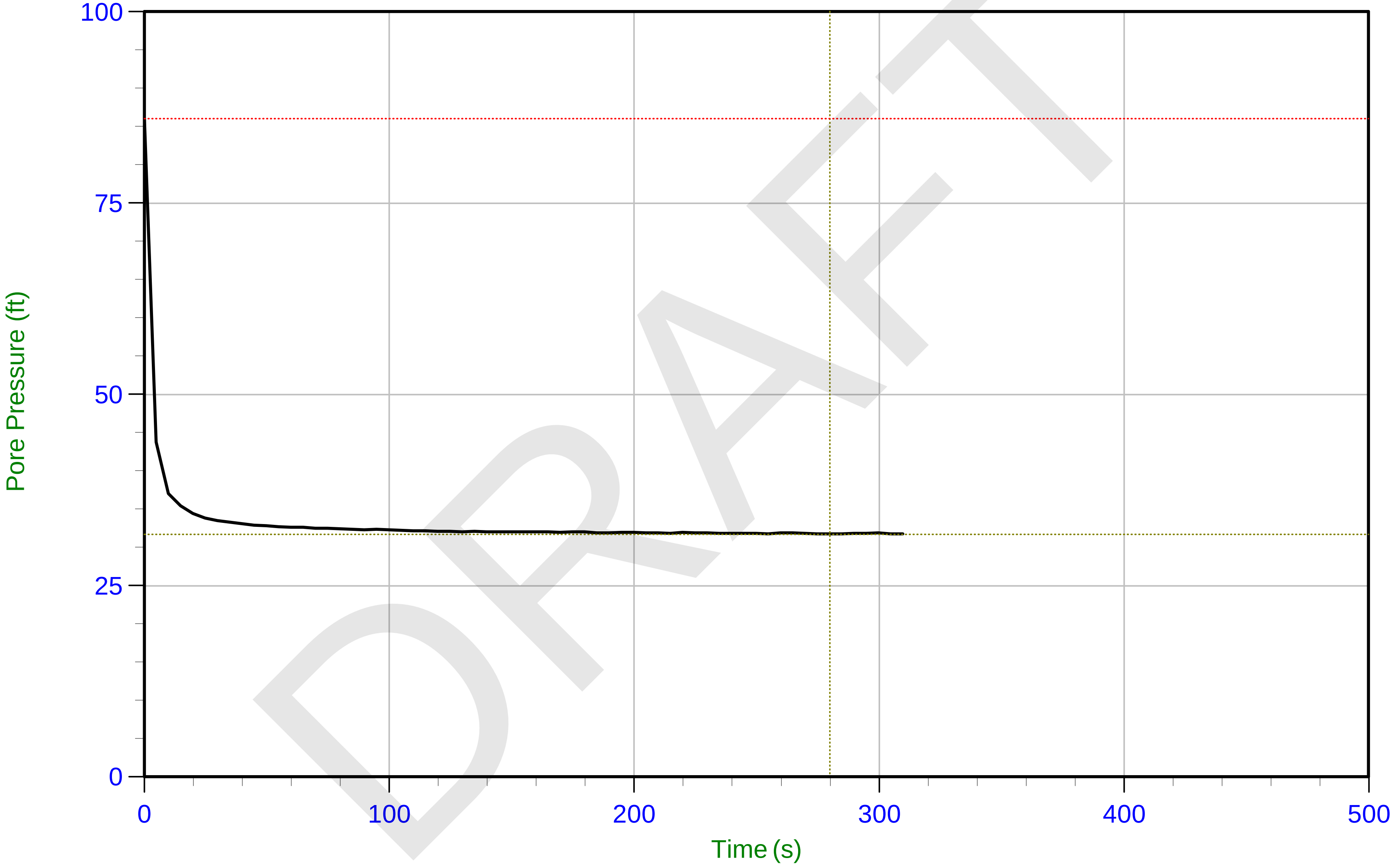
WT: 1.124 m / 3.689 ft
Ueq: 12.4 ft

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

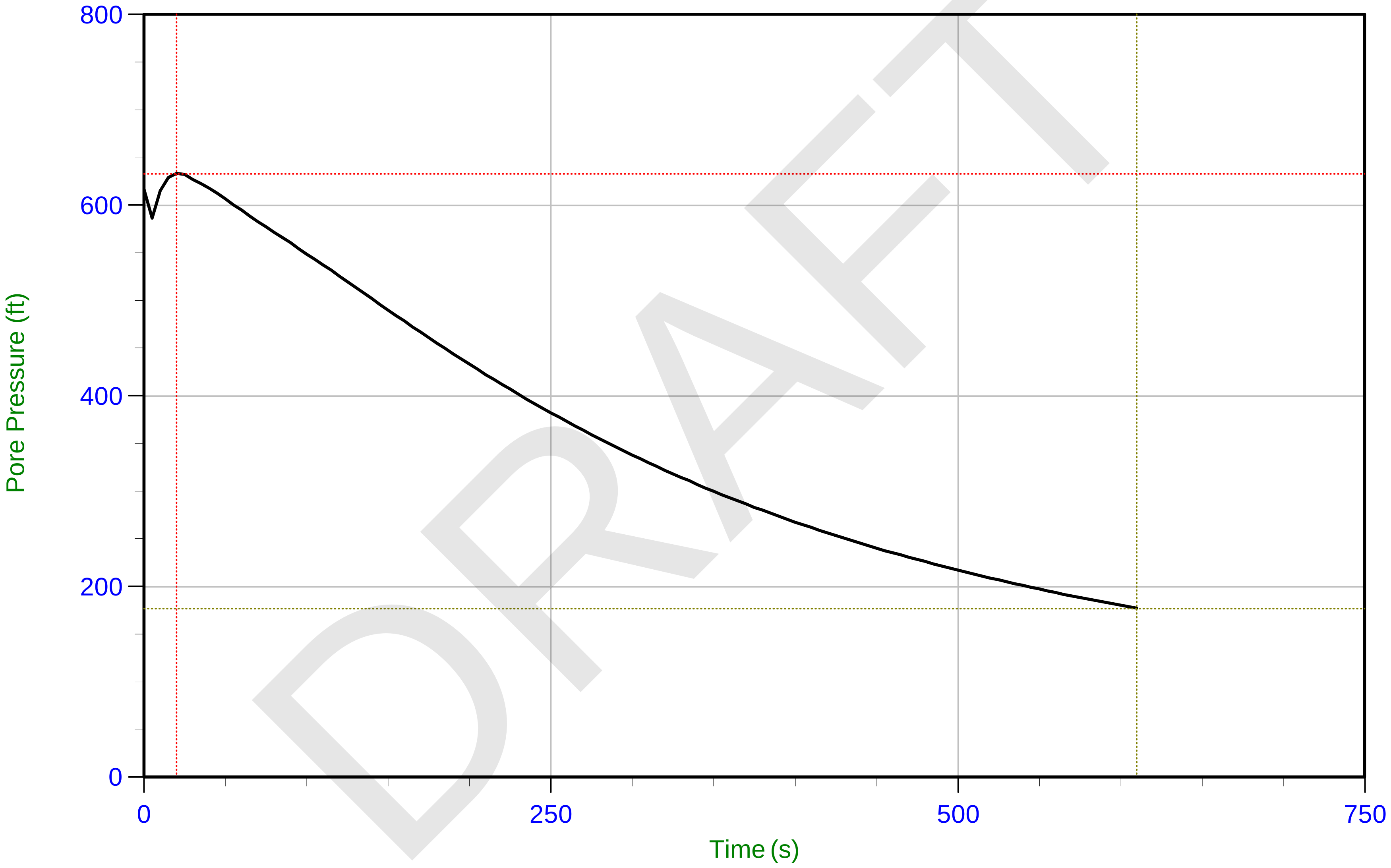
U Min: 31.8 ft
U Max: 86.1 ft

WT: 1.166 m / 3.826 ft
Ueq: 31.9 ft

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

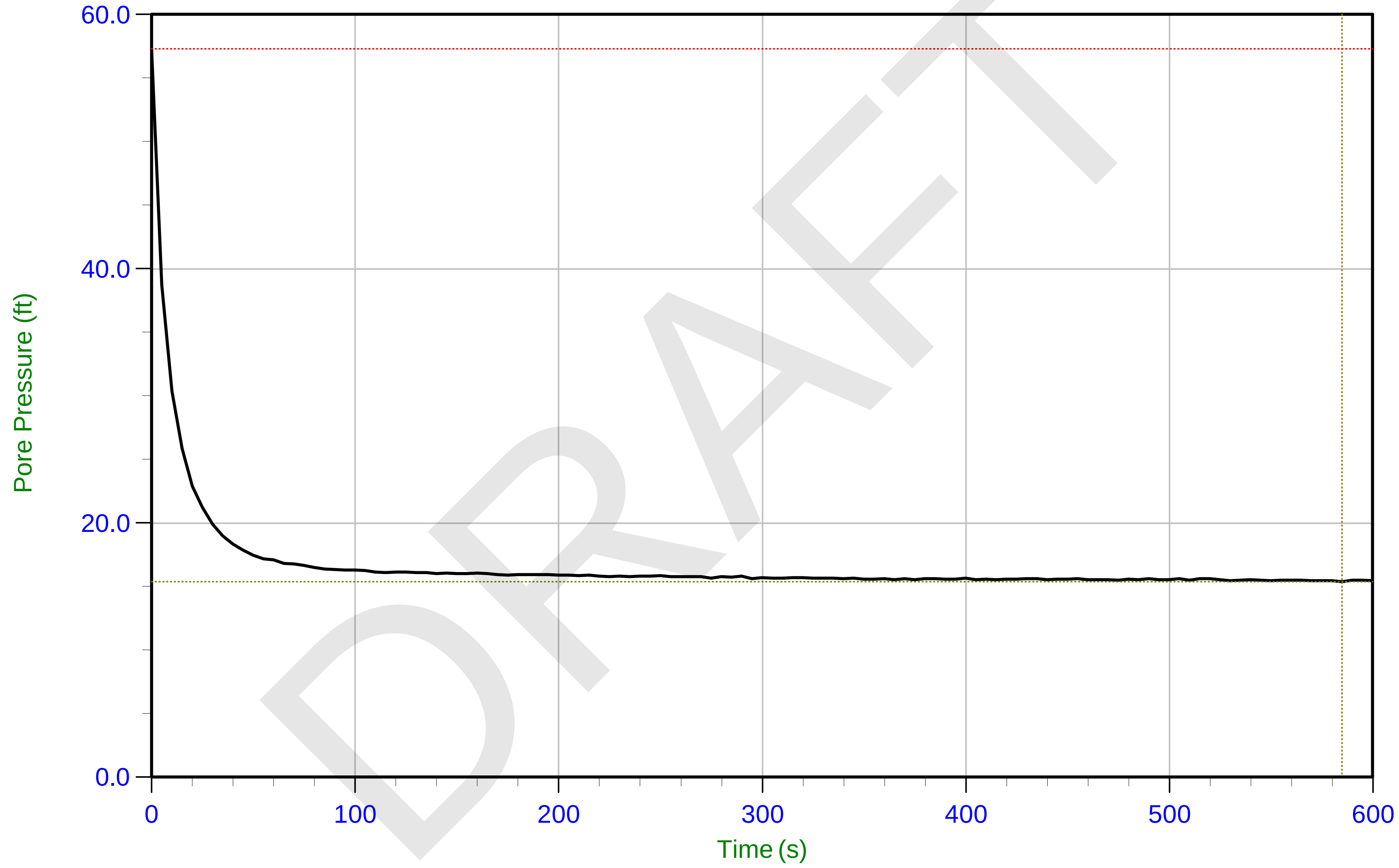
U Min: 177.1 ft
U Max: 633.3 ft

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

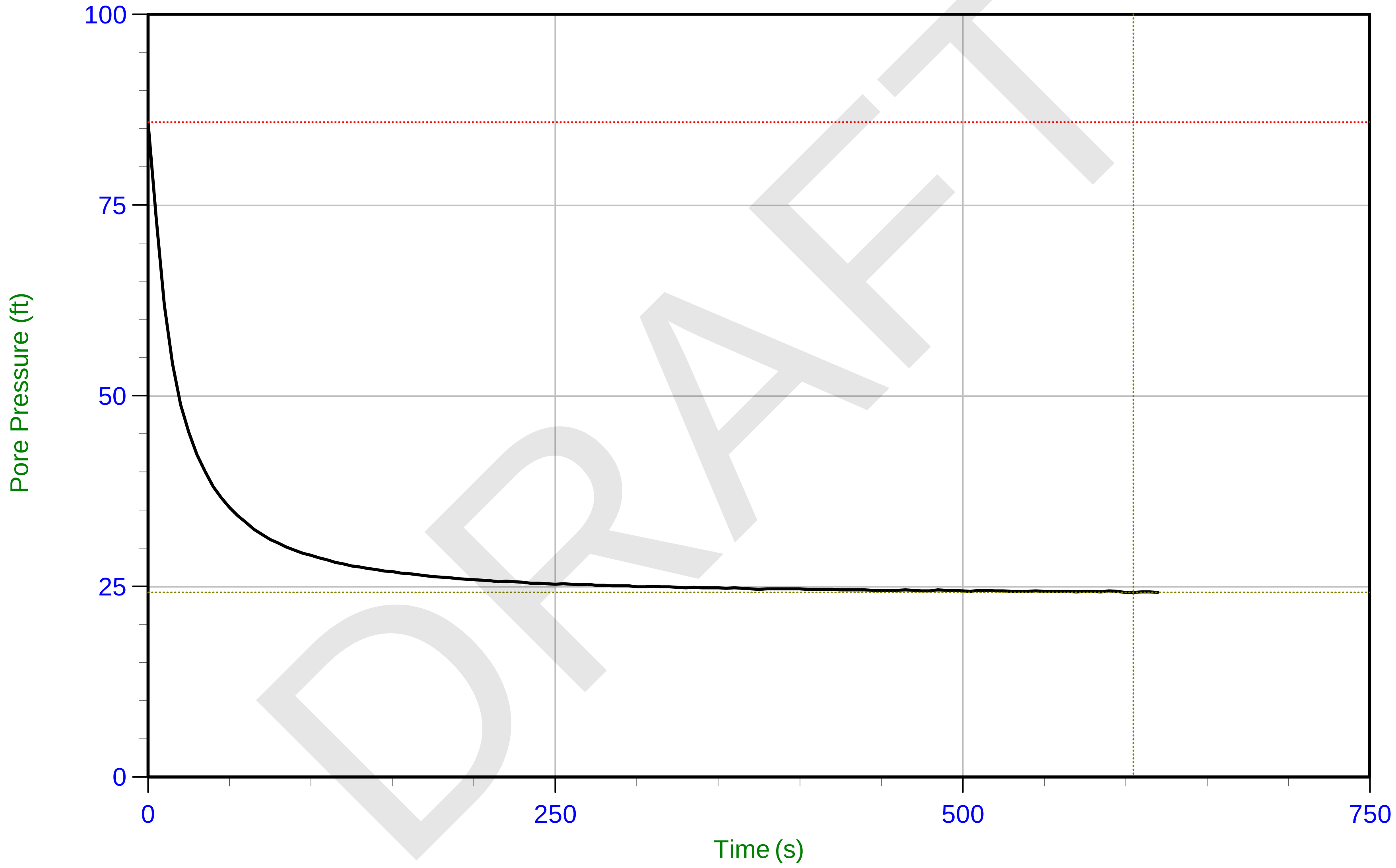
WT: 1.172 m / 3.845 ft
Ueq: 15.7 ft

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

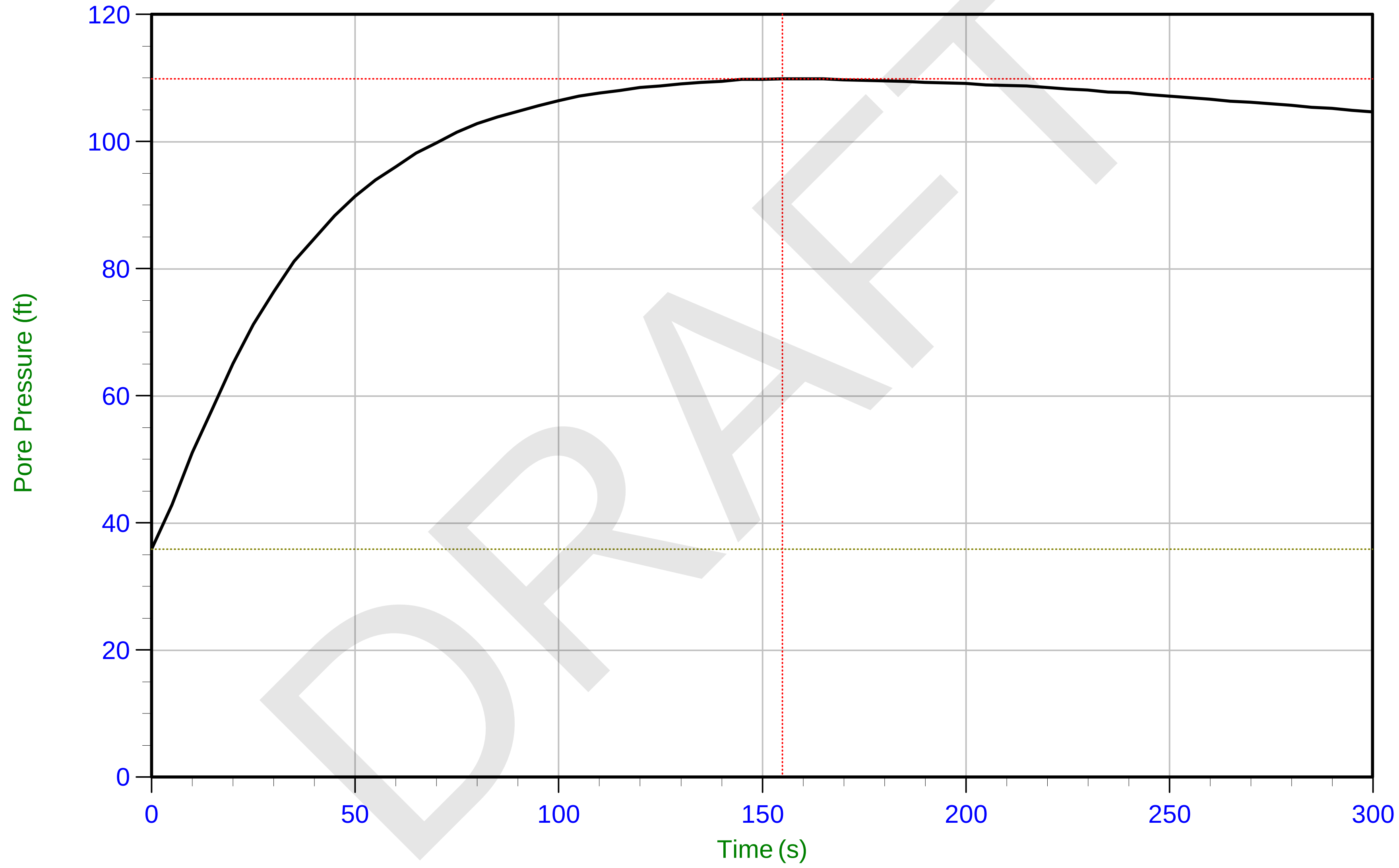
U Min: 24.2 ft
U Max: 85.9 ft

WT: 1.077 m / 3.533 ft
Ueq: 24.5 ft

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

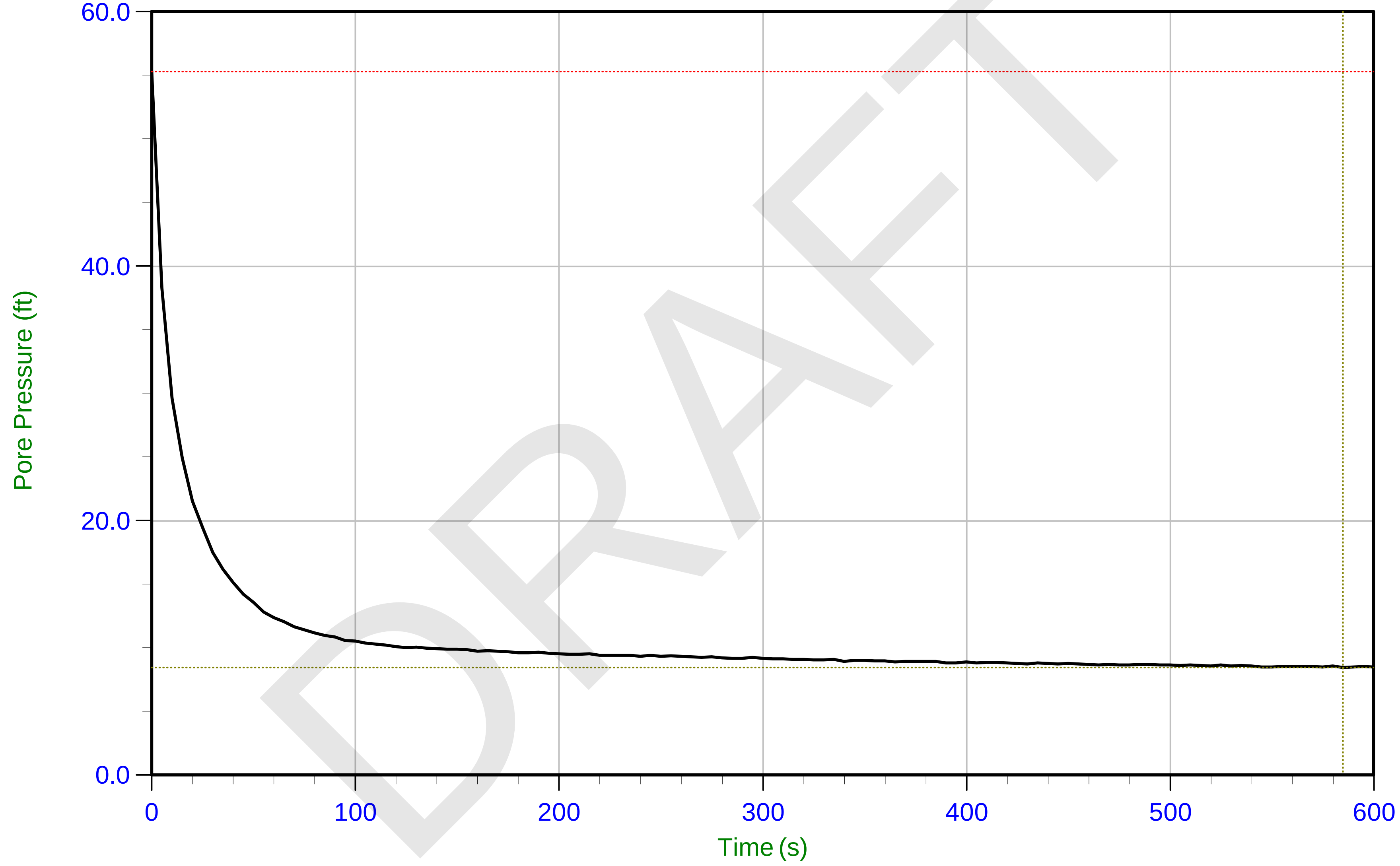
U Min: 35.9 ft
U Max: 109.9 ft

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

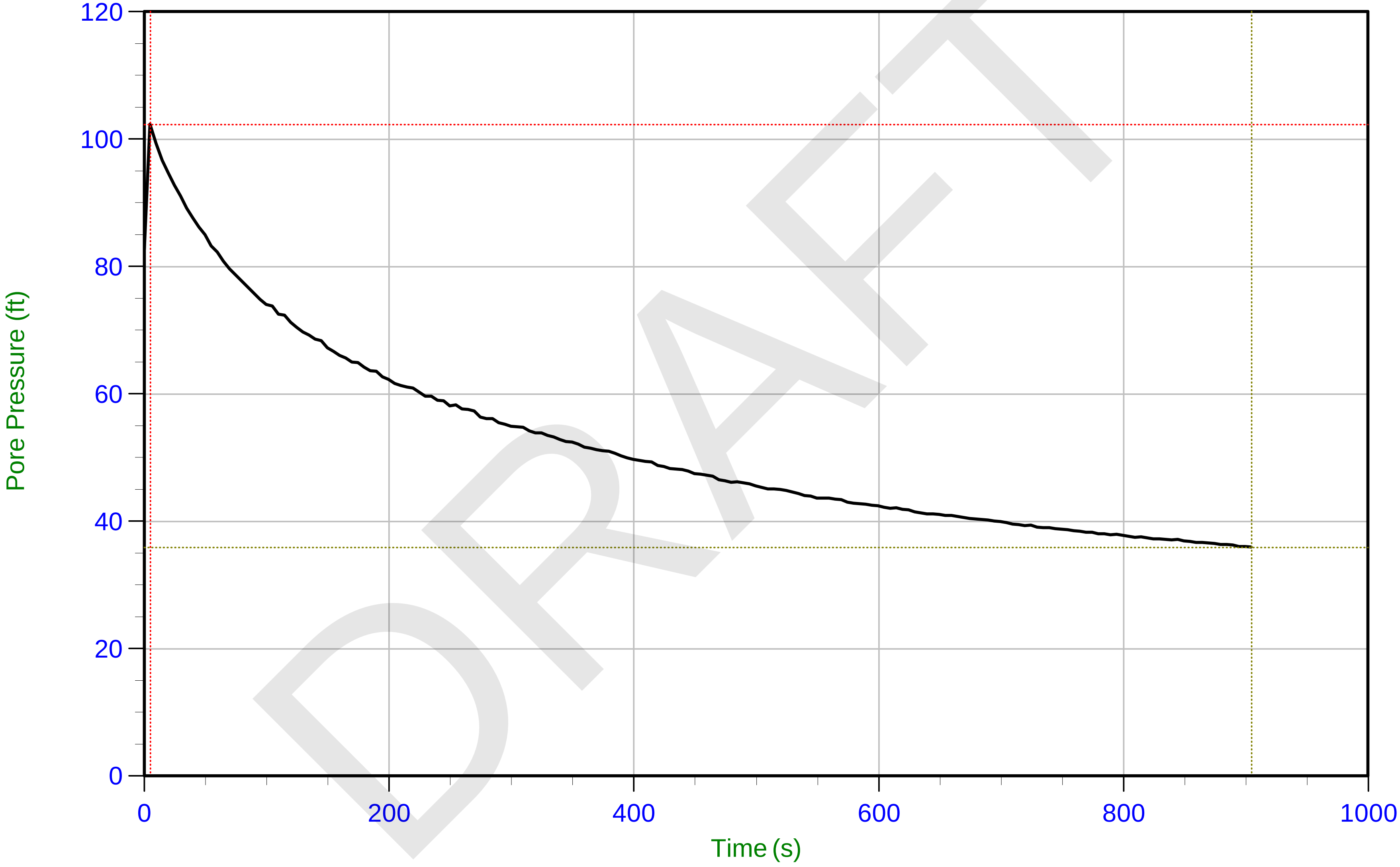


Trace Summary:

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



Trace Summary:

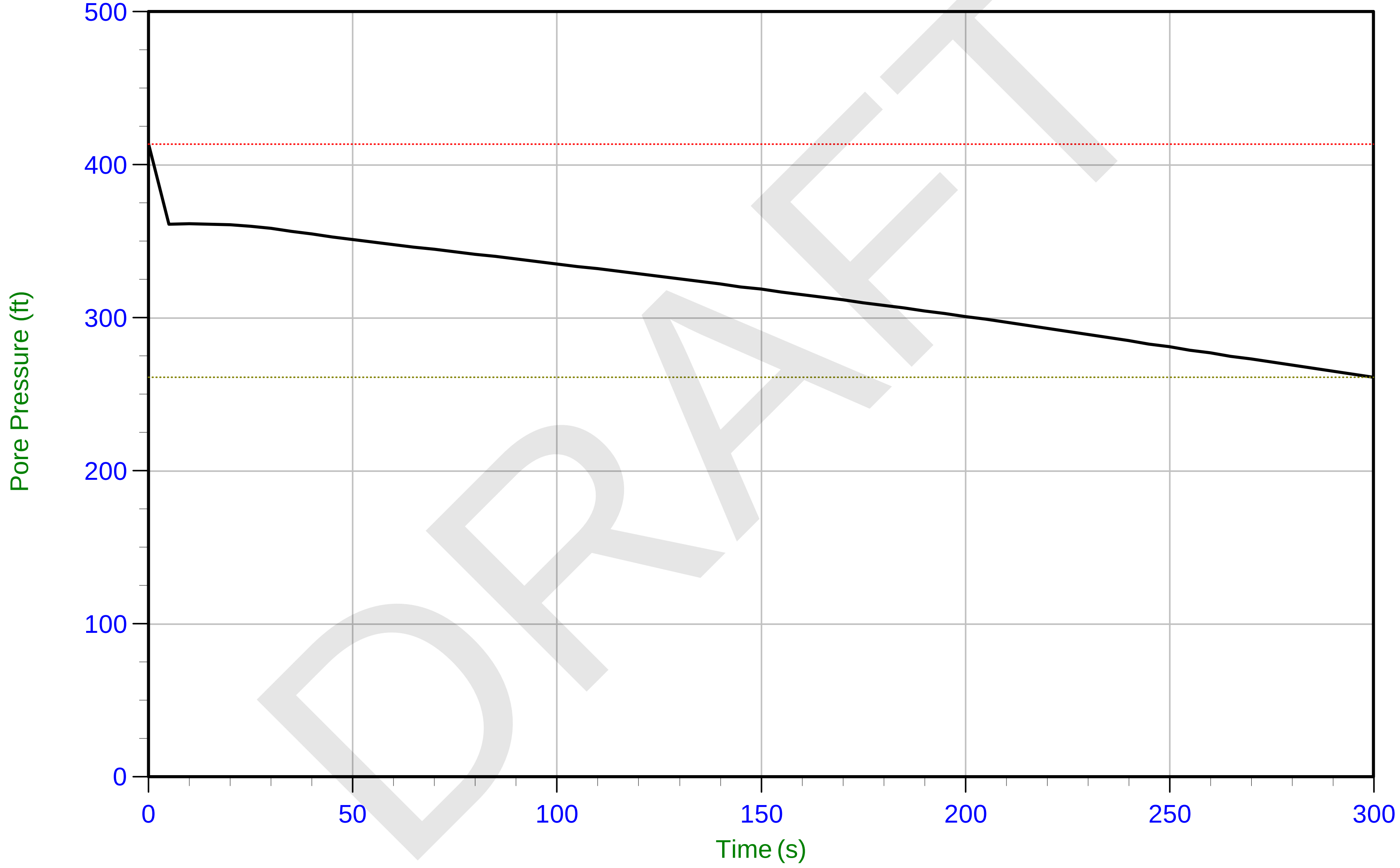
Filename: 15-54071_CP JOP-C030.PPD
Depth: 9.900 m / 32.480 ft
Duration: 905.0 s

U Min: 35.9 ft
U Max: 102.3 ft

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:

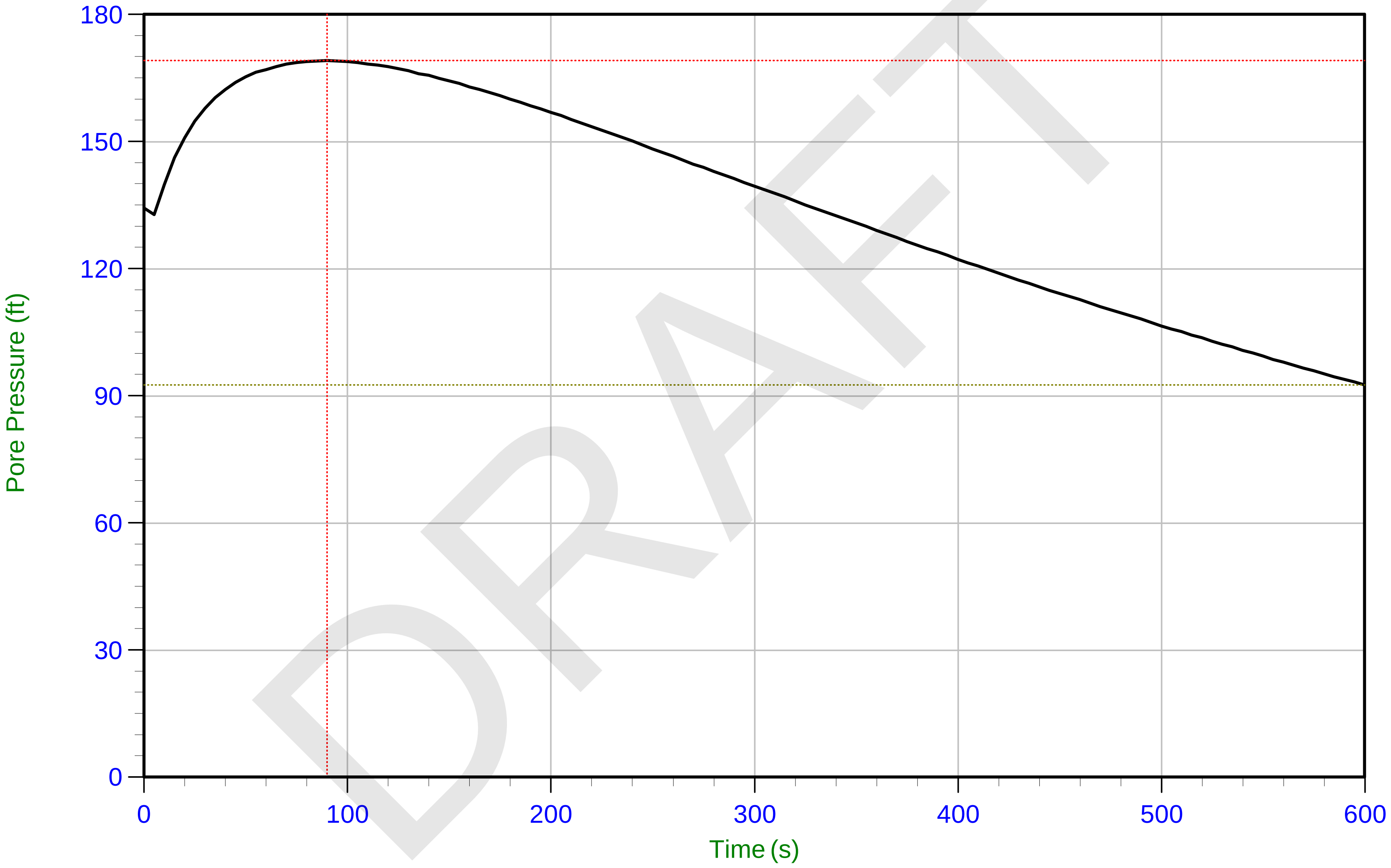
Filename: 15-54071_CP JOP-C030.PPD
Depth: 15.300 m / 50.196 ft
Duration: 300.0 s

U Min: 261.3 ft
U Max: 413.7 ft

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

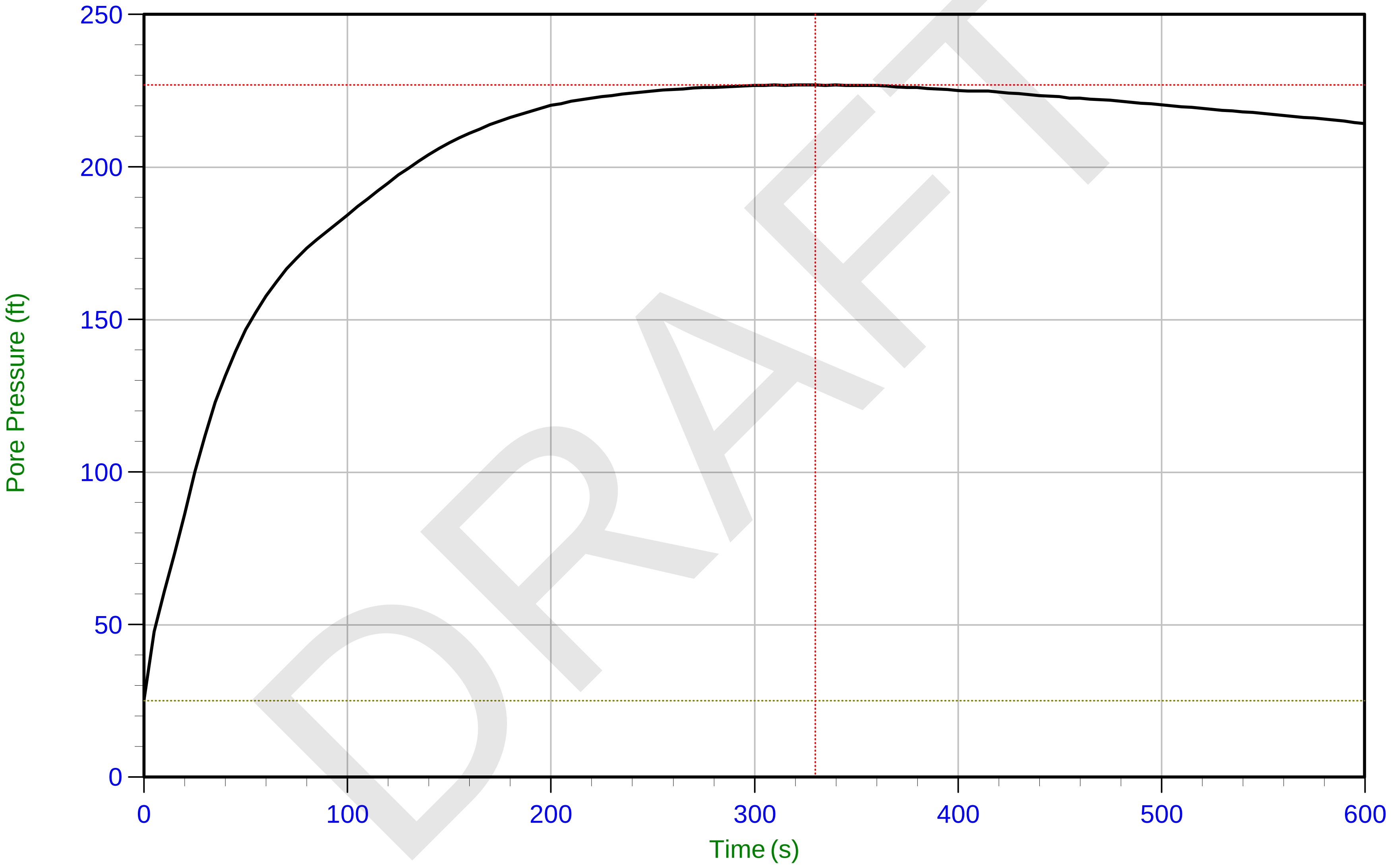
U Min: 92.6 ft
U Max: 169.2 ft

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

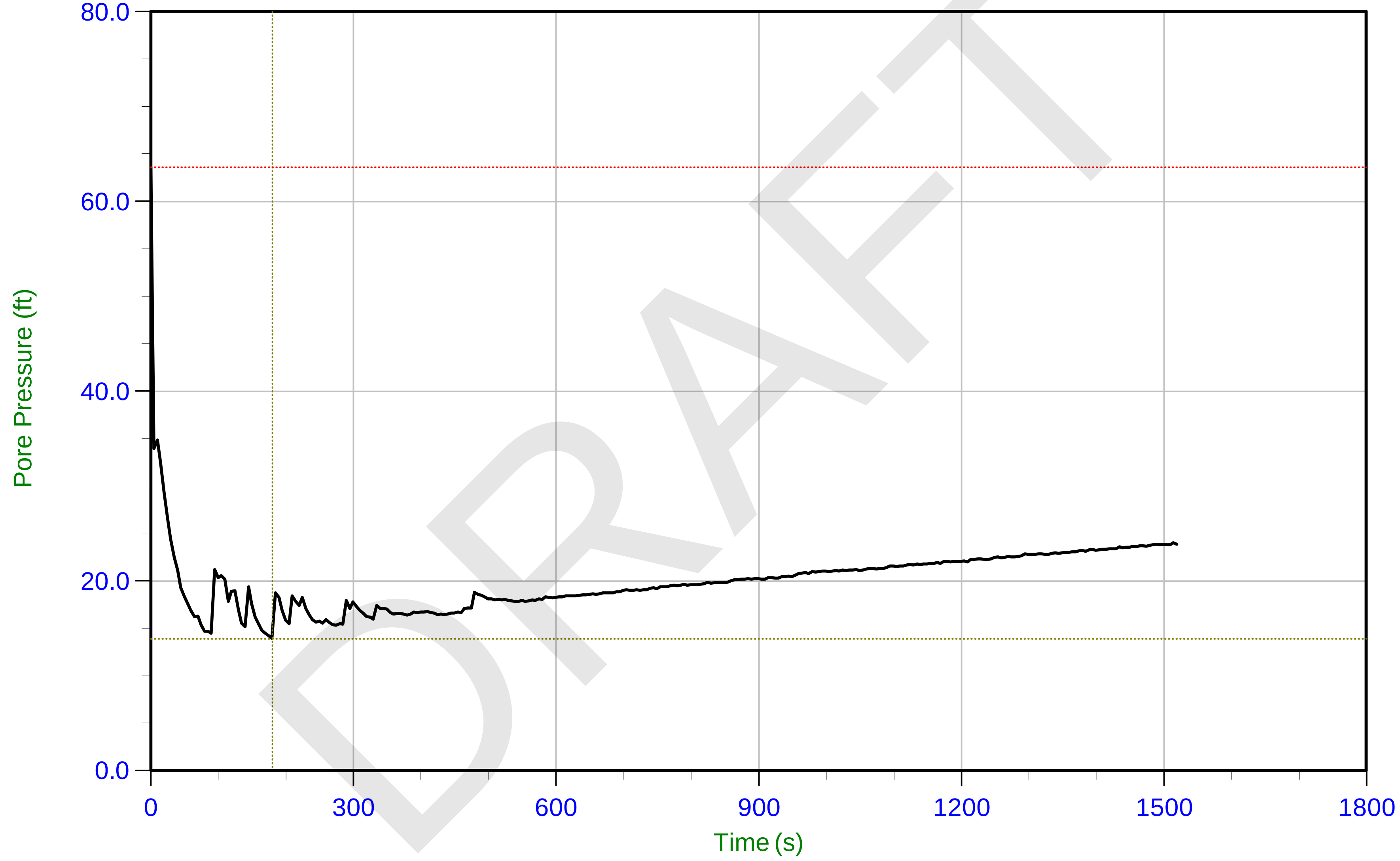
U Min: 25.2 ft
U Max: 226.9 ft

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:

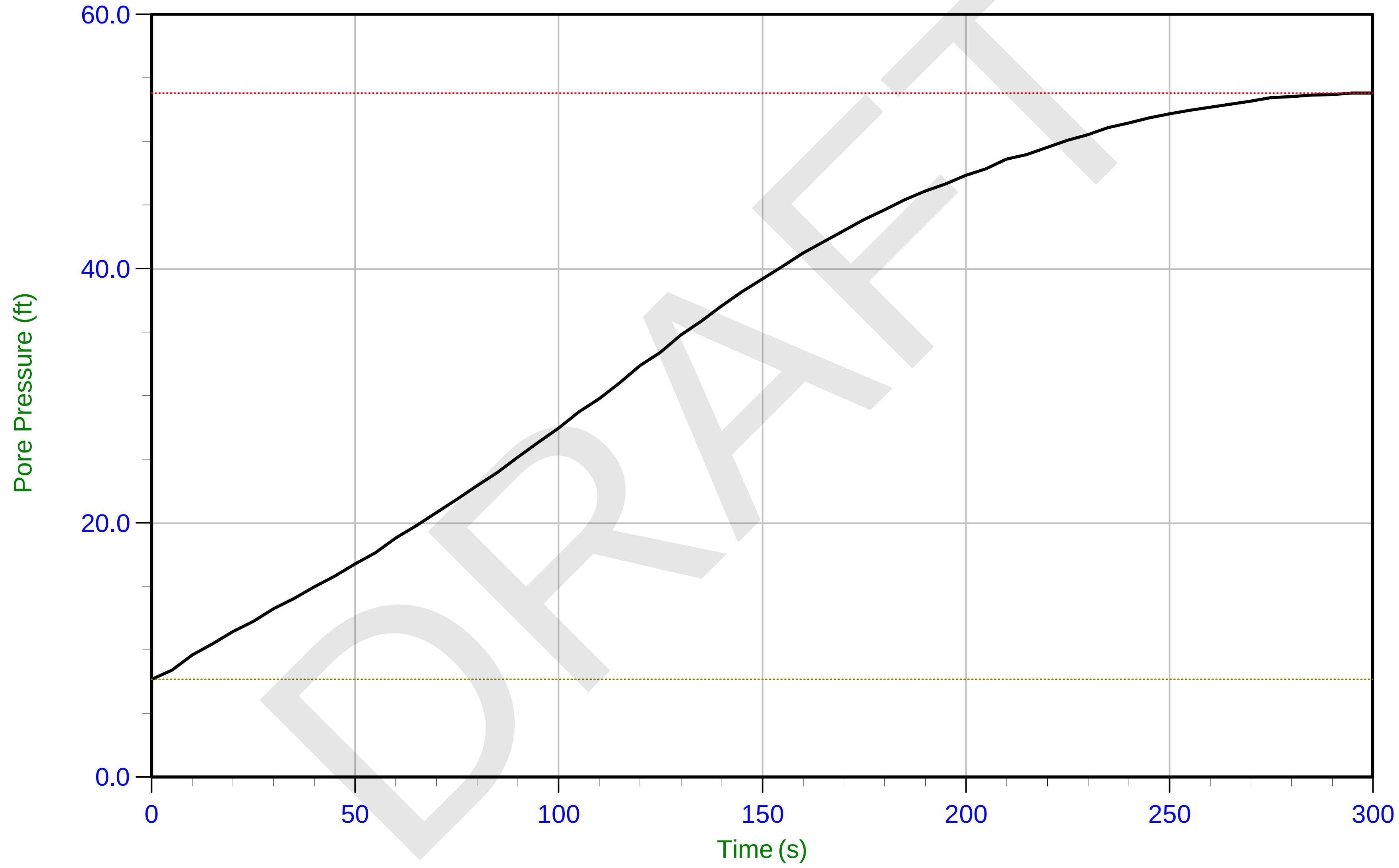
Filename: 15-54071_CP JOP-C031A.PPD
Depth: 23.750 m / 77.919 ft
Duration: 1520.0 s

U Min: 13.9 ft
U Max: 63.6 ft

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

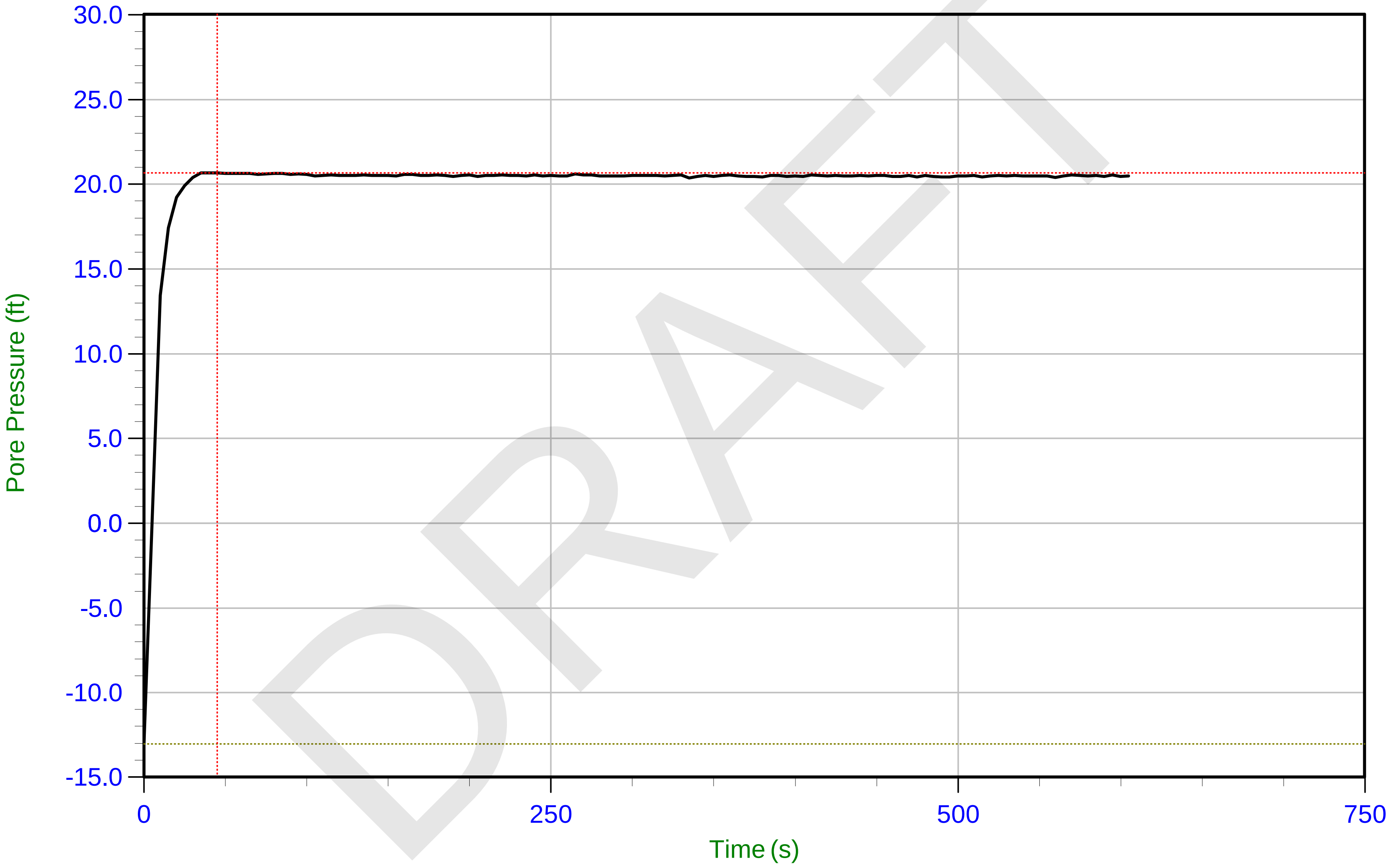
U Min: 7.7 ft
U Max: 53.8 ft

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

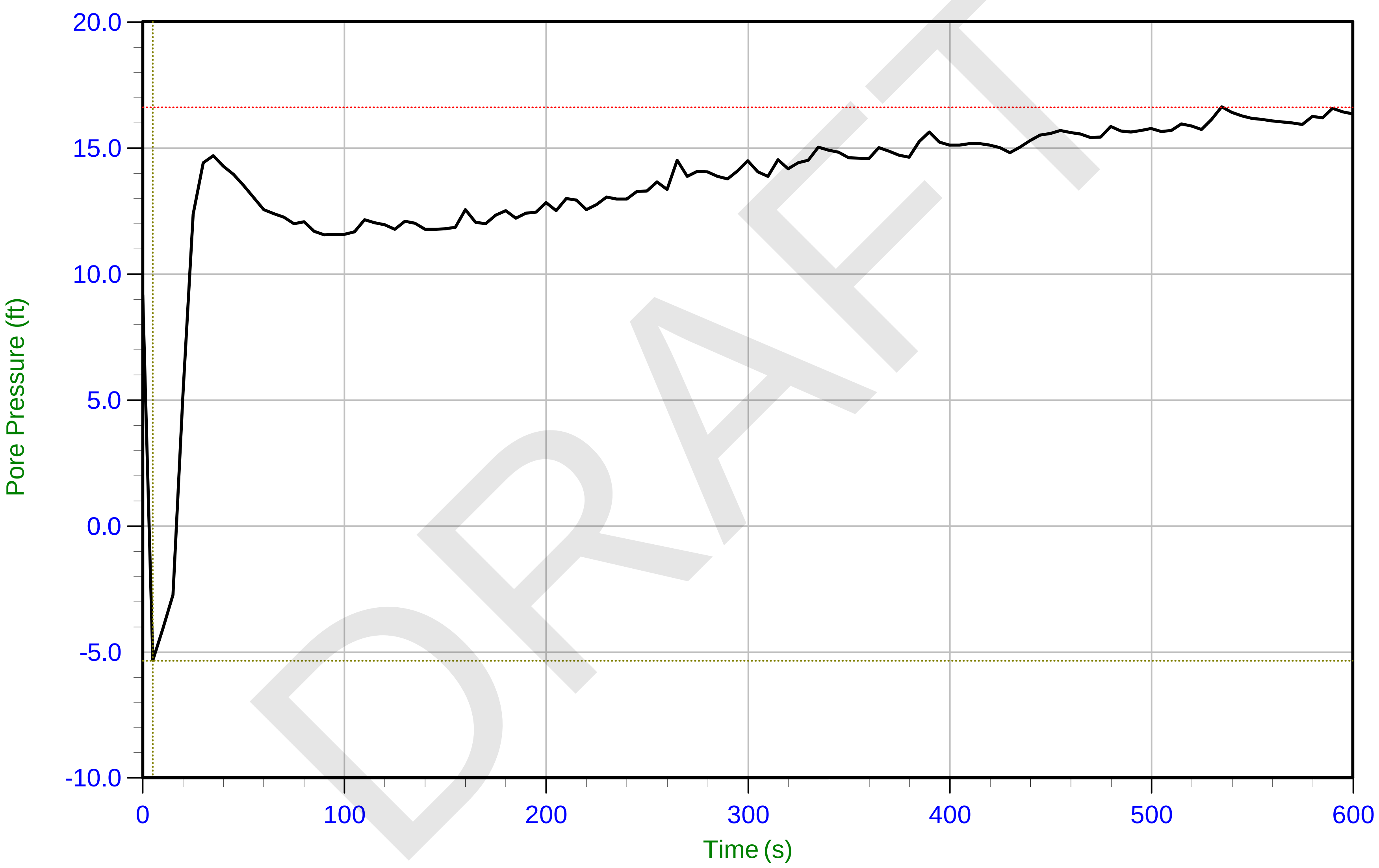
U Min: -13.0 ft
U Max: 20.7 ft

WT: 8.026 m / 26.332 ft
Ueq: 20.4 ft

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

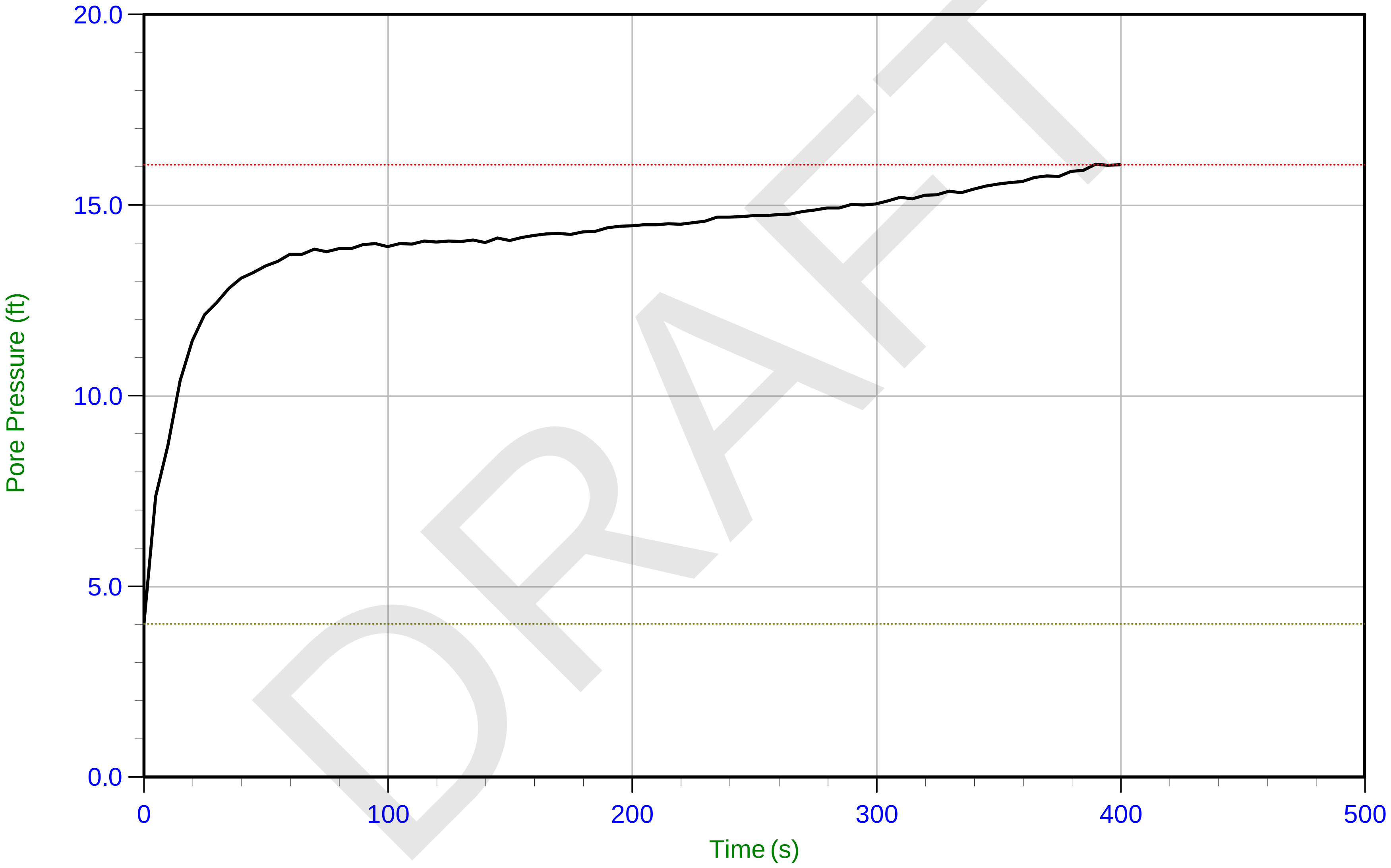
WT: 19.063 m / 62.542 ft
Ueq: 16.0 ft

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

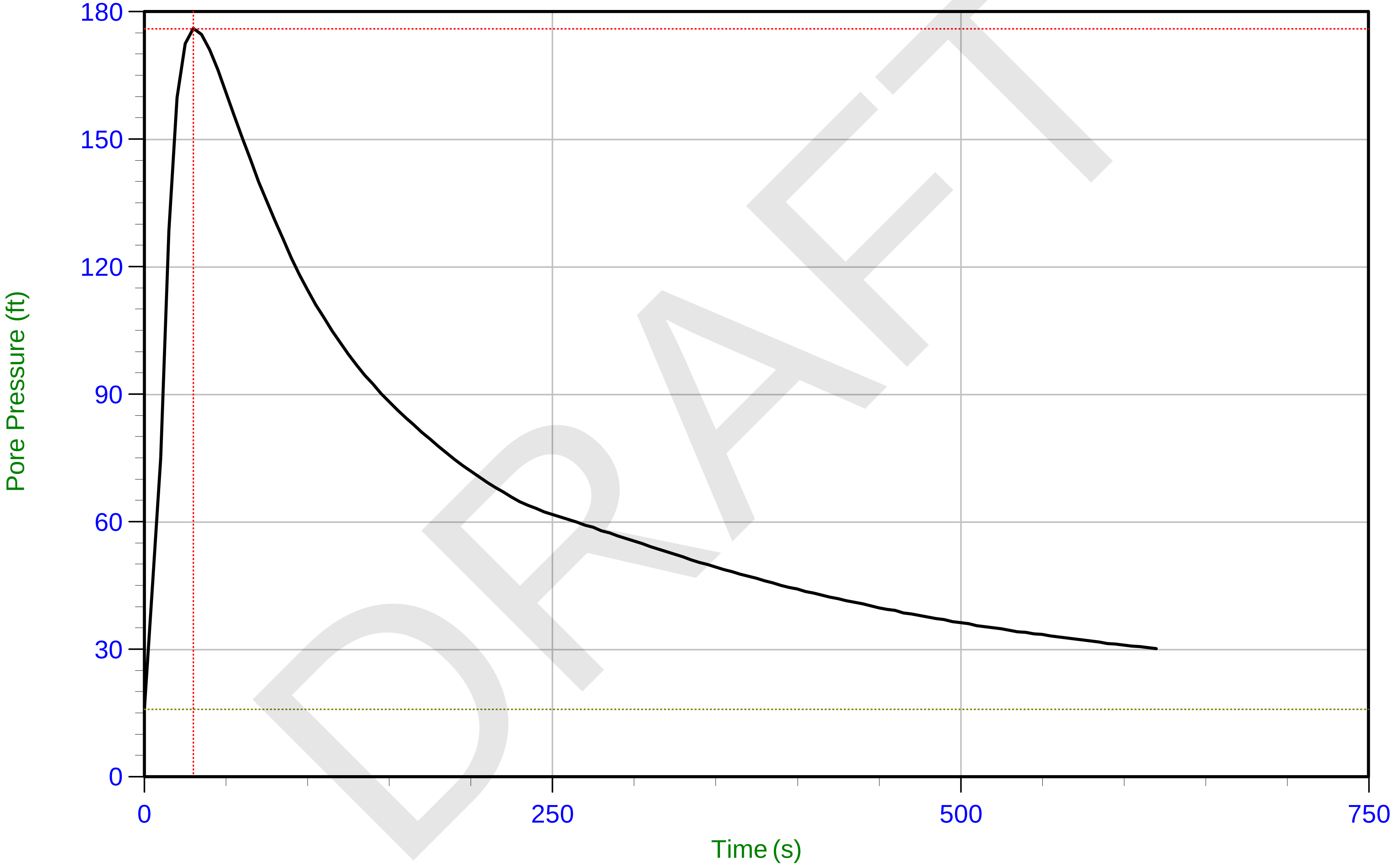
U Min: 4.0 ft
U Max: 16.1 ft

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

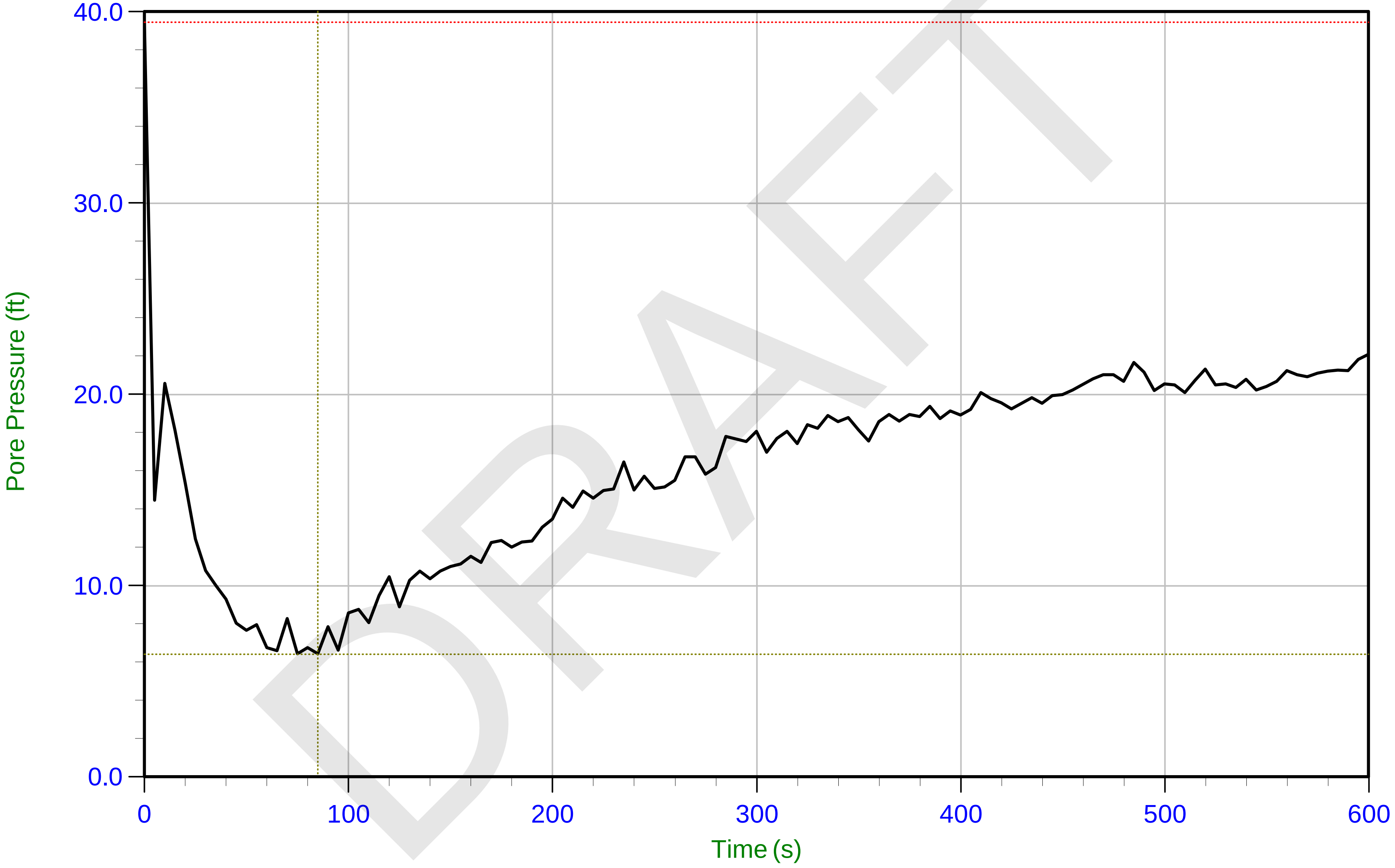
U Min: 15.9 ft
U Max: 176.1 ft

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

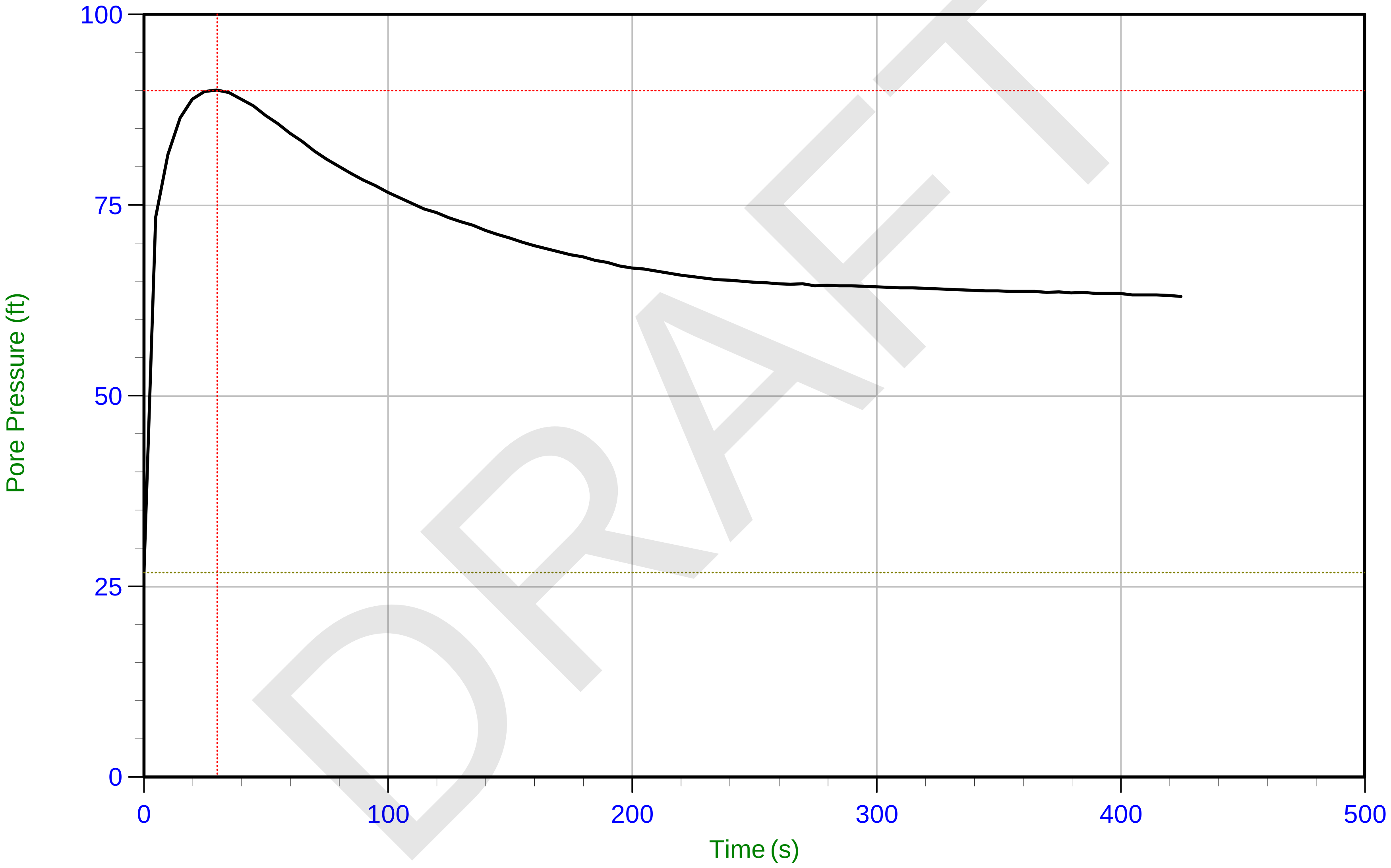
WT: 19.471 m / 63.882 ft
Ueq: 21.4 ft

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

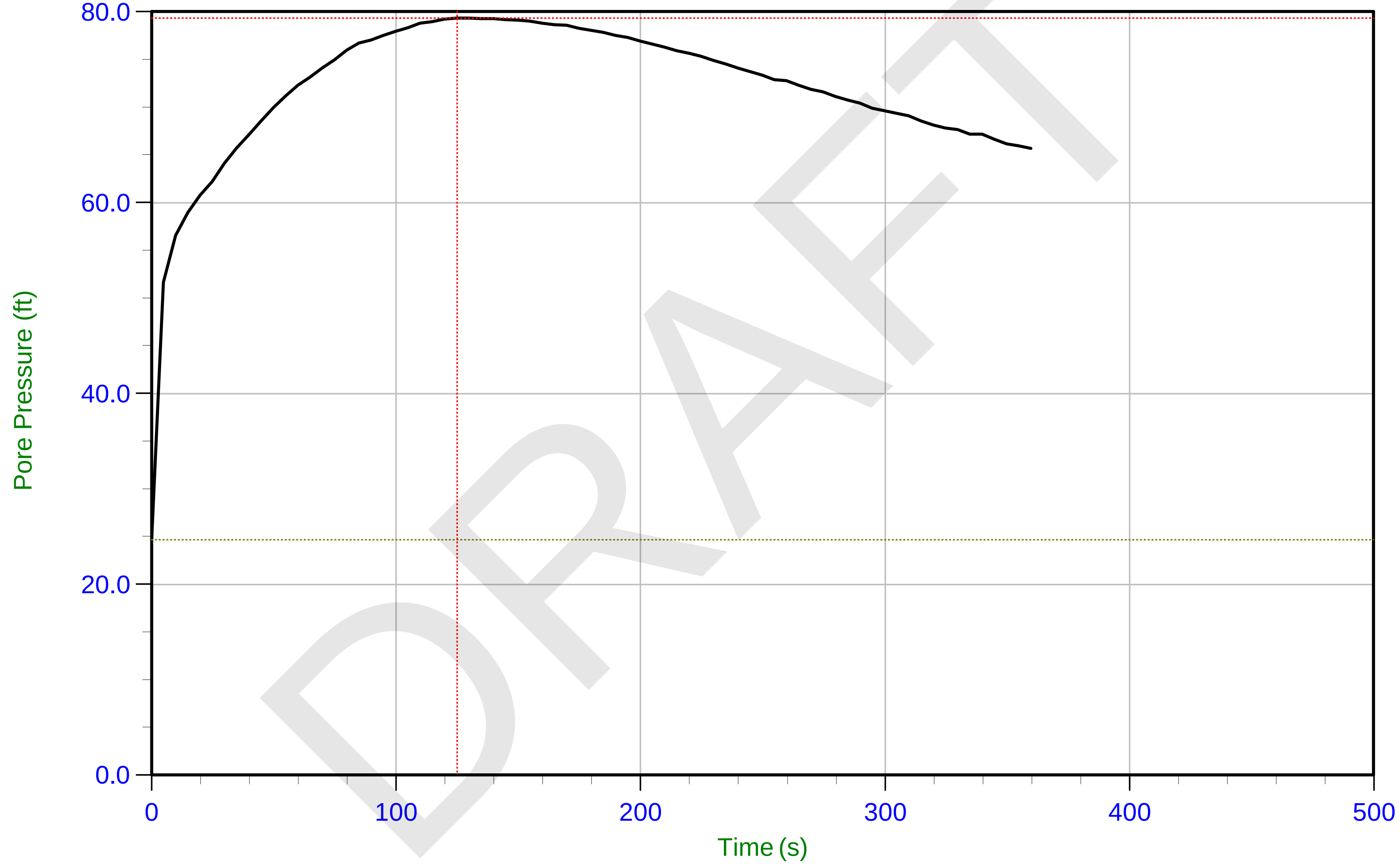


Trace Summary:

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



Trace Summary:

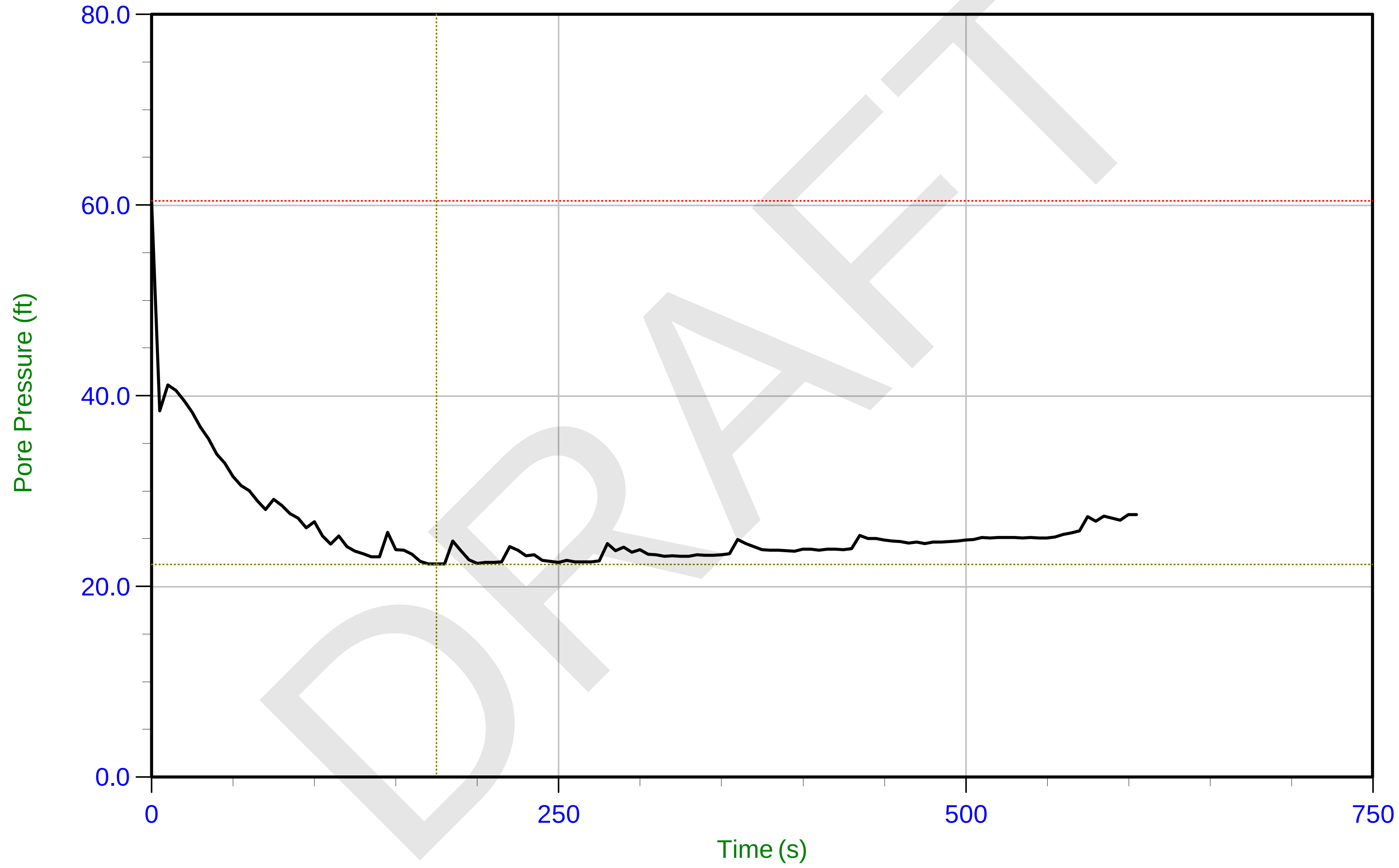
Filename: 15-54071_CP JOP-C034.PPD
Depth: 16.350 m / 53.641 ft
Duration: 360.0 s

U Min: 24.7 ft
U Max: 79.4 ft

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

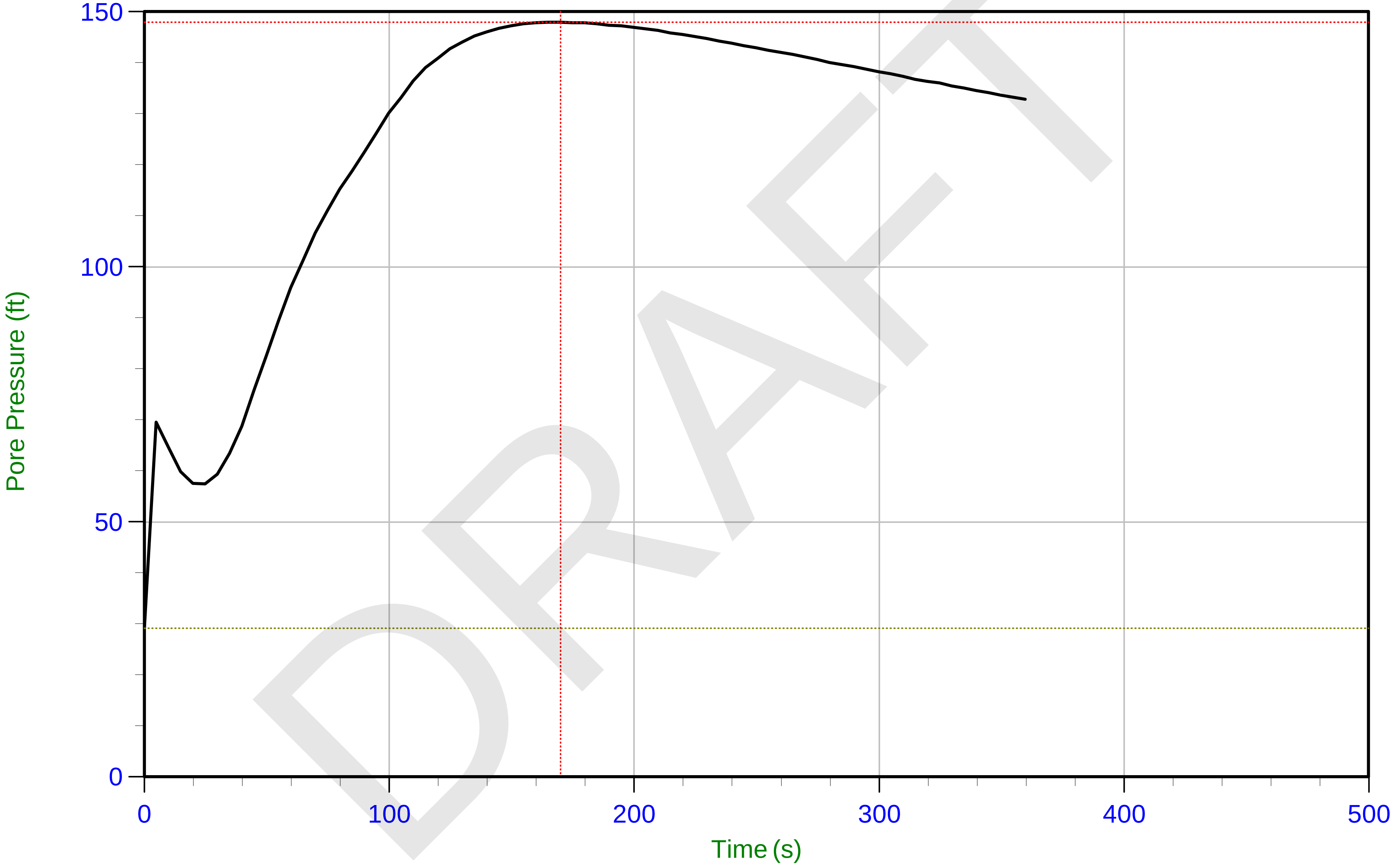
U Min: 22.4 ft
U Max: 60.5 ft

WT: 16.113 m / 52.863 ft
Ueq: 25.5 ft

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

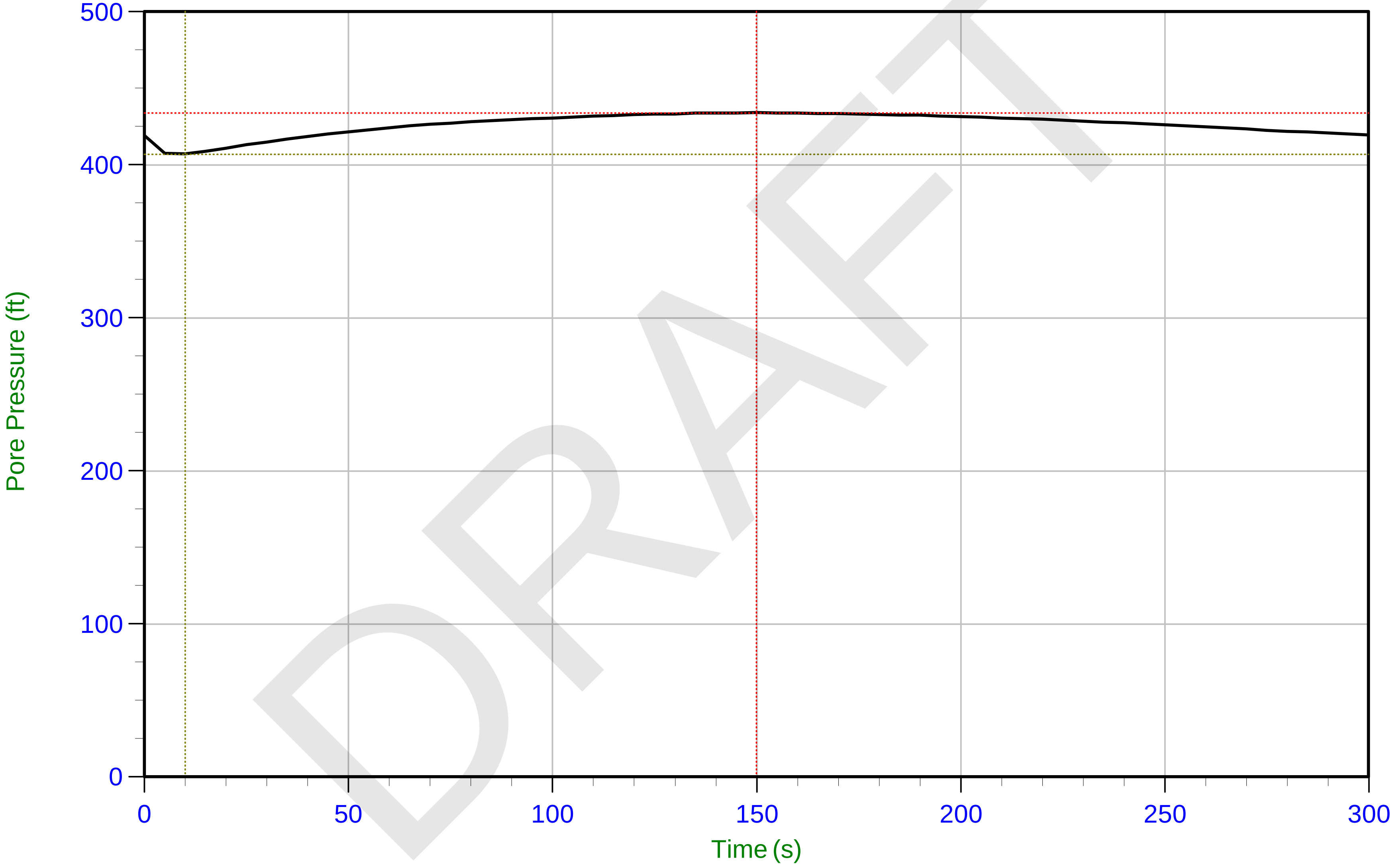
U Min: 29.2 ft
U Max: 148.0 ft

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

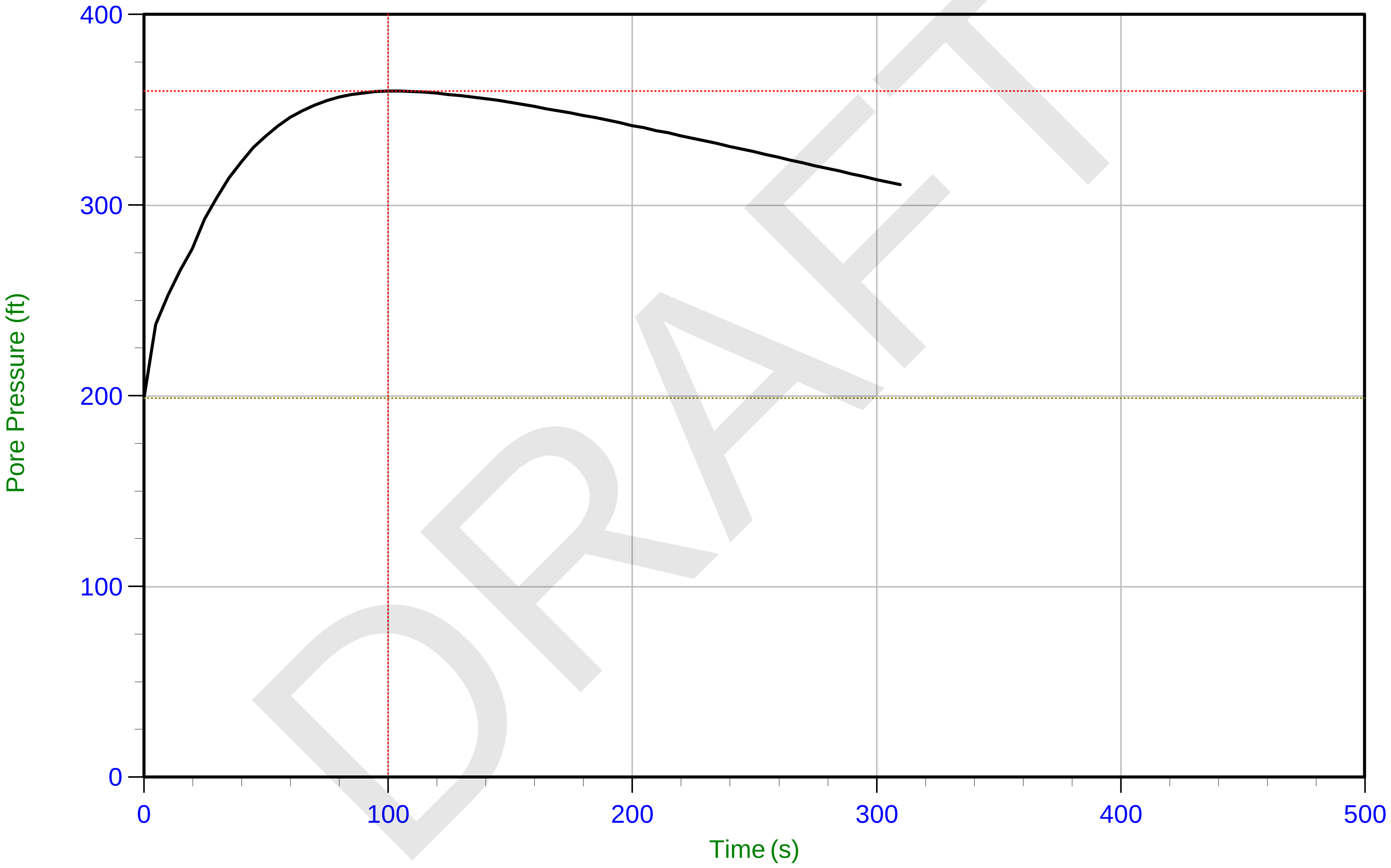
U Min: 407.1 ft
U Max: 434.0 ft

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

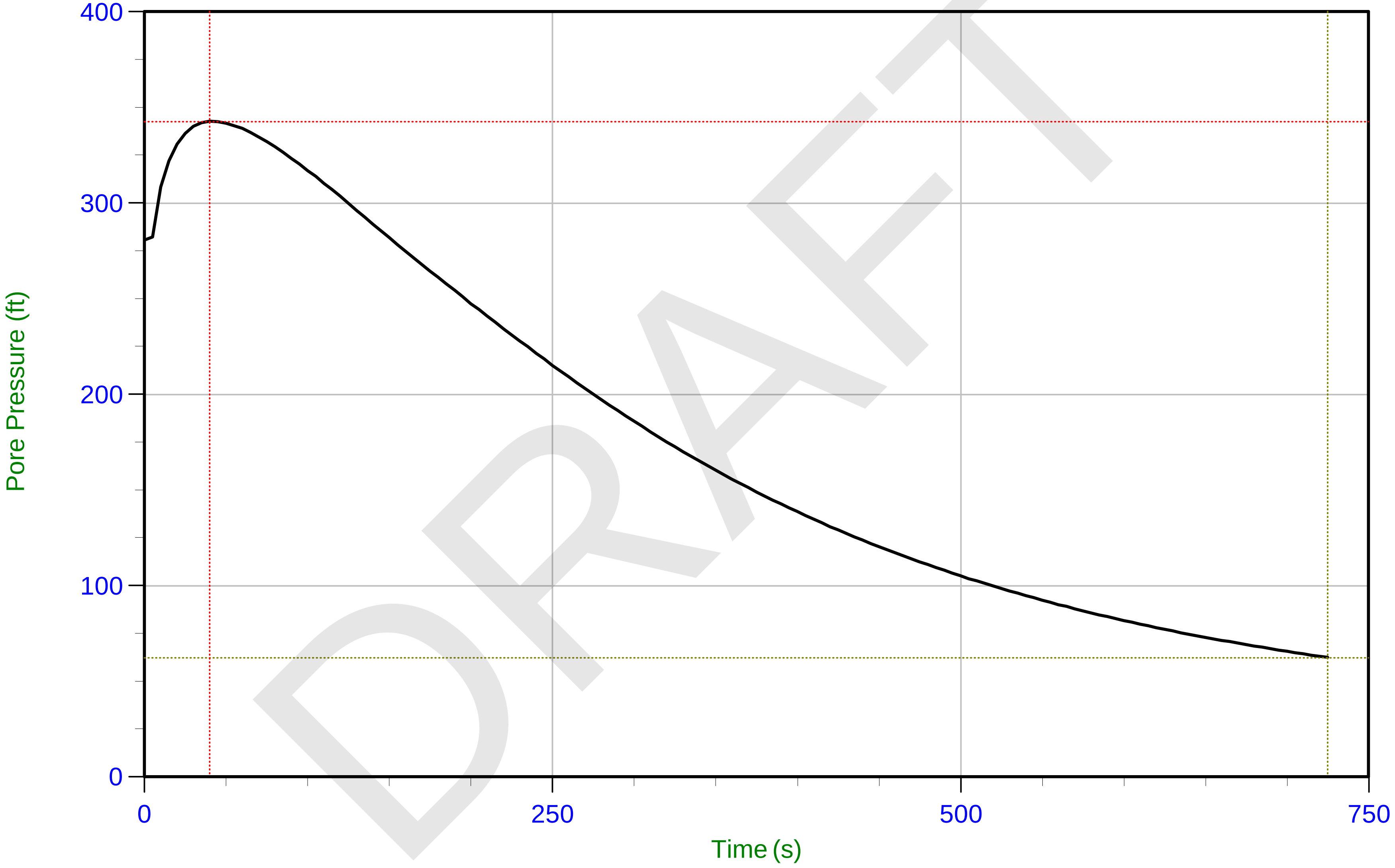
U Min: 198.8 ft
U Max: 360.0 ft

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

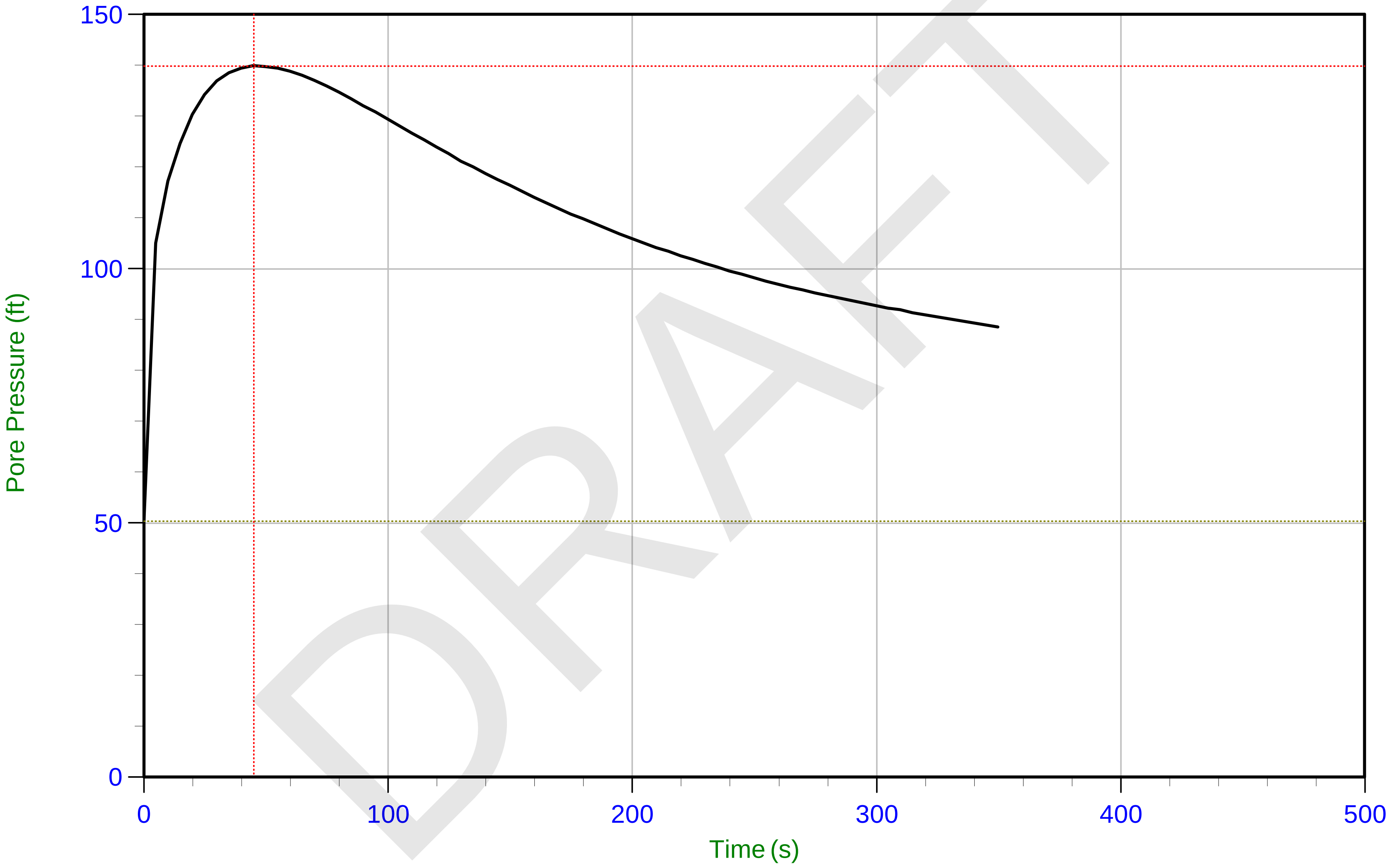
U Min: 62.4 ft
U Max: 342.7 ft

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:

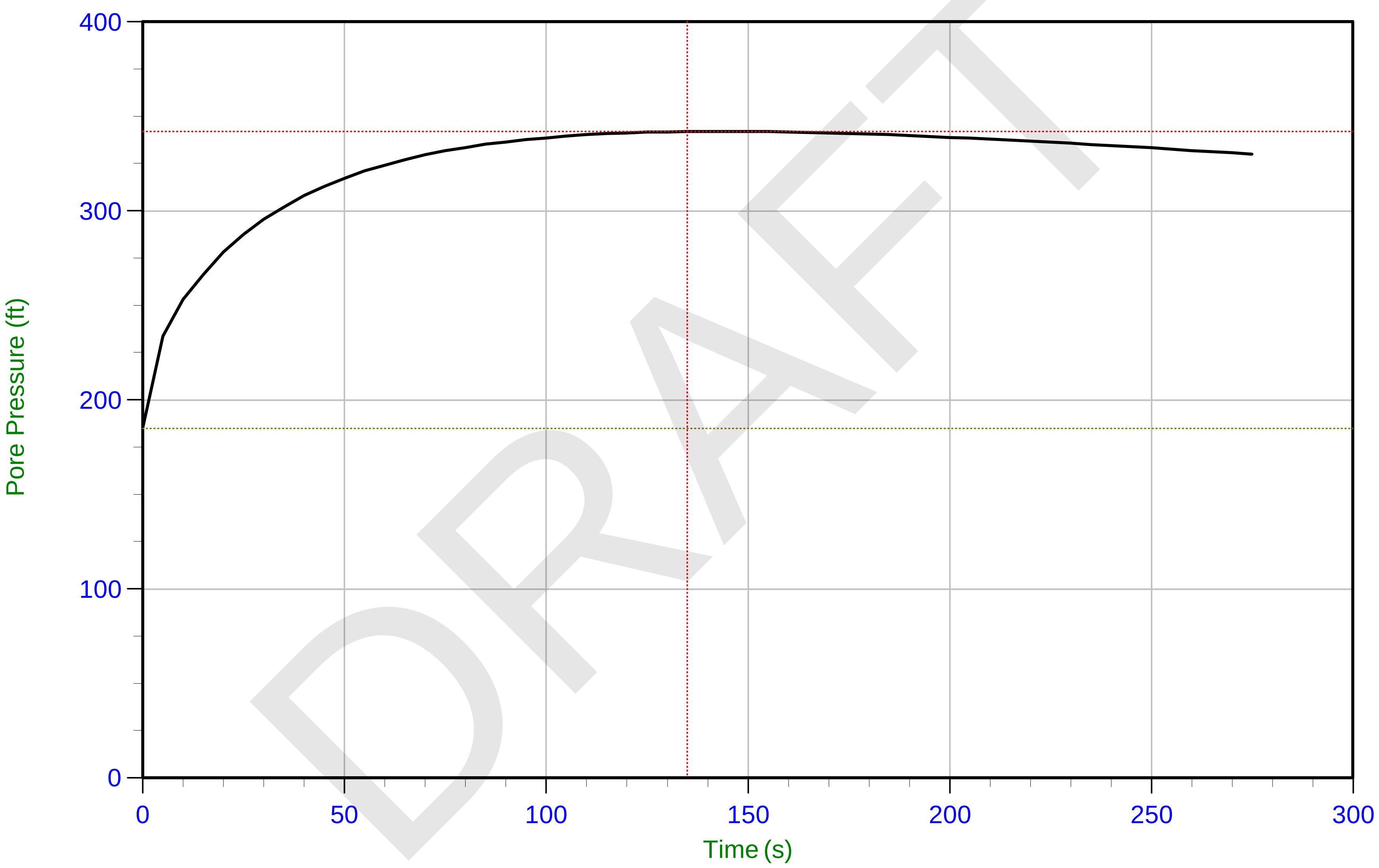
Filename: 15-54071_CP JOP-C036.PPD
Depth: 10.000 m / 32.808 ft
Duration: 350.0 s
U Min: 50.4 ft
U Max: 139.9 ft

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:

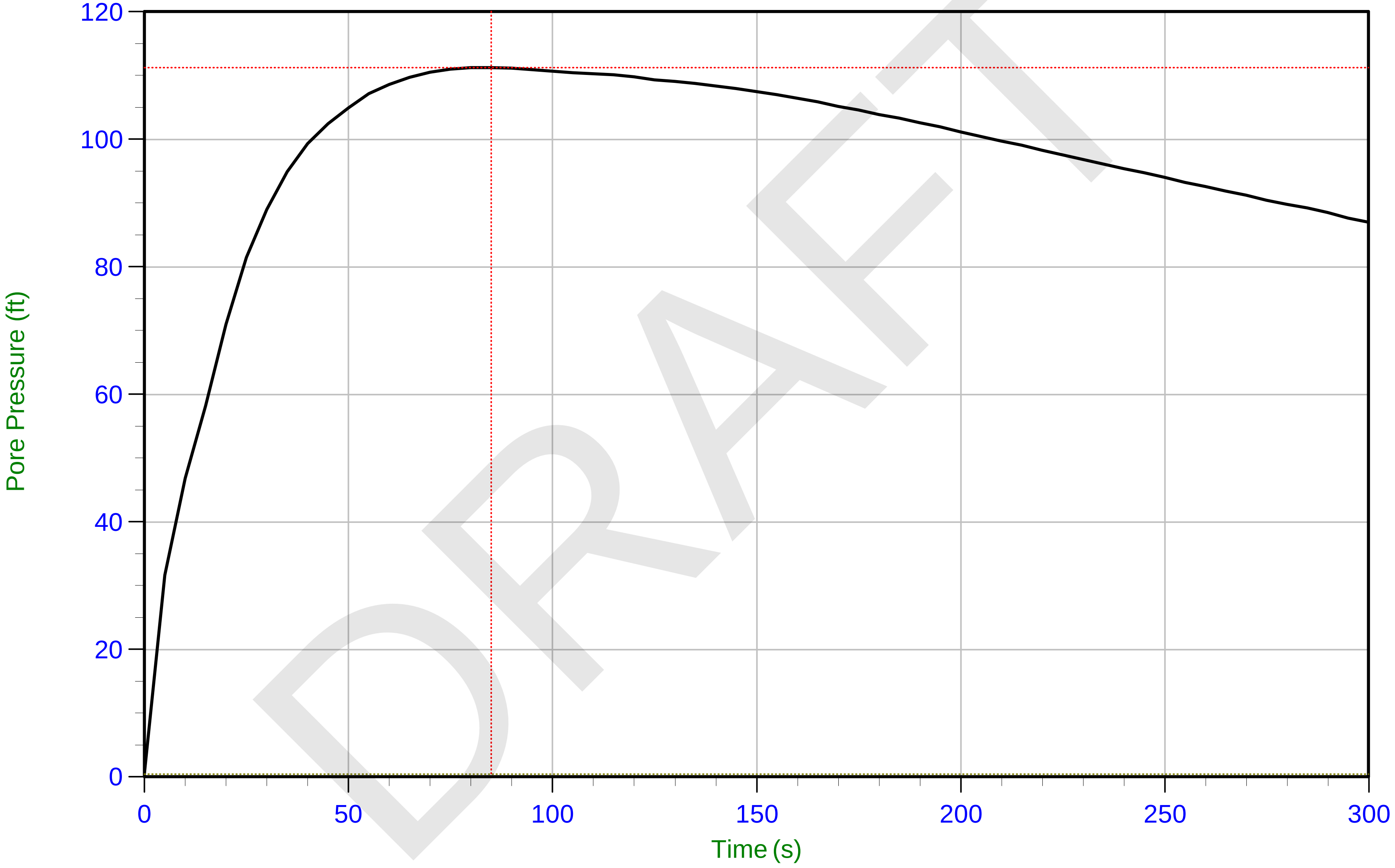
Filename: 15-54071_CP JOP-C036.PPD
Depth: 15.250 m / 50.032 ft
Duration: 275.0 s

U Min: 185.2 ft
U Max: 342.1 ft

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

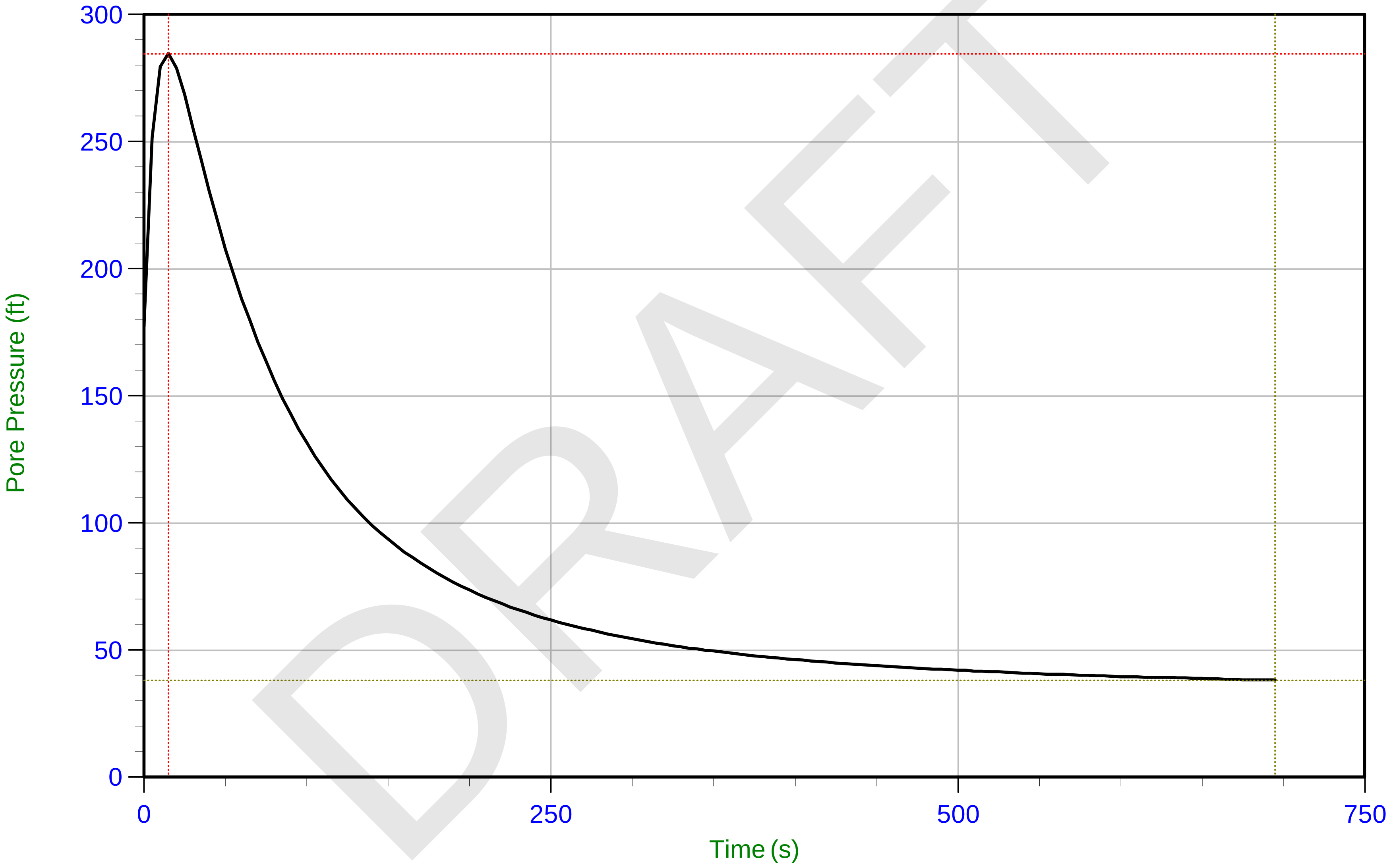
U Min: 0.5 ft
U Max: 111.3 ft

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_CPJOP-C037.PPD
Depth: 10.850 m / 35.597 ft
Duration: 695.0 s

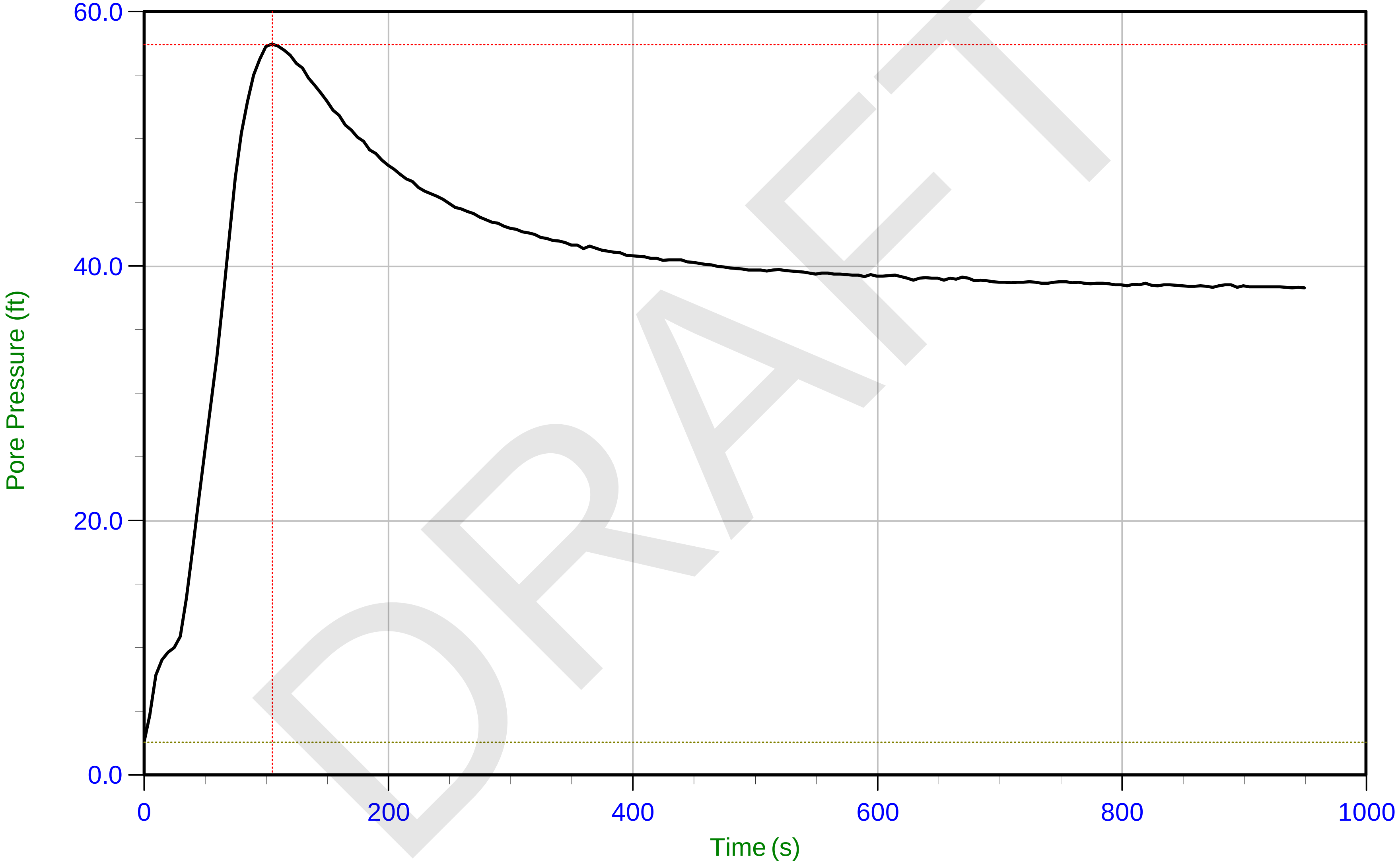
U Min: 38.2 ft
U Max: 284.6 ft

WT: 0.000 m / 0.000 ft
Ueq: 35.6 ft

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

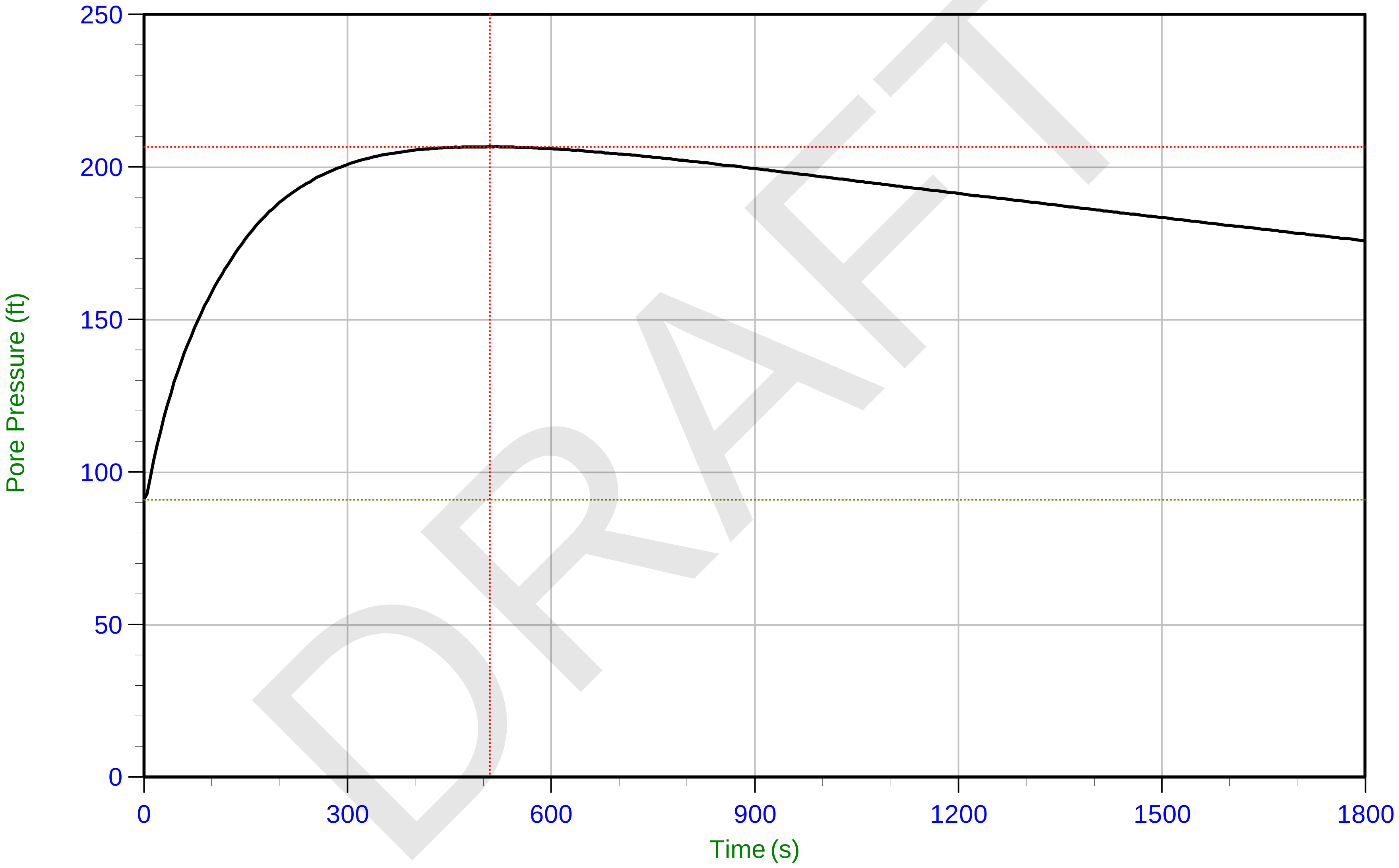


Trace Summary:	Filename: 15-54071_CP JOP-C037.PPD	U Min: 2.6 ft	WT: 0.519 m / 1.703 ft
	Depth: 12.200 m / 40.026 ft	U Max: 57.4 ft	Ueq: 38.3 ft
	Duration: 950.0 s		

AECOM

Job No: 15-54071
Date: 08/07/2015 11:37
Site: Dynegy Joppa IL

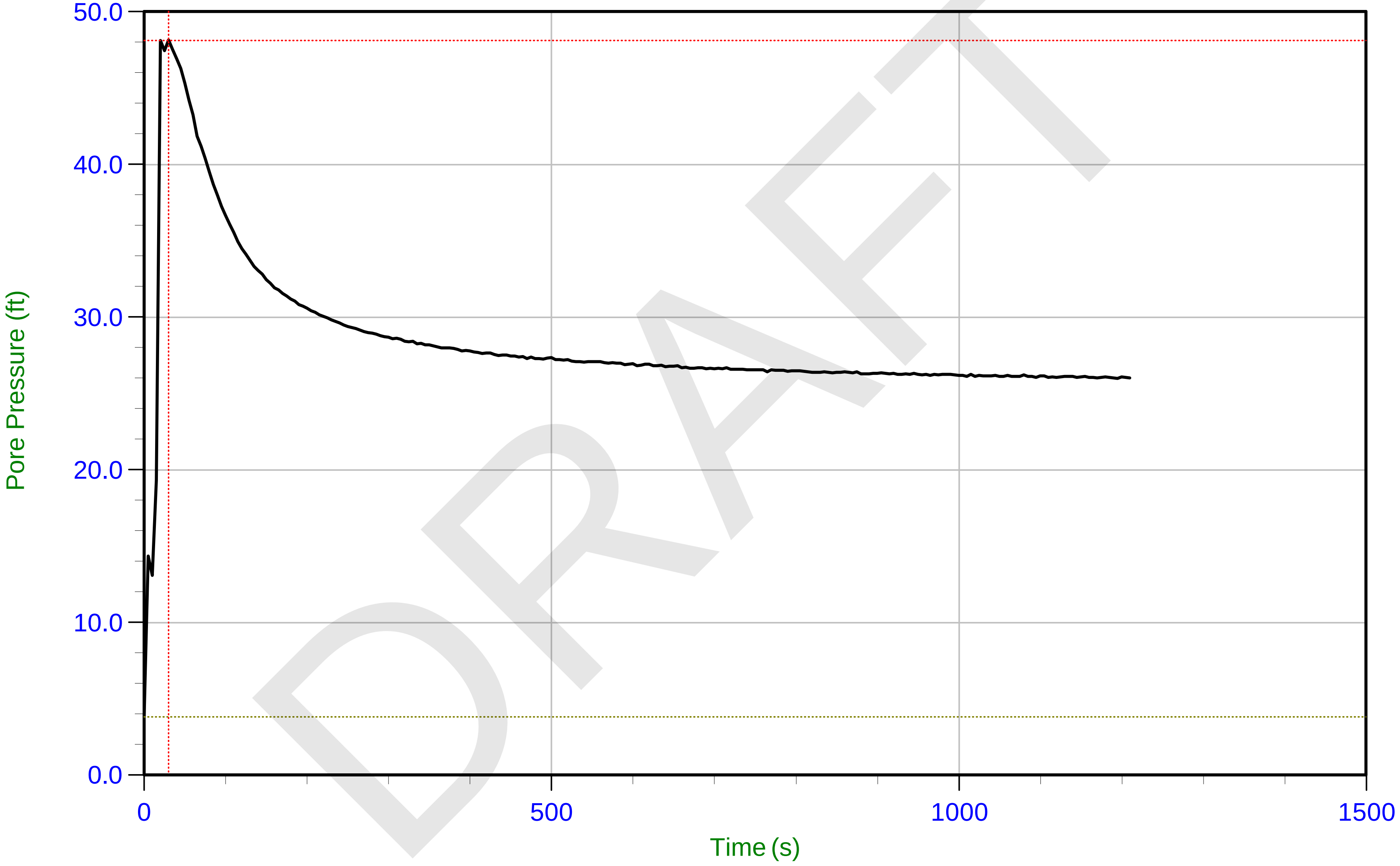
Sounding: JOP-SC002
Cone: 349:T1500F15U500
Cone Area: 15 sq cm



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

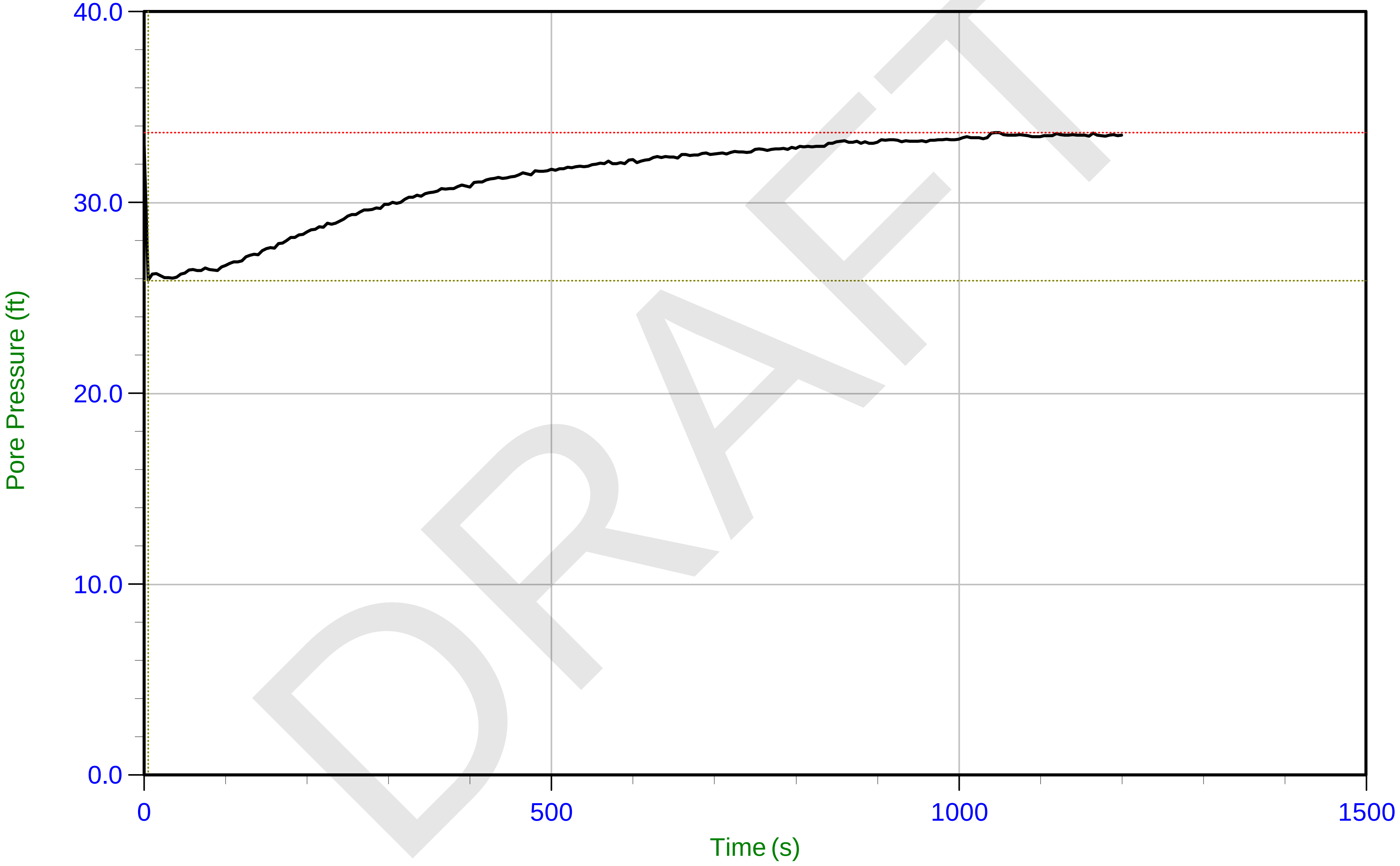


Trace Summary:

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



Trace Summary:

Filename: 15-54071_SP JOP-SC002.PPD
Depth: 30.300 m / 99.408 ft
Duration: 1200.0 s

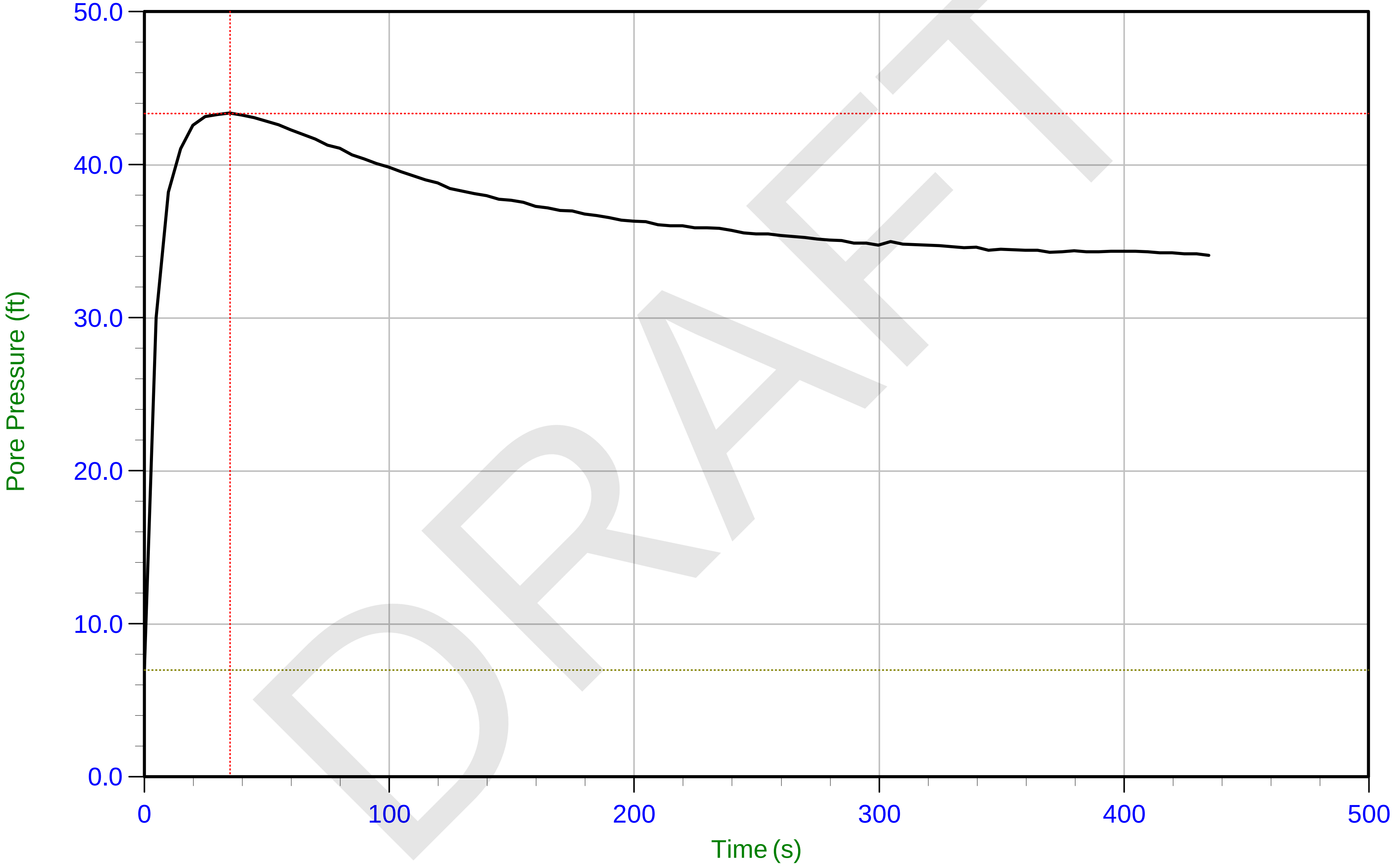
U Min: 25.9 ft
U Max: 33.7 ft

WT: 20.114 m / 65.989 ft
Ueq: 33.4 ft

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

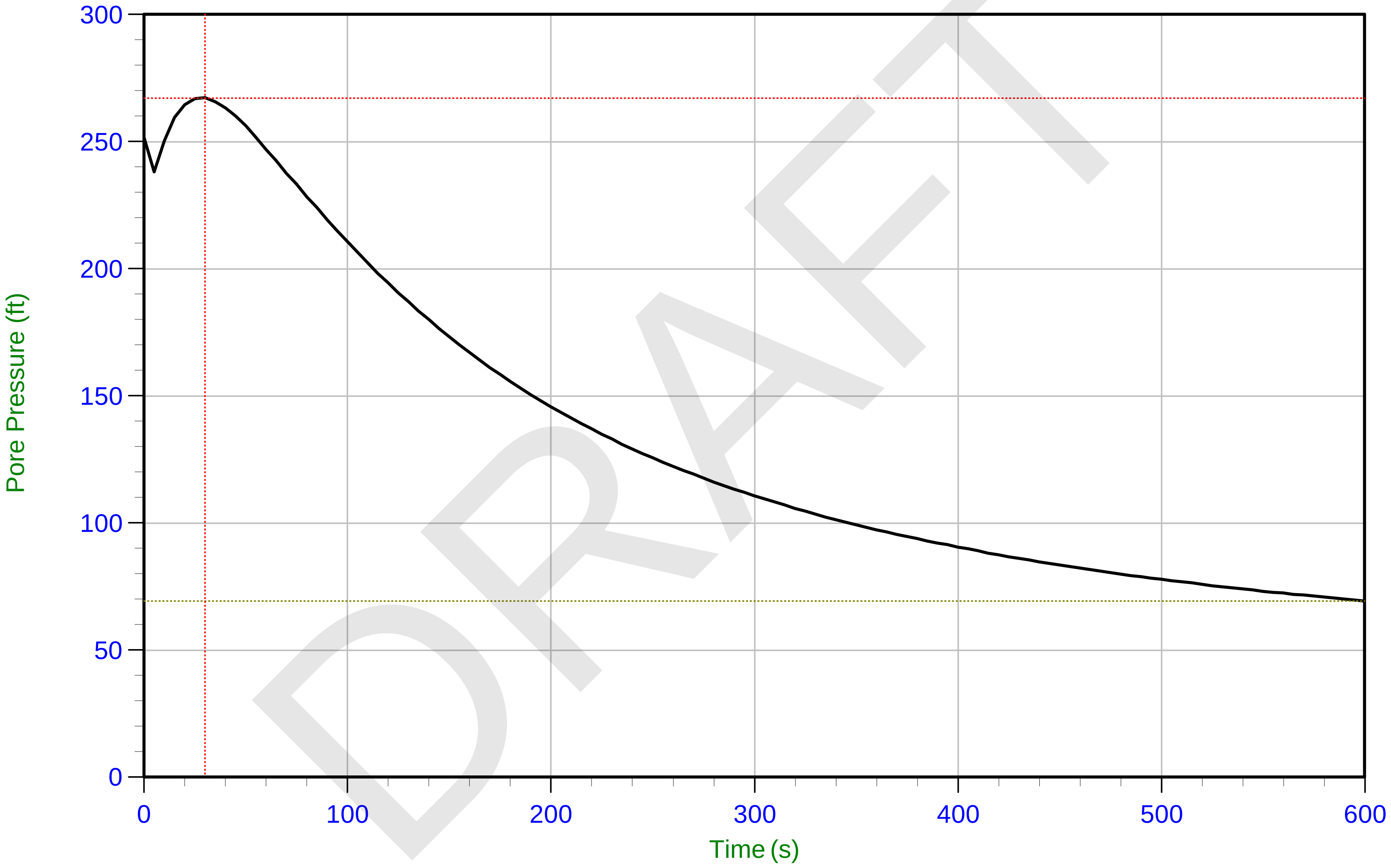
U Min: 7.0 ft
U Max: 43.4 ft

WT: 2.826 m / 9.272 ft
Ueq: 33.9 ft

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

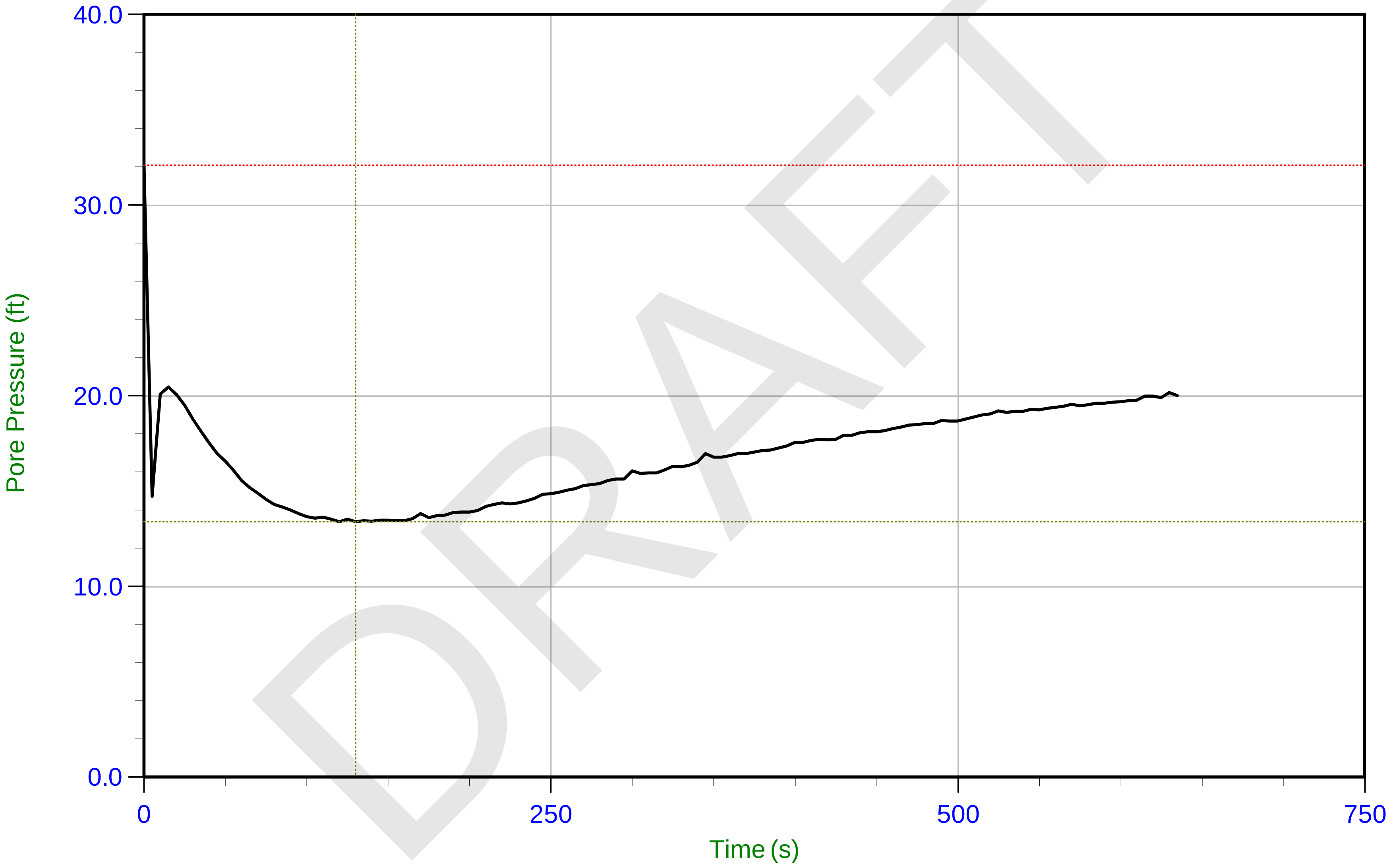
U Min: 69.4 ft
U Max: 267.3 ft

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

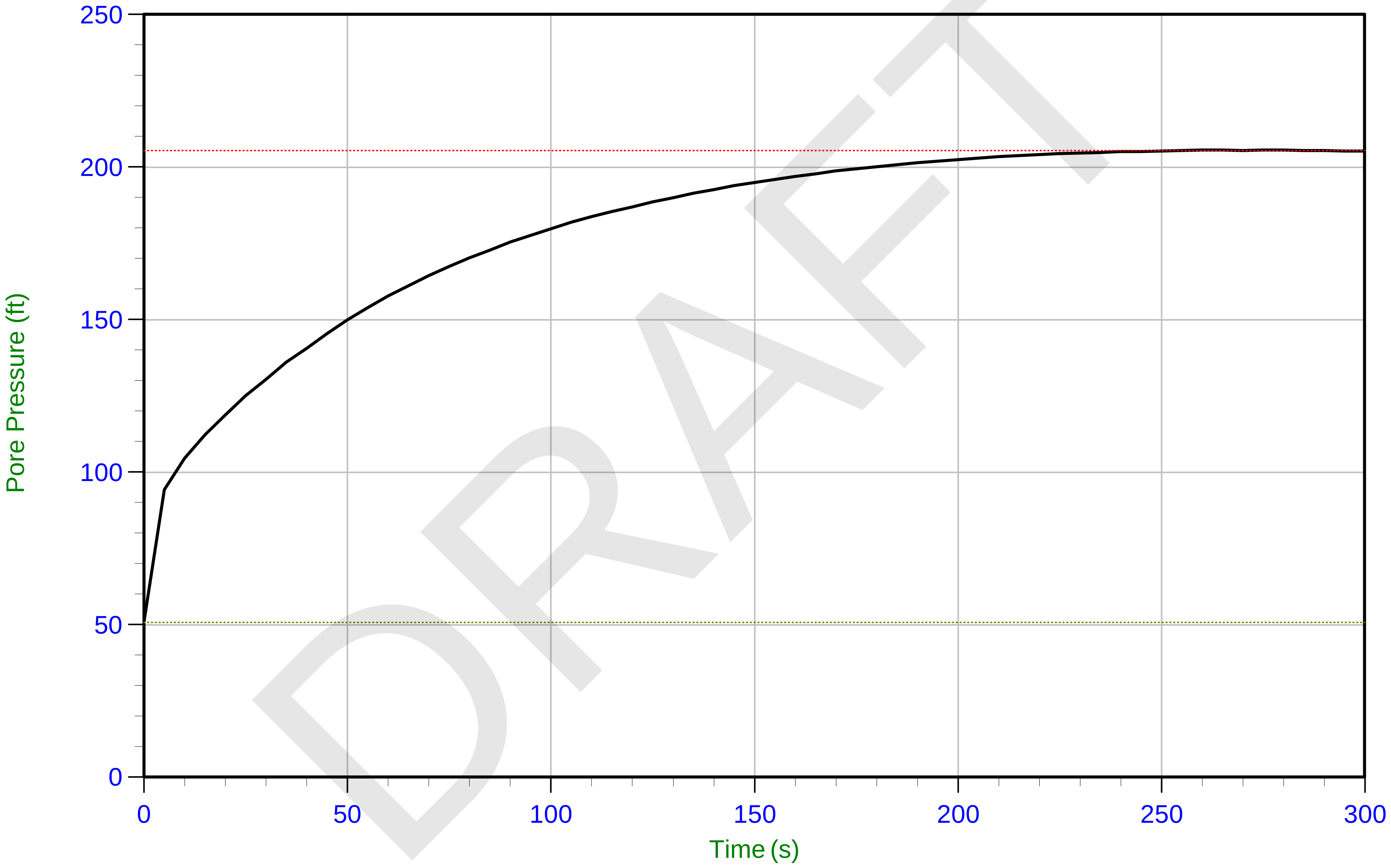
U Min: 13.4 ft
U Max: 32.1 ft

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:

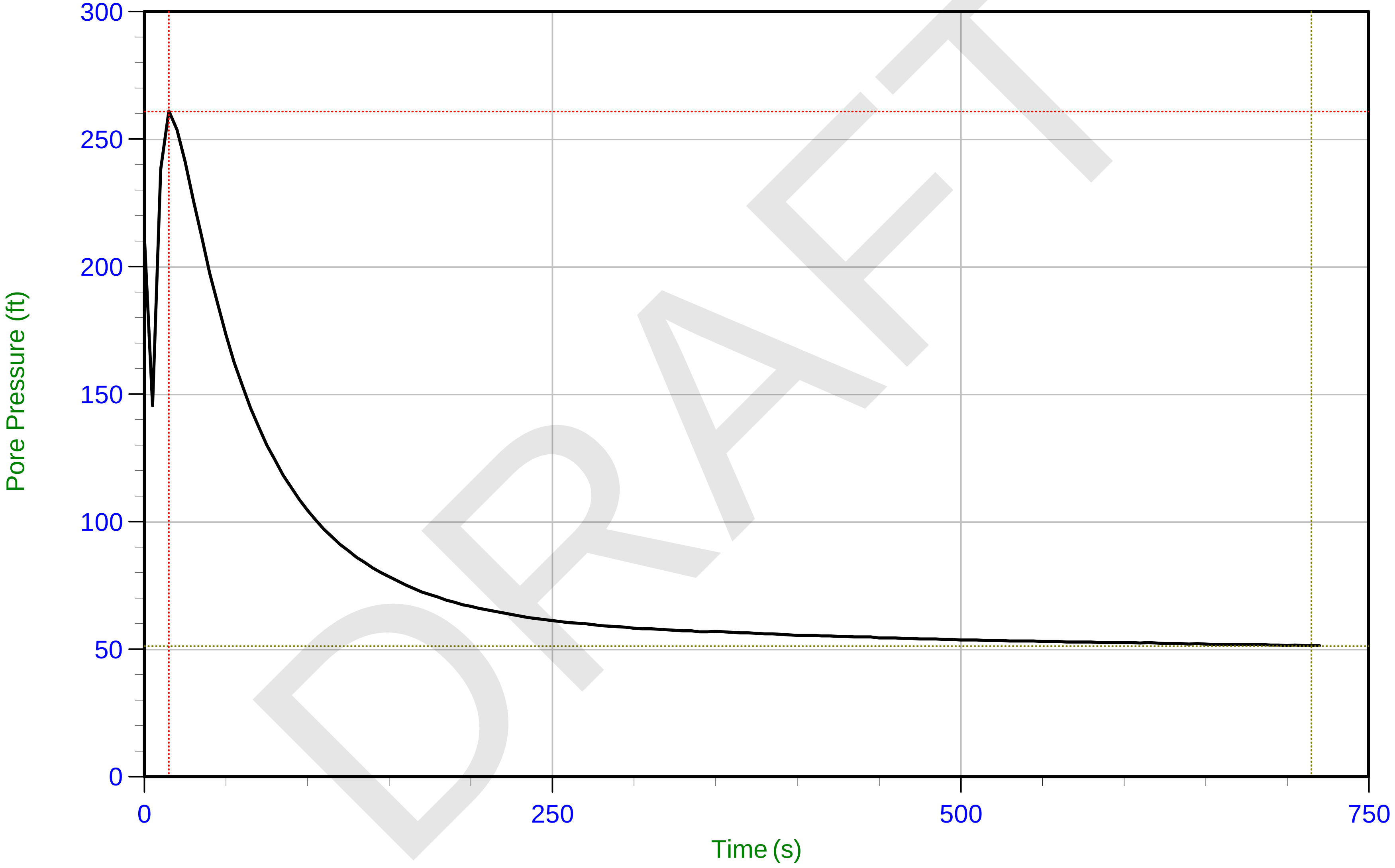
Filename: 15-54071_SP JOP-SC012A.PPD
Depth: 12.450 m / 40.846 ft
Duration: 300.0 s

U Min: 50.9 ft
U Max: 205.6 ft

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

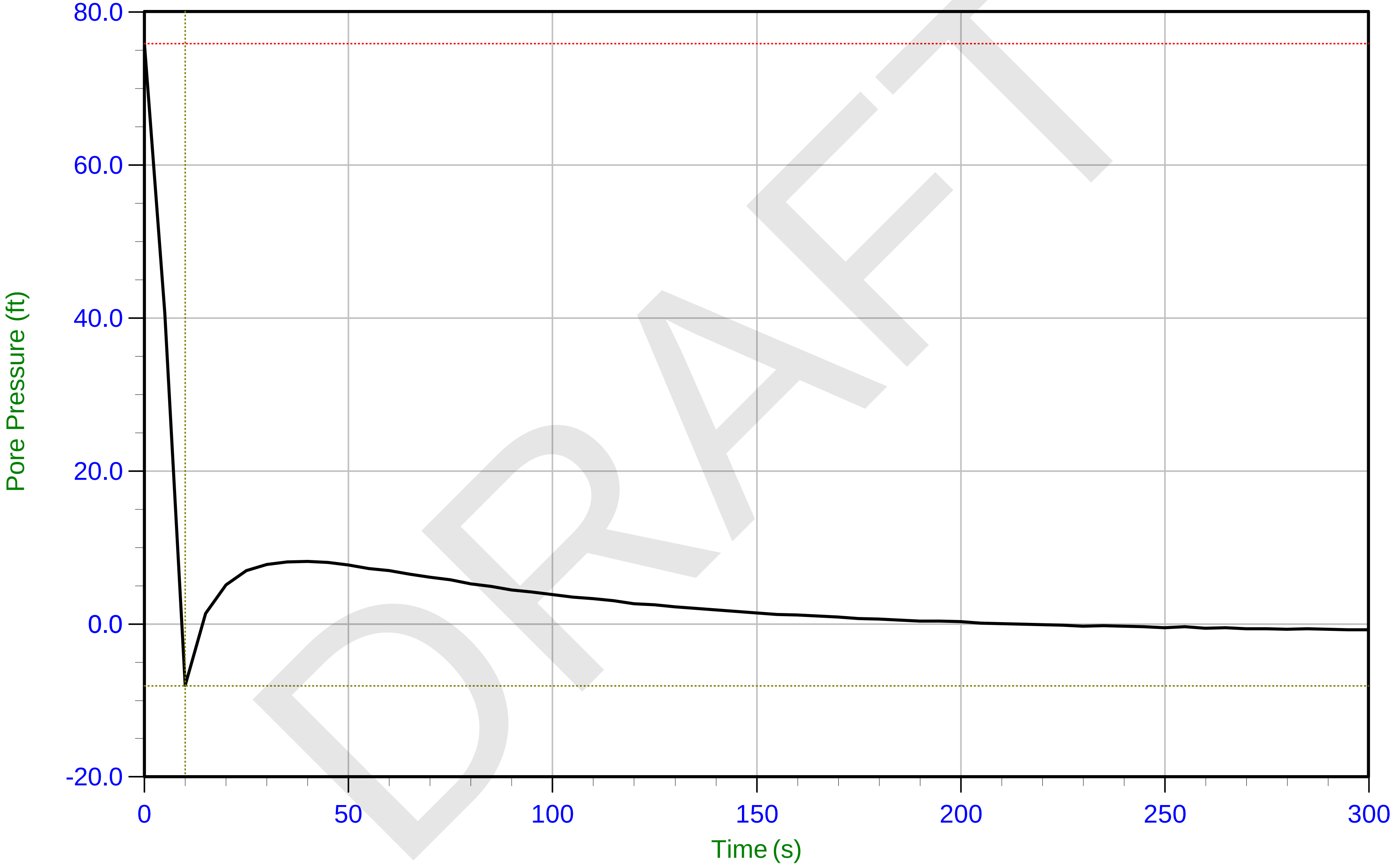


Trace Summary:

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

AECOM	Job No: 15-54071	Sounding: JOP-SC012A
	Date: 08/10/2015 08:43	Cone: 184:T1500F15U500
	Site: Dynegy Joppa IL	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
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 μm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	INITIAL CONDITIONS VOID RATIO (-)	SATUR-ATION (%)	
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
																		INITIAL CONDITIONS		
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	VOID RATIO (-)	SATUR-ATION (%)	
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
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 μm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	INITIAL CONDITIONS VOID RATIO (-)	INITIAL CONDITIONS SATUR-ATION (%)	
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			

Prepared by: YC
Reviewed by: GET
Date: 12/9/2015

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION INITIAL CONDITIONS		REMARKS
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	VOID RATIO (-)	SATUR-ATION (%)	
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
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 μm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	INITIAL CONDITIONS VOID RATIO (-)	SATUR-ATION (%)	
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
																		INITIAL CONDITIONS		
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	VOID RATIO (-)	SATUR-ATION (%)	
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

Prepared by: YC
Reviewed by: GET
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Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING NO.	SAMPLE NO.	DEPTH (ft)	IDENTIFICATION TESTS										PERMEABILITY (cm/sec)	STRENGTH				CONSOLIDATION		REMARKS
			WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)		TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	INITIAL CONDITIONS VOID RATIO (-)	SATUR-ATION (%)	
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 NO.	SAMPLE NO.	DEPTH (ft)	IDENTIFICATION TESTS WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	PERMEABILITY (cm/sec)	STRENGTH TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	CONSOLIDATION INITIAL CONDITIONS VOID RATIO (-)	SATUR-ATION (%)	REMARKS
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											

Prepared by: YC
Reviewed by: GET
Date: 12/9/2015

TerraSense, LLC
45H Commerce Way
Totowa, NJ 07512

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
																		INITIAL CONDITIONS		
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 μm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	VOID RATIO (-)	SATUR-ATION (%)	
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																	

Prepared by: YC
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Project No.: T60428794
File: Indx1.xlsx

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	INITIAL CONDITIONS VOID RATIO (-)	INITIAL CONDITIONS SATUR-ATION (%)	
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
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 μm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	INITIAL CONDITIONS VOID RATIO (-)	INITIAL CONDITIONS SATUR-ATION (%)	
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
																		INITIAL CONDITIONS		
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 μm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	VOID RATIO (-)	SATUR-ATION (%)	
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
																		INITIAL CONDITIONS		
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	VOID RATIO (-)	SATUR-ATION (%)	
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

Prepared by: YC
Reviewed by: GET
Date: 12/9/2015

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	INITIAL CONDITIONS VOID RATIO (-)	INITIAL CONDITIONS SATUR-ATION (%)	
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																	

Prepared by: YC
Reviewed by: GET
Date: 12/9/2015

AECOM #60428794-107
Dynegy CCR - Joppa
LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS										PERMEABILITY	STRENGTH				CONSOLIDATION		REMARKS
																		INITIAL CONDITIONS		
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 µm (%)	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY (-)	(cm/sec)	TEST TYPE @ STRESS (ksf)	PEAK SHEAR STRESS (ksf)	STRAIN @ PEAK STRESS (%)	RESIDUAL SHEAR STRESS (ksf)	VOID RATIO (-)	SATUR-ATION (%)	
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.

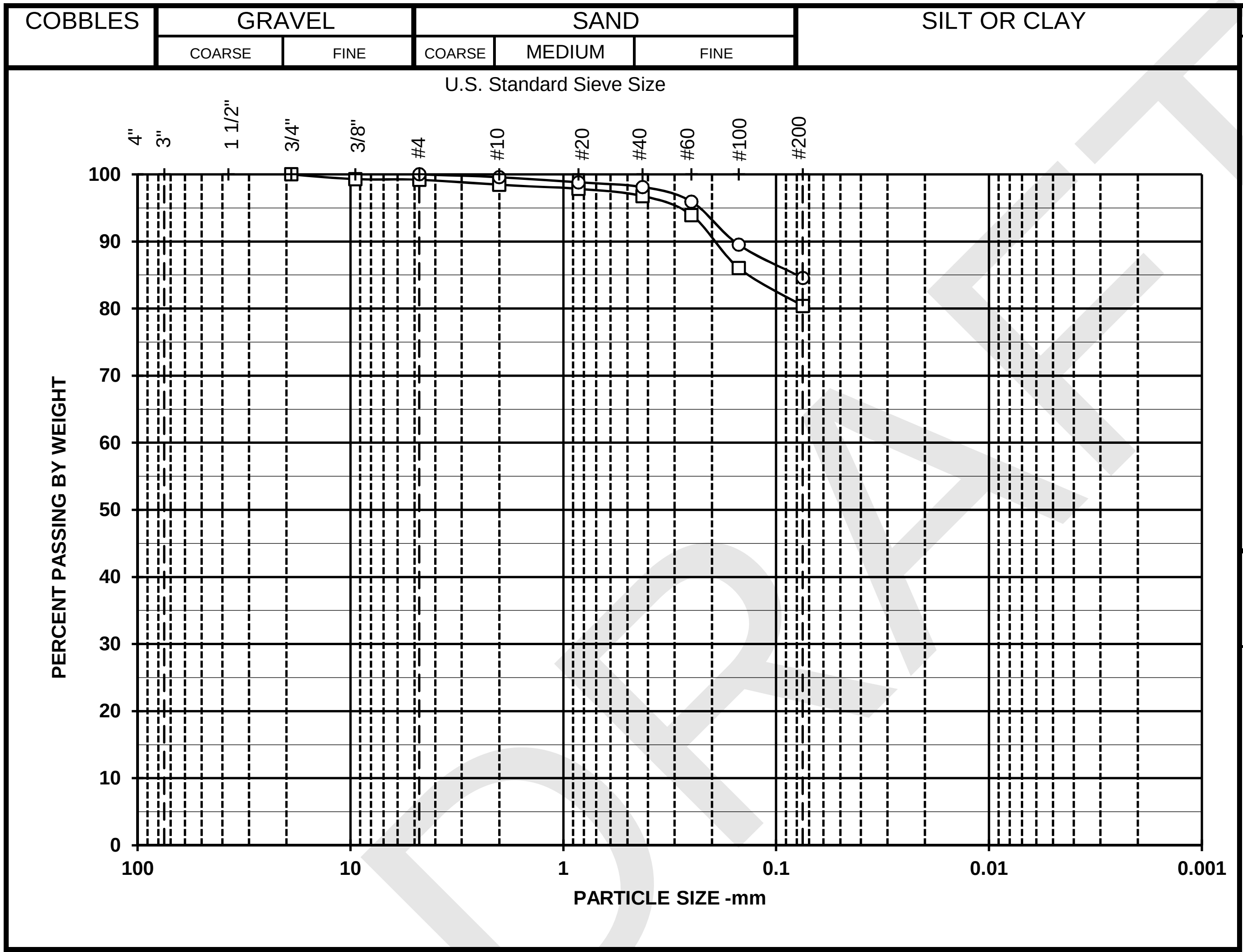
AECOM #60428794-107
Dynegy CCR - Joppa
Summary of Corrosion Testing

SAMPLE ID			RESISTIVITY TESTS					CHEMICAL TESTS							REMARKS
Boring No.	Sample No.	Depth	Test Method	As-Received		@ Minimum Resistivity		pH ASTM G51		Awwa Appendix A					
				Water Content	Resistivity	Water Content	Resistivity			Redox Potential				Sulfide Response	
								pH	Temperature	R1	R2	R3	Average		
		(ft)		(%)	(kΩ - cm)	(%)	(kΩ - cm)	(pH units)	(°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

Project No. T60428794
File: CorrosionSuite.xlsx



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 (Sieve #)	PERCENT FINER □	PERCENT FINER ■	PERCENT FINER ○
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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Dynegy CCR - Joppa

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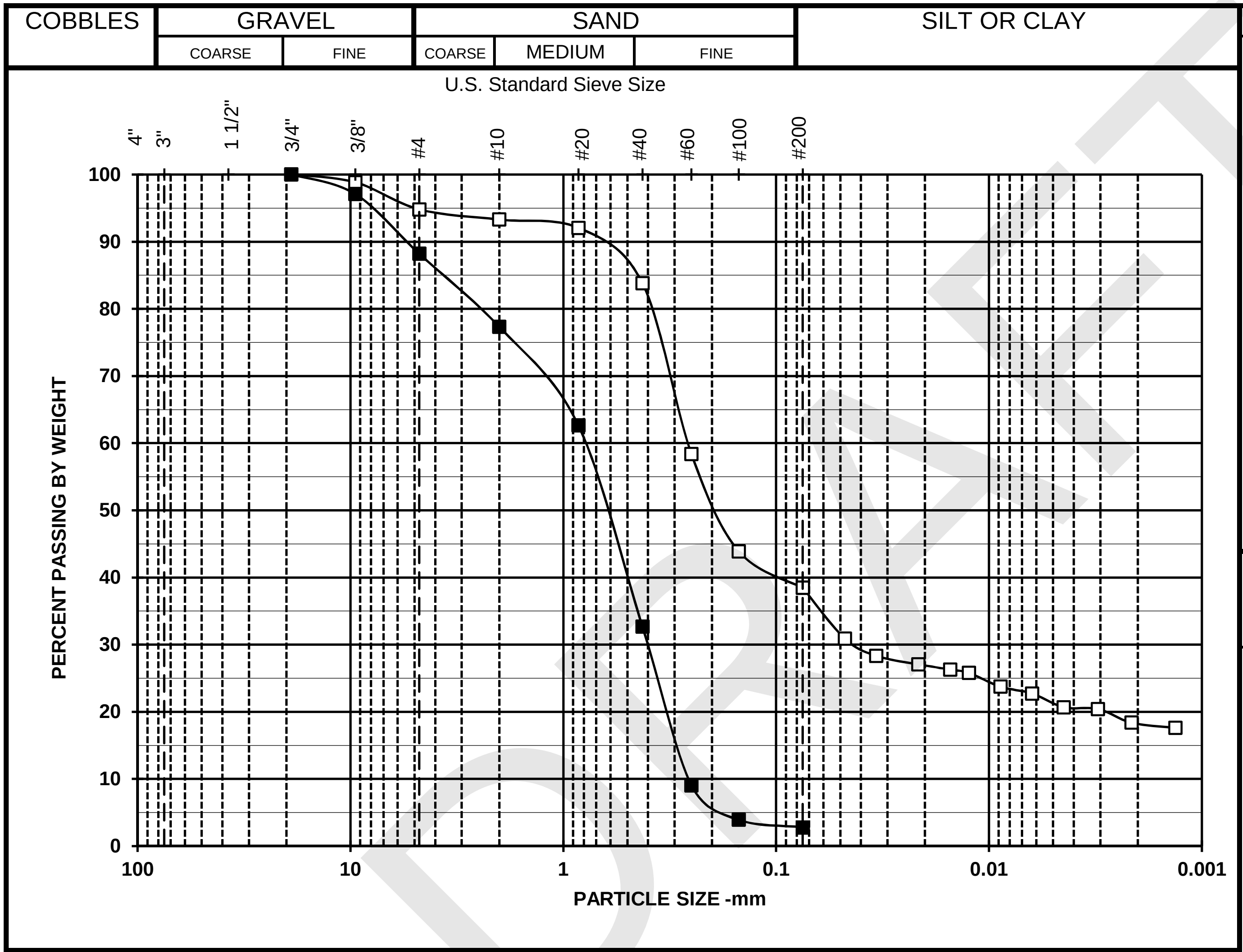

Symbol	□	■	○
Boring	JOP-B001	JOP-B001	
Sample	ST-4C	S-8	
Depth	44.35	48.5-50	
% +3"	0.0	0.0	
% Gravel	5.2	11.8	
% SAND	56.3	85.4	
%C SAND	1.5	10.9	
%M SAND	9.5	44.6	
%F SAND	45.3	29.9	
% FINES	38.5	2.8	
% -2μ	18		
D_{100} (mm)	19.00	19.00	
D_{60} (mm)	0.26	0.81	
D_{30} (mm)	0.04	0.41	
D_{10} (mm)		0.26	
Cc		0.8	
Cu		3.2	

Particle Size (Sieve #)	PERCENT FINER □	PERCENT FINER ■	PERCENT FINER ○
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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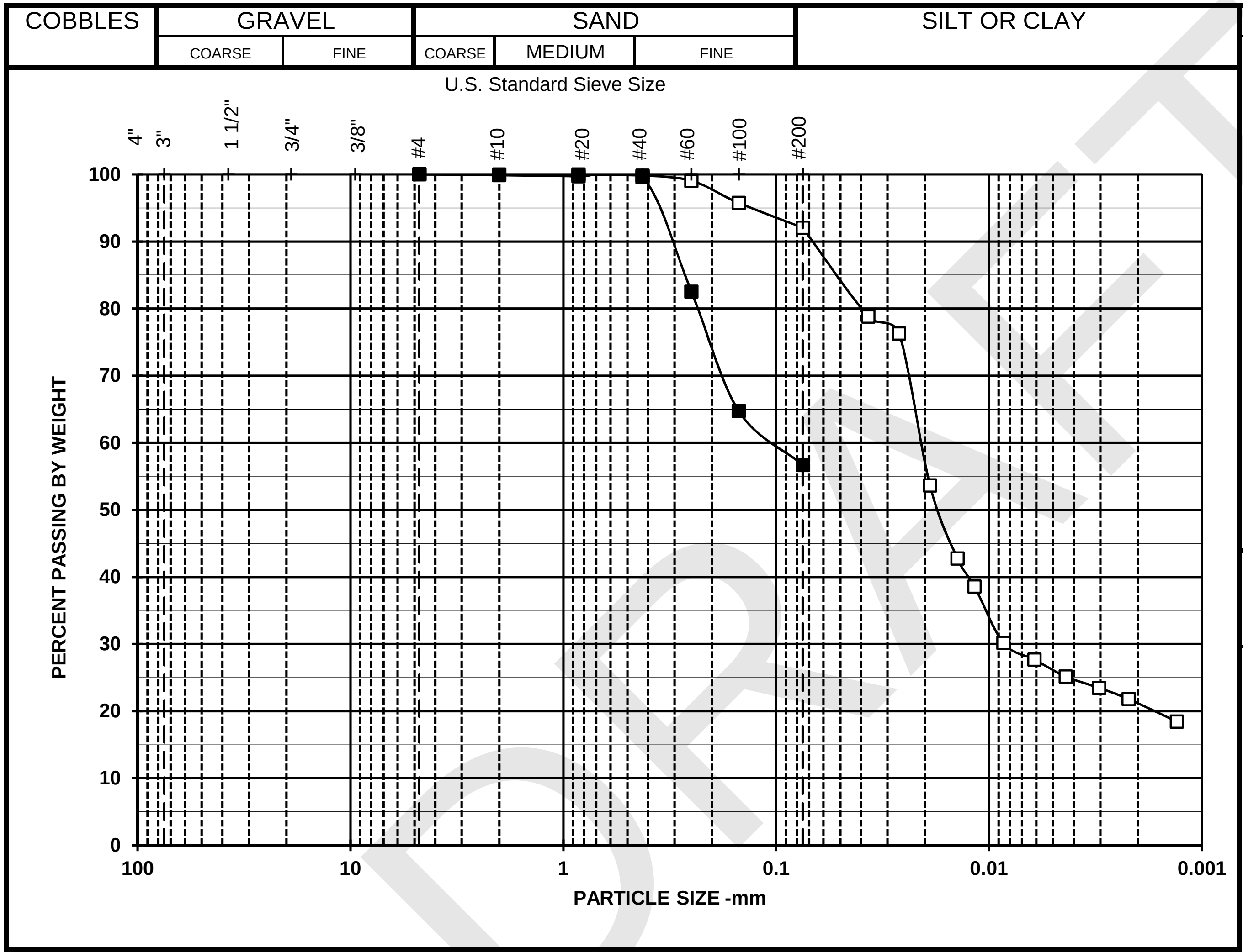
PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa



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	

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
○							

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Dynegy CCR - Joppa

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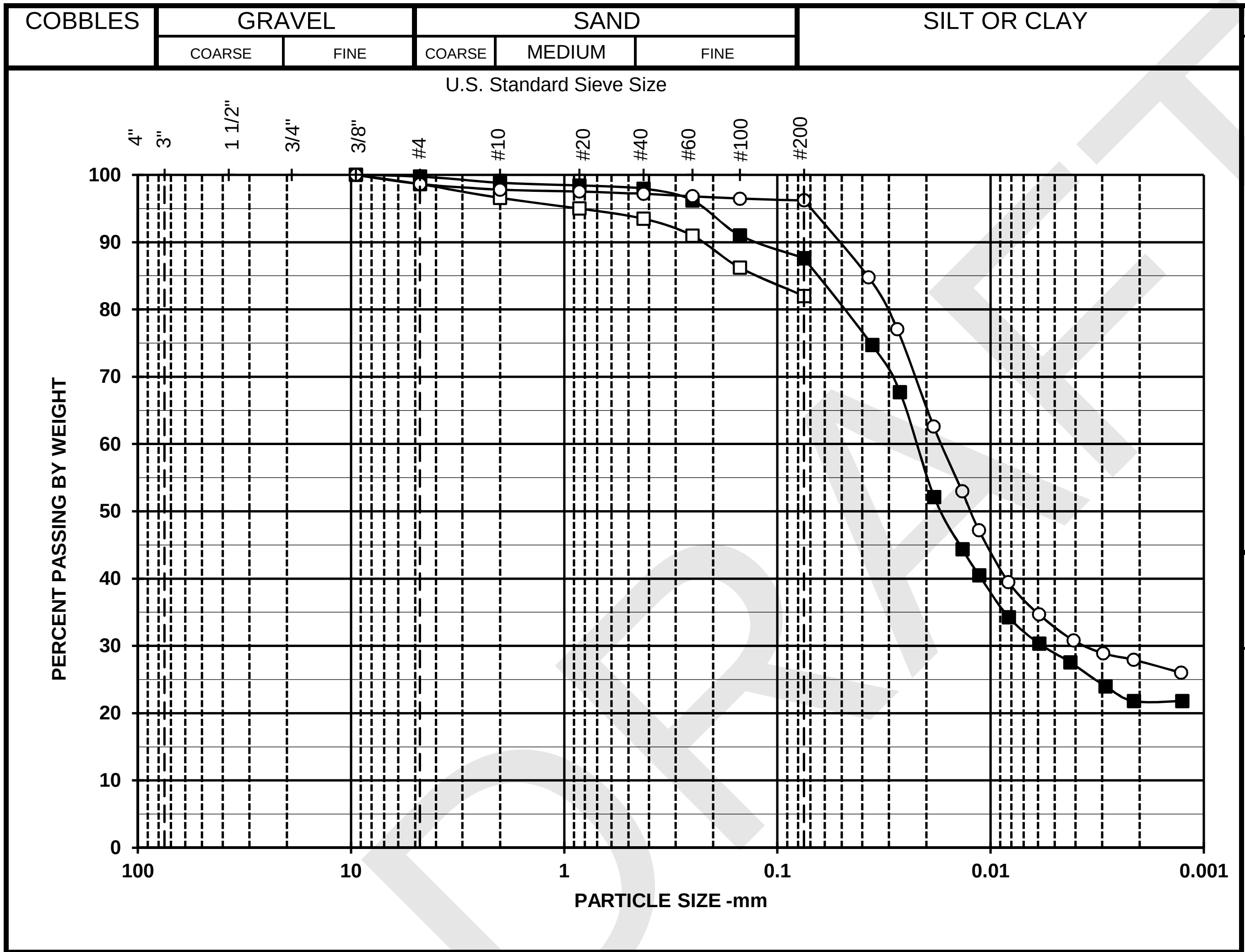

Symbol	□	■	○
Boring	JOP-B003	JOP-B003	JOP-B003
Sample	ST-1B	S-4	ST-3B
Depth	3.5	28.5-30	34.25
% +3"	0.0	0.0	0.0
% Gravel	1.4	0.3	1.4
% SAND	16.6	12.1	2.4
%C SAND	2.1	0.9	0.8
%M SAND	3.1	0.9	0.6
%F SAND	11.5	10.3	1.0
% FINES	82.0	87.6	96.2
% -2µ		22	28
D_{100} (mm)	9.50	9.50	9.50
D_{60} (mm)		0.02	0.02
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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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

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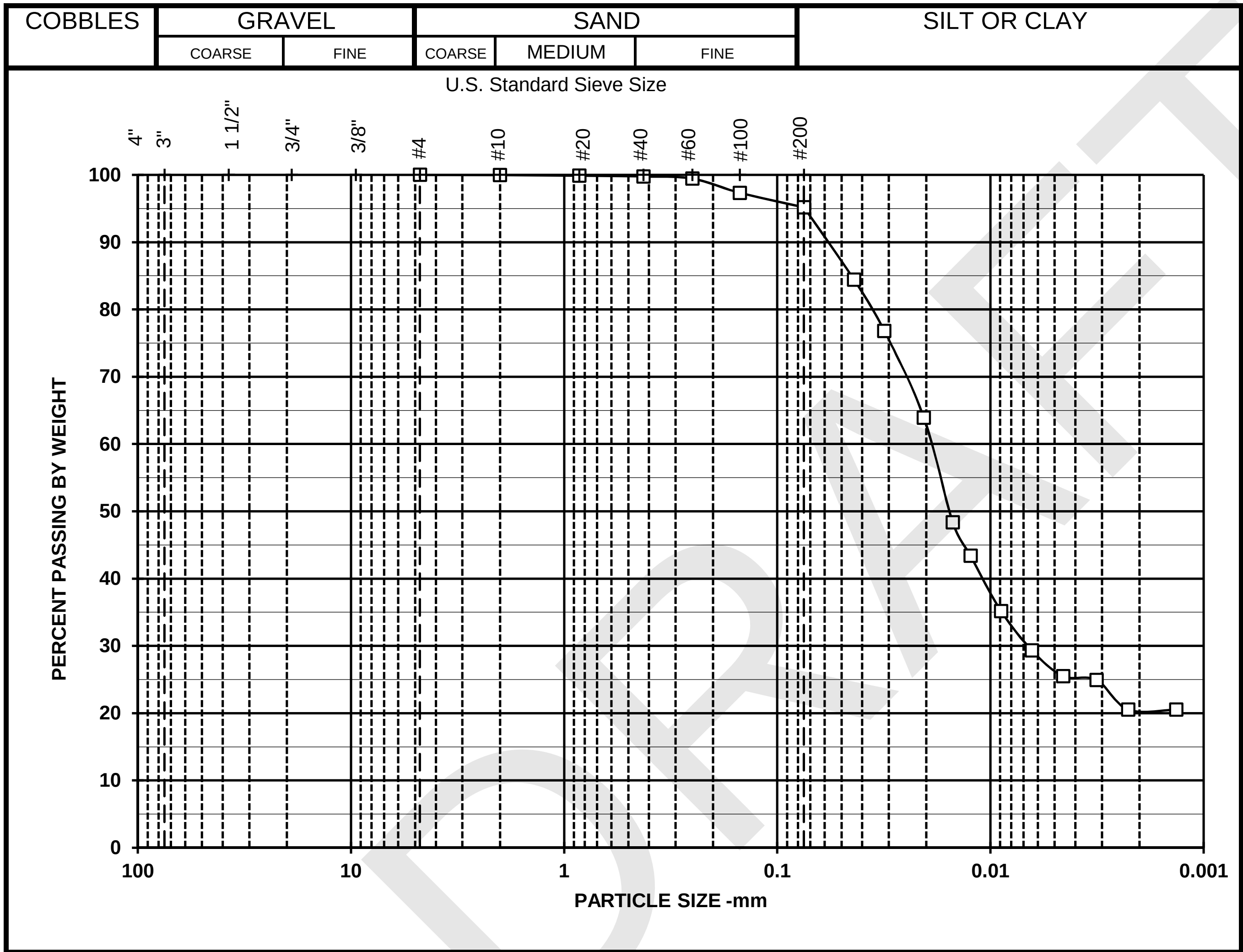

Symbol	☐	■	○
Boring	JOP-B003		
Sample	S-7		
Depth	48.5-50		
% +3"	0.0		
% Gravel	0.0		
% SAND	4.8		
%C SAND	0.0		
%M SAND	0.2		
%F SAND	4.6		
% FINES	95.2		
% -2µ	21		
D_{100} (mm)	4.75		
D_{60} (mm)	0.02		
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

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
■							
○							

TerraSense, LLC	**AECOM**
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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

Analysis File: 3SV-MasterRev4b

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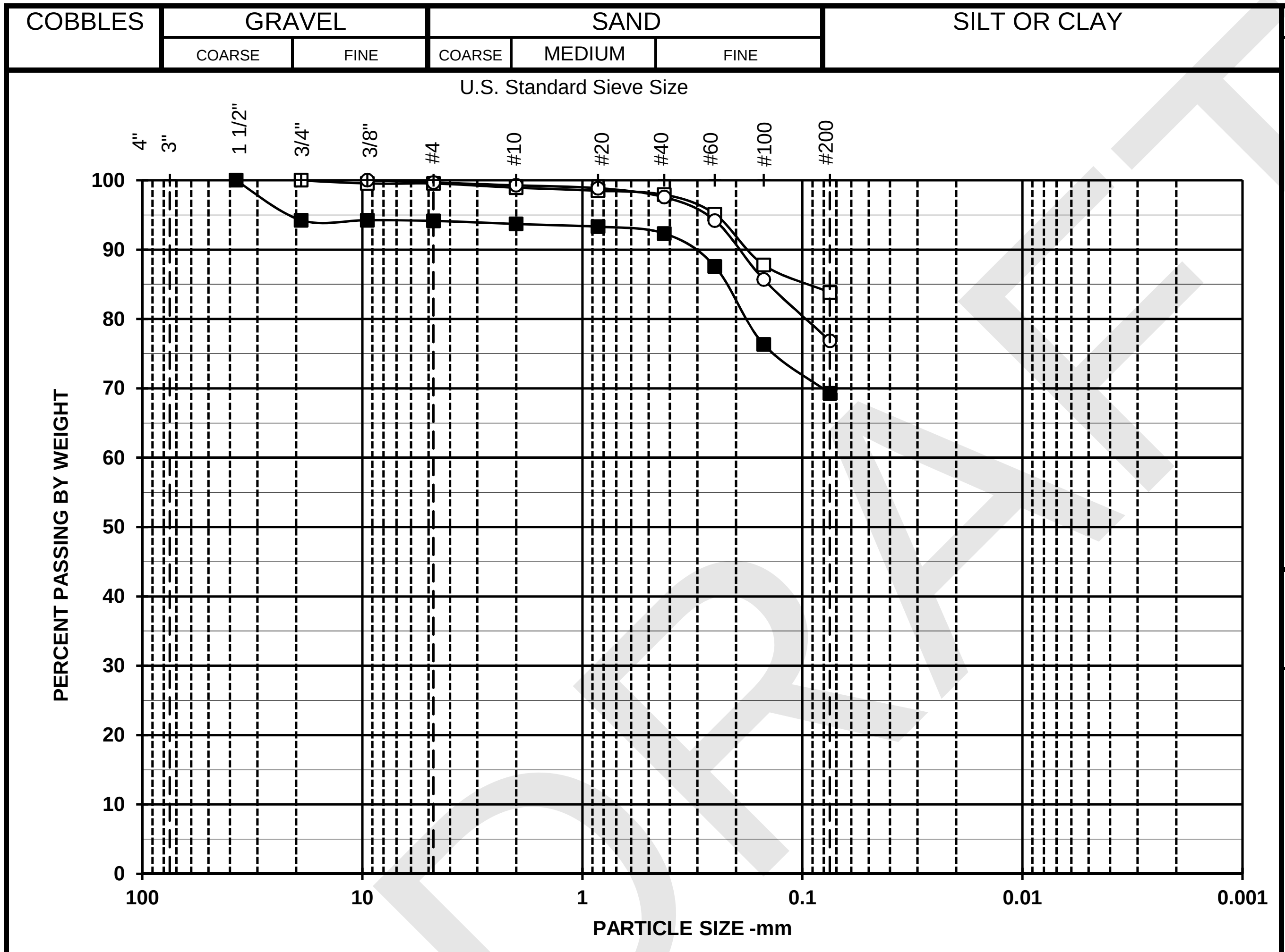

Symbol	□	■	○
Boring	JOP-B004	JOP-B004	JOP-B004
Sample	ST-10C	S-11	S-13B
Depth	49.7	53.5-55	64-65
% +3"	0.0	0.0	0.0
% Gravel	0.5	5.9	0.3
% SAND	15.7	24.8	22.8
%C SAND	0.6	0.4	0.4
%M SAND	1.0	1.4	1.7
%F SAND	14.1	23.1	20.7
% FINES	83.8	69.3	76.9
% -2μ			
D_{100} (mm)	19.00	37.50	9.50
D_{60} (mm)			
D_{30} (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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PARTICLE SIZE DISTRIBUTION

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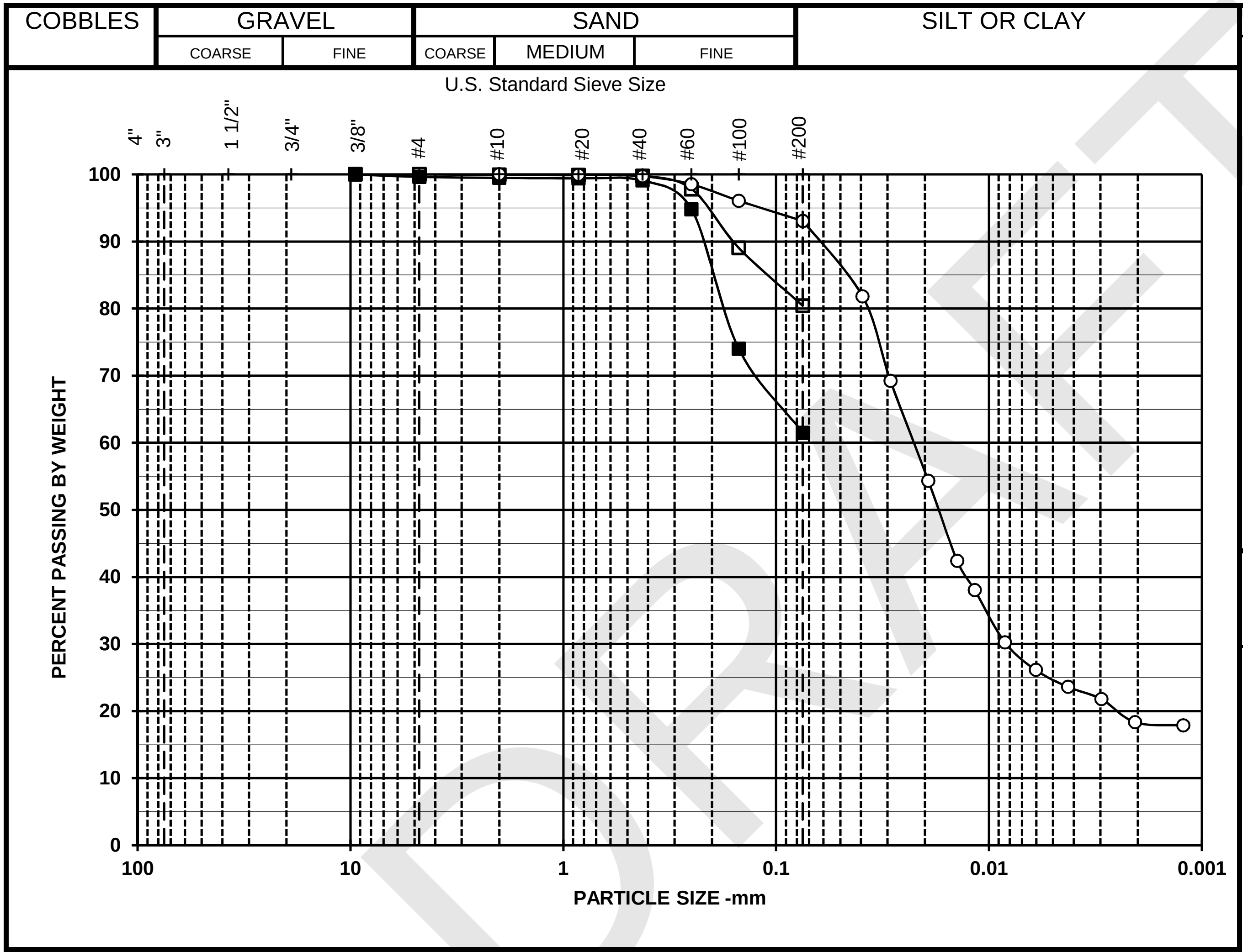

Symbol	□	■	○
Boring	JOP-B004	JOP-B004	JOP-B004
Sample	ST-14	S-15	ST-16C
Depth	65.9	67-68.5	70.1
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.4	0.0
% SAND	19.6	38.1	6.9
%C SAND	0.1	0.1	0.0
%M SAND	0.2	0.4	0.3
%F SAND	19.3	37.6	6.7
% FINES	80.4	61.5	93.1
% -2μ			18
D_{100} (mm)	4.75	9.50	2.00
D_{60} (mm)			0.02
D_{30} (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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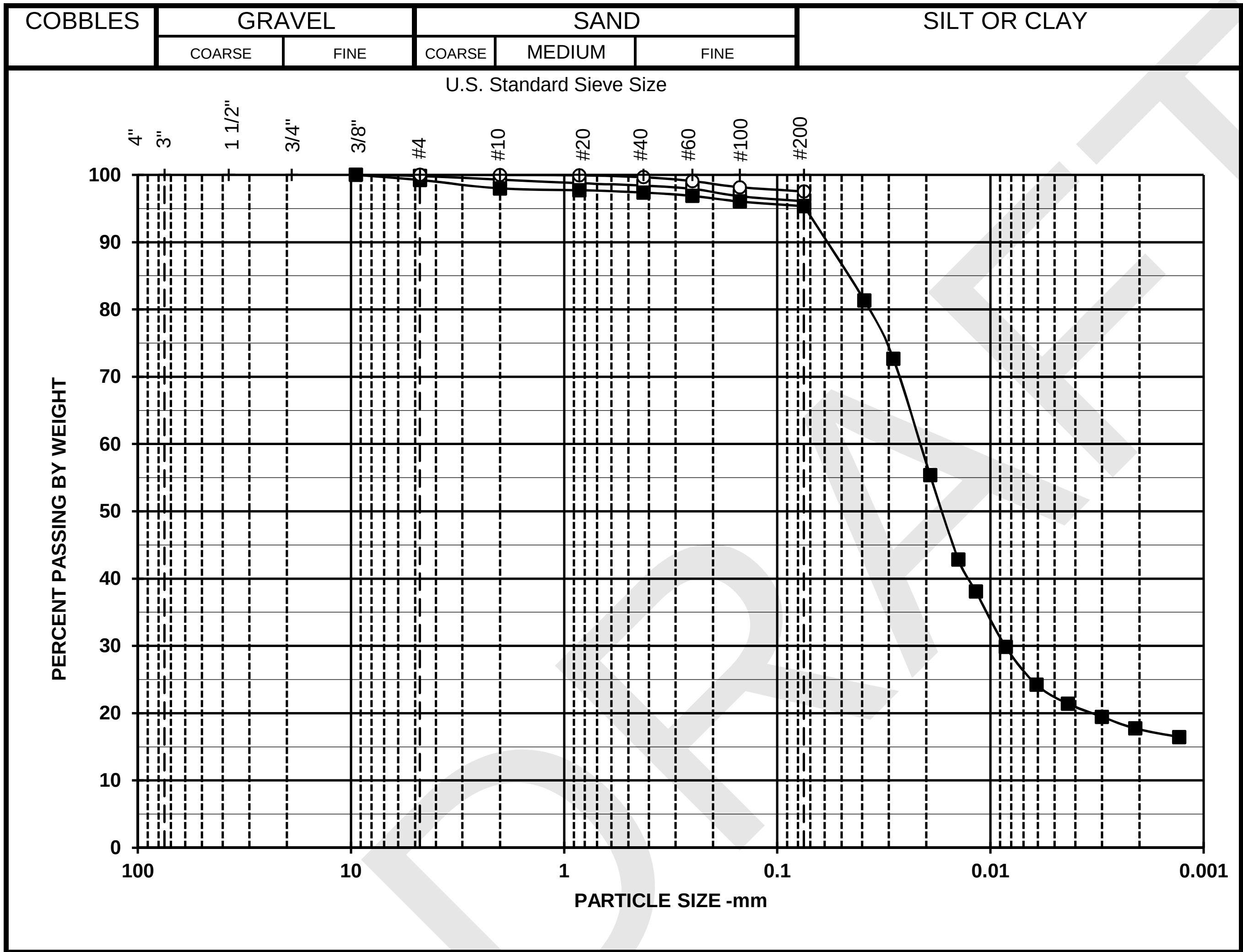

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□					CL	Grayish brown, Lean clay	9/11/2015
■		37	21	16	CL	Gray and brown, Lean clay	8/31/2015
○		38	19	19	CL	Gray and brown, Lean clay	9/14/2015

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 (Sieve #)	PERCENT FINER		
	□	■	○
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

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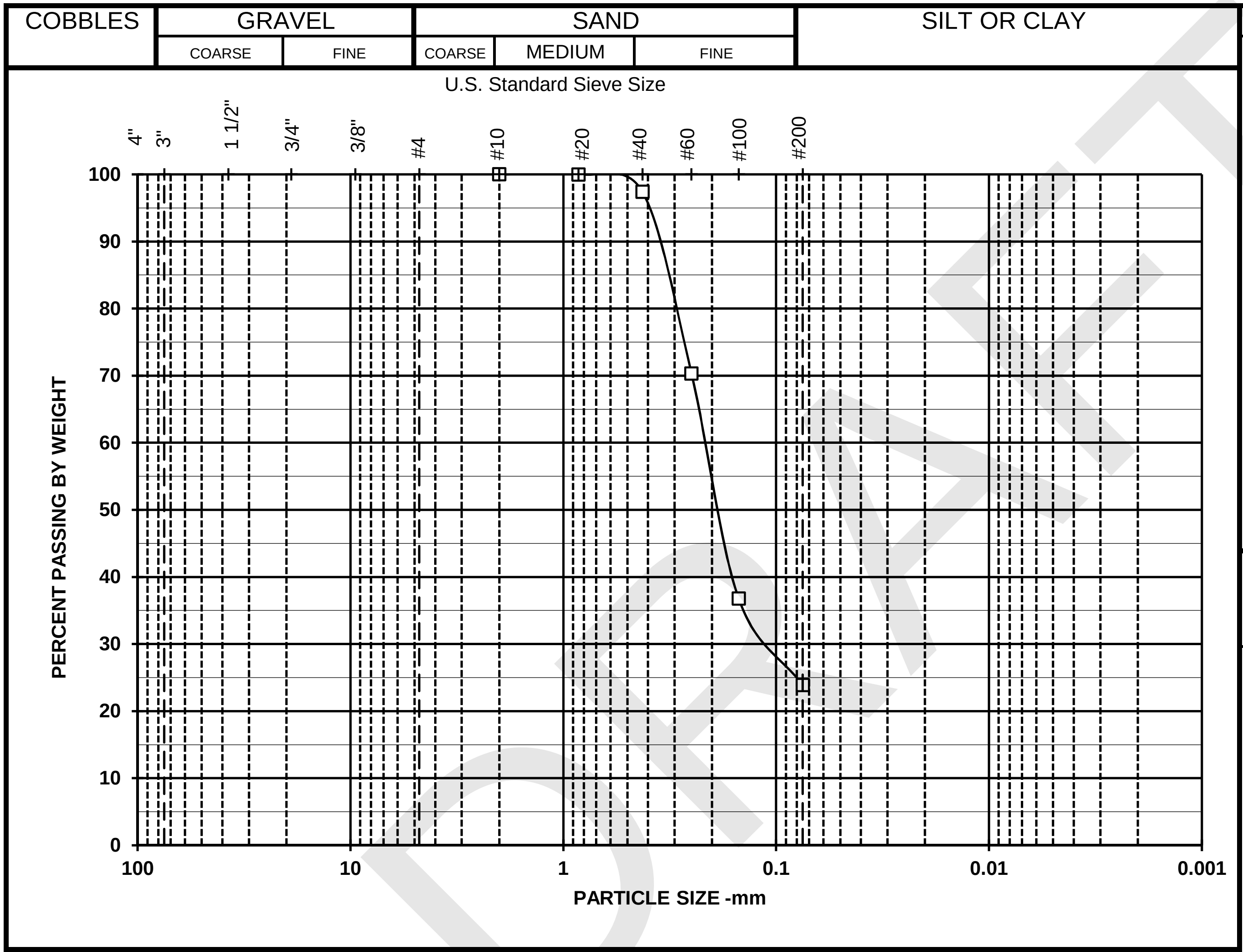

Symbol	□	■	○
Boring	JOP-B005		
Sample	S-17		
Depth	78.5-80		
% +3"	0.0		
% Gravel	0.0		
% SAND	76.1		
%C SAND	0.0		
%M SAND	2.6		
%F SAND	73.5		
% FINES	23.9		
% -2µ			
D_{100} (mm)	2.00		
D_{60} (mm)	0.22		
D_{30} (mm)	0.11		
D_{10} (mm)			
Cc			
Cu			

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		

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	15.3	19	18	1	SM	Light gray, Silty sand	8/19/2015
■							
○							

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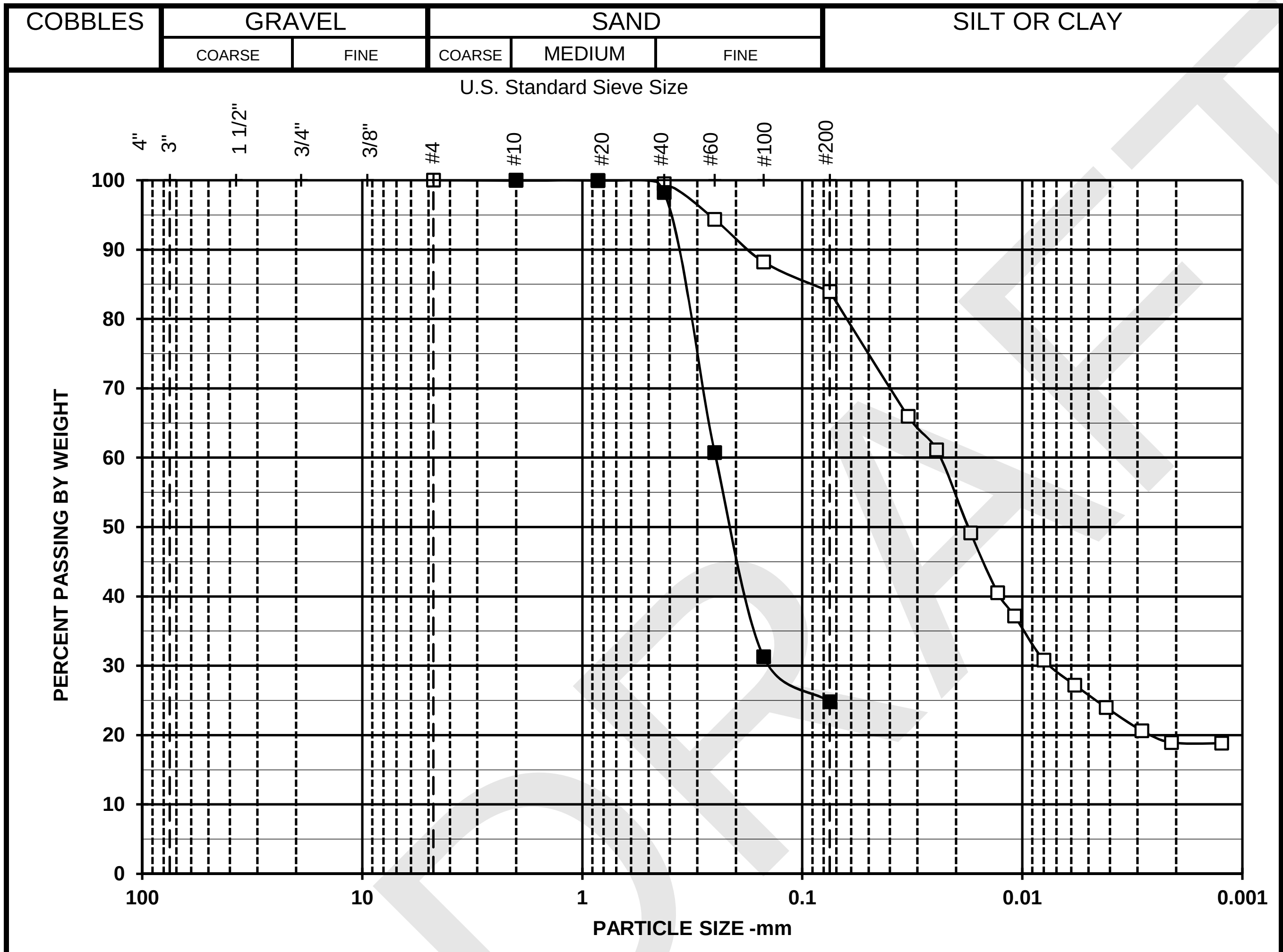

Symbol	□	■	○
Boring	JOP-B006	JOP-B006	
Sample	S-6	S-7	
Depth	33.5-35	38.5-40	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	16.1	75.2	
%C SAND	0.0	0.0	
%M SAND	0.5	1.7	
%F SAND	15.5	73.5	
% FINES	83.9	24.8	
% -2μ	19		
D_{100} (mm)	4.75	2.00	
D_{60} (mm)	0.02	0.25	
D_{30} (mm)	0.01	0.14	
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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	

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
○							

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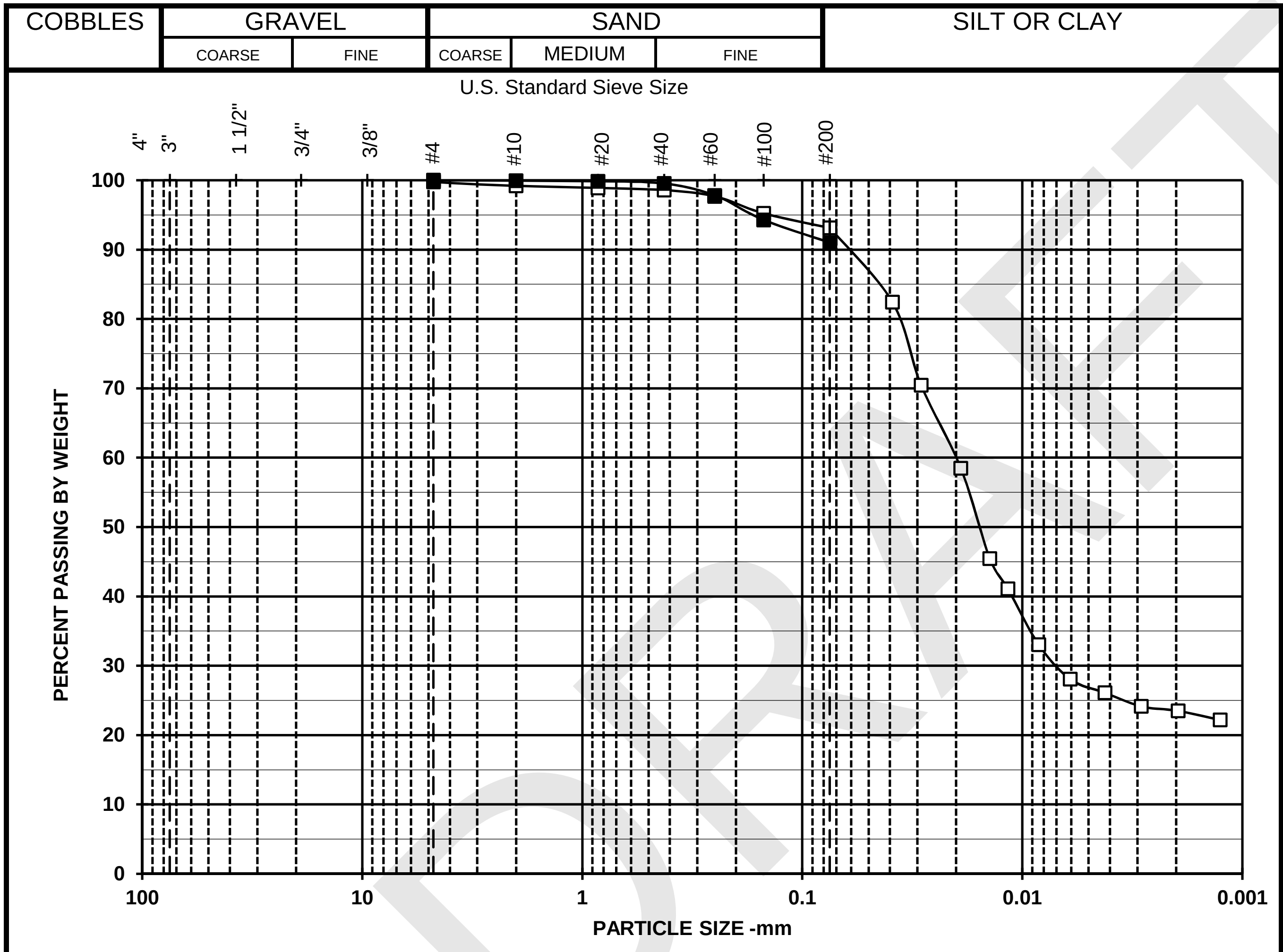

Symbol	□	■	○
Boring	JOP-B007	JOP-B007	
Sample	ST-2B	ST-3C	
Depth	9.55	29.6	
% +3"	0.0	0.0	
% Gravel	0.2	0.0	
% SAND	6.7	9.0	
%C SAND	0.6	0.1	
%M SAND	0.6	0.4	
%F SAND	5.5	8.5	
% FINES	93.1	91.0	
% -2µ	24		
D_{100} (mm)	9.50	4.75	
D_{60} (mm)	0.02		
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

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	

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
○							

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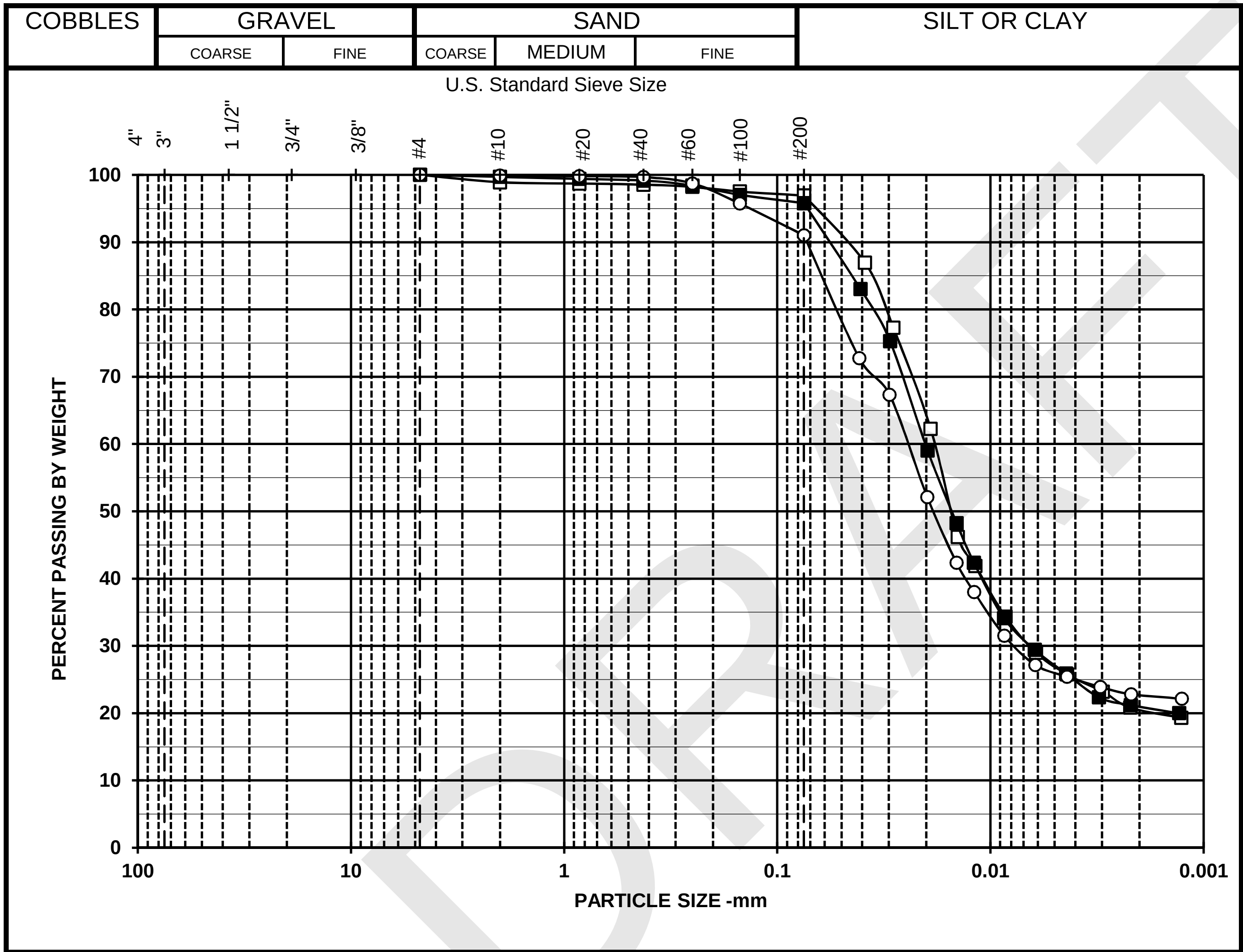

Symbol	□	■	○
Boring	JOP-B008	JOP-B008	JOP-B008
Sample	S-4	ST-3C	S-8
Depth	23.5-25	39.8	48.5-50
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% SAND	3.1	4.2	9.0
%C SAND	1.1	0.3	0.1
%M SAND	0.4	0.5	0.2
%F SAND	1.6	3.4	8.6
% FINES	96.9	95.8	91.0
% -2µ	21	21	23
D_{100} (mm)	4.75	4.75	4.75
D_{60} (mm)	0.02	0.02	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

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

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PARTICLE SIZE DISTRIBUTION

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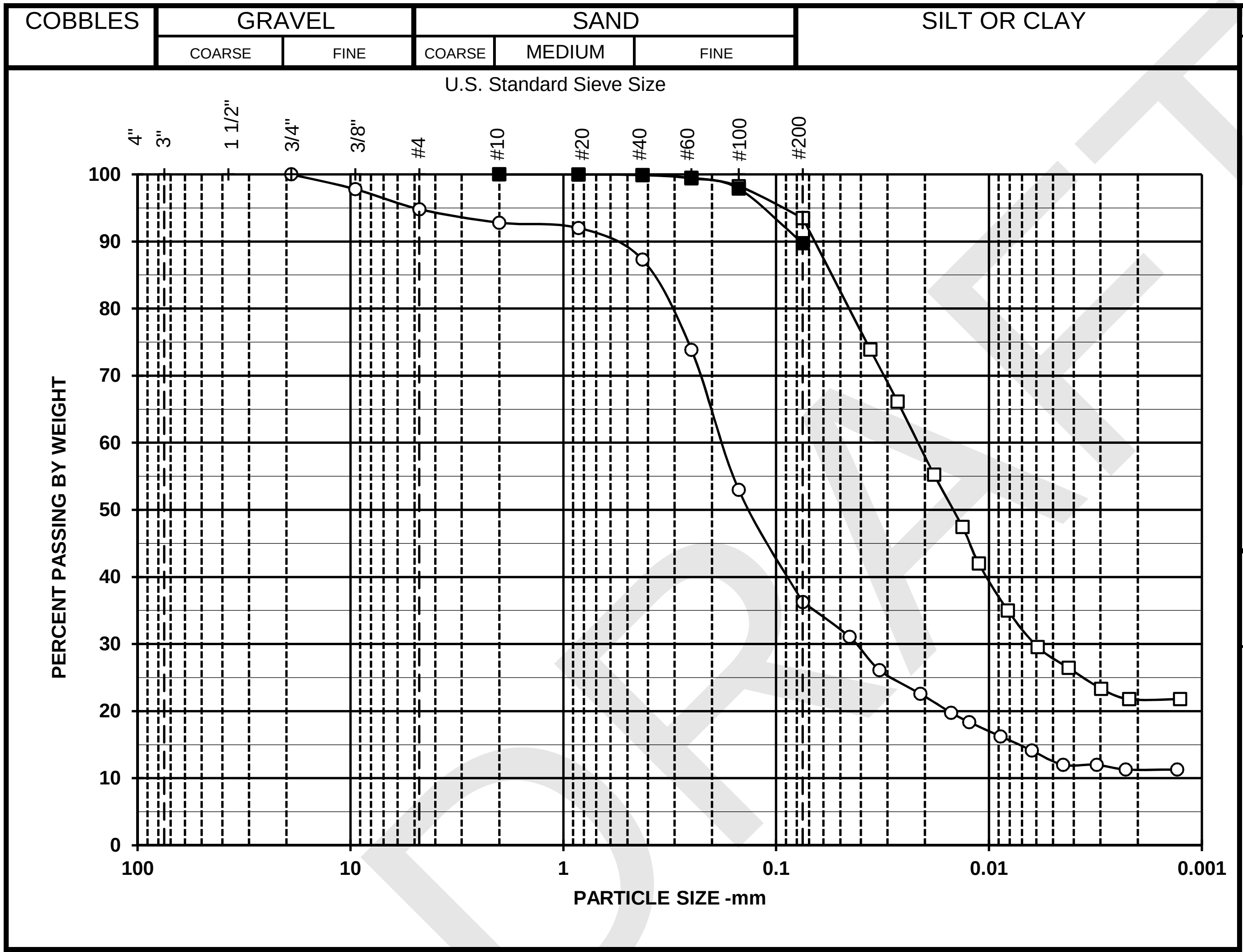

Symbol	□	■	○
Boring	JOP-B008	JOP-B008	JOP-B008
Sample	ST-5C	S-11	ST-6C
Depth	64.75	68.5-70	79.5
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	5.2
% SAND	6.5	10.3	58.6
%C SAND	0.0	0.0	2.0
%M SAND	0.1	0.1	5.5
%F SAND	6.4	10.2	51.1
% FINES	93.5	89.7	36.2
% -2µ	22		11
D_{100} (mm)	2.00	2.00	19.00
D_{60} (mm)	0.02		0.18
D_{30} (mm)	0.01		0.04
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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

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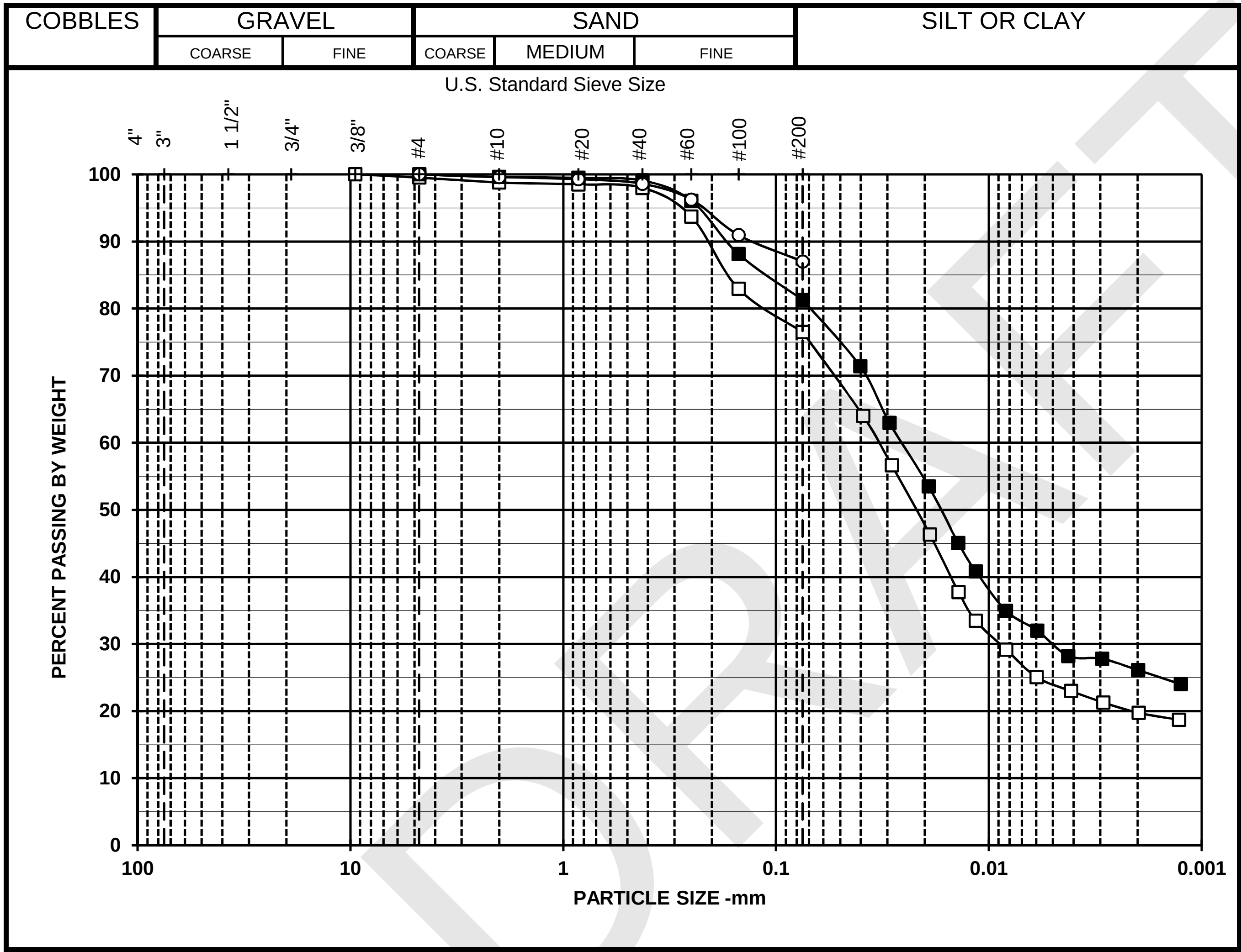

Symbol	□	■	○
Boring	JOP-B009	JOP-B009	JOP-B009
Sample	ST-3C	S-7	ST-11D
Depth	14.35	31-32.5	49.85
% +3"	0.0	0.0	0.0
% Gravel	0.5	0.0	0.0
% SAND	23.0	18.7	13.0
%C SAND	0.7	0.4	0.4
%M SAND	0.8	0.5	1.0
%F SAND	21.5	17.8	11.6
% FINES	76.5	81.3	87.0
% -2μ	20	26	
D_{100} (mm)	9.50	4.75	4.75
D_{60} (mm)	0.03	0.03	
D_{30} (mm)	0.01	0.01	
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	PERCENT FINER ■	PERCENT FINER ○
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

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

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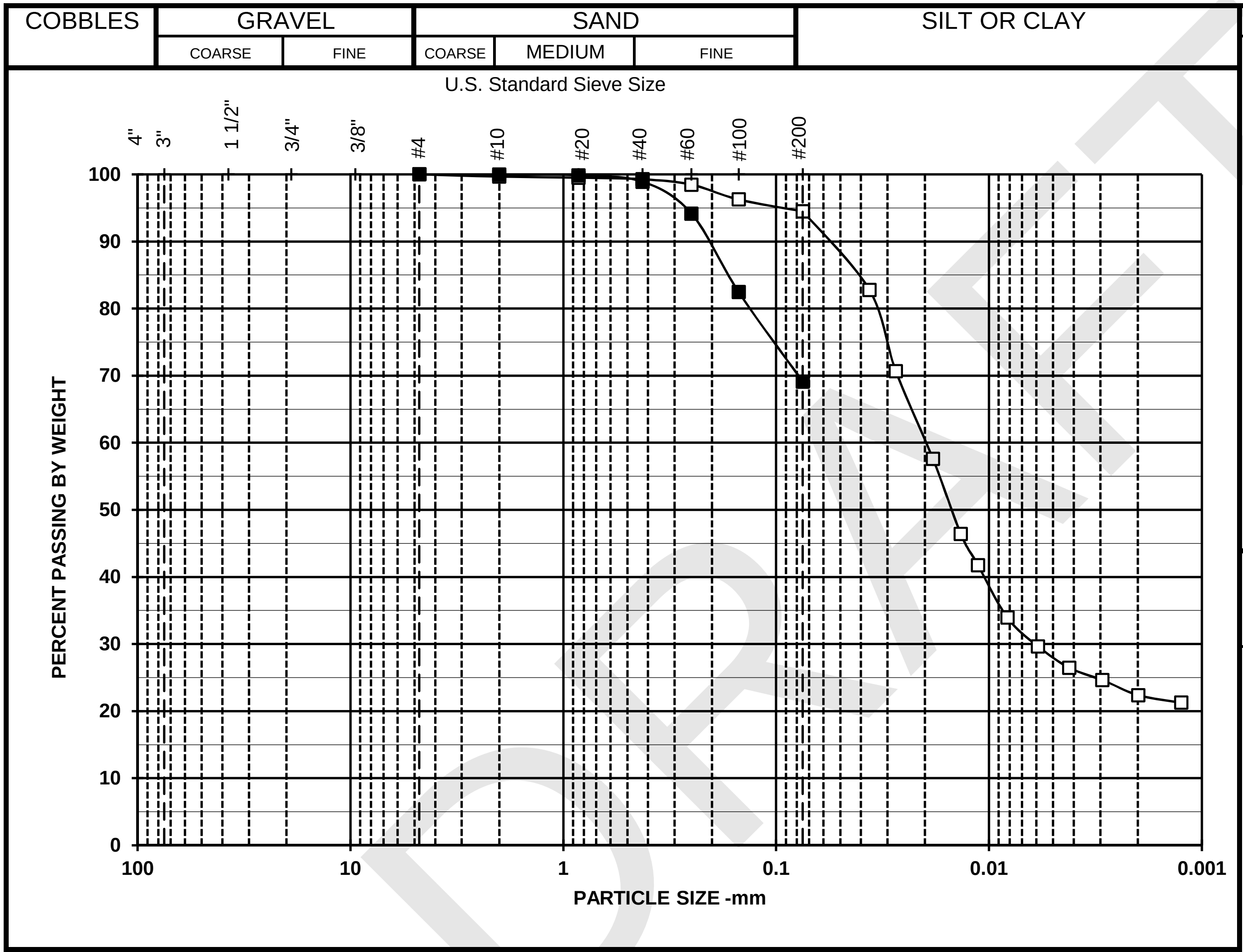

Symbol	□	■	○
Boring	JOP-B009	JOP-B009	
Sample	S-12	ST-14C	
Depth	53.5-55	64.85	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	5.5	30.9	
%C SAND	0.3	0.0	
%M SAND	0.4	1.1	
%F SAND	4.8	29.8	
% FINES	94.5	69.1	
% -2µ	22		
D_{100} (mm)	4.75	4.75	
D_{60} (mm)	0.02		
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

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	

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
○							

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PARTICLE SIZE DISTRIBUTION

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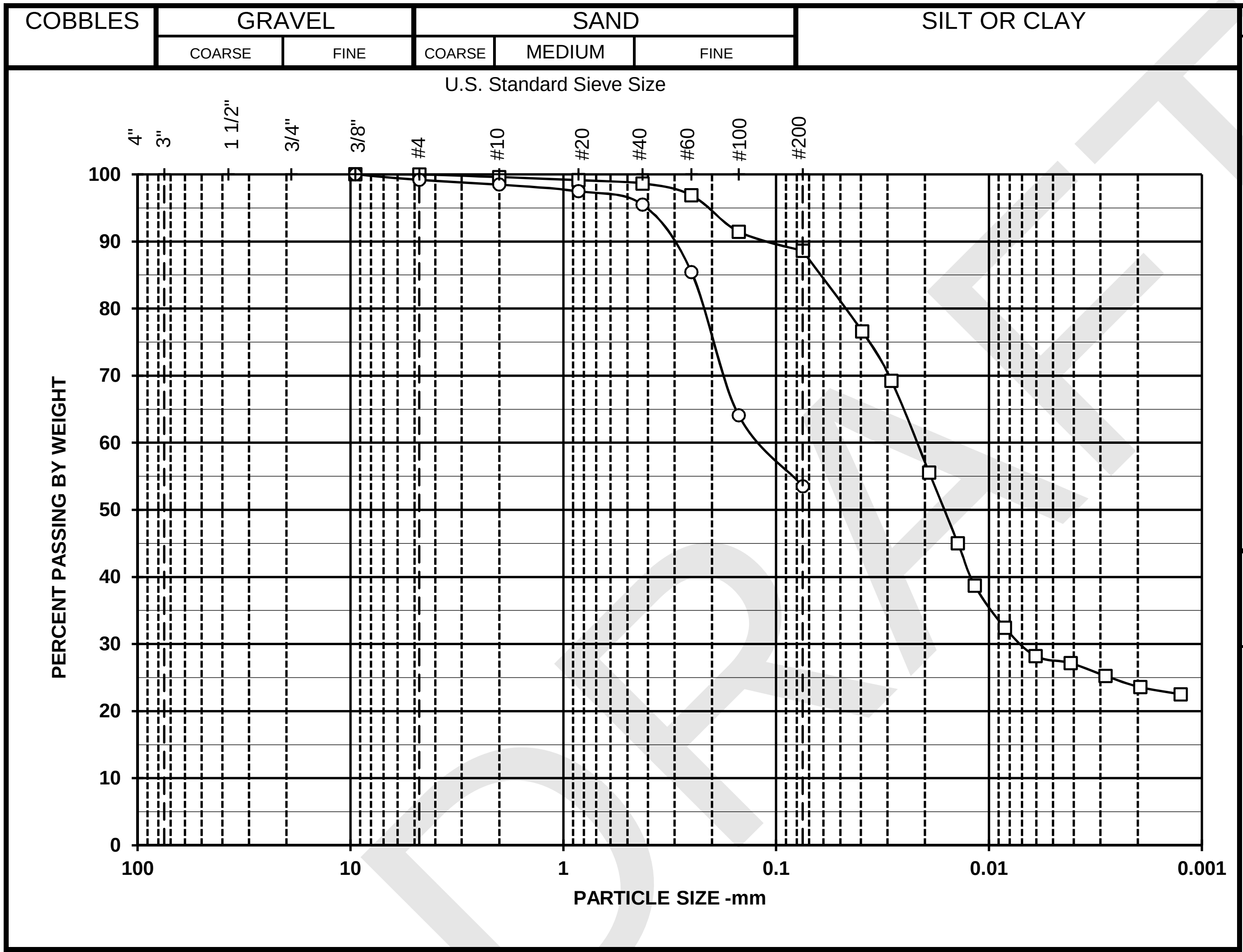

Symbol	□	■	○
Boring	JOP-B010		JOP-B010
Sample	ST-1B		ST-3D
Depth	1.1		35.35
% +3"	0.0		0.0
% Gravel	0.0		0.8
% SAND	11.4		45.7
%C SAND	0.4		0.7
%M SAND	1.0		3.0
%F SAND	10.1		42.0
% FINES	88.6		53.5
% -2µ	24		
D_{100} (mm)	9.50		9.50
D_{60} (mm)	0.02		0.12
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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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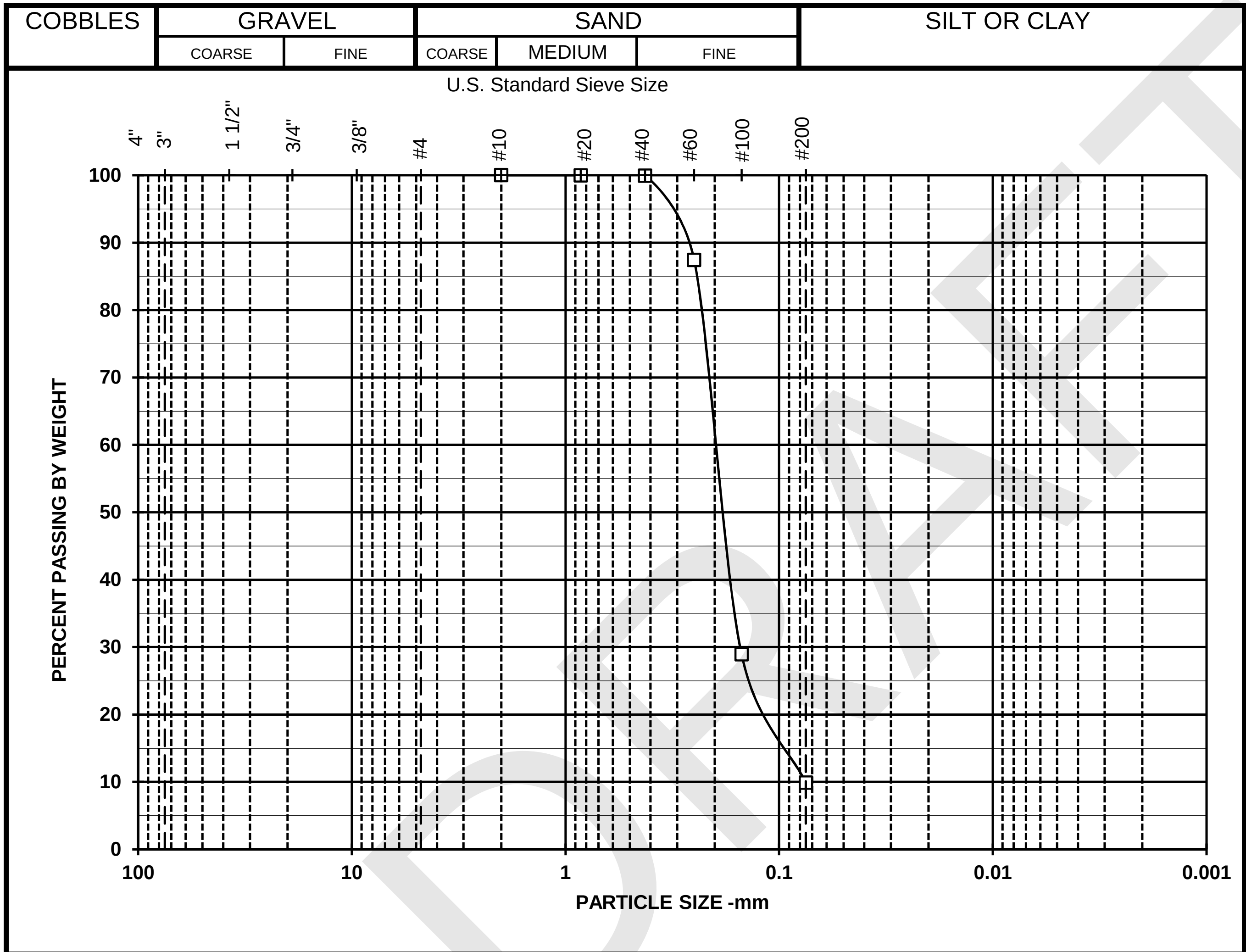

Symbol	☐	■	○
Boring	JOP-010		
Sample	S-9		
Depth	48.5-50		
% +3"	0.0		
% Gravel	0.0		
% SAND	90.1		
%C SAND	0.0		
%M SAND	0.1		
%F SAND	90.0		
% FINES	9.9		
% -2µ			
D_{100} (mm)	2.00		
D_{60} (mm)	0.20		
D_{30} (mm)	0.15		
D_{10} (mm)	0.08		
Cc	1.5		
Cu	2.7		

Particle Size (Sieve #)	PERCENT FINER ☐	■	○
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		

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
■							
○							

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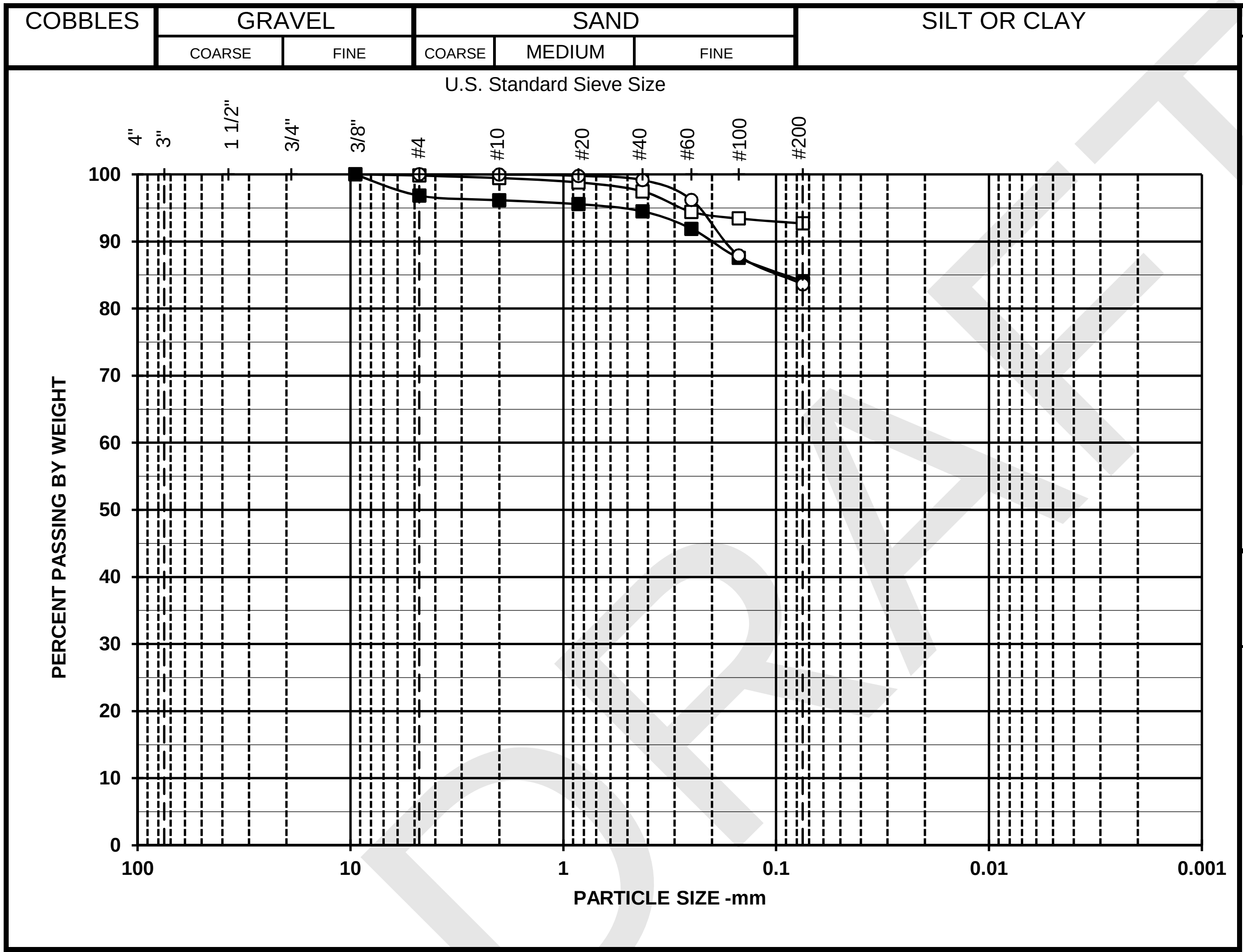

Symbol	□	■	○
Boring	JOP-B011	JOP-B011	JOP-B011
Sample	ST-5C	S-6	S-8
Depth	24.25	28.5-30	38.5-40
% +3"	0.0	0.0	0.0
% Gravel	0.2	3.2	0.0
% SAND	7.1	12.7	16.4
%C SAND	0.4	0.7	0.0
%M SAND	2.0	1.7	0.8
%F SAND	4.8	10.4	15.5
% FINES	92.7	84.1	83.6
% -2μ			
D_{100} (mm)	9.50	9.50	4.75
D_{60} (mm)			
D_{30} (mm)			
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

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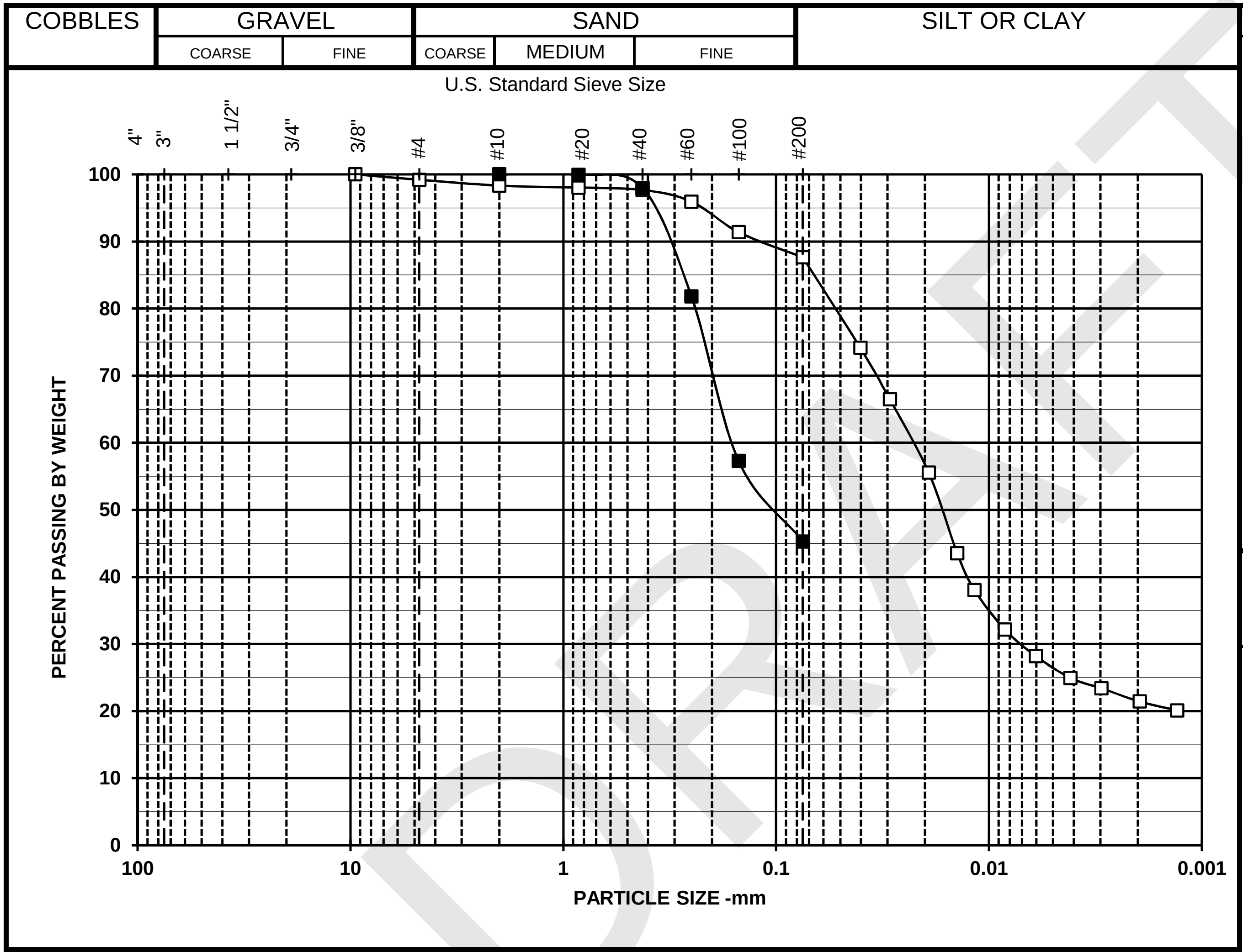

Symbol	□	■	○
Boring	JOP-B011	JOP-B011	
Sample	ST-9C	ST-14C	
Depth	44.8	69.8	
% +3"	0.0	0.0	
% Gravel	0.8	0.0	
% SAND	11.6	54.7	
%C SAND	0.9	0.0	
%M SAND	0.6	2.0	
%F SAND	10.0	52.7	
% FINES	87.6	45.3	
% -2µ	22		
D_{100} (mm)	9.50	2.00	
D_{60} (mm)	0.02	0.16	
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

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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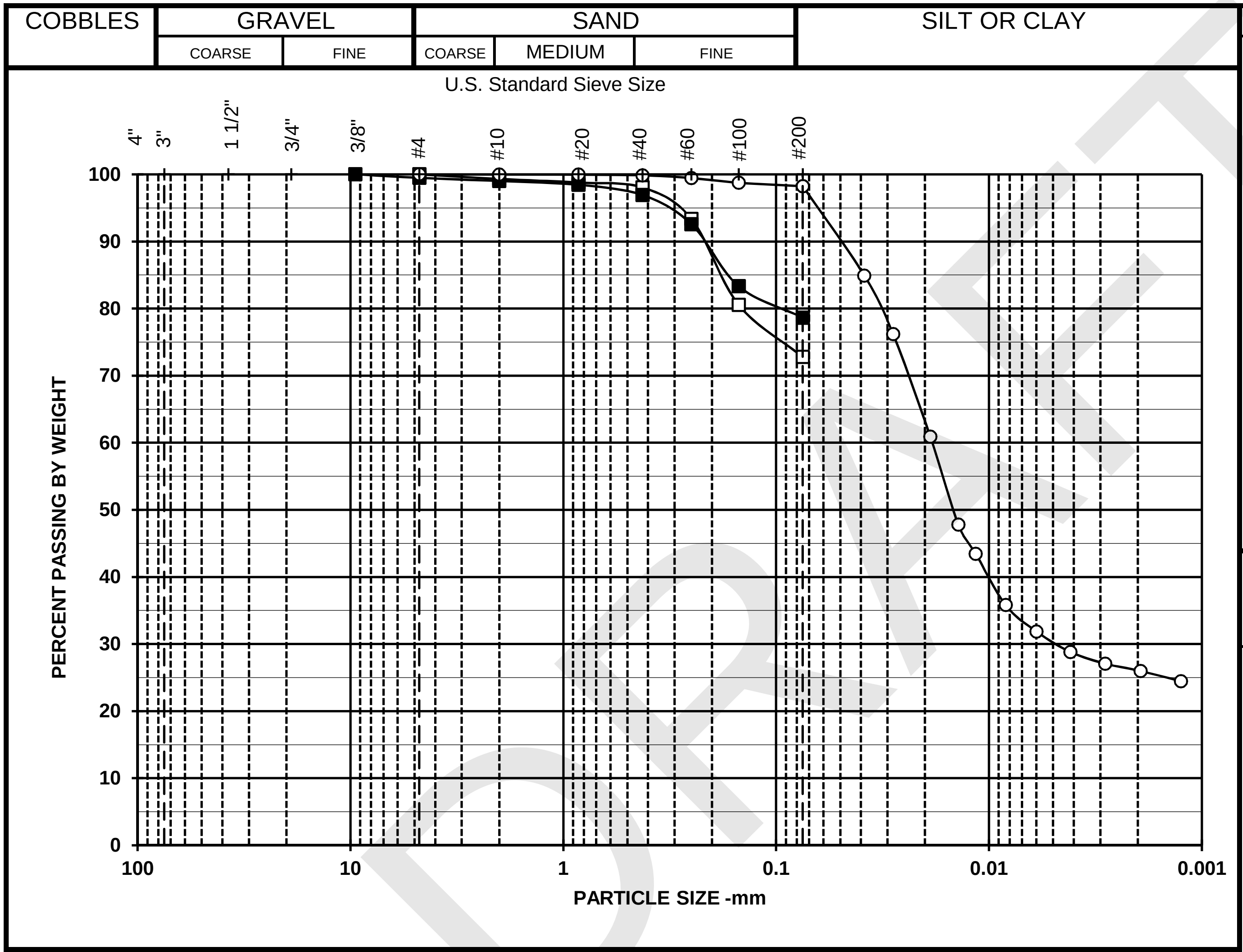

Symbol	□	■	○
Boring	JOP-B012	JOP-B012	JOP-B012
Sample	ST-3C	S-5	ST-8C
Depth	16.45	23.5-25	33.6
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.5	0.0
% SAND	27.2	20.9	1.8
%C SAND	0.7	0.5	0.0
%M SAND	1.3	2.1	0.1
%F SAND	25.3	18.3	1.6
% FINES	72.8	78.6	98.2
% -2µ			26
D_{100} (mm)	4.75	9.50	4.75
D_{60} (mm)			0.02
D_{30} (mm)			0.00
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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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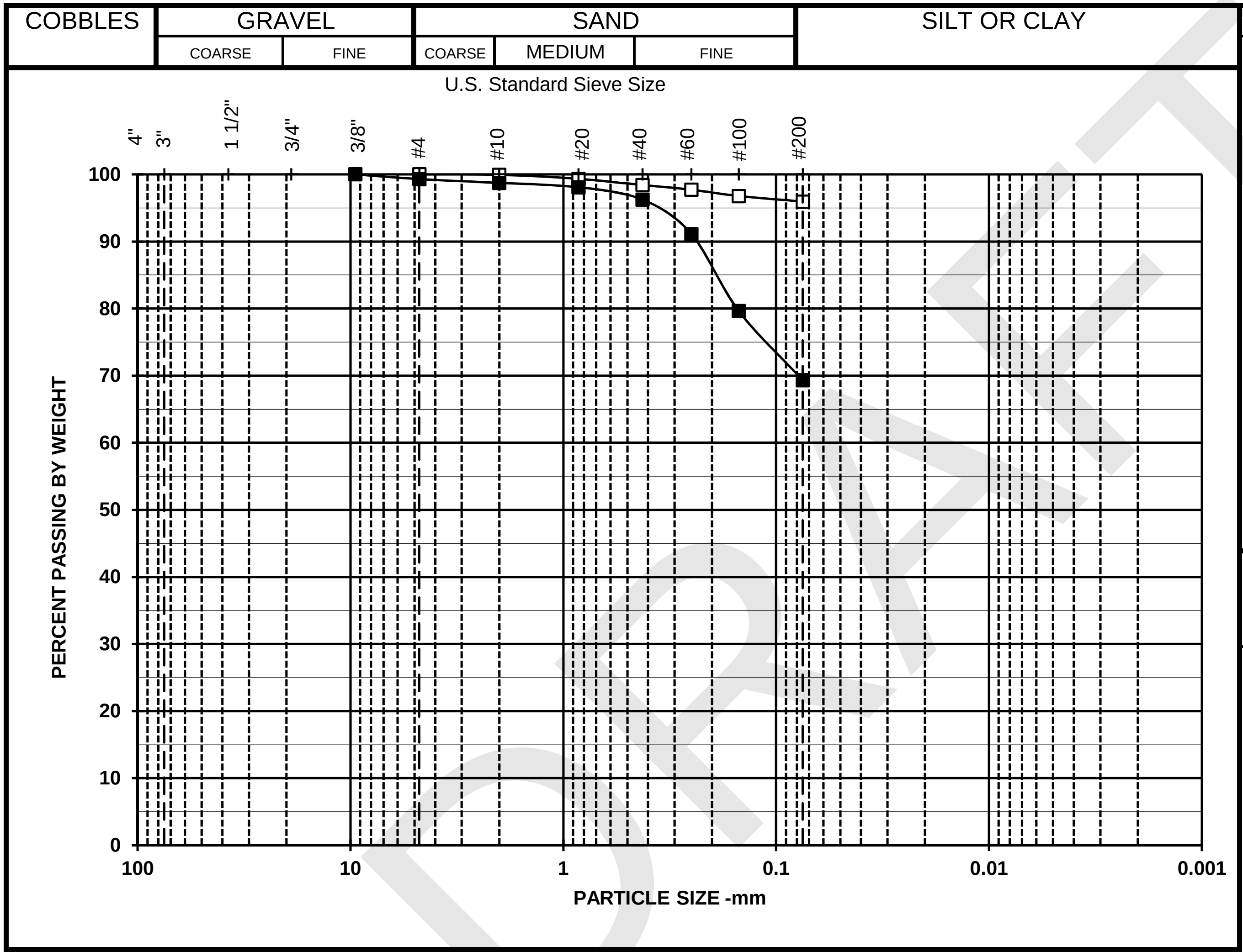

Symbol	□	■	○
Boring	JOP-B012	JOP-B012	
Sample	S-9	S-12	
Depth	36.37.5	48.5-50	
% +3"	0.0	0.0	
% Gravel	0.0	0.7	
% SAND	4.1	30.0	
%C SAND	0.0	0.6	
%M SAND	1.5	2.5	
%F SAND	2.5	26.9	
% FINES	95.9	69.3	
% -2μ			
D_{100} (mm)	4.75	9.50	
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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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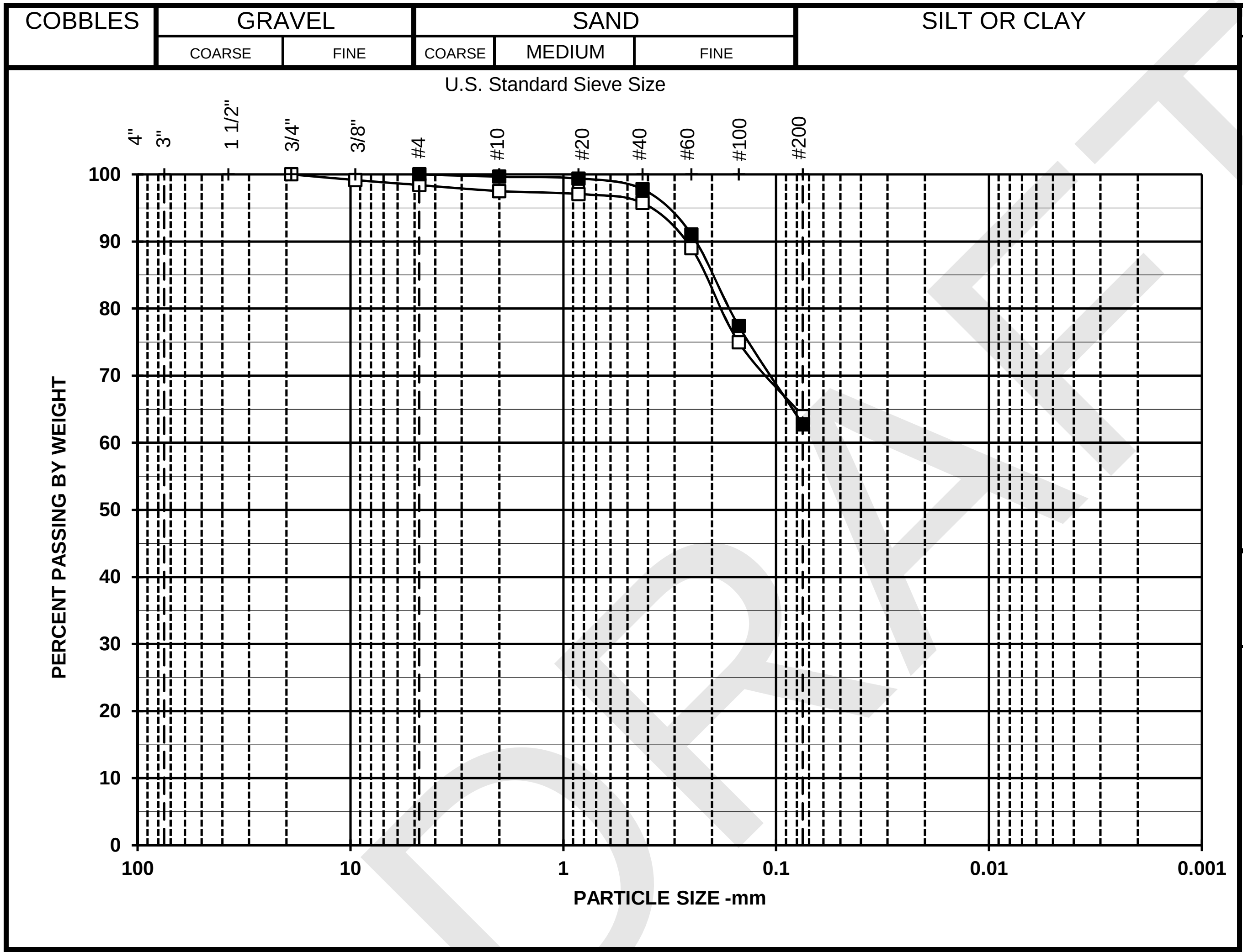

Symbol	□	■	○
Boring	JOP-B012	JOP-B012	
Sample	ST-13B	ST-16C	
Depth	53.95	66.6	
% +3"	0.0	0.0	
% Gravel	1.6	0.0	
% SAND	34.5	37.3	
%C SAND	0.9	0.3	
%M SAND	1.8	1.9	
%F SAND	31.8	35.1	
% FINES	63.9	62.7	
% -2μ			
D_{100} (mm)	19.00	4.75	
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

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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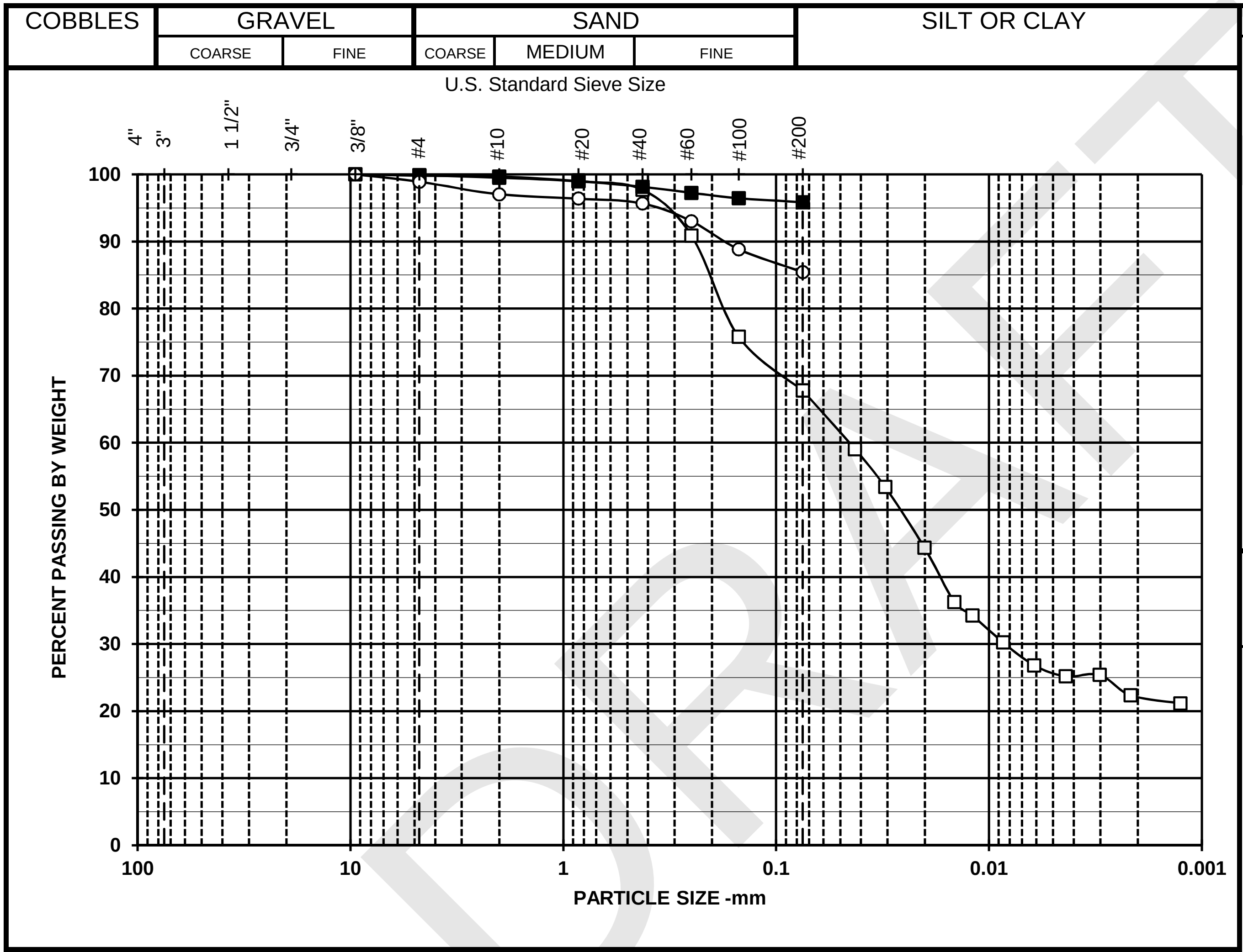

Symbol	□	■	○
Boring	JOP-B013	JOP-B013	JOP-B013
Sample	S-2	S-4	S-7
Depth	8.5-10	23.5-25	43.5-45
% +3"	0.0	0.0	0.0
% Gravel	0.1	0.2	1.1
% SAND	32.1	4.0	13.5
%C SAND	0.4	0.1	1.9
%M SAND	1.8	1.6	1.4
%F SAND	29.9	2.3	10.2
% FINES	67.8	95.8	85.4
% -2μ	22		
D_{100} (mm)	9.50	9.50	9.50
D_{60} (mm)	0.05		
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	 ■	 ○
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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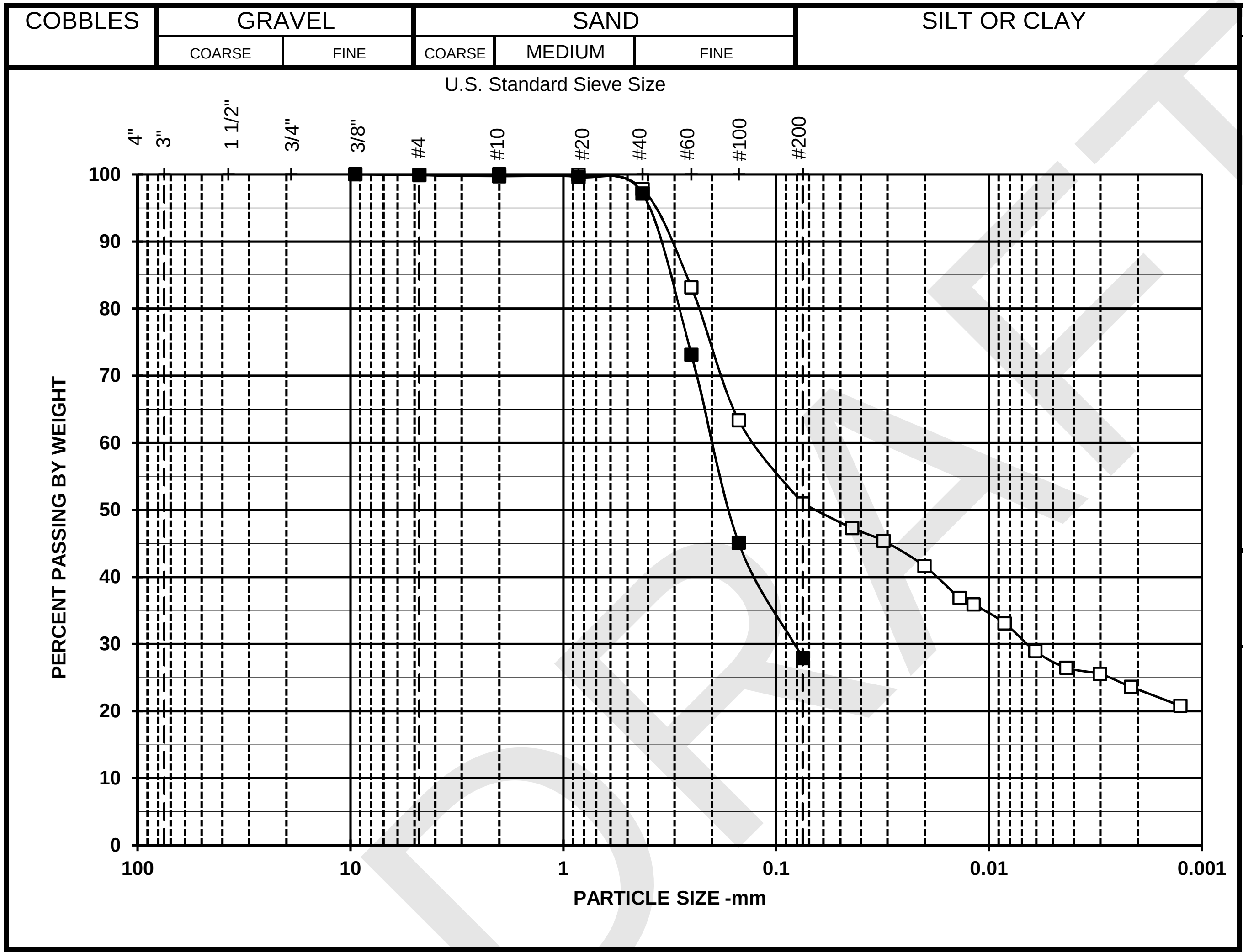

Symbol	□	■	○
Boring	JOP-B013	JOP-B013	
Sample	S-12	S-13	
Depth	68.5-70	73.5-75	
% +3"	0.0	0.0	
% Gravel	0.0	0.1	
% SAND	49.1	72.0	
%C SAND	0.0	0.2	
%M SAND	2.2	2.6	
%F SAND	46.9	69.3	
% FINES	50.9	27.9	
% -2μ	23		
D_{100} (mm)	2.00	9.50	
D_{60} (mm)	0.13	0.20	
D_{30} (mm)	0.01	0.08	
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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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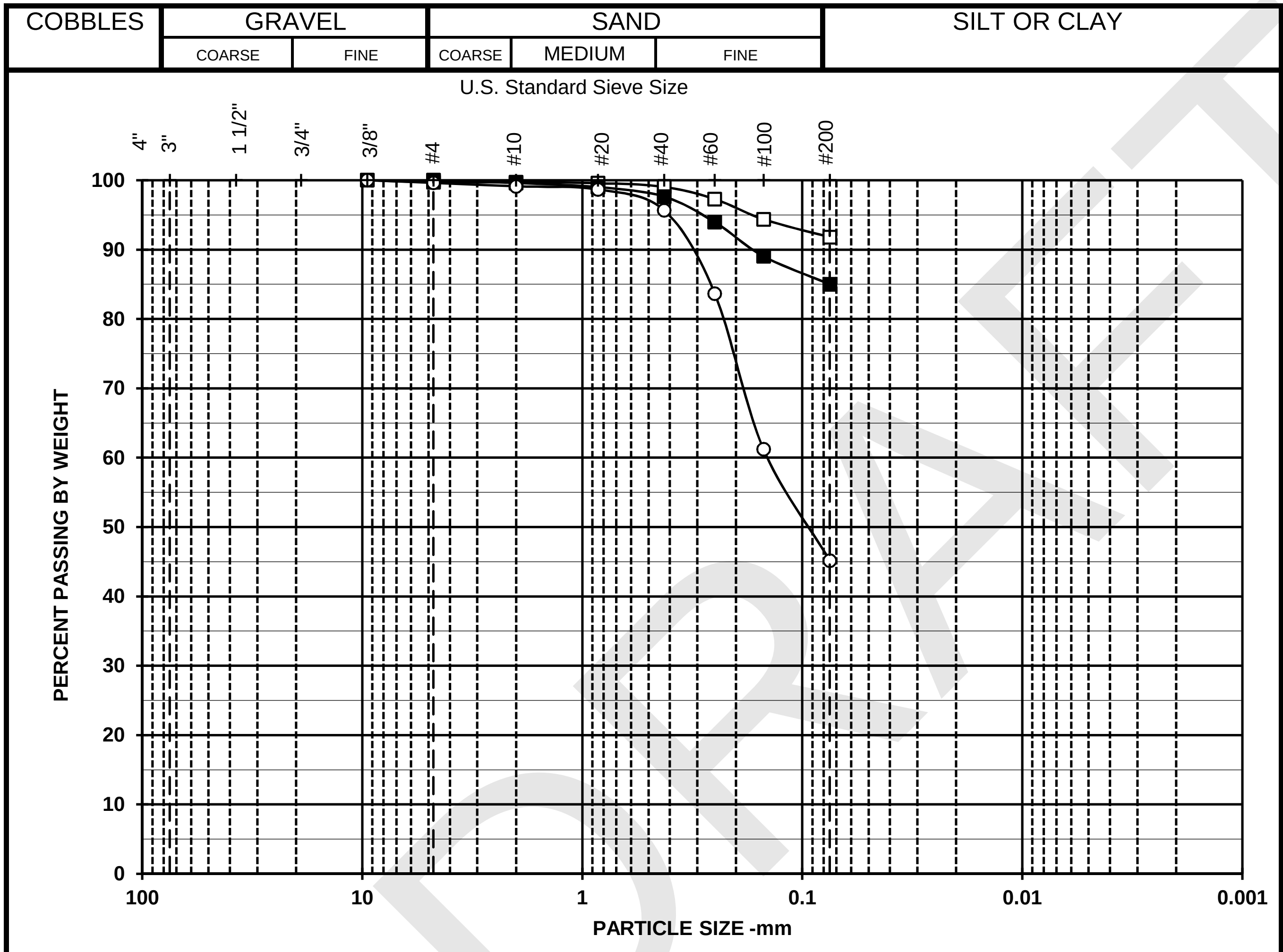

Symbol	□	■	○
Boring	JOP-B014	JOP-B014	JOP-B014
Sample	ST-2C	S-6	ST-3C
Depth	10.3	28.5-30	34.65
% +3"	0.0	0.0	0.0
% Gravel	0.3	0.0	0.4
% SAND	7.9	15.0	54.4
%C SAND	0.0	0.4	0.5
%M SAND	0.7	2.0	3.5
%F SAND	7.3	12.6	50.5
% FINES	91.8	85.0	45.2
% -2μ			
D_{100} (mm)	9.50	4.75	9.50
D_{60} (mm)			0.14
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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

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

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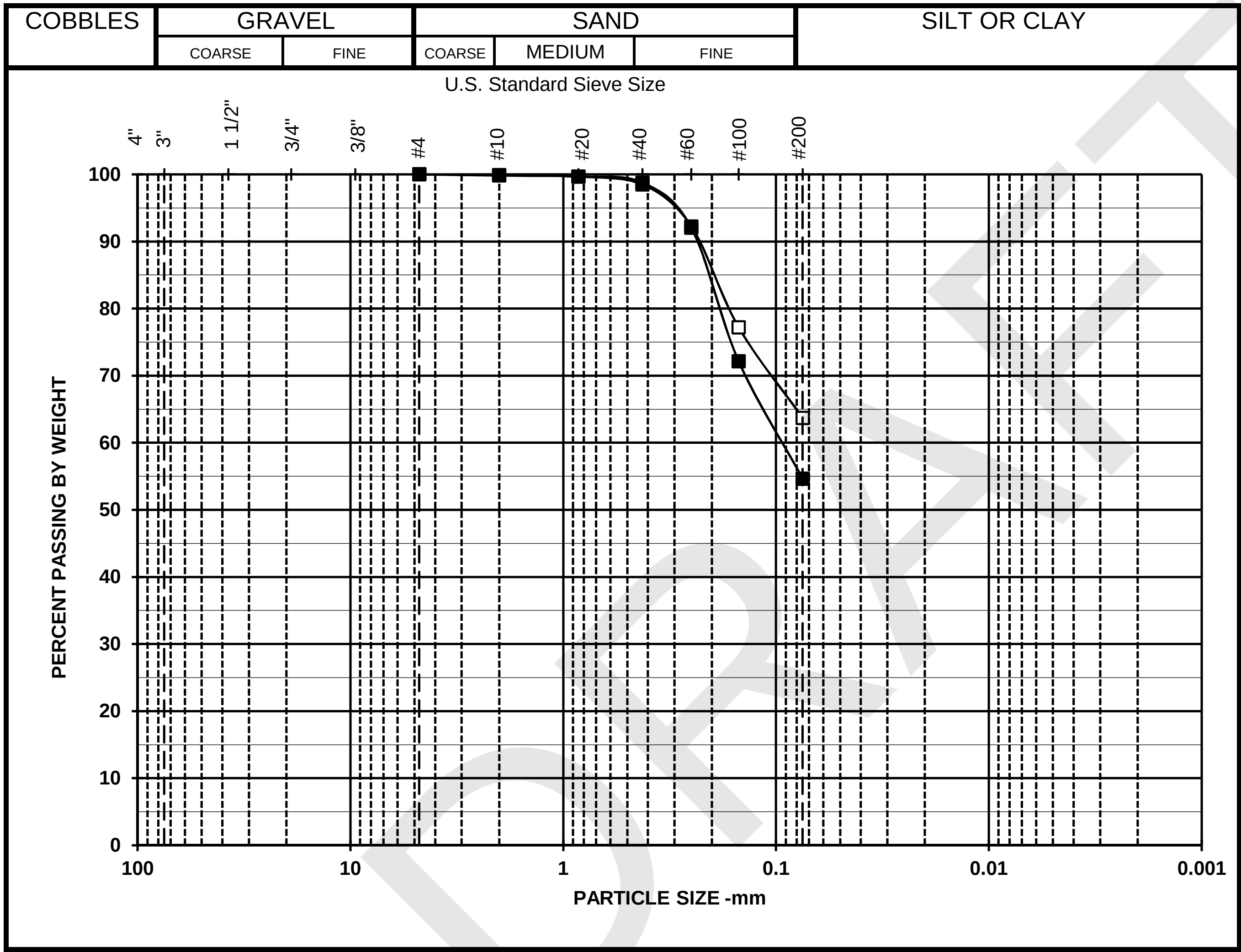

Symbol	□	■	○
Boring	JOP-B014	JOP-B014	
Sample	ST-4C	S-8	
Depth	44.6	48.5-50	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	36.3	45.4	
%C SAND	0.1	0.2	
%M SAND	1.4	1.1	
%F SAND	34.8	44.1	
% FINES	63.7	54.6	
% -2µ			
D_{100} (mm)	4.75	4.75	
D_{60} (mm)		0.10	
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

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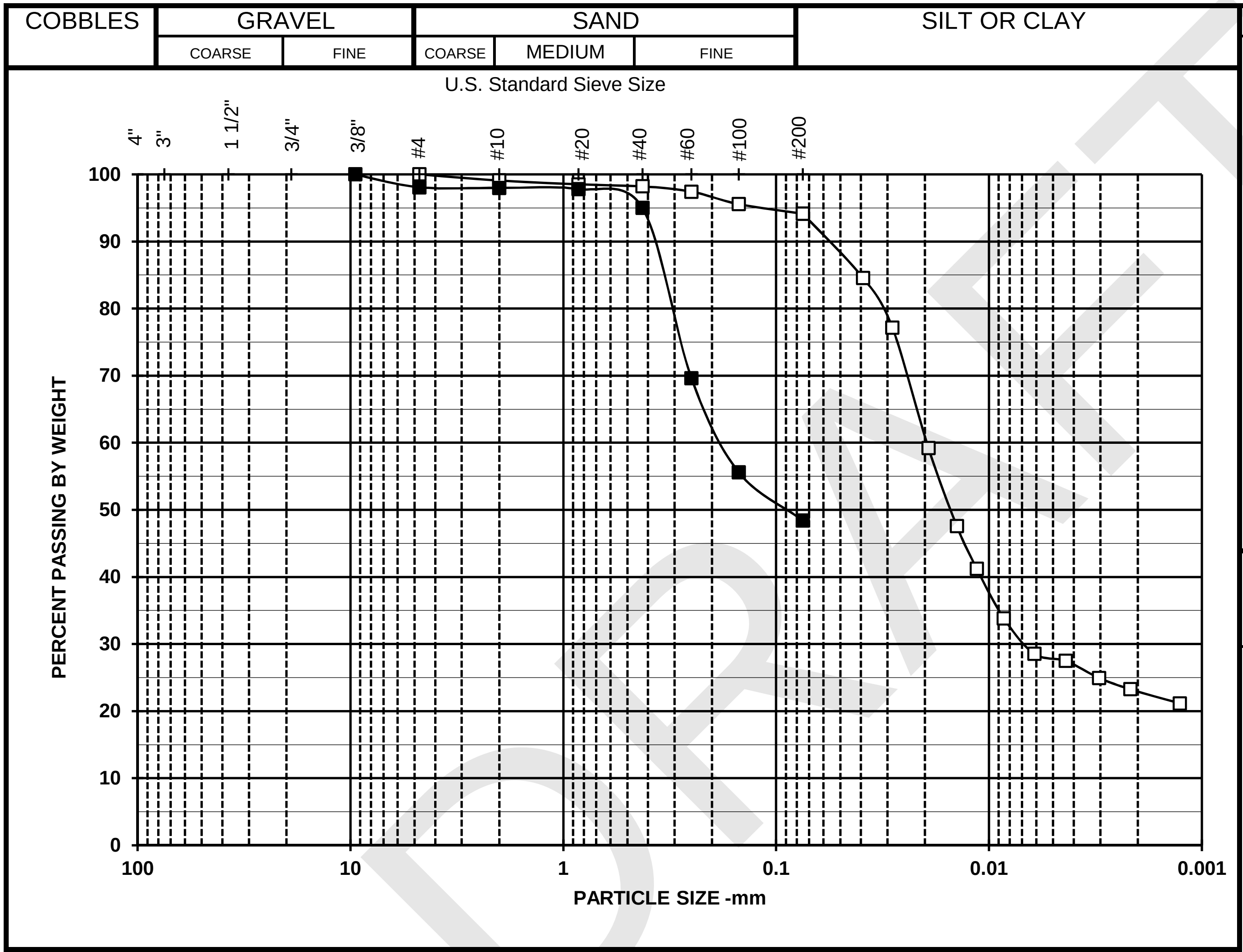

Symbol	□	■	○
Boring	JOP-B015	JOP-B015	
Sample	S-4	S-12	
Depth	23.5-25	63.5-65	
% +3"	0.0	0.0	
% Gravel	0.0	1.9	
% SAND	5.9	49.7	
%C SAND	0.9	0.1	
%M SAND	0.9	3.0	
%F SAND	4.1	46.6	
% FINES	94.1	48.4	
% -2μ	23		
D_{100} (mm)	4.75	9.50	
D_{60} (mm)	0.02	0.18	
D_{30} (mm)	0.01		
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER		
	□	■	○
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

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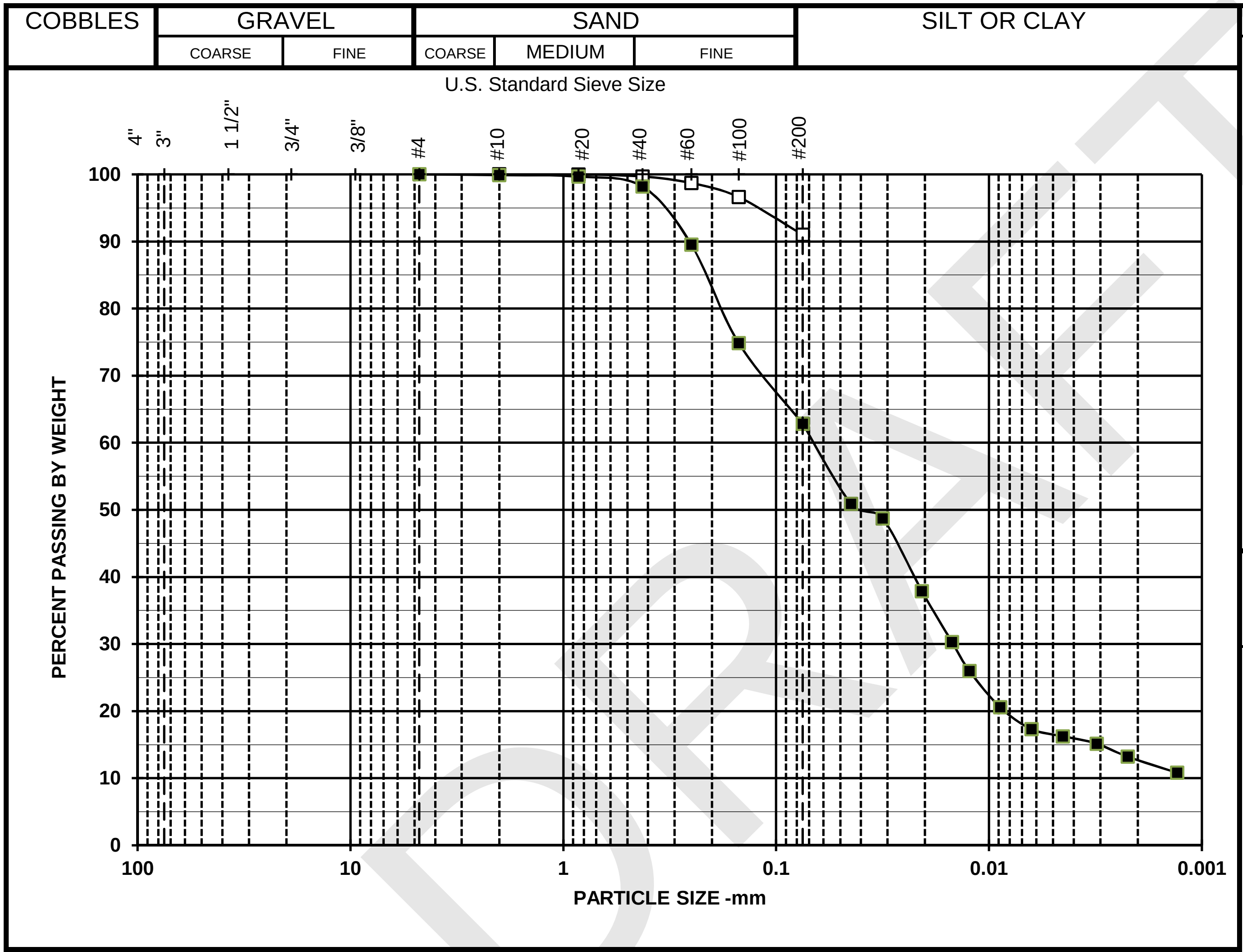

Symbol	□	■	○
Boring	JOP-B015	JOP-B015	
Sample	ST-4B	S-13	
Depth	69.25	73.5-75	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	9.0	37.2	
%C SAND	0.0	0.1	
%M SAND	0.3	1.7	
%F SAND	8.7	35.3	
% FINES	91.0	62.8	
% -2μ		13	
D_{100} (mm)	2.00	4.75	
D_{60} (mm)		0.07	
D_{30} (mm)		0.01	
D_{10} (mm)			
Cc			
Cu			

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

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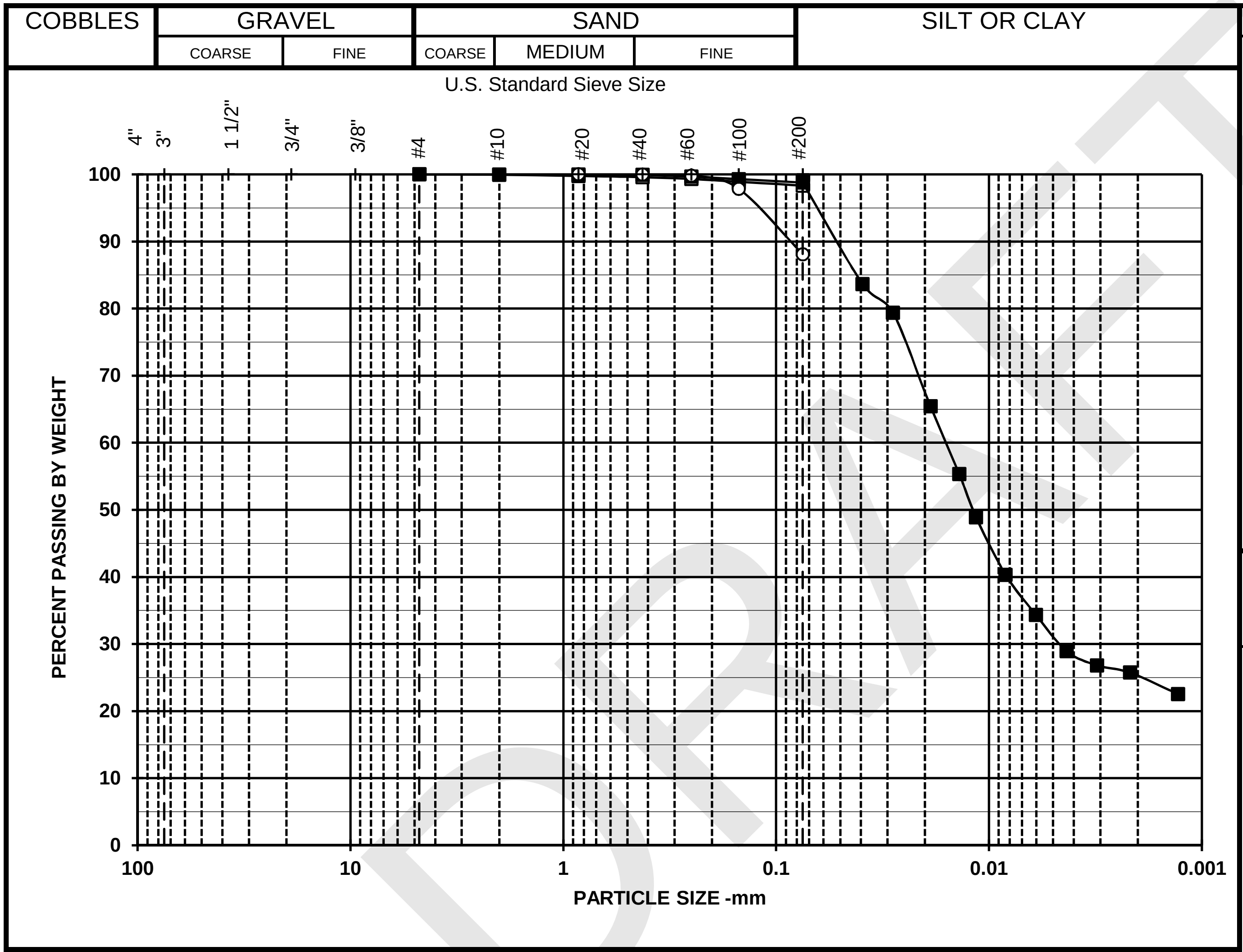

Symbol	☐	■	○
Boring	JOP-B016	JOP-B016	JOP-B016
Sample	ST-1C	ST-3B	ST-4C
Depth	4.8	23.7	44.60
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% SAND	1.7	1.2	11.9
%C SAND	0.1	0.0	0.0
%M SAND	0.4	0.1	0.0
%F SAND	1.2	1.2	11.9
% FINES	98.3	98.8	88.1
% -2μ		25	
D_{100} (mm)	4.75	4.75	0.85
D_{60} (mm)		0.02	
D_{30} (mm)		0.00	
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER ☐	■	○
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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T60428794	60428794-107

PARTICLE SIZE DISTRIBUTION

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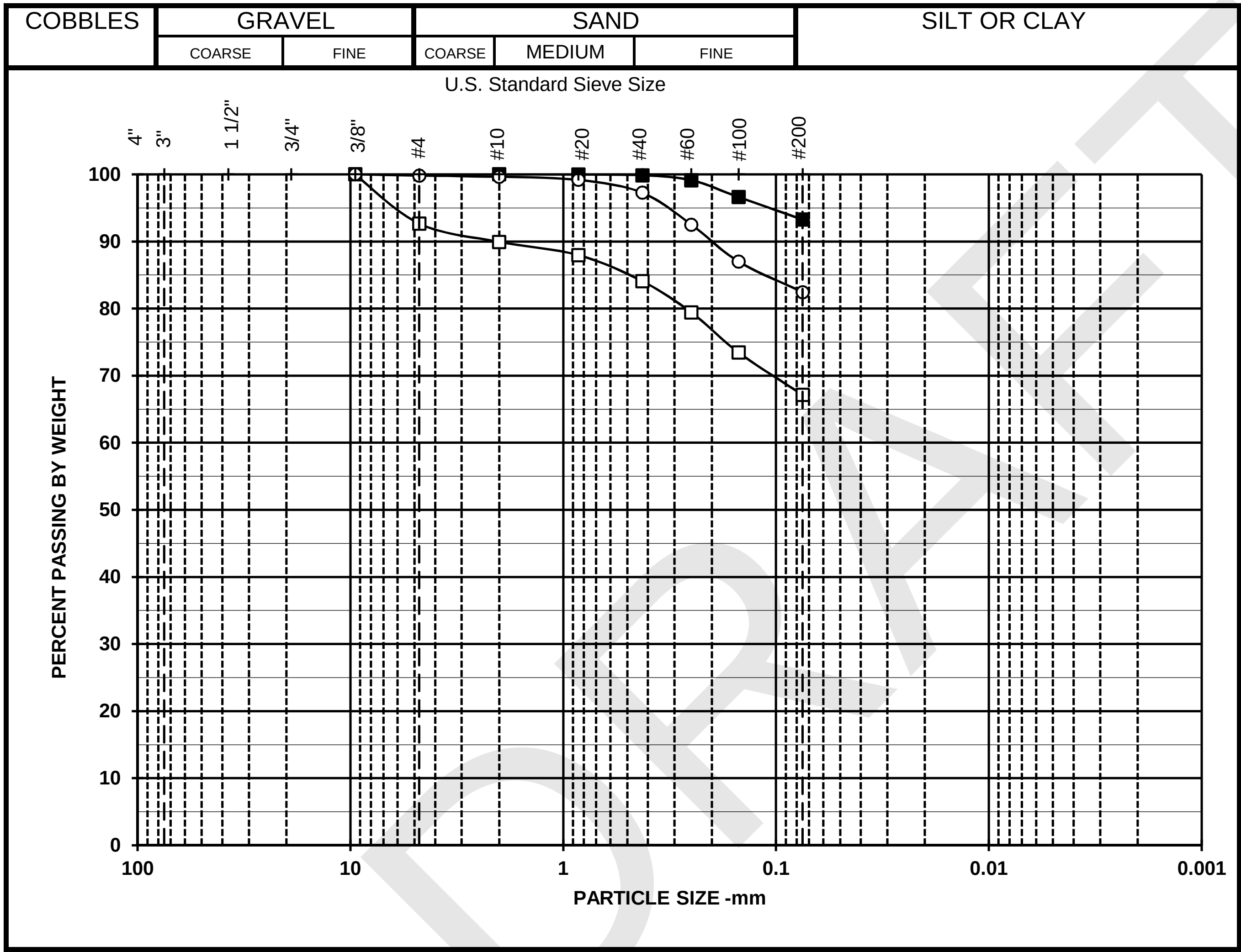

Symbol	□	■	○
Boring	JOP-017	JOP-B017	JOP-B017
Sample	ST-2B	ST-3C	ST-4D
Depth	8.85	24.8	34.85
% +3"	0.0	0.0	0.0
% Gravel	7.3	0.0	0.2
% SAND	25.6	6.7	17.4
%C SAND	2.7	0.0	0.2
%M SAND	5.9	0.1	2.4
%F SAND	16.9	6.6	14.8
% FINES	67.1	93.3	82.4
% -2µ			
D_{100} (mm)	9.50	2.00	9.50
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	■	○
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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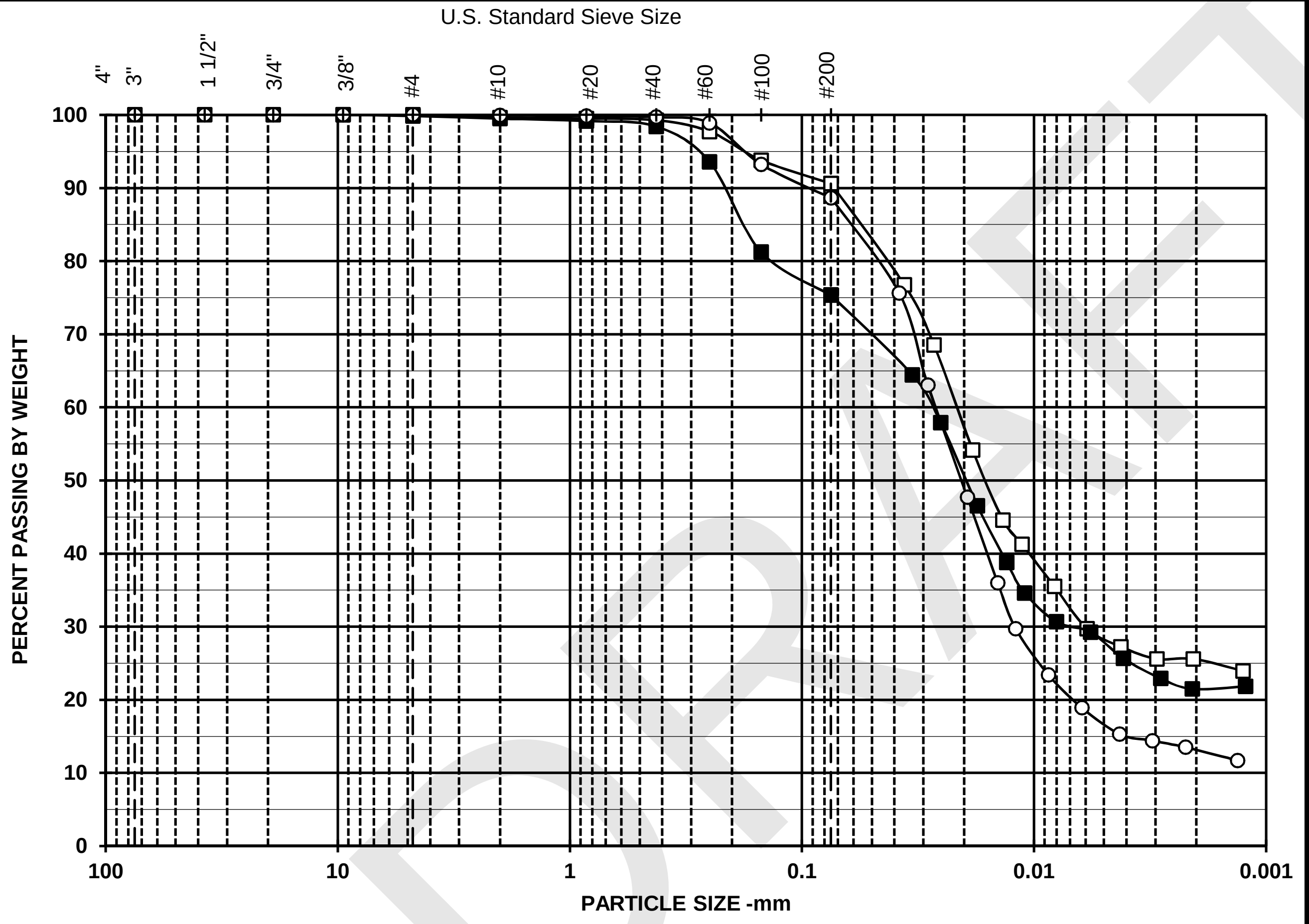
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	J0P-B018	J0P-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

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

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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

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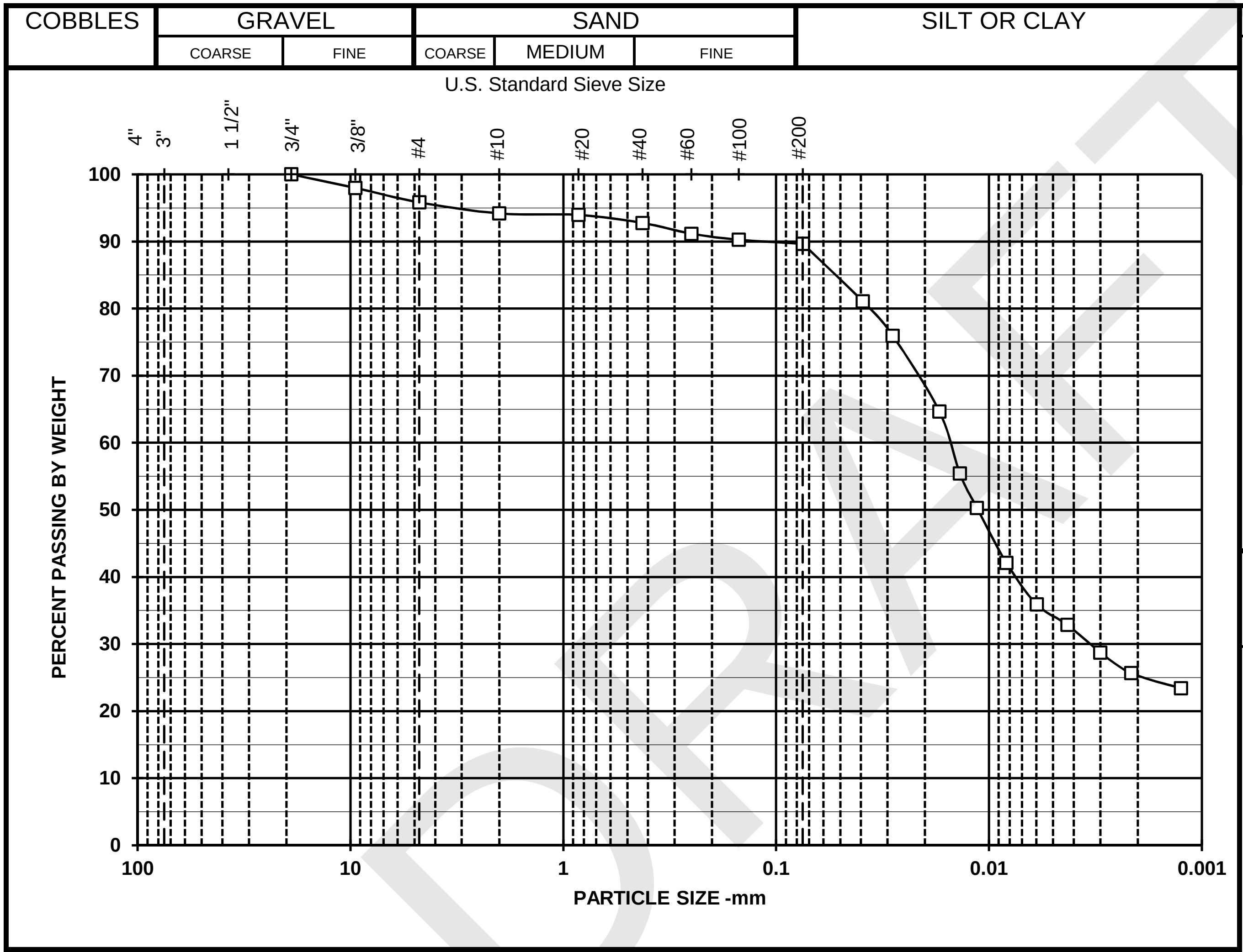

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	21.5				CL	Light brown, Lean clay	9/30/2015
■							
○							

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		

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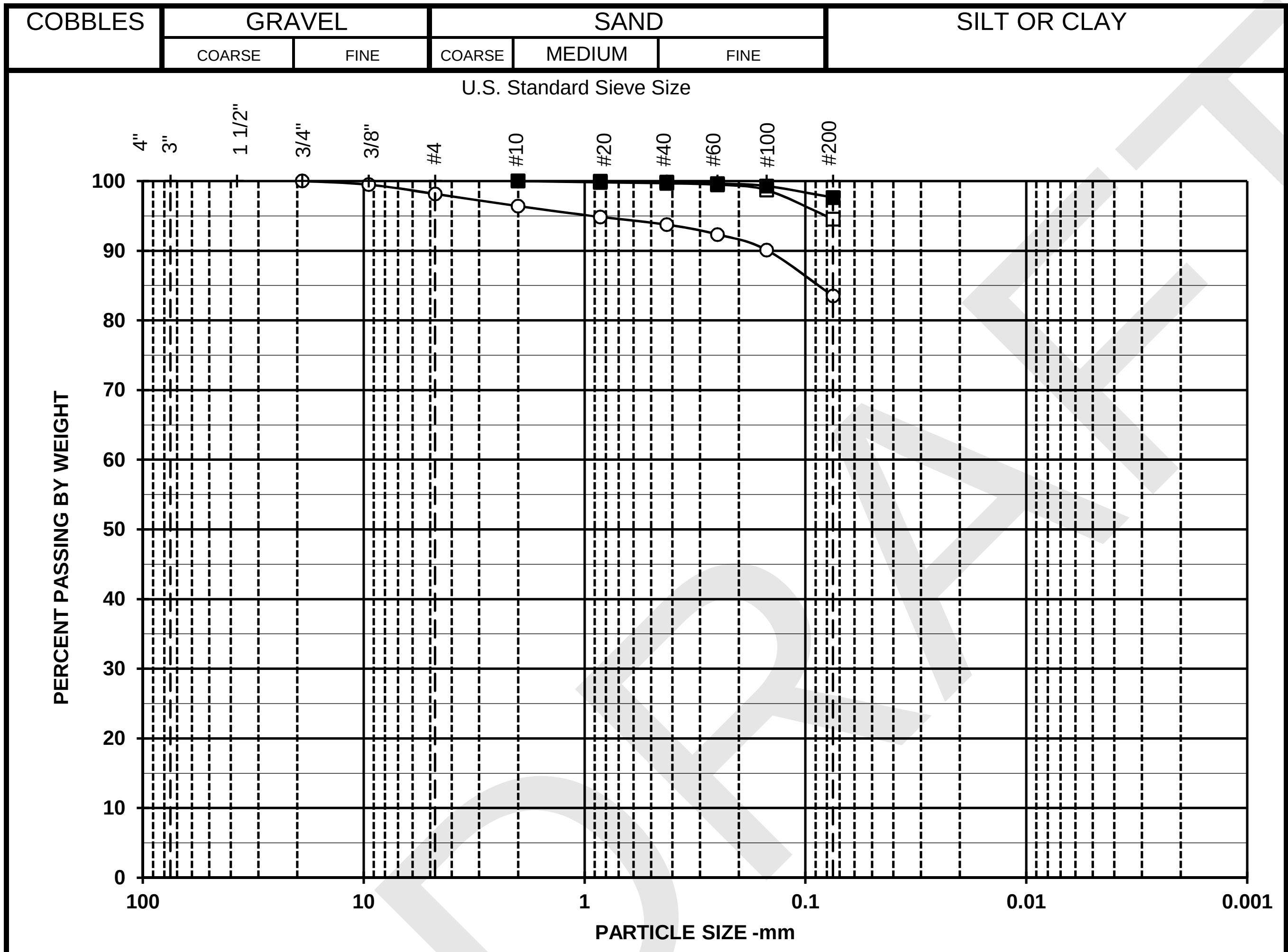

Symbol	□	■	○
Boring	JOP-B019	JOP-B019	JOP-B019
Sample	ST-1A	S-5	ST-2B
Depth	8.15	28.5-30	43.8
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	1.8
% SAND	5.5	2.4	14.7
%C SAND	0.0	0.0	1.8
%M SAND	0.3	0.2	2.7
%F SAND	5.2	2.2	10.2
% FINES	94.5	97.6	83.5
% -2µ			
D_{100} (mm)	2.00	2.00	19.00
D_{60} (mm)			
D_{30} (mm)			
D_{10} (mm)			
Cc			
Cu			

Particle Size (Sieve #)	PERCENT FINER □	 ■	 ○
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

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

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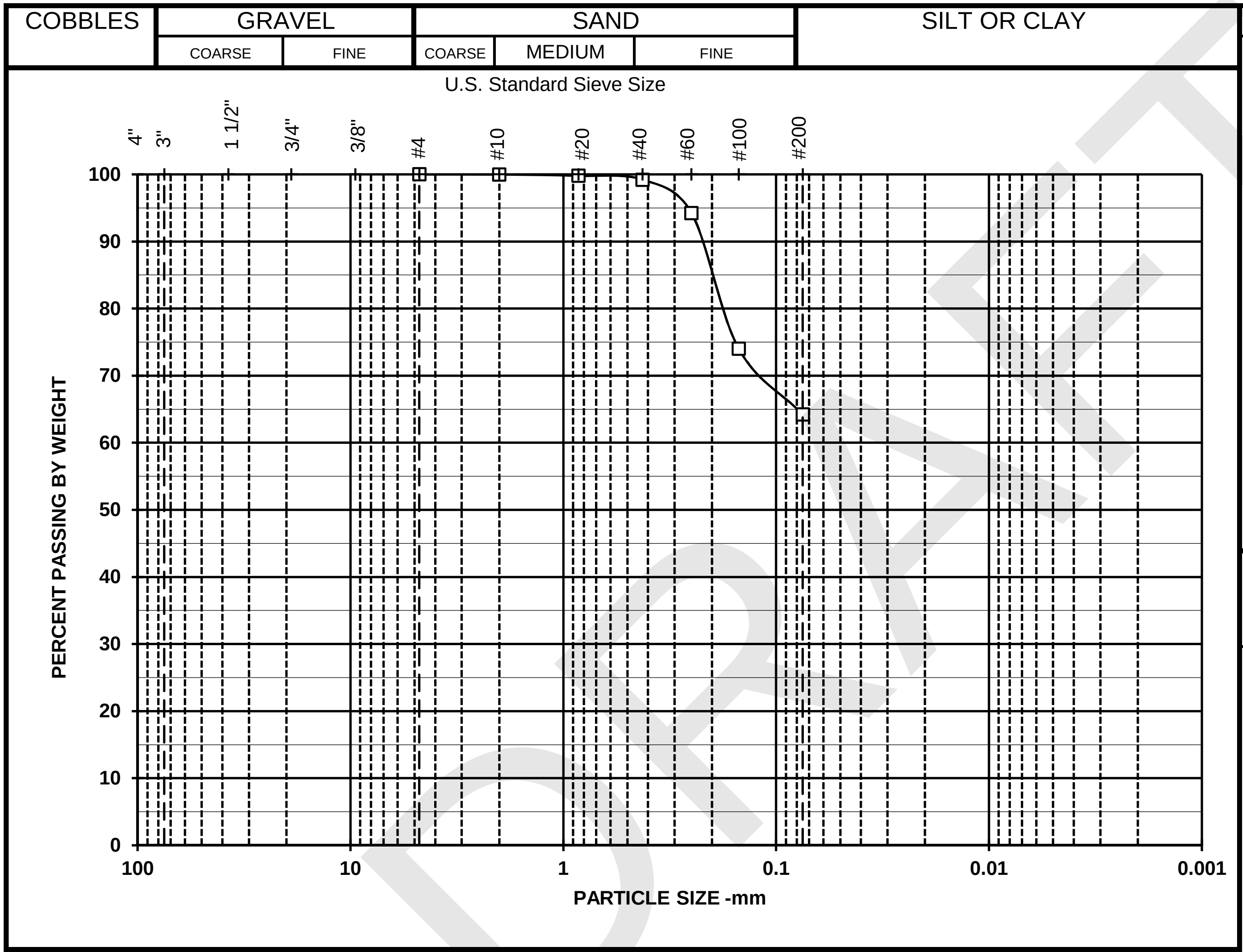
Dynegy CCR - Joppa



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 (Sieve #)	PERCENT FINER □	PERCENT FINER ■	PERCENT FINER ○
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		

SYMBOL	w (%)	LL	PL	PI	USCS	DESCRIPTION AND REMARKS	Date Tested
□	18.9				CL	Light brown, Sandy lean clay	8/21/2015
■							
○							

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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

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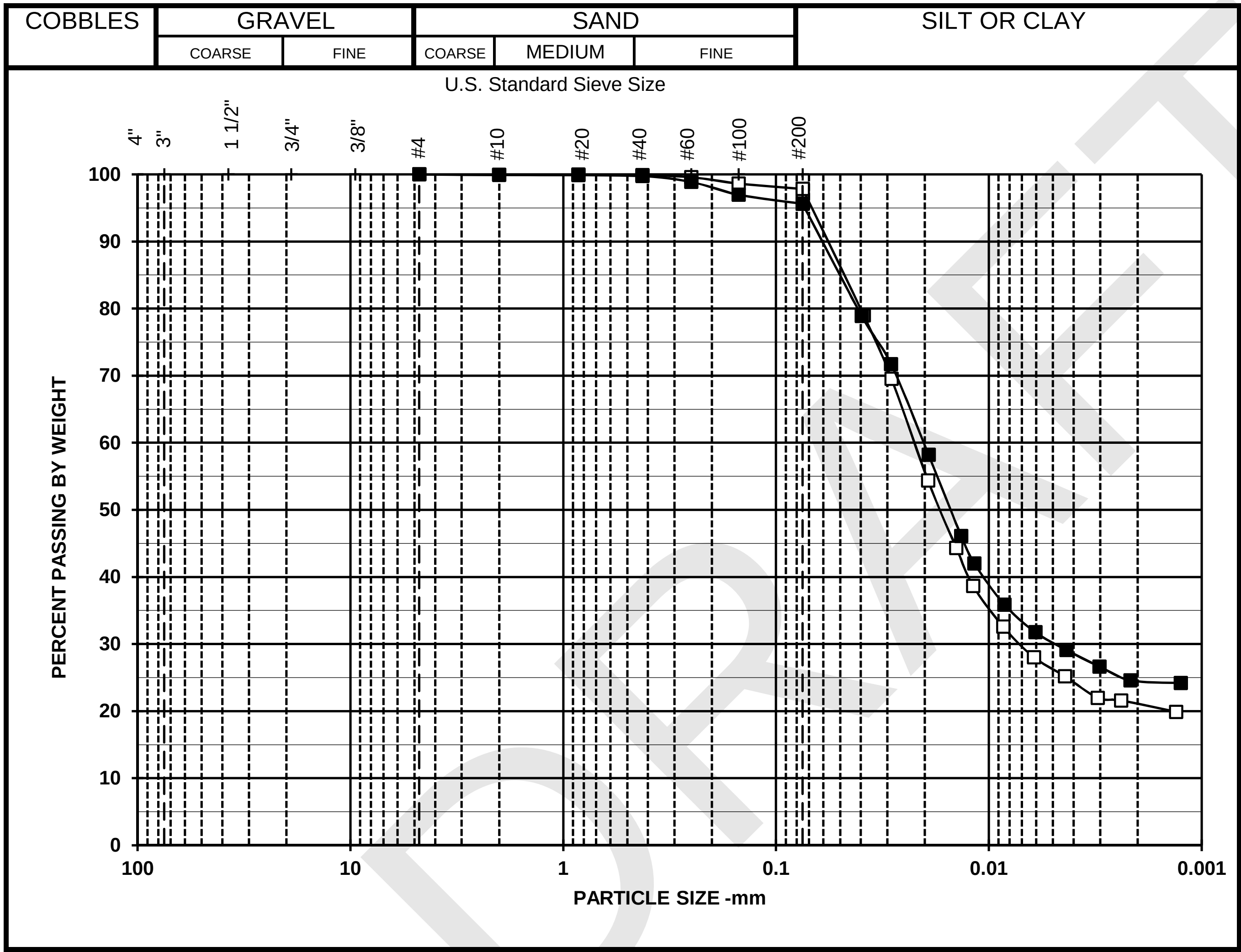

Symbol	□	■	○
Boring	JOP-B020	JOP-B020	
Sample	ST-2B	S-4	
Depth	19.25	28.5-30	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	2.2	4.4	
%C SAND	0.1	0.1	
%M SAND	0.0	0.2	
%F SAND	2.1	4.1	
% FINES	97.8	95.6	
% -2µ	21	25	
D_{100} (mm)	4.75	4.75	
D_{60} (mm)	0.02	0.02	
D_{30} (mm)	0.01	0.00	
D_{10} (mm)			
Cc			
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	

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
○							

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Dynegy CCR - Joppa

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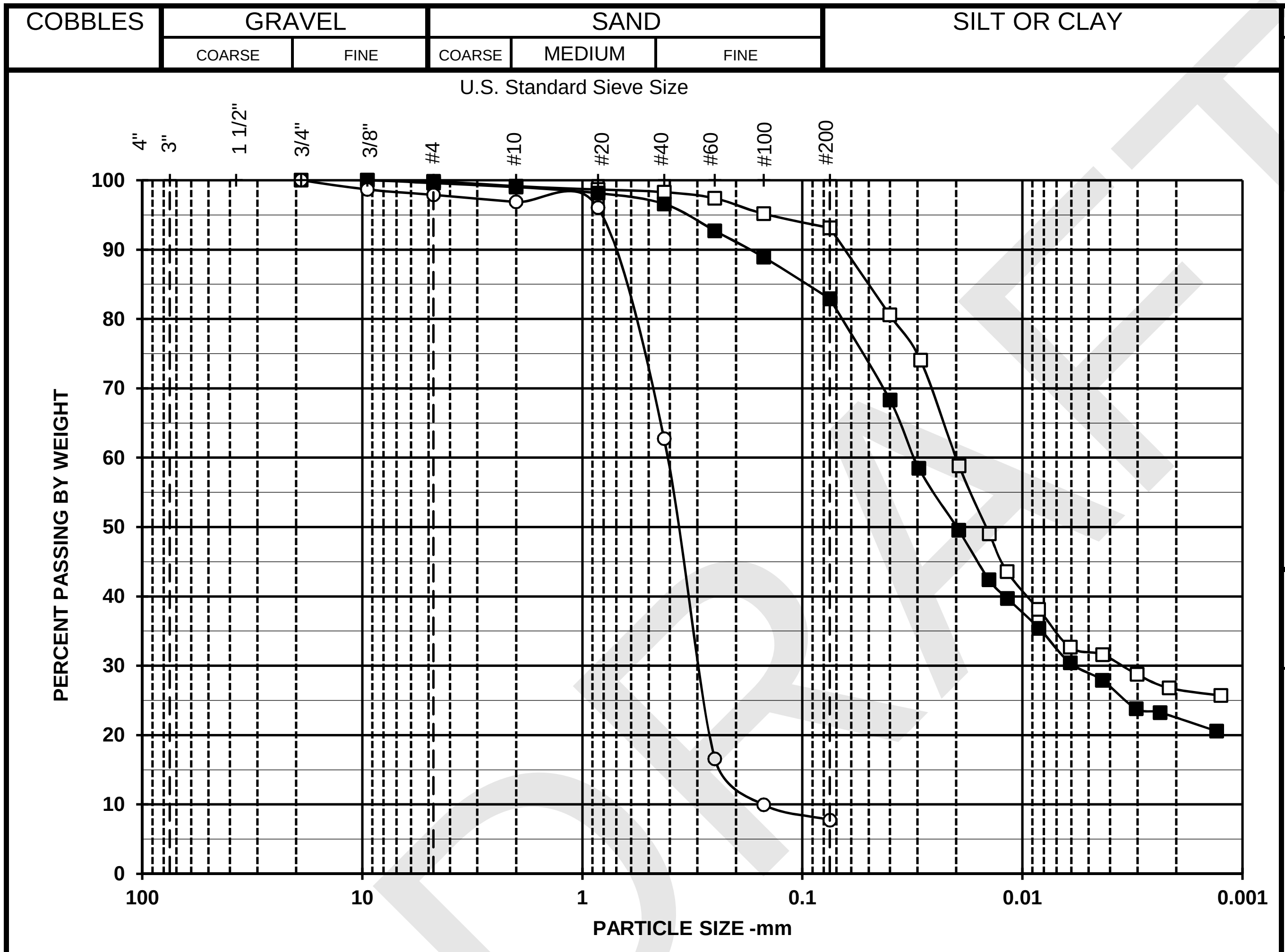

Symbol	□	■	○
Boring	JOP-B020	JOP-B020	JOP-B020
Sample	S-7	ST-5C	S-12
Depth	53.5-50	69.8	78.5-80
% +3"	0.0	0.0	0.0
% Gravel	0.1	0.4	2.1
% SAND	6.8	16.7	90.2
%C SAND	0.7	0.6	1.0
%M SAND	0.9	2.4	34.2
%F SAND	5.2	13.7	55.0
% FINES	93.1	82.9	7.7
% -2µ	27	22	
D_{100} (mm)	9.50	9.50	19.00
D_{60} (mm)	0.02	0.03	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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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

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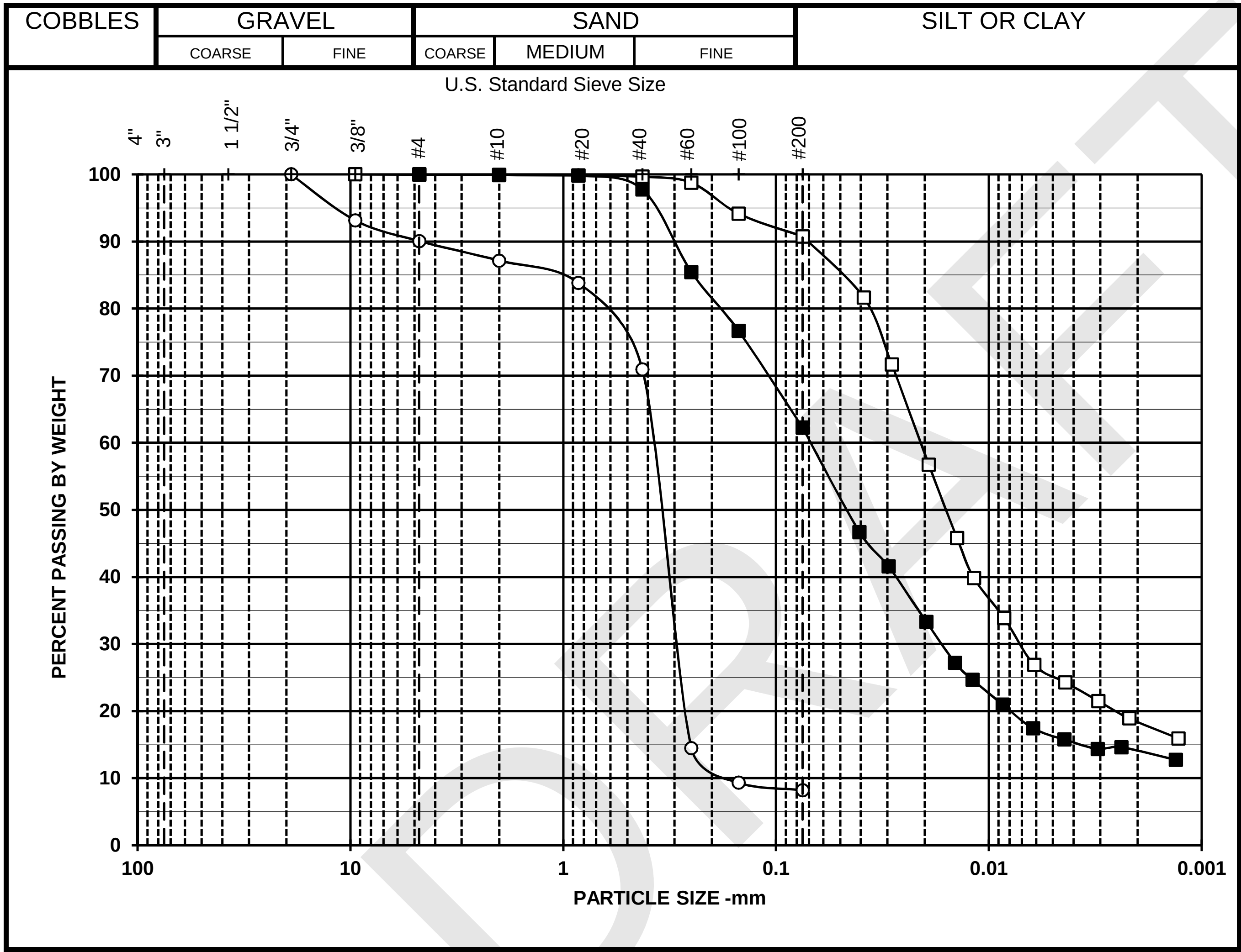

Symbol	□	■	○
Boring	JOP-B021	JOP-B021	JOP-B021
Sample	S-5	ST-3B	S-9
Depth	23.5-25	34.1	48.5-50
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	9.9
% SAND	9.3	37.8	81.9
%C SAND	0.1	0.1	2.9
%M SAND	0.2	2.2	16.2
%F SAND	8.9	35.5	62.7
% FINES	90.7	62.2	8.2
% -2µ	18	14	
D_{100} (mm)	9.50	4.75	19.00
D_{60} (mm)	0.02	0.07	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

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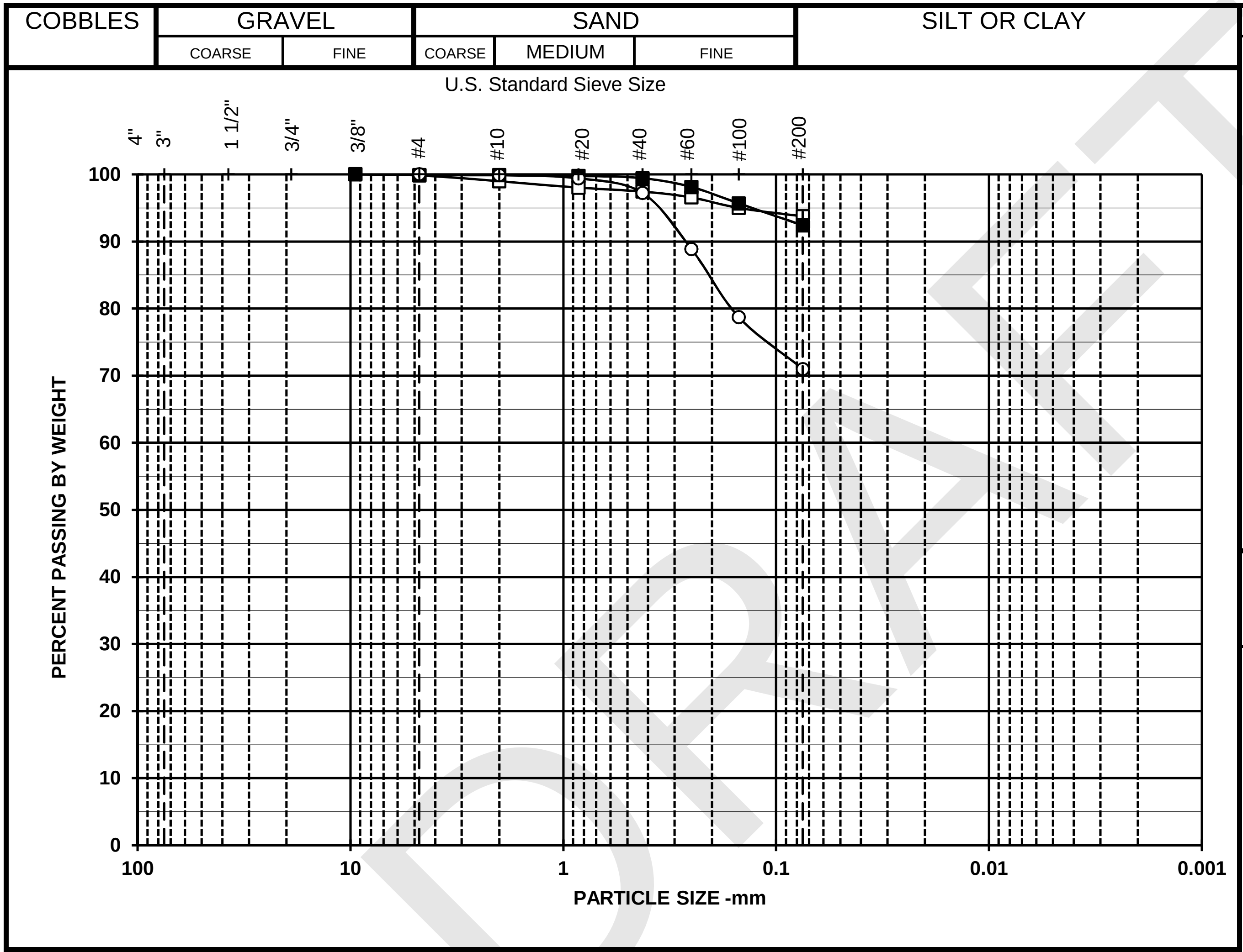

Symbol	☐	■	○
Boring	JOP-B022	JOP-B022	JOP-B022
Sample	ST-2C	ST-3C	ST-4B
Depth	9.4	24.5	38.8
% +3"	0.0	0.0	0.0
% Gravel	0.1	0.1	0.0
% SAND	6.2	7.5	29.0
%C SAND	0.9	0.0	0.1
%M SAND	1.5	0.5	2.7
%F SAND	3.7	7.0	26.3
% FINES	93.7	92.4	71.0
% -2μ			
D_{100} (mm)	9.50	9.50	4.75
D_{60} (mm)			
D_{30} (mm)			
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

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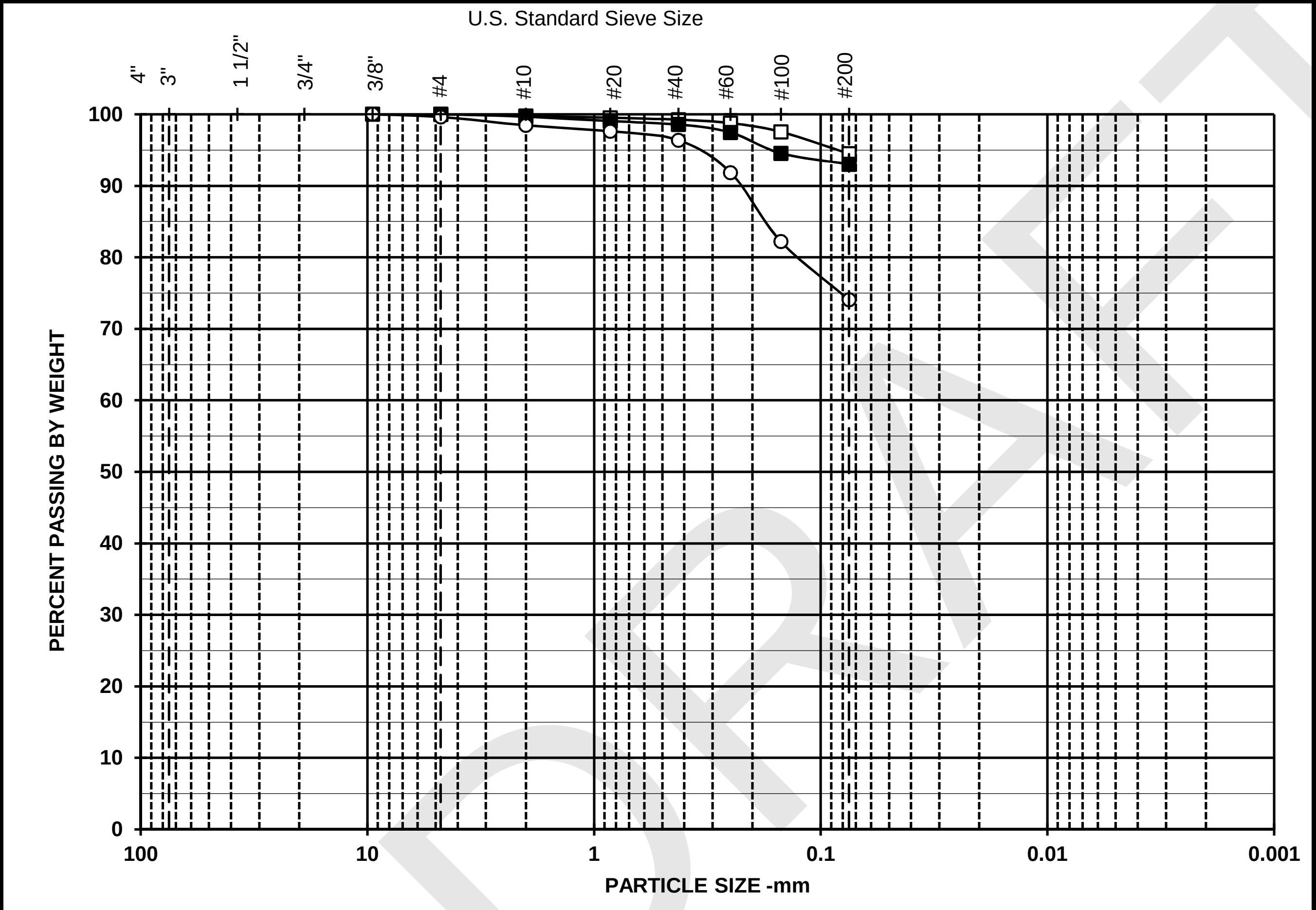
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



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

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PARTICLE SIZE DISTRIBUTION

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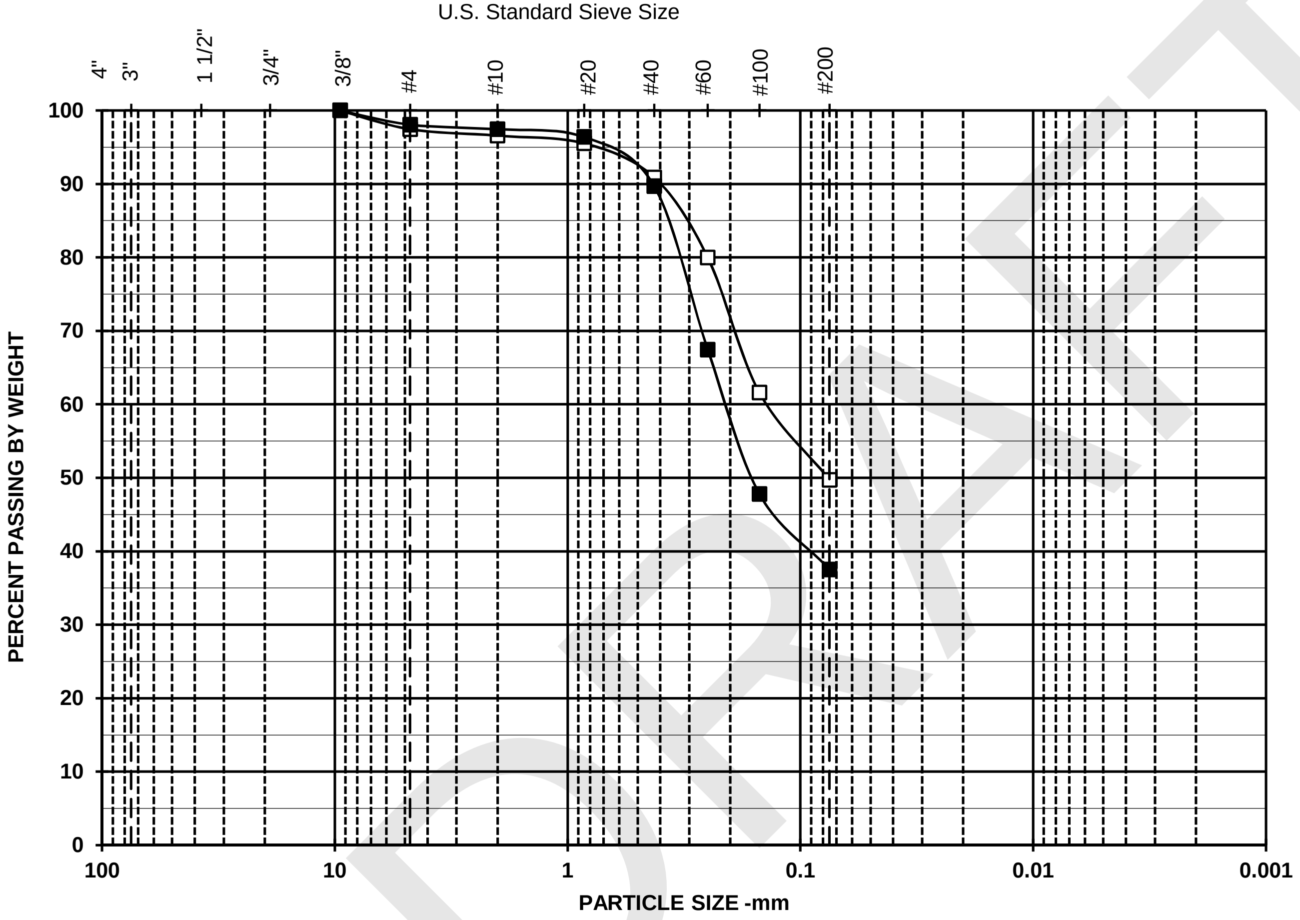
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	☐	■	○
Boring	JOP-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 (Sieve #)	PERCENT FINER ☐	■	○
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
○							

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PARTICLE SIZE DISTRIBUTION

Dynegy CCR - Joppa

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 : ☒ Triaxial Cell or ☐ Compaction Mold or

☒ with stones or ☐ Stones with filter paper or top + bottom

2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination

3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes

4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only

5) Direction of permeant : ☒ Up during or ☐ Down during permeation

6) Permeant: water used ☒ 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. º C	Date	Time hr	min	sec	Initial σ_c psi	Ub psi	U-tube Reading Head (cm) (cc)	Tail (cm) (cc)	Flow in/out gradient	Permeability 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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or top + bottom
2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination
3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes
4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only
5) Direction of permeant : ☒ Up during or ☐ Down during permeation
6) Permeant: water used ☒ 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. º C	Date	Time hr	min	sec	Initial σ_c psi	Ub psi	U-tube Reading Head (cm) (cc)	Tail (cm) (cc)	Flow in/out gradient	Permeability 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_t (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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or ______ top + bottom
2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination
3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes
4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only
5) Direction of permeant : ☒ Up during or ☐ Down during permeation
6) Permeant: water used ☒ Tap ☐ Distilled
or ☐ ☐ Demineralized ☐ 0.005 N calcium sulfate (CaSO4)

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

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_t (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

Consol Stage- Trial No.	Temp. º C	Date	Time hr	min	sec	Initial σ_c psi	Ub psi	U-tube Reading Head (cm) (cc)	Tail (cm) (cc)	Flow in/out gradient	Permeability 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 =					

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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or top + bottom

2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination

3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes

4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only

5) Direction of permeant : ☒ Up during or ☐ Down during permeation

6) Permeant: water used ☒ Tap ☐ Distilled

or ☐ ☐ Demineralized ☐ 0.005 N calcium sulfate (CaSO4)

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	Permeability 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_t (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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or top + bottom
2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination
3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes
4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only
5) Direction of permeant : ☒ Up during or ☐ Down during permeation
6) Permeant: water used ☒ 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. 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	Permeability 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_t (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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or top + bottom
2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination
3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes
4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only
5) Direction of permeant : ☒ Up during or ☐ Down during permeation
6) Permeant: water used ☒ 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. º C	Date	Time hr	min	sec	Initial σ_c psi	Ub psi	U-tube Reading Head (cm) (cc)	Tail (cm) (cc)	Flow in/out gradient	Permeability 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_t (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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or top + bottom
2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination
3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes
4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only
5) Direction of permeant : ☒ Up during or ☐ Down during permeation
6) Permeant: water used ☒ 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. º C	Date	Time hr	min	sec	Initial σ_c psi	Ub psi	U-tube Reading Head (cm) (cc)	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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or top + bottom
2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination
3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes
4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only
5) Direction of permeant : ☒ Up during or ☐ Down during permeation
6) Permeant: water used ☒ Tap ☐ Distilled
or ☐ ☐ Demineralized ☐ 0.005 N calcium sulfate (CaSO4)

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	Permeability 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_t (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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or top + bottom
2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination
3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes
4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only
5) Direction of permeant : ☒ Up during or ☐ Down during permeation
6) Permeant: water used ☒ Tap ☐ Distilled
or ☐ ☐ Demineralized ☐ 0.005 N calcium sulfate (CaSO4)

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	min	sec	Initial σ_c psi	Ub psi	U-tube Reading Head (cm) (cc)	Tail (cm) (cc)	Flow in/out gradient	Permeability 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 : ☒ Triaxial Cell or ☐ Compaction Mold or
☒ with stones or ☐ Stones with filter paper or top + bottom
2) Specimen orientation for: ☒ Vertical or ☐ Horizontal permeability determination
3) During saturation: Water flushed up sides of specimen to remove air ☒ No ☐ Yes
4) During consolidation: ☒ Top and bottom drainage or ☐ Top ☐ Bottom only
5) Direction of permeant : ☒ Up during or ☐ Down during permeation
6) Permeant: water used ☒ 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. º C	Date	Time hr	min	sec	Initial σ_c psi	Ub psi	U-tube Reading Head (cm) (cc)	Tail (cm) (cc)	Flow in/out gradient	Permeability 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_t (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)			

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. 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	Permeability 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 =					

TEST SUMMARY

Final Specimen and Test Conditions

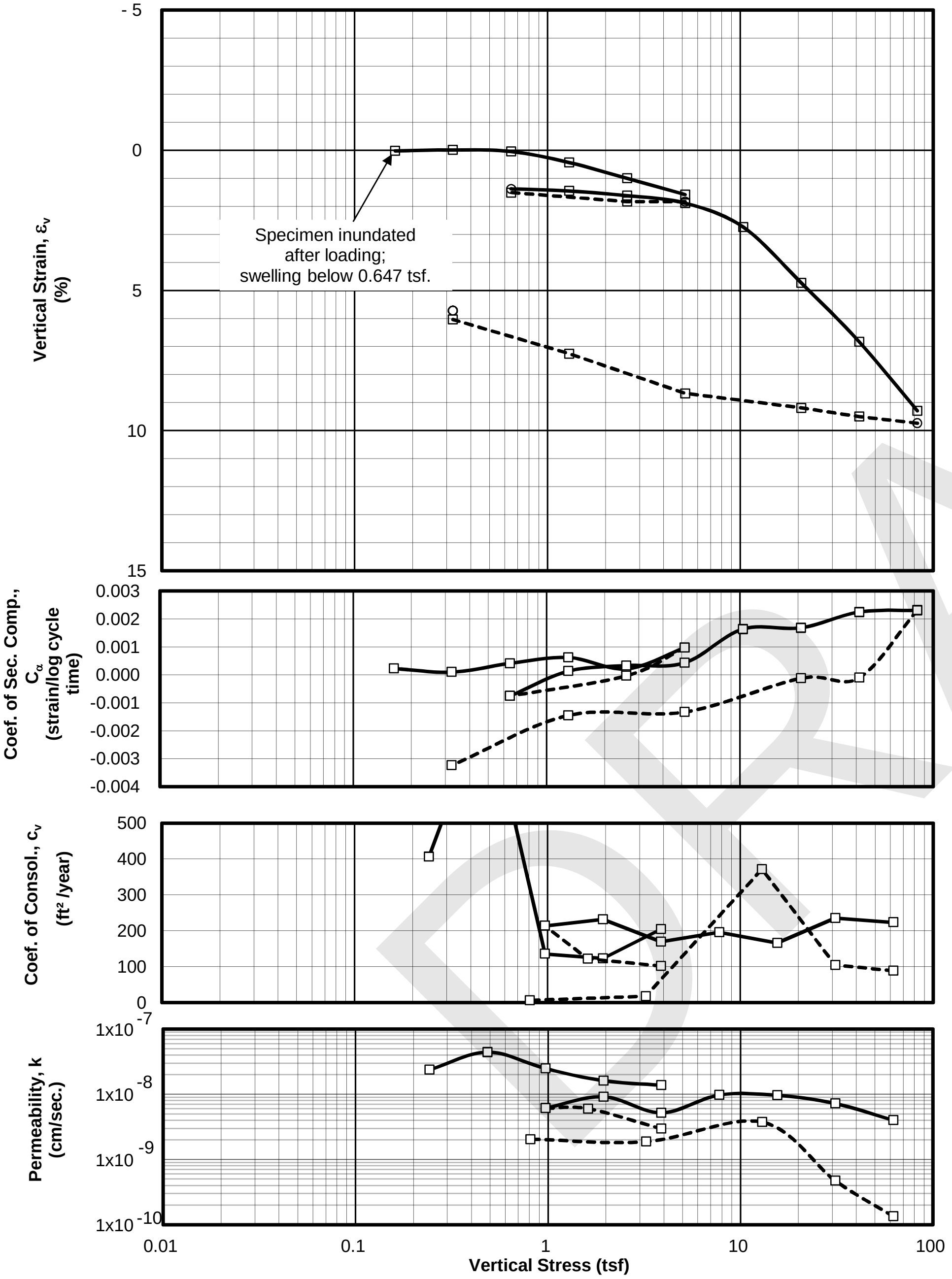
Lc = 9.030 cm ε_{axial} = 6.6%
Ac = 36.487 cm^2
Vc= 329.48 cm^3 ε_{vol} = 19.1%
Sc = 0.247 cm^{-1} Sc = Lc / Ac , final

	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



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

Analysis File: Conv41.xls (4/12) C15151.xlsx 11/20/2015

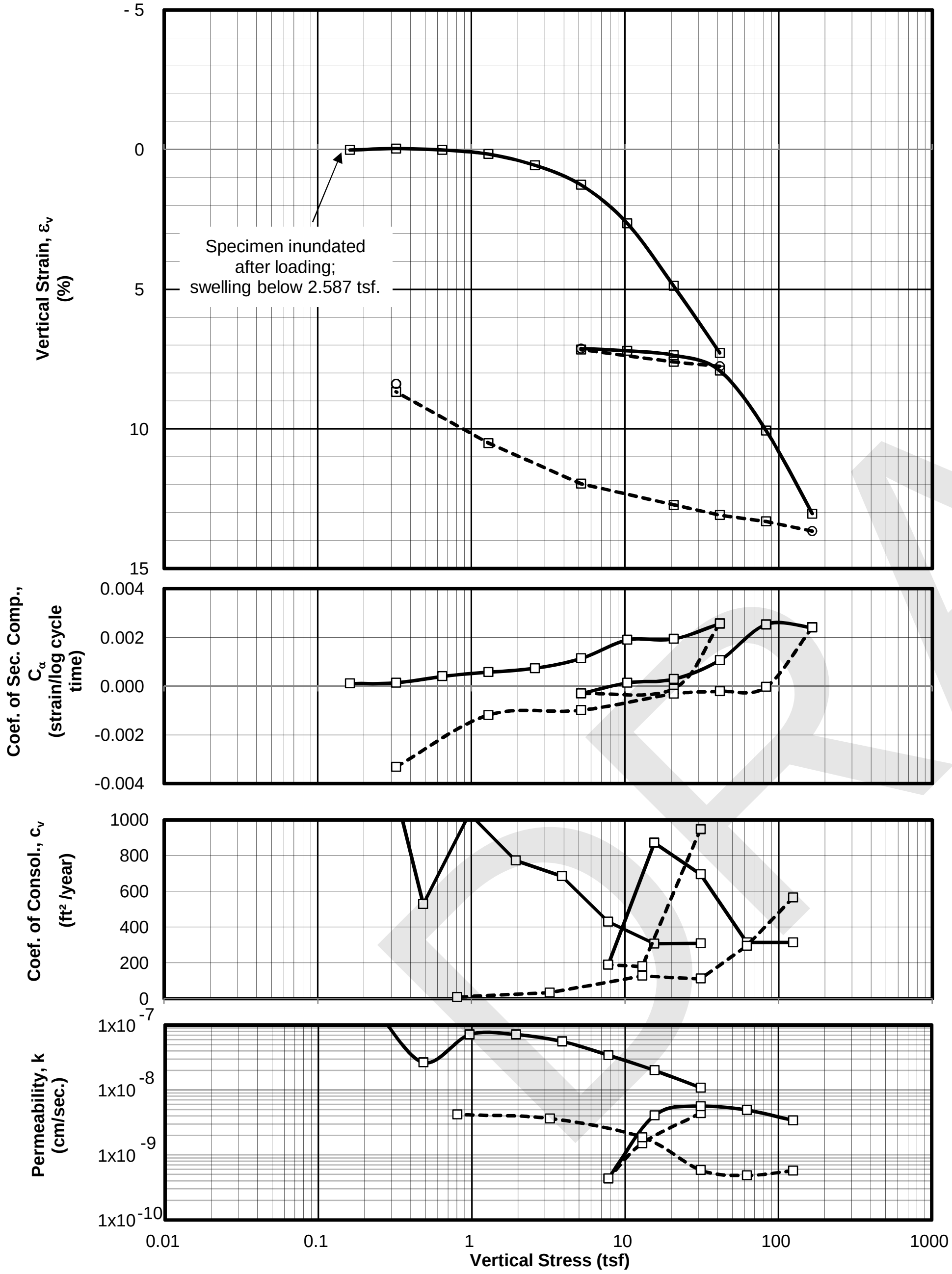
PROJECT:	Dynegy CCR - Joppa						
PROJECT NO.:	T60428794	Initial height:	0.617	inch	Final height:	0.610	inch
BORING:	JOP-B007	Initial water content:	18.6	%	Final water content:	20.0	%
SAMPLE:	ST-2C	Initial dry density:	107.8	pcf	Final dry density:	109.1	pcf
TEST:	C15151	Initial total density:	127.9	pcf	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:

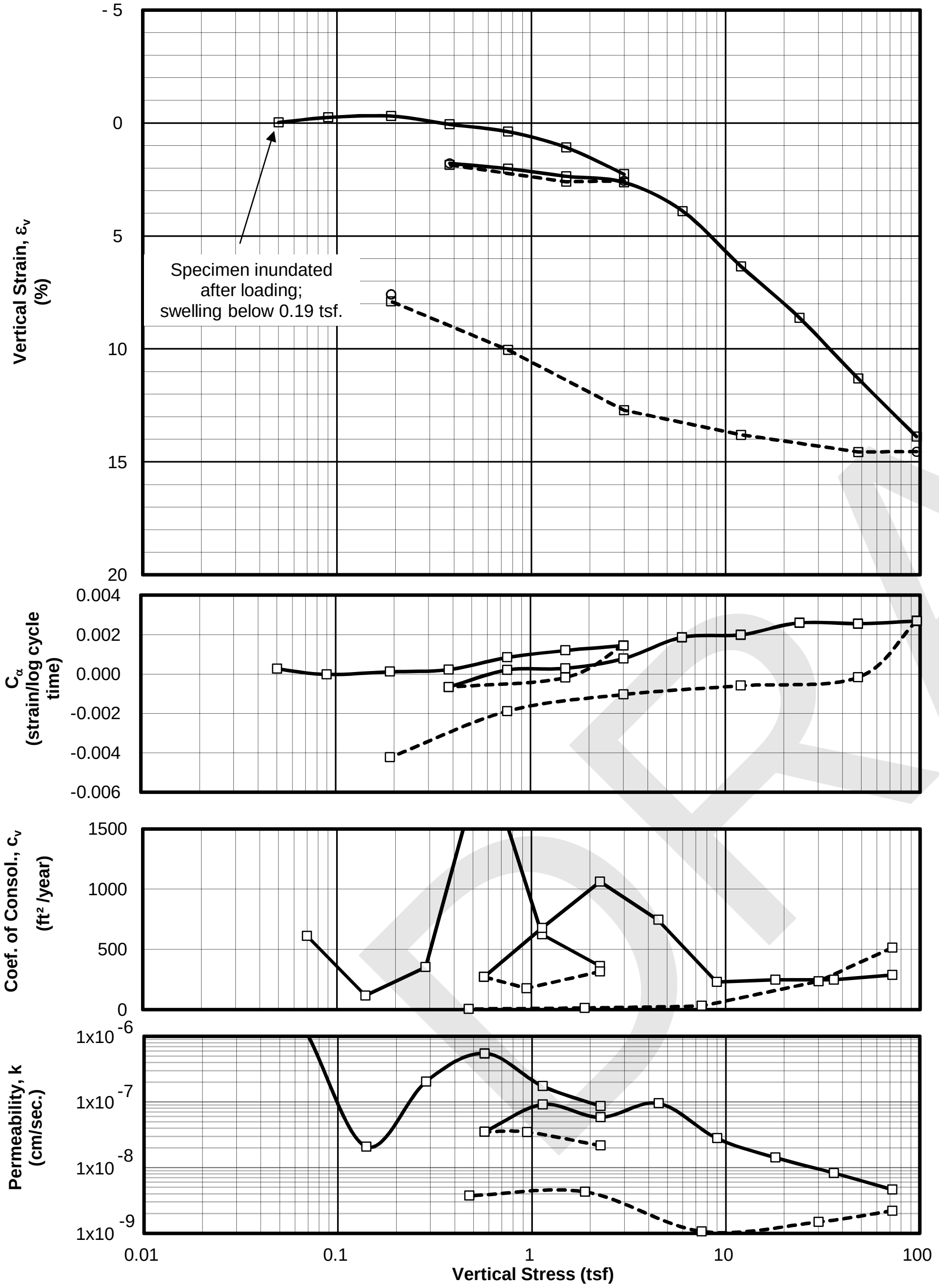
Load Frame No.: 5

Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: CL, yellowish brown clay

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:

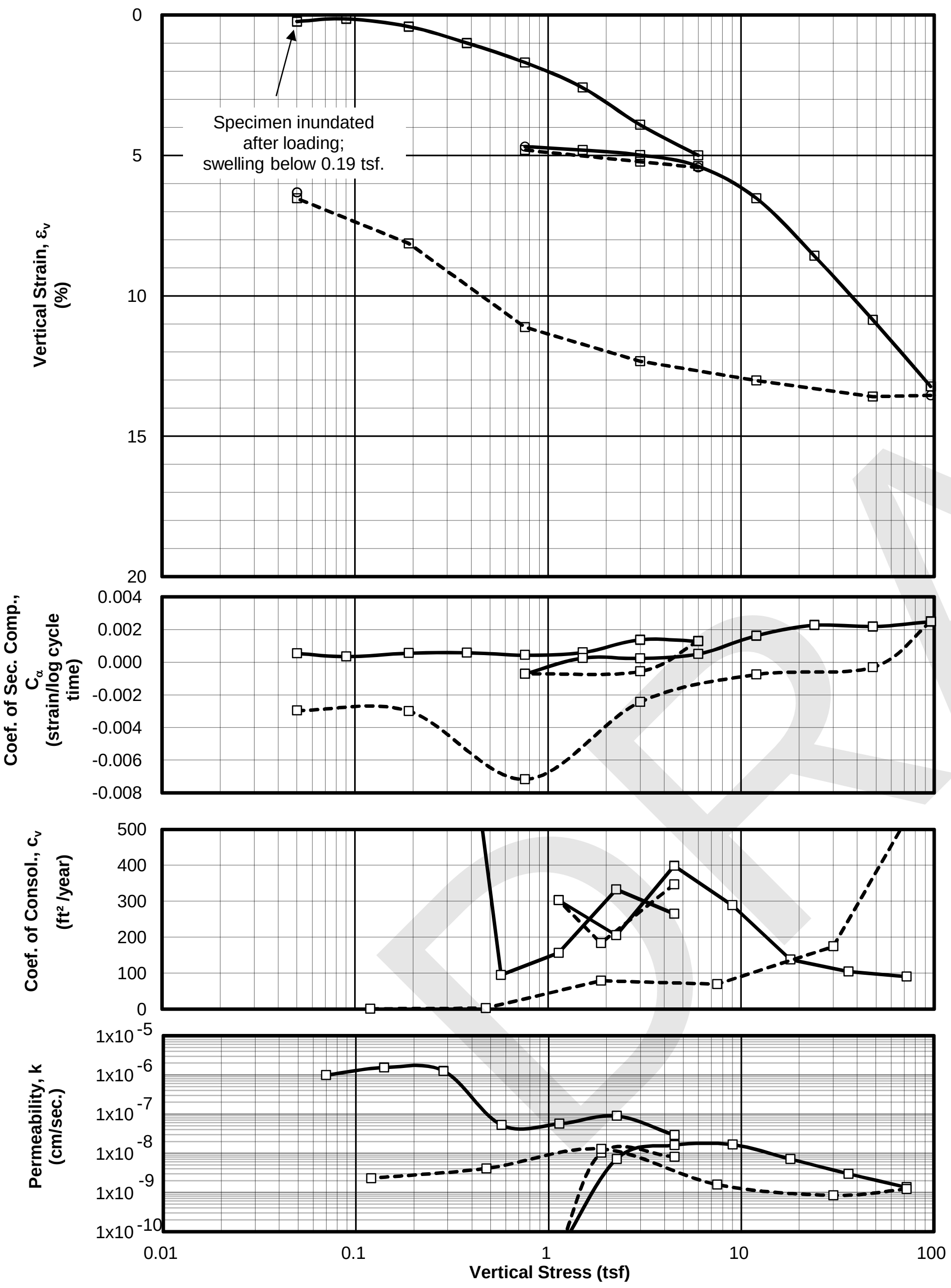
Load Frame No.: 2

Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: CL, light yellowish-gray lean clay

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 (ft²/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:

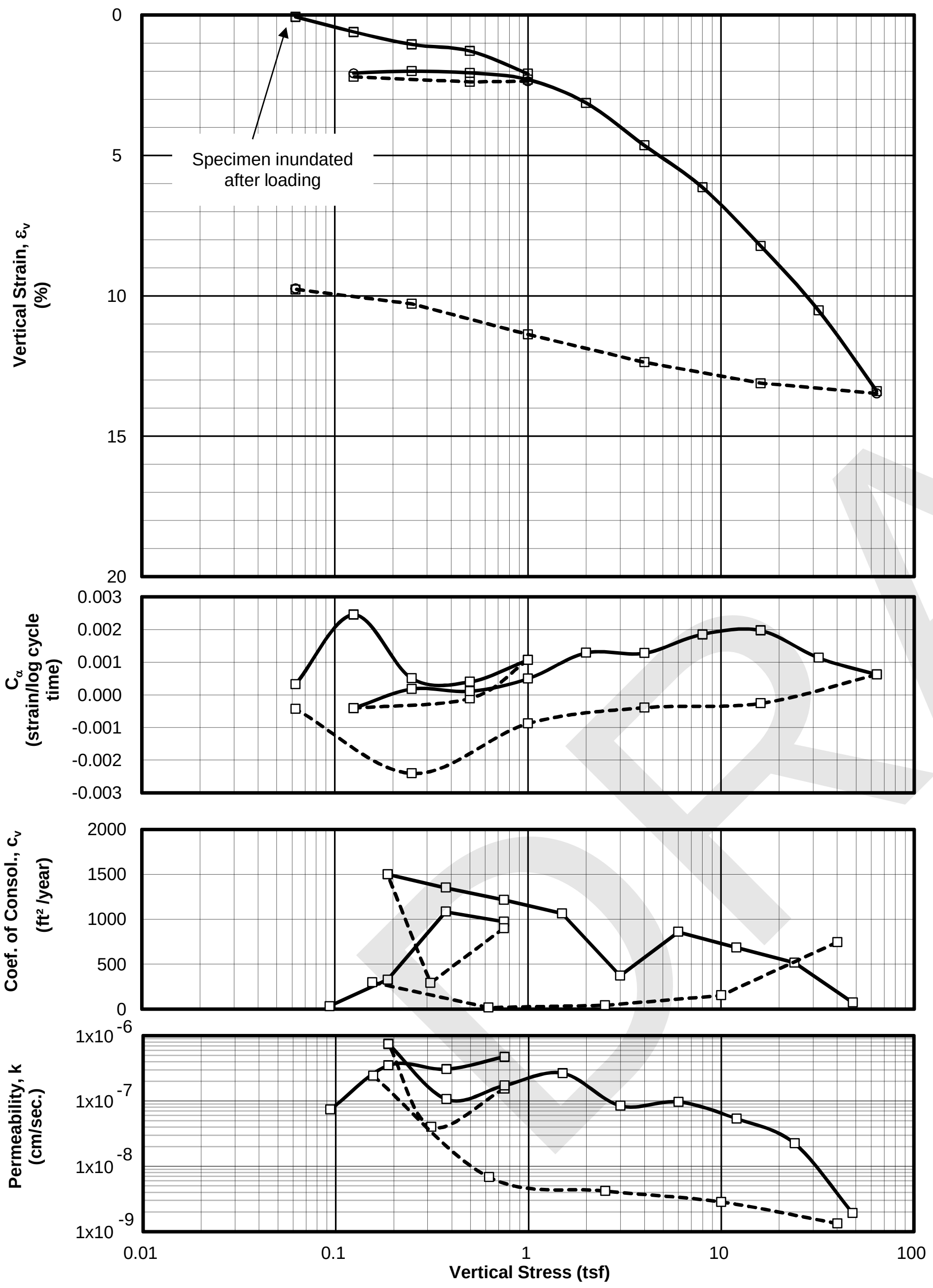
Load Frame No.: 3

Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: CL, light brown sandy lean clay with gravel

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 (ft²/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
BORING: JOP-B014
SAMPLE: ST-3A
TEST: C15137
DEPTH, feet: 33.5
BY: CMJ/YC
TEST DATE: 8/25/2015

Initial height: 0.615 inch
Initial water content: 13.8 %
Initial dry density: 111.3 pcf
Initial total density: 126.7 pcf
Initial saturation: 74 %
Initial void ratio: 0.498

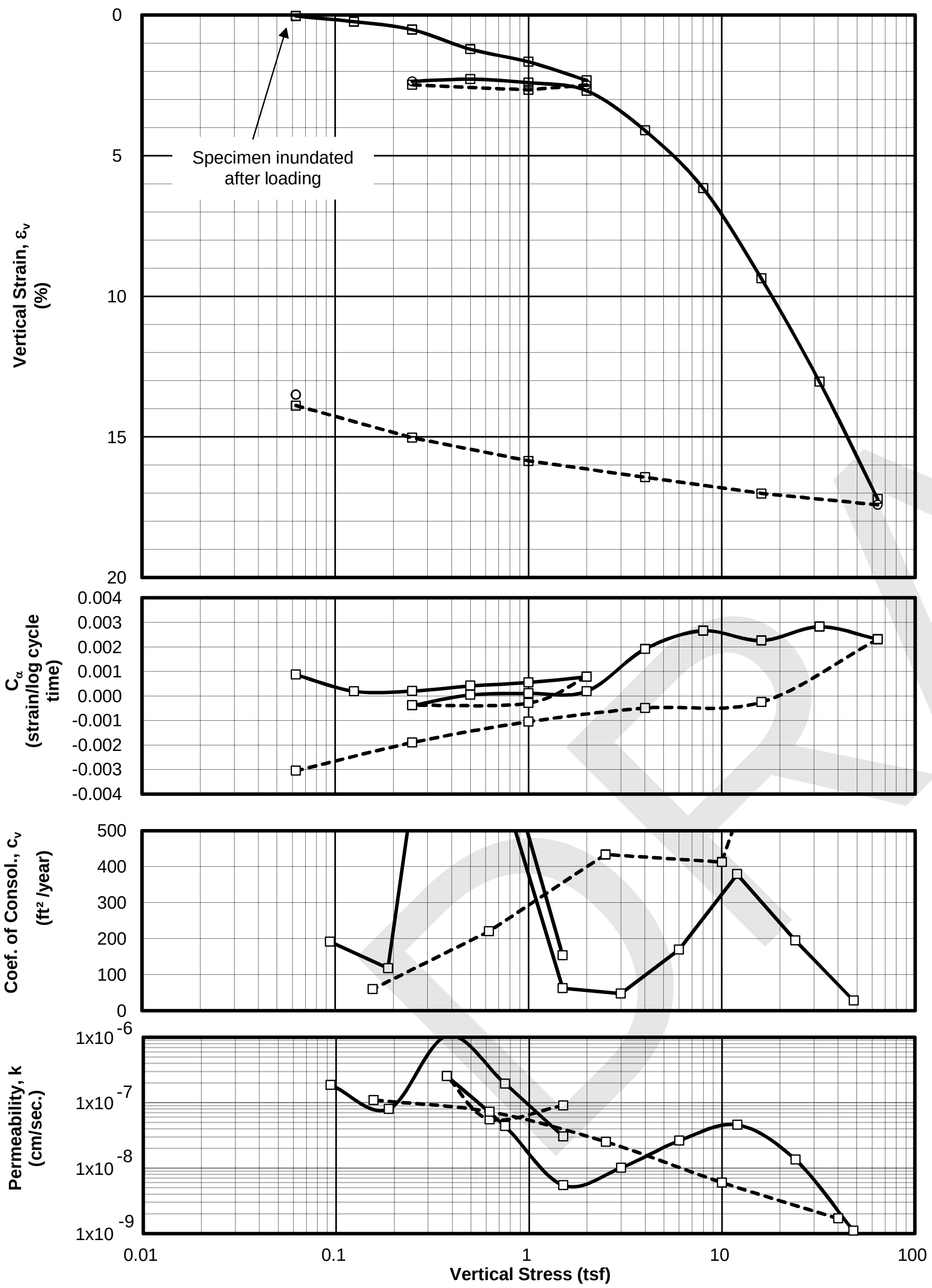
Final height: 0.589 inch
Final water content: 16.3 %
Final dry density: 116.2 pcf
Final total density: 135.1 pcf
Final saturation: 100 %
Final void ratio: 0.435
Final strain: 4.2 %

EQUIPMENT:
Load Frame No.: 2
Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: SC, light brown clayey sand

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 (ft²/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:

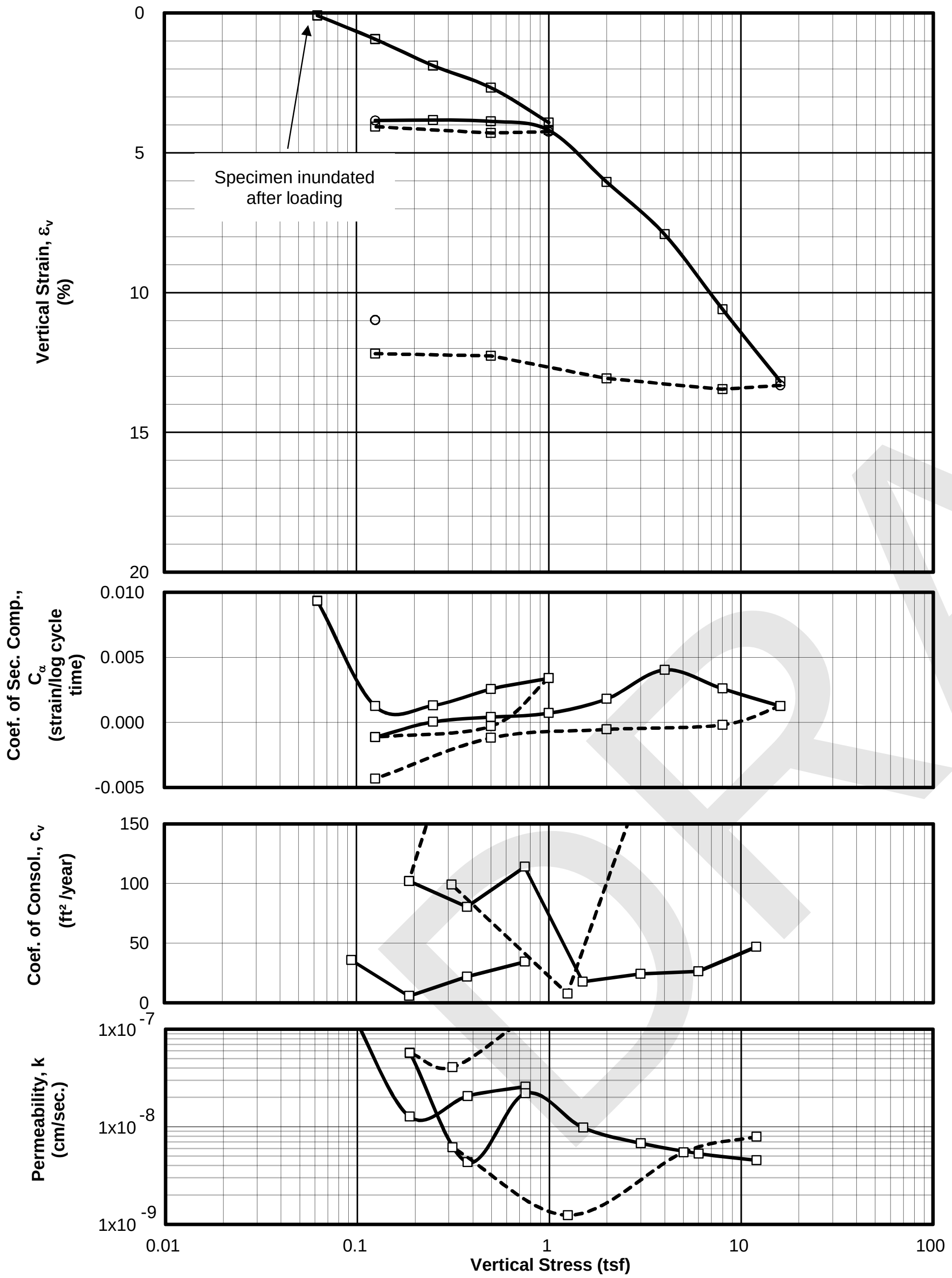
SPECIMEN DESCRIPTION: CL, light brown lean clay

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
BORING: JOP-B017
SAMPLE: ST-2A
TEST: C15136
DEPTH, feet: 8.25
BY: CMJ/YC
TEST DATE: 8/24/2015

Initial height: 0.610 inch
Initial water content: 22.5 %
Initial dry density: 100.4 pcf
Initial total density: 123.0 pcf
Initial saturation: 98 %
Initial void ratio: 0.585

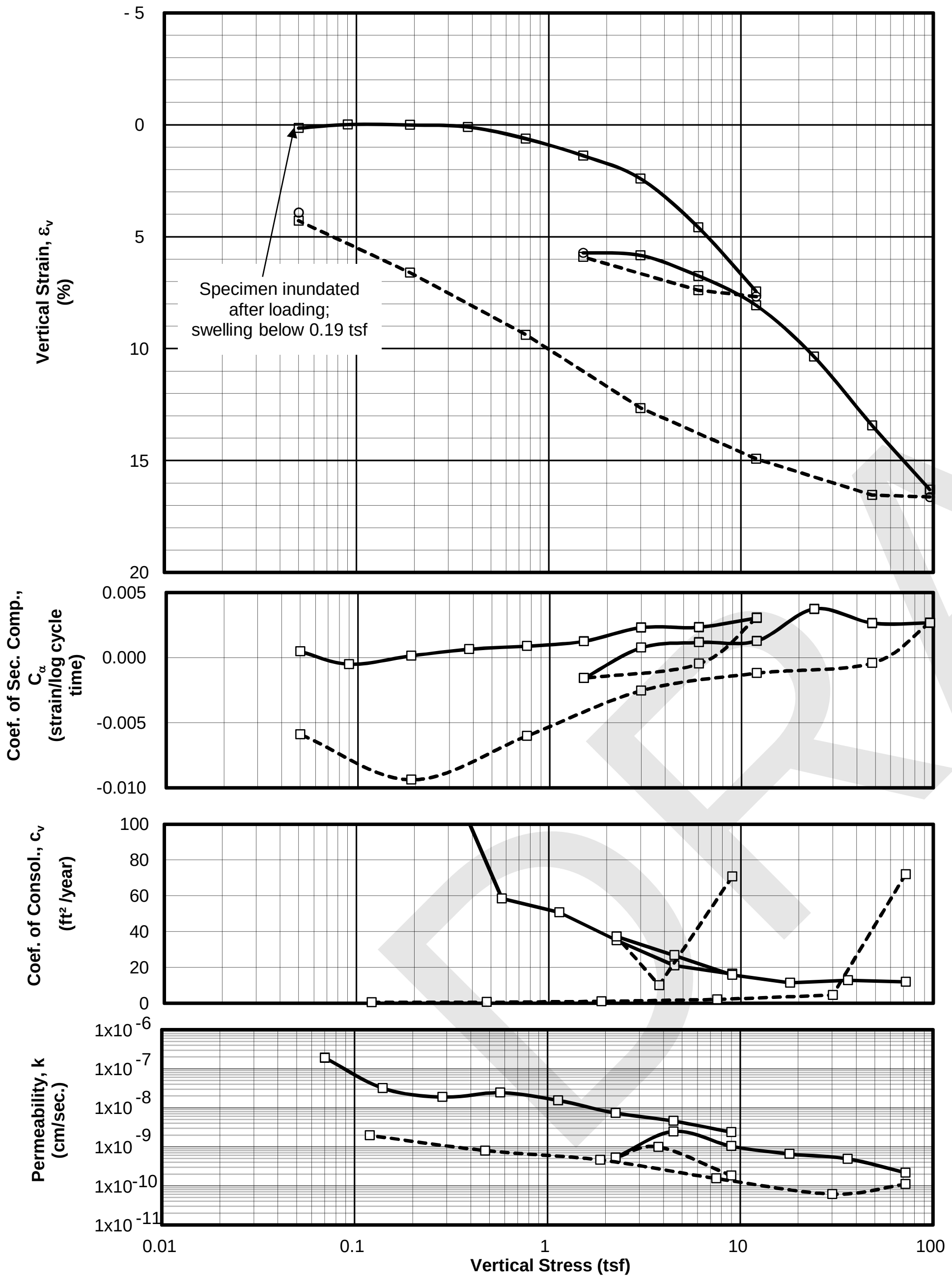
Final height: 0.576 inch
Final water content: 19.5 %
Final dry density: 106.4 pcf
Final total density: 127.1 pcf
Final saturation: 100 %
Final void ratio: 0.496
Final strain: 5.6 %

EQUIPMENT:
Load Frame No.: 1
Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: CL, brown sandy lean clay

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 (ft²/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:

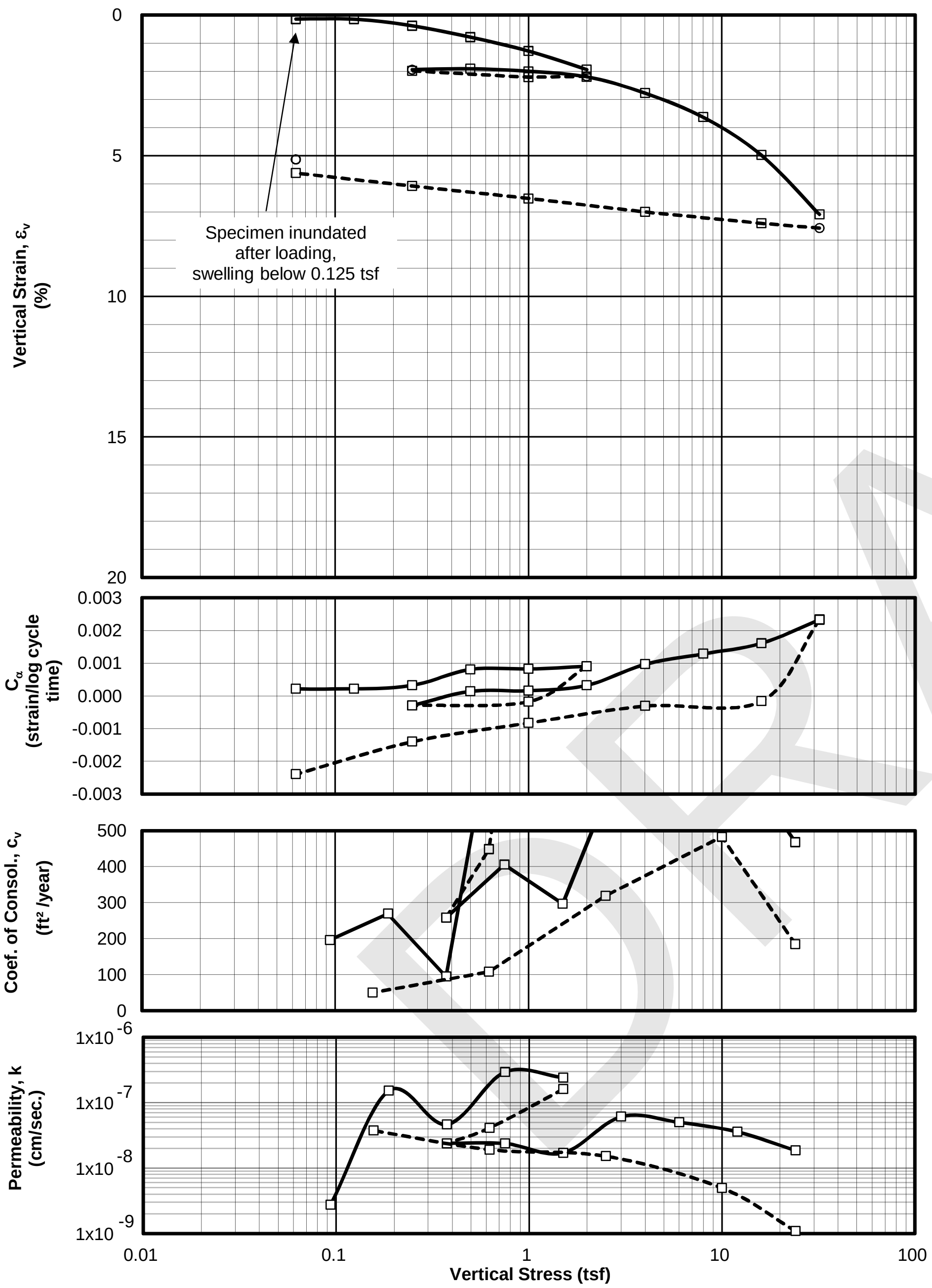
Load Frame No.: 2

Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: CL, greenish gray lean clay

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 (ft^2/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
BORING: JOP-B022
SAMPLE: ST-2A
TEST: C15138
DEPTH, feet: 8.3
BY: CMJ/YC
TEST DATE: 8/25/2015

Initial height: 0.617 inch
Initial water content: 20.8 %
Initial dry density: 105.2 pcf
Initial total density: 127.1 pcf
Initial saturation: 95 %
Initial void ratio: 0.590

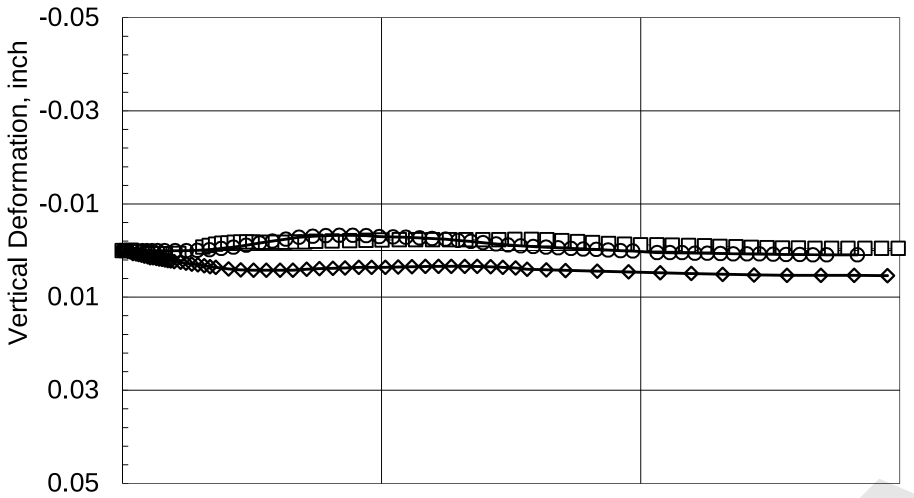
Final height: 0.594 inch
Final water content: 19.9 %
Final dry density: 109.1 pcf
Final total density: 130.8 pcf
Final saturation: 100 %
Final void ratio: 0.533
Final strain: 3.6 %

EQUIPMENT:
Load Frame No.: 3
Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: CL, light brown lean clay; peat noted

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

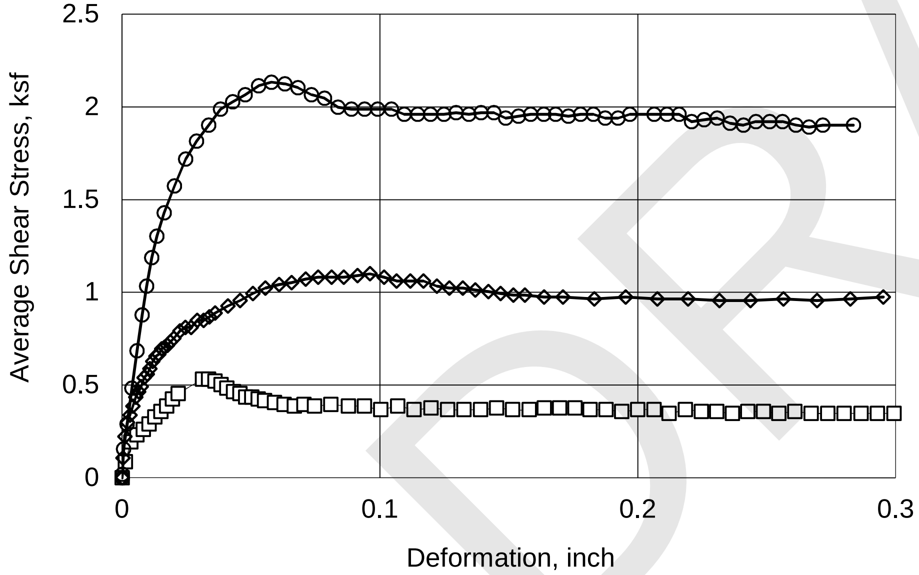
TEST INFORMATION

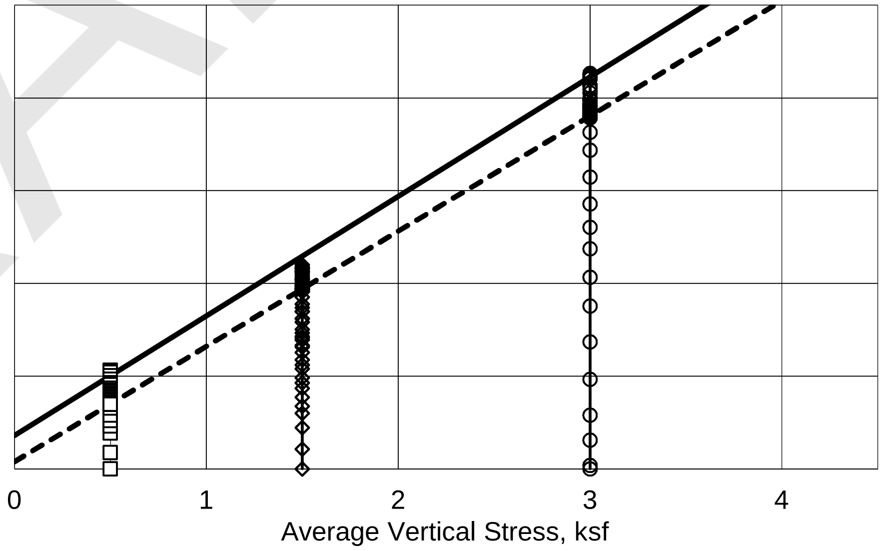
Symbol	Stage	Vertical Stress ksf	Deformation Rate inch/min.
□	6	0.5	0.0025
◊	6	1.5	0.0024
○	6	3.0	0.0020

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	

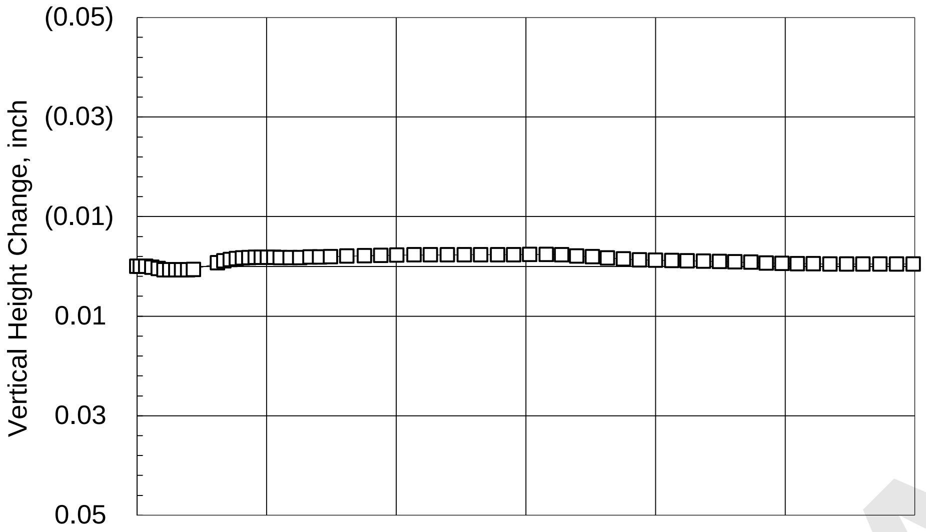
Description of Material Tested and Remarks
CL, brown lean clay

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

Prepared by: MHC Checked by: GET	AECOM #60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR SERIES SUMMARY**
	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

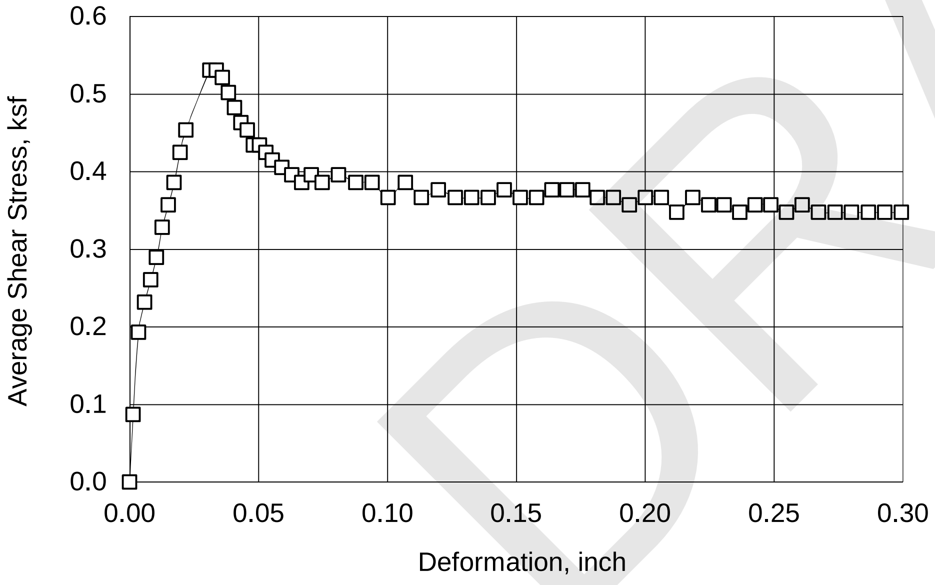
SPECIMEN INFORMATION (Initial)

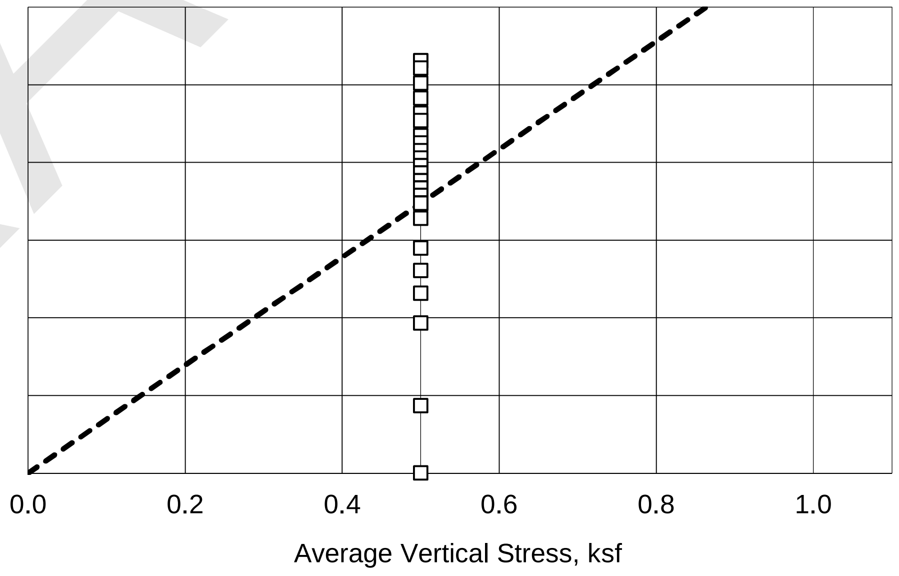
Description: CL, brown lean clay
Height: 1.01 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 19.8 % Dry Unit Weight: 102.2 pcf

TEST SUMMARY

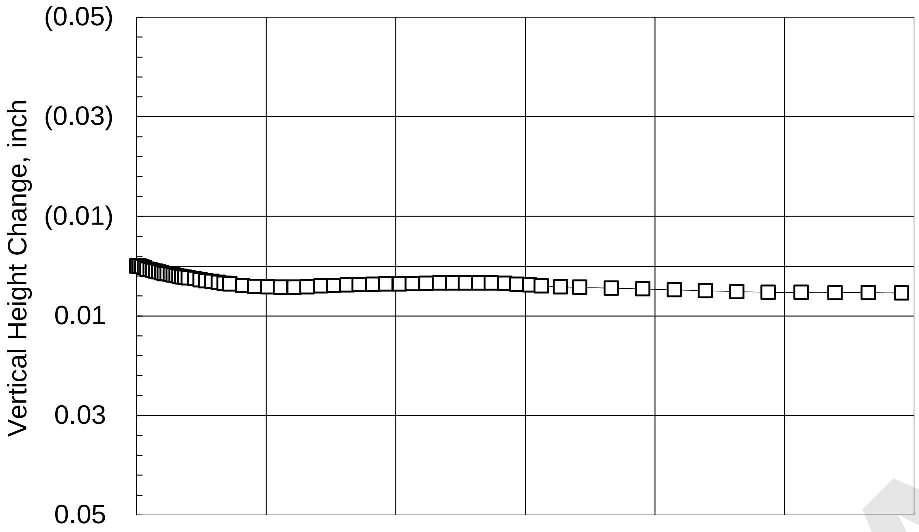
Vertical Consolidation Stress: 0.50 ksf
Water Content: 23.8 % Dry Unit Weight: 102.3 pcf
Deformation Rate: 0.00246 inch/min.
Peak Shear Strength: 0.53 ksf @ 0.03 inch deformation
Peak Effective Friction Angle: 46.7°, cohesion = 0.0ksf
Final Shear Strength: 0.35 ksf @ 0.30 inch deformation
Final Effective Friction Angle: 34.8° (Shown)

REMARKS:





	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY** Boring: JOP-010 Sample: ST-1 Specimen: D Depth: 1.65 ft	
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794		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.

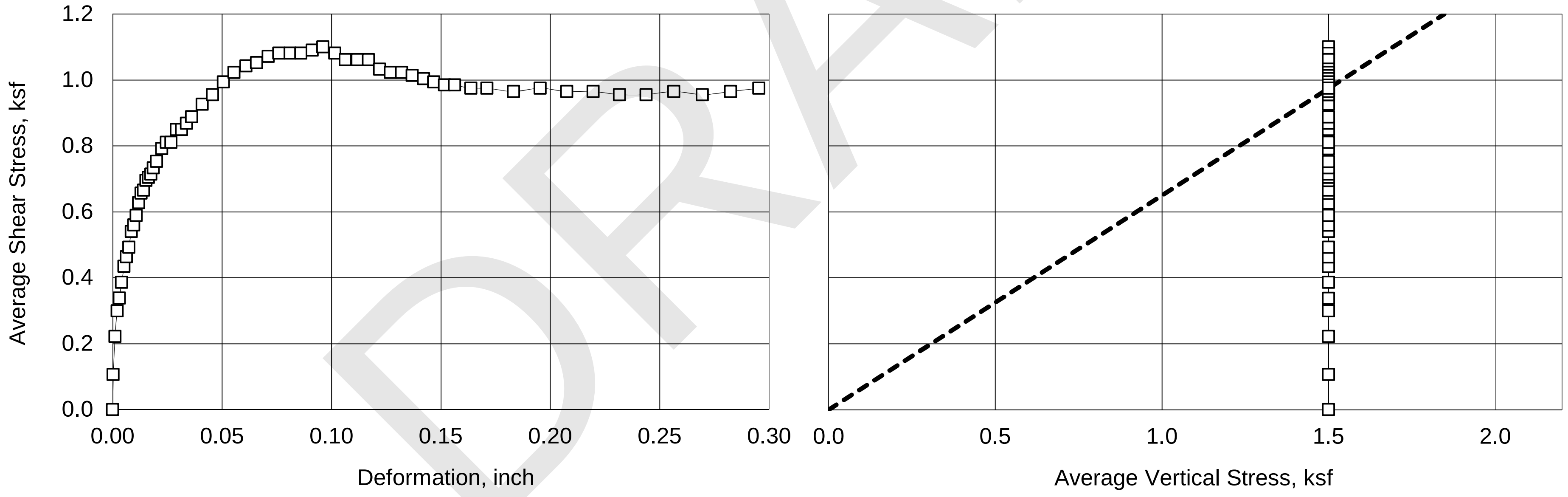
Peak Shear Strength: 1.10 ksf @ 0.10 inch deformation

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:



Prepared by: MHC
Checked by: GET

AECOM
60428794-107

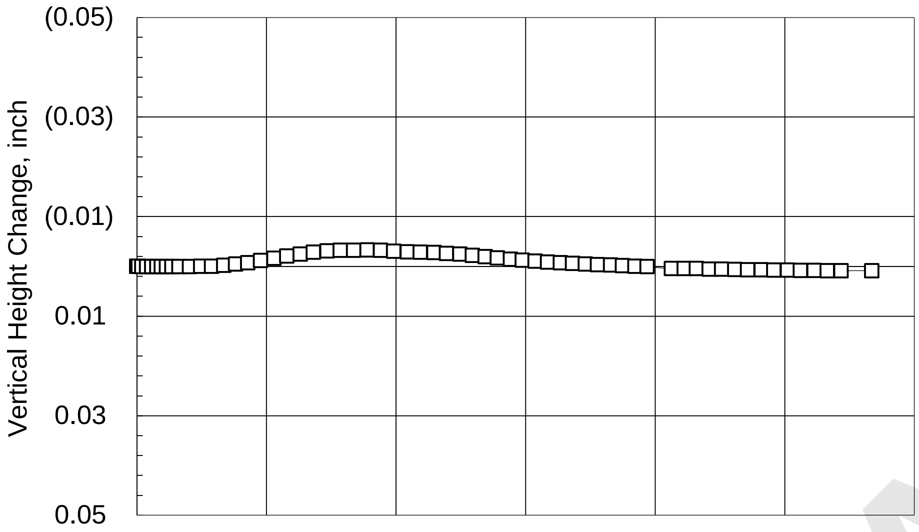
TerraSense, LLC

Dynegy CCR - Joppa

T60428794

DRAINED DIRECT SHEAR
TEST SUMMARY
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

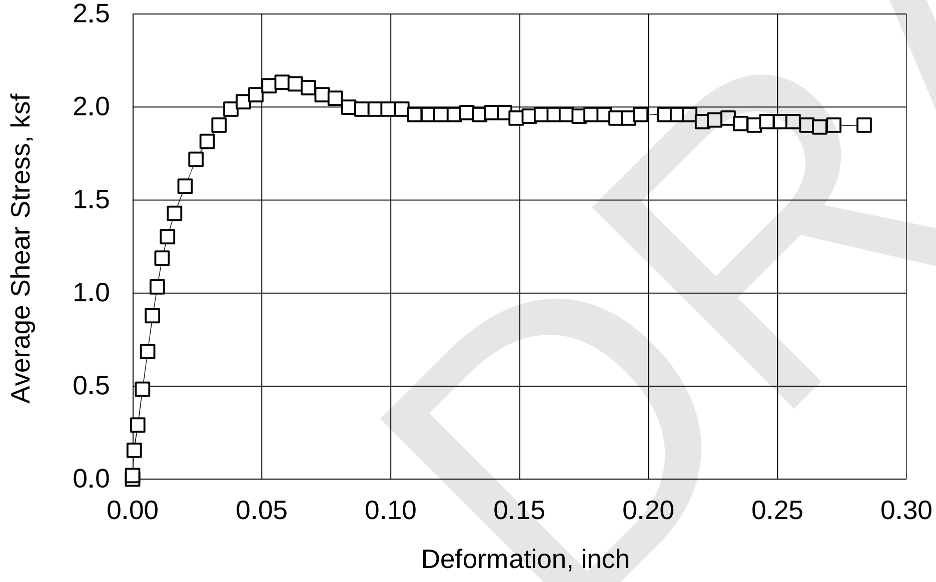
SPECIMEN INFORMATION (Initial)

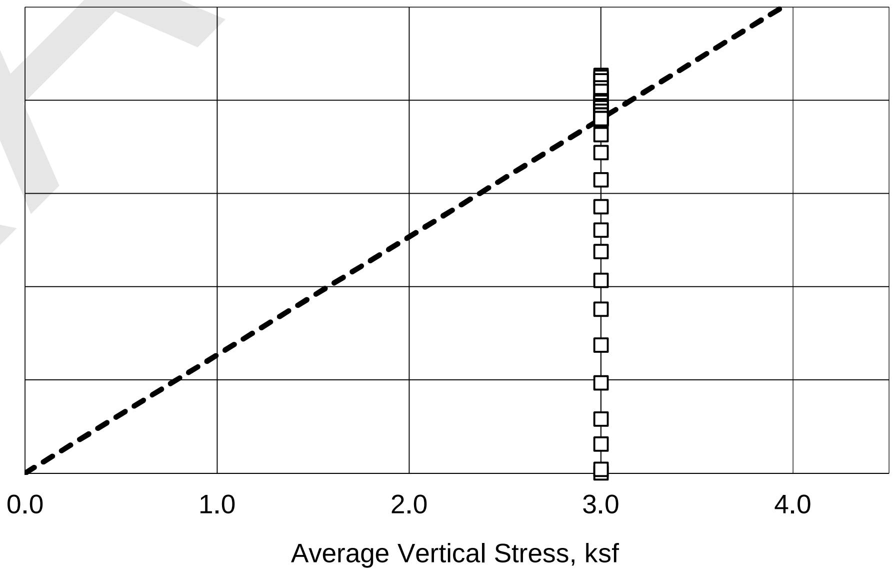
Description: CL, brown lean clay
Height: 1.03 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 18.0 % Dry Unit Weight: 105.8 pcf

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)

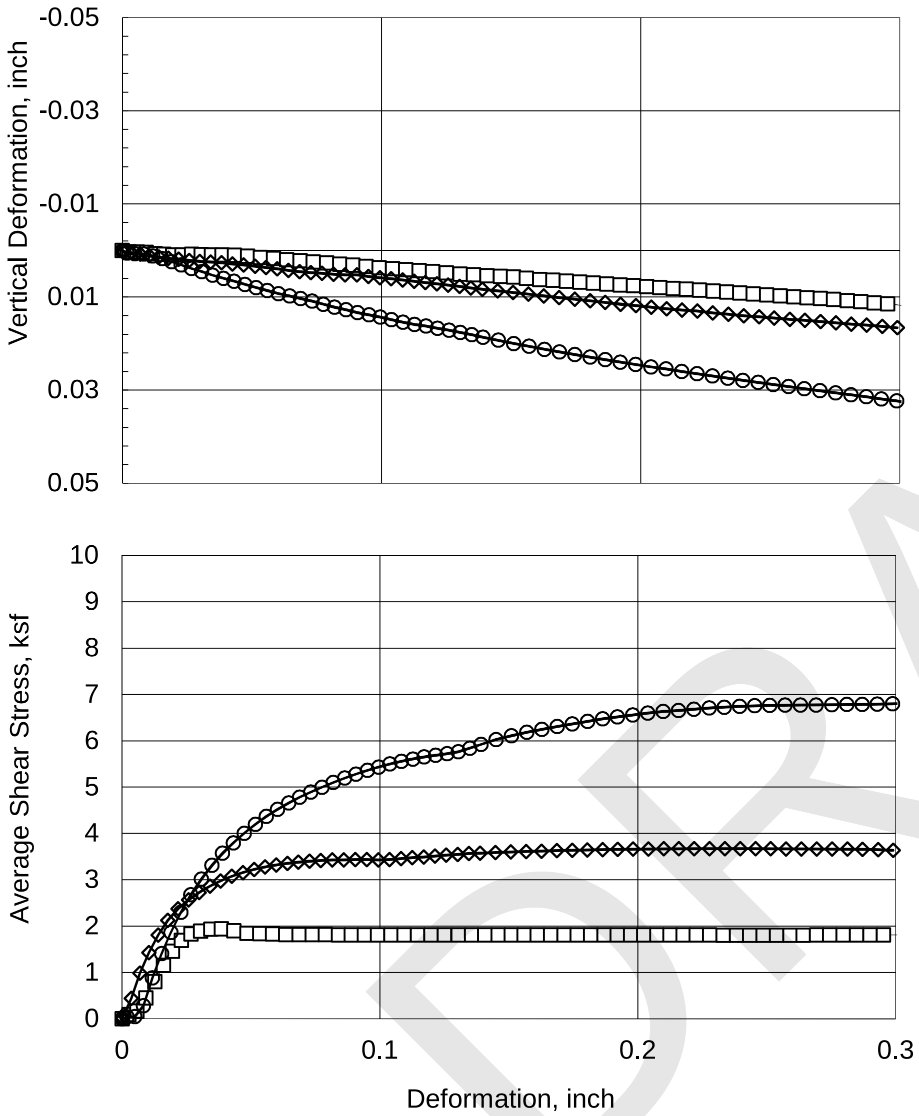
REMARKS:





AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY** Boring: JOP-010 Sample: ST-1 Specimen: F Depth: 2.2 ft	
TerraSense, LLC	T60428794		October 15

Prepared by: MHC
Checked by: GET



SAMPLE INFORMATION

Boring: JOP-B016 Sample: ST-3 Depth: 23-25 feet

Type: Intact tube sample

Description: CL, Brown lean clay

TEST INFORMATION

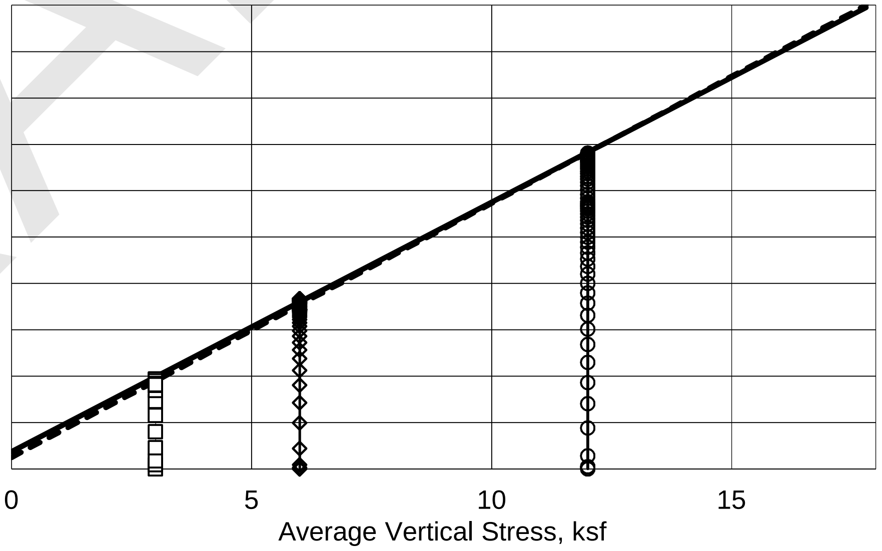
Symbol	Stage	Vertical Stress ksf	Deformation Rate inch/min.
□	6	3.0	0.0003
◊	6	6.0	0.0003
○	6	12.0	0.0003

TEST SUMMARY

Peak Effective Friction Angle: 28.3°, cohesion = 0.4ksf ———

Final Effective Friction Angle: 28.7°, cohesion = 0.2ksf - - - -

REMARKS:



AECOM #60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **SERIES SUMMARY** Boring: JOP-B016 Sample: ST-3 Depth: 23-25	
TerraSense, LLC	T60428794		October 2015

Prepared by: MHC
Checked by: GET

STAGED DRAINED DIRECT SHEAR TEST SERIES

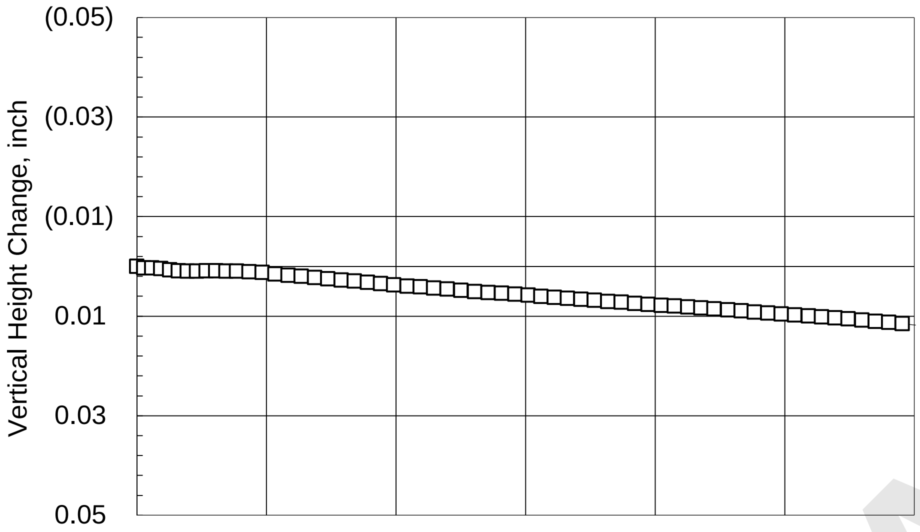
Boring No Sample/ Specimen	Stage No	w_o w_c (estimated) (%)	γ_{to} γ_{tc} (estimated) (pcf)	γ_{do} γ_{dc} (estimated) (pcf)	$\sigma'_{v,c}$ (ksf) $\varepsilon_{v,c}$ (%)	Deformation rate (inch/min) t_c (days)	at Peak Shear Stress at High Deformation ΔL (inch)	τ_h (ksf)	ε_v (%)	Φ' for c'=0	Remarks
JOP-B016	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.

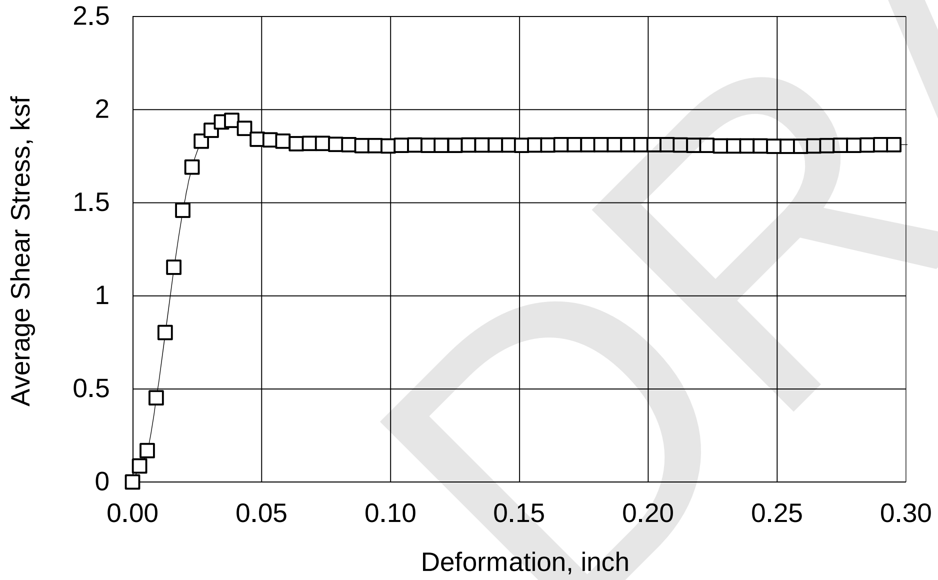
Peak Shear Strength: 1.94 ksf @ 0.04 inch deformation

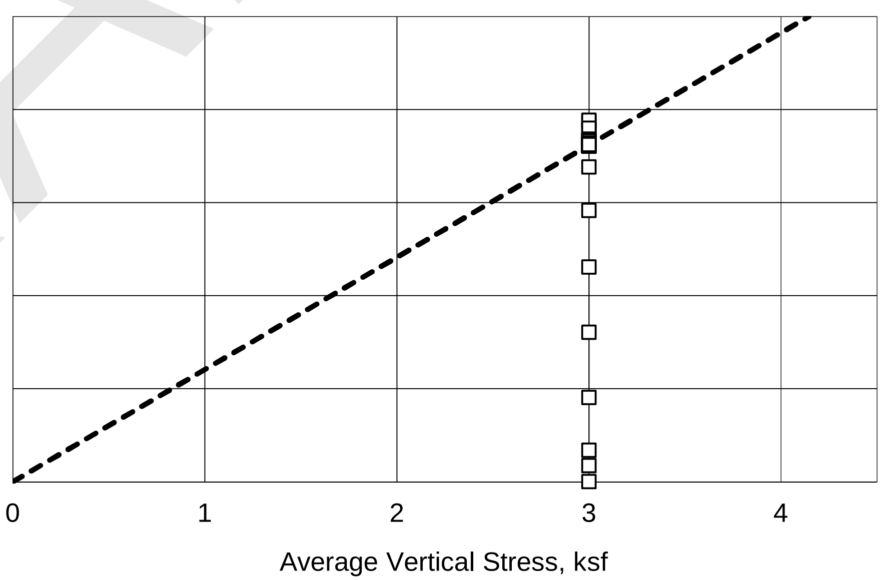
Peak Effective Friction Angle: 32.9°, cohesion = 0.0 ksf

Final Shear Strength: 1.81 ksf @ 0.28 inch deformation

Final Effective Friction Angle: 31.1° (Shown)

REMARKS:





AECOM
60428794-107

Dynegy CCR - Joppa

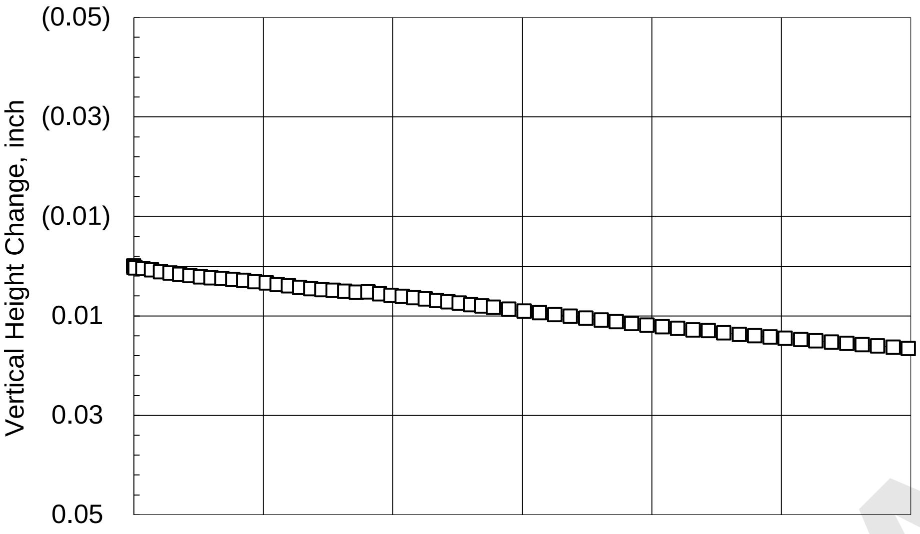
DRAINED DIRECT SHEAR
TEST SUMMARY
Boring: JOP-B016 Sample: ST-3
Specimen: C Depth: 24.15 ft

Prepared by: MHC
Checked by: GET

TerraSense, LLC

T60428794

October 15



SAMPLE INFORMATION

Boring: JOP-B016 Sample: ST-3 Specimen: E Depth: 24.5 ft
Type: Intact tube sample

SPECIMEN INFORMATION (Initial)

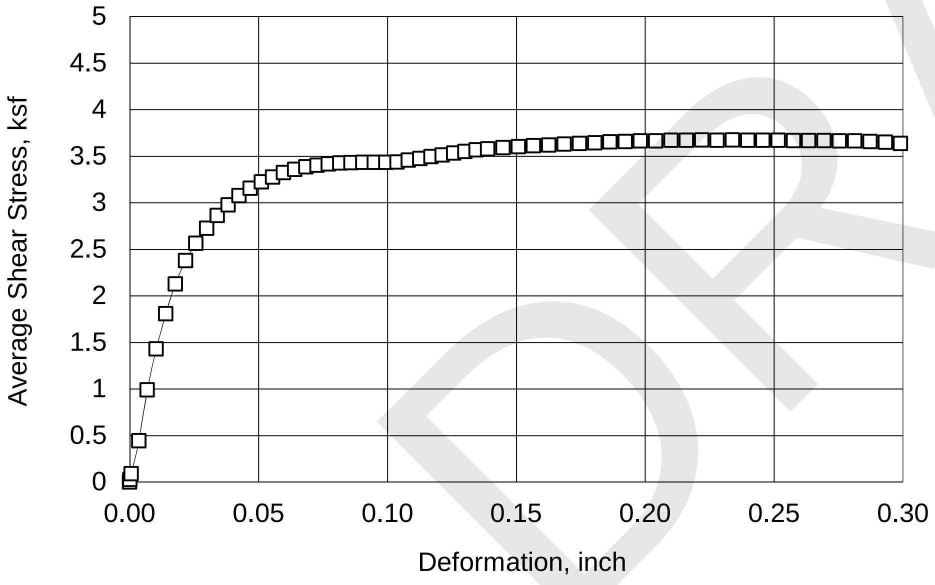
Description: CL, Brown lean clay
Height: 1.51 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 17.6 % Dry Unit Weight: 108.4 pcf

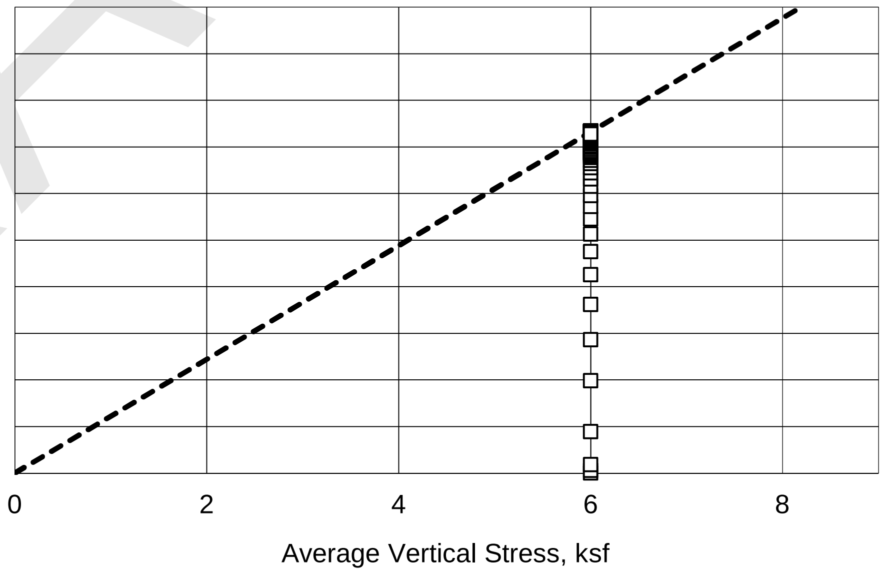
TEST SUMMARY

Vertical Consolidation Stress: 6.00 ksf

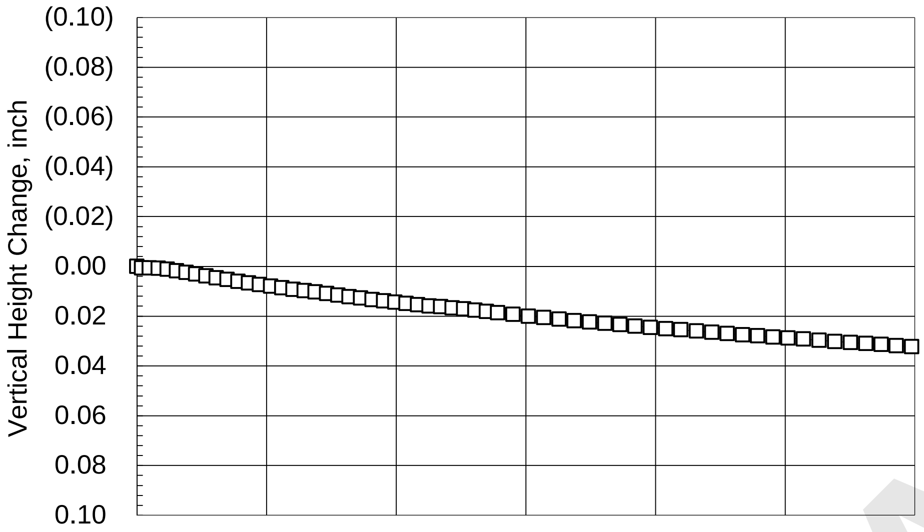
Deformation Rate: 0.00028 inch/min.
Peak Shear Strength: 3.67 ksf @ 0.22 inch deformation
Peak Effective Friction Angle: 31.5°, cohesion = 0.0 ksf
Final Shear Strength: 3.66 ksf @ 0.28 inch deformation
Final Effective Friction Angle: 31.4° (Shown)

REMARKS:





	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY** Boring: JOP-B016 Sample: ST-3 Specimen: E Depth: 24.5 ft	
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794		October 15



SAMPLE INFORMATION

Boring: JOP-B016 Sample: ST-3 Specimen: E Depth: 24.8 ft
Type: Intact tube sample

SPECIMEN INFORMATION (Initial)

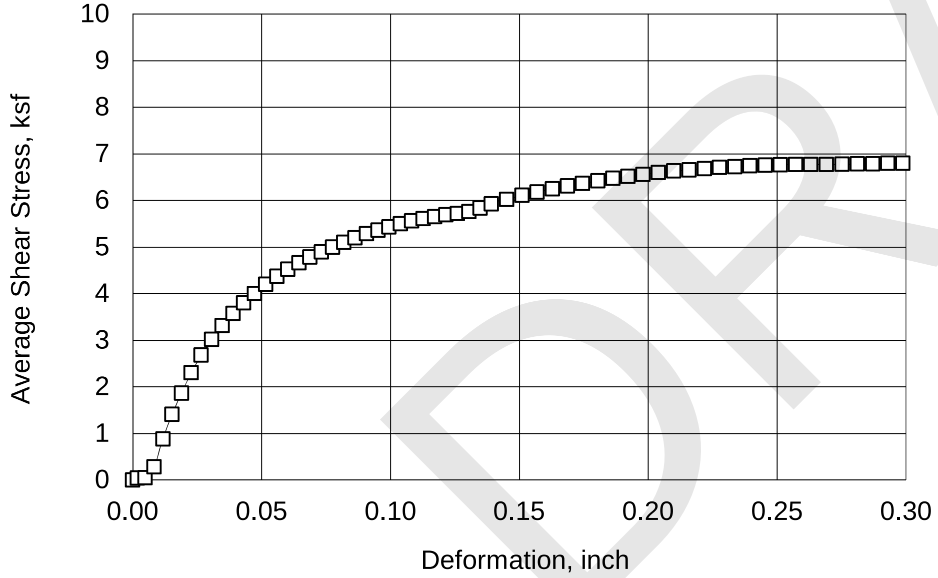
Description: CL, Brown lean clay
Height: 1.51 inch Diameter: 2.50 inch Area: 4.91 in²
Water Content: 18.2 % Dry Unit Weight: 109.3 pcf

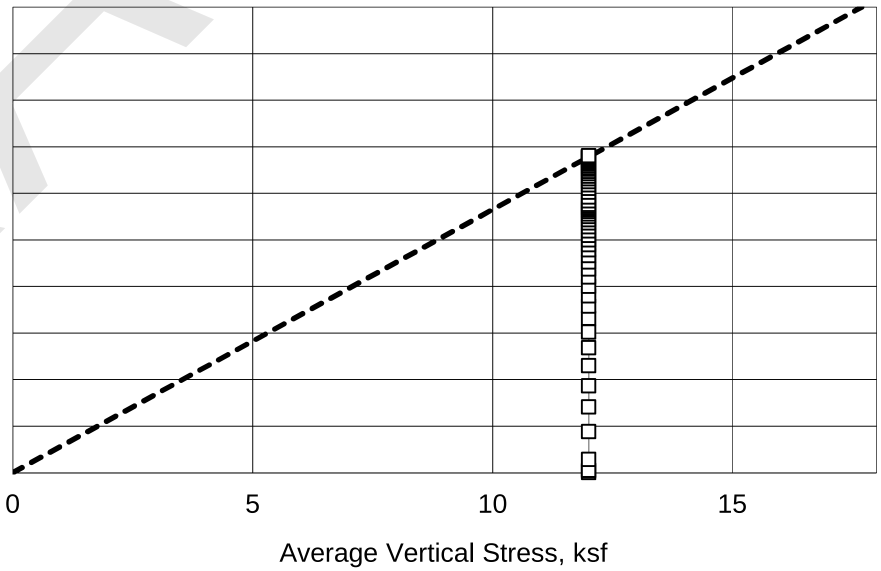
TEST SUMMARY

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)

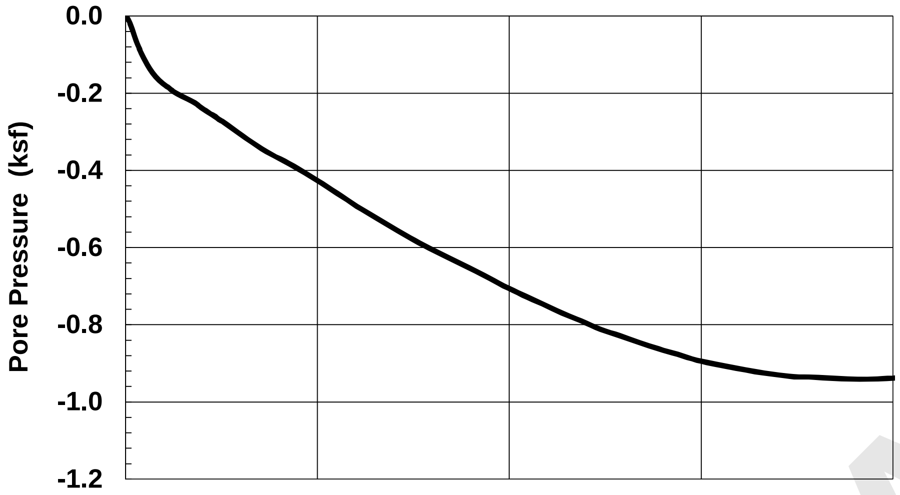
REMARKS:





	AECOM 60428794-107	Dynegy CCR - Joppa	**DRAINED DIRECT SHEAR** **TEST SUMMARY** Boring: JOP-B016 Sample: ST-3 Specimen: E Depth: 24.8 ft	
Prepared by: MHC Checked by: GET	**TerraSense, LLC**	T60428794		October 15

Analysis File: Dsv7rev.xls (8/08) DS1618.xlsx 10/23/2015



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

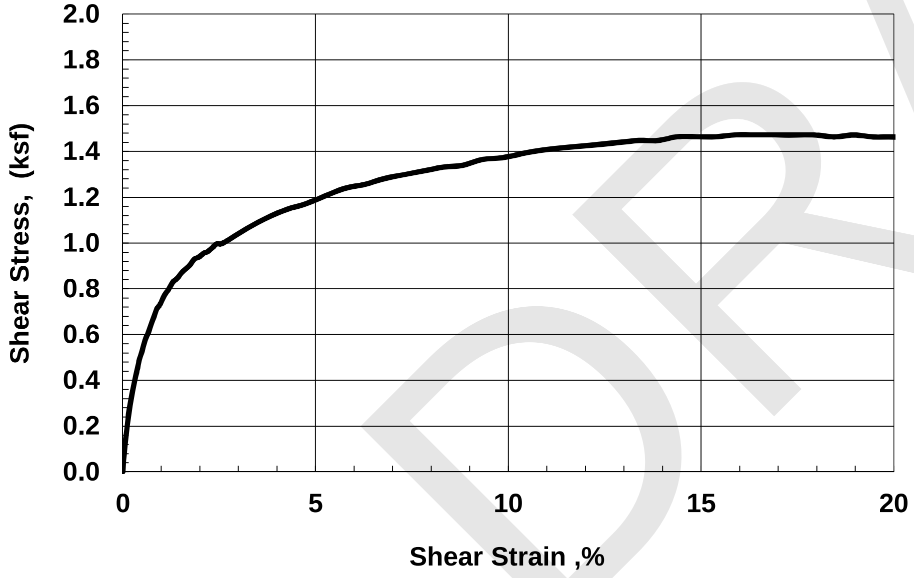
SPECIMEN INFORMATION (Initial)

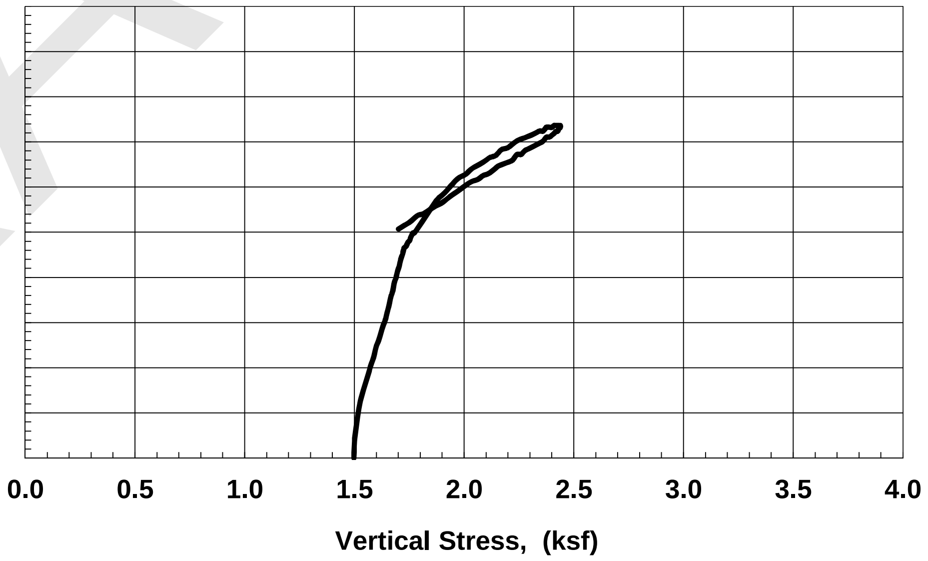
Height: 0.76 Diameter: 2.63 inch Area: 5.43 in²
Water Content: 20.6 % Total Unit Weight: 117.0 pcf

TEST SUMMARY

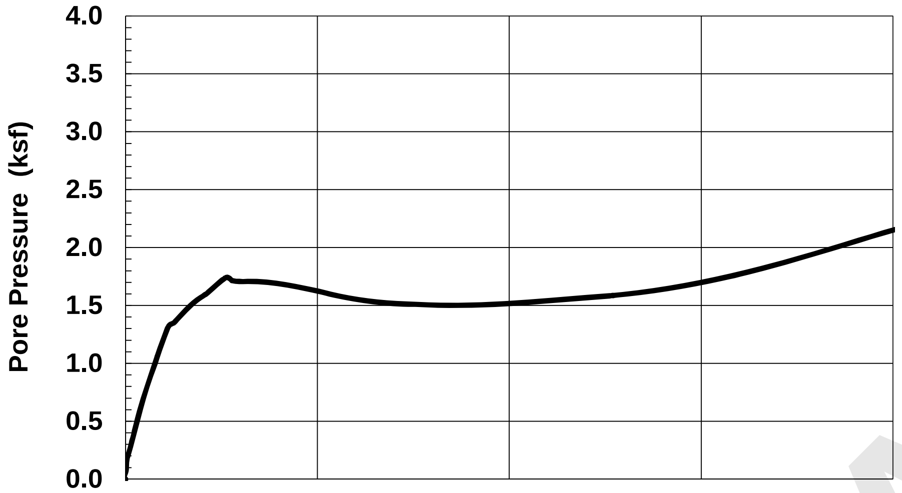
Vertical Consolidation Stress: 1.50 ksf OCR = 1.0
Water Content: 18.7 % Total Unit Weight: 120.6 pcf
Peak Shear Strength: 1.47 ksf @ 15.9 % Strain
Strain Rate: 0.063 %/min

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

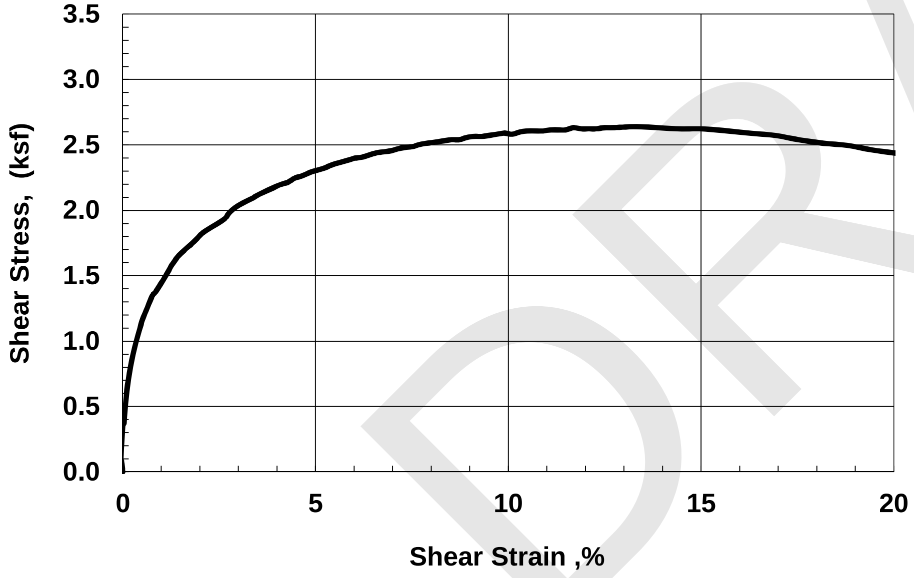
SPECIMEN INFORMATION (Initial)

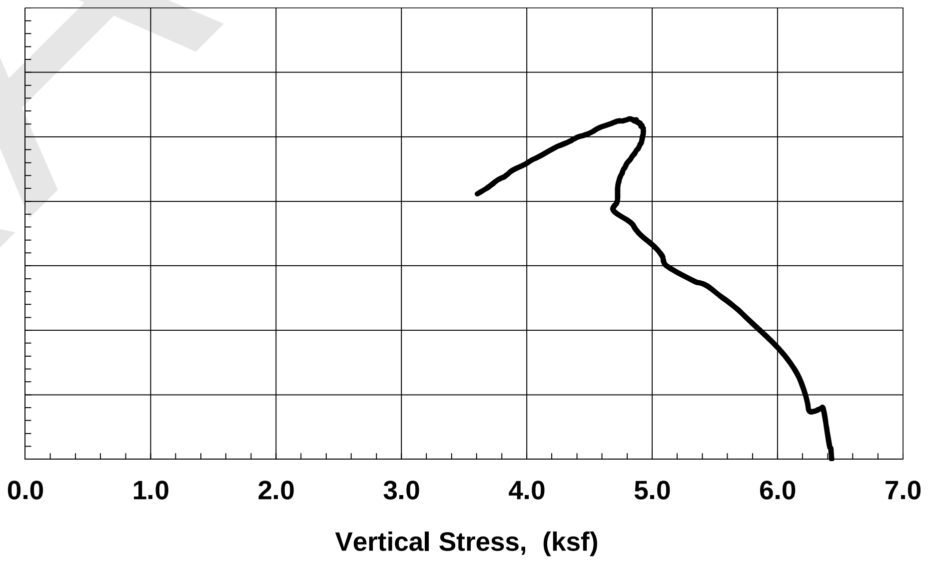
Height: 0.72 Diameter: 2.63 inch Area: 5.42 in²
Water Content: 20.1 % Total Unit Weight: 127.9 pcf

TEST SUMMARY

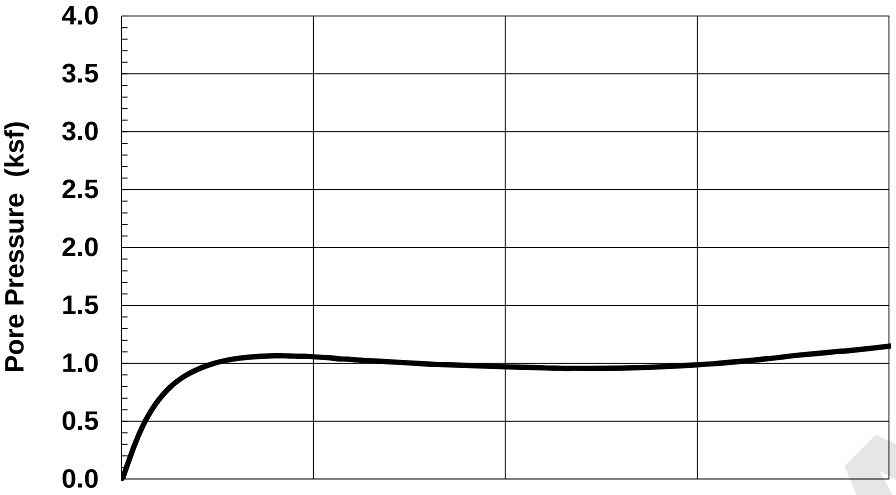
Vertical Consolidation Stress: 6.44 ksf OCR = 1.0
Water Content: 18.4 % Total Unit Weight: 131.2 pcf
Peak Shear Strength: 2.64 ksf @ 13.3 % Strain
Strain Rate: 0.051 %/min

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	
Checked by: GET	**TerraSense, LLC**			October-15



SAMPLE INFORMATION

Boring: JOP-010 Sample: ST-3 Depth: 34.35 feet
Type: Intact tube sample
Description: CL, mottled gray and brown sandy clay

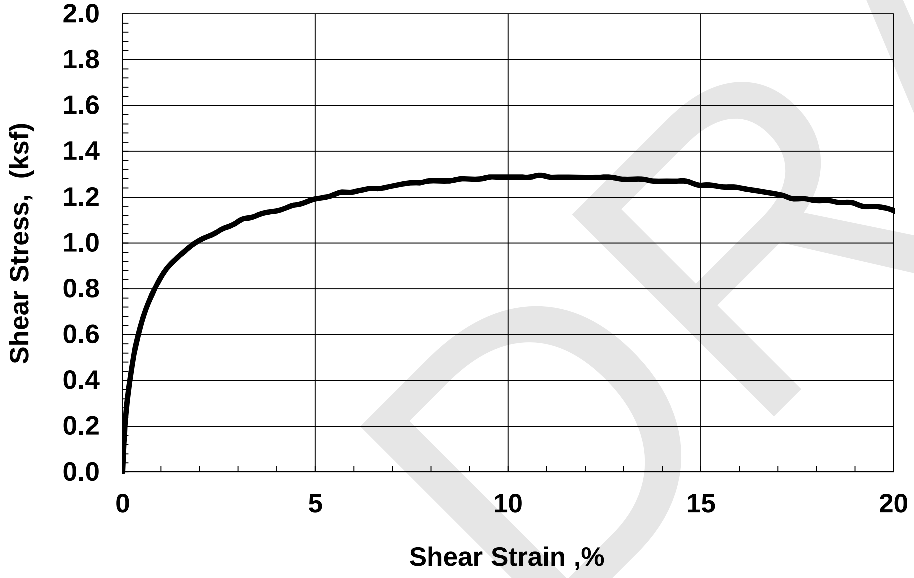
SPECIMEN INFORMATION (Initial)

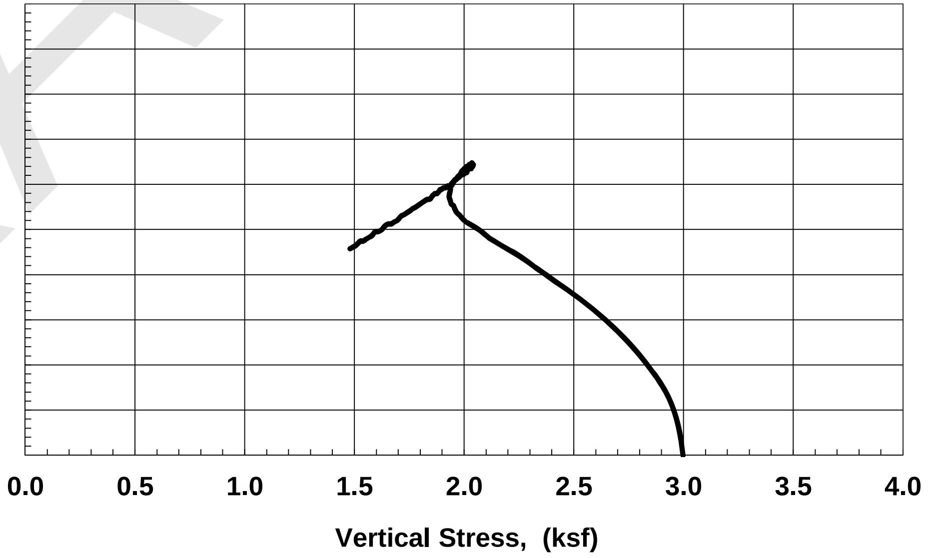
Height: 0.77 Diameter: 2.63 inch Area: 5.43 in^2
Water Content: 15.8 % Total Unit Weight: 120.3 pcf

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:





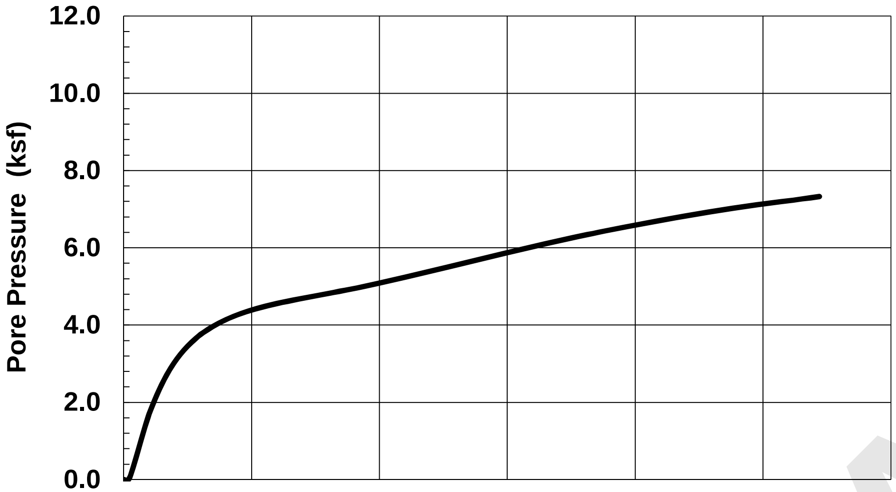
Test by: G. Thomas
Checked by: GET

Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa

TerraSense, LLC

CONSTANT VOLUME
DIRECT SIMPLE SHEAR
Boring: JOP-010 Sample: ST-3
Depth: 34.35 feet

October-15



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

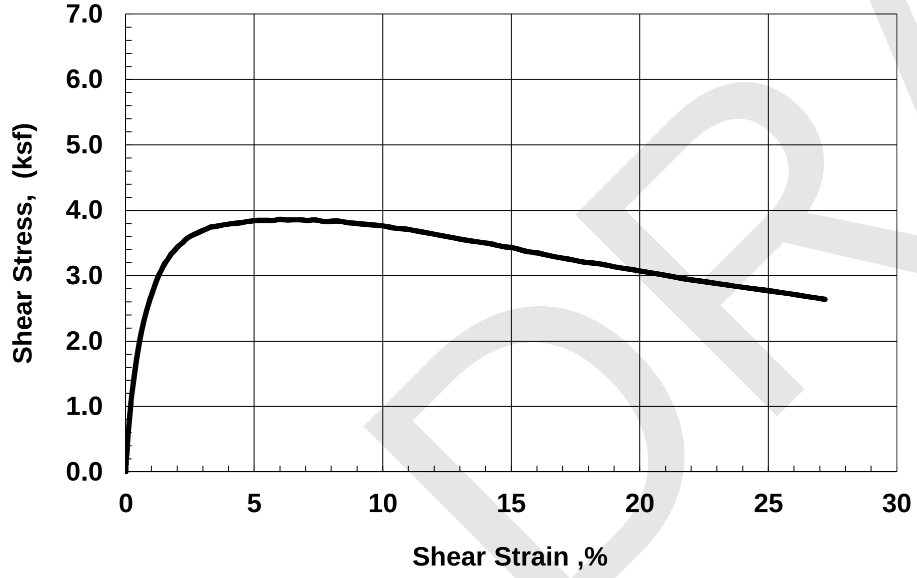
SPECIMEN INFORMATION (Initial)

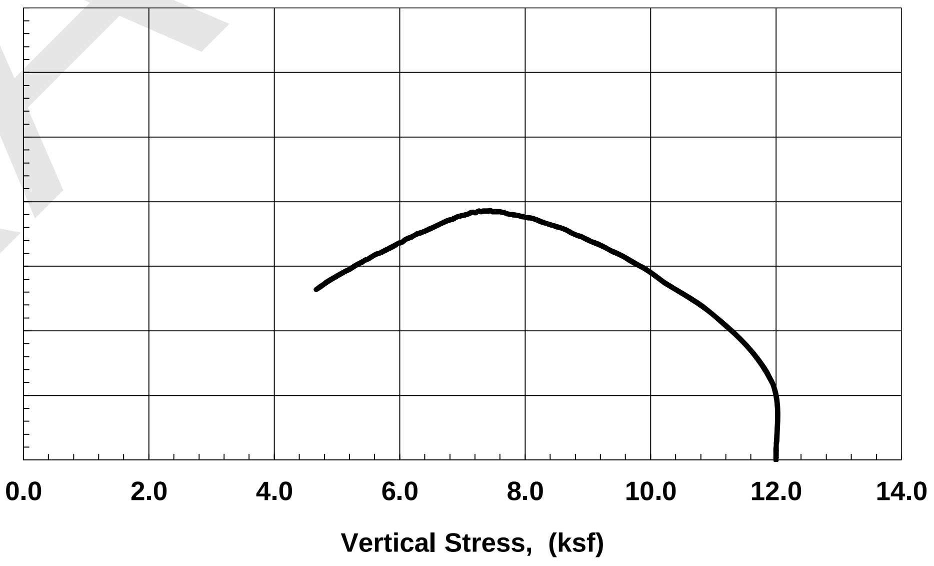
Height: 0.71 Diameter: 2.63 inch Area: 5.42 in²
Water Content: 16.4 % Total Unit Weight: 130.2 pcf

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
Checked by: GET

Project No.
T60428794

AECOM #60428794-107
Dynegy CCR - Joppa

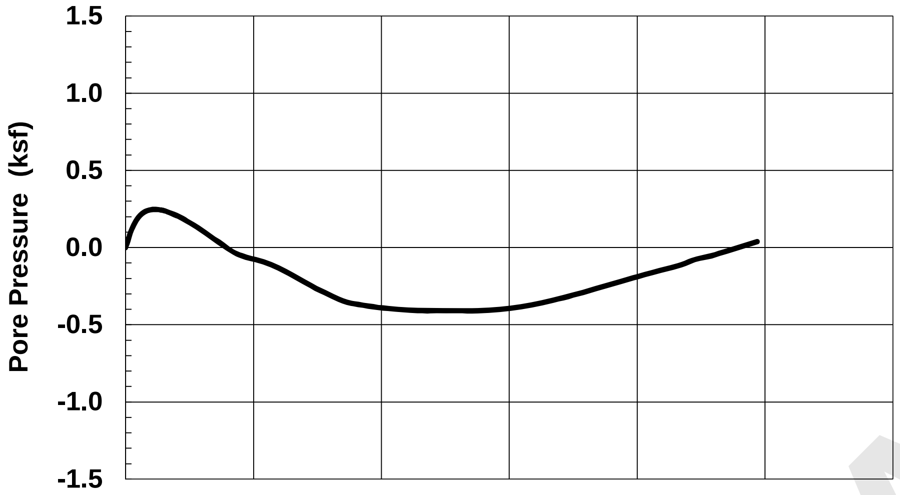
TerraSense, LLC

CONSTANT VOLUME
DIRECT SIMPLE SHEAR
Boring: JOP-011 Sample: ST-14
Depth: 69.8 feet

October-15

Analysis File: DSSV5a.XLS

10/16/2015 DSS854.xls



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

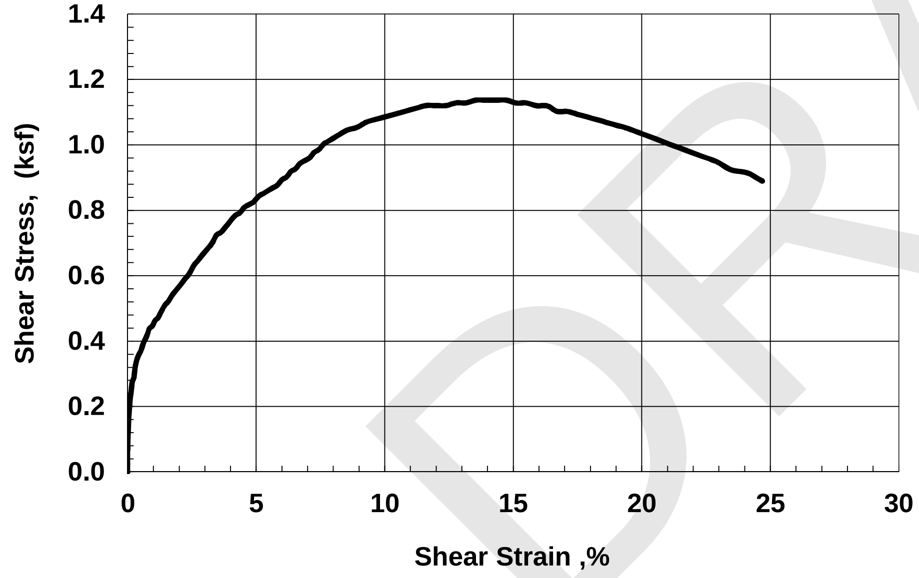
SPECIMEN INFORMATION (Initial)

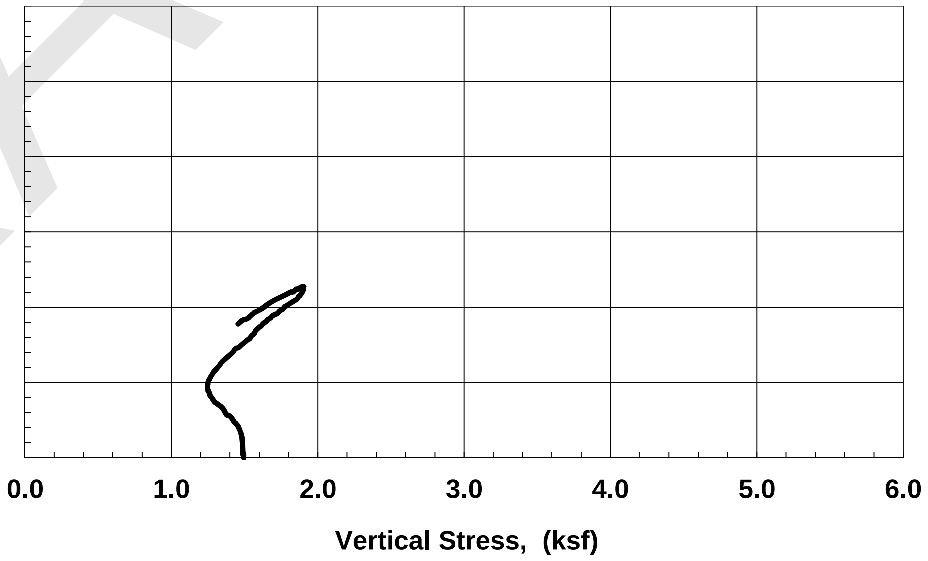
Height: 0.72 Diameter: 2.62 inch Area: 5.40 in²
Water Content: 21.5 % Total Unit Weight: 126.8 pcf

TEST SUMMARY

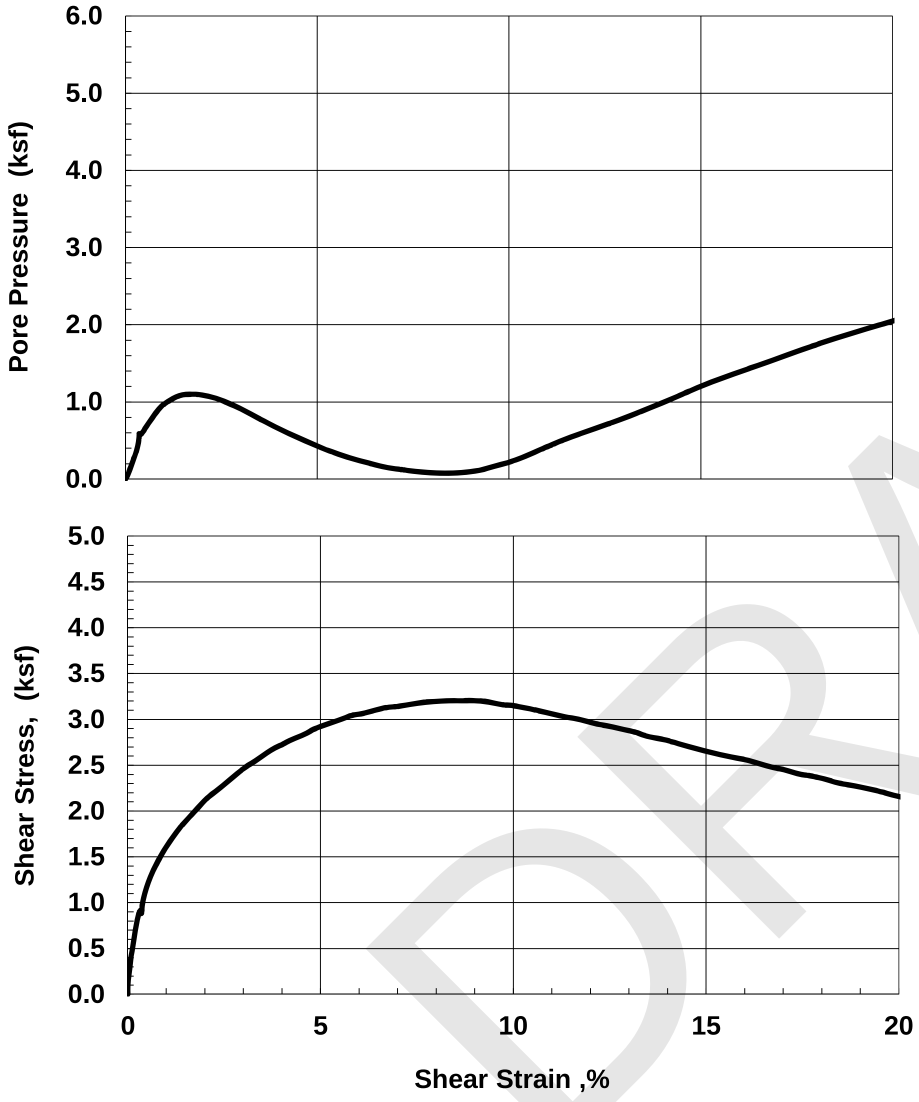
Vertical Consolidation Stress: 1.50 ksf OCR = 1.0
Water Content: 21.5 % Total Unit Weight: 127.5 pcf
Peak Shear Strength: 1.14 ksf @ 13.5 % Strain
Strain Rate: 0.062 %/min

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

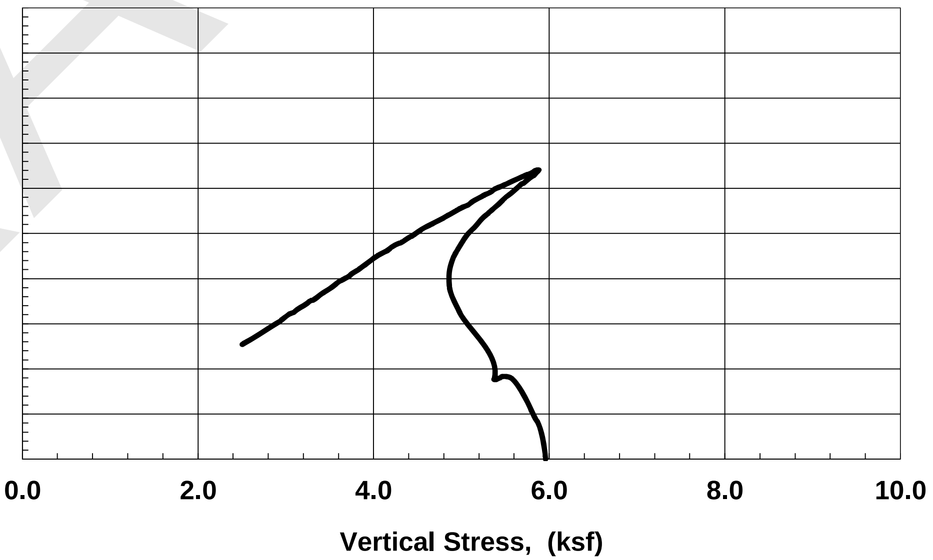


SAMPLE INFORMATION
Boring: JOP-016 Sample: ST-4 Depth: 44.6 feet
Type: Intact tube sample
Description: CL, pinkish clay with sand texture
LL = 27 PL = 17 PI = 10

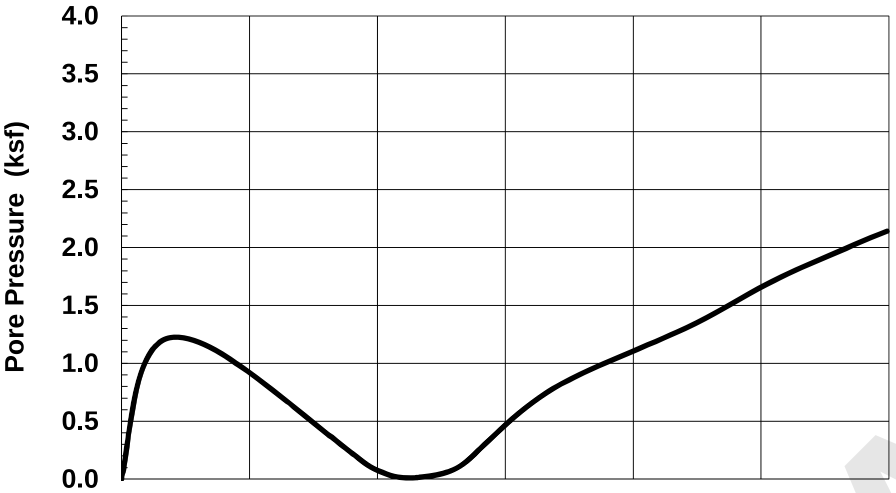
SPECIMEN INFORMATION (Initial)
Height: 0.72 Diameter: 2.62 inch Area: 5.39 in²
Water Content: 18.1 % Total Unit Weight: 129.2 pcf

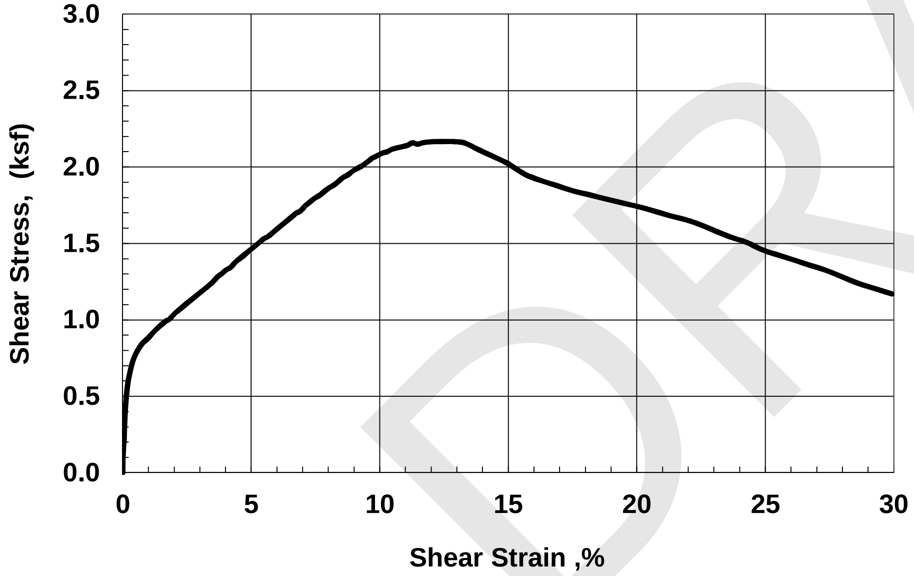
TEST SUMMARY
Vertical Consolidation Stress: 5.97 ksf OCR = 1.0
Water Content: 17.2 % Total Unit Weight: 130.7 pcf
Peak Shear Strength: 3.20 ksf @ 8.3 % Strain
Strain Rate: 0.063 %/min

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)

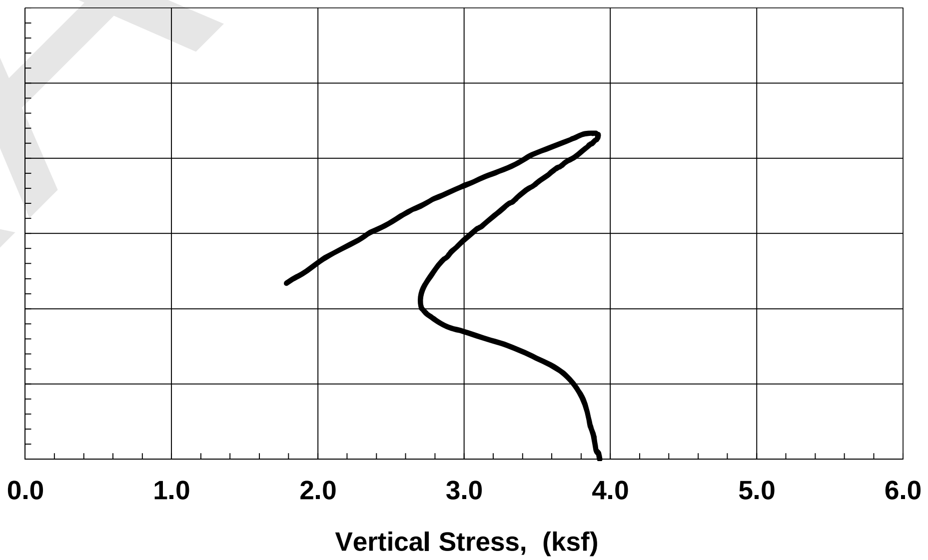
SPECIMEN INFORMATION (Initial)

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

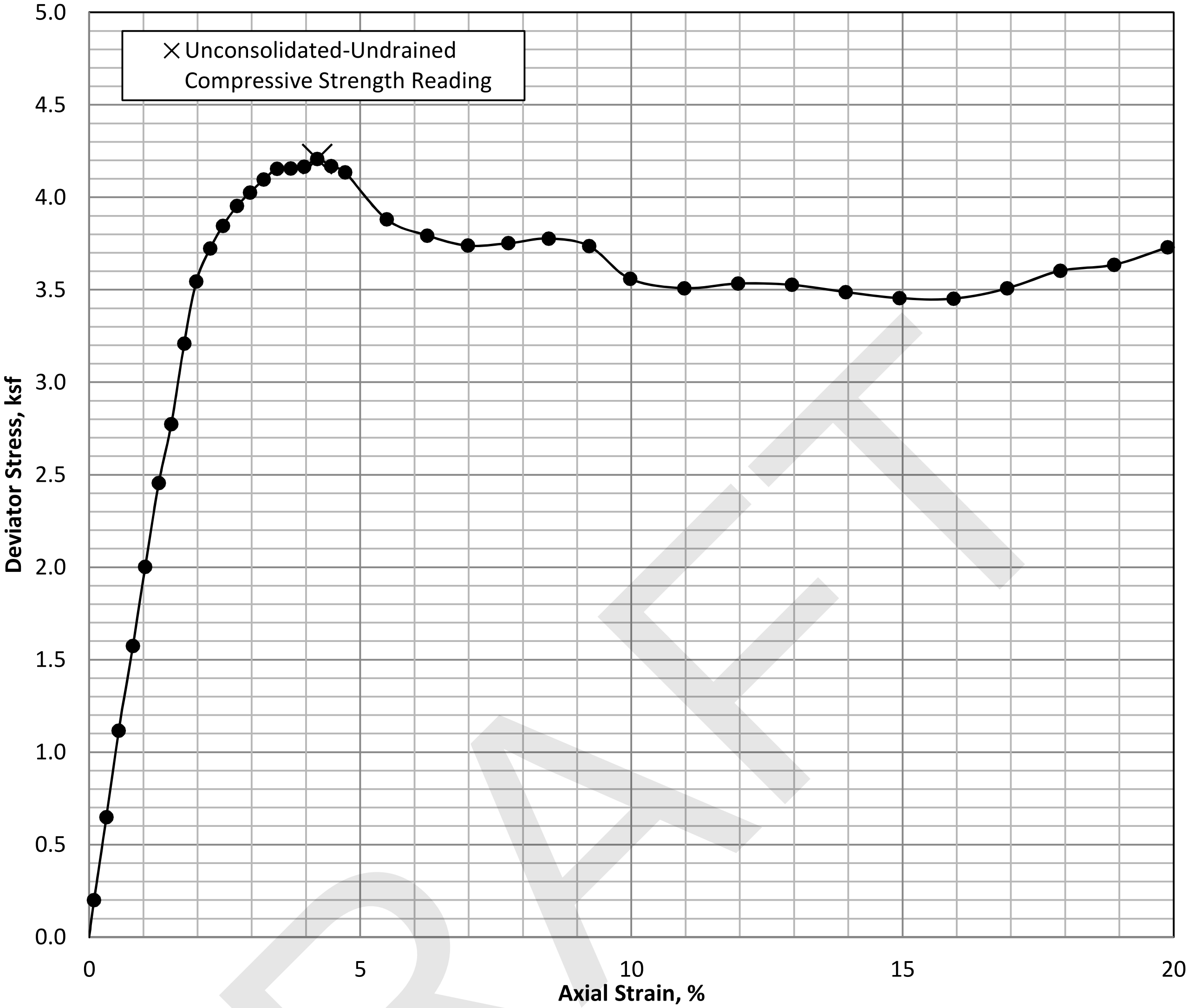
REMARKS:



Test by: D. Tso
Checked by: GET

Project No. T60428794	AECOM #60428794-107 Dynegy CCR - Joppa	CONSTANT VOLUME DIRECT SIMPLE SHEAR Boring: JOP-019 Sample: ST-2 Depth: 43.25 feet	October-15
TerraSense, LLC			

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

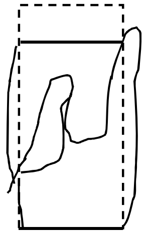
Sample Type: Intact tube sample

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.

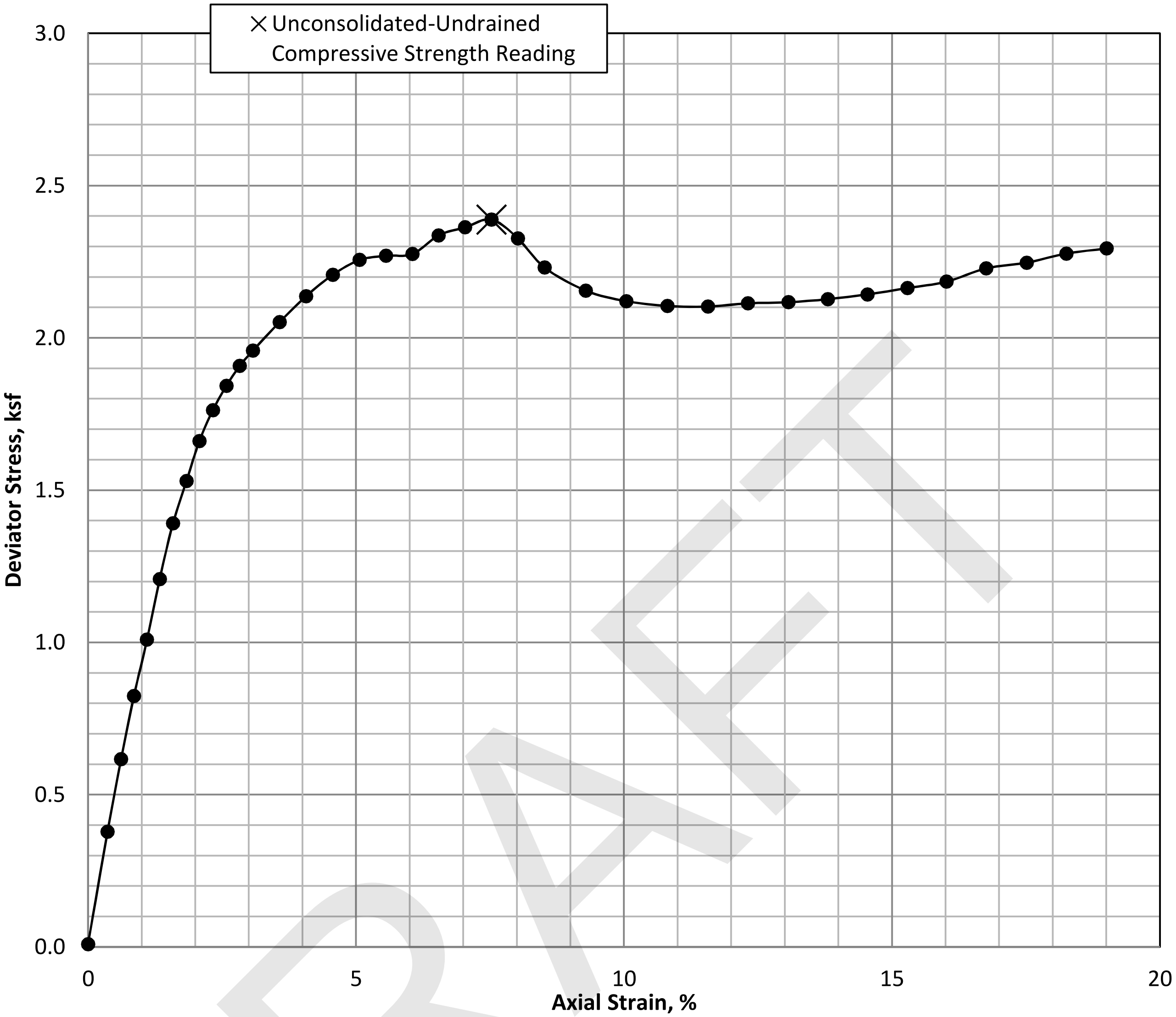
(2) Assumed specific gravity

Tested by: BB
Test Date: 9/9/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM **Project # 60428794-107** **TerraSense, LLC** **Project # T60428794**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST** **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

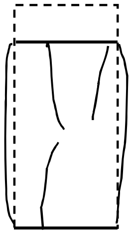
Sample Type: Intact tube sample

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

Test Date: 10/8/2015

Reviewed by: CMJ

Review Date: 10/12/2015

AECOM
Project # 60428794-107

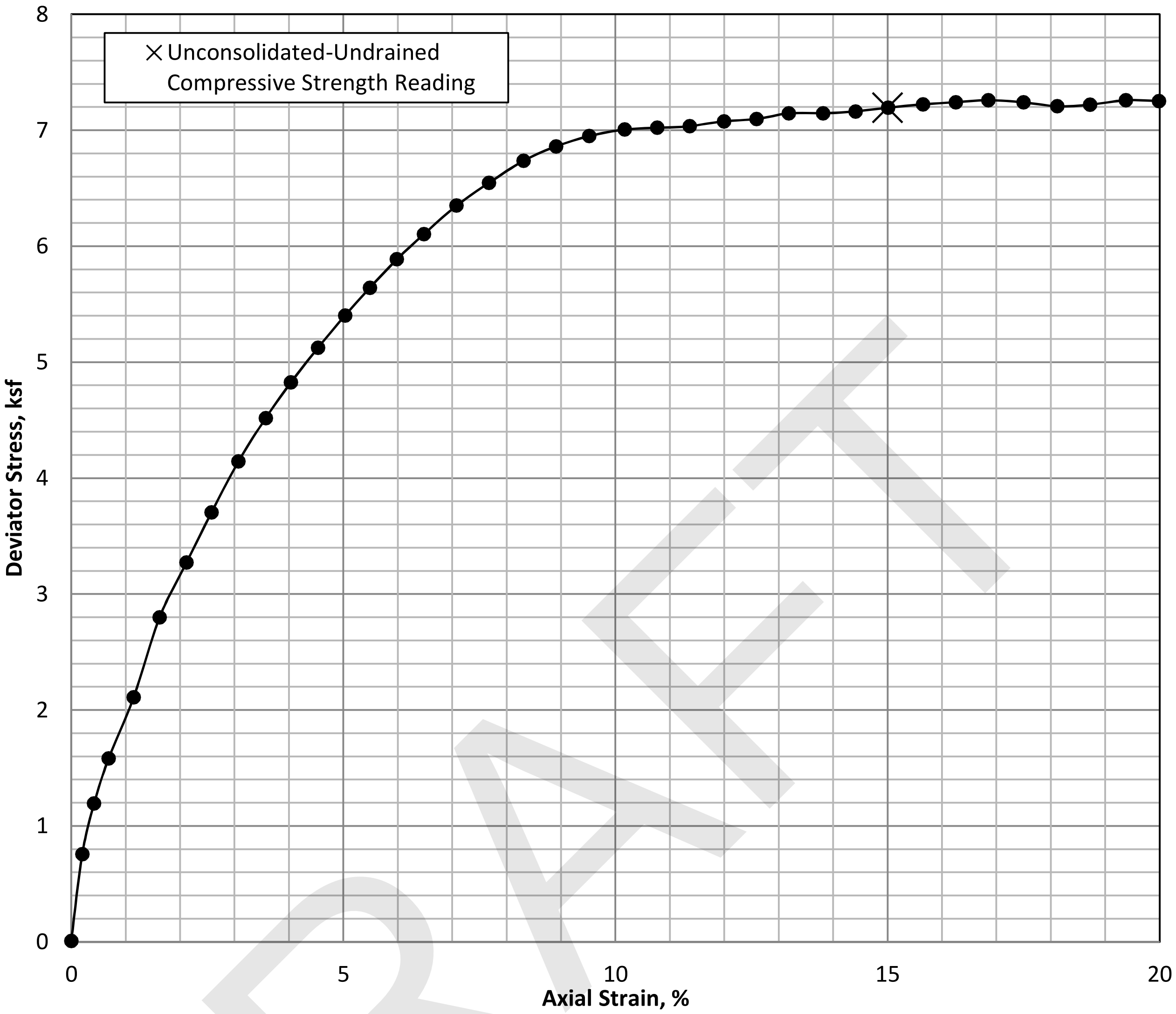
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

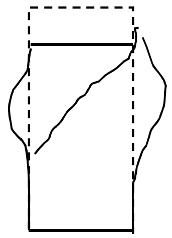
Cell Pressure (ksf)	Water [(1)] Content (%)	Wet Unit Weight (pcf)	Dry Unit [(1)] Weight (pcf)	Void Ratio (-)	Saturation[(2)] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific [(2)] Gravity (-)
0 (Initial)	15.7	134.8	116.6	0.42	98.1	6.050	2.865	2.1			2.66
1.5	15.7	135.5	117.1	0.42	99.8	6.040	2.860	2.1			

Failure Summary

U-U Compressive Strength (ksf)	U-U Shear Strength, s_u (ksf)	Strain to Peak (%)	Strain Rate (%/min)
7.19	3.595	15.0	0.73

Tested by: BB
Test Date: 8/24/2015

Reviewed by: CMJ
Review Date: 9/2/2015



FAILURE SKETCH

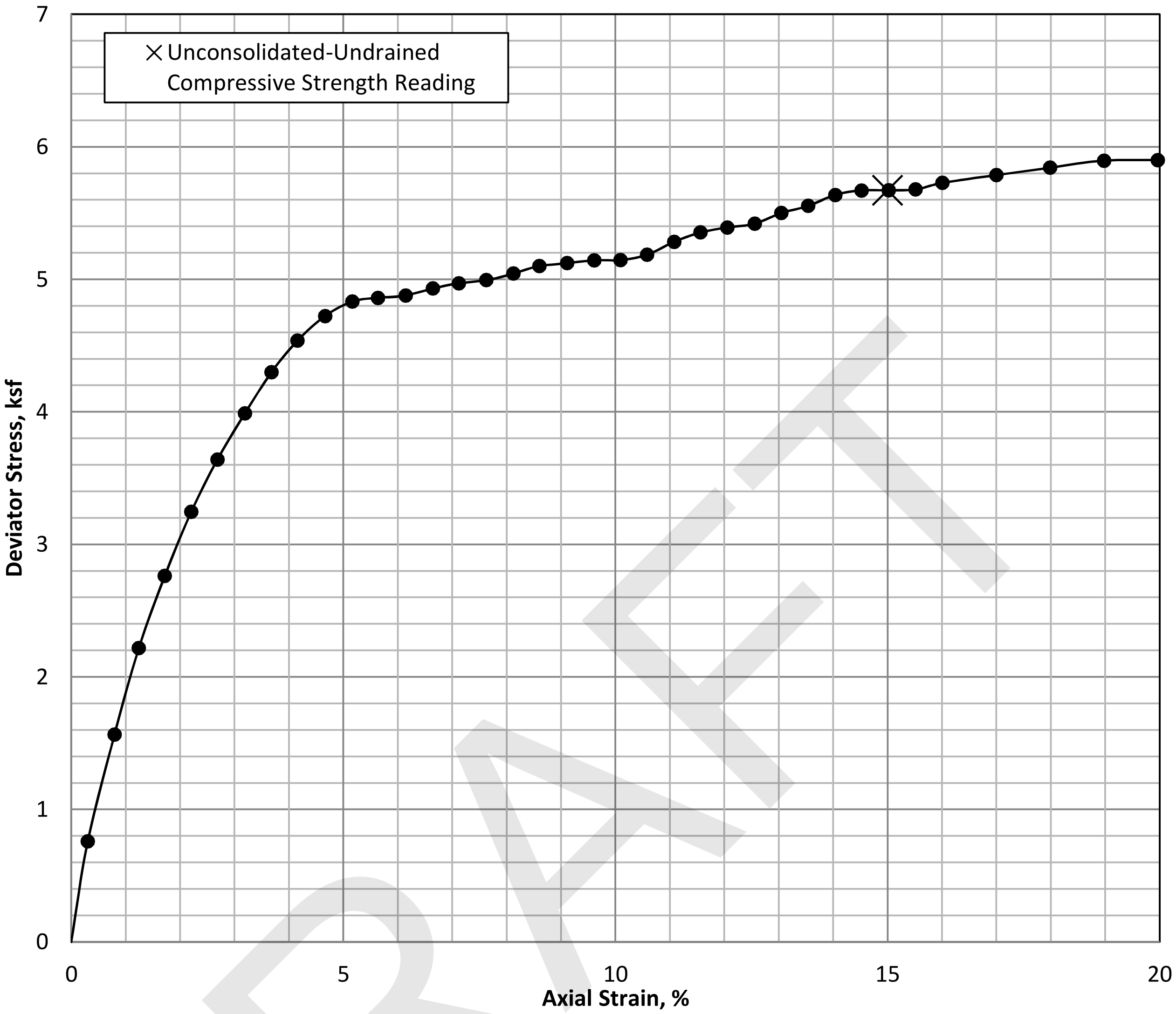
Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

(2) Assumed specific gravity

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

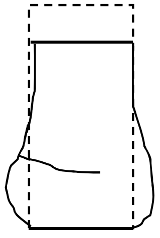
Sample Type: Intact tube sample

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
Test Date: 9/4/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM
Project # 60428794-107

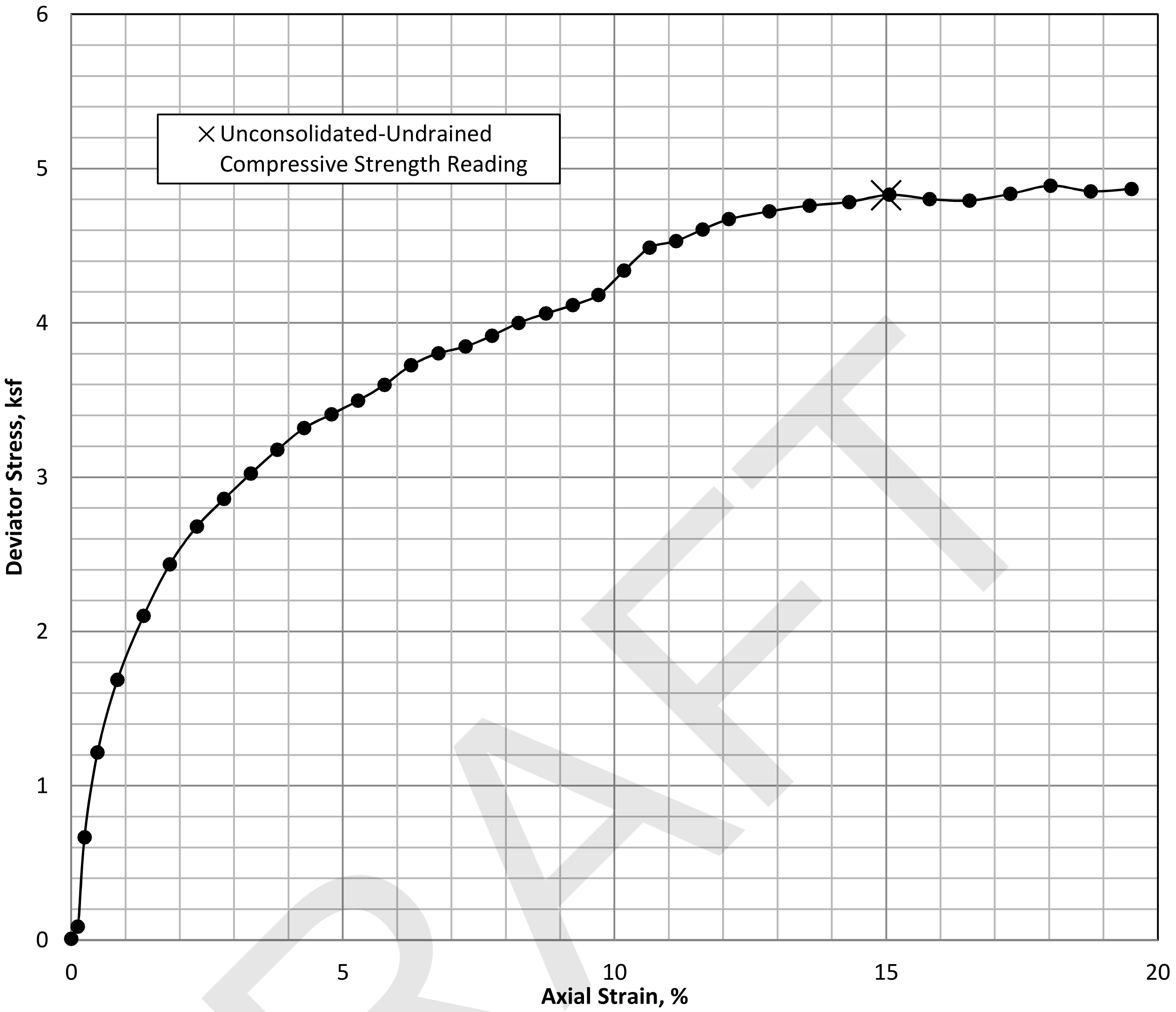
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

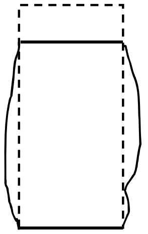
Sample Type: Intact tube sample

Description and/or Classification: CL, gray and brown lean clay

Cell Pressure (ksf)	Water Content (%) (1)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf) (1)	Void Ratio (-)	Saturation (%) (2)	Length (inch)	Diameter (inch)	L/D (-)	LL/PL (-)	PI (-)	Specific Gravity (-) (2)
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
Test Date: 9/4/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM
Project # 60428794-107

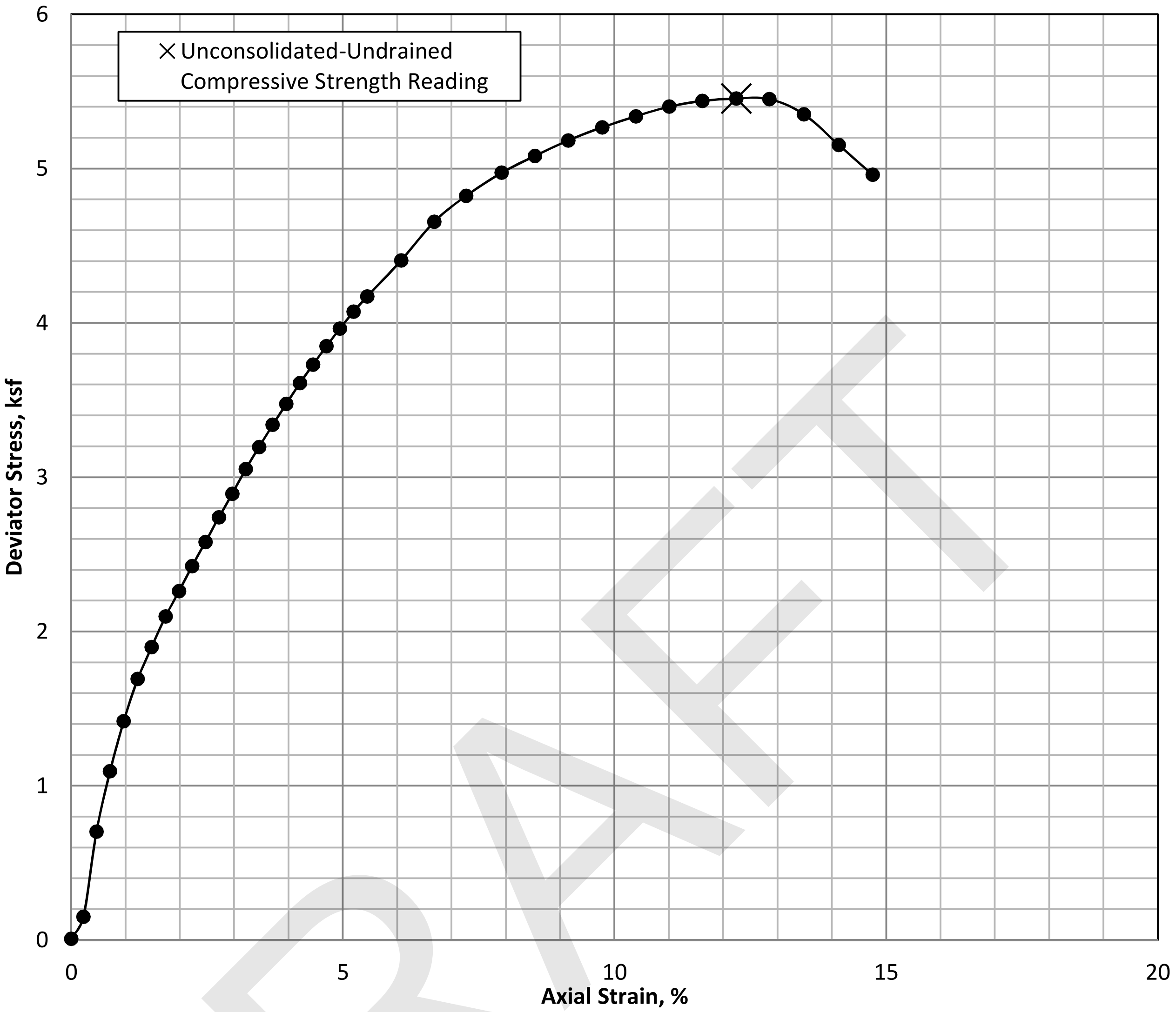
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

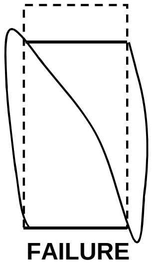
Sample Type: Intact tube sample

Description and/or Classification: CL, brown clay with sand and gravel

Cell Pressure (ksf)	Water Content (%) [(1)]	Wet Unit Weight (pcf)	Dry Unit Weight (pcf) [(1)]	Void Ratio (-)	Saturation (%) [(2)]	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific Gravity (-) [(2)]
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.

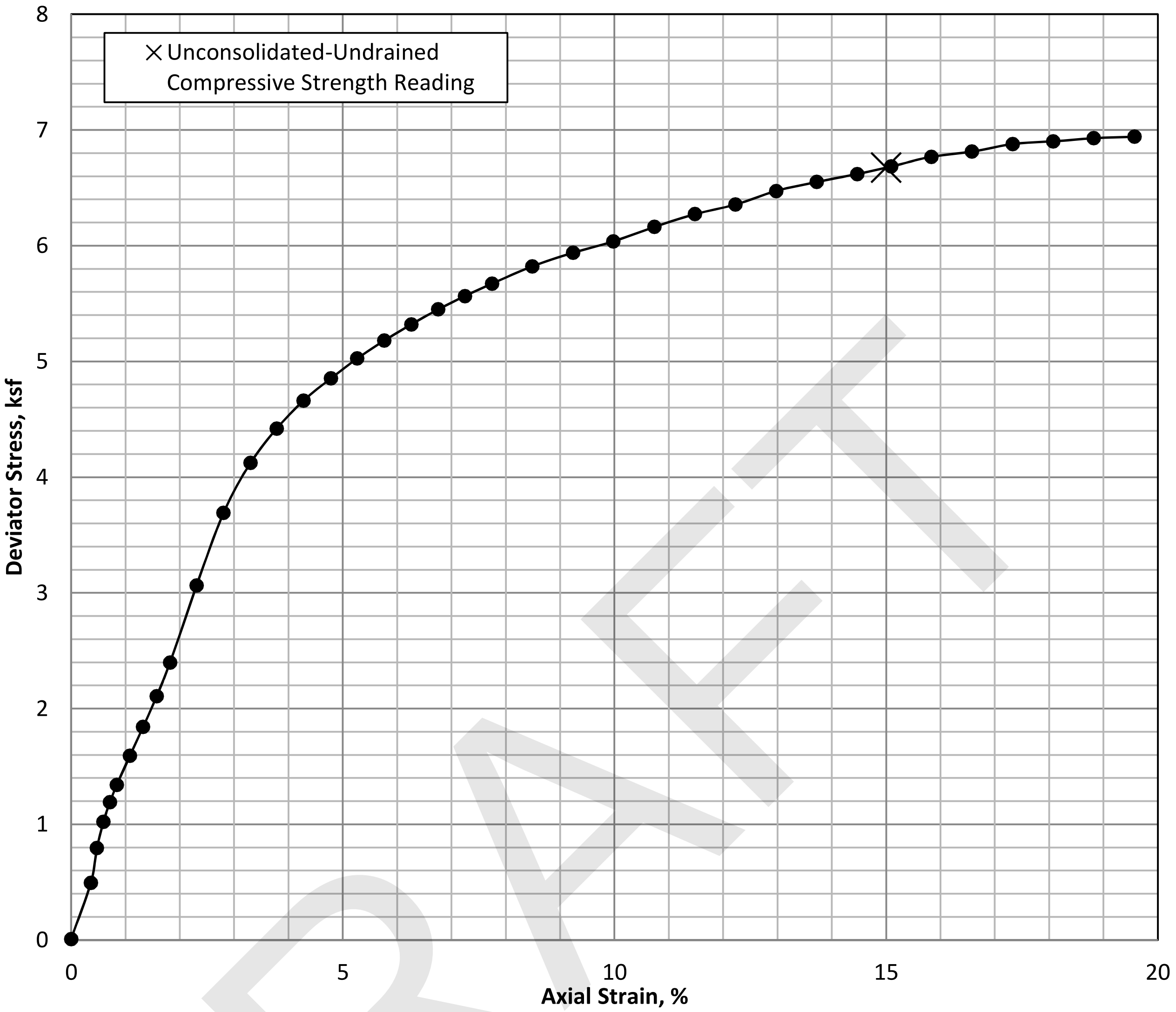
(2) Assumed specific gravity

Tested by: BB
Test Date: 10/6/2015

Reviewed by: GET
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

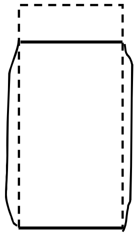
Sample Type: Intact tube sample

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 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
Test Date: 9/18/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM
Project # 60428794-107

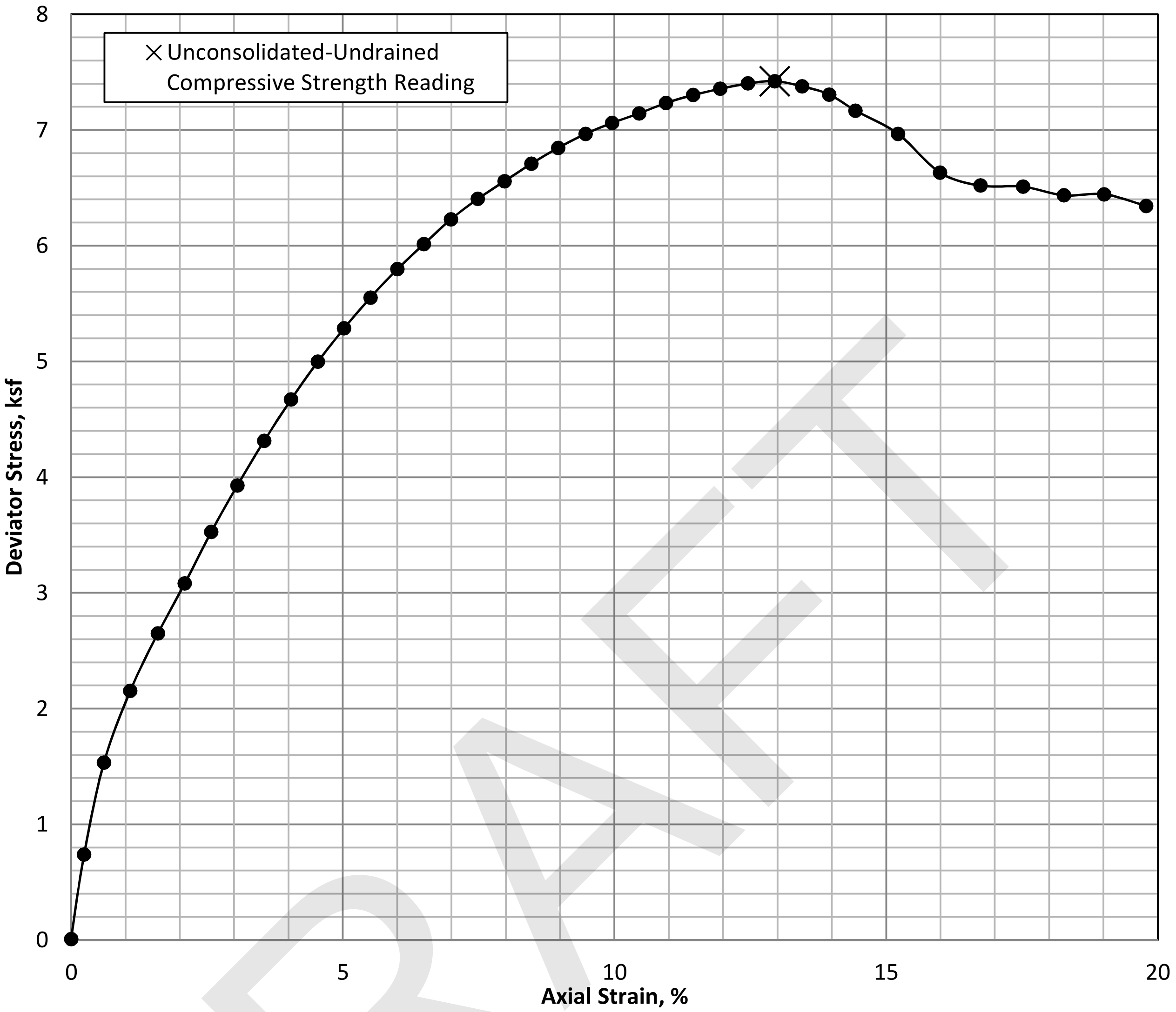
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

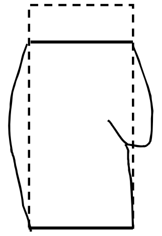
Sample Type: Intact tube sample

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
Test Date: 9/29/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM
Project # 60428794-107

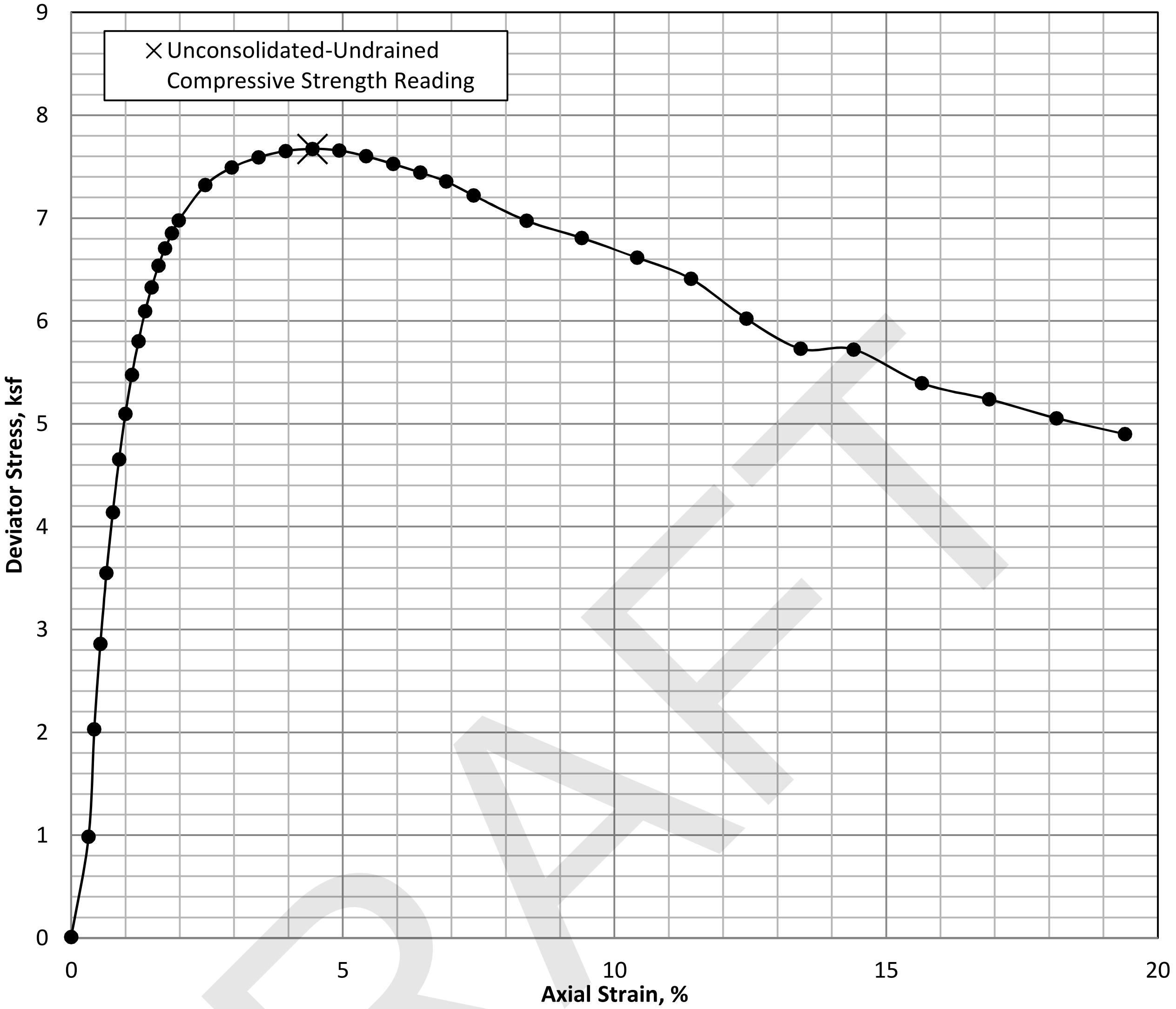
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

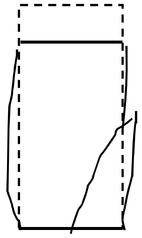
Sample Type: Intact tube sample

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

Tested by: BB
Test Date: 9/8/2015

Reviewed by: CMJ
Review Date: 10/5/2015

Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

(2) Assumed specific gravity

AECOM
Project # 60428794-107

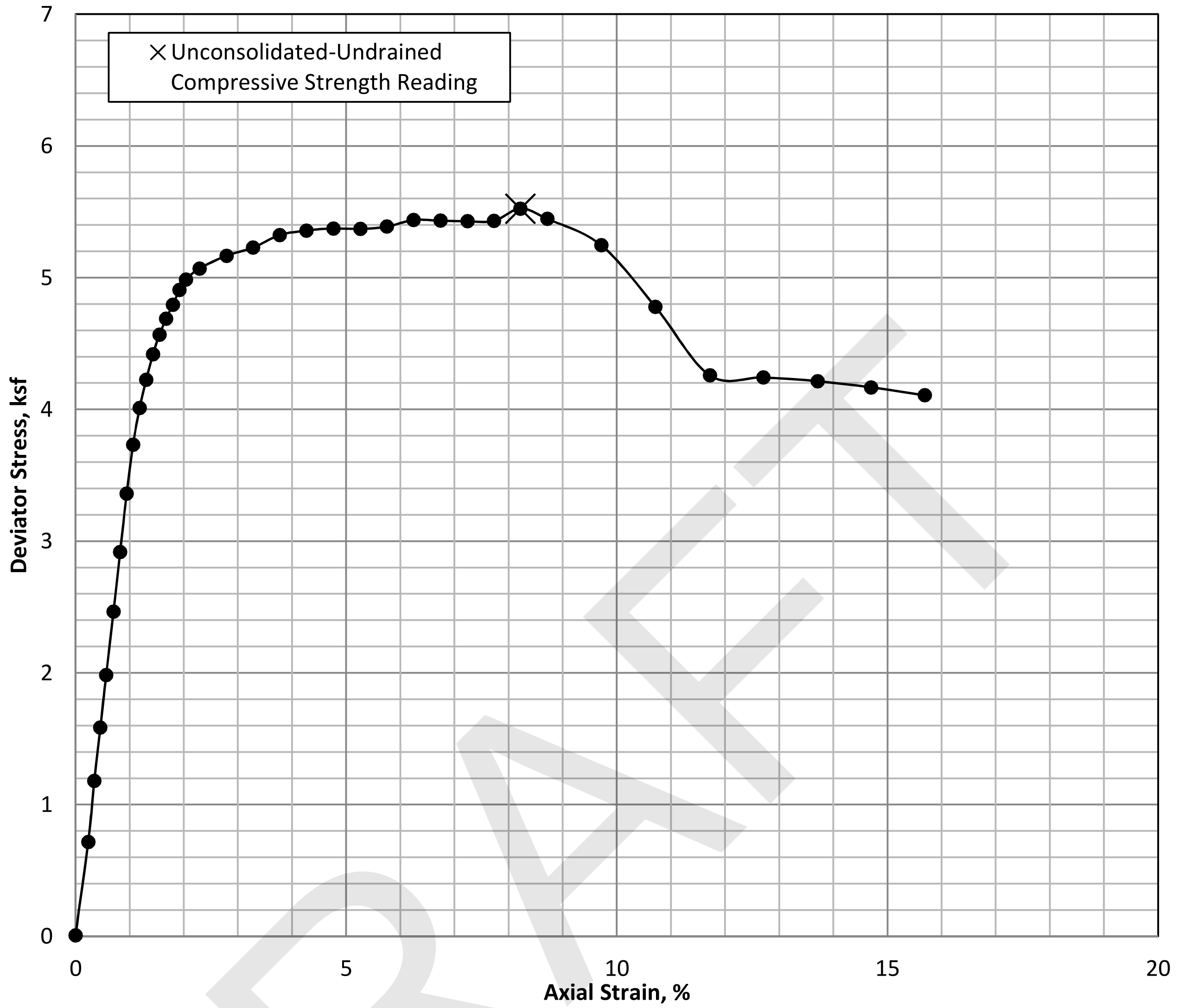
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

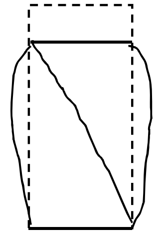
Sample Type: Intact tube sample

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

Tested by: BB
Test Date: 9/9/2015

Reviewed by: CMJ
Review Date: 10/5/2015

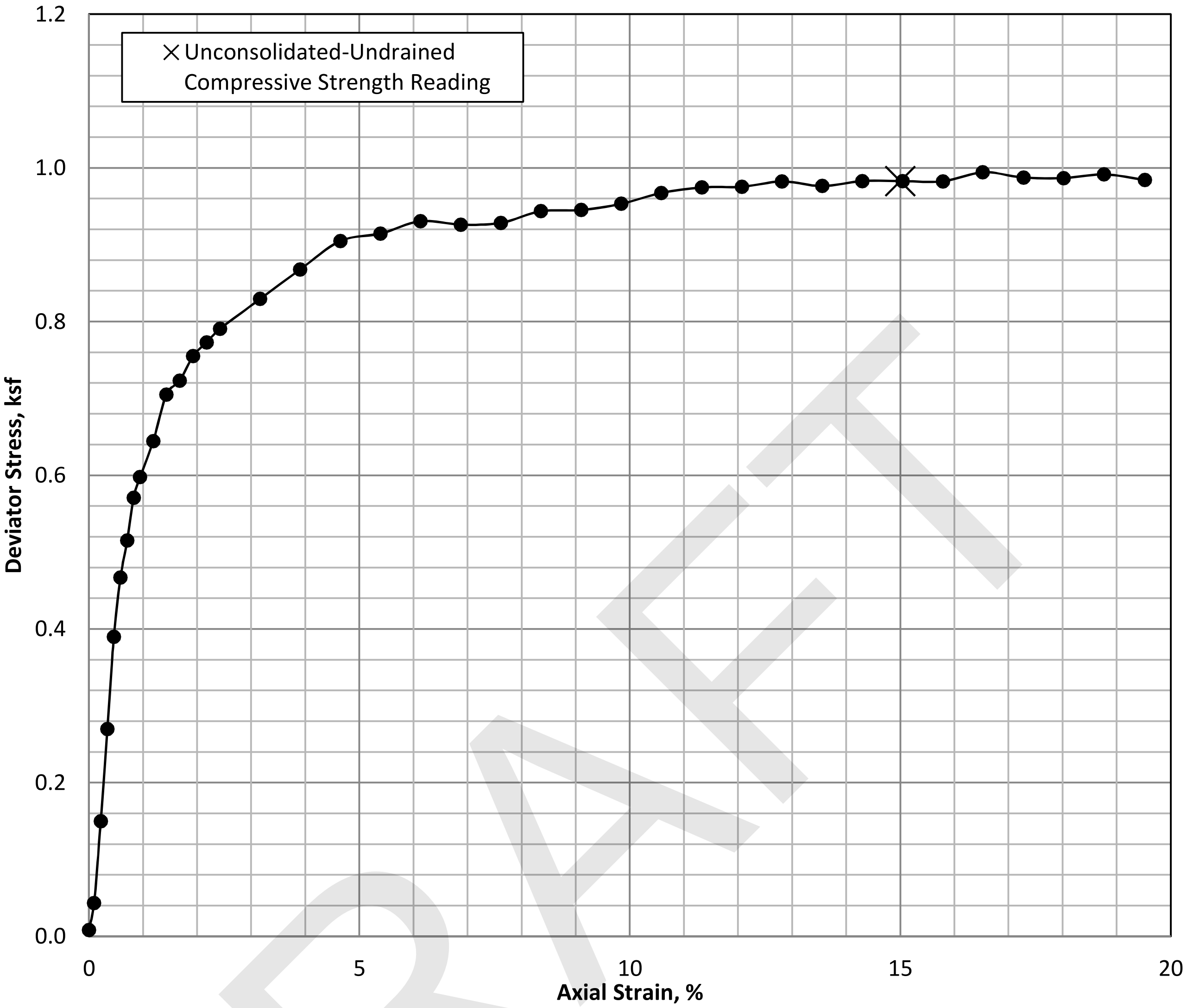
Remarks and Notes:

(1) Water Content determined after shear from partial specimen.

(2) Assumed specific gravity

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

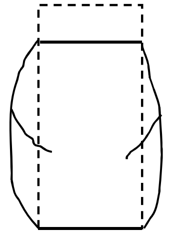
Sample Type: Intact tube sample

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
Test Date: 9/10/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM
Project # 60428794-107

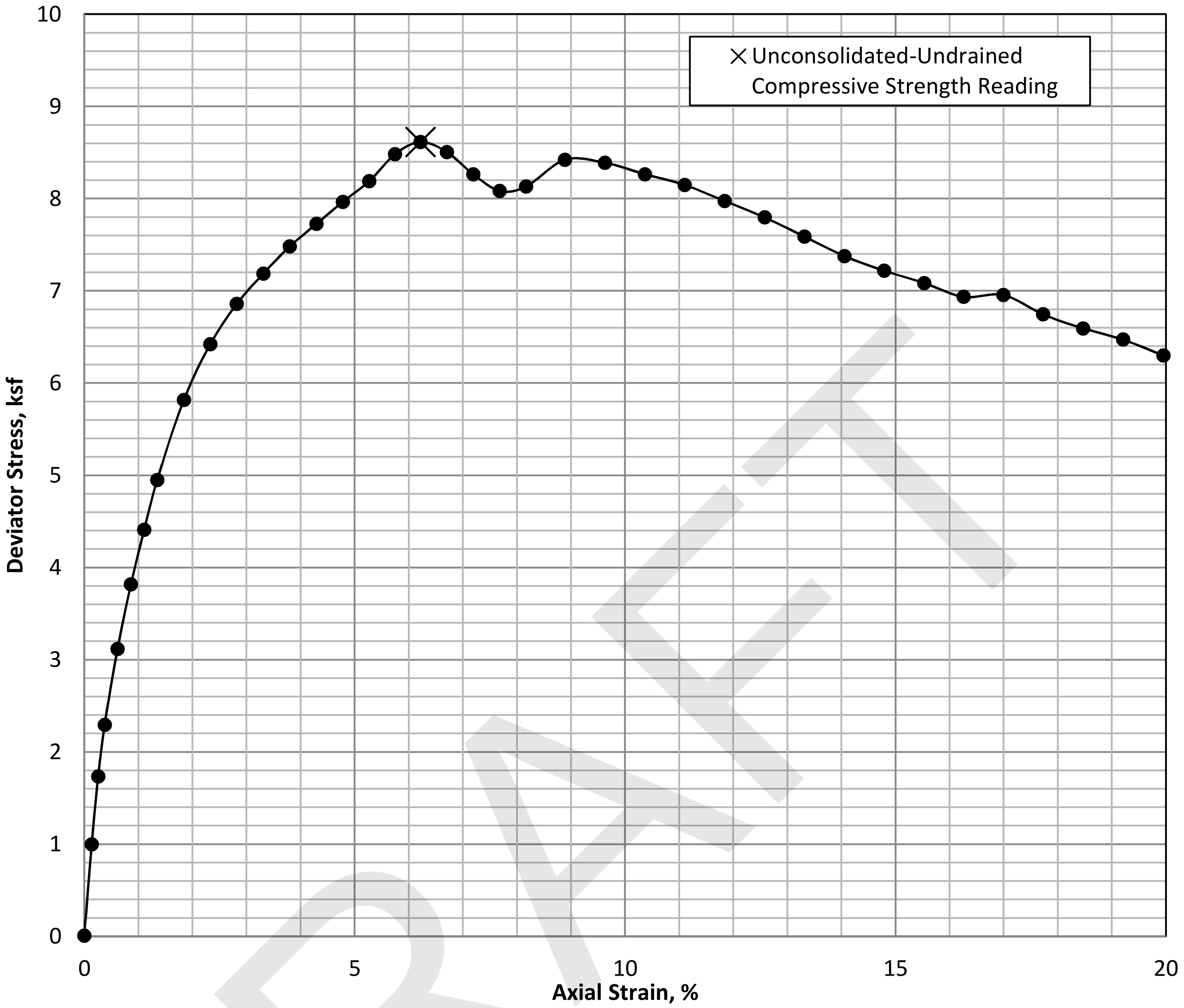
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

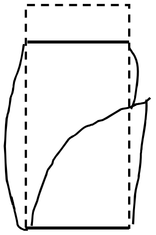
Sample Type: Intact tube sample

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
Test Date: 8/25/2015

Reviewed by: CMJ
Review Date: 9/2/2015

AECOM
Project # 60428794-107

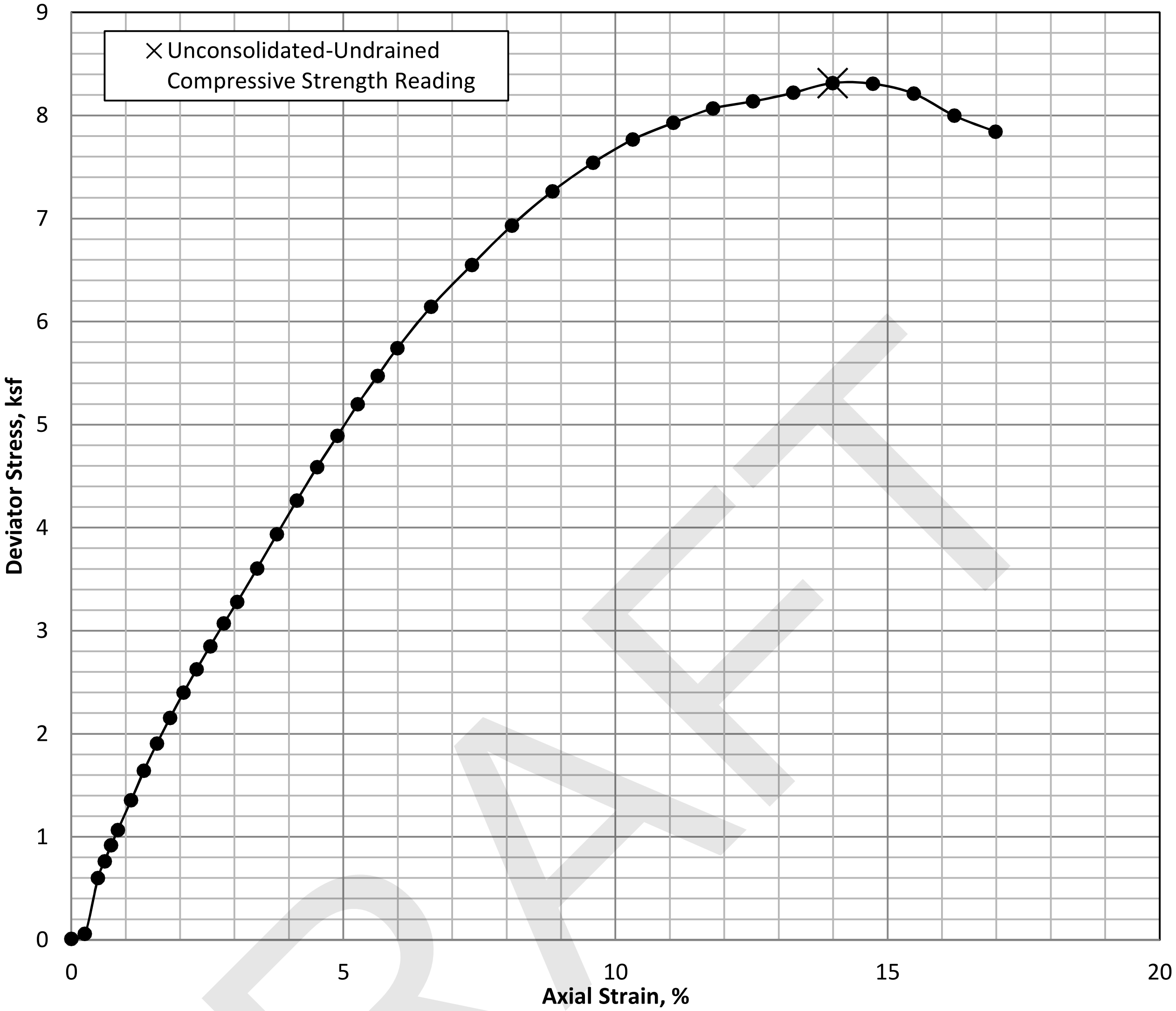
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

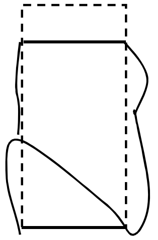
Sample Type: Intact tube sample

Description and/or Classification: CL, orange-brown clay

Cell Pressure (ksf)	Water Content [1] (%)	Wet Unit Weight (pcf)	Dry Unit Weight [1] (pcf)	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific Gravity [2] (-)
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

Test Date: 10/9/2015

Reviewed by: GET

Review Date: 10/12/2015

AECOM
Project # 60428794-107

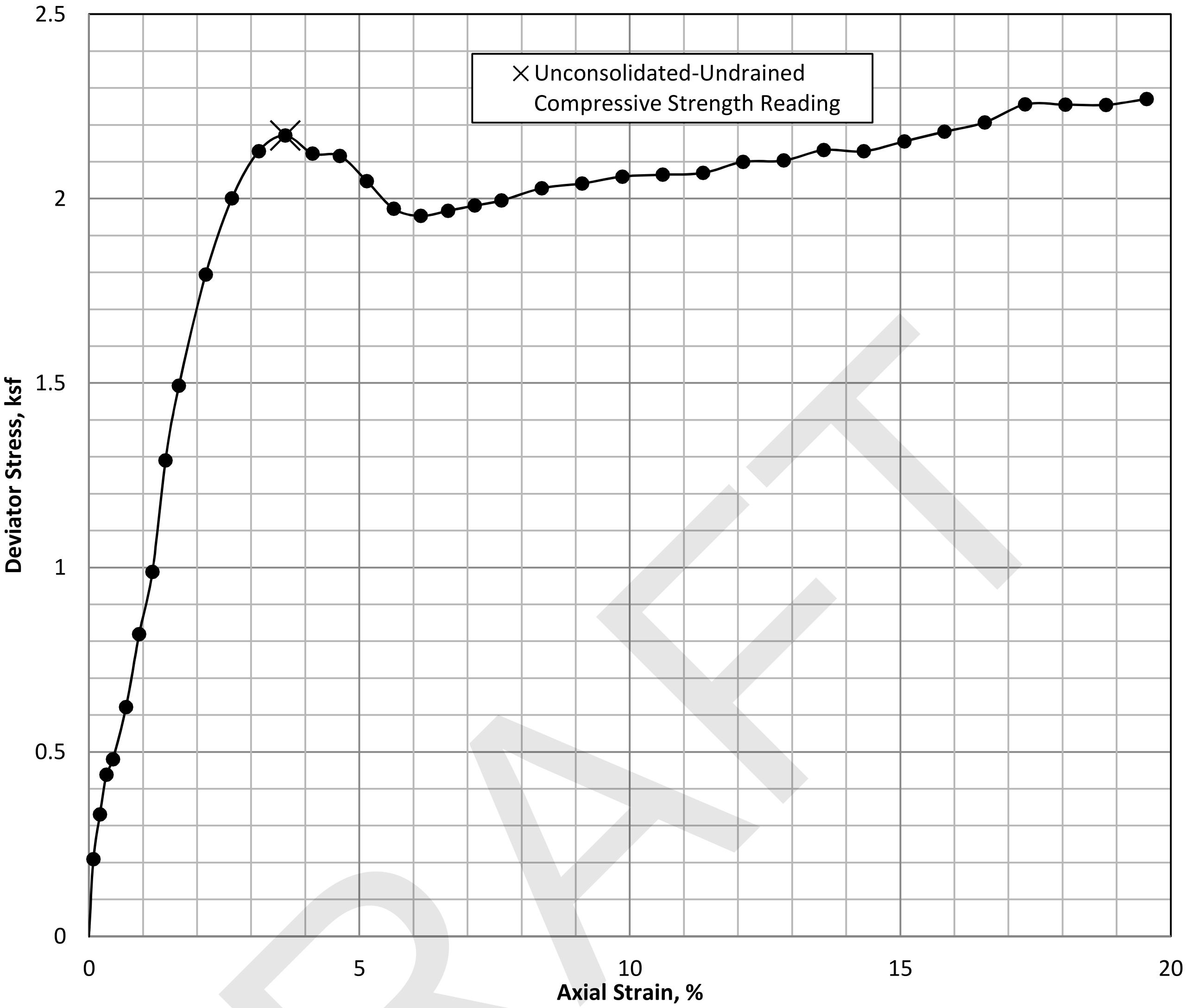
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

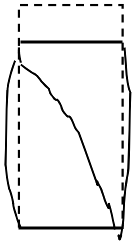
Sample Type: Intact tube sample

Description and/or Classification: CL, orangish brown lean clay

Cell Pressure (ksf)	Water Content (%) [1]	Wet Unit Weight (pcf)	Dry Unit Weight (pcf) [1]	Void Ratio (-)	Saturation [2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/ PL (-)	PI (-)	Specific Gravity [2] (-)
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
Test Date: 8/27/2015

Reviewed by: CMJ
Review Date: 9/2/2015

AECOM
Project # 60428794-107

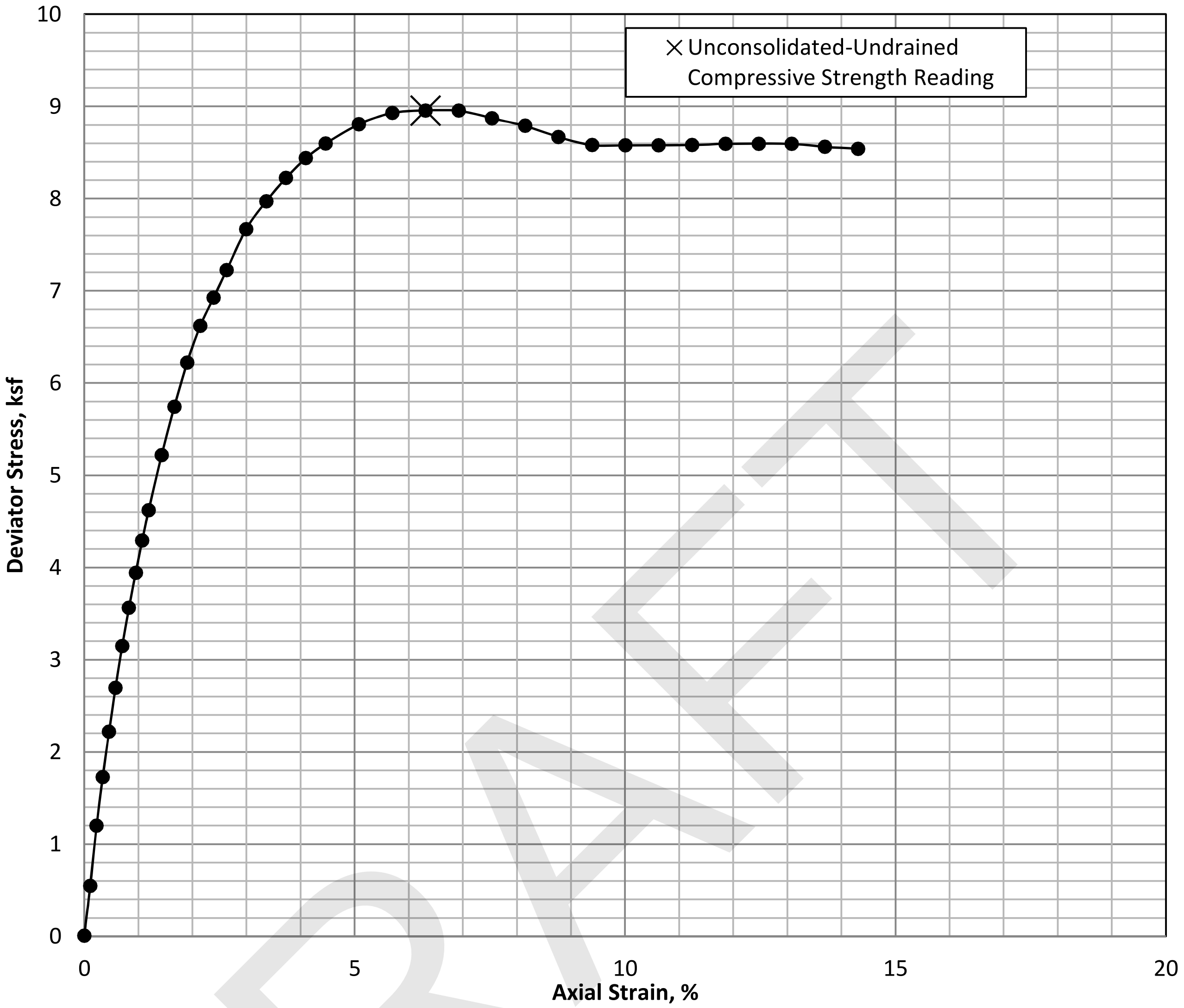
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

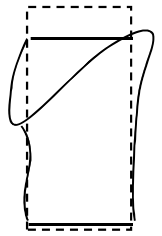
Sample Type: Intact tube sample

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
Test Date: 10/7/2015

Reviewed by: GET
Review Date: 10/12/2015

AECOM
Project # 60428794-107

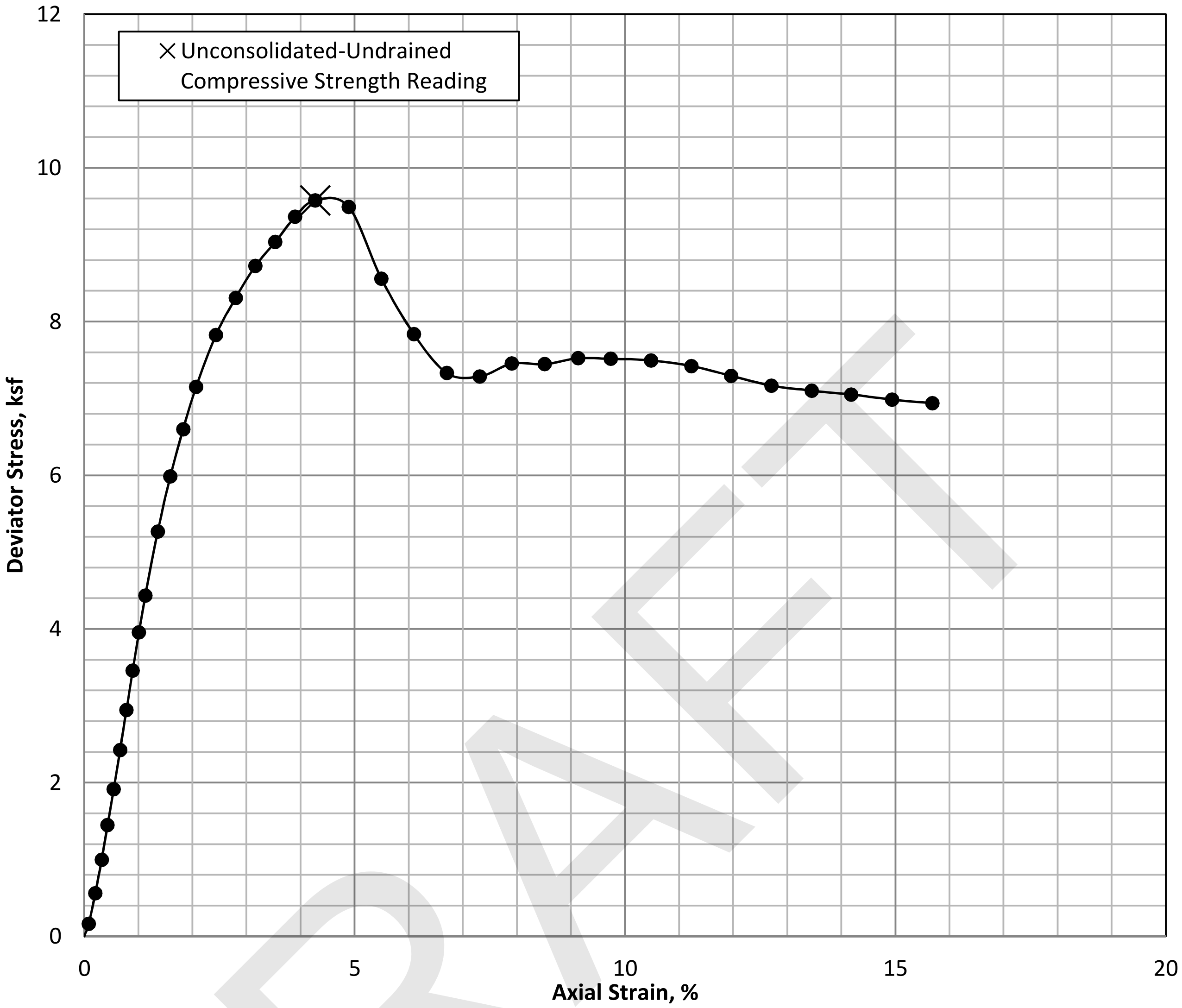
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

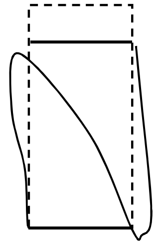
Sample Type: Intact tube sample

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
Test Date: 10/7/2015

Reviewed by: GET
Review Date: 10/12/2015

AECOM
Project # 60428794-107

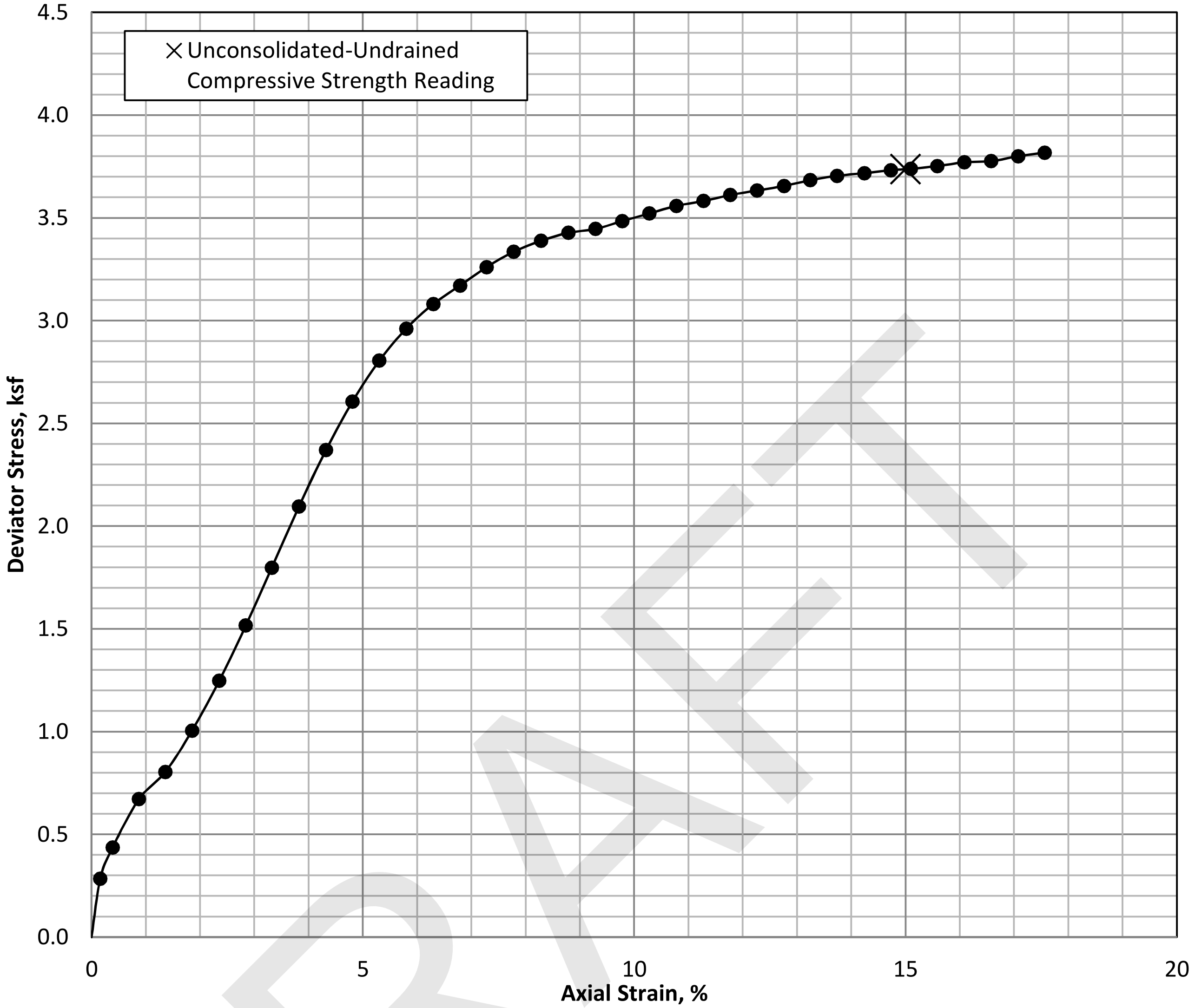
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

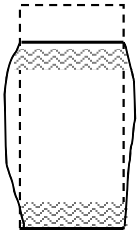
Sample Type: Intact tube sample

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
Test Date: 10/13/2015

Reviewed by: CMJ
Review Date: 10/15/2015

AECOM
Project # 60428794-107

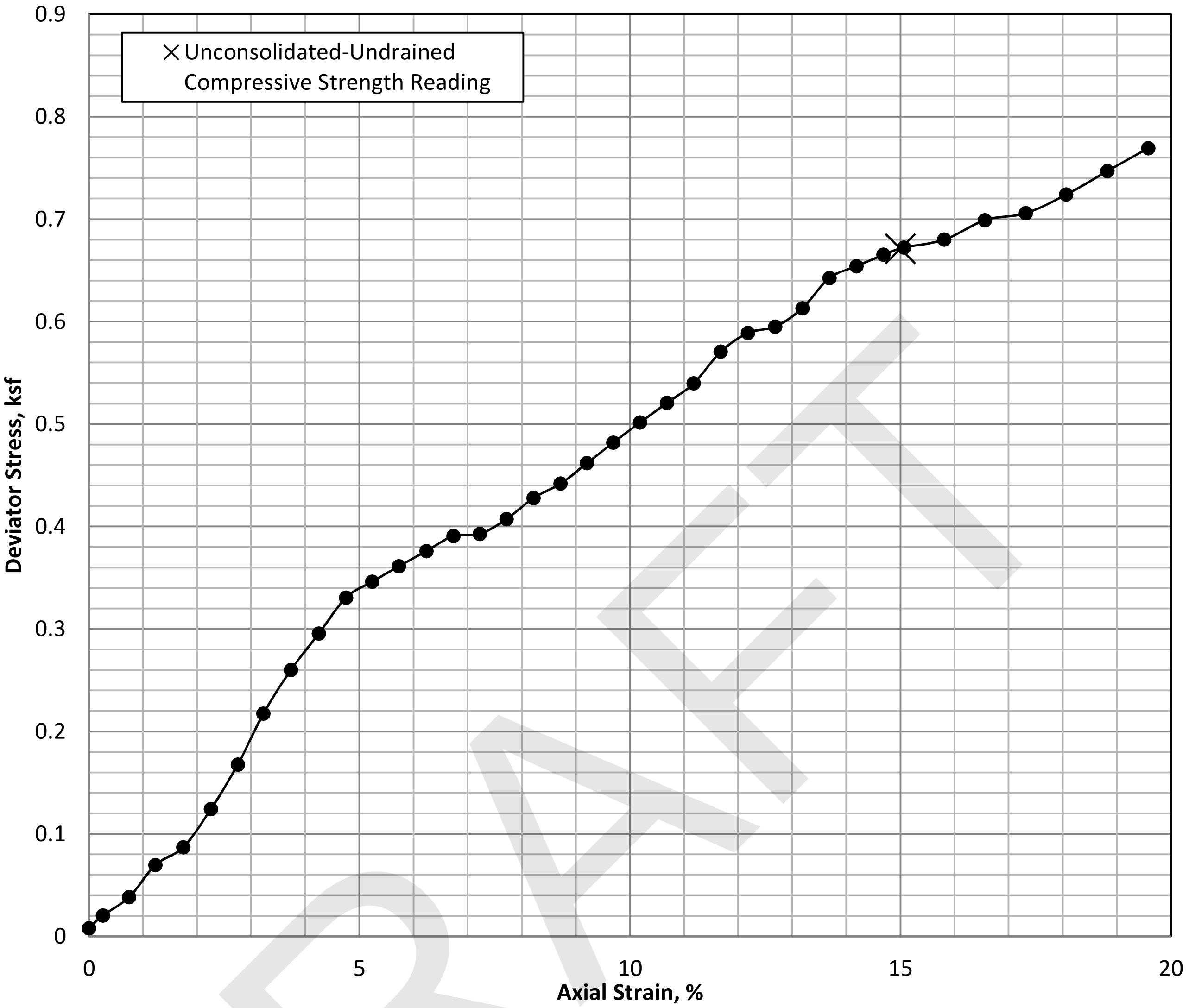
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

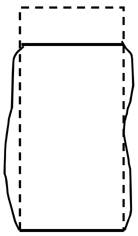
Sample Type: Intact tube sample

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.

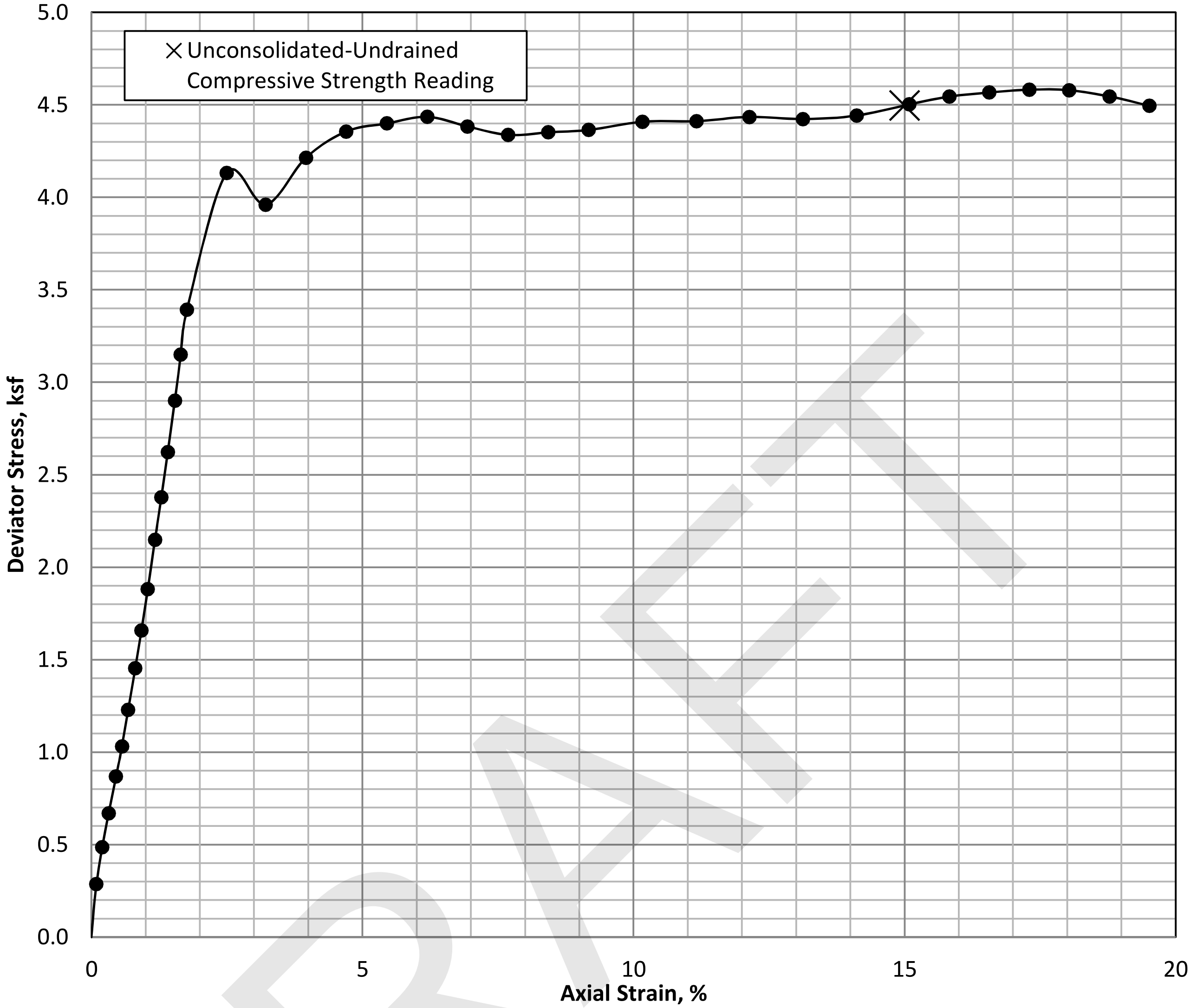
(2) Assumed specific gravity

Tested by: BB
Test Date: 9/18/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM **Project # 60428794-107**	**Dynegy CCR - Joppa**	**UNCONSOLIDATED-UNDRAINED COMPRESSION TEST** **Boring: JOP-B021 Sample: ST-2** **Section: A Depth: 13.55 ft.**
TerraSense, LLC **Project # T60428794**		

UNCONSOLIDATED-UNDRAINED COMPRESSIVE STRENGTH TEST, ASTM METHOD D2850



Specimen and Material Property Information

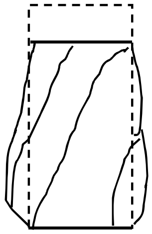
Sample Type: Intact tube sample

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
Test Date: 8/25/2015

Reviewed by: CMJ
Review Date: 9/2/2015

AECOM
Project # 60428794-107

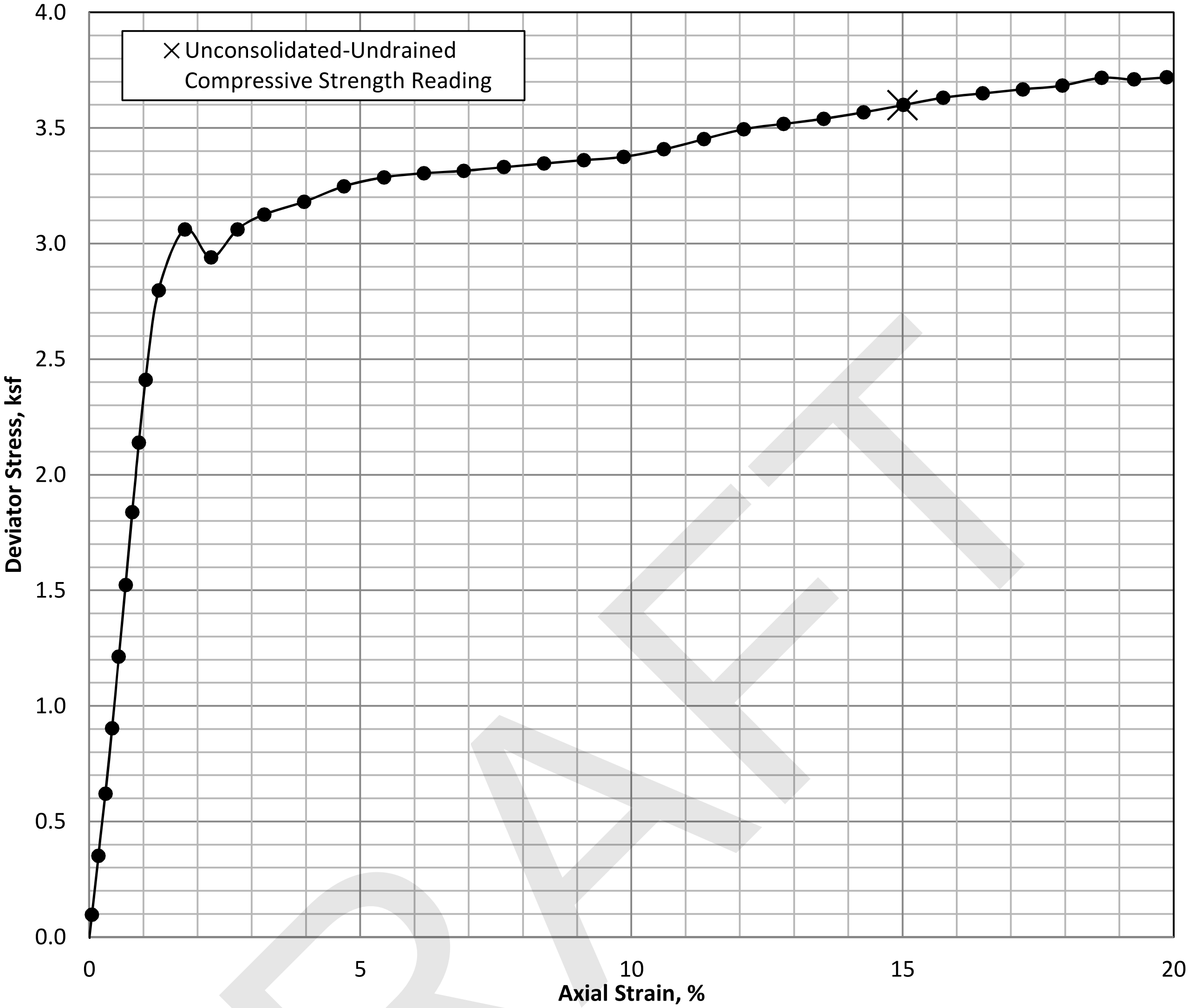
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

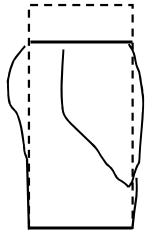
Sample Type: Intact tube sample

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 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
Test Date: 9/15/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM
Project # 60428794-107

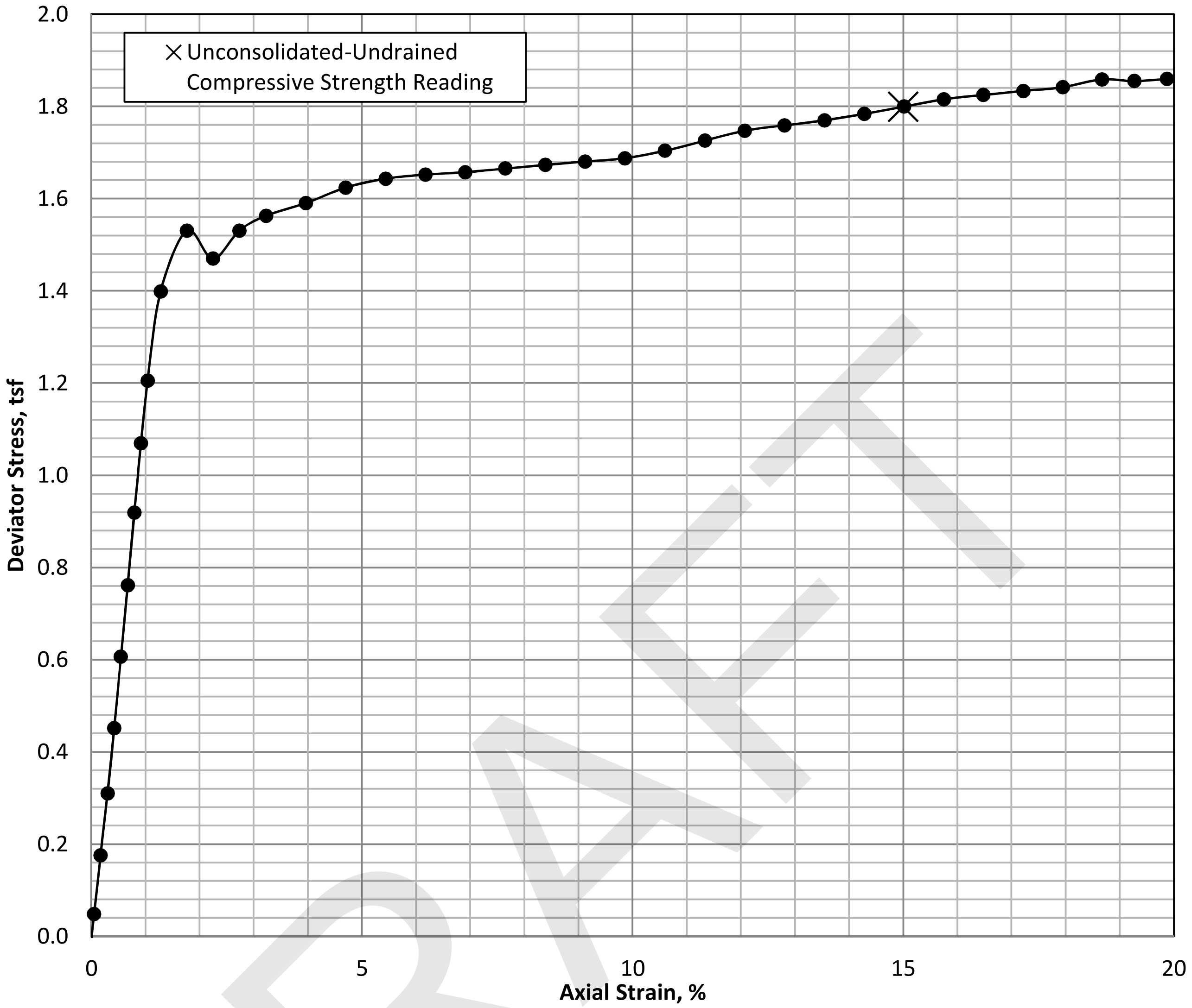
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

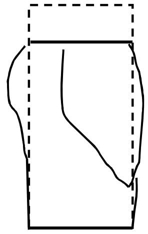
Sample Type: Intact tube sample

Description and/or Classification: CL, orangeish brown lean clay

Cell Pressure (tsf)	Water Content (%) [(1)]	Wet Unit Weight (pcf)	Dry Unit Weight (pcf) [(1)]	Void Ratio (-)	Saturation (%) [(2)]	Length (inch)	Diameter (inch)	L/D (-)	LL/PL (-)	PI (-)	Specific Gravity (-) [(2)]
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.

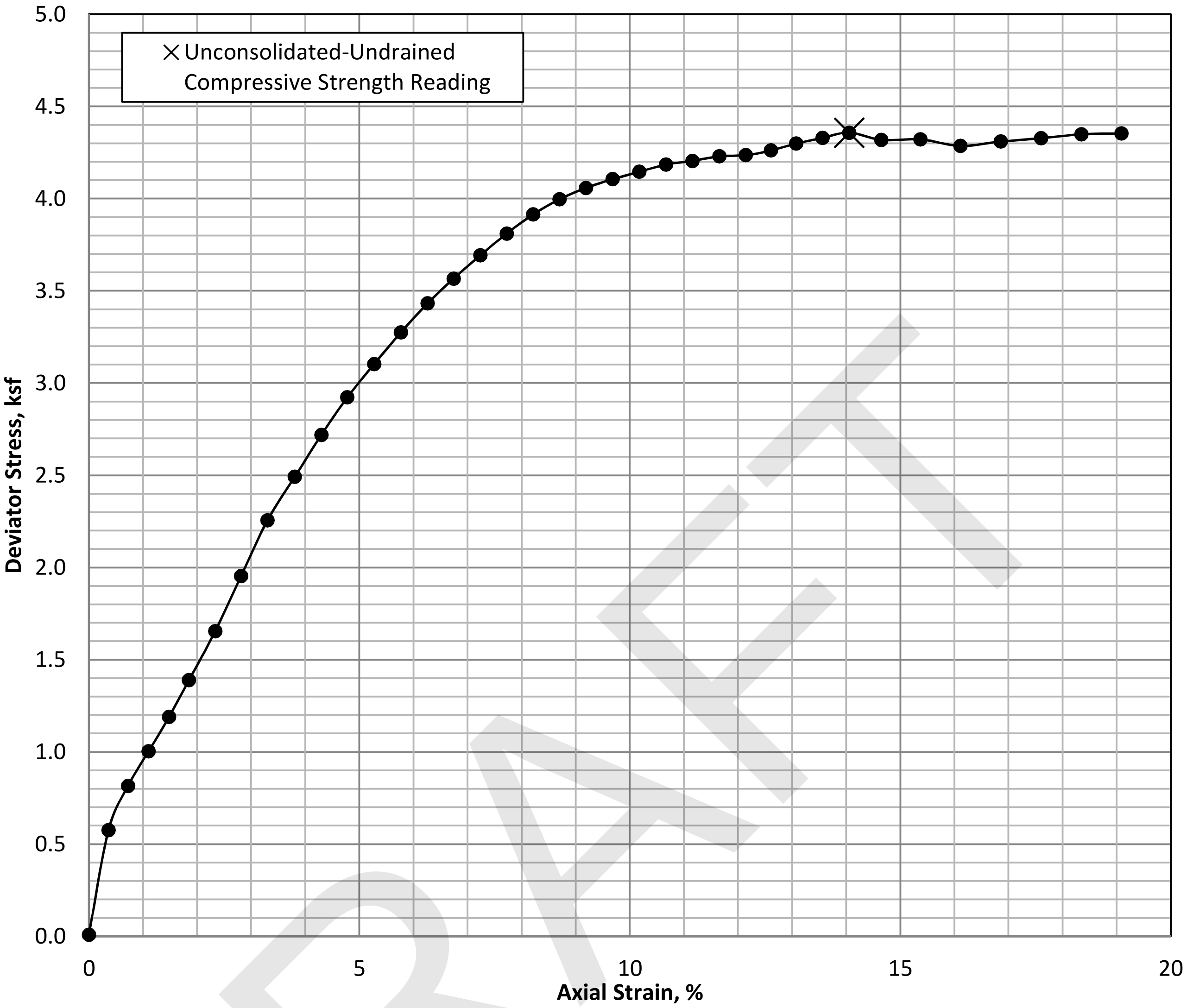
(2) Assumed specific gravity

Tested by: BB
Test Date: 9/15/2015

Reviewed by: CMJ
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

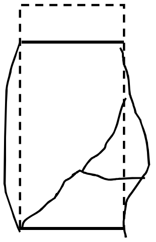
Sample Type: Intact tube sample

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
Test Date: 9/15/2015

Reviewed by: CMJ
Review Date: 10/5/2015

AECOM
Project # 60428794-107

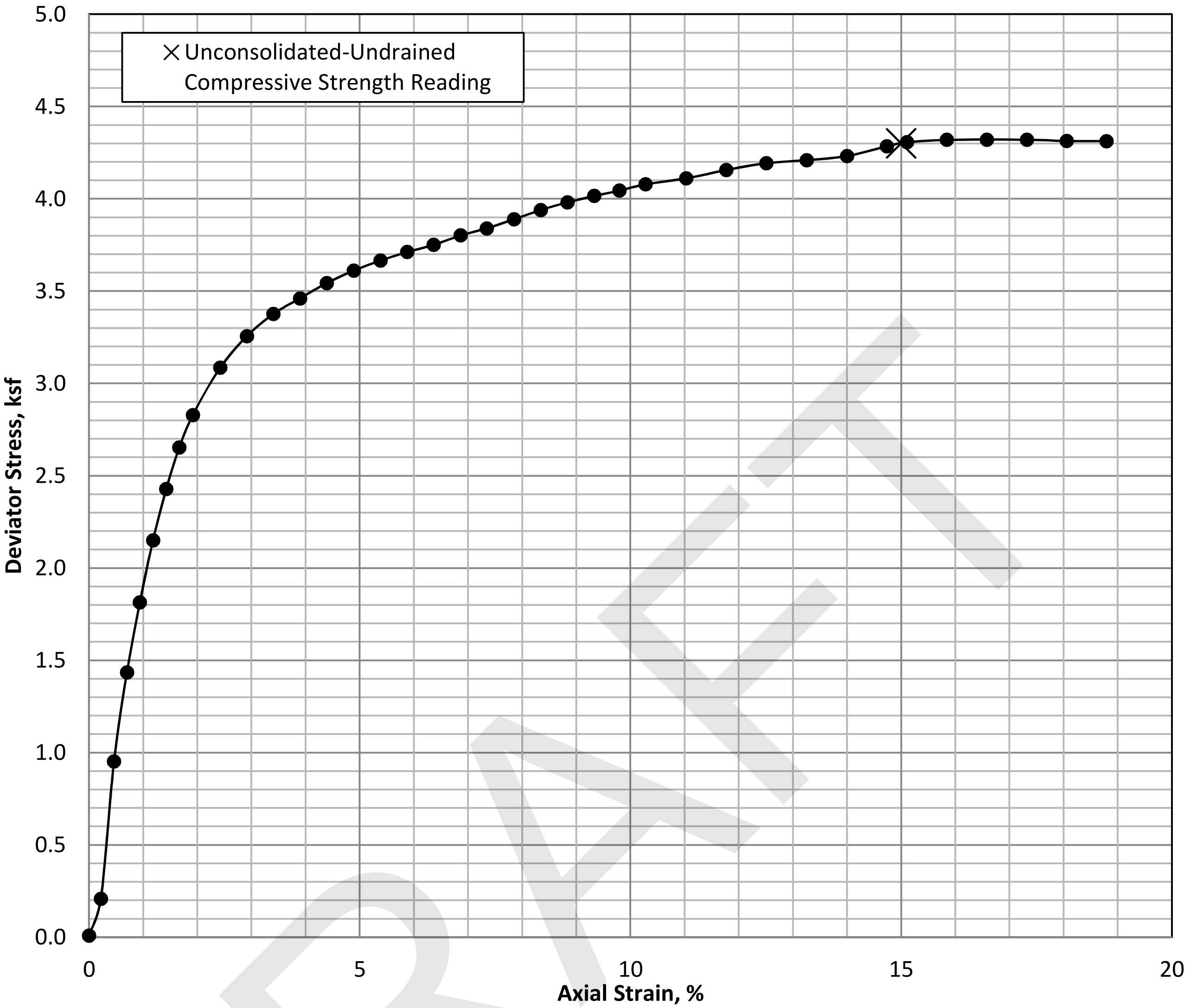
TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

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

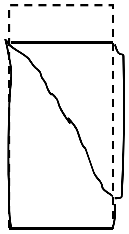
Sample Type: Intact tube sample

Description and/or Classification: CL, orangish brown lean clay

Cell Pressure (ksf)	Water Content[1] (%)	Wet Unit Weight (pcf)	Dry Unit Weight[1] (pcf)	Void Ratio (-)	Saturation[2] (%)	Length (inch)	Diameter (inch)	L/D (-)	LL/PL (-)	PI (-)	Specific Gravity[2] (-)
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

Test Date: 9/17/2015

Reviewed by: CMJ

Review Date: 10/5/2015

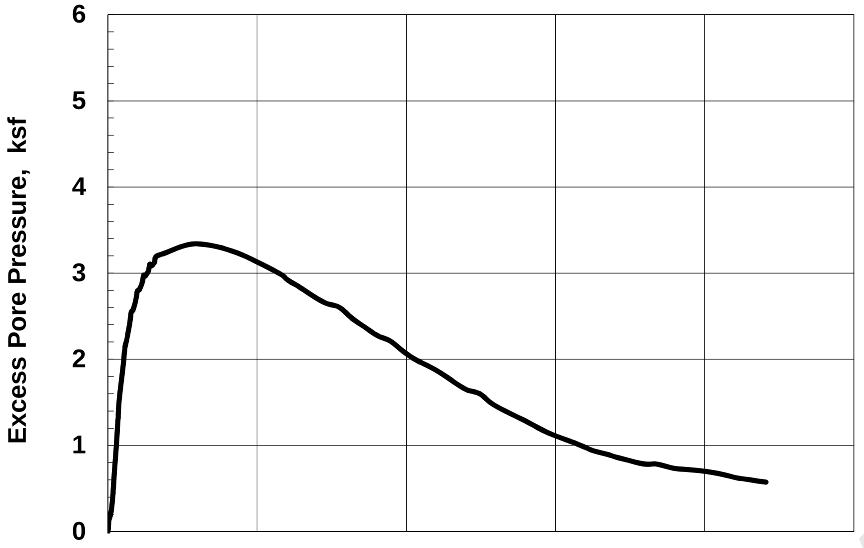
AECOM
Project # 60428794-107

TerraSense, LLC
Project # T60428794

Dynegy CCR - Joppa

UNCONSOLIDATED-UNDRAINED COMPRESSION TEST

Boring: JOP-B023 Sample: ST-2
Section: A Depth: 48.45 ft.



SAMPLE INFORMATION

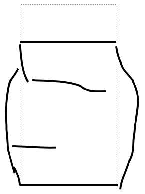
Boring: JOP-B001 Sample: ST-4C Depth: 44.35 ft
Type: Intact tube sample
Description: SC, light gray clayey sand
LL = 29 PL = 12 PI = 17

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

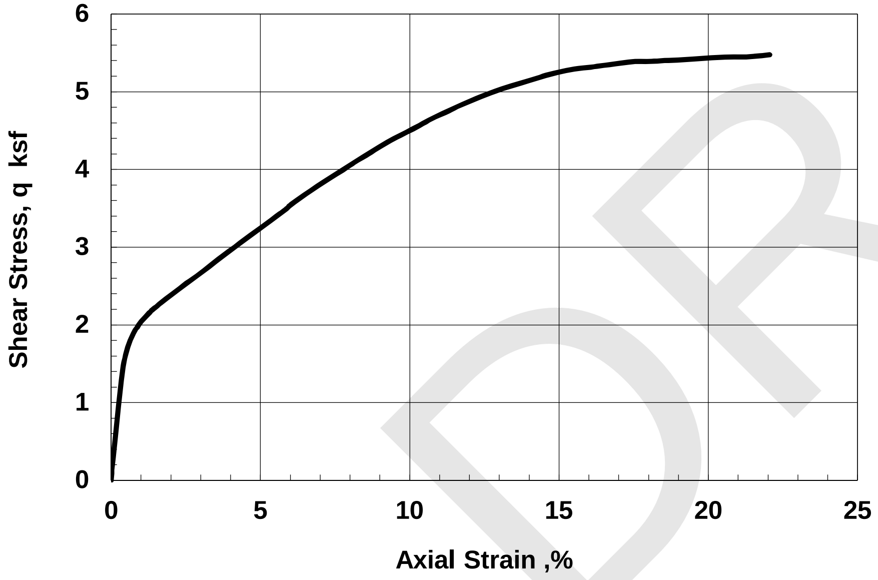
TEST SUMMARY

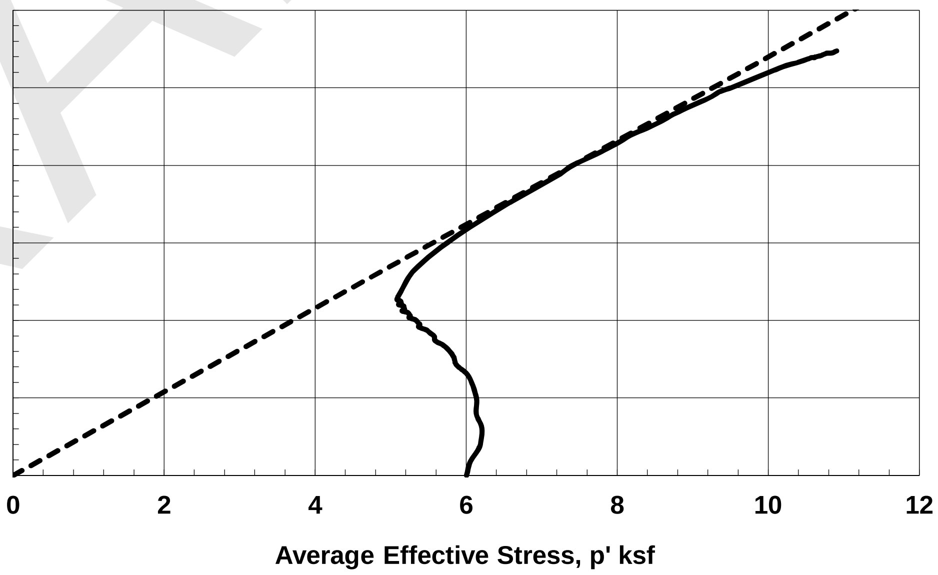
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 14.8 % Total Unit Weight: 136.1 pcf
B Coefficient: 98.67 Strain Rate: 0.021 %/min
Peak Shear Strength: 5.48 ksf @ 22.1 % Strain
Peak Effective Friction Angle: 32.7°



Failure
Sketch

REMARKS:

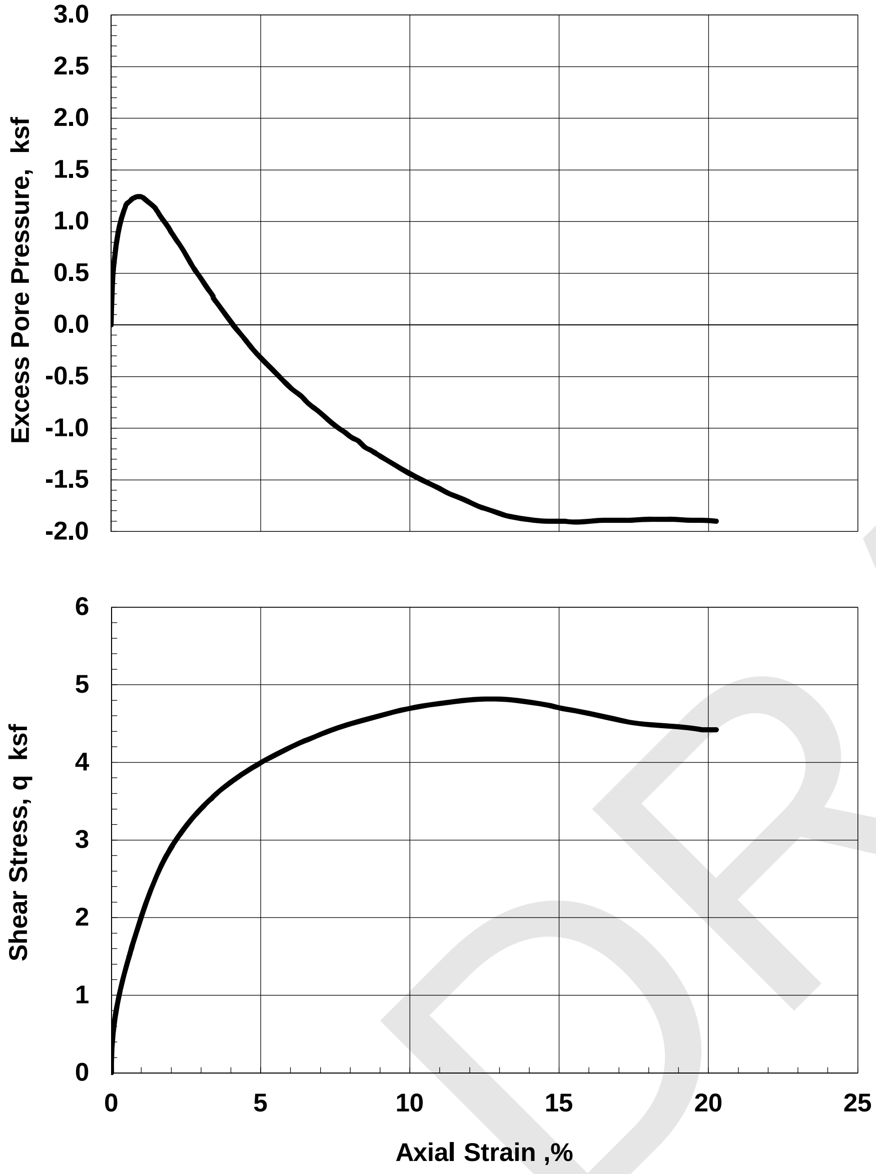




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B001 Sample: ST-4C	November-15
TerraSense, LLC			



SAMPLE INFORMATION

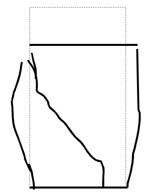
Boring: JOP-B002 Sample: ST-3C Depth: 39.55 ft
Type: Intact tube sample
Description: CL, brown lean clay

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

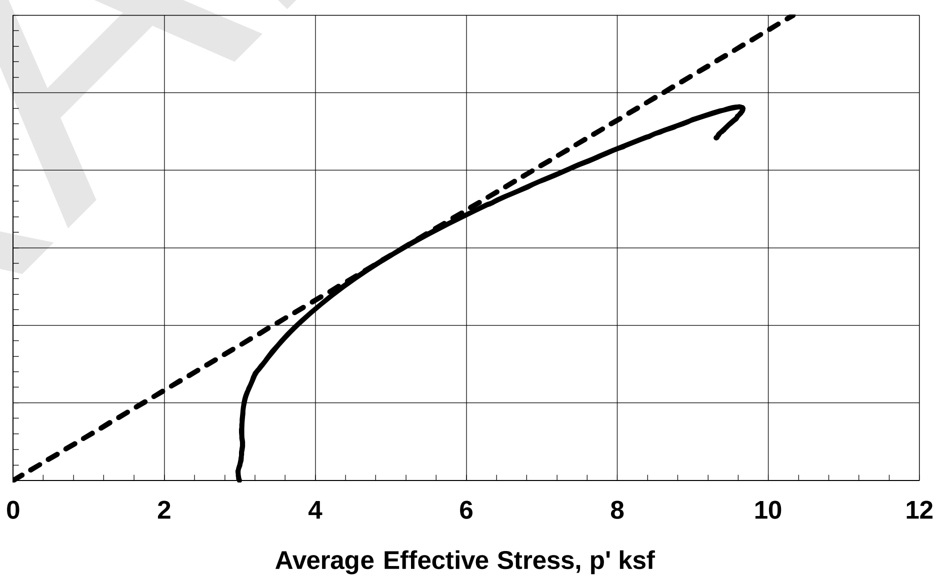
TEST SUMMARY

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°



Failure Sketch

REMARKS:



Test by: DT

Checked by: GET

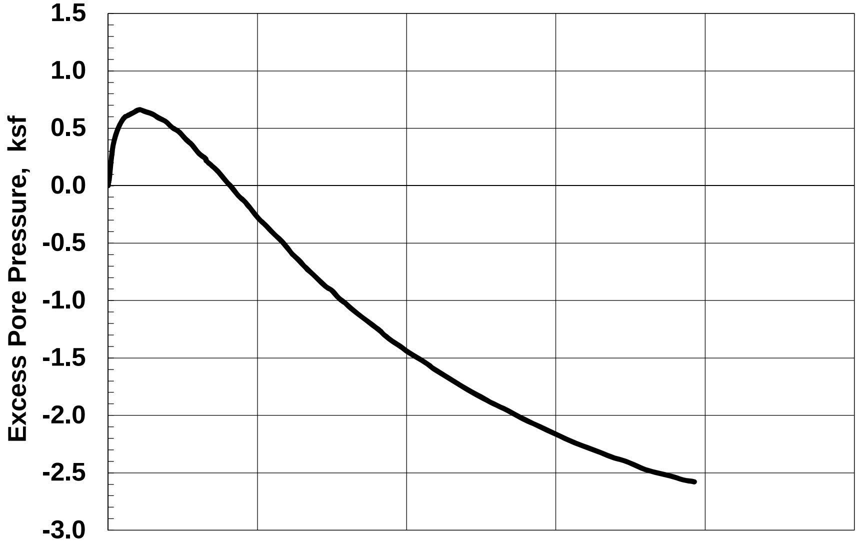
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B002 Sample: ST-3C

October-15

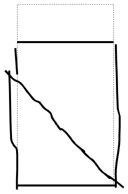


SAMPLE INFORMATION

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

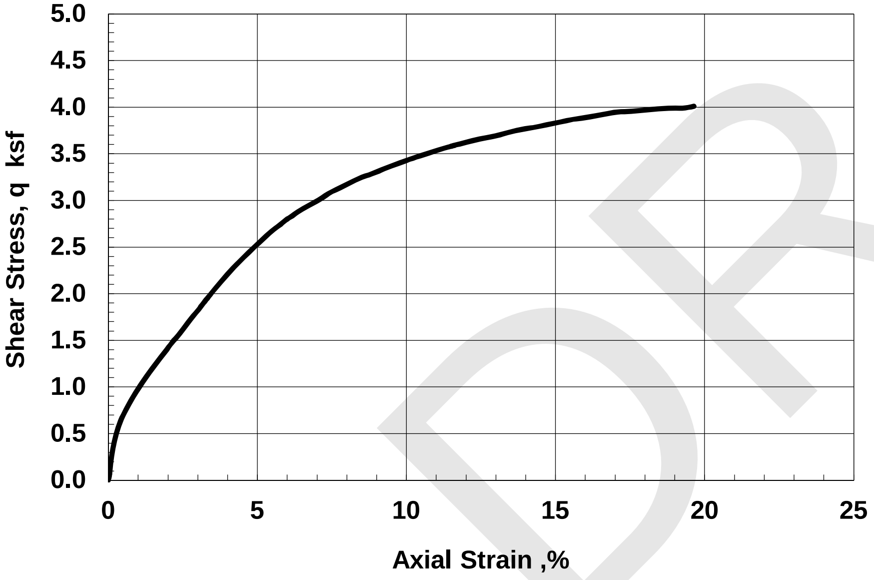


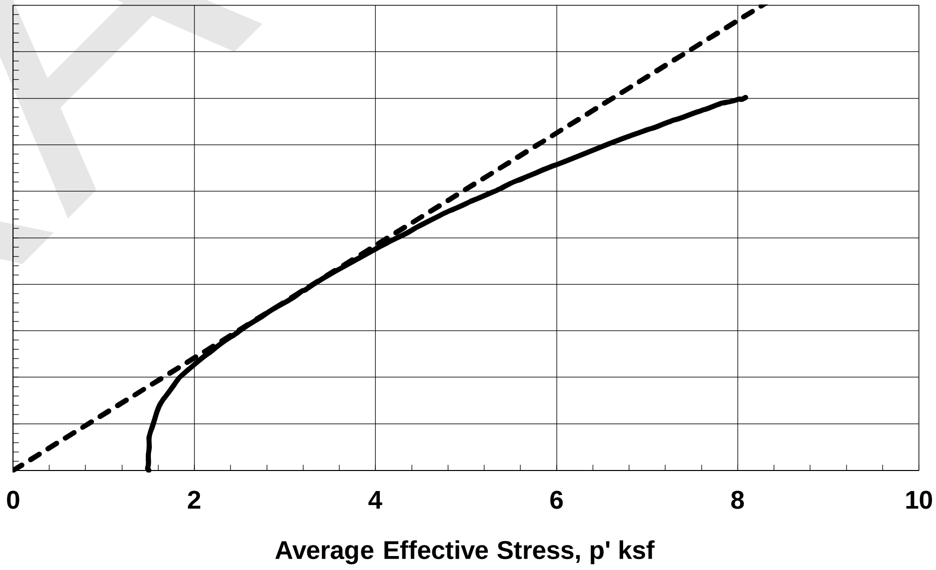
Failure
Sketch

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:

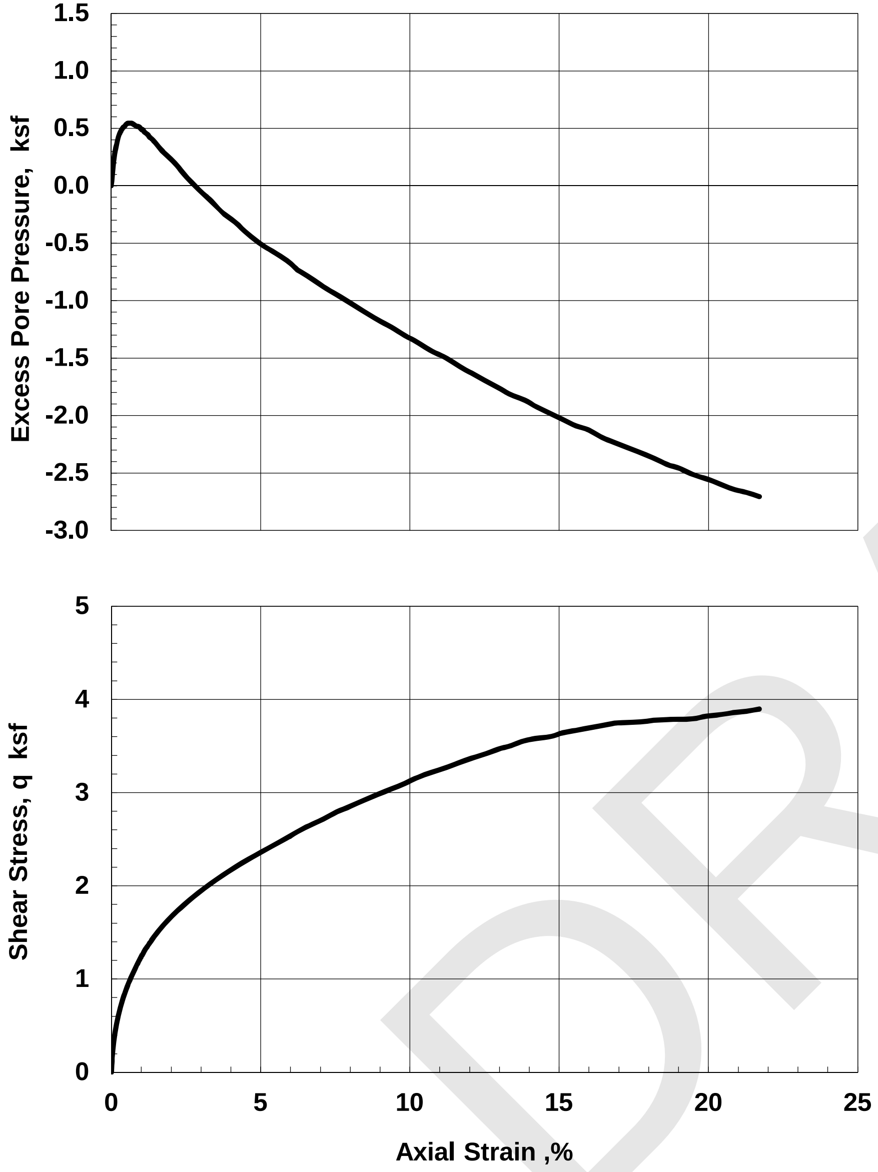




Test by: DT

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B003 Sample: ST-2B	October-15
TerraSense, LLC			

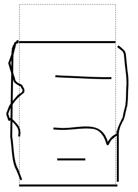


SAMPLE INFORMATION

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

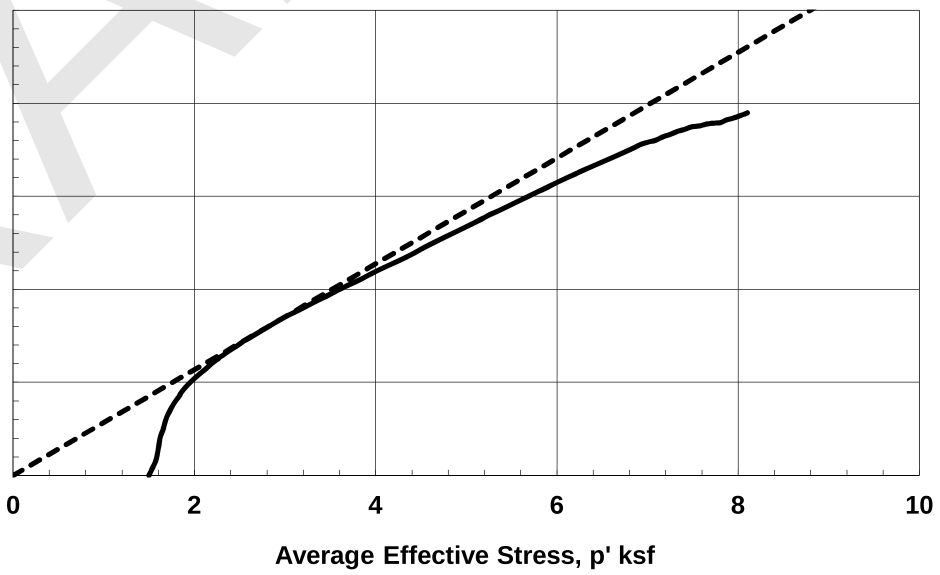


Failure Sketch

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°

REMARKS:



Test by: BB

Checked by: GET

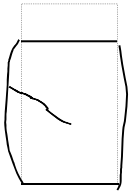
Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B004 Sample: ST-4C	
TerraSense, LLC			September-15

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

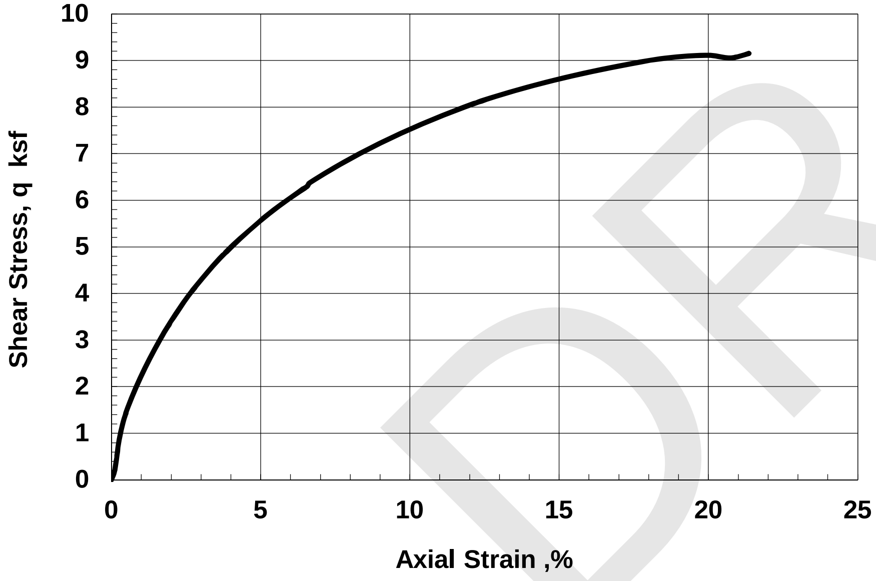


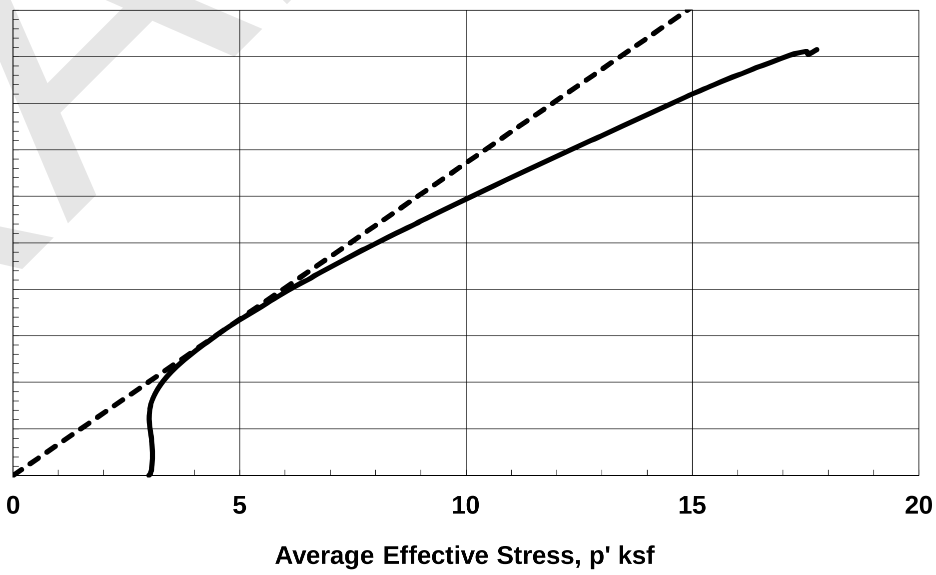
Failure
Sketch

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°

REMARKS:

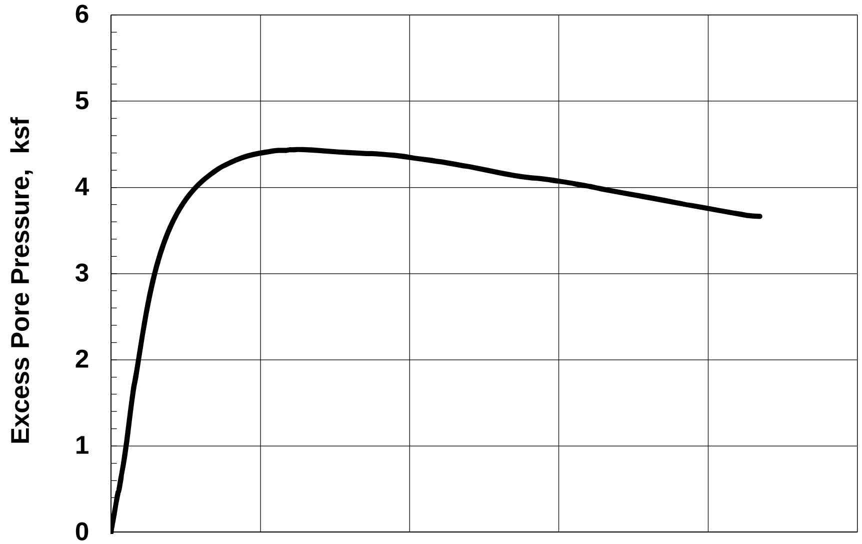




Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B004 Sample: ST-10C	
	TerraSense, LLC		September-15

Test by: BB

Checked by: GET



SAMPLE INFORMATION

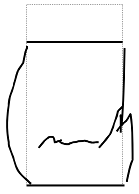
Boring: JOP-B004 Sample: ST-12A Depth: 58.3 ft
Type: Intact tube sample
Description: CL, brown lean clay with fine sand
LL = 37 PL = 14 PI = 23

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

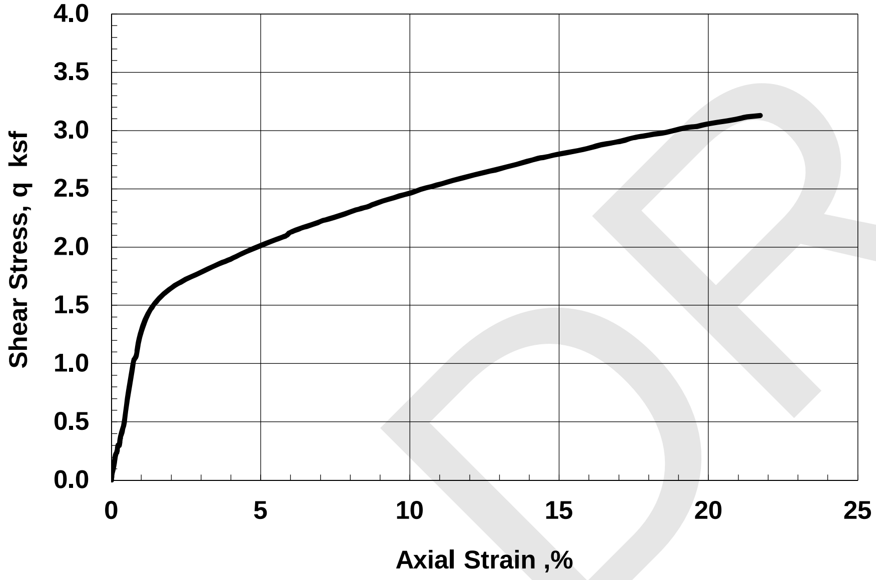
TEST SUMMARY

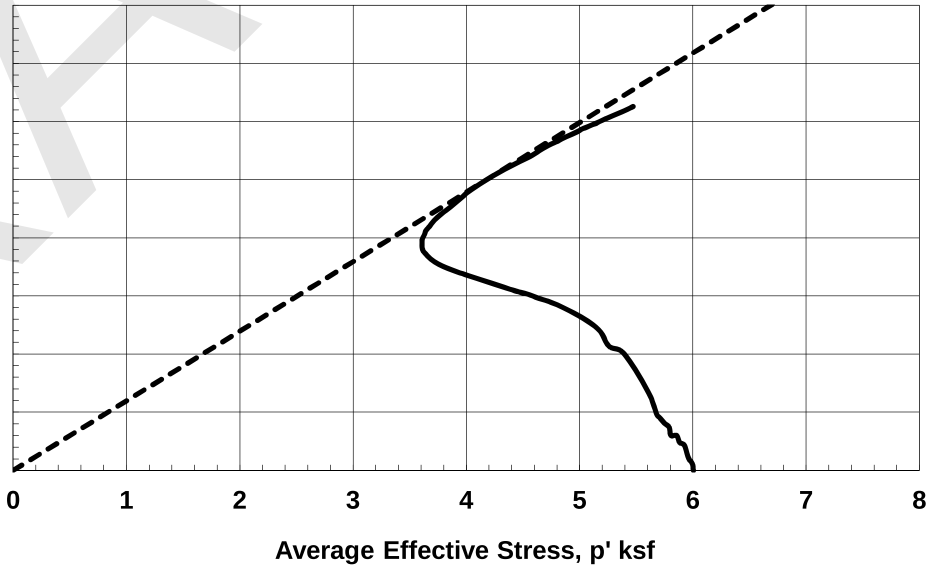
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 17.3 % Total Unit Weight: 138.2 pcf
B Coefficient: 99.65 Strain Rate: 0.023 %/min
Peak Shear Strength: 3.13 ksf @ 21.7 % Strain
Peak Effective Friction Angle: 36.7°



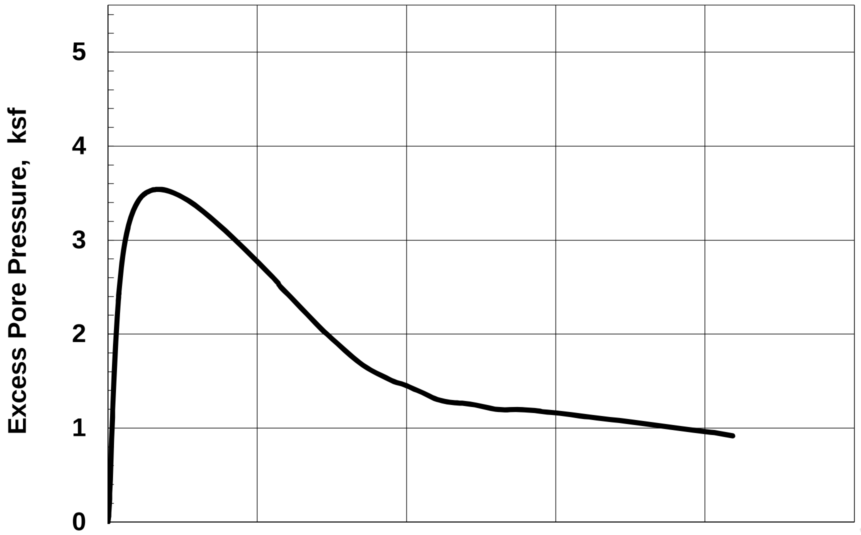
Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B004 Sample: ST-12A	
Checked by: GET	TerraSense, LLC			September-15

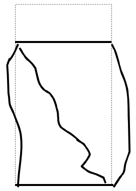


SAMPLE INFORMATION

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

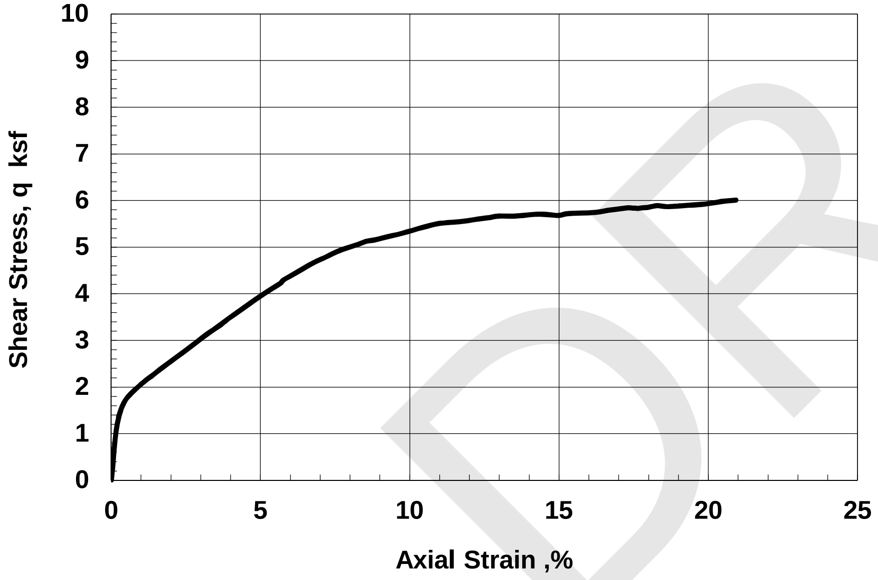


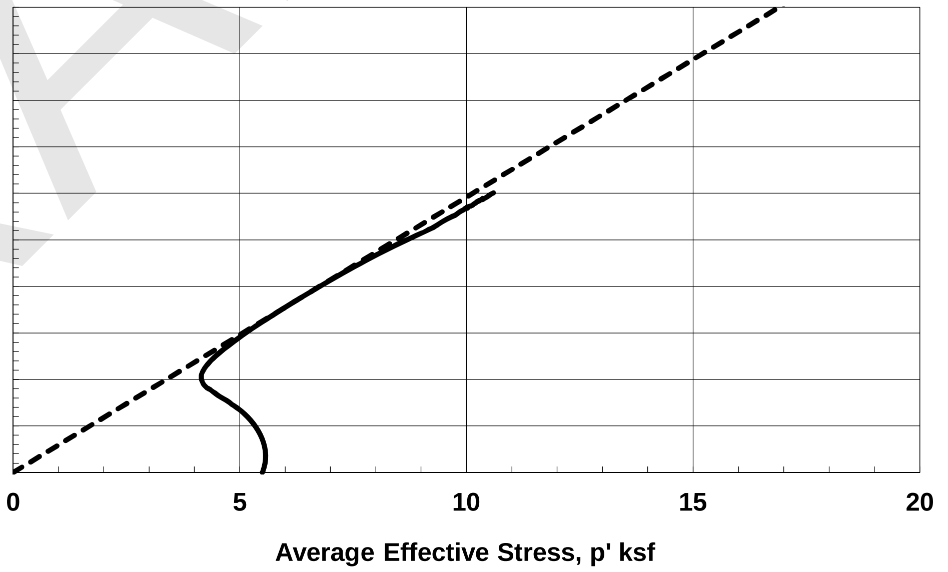
Failure
Sketch

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:

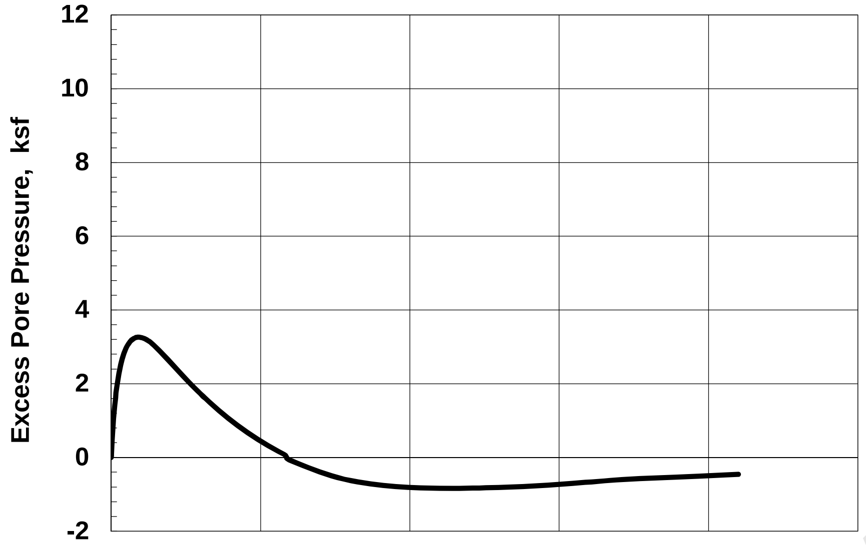




Test by: NB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B004 Sample: ST-14B	
TerraSense, LLC			December-15



SAMPLE INFORMATION

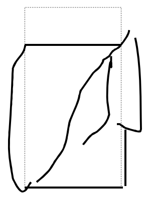
Boring: JOP-B004 Sample: ST-16C Depth: 70.1 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 32 PL = 16 PI = 16

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

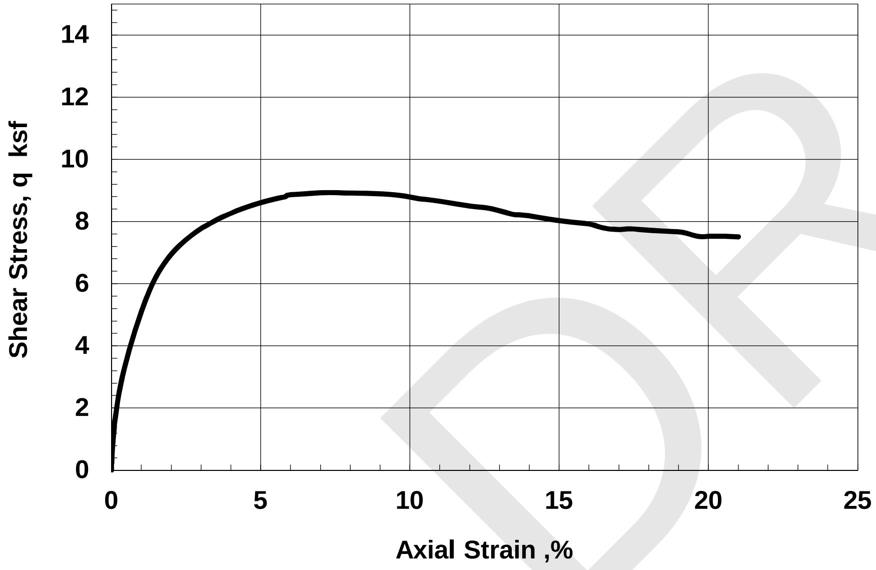
TEST SUMMARY

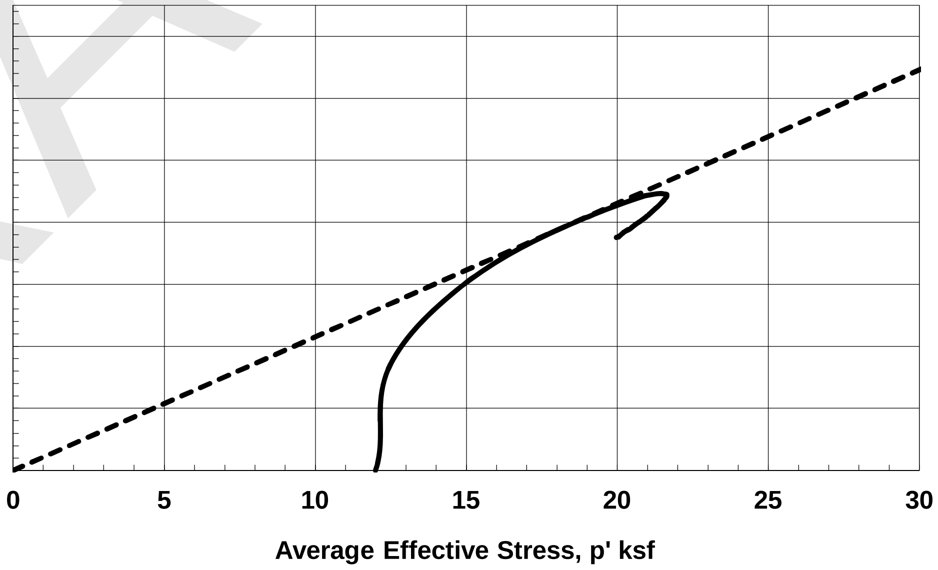
Consolidation Stresses: 12.00 ksf vertical, 12.00 ksf lateral
Water Content: 18.4 % Total Unit Weight: 134.7 pcf
B Coefficient: 99.12 Strain Rate: 0.022 %/min
Peak Shear Strength: 8.93 ksf @ 7.6 % Strain
Peak Effective Friction Angle: 25.5°



Failure Sketch

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B004 Sample: ST-16C	
Checked by: GET	**TerraSense, LLC**			September-15

SAMPLE INFORMATION

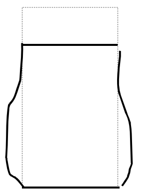
Boring: JOP-B005 Sample: ST-2B Depth: 9 ft
Type: Intact tube sample
Description: CL, gray-brown lean clay

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

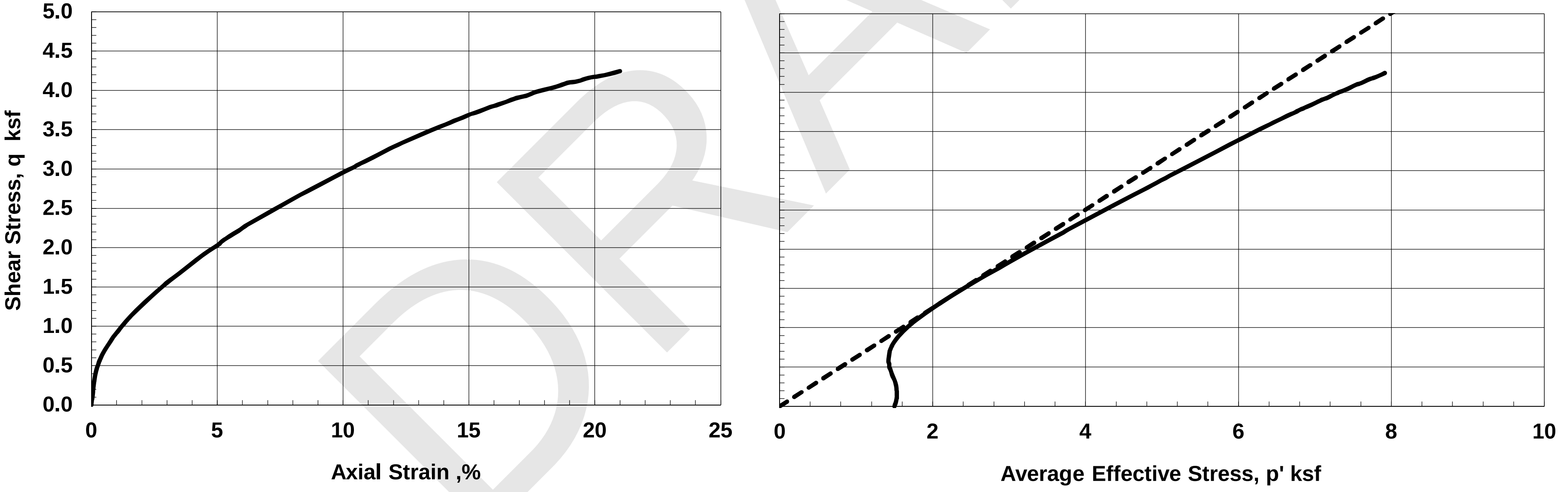
TEST SUMMARY

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°



Failure
Sketch

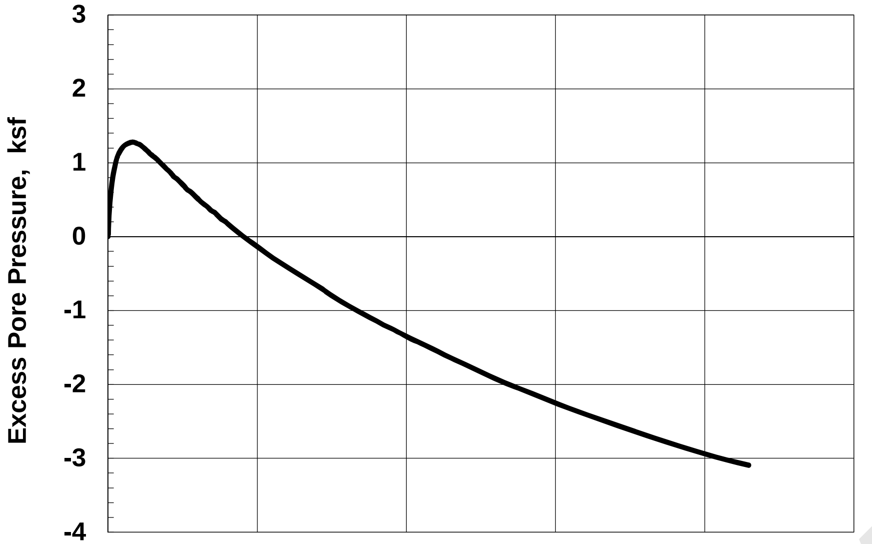
REMARKS:



Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B005 Sample: ST-2B	September-15
TerraSense, LLC			

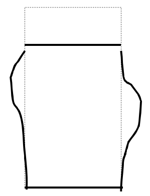


SAMPLE INFORMATION

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

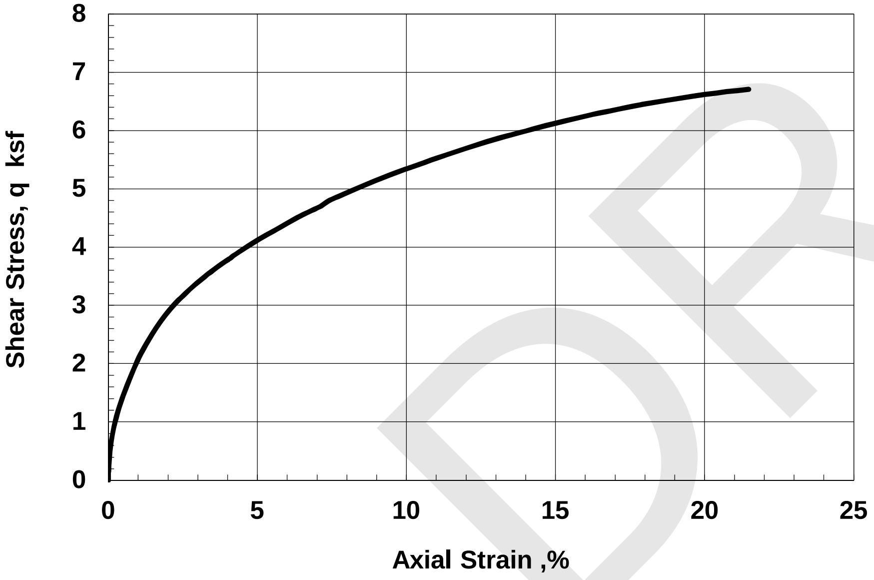


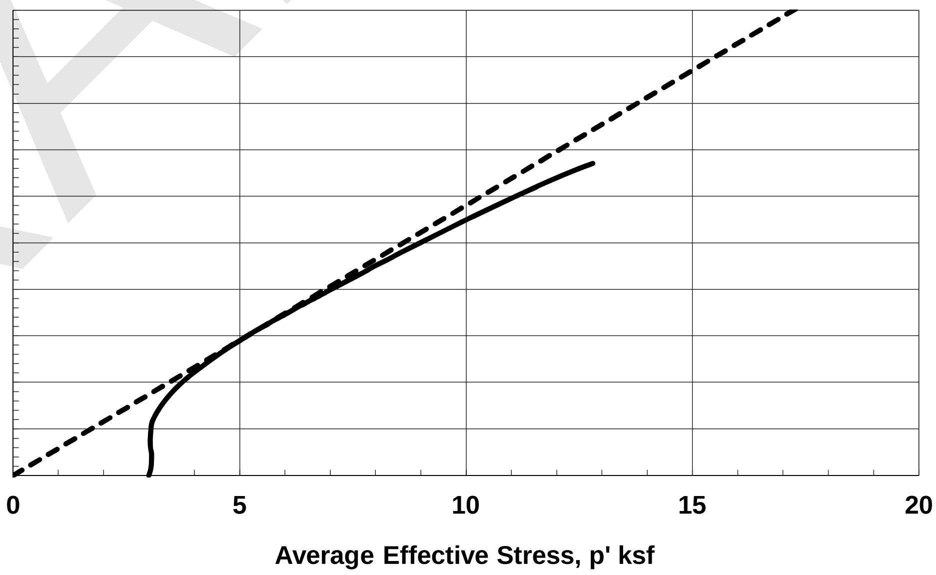
Failure Sketch

TEST SUMMARY

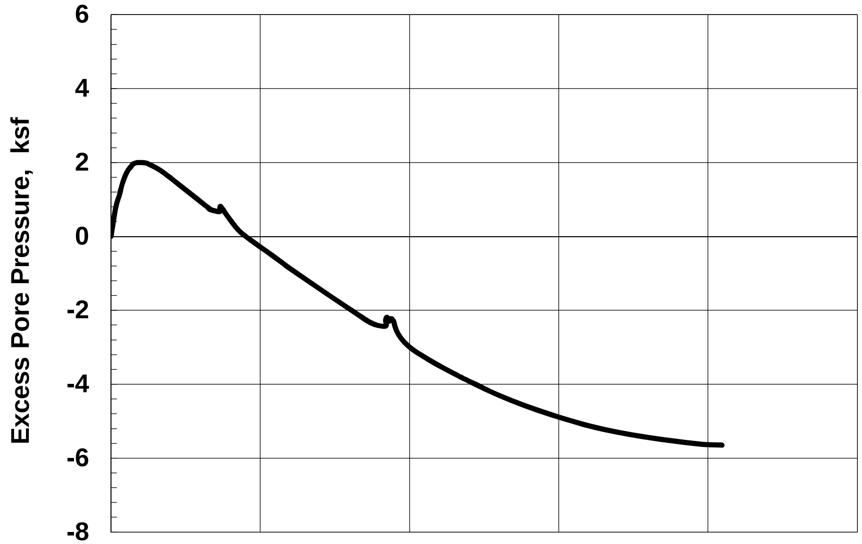
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 20.5 % Total Unit Weight: 131.4 pcf
B Coefficient: 97.22 Strain Rate: 0.023 %/min
Peak Shear Strength: 6.71 ksf @ 21.5 % Strain
Peak Effective Friction Angle: 35.5°

REMARKS:





Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B005 Sample: ST-4B	
Checked by: GET	**TerraSense, LLC**			September-15



SAMPLE INFORMATION

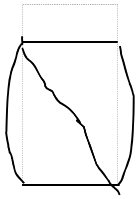
Boring: JOP-B005 Sample: ST-7B Depth: 33.9 ft
Type: Intact tube sample
Description: CL, gray and brown lean clay
LL = 38 PL = 19 PI = 19

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

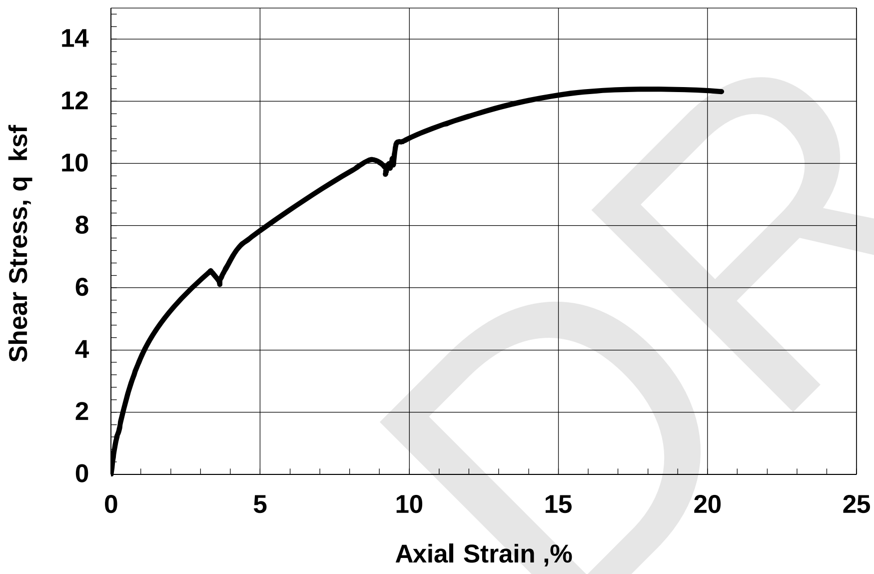
TEST SUMMARY

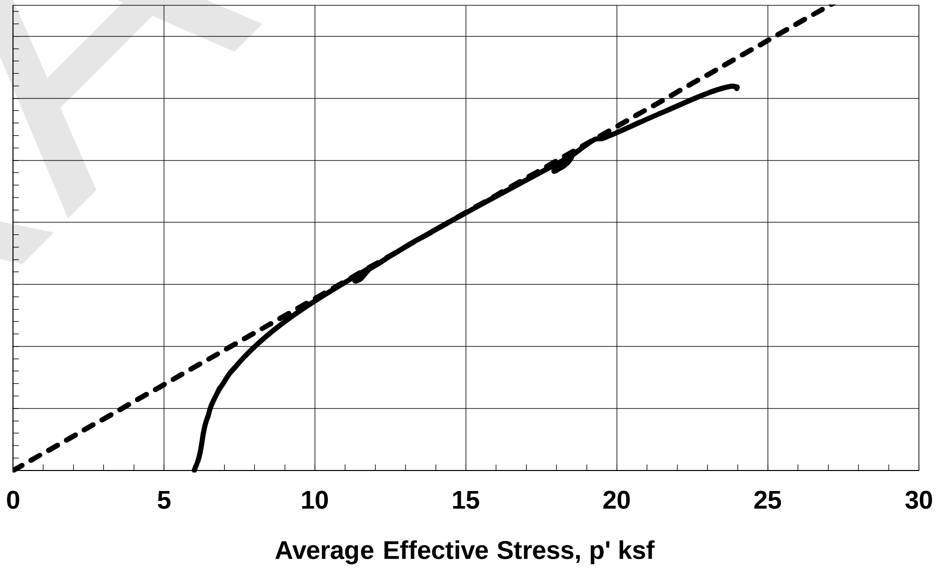
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 19.8 % Total Unit Weight: 134.1 pcf
B Coefficient: 97.32 Strain Rate: 0.010 %/min
Peak Shear Strength: 12.39 ksf @ 17.9 % Strain
Peak Effective Friction Angle: 33.7°



Failure Sketch

REMARKS:

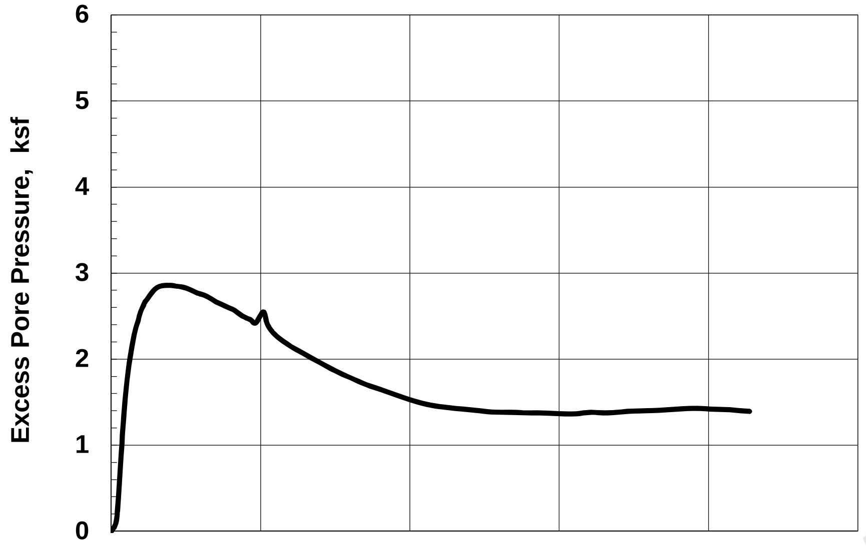




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B005 Sample: ST-7B	
TerraSense, LLC			November-15

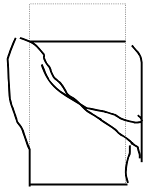


SAMPLE INFORMATION

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

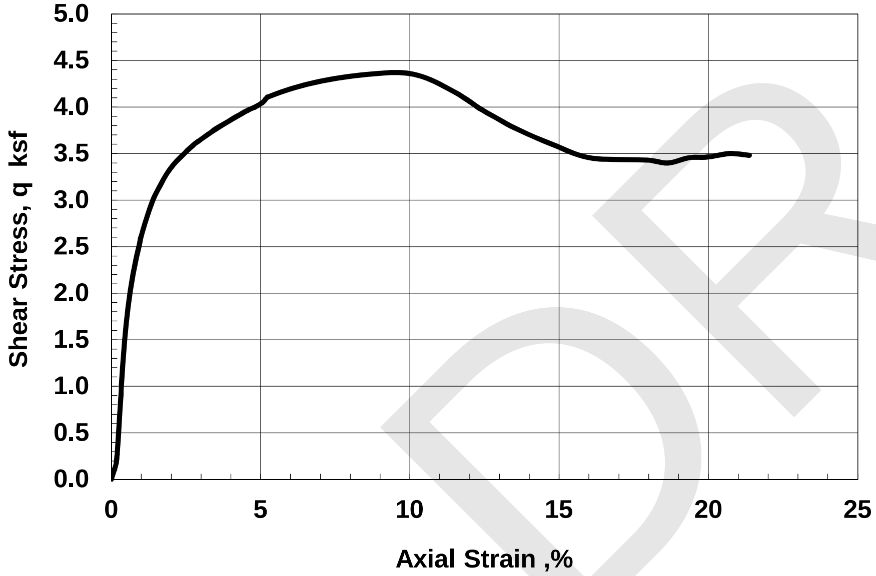


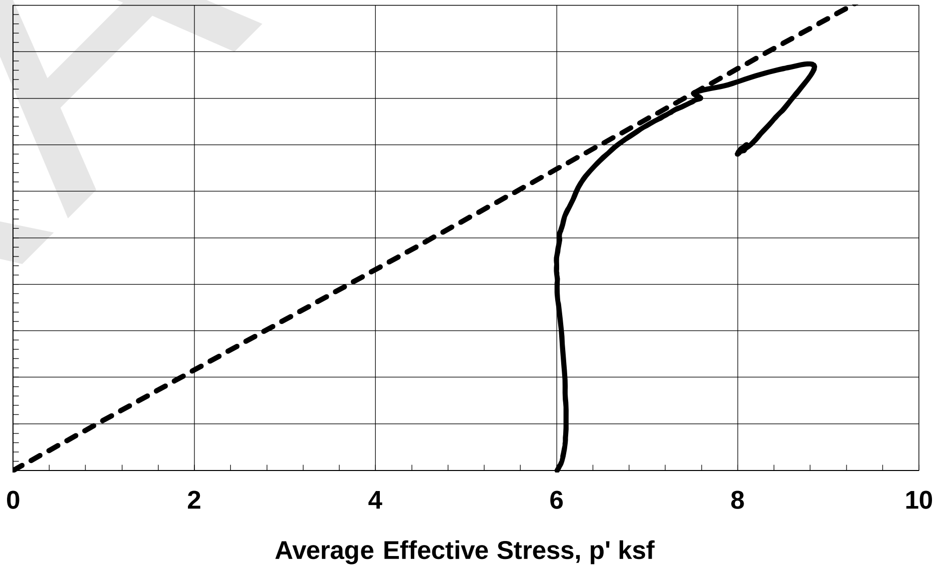
Failure
Sketch

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

Checked by: GET

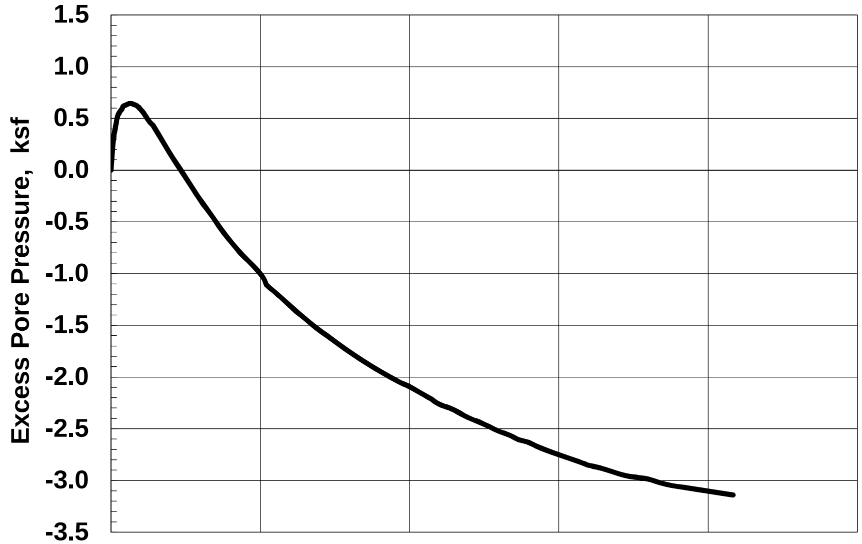
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B005 Sample: ST-10C

September-15



SAMPLE INFORMATION

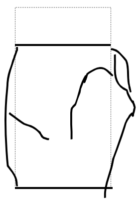
Boring: JOP-B007 Sample: ST-3C Depth: 29.6 ft
Type: Intact tube sample
Description: CL, light gray lean clay
LL = 37 PL = 15 PI = 22

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

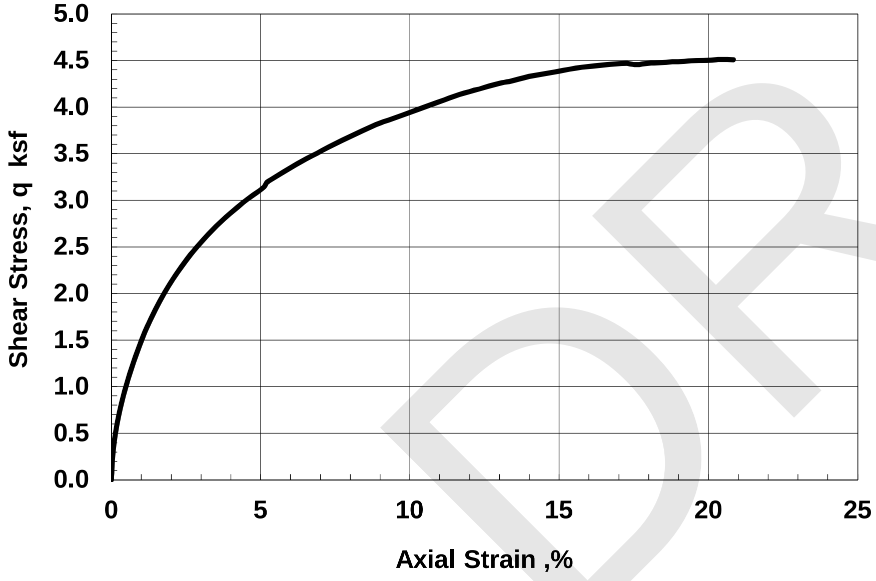
TEST SUMMARY

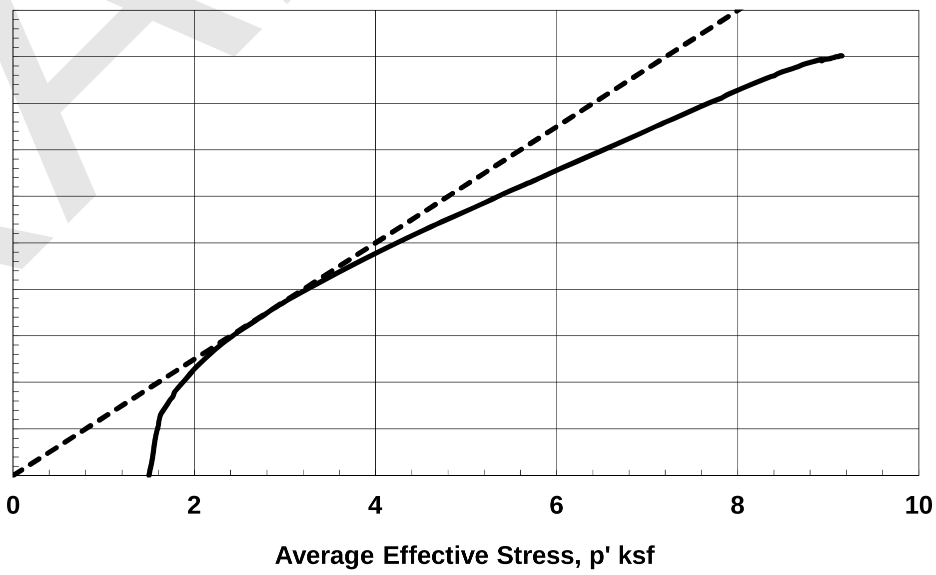
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 19.3 % Total Unit Weight: 132.5 pcf
B Coefficient: 99.68 Strain Rate: 0.021 %/min
Peak Shear Strength: 4.51 ksf @ 20.4 % Strain
Peak Effective Friction Angle: 38.7°



Failure Sketch

REMARKS:

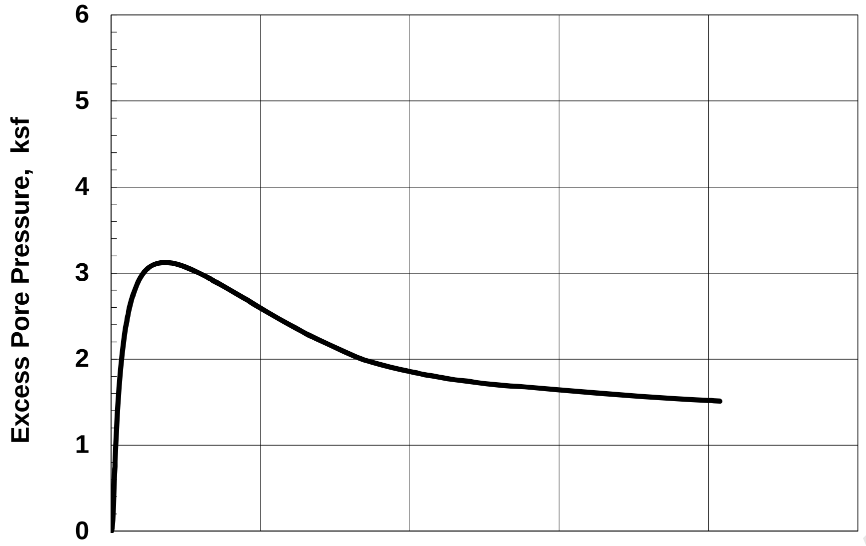




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B007 Sample: ST-3C	September-15
TerraSense, LLC			



SAMPLE INFORMATION

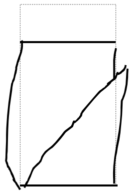
Boring: JOP-B008 Sample: ST-5C Depth: 64.75 ft
Type: Intact tube sample
Description: CL, light brown lean clay

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

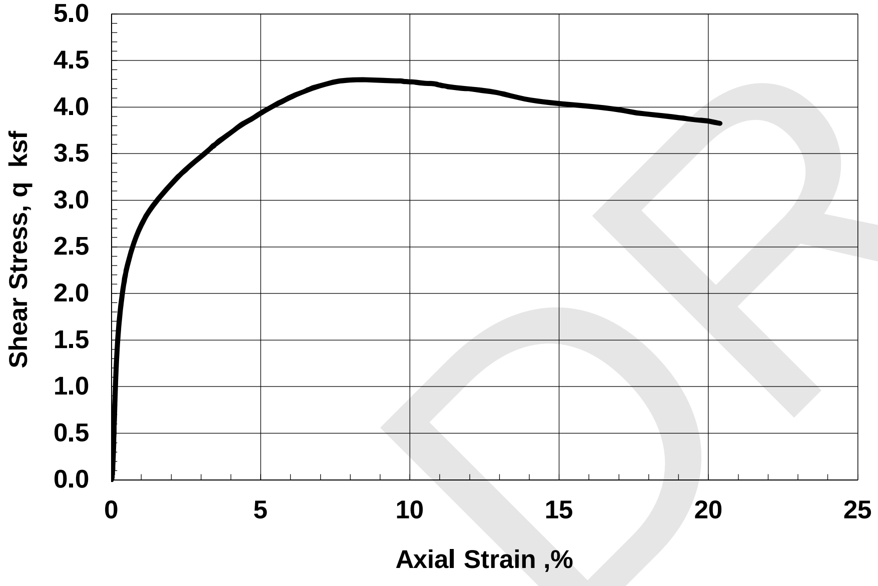
TEST SUMMARY

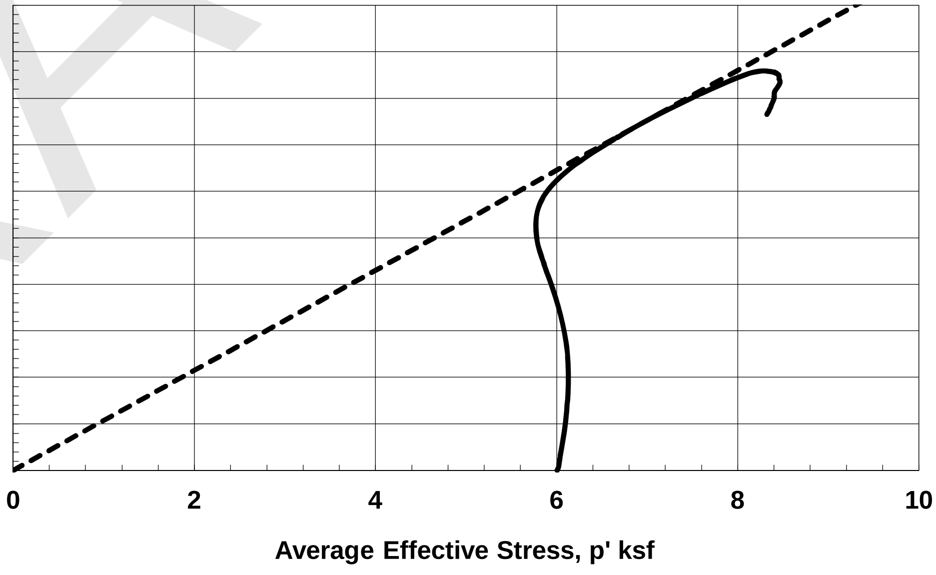
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 18.5 % Total Unit Weight: 132.6 pcf
B Coefficient: Strain Rate: 0.019 %/min
Peak Shear Strength: 4.30 ksf @ 8.2 % Strain
Peak Effective Friction Angle: 32.5°



Failure Sketch

REMARKS:





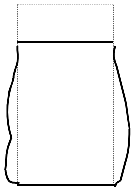
Test by: BB	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B008 Sample: ST-5C
Checked by: GET	**TerraSense, LLC**		October-15

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

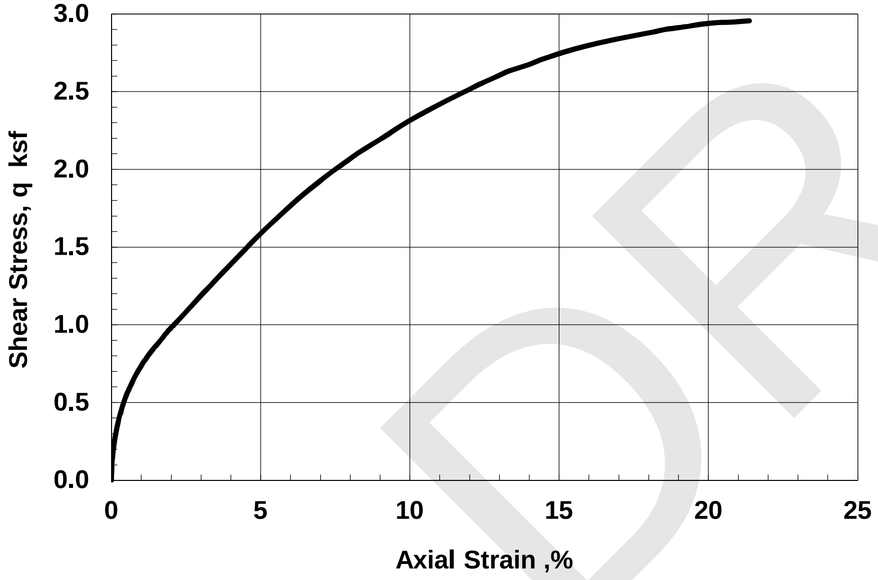


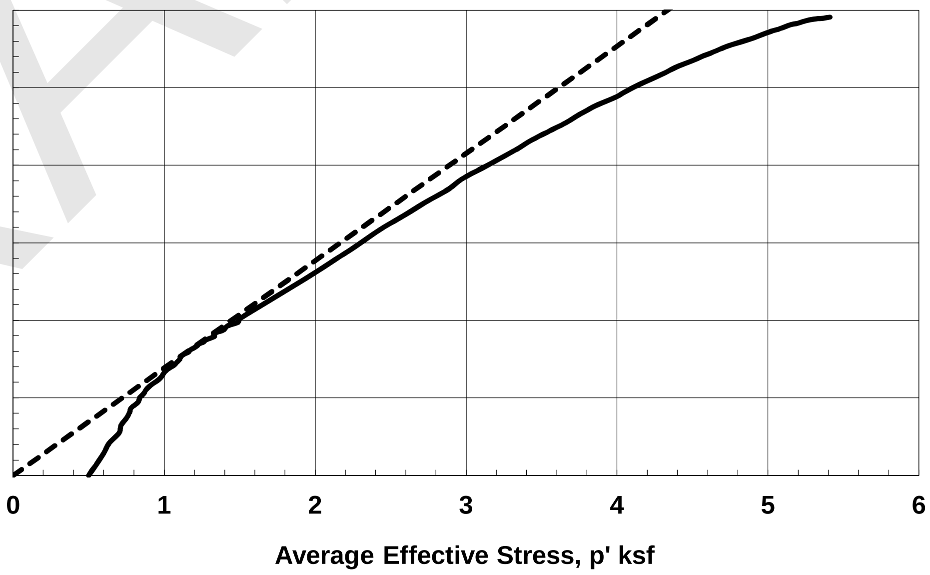
Failure Sketch

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:

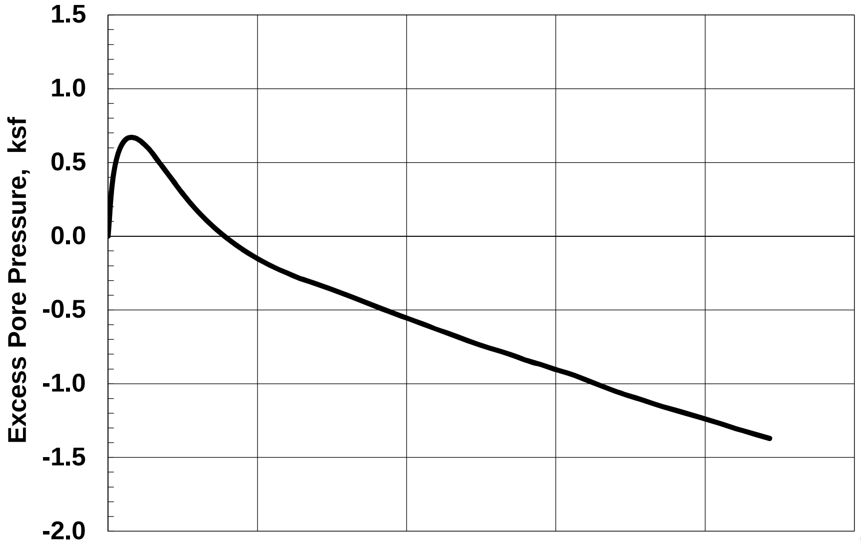




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B009 Sample: ST-3B
TerraSense, LLC		September-15



SAMPLE INFORMATION

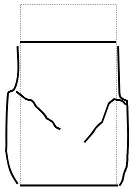
Boring: JOP-B009 Sample: ST-3C Depth: 14.35 ft
Type: Intact tube sample
Description: CL, brown sandy lean clay
LL = 34 PL = 14 PI = 20

SPECIMEN INFORMATION (Initial)

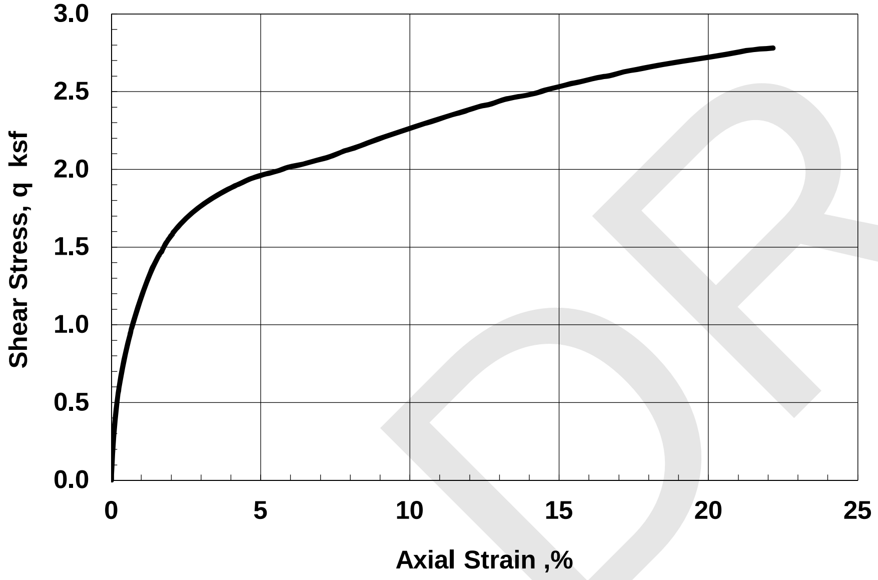
Height: 6.02 inch Diameter: 2.87 inch Area: 6.46 in²
Water Content: 15.5 % Total Unit Weight: 134.9 pcf

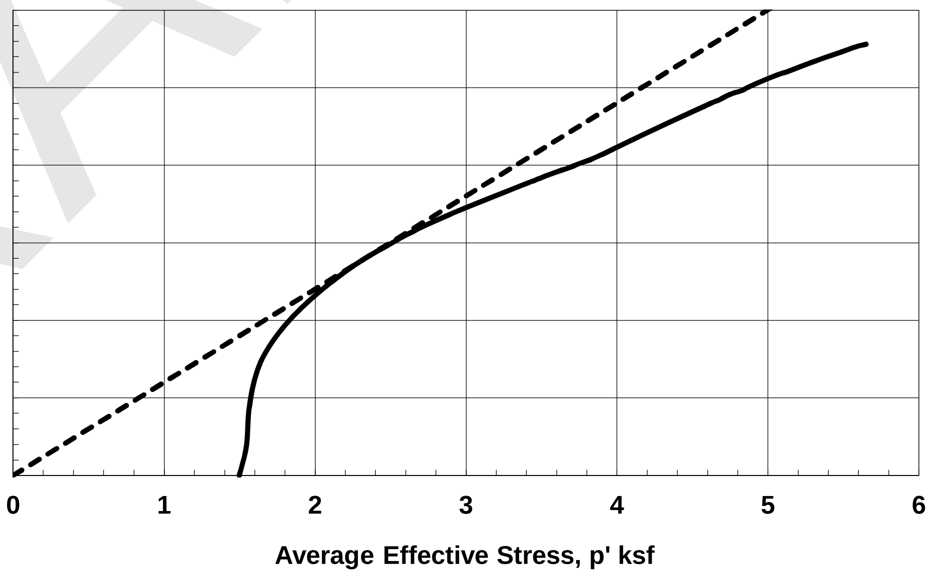
TEST SUMMARY

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°


Failure Sketch

REMARKS:





Test by: BB
Checked by: GET

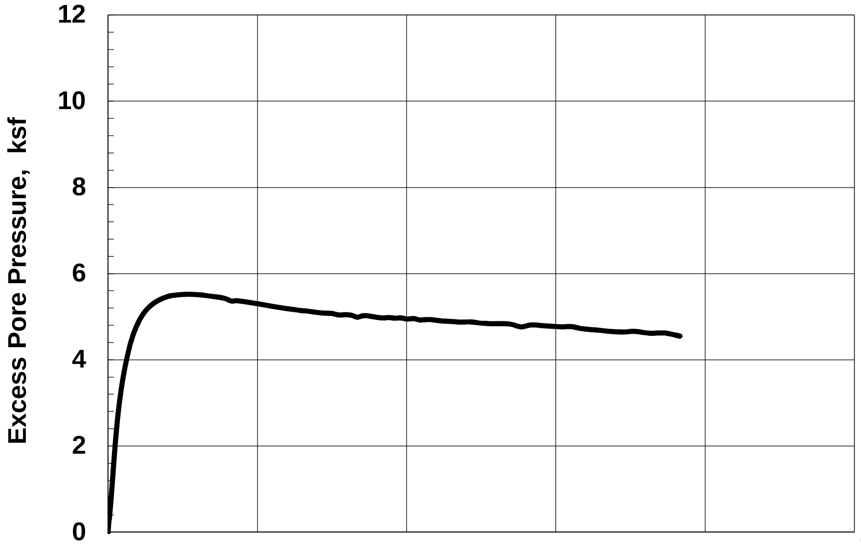
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B009 Sample: ST-3C

September-15



SAMPLE INFORMATION

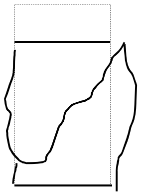
Boring: JOP-B009 Sample: ST-14C Depth: 64.85 ft
Type: Intact tube sample
Description: CL, gray sandy lean clay
LL = 27 PL = 10 PI = 17

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

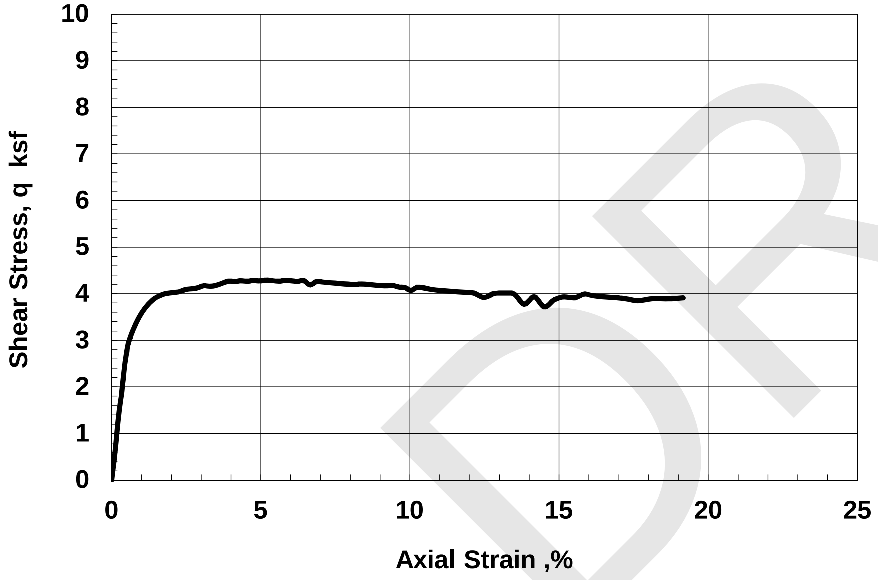
TEST SUMMARY

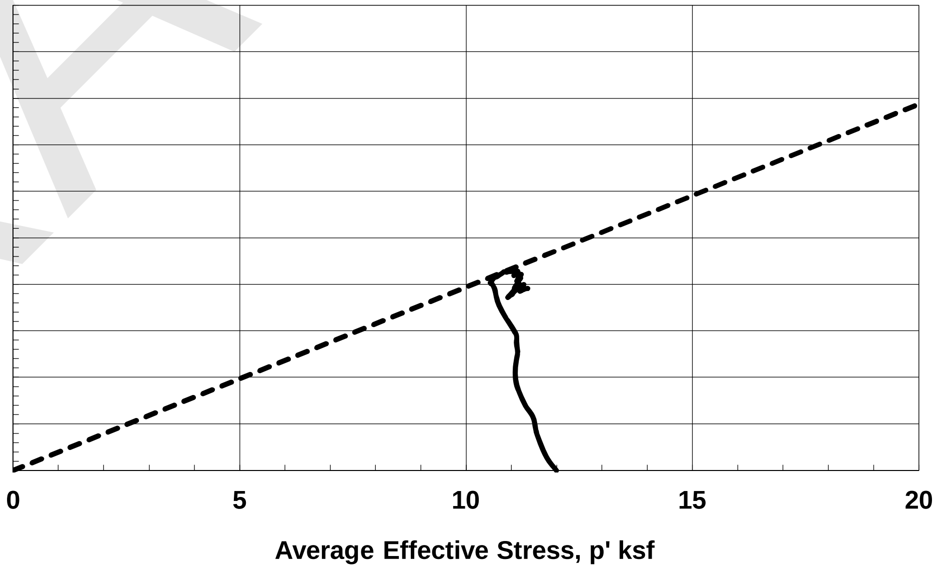
Consolidation Stresses: 12.00 ksf vertical, 12.00 ksf lateral
Water Content: 17.4 % Total Unit Weight: 134.2 pcf
B Coefficient: 97.68 Strain Rate: 0.021 %/min
Peak Shear Strength: 4.29 ksf @ 5.2 % Strain
Peak Effective Friction Angle: 23.2°



Failure
Sketch

REMARKS:

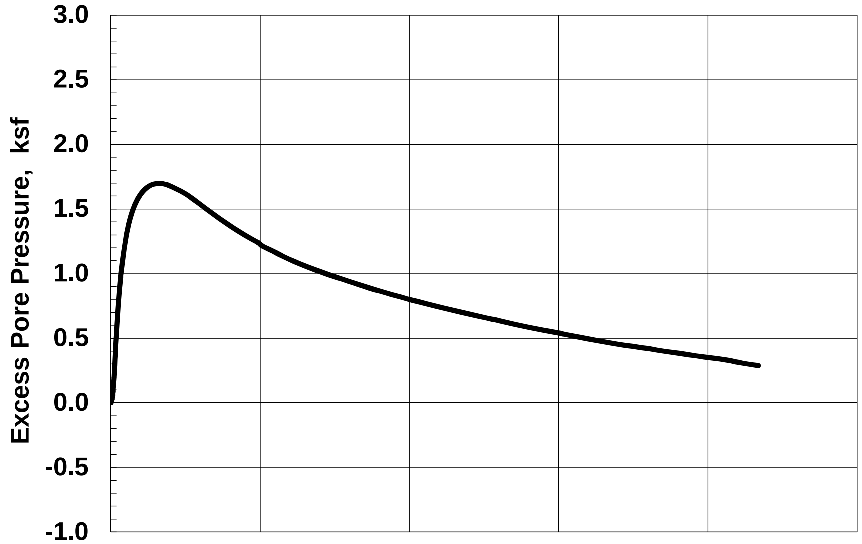




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B009 Sample: ST-14C	
TerraSense, LLC			September-15

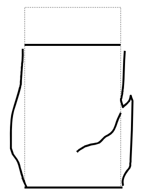


SAMPLE INFORMATION

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

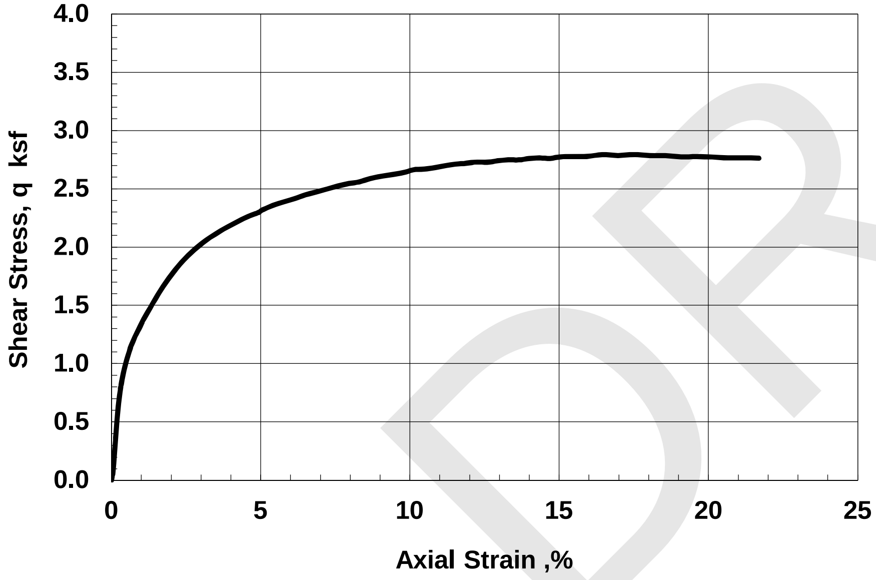


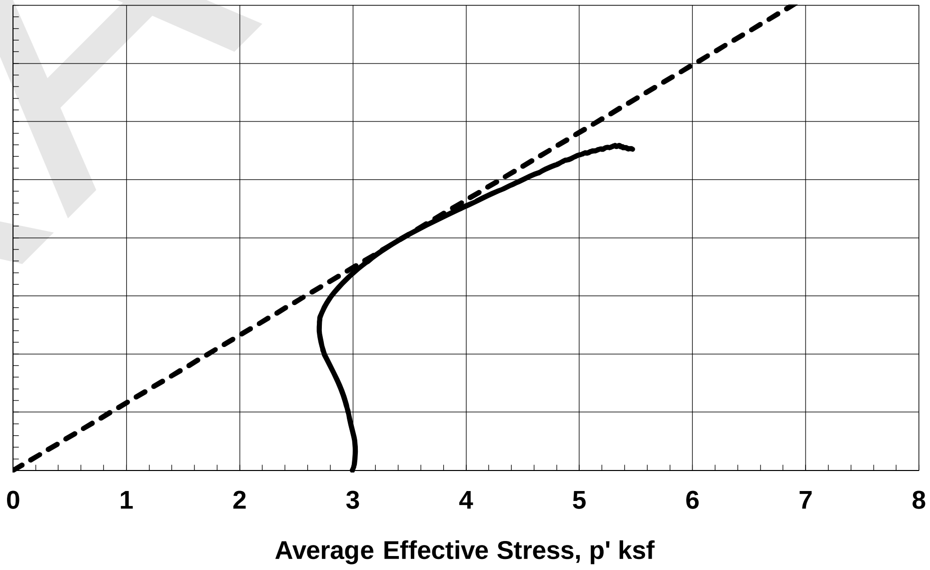
Failure Sketch

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°

REMARKS:

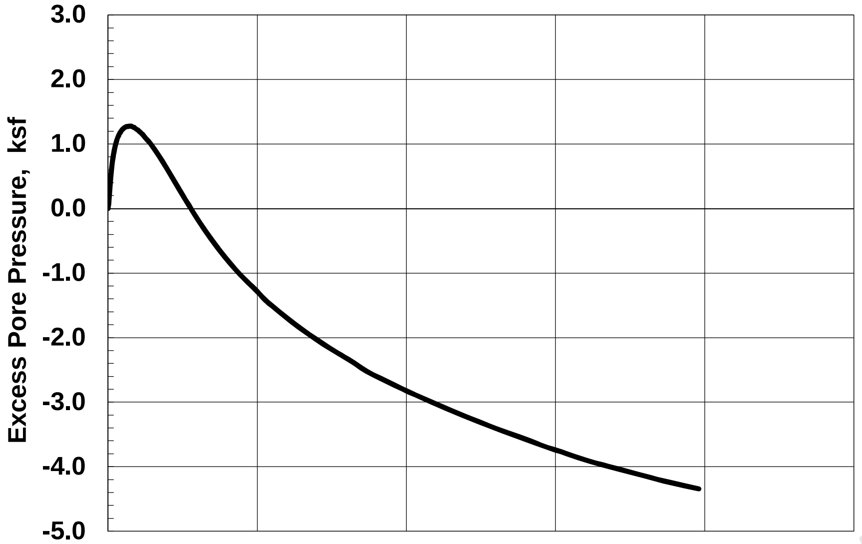




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B010 Sample: ST-3D	
TerraSense, LLC			September-15



SAMPLE INFORMATION

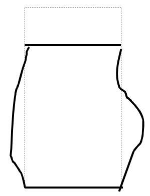
Boring: JOP-B011 Sample: ST-5C Depth: 24.25 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 33 PL = 18 PI = 15

SPECIMEN INFORMATION (Initial)

Height: 6.03 inch Diameter: 2.87 inch Area: 6.49 in^2
Water Content: 18.0 % Total Unit Weight: 129.4 pcf

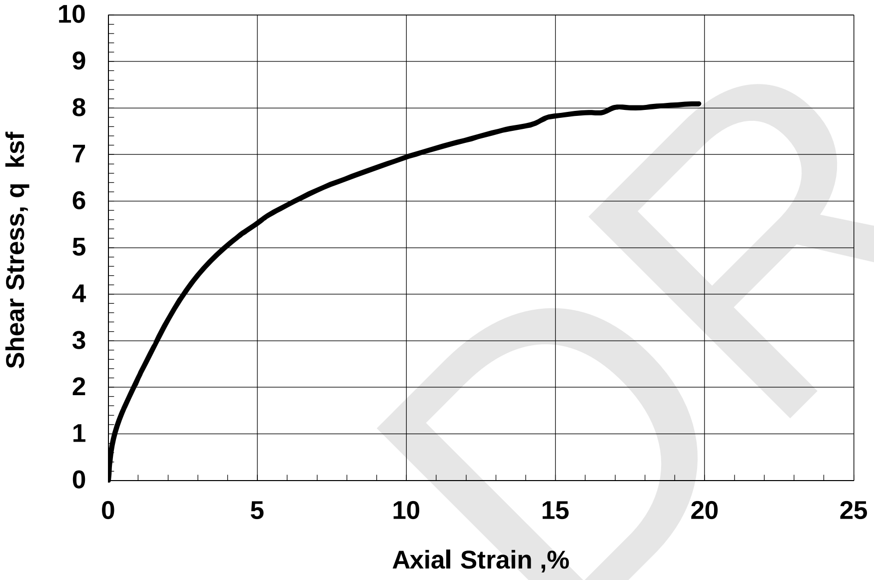
TEST SUMMARY

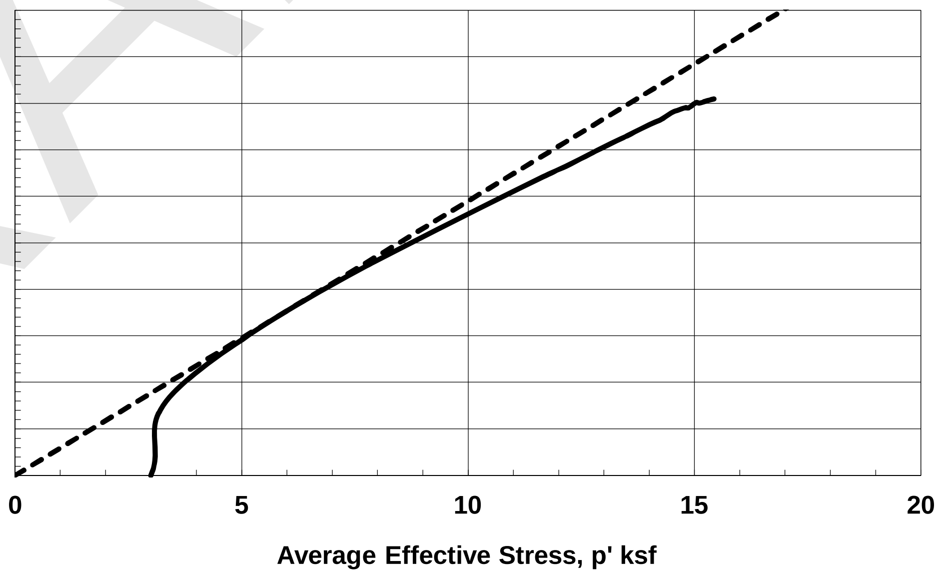
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 19.2 % Total Unit Weight: 133.3 pcf
B Coefficient: 99.72 Strain Rate: 0.020 %/min
Peak Shear Strength: 8.09 ksf @ 19.8 % Strain
Peak Effective Friction Angle: 36.1°



Failure Sketch

REMARKS:





Test by: BB

Checked by: GET

Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B011 Sample: ST-5C

September-15

SAMPLE INFORMATION

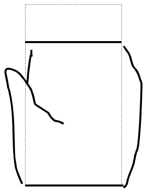
Boring: JOP-B011 Sample: ST-9C Depth: 44.8 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 36 PL = 14 PI = 22

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

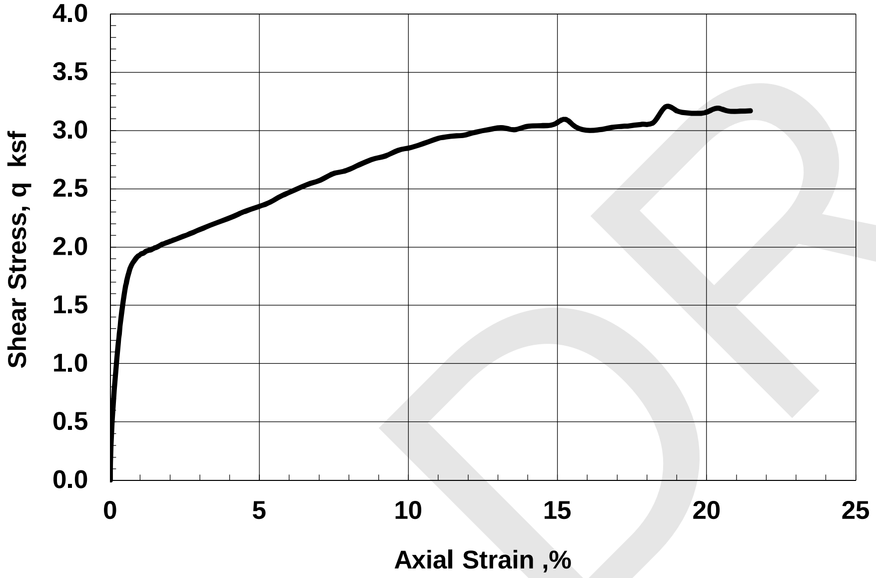
TEST SUMMARY

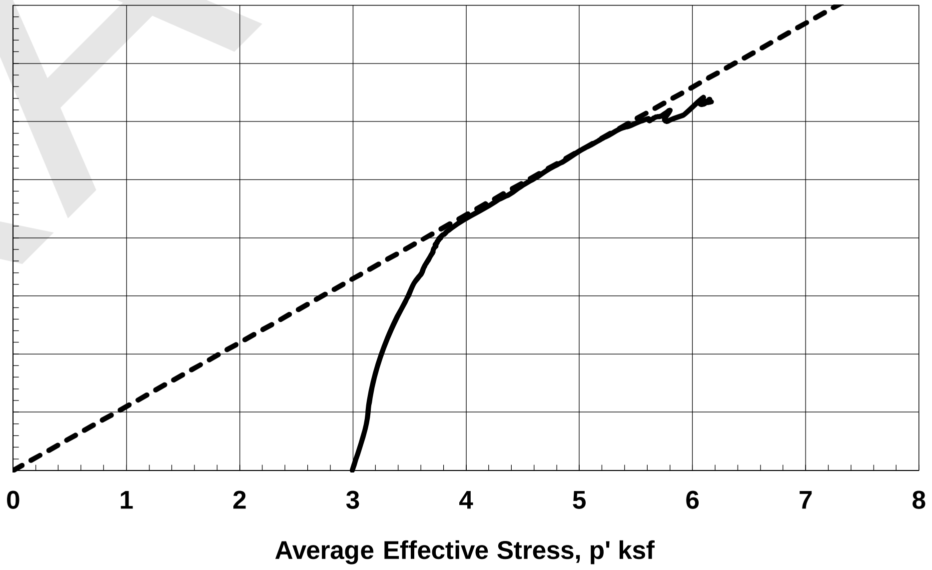
Consolidation Stresses: 3.00 ksf vertical, 3.00 ksf lateral
Water Content: 19.4 % Total Unit Weight: 133.7 pcf
B Coefficient: 99.25 Strain Rate: 0.022 %/min
Peak Shear Strength: 3.21 ksf @ 18.6 % Strain
Peak Effective Friction Angle: 33.3°



Failure
Sketch

REMARKS:

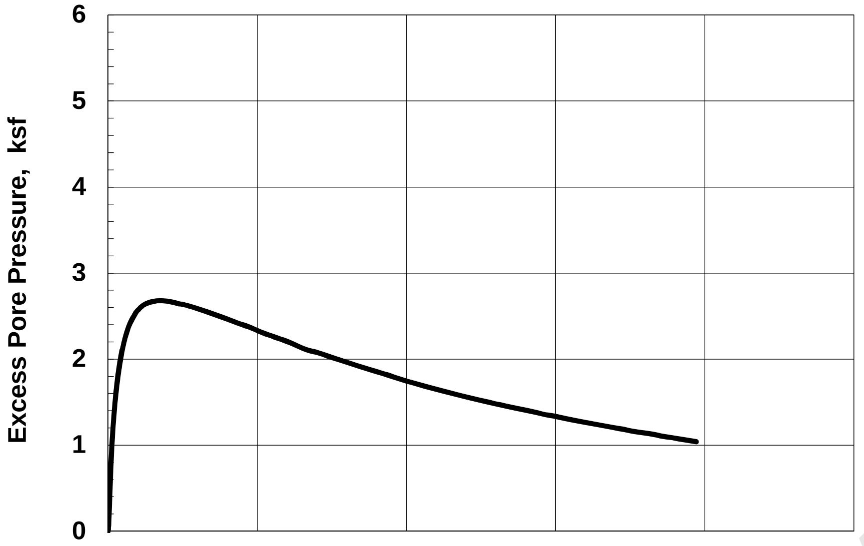




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B011 Sample: ST-9C	September-15
TerraSense, LLC			



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

TEST SUMMARY

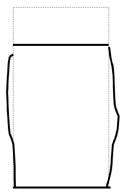
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral

Water Content: 17.3 % Total Unit Weight: 137.1 pcf

B Coefficient: 98.64 Strain Rate: 0.020 %/min

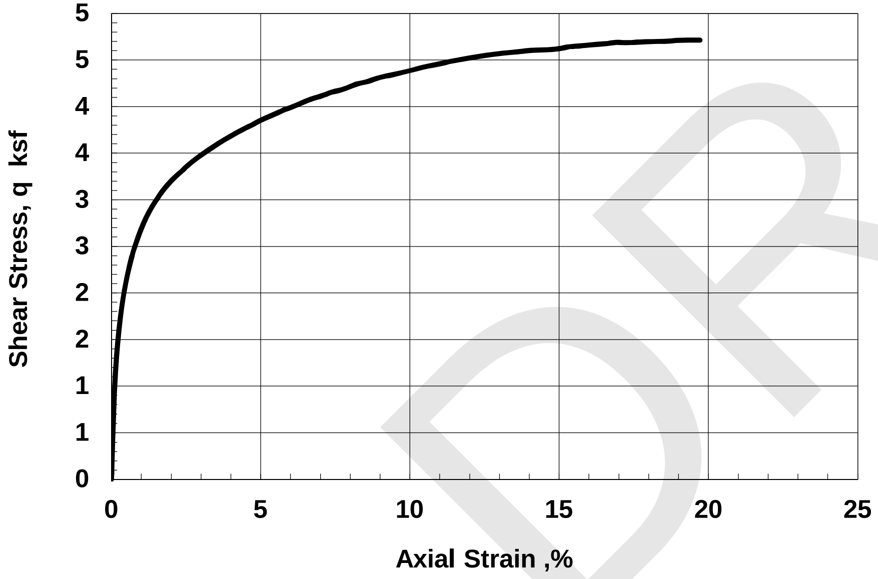
Peak Shear Strength: 4.71 ksf @ 19.7 % Strain

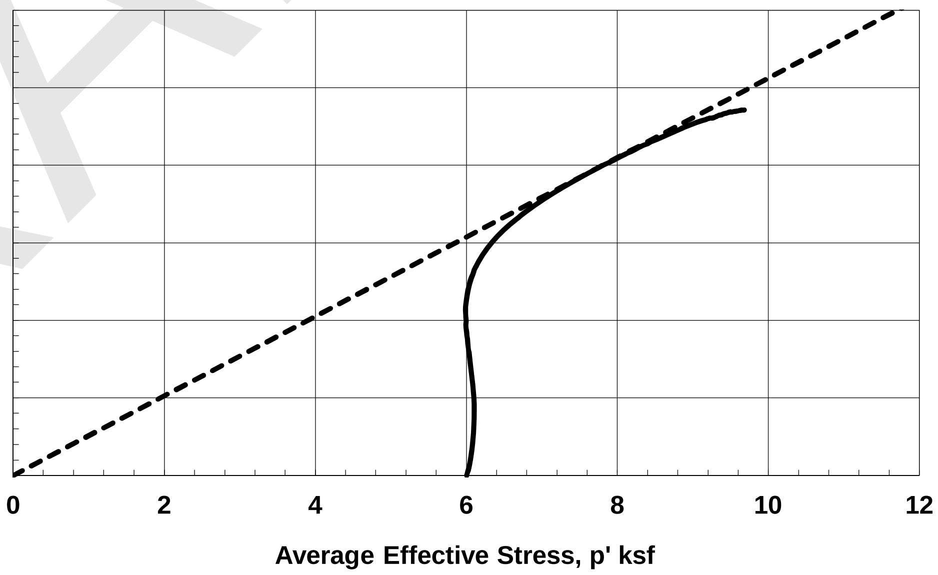
Peak Effective Friction Angle: 30.8°



Failure Sketch

REMARKS:

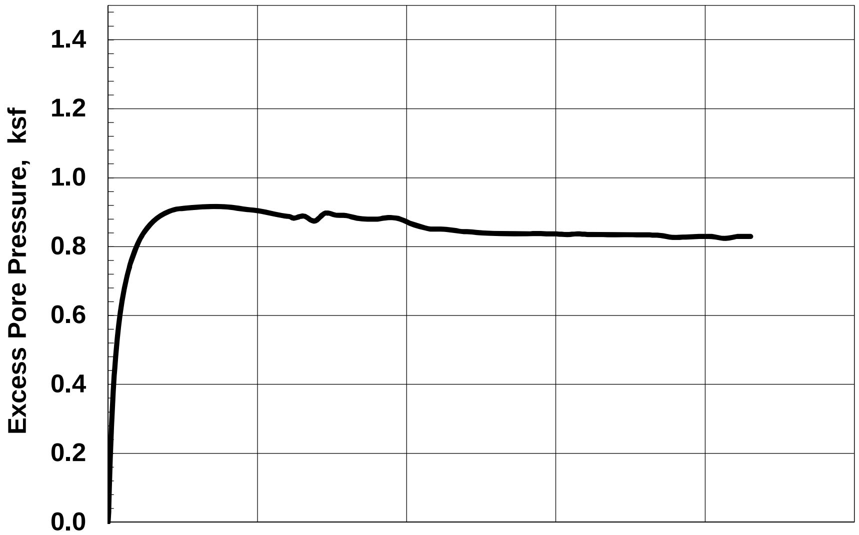




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B012 Sample: ST-3C	September-15
TerraSense, LLC			

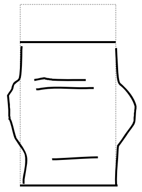


SAMPLE INFORMATION

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

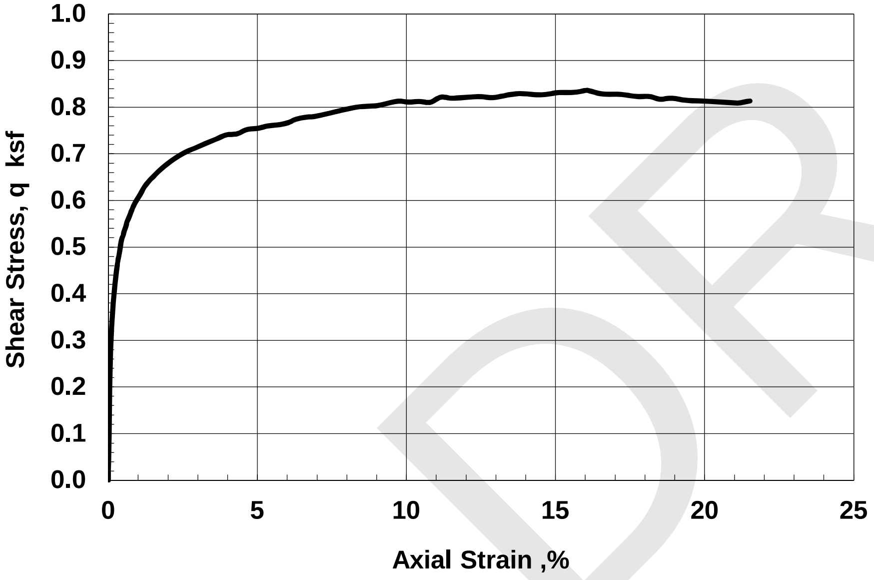


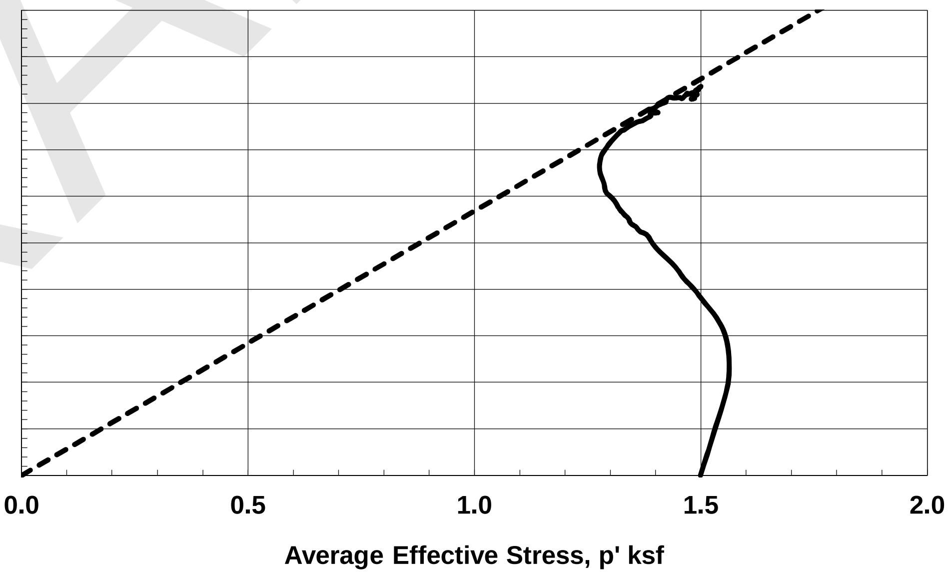
Failure
Sketch

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°

REMARKS:





Test by: BB

Checked by: GET

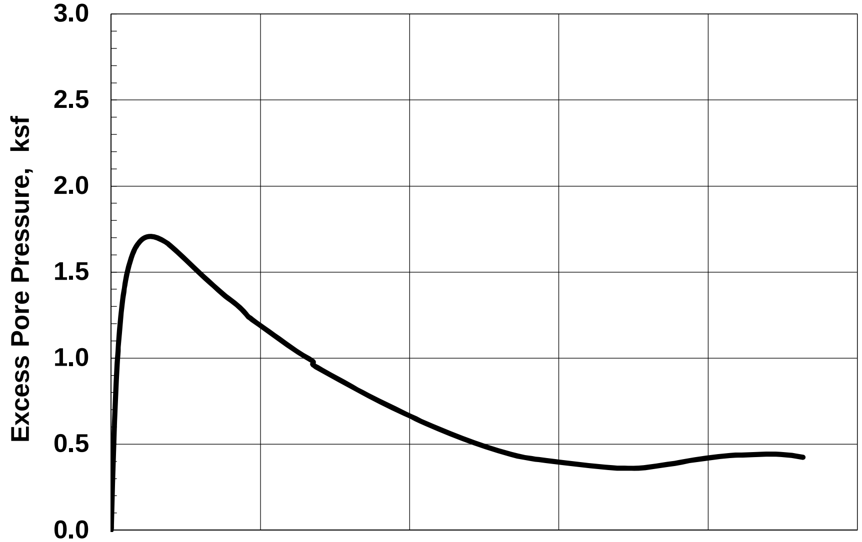
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B012 Sample: ST-8C

September-15

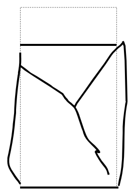


SAMPLE INFORMATION

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

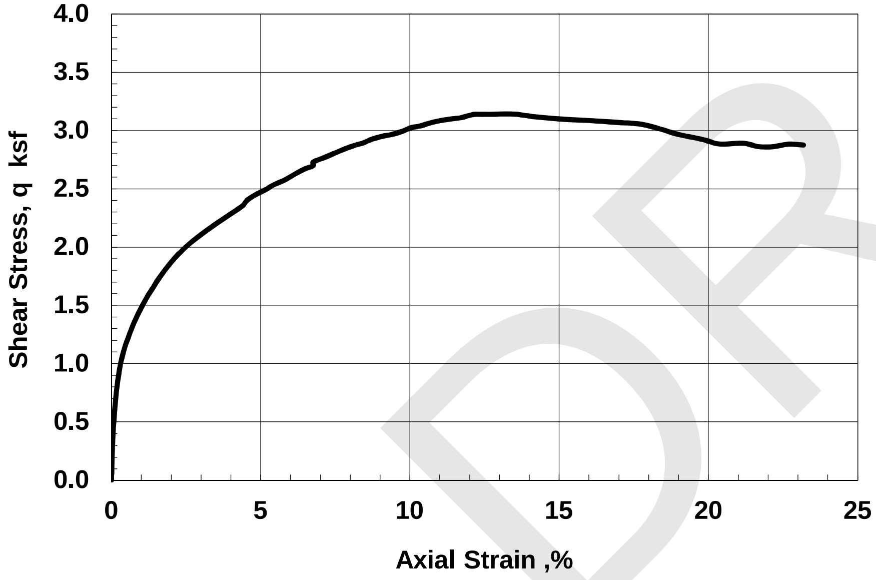


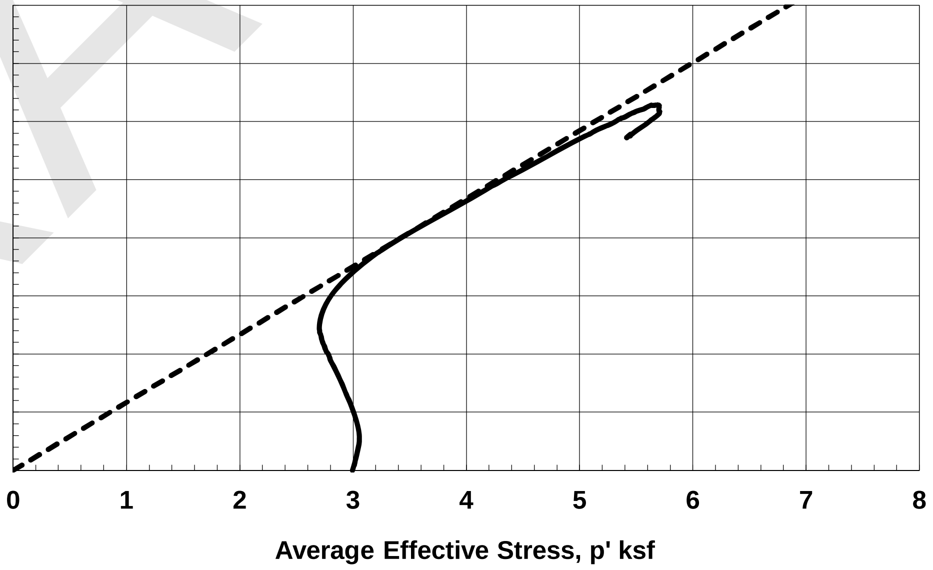
Failure
Sketch

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

Checked by: GET

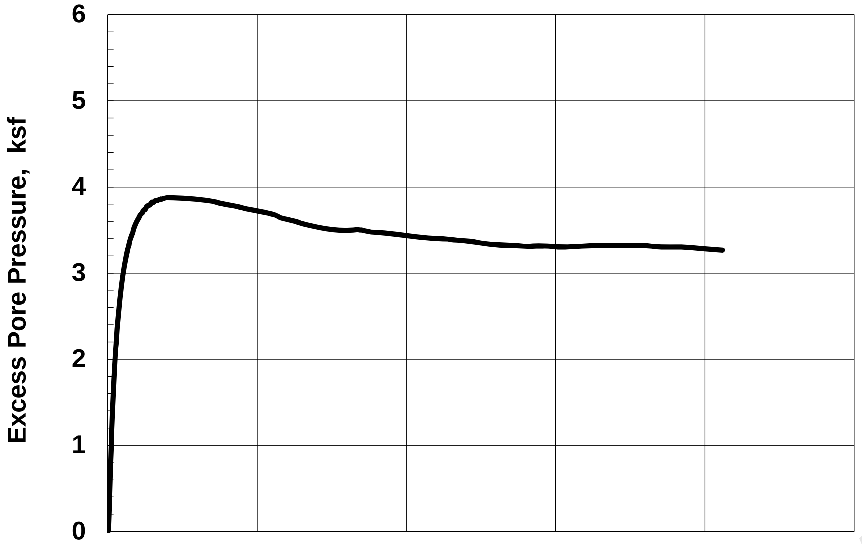
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B012 Sample: ST-13B

September-15



SAMPLE INFORMATION

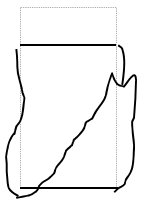
Boring: JOP-B012 Sample: ST-13C Depth: 54.55 ft
Type: Intact tube sample
Description: CL, yellowish brown sandy lean clay

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

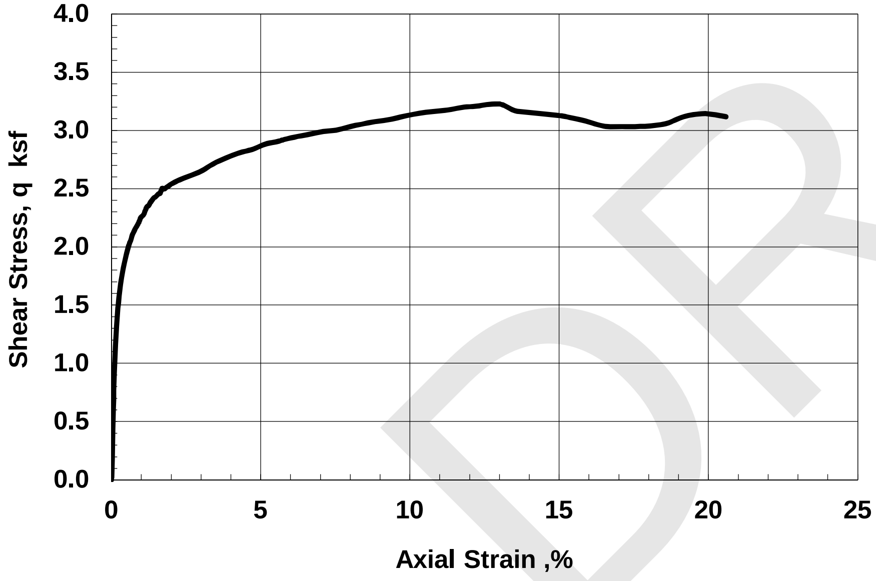
TEST SUMMARY

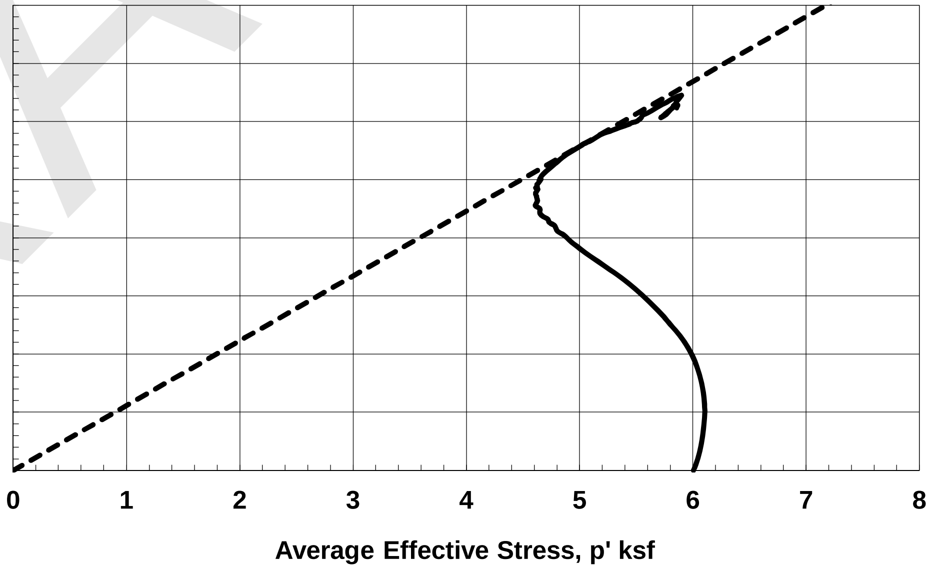
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 17.3 % Total Unit Weight: 136.7 pcf
B Coefficient: 99.26 Strain Rate: 0.021 %/min
Peak Shear Strength: 3.22 ksf @ 13.1 % Strain
Peak Effective Friction Angle: 33.9°



Failure
Sketch

REMARKS:





Test by: BB

Checked by: GET

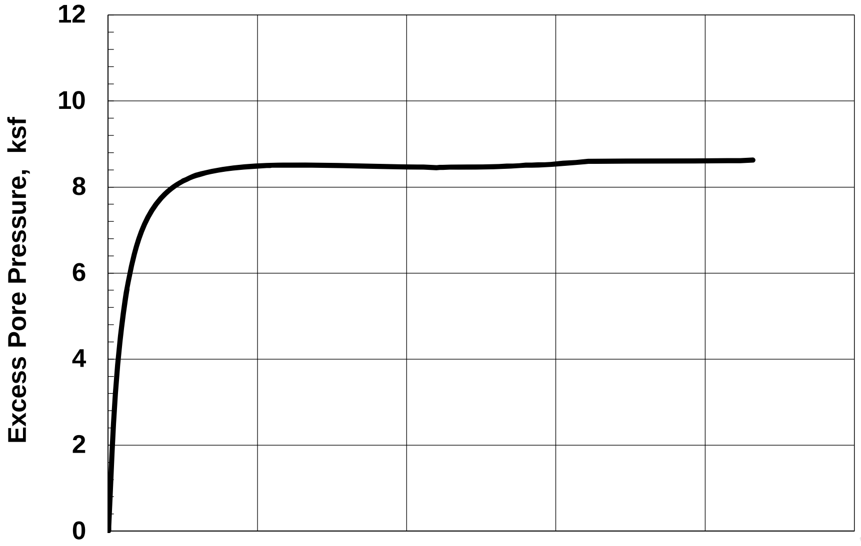
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B012 Sample: ST-13C

September-15



SAMPLE INFORMATION

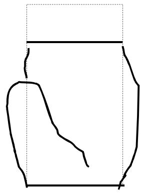
Boring: JOP-B012 Sample: ST-16C Depth: 66.6 ft
Type: Intact tube sample
Description: CL, gray brown sandy lean clay
LL = 33 PL = 13 PI = 20

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

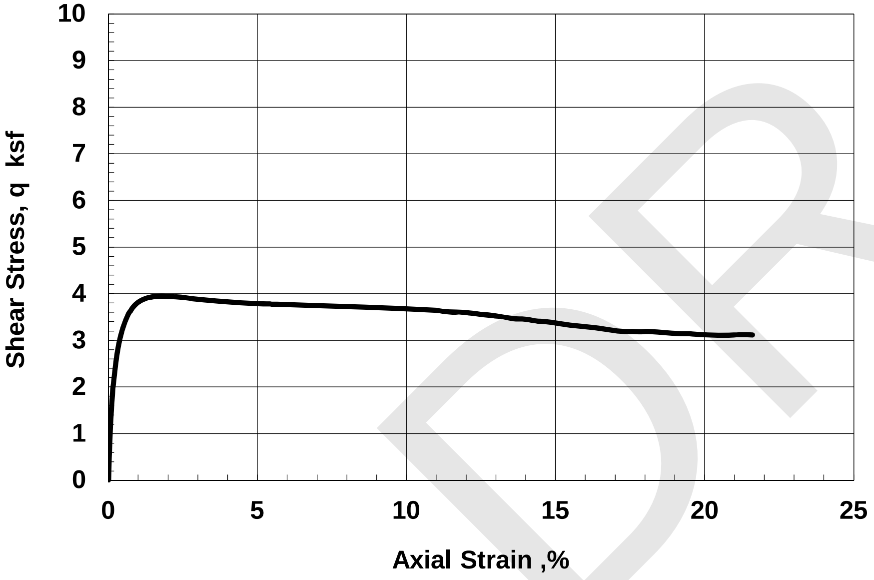
TEST SUMMARY

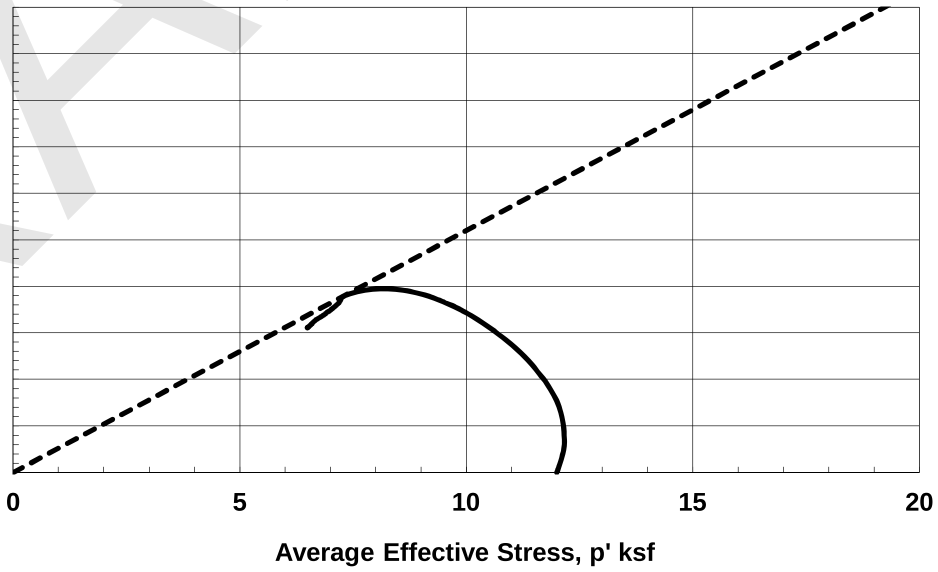
Consolidation Stresses: 12.00 ksf vertical, 12.00 ksf lateral
Water Content: 19.4 % Total Unit Weight: 135.2 pcf
B Coefficient: 98.12 Strain Rate: 0.022 %/min
Peak Shear Strength: 3.95 ksf @ 1.8 % Strain
Peak Effective Friction Angle: 31.3°



Failure
Sketch

REMARKS:

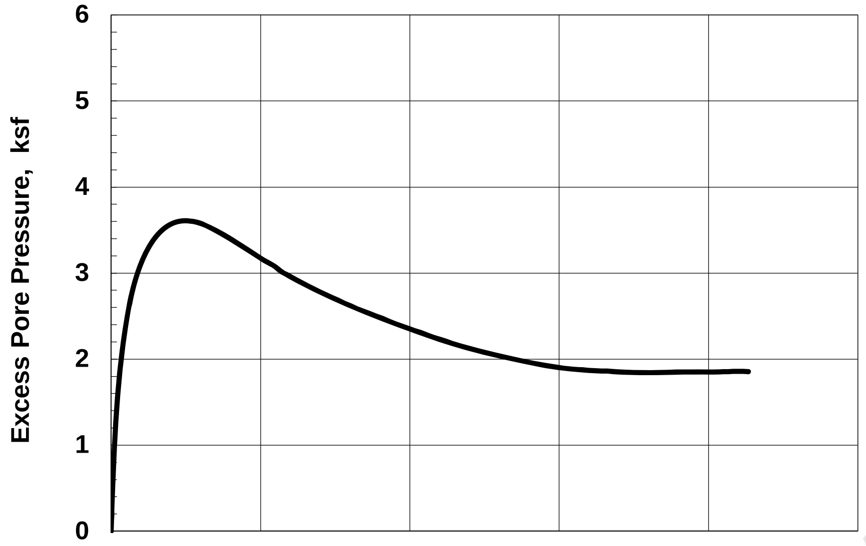




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B012 Sample: ST-16C	September-15
TerraSense, LLC			

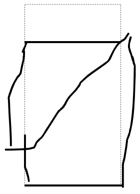


SAMPLE INFORMATION

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

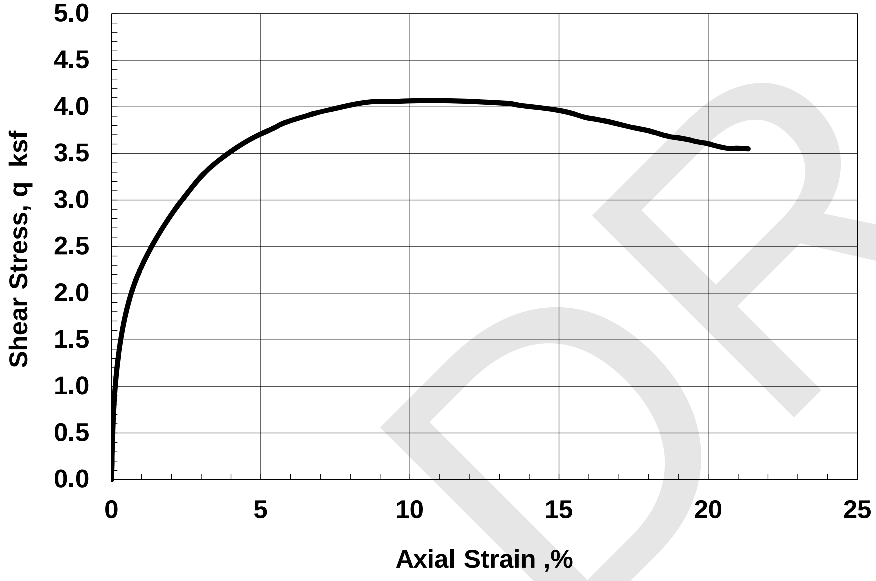


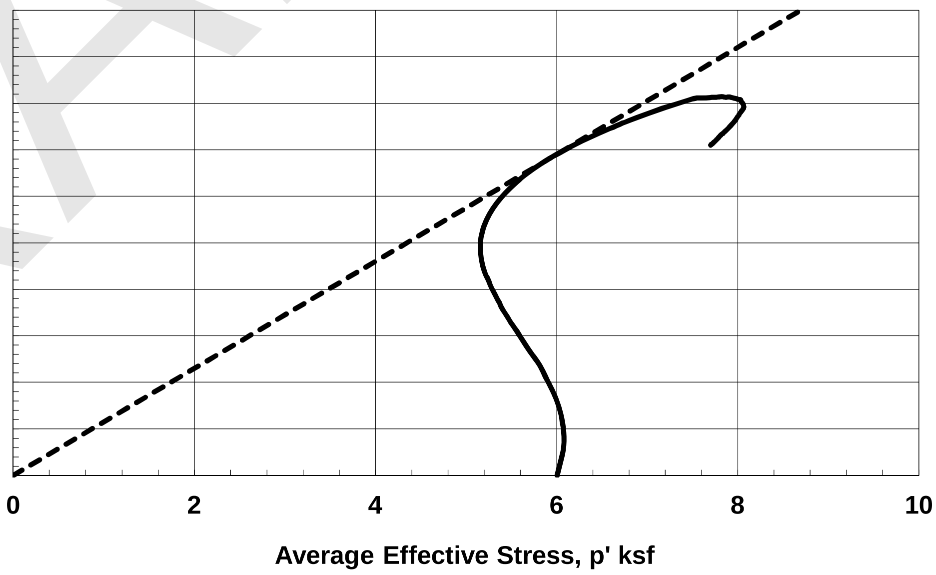
Failure
Sketch

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°

REMARKS:

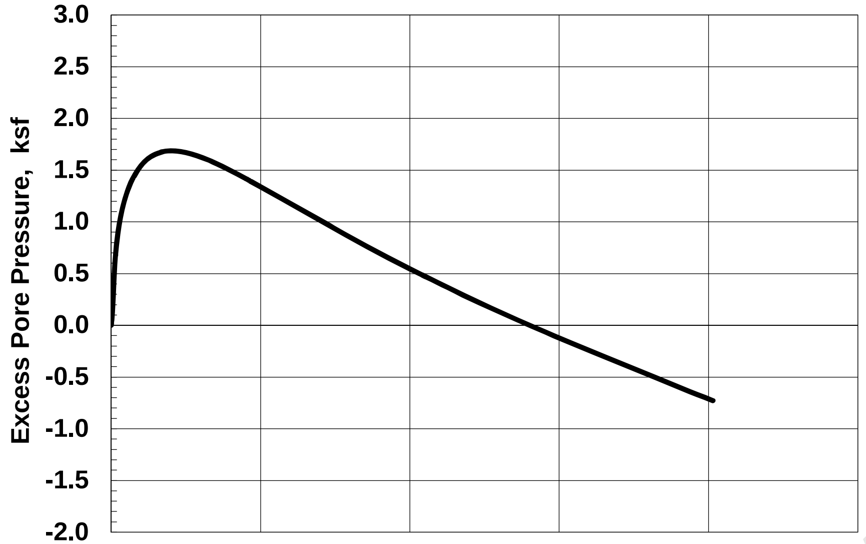




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B014 Sample: ST-4C	
TerraSense, LLC			September-15



SAMPLE INFORMATION

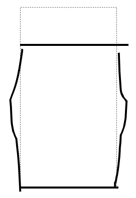
Boring: JOP-B015 Sample: ST-1C Depth: 19.35 ft
Type: Intact tube sample
Description: CH, brown fat clay
LL = 53 PL = 14 PI = 39

SPECIMEN INFORMATION (Initial)

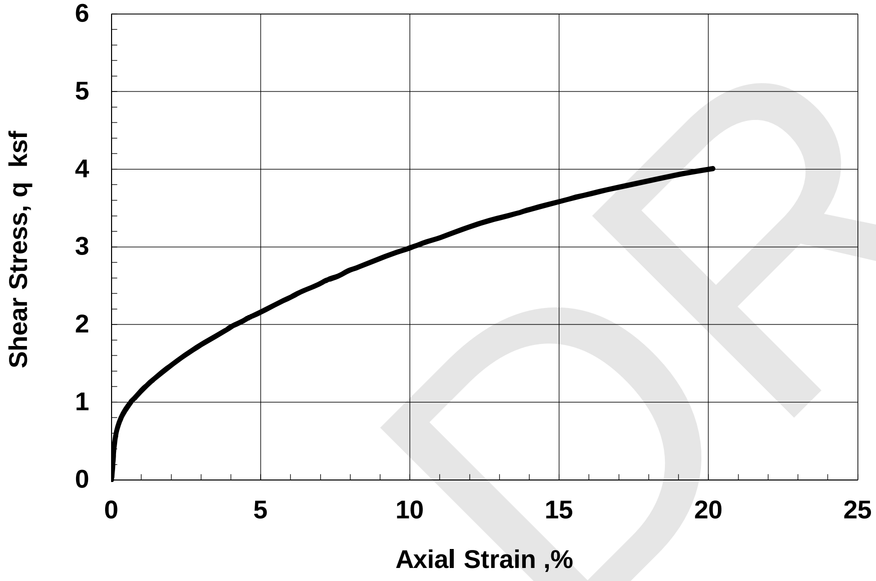
Height: 6.00 inch Diameter: 2.86 inch Area: 6.43 in²
Water Content: 18.7 % Total Unit Weight: 128.4 pcf

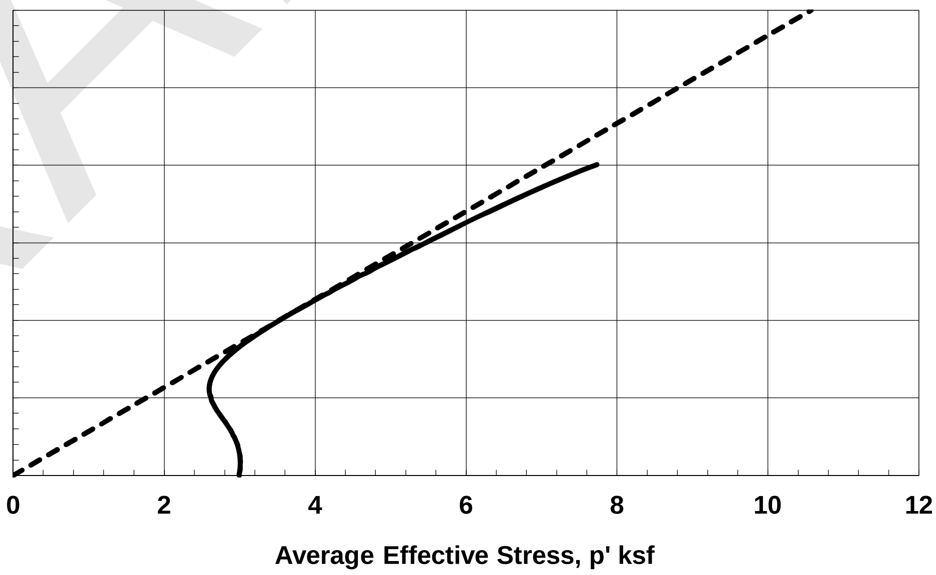
TEST SUMMARY

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:

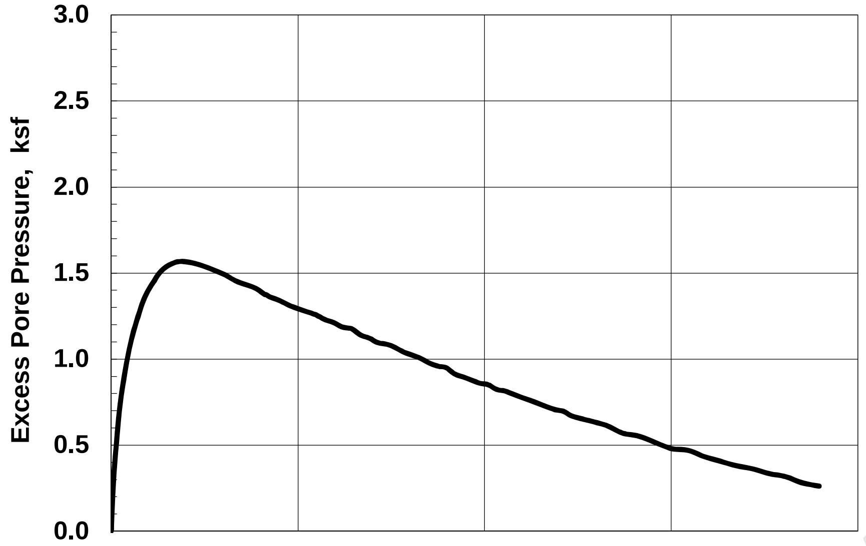




Test by: DT

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B015 Sample: ST-1C	
TerraSense, LLC			October-15

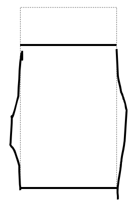


SAMPLE INFORMATION

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

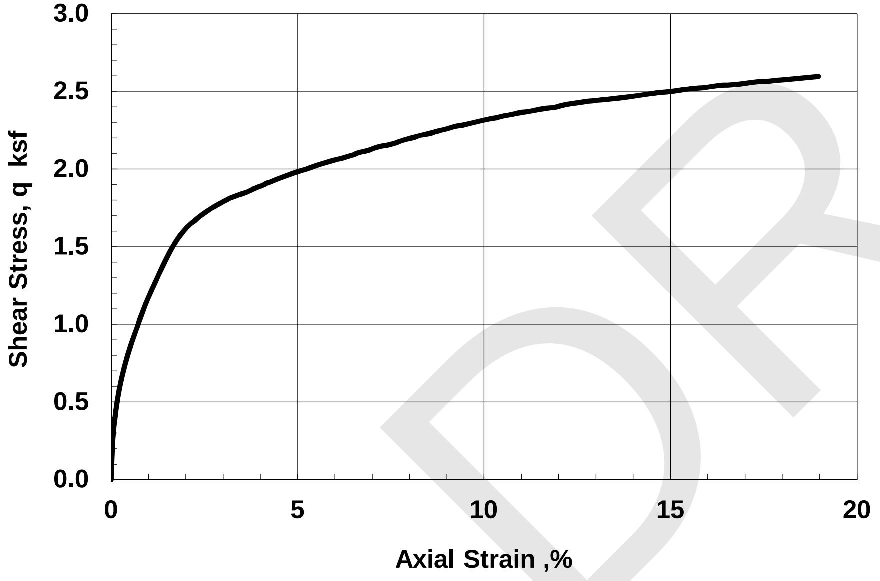


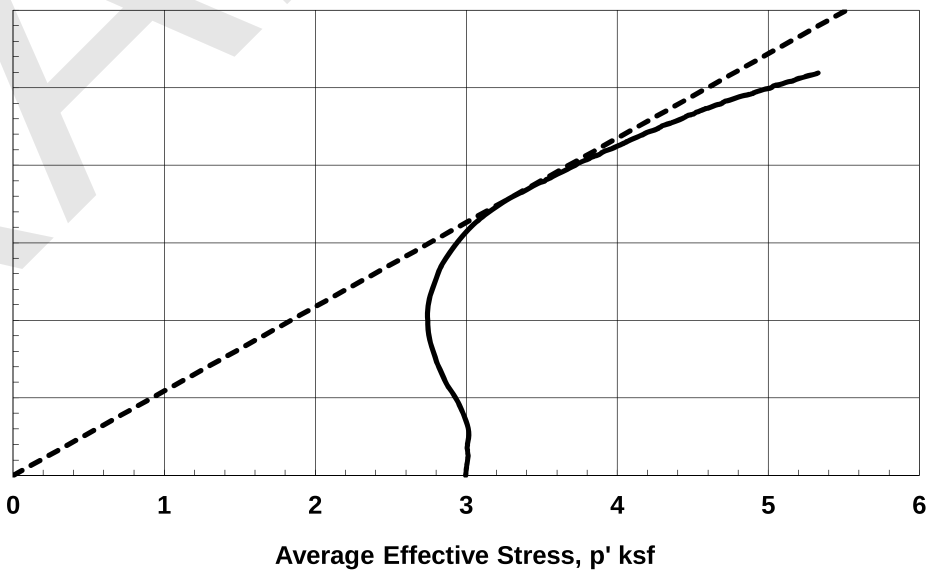
Failure
Sketch

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:

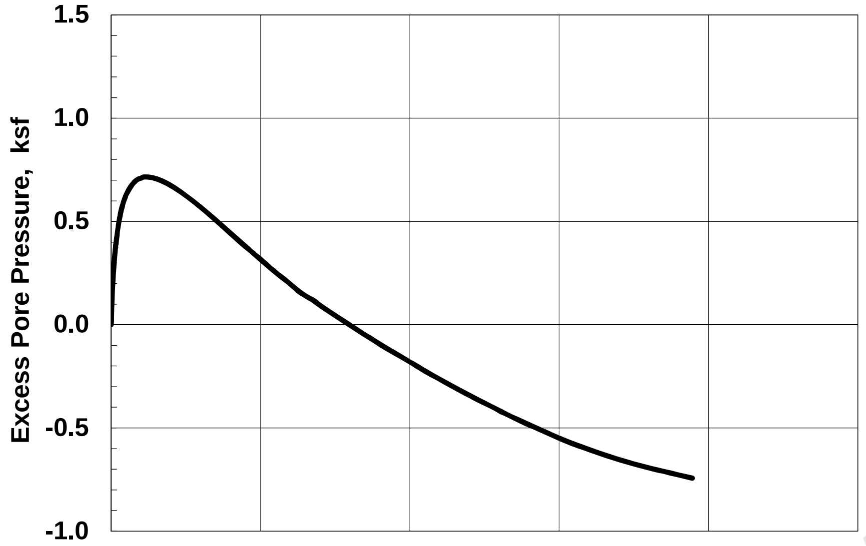




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B015 Sample: ST-2B	October-15
TerraSense, LLC			



SAMPLE INFORMATION

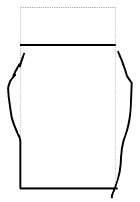
Boring: JOP-B015 Sample: ST-3C Depth: 47.3 ft
Type: Intact tube sample
Description: CL, gray brown lean clay
LL = 31 PL = 15 PI = 16

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

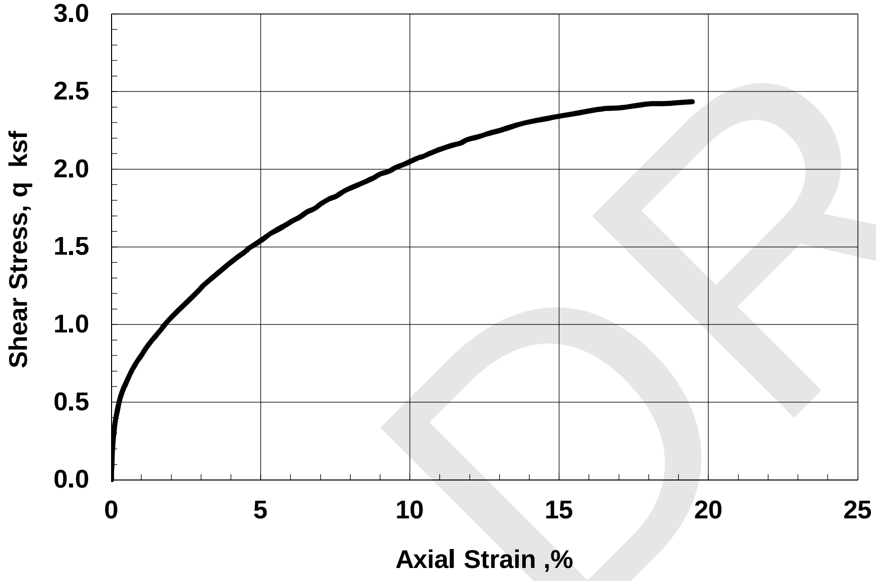
TEST SUMMARY

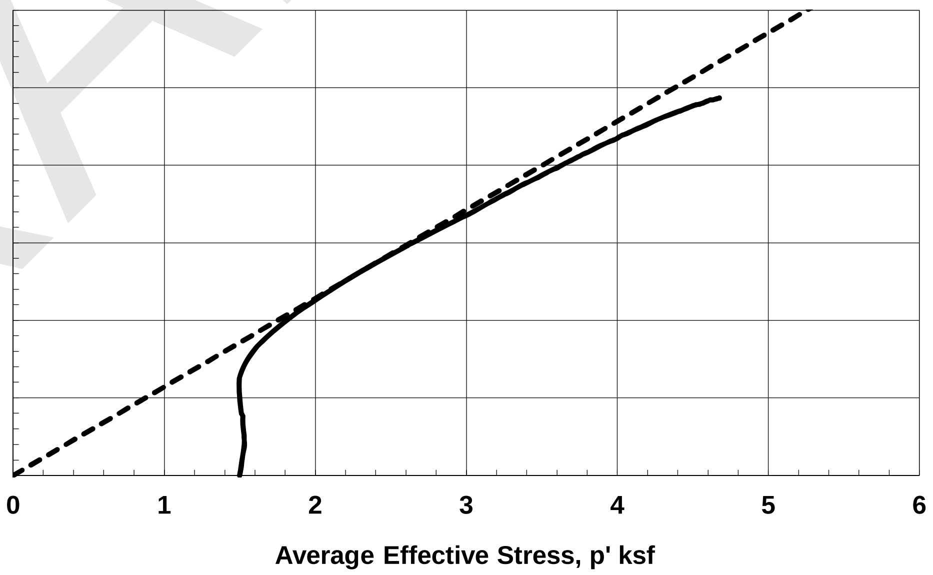
Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral
Water Content: 19.1 % Total Unit Weight: 131.1 pcf
B Coefficient: Strain Rate: 0.020 %/min
Peak Shear Strength: 2.43 ksf @ 19.5 % Strain
Peak Effective Friction Angle: 34.8°



Failure Sketch

REMARKS:

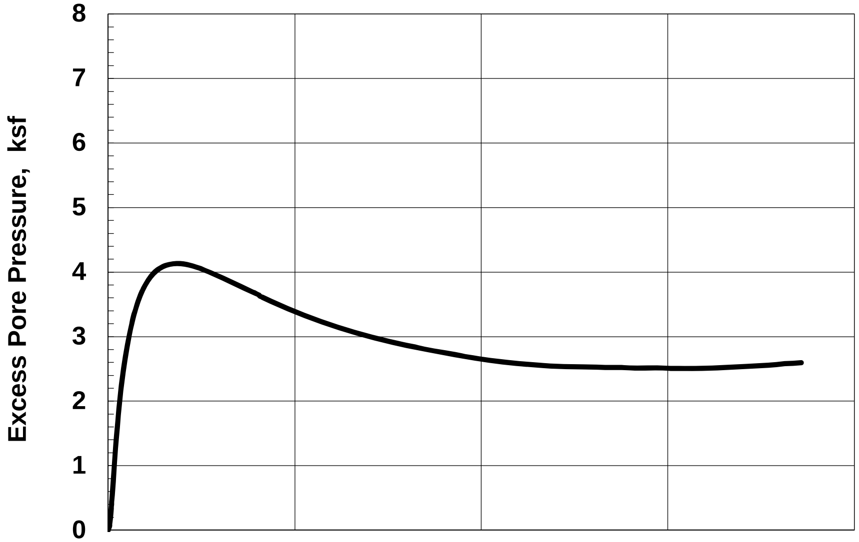




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B015 Sample: ST-3C	October-15
TerraSense, LLC			



SAMPLE INFORMATION

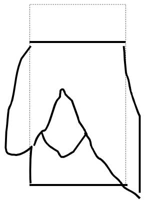
Boring: JOP-B015 Sample: ST-4B Depth: 69.25 ft
Type: Intact tube sample
Description: CL, light gray lean clay

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

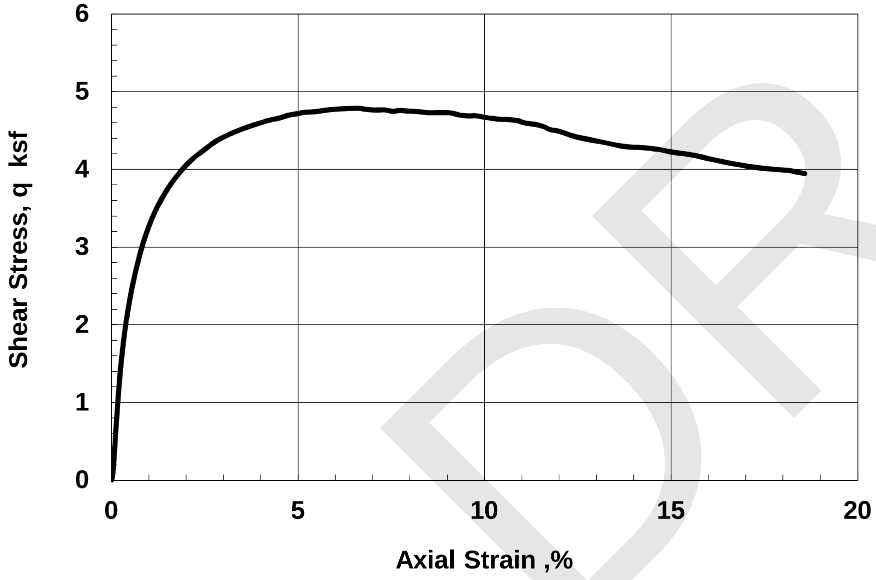
TEST SUMMARY

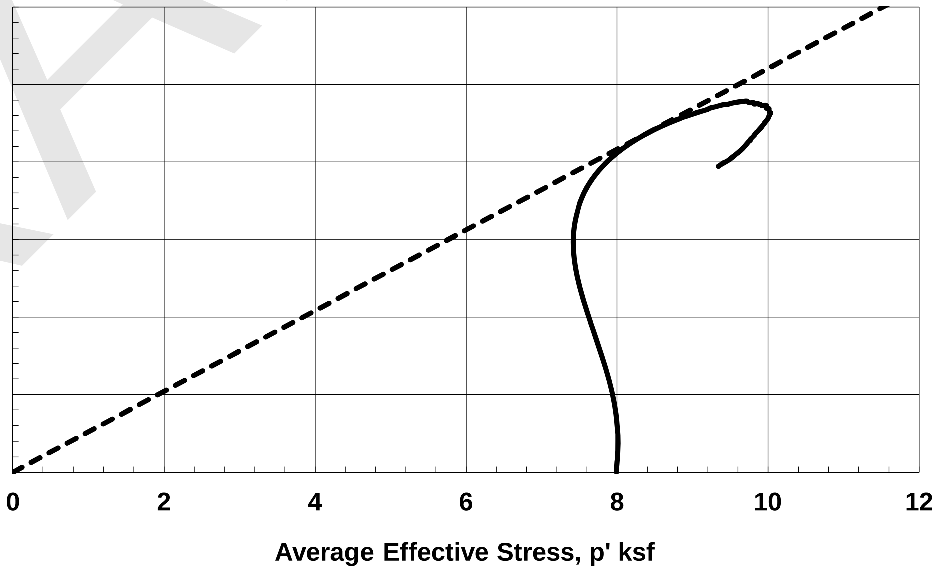
Consolidation Stresses: 7.99 ksf vertical, 7.99 ksf lateral
Water Content: 20.9 % Total Unit Weight: 127.8 pcf
B Coefficient: Strain Rate: 0.019 %/min
Peak Shear Strength: 4.79 ksf @ 6.6 % Strain
Peak Effective Friction Angle: 31.4°



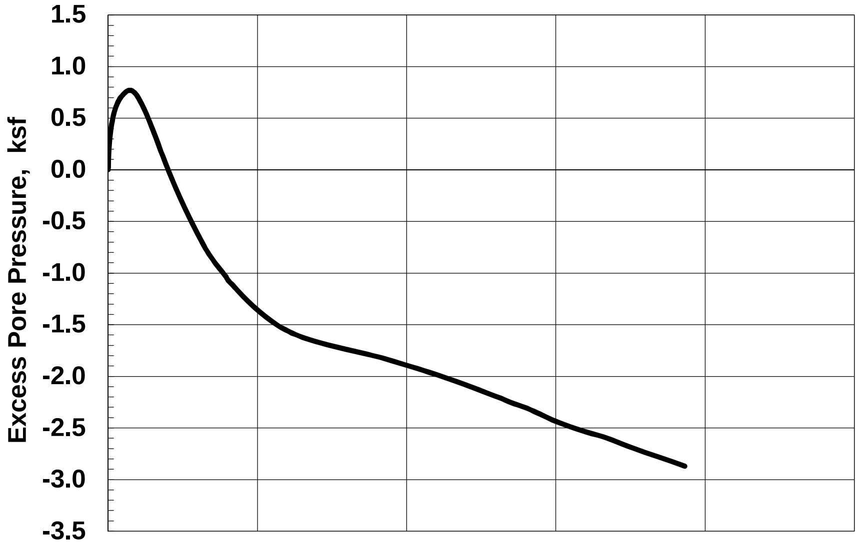
Failure
Sketch

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

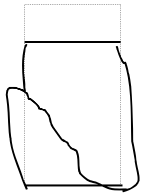
Description: CL, lean clay

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



Failure
Sketch

TEST SUMMARY

Consolidation Stresses: 1.50 ksf vertical, 1.50 ksf lateral

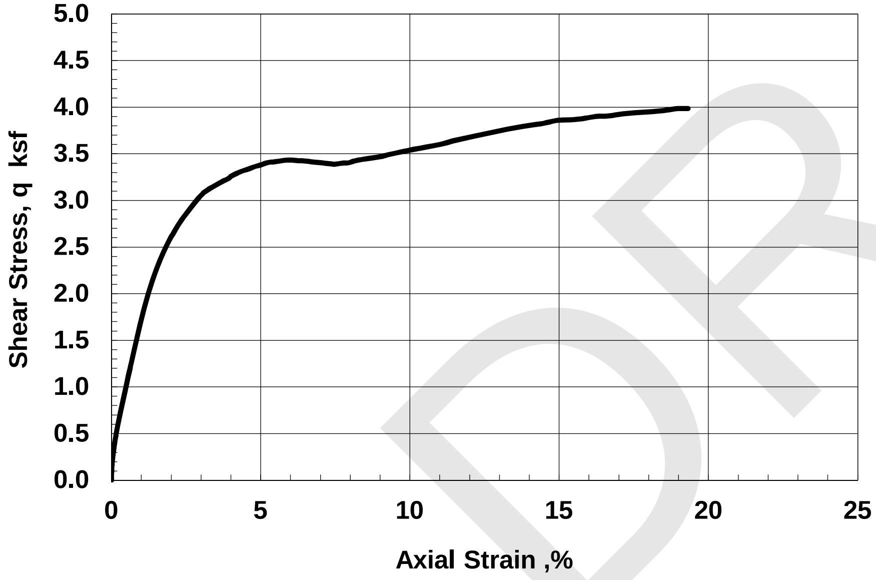
Water Content: 19.6 % Total Unit Weight: 129.6 pcf

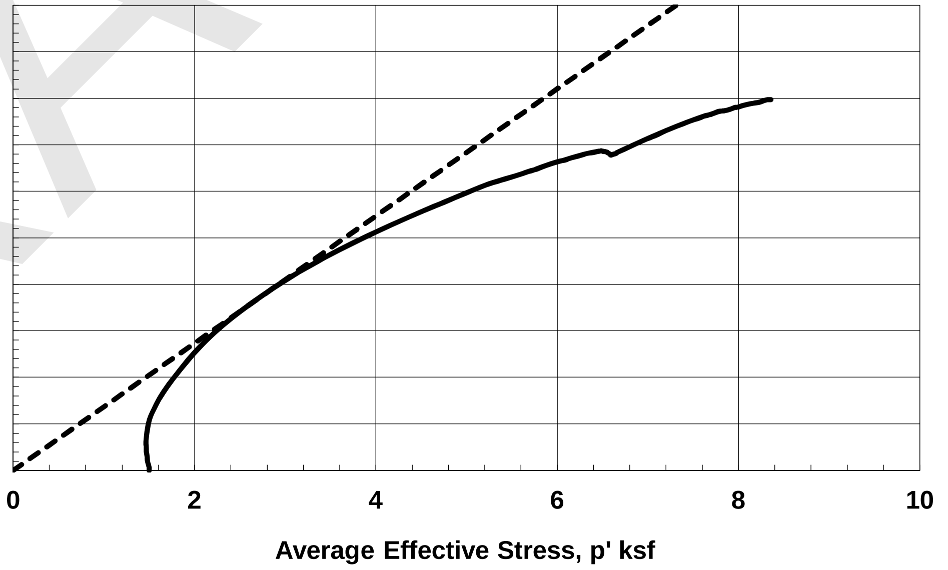
B Coefficient: Strain Rate: 0.018 %/min

Peak Shear Strength: 3.99 ksf @ 19.3 % Strain

Peak Effective Friction Angle: 43.1°

REMARKS:

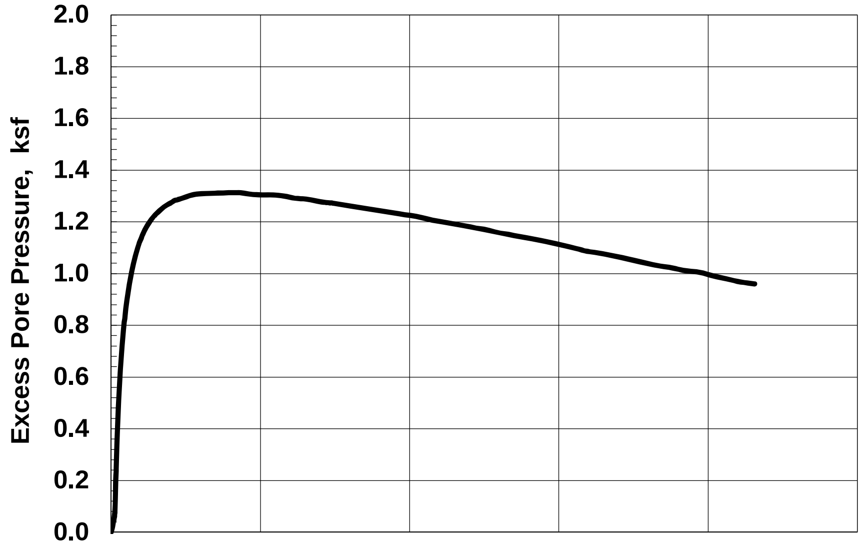




Test by: DT

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B016 Sample: ST-3B	October-15
TerraSense, LLC			



SAMPLE INFORMATION

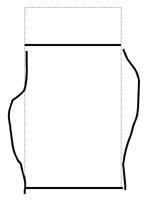
Boring: JOP-B017 Sample: ST-2B Depth: 8.85 ft
Type: Intact tube sample
Description: CL, brown sandy lean clay

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

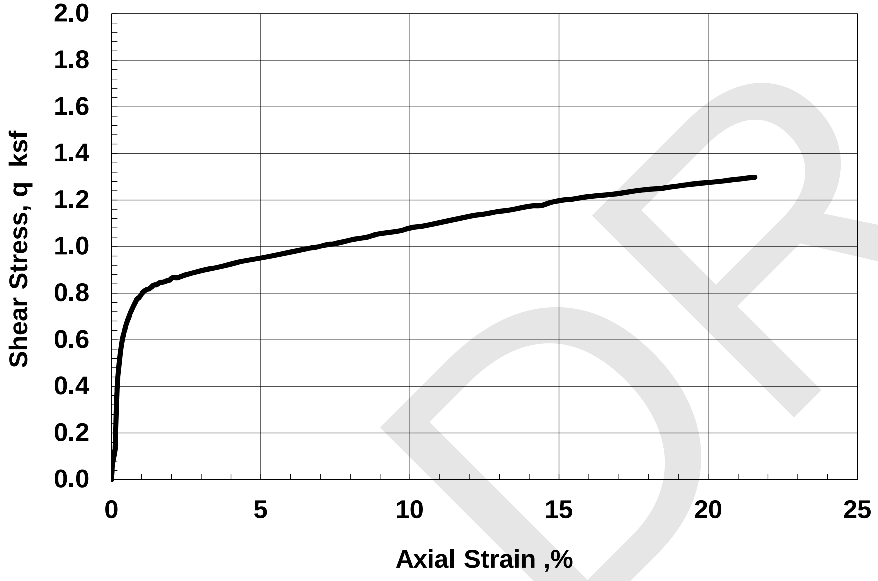
TEST SUMMARY

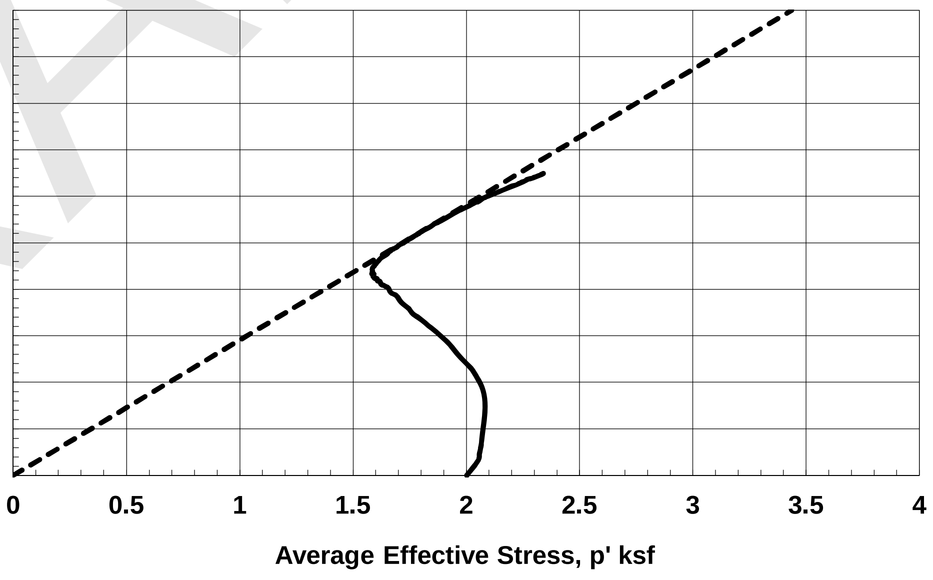
Consolidation Stresses: 2.00 ksf vertical, 2.00 ksf lateral
Water Content: 17.6 % Total Unit Weight: 133.6 pcf
B Coefficient: 98.42 Strain Rate: 0.023 %/min
Peak Shear Strength: 1.30 ksf @ 21.6 % Strain
Peak Effective Friction Angle: 35.6°



Failure Sketch

REMARKS:





Test by: BB

Checked by: GET

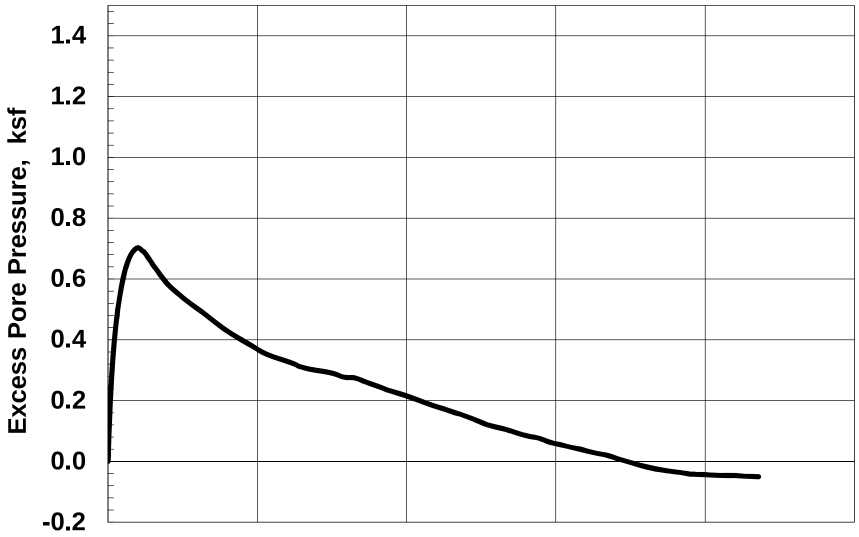
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B017 Sample: ST-2B

September-15

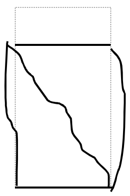


SAMPLE INFORMATION

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

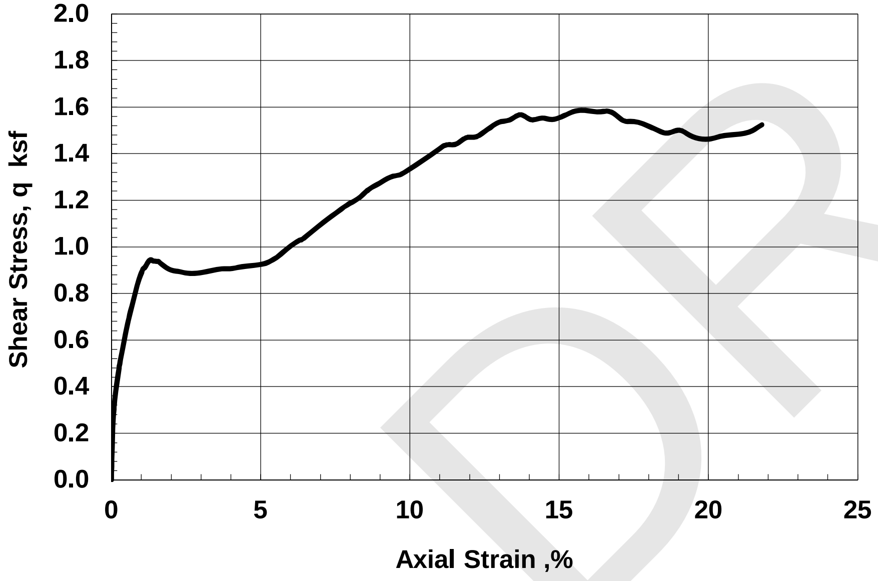


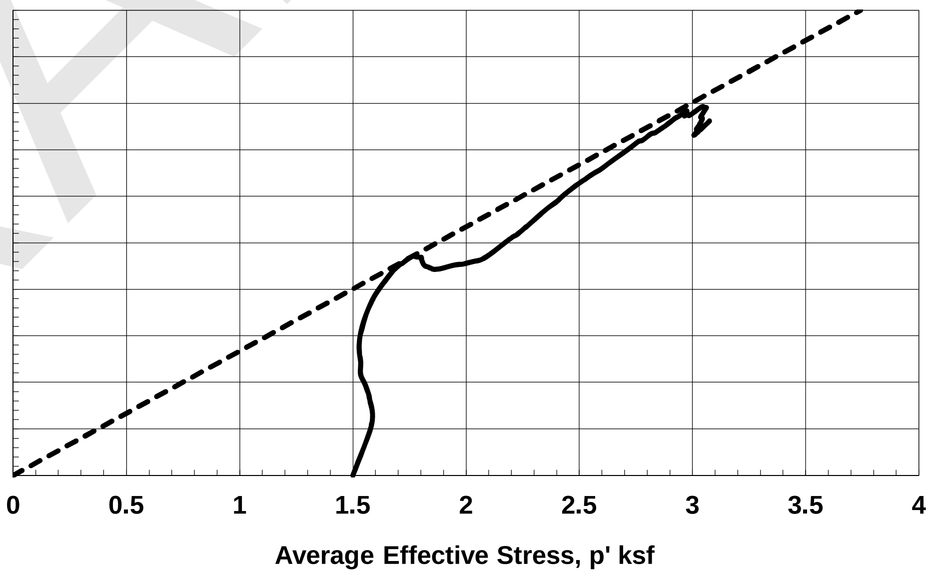
Failure Sketch

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:

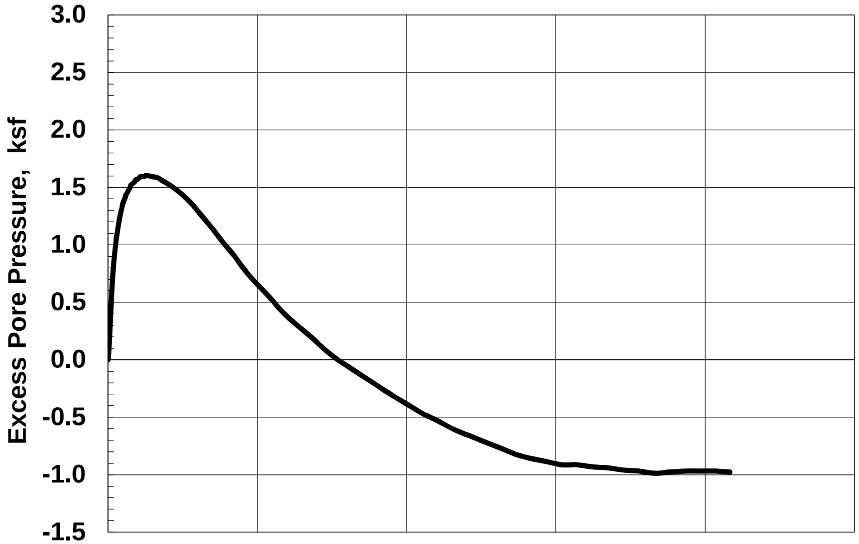




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B017 Sample: ST-3C	September-15
TerraSense, LLC			

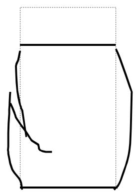


SAMPLE INFORMATION

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

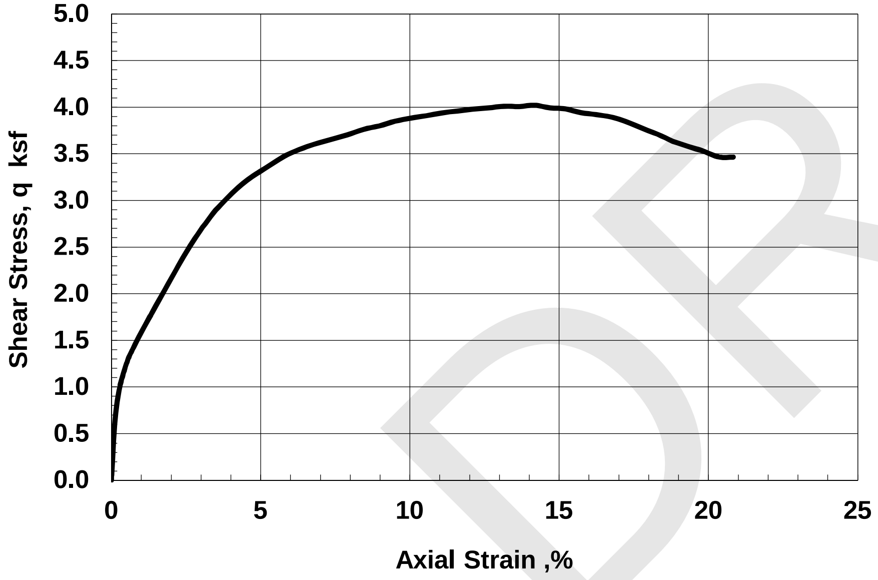


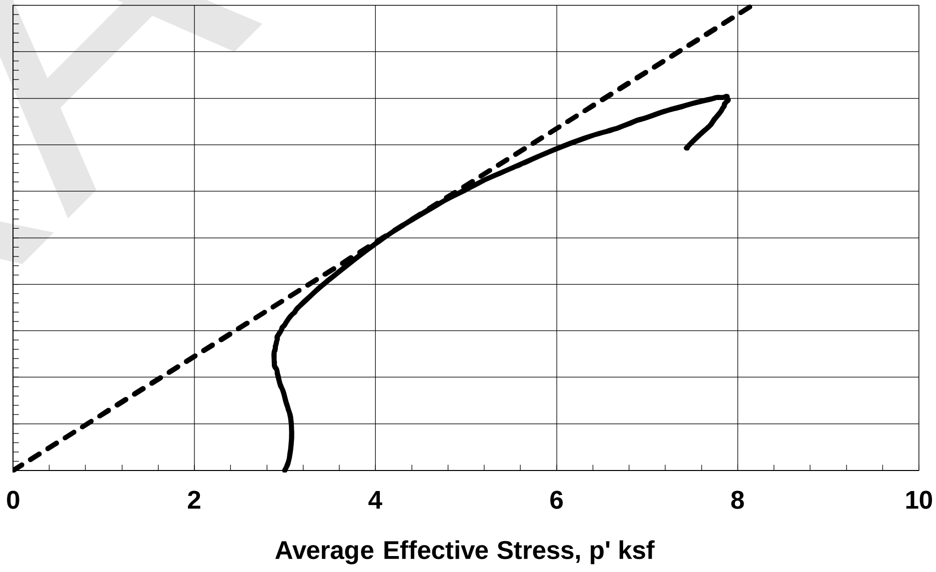
Failure
Sketch

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°

REMARKS:





Test by: BB

Checked by: GET

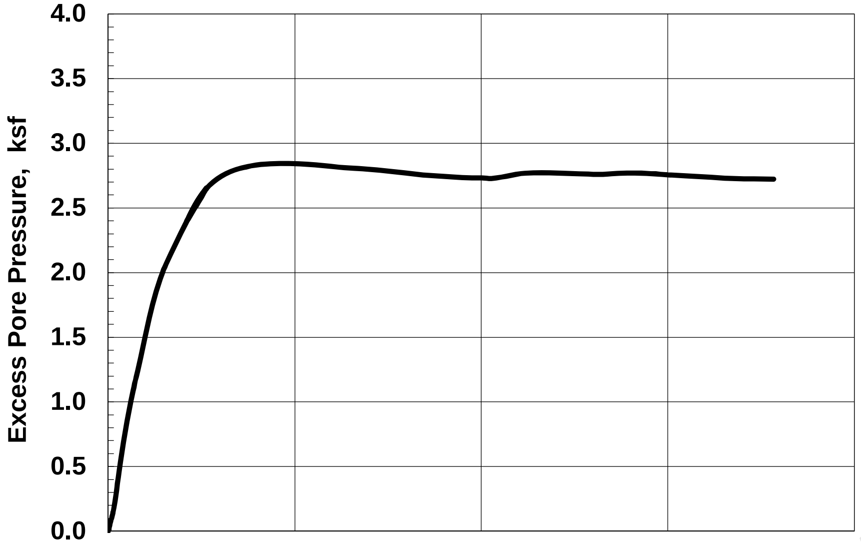
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B017 Sample: ST-4D

October-15

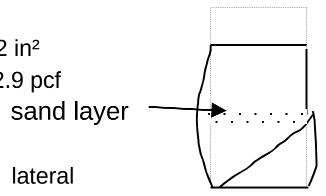


SAMPLE INFORMATION

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

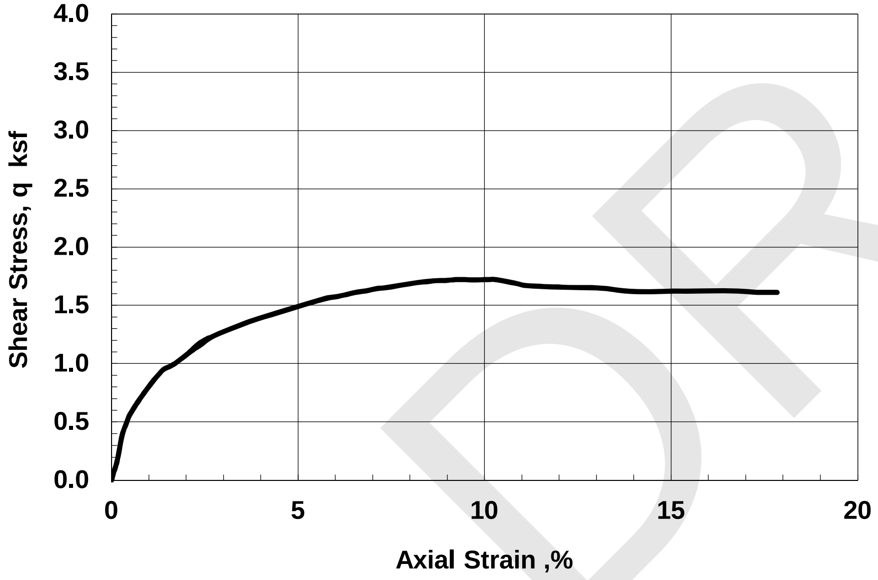


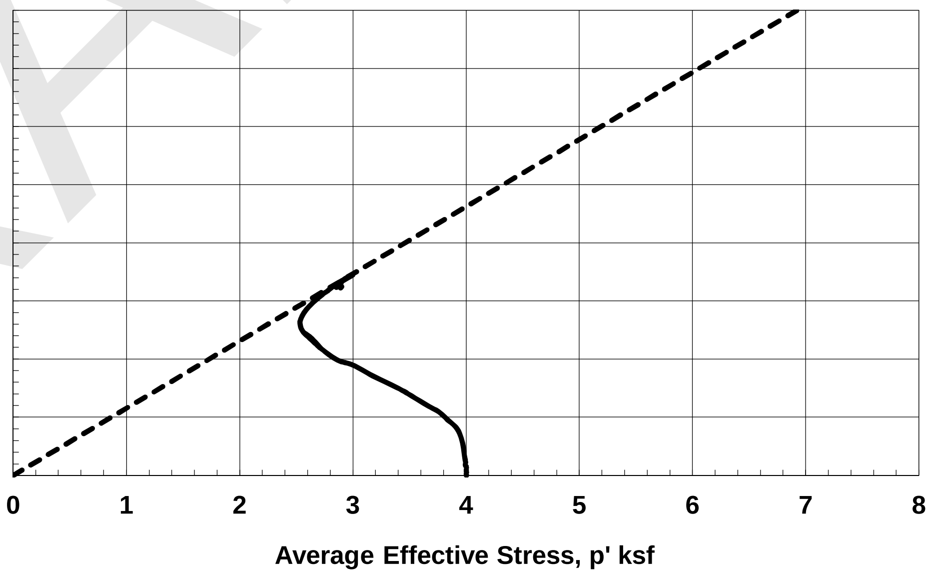
Failure
Sketch

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 Boring: JOP-B019 Sample: ST-2B	
Checked by: GET	TerraSense, LLC			October-15

SAMPLE INFORMATION

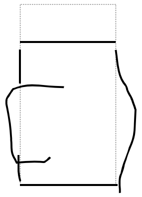
Boring: JOP-B020 Sample: ST-2B Depth: 19.25 ft
Type: Intact tube sample
Description: CL, gray brown lean clay

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

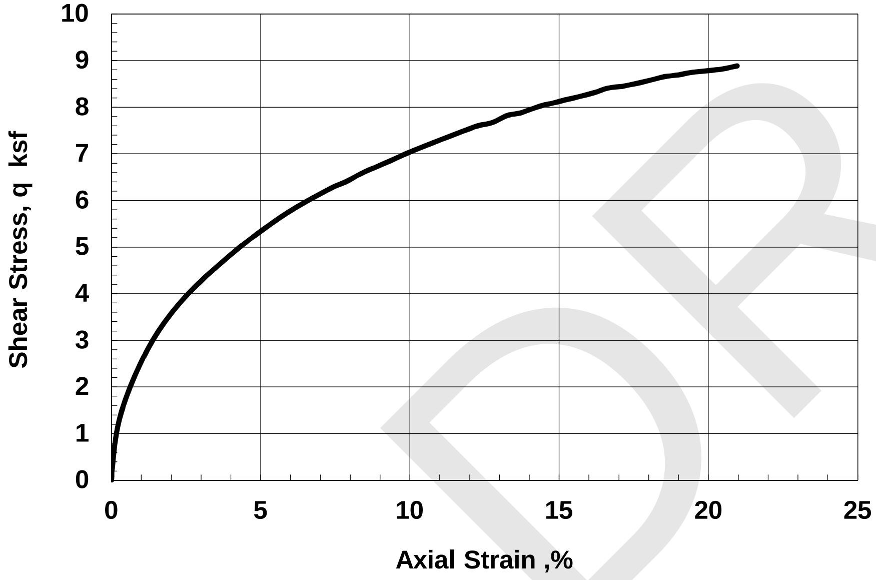
TEST SUMMARY

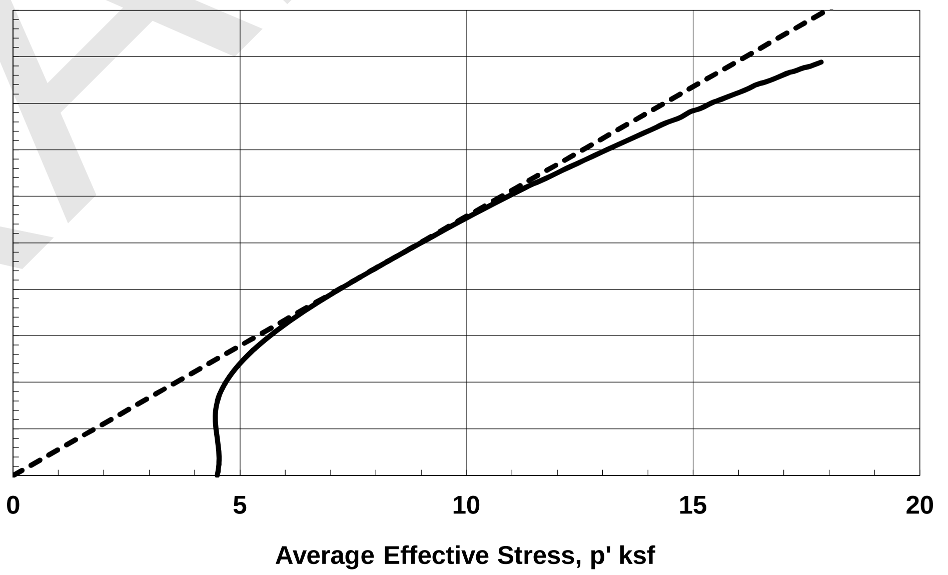
Consolidation Stresses: 4.50 ksf vertical, 4.50 ksf lateral
Water Content: 16.0 % Total Unit Weight: 134.4 pcf
B Coefficient: 99.12 Strain Rate: 0.020 %/min
Peak Shear Strength: 8.89 ksf @ 21.0 % Strain
Peak Effective Friction Angle: 33.9°



Failure Sketch

REMARKS:

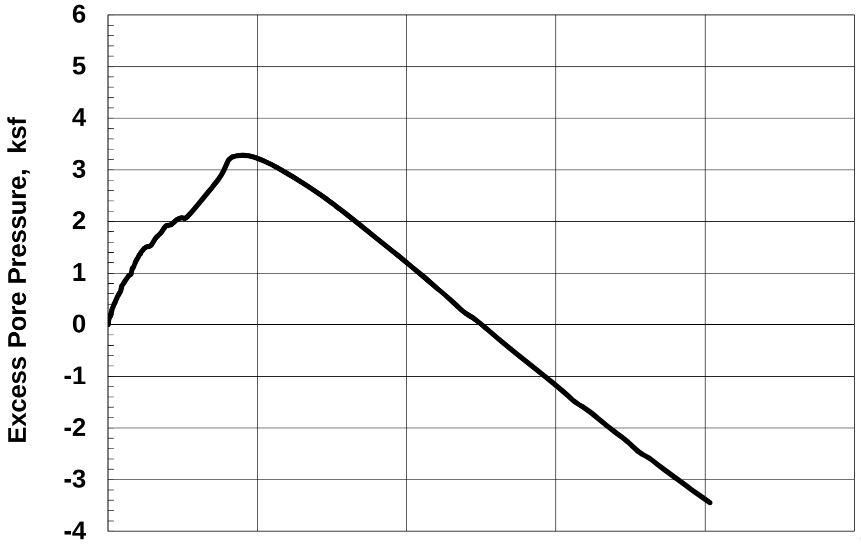




Test by: NB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B020 Sample: ST-2B	October-15
TerraSense, LLC			



SAMPLE INFORMATION

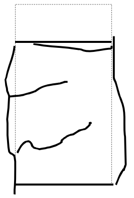
Boring: JOP-B020 Sample: ST-4C Depth: 49.75 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 31 PL = 14 PI = 17

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

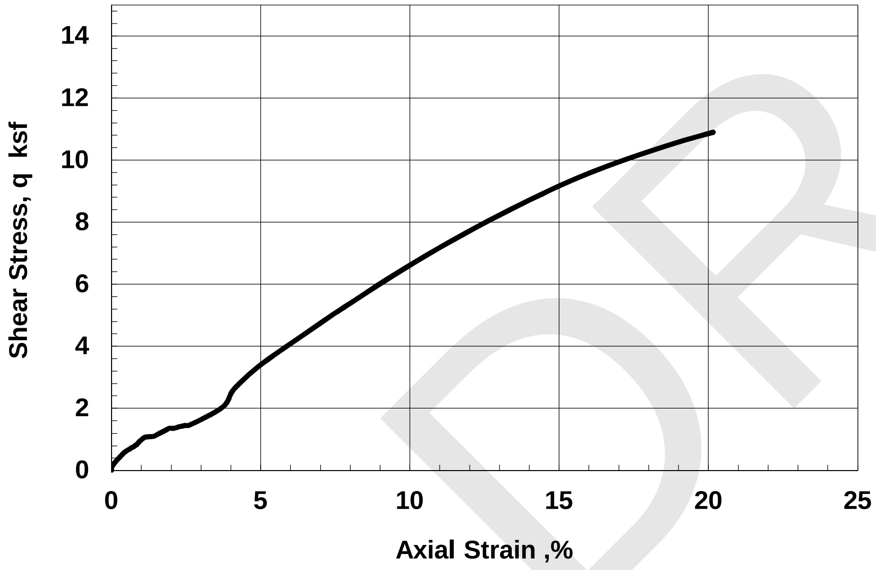
TEST SUMMARY

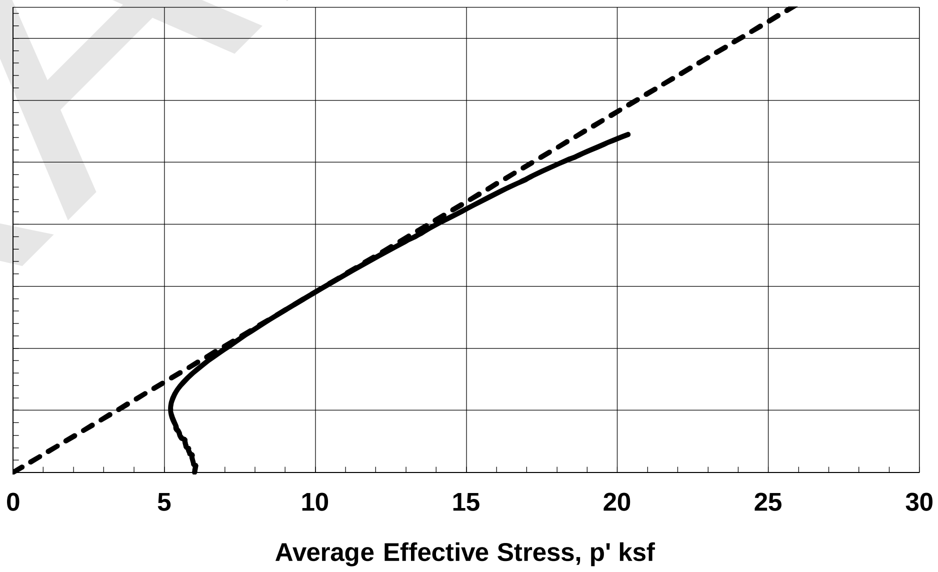
Consolidation Stresses: 6.00 ksf vertical, 6.00 ksf lateral
Water Content: 13.5 % Total Unit Weight: 137.5 pcf
B Coefficient: 99.7 Strain Rate: 0.020 %/min
Peak Shear Strength: 10.90 ksf @ 20.2 % Strain
Peak Effective Friction Angle: 35.6°



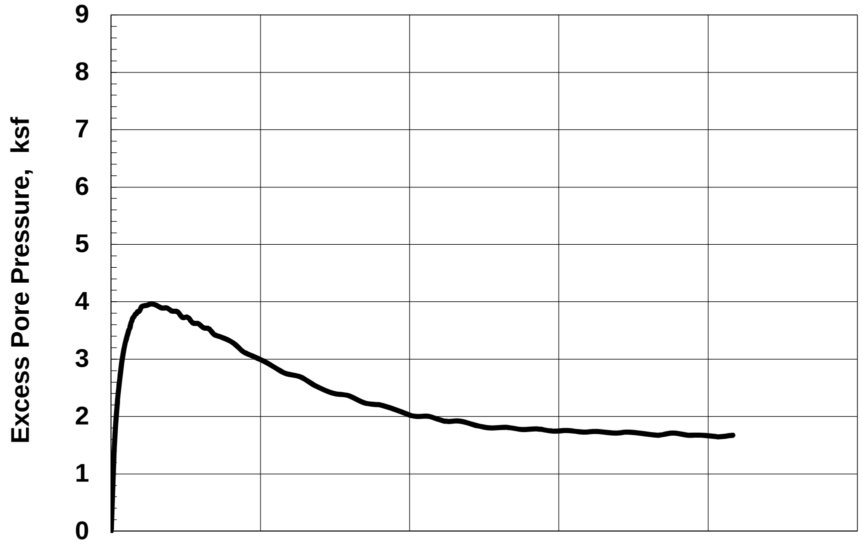
Failure Sketch

REMARKS:





Test by: DT	Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B020 Sample: ST-4C	
Checked by: GET	**TerraSense, LLC**			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)

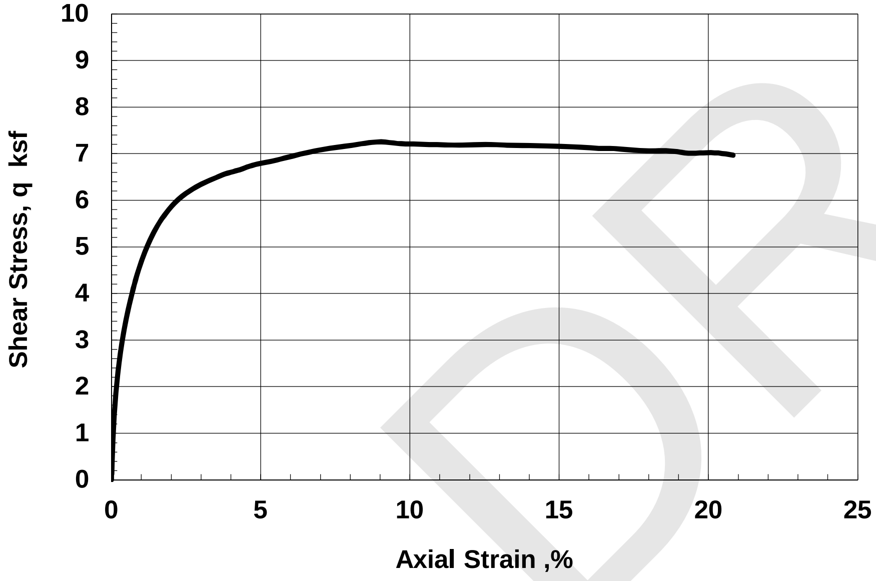
Height: 6.20 inch Diameter: 2.86 inch Area: 6.43 in²
Water Content: 18.2 % Total Unit Weight: 128.6 pcf

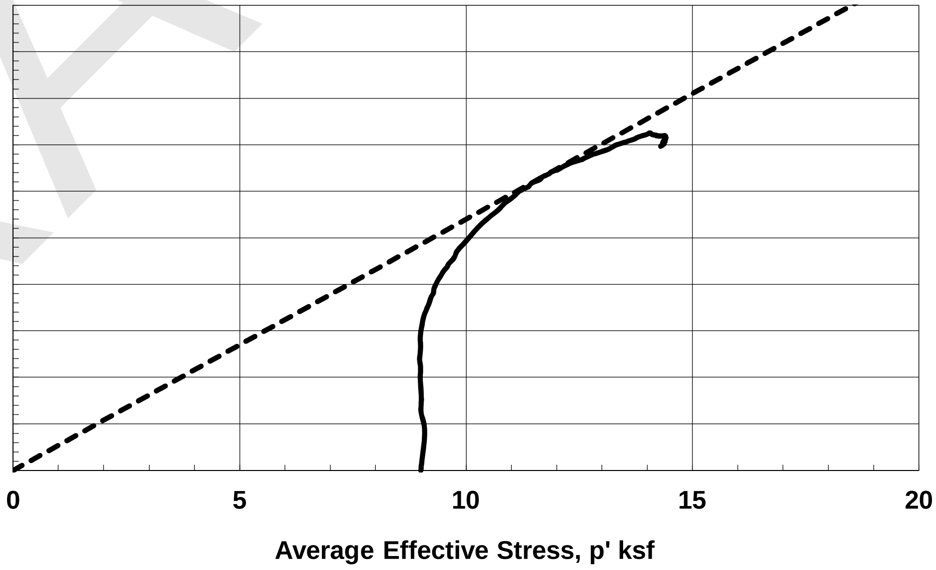
TEST SUMMARY

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:

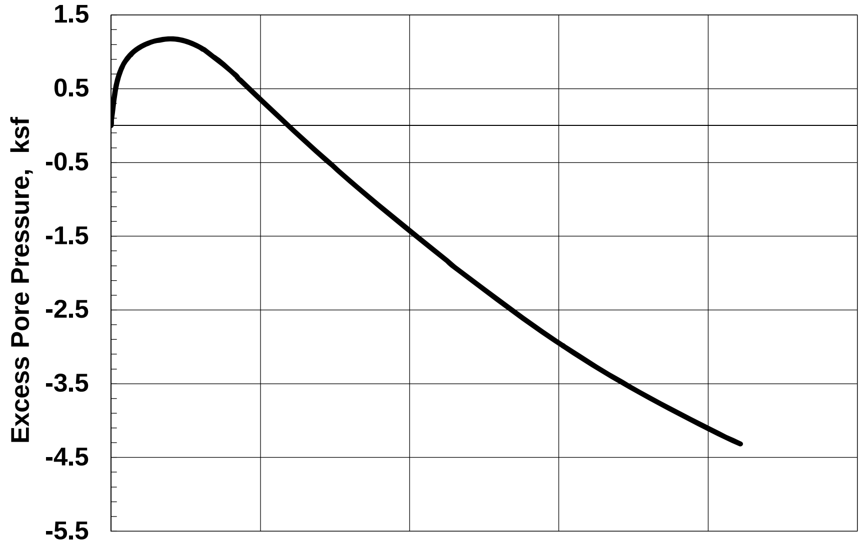




Test by: DT

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B020 Sample: ST-5C	October-15
TerraSense, LLC			

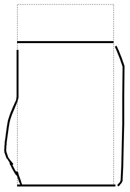


SAMPLE INFORMATION

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

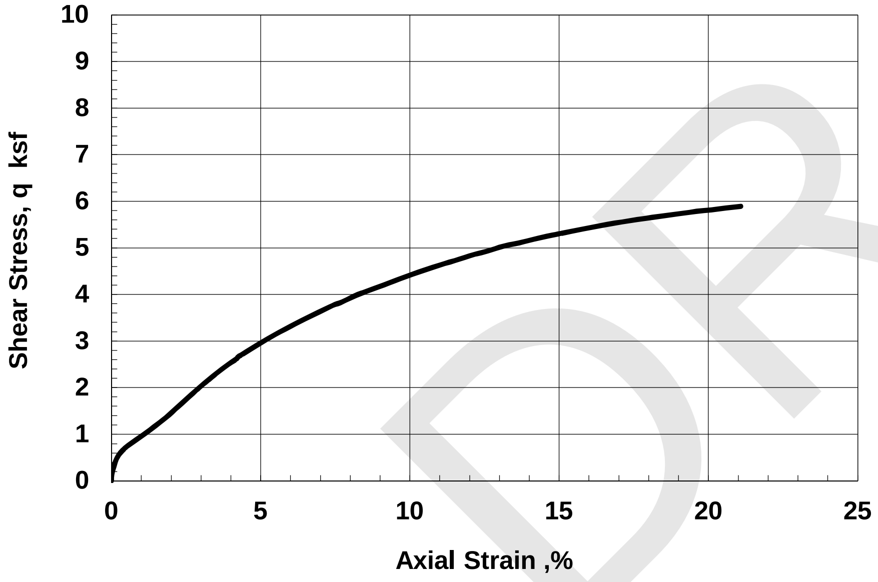


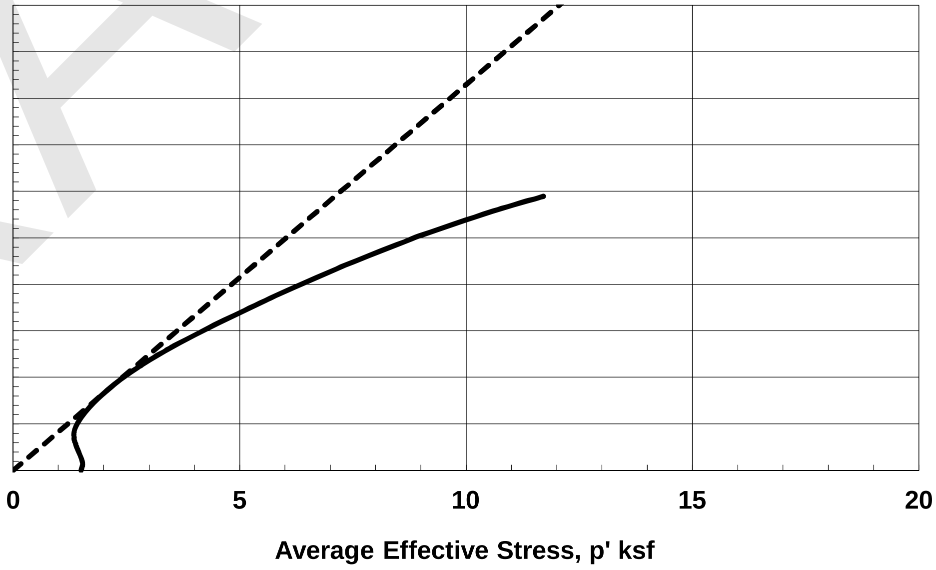
Failure Sketch

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°

REMARKS:

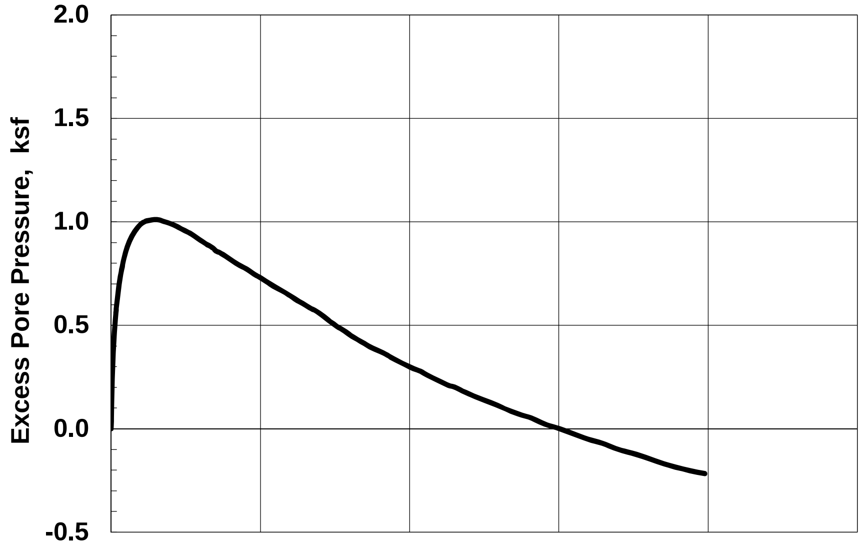




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B021 Sample: ST-1C	
TerraSense, LLC			October-15



SAMPLE INFORMATION

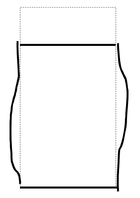
Boring: JOP-B021 Sample: ST-2C Depth: 14.6 ft
Type: Intact tube sample
Description: CL, gray lean clay

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

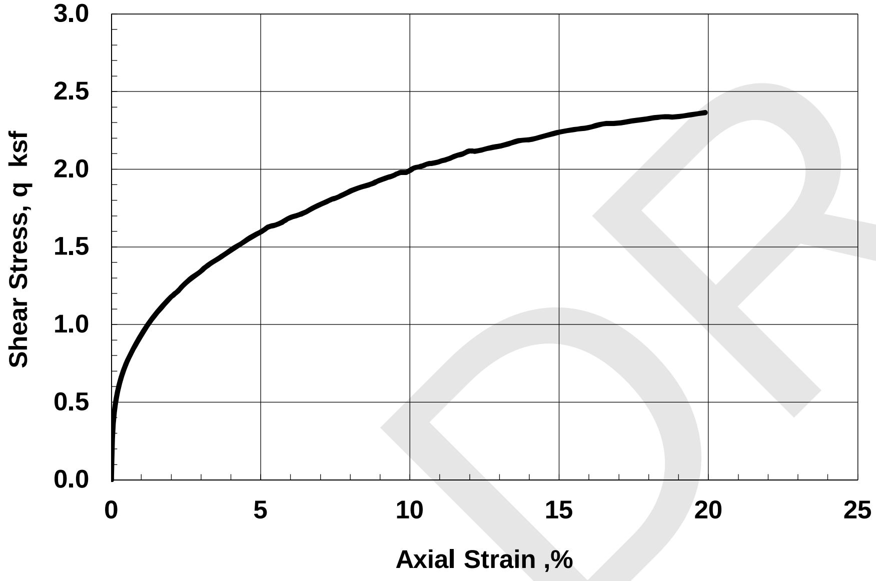
TEST SUMMARY

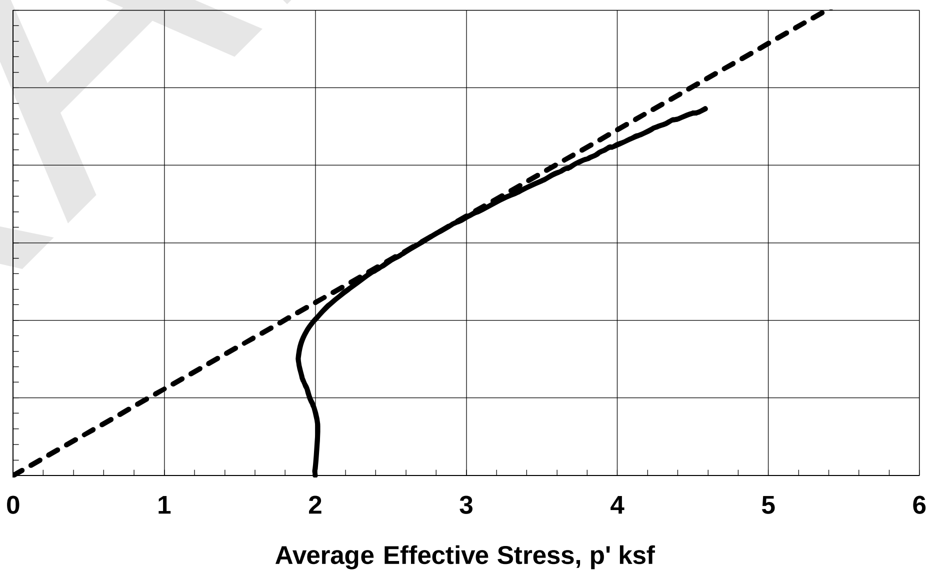
Consolidation Stresses: 2.00 ksf vertical, 2.00 ksf lateral
Water Content: 22.5 % Total Unit Weight: 127.5 pcf
B Coefficient: Strain Rate: 0.019 %/min
Peak Shear Strength: 2.37 ksf @ 19.9 % Strain
Peak Effective Friction Angle: 33.9°



Failure Sketch

REMARKS:

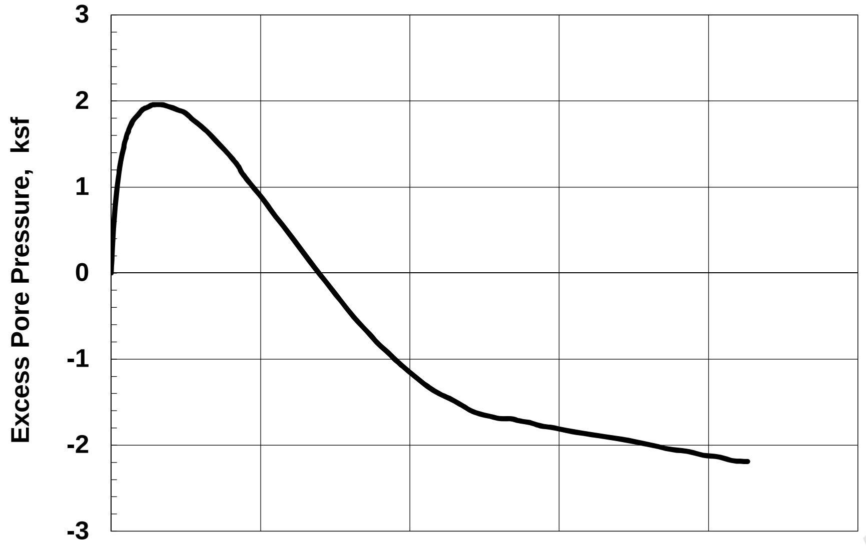




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B021 Sample: ST-2C	October-15
TerraSense, LLC			

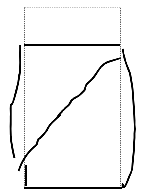


SAMPLE INFORMATION

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

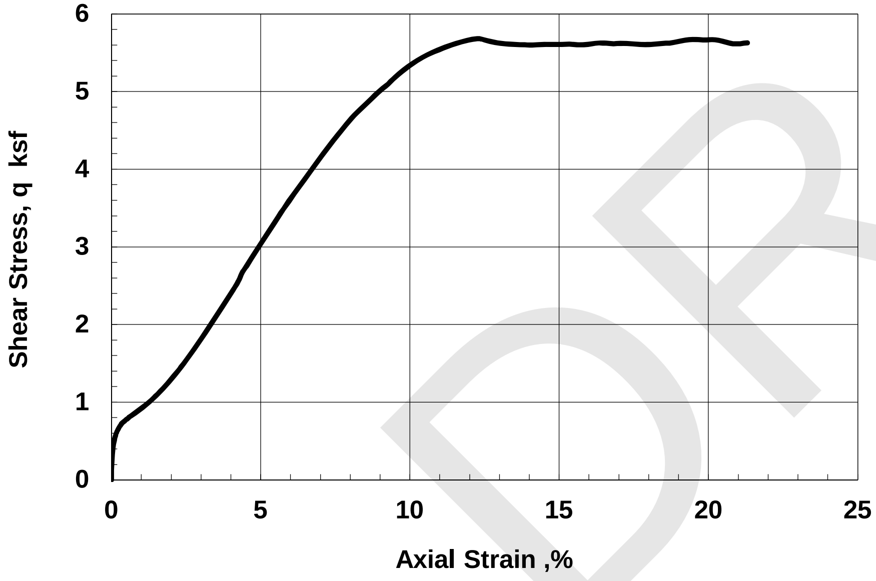


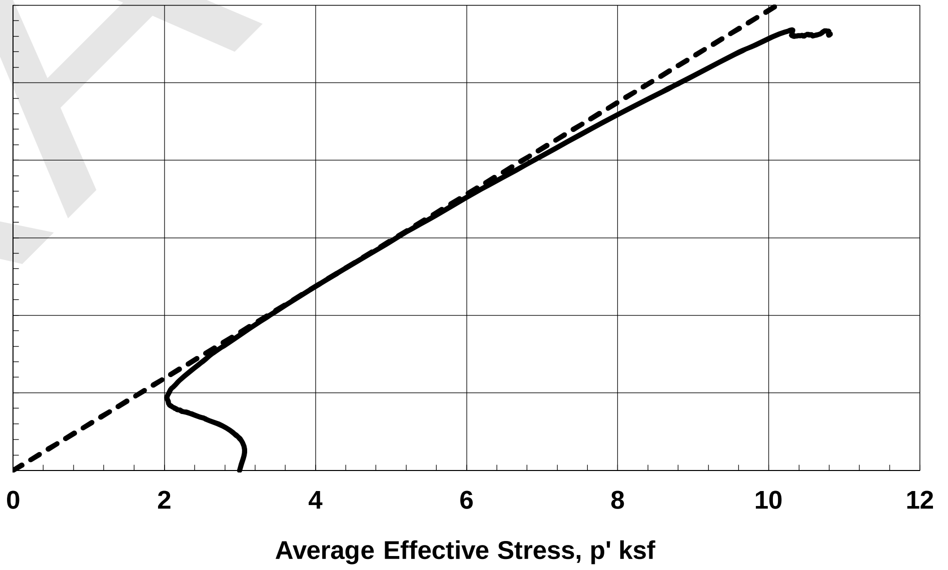
Failure Sketch

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:

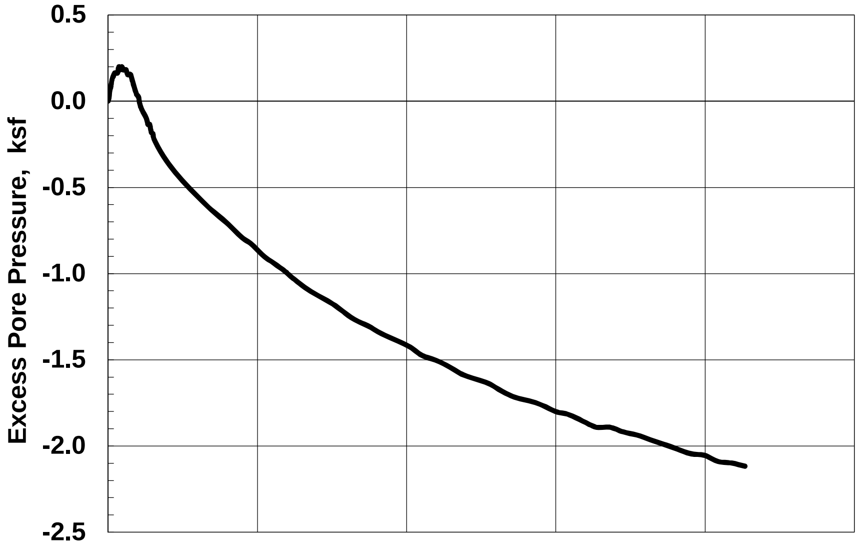




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B021 Sample: ST-3B	October-15
TerraSense, LLC			



SAMPLE INFORMATION

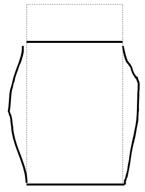
Boring: JOP-B022 Sample: ST-2C Depth: 9.4 ft
Type: Intact tube sample
Description: CL, brown lean clay
LL = 35 PL = 18 PI = 17

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

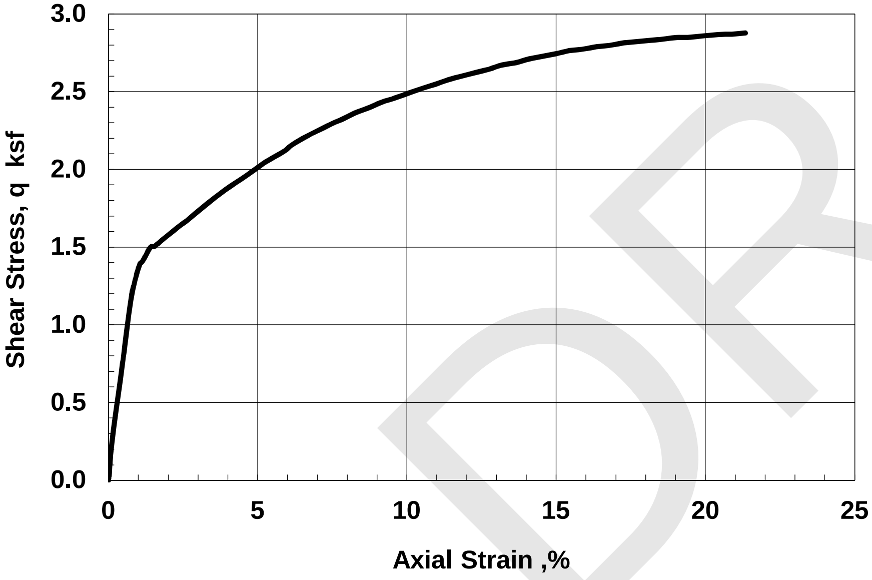
TEST SUMMARY

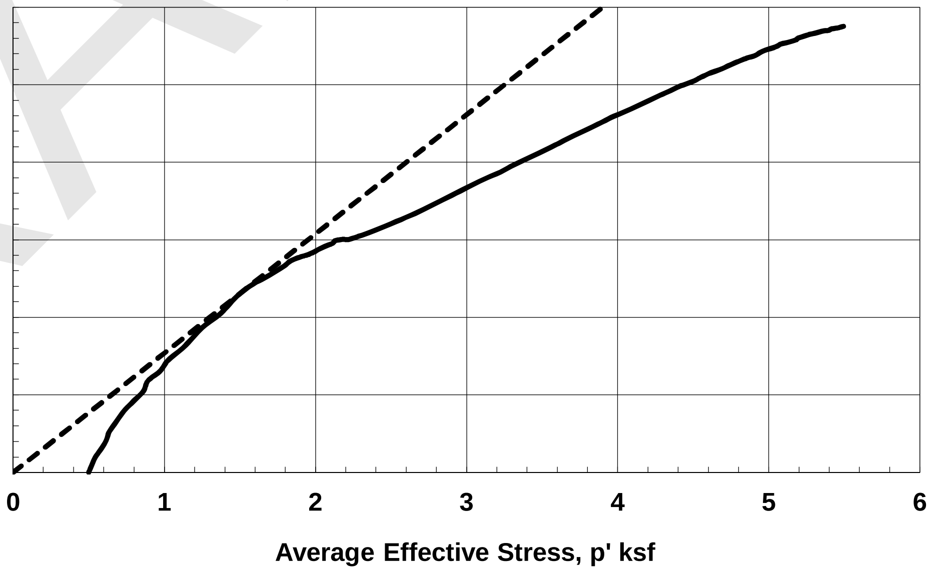
Consolidation Stresses: 0.50 ksf vertical, 0.50 ksf lateral
Water Content: 21.7 % Total Unit Weight: 129.7 pcf
B Coefficient: 99.87 Strain Rate: 0.022 %/min
Peak Shear Strength: 2.88 ksf @ 21.3 % Strain
Peak Effective Friction Angle: 50.3°



Failure Sketch

REMARKS:





Test by: BB

Checked by: GET

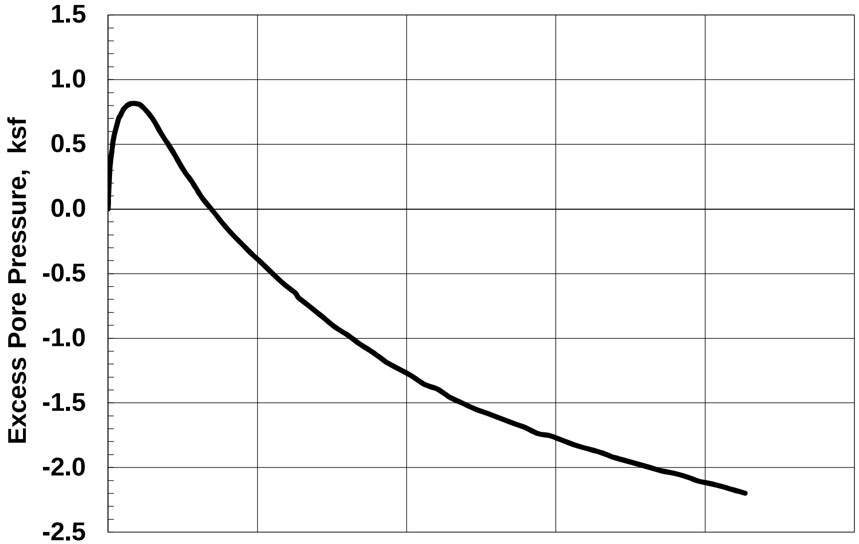
Project No.
T60428794

AECOM
Dynegy CCR - Joppa

TerraSense, LLC

CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION
with Pore Pressure Measurements
Boring: JOP-B022 Sample: ST-2C

September-15

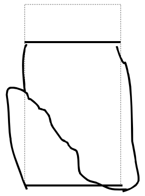


SAMPLE INFORMATION

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

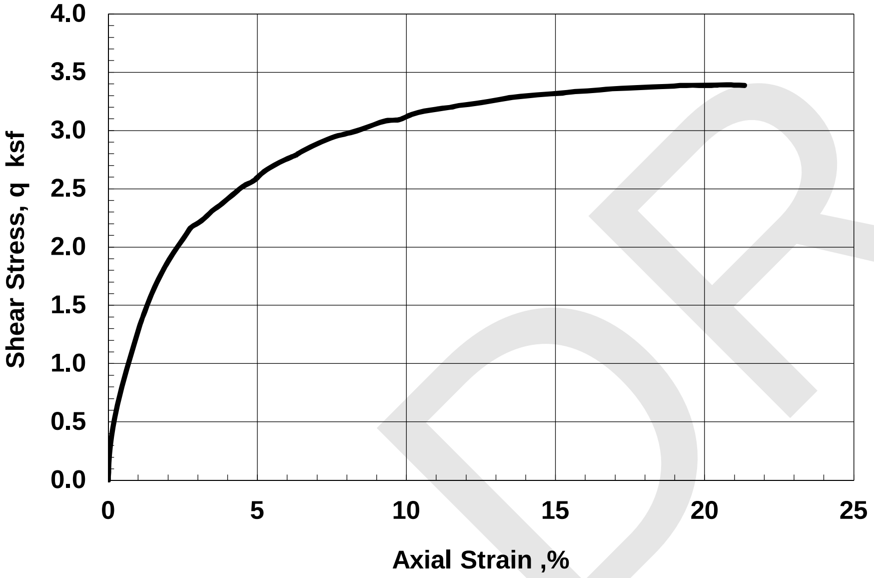


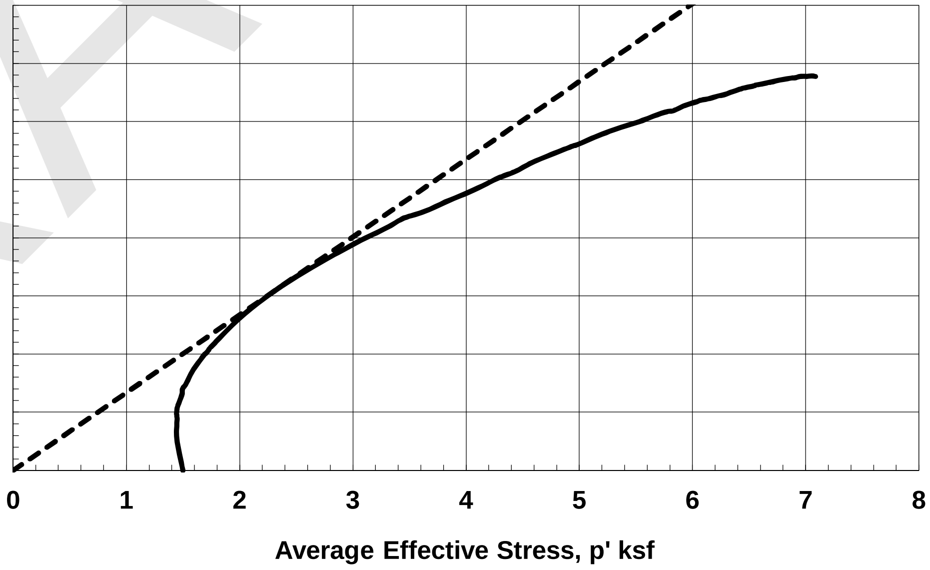
Failure
Sketch

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:

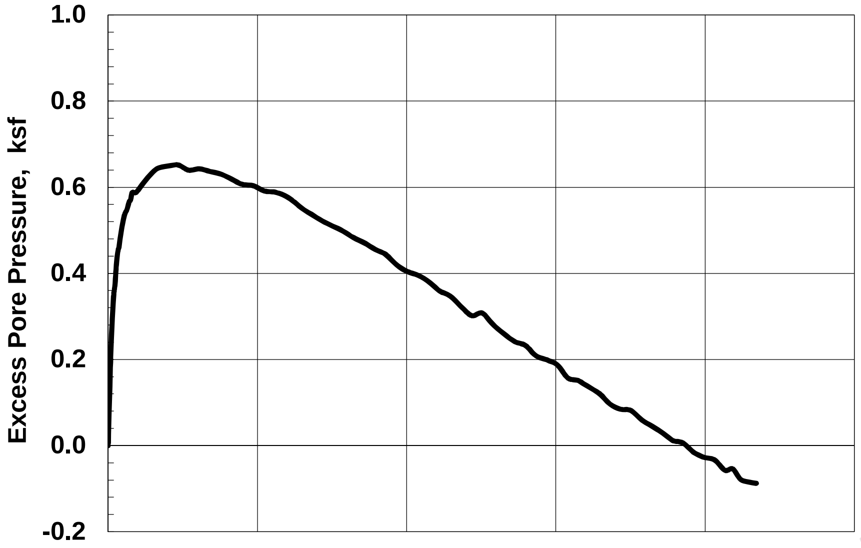




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B022 Sample: ST-3C	September-15
TerraSense, LLC			

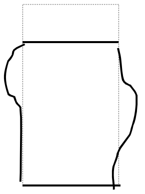


SAMPLE INFORMATION

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

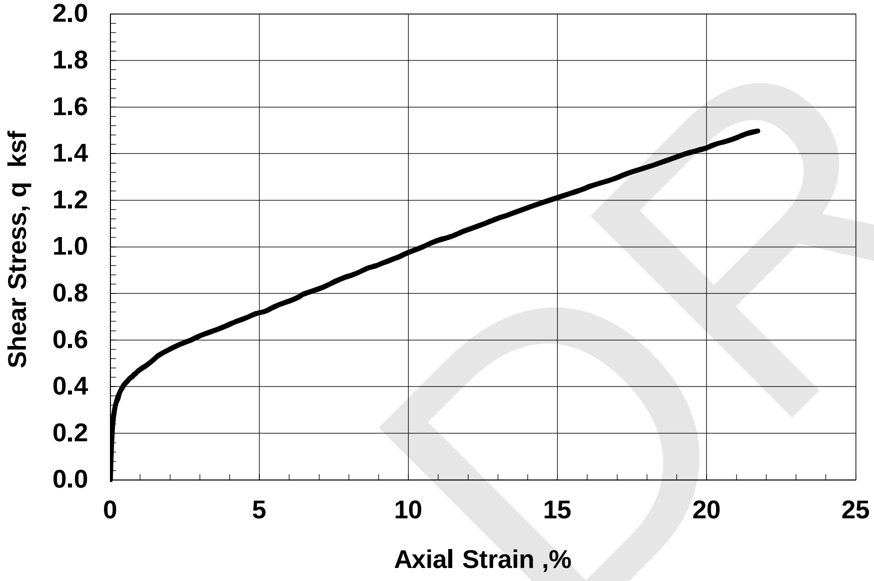


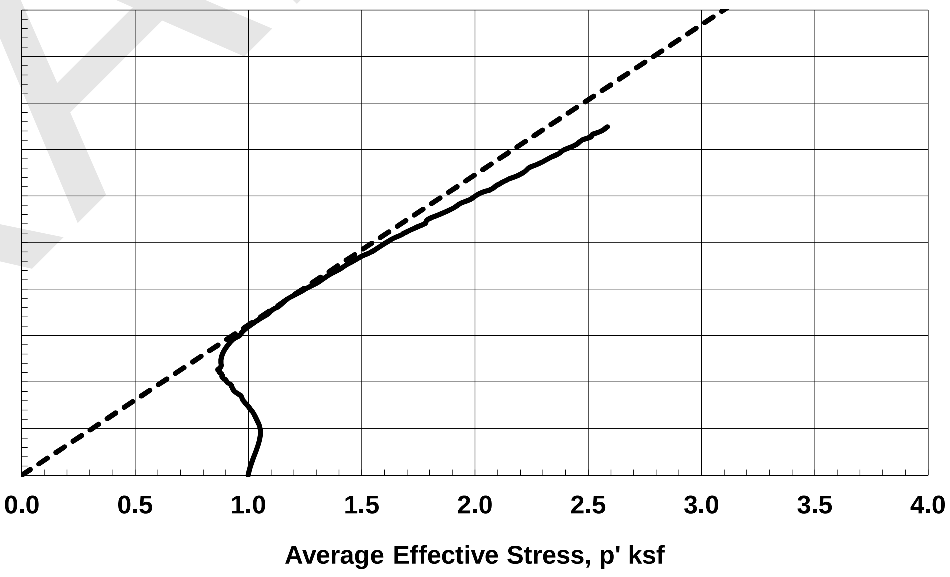
Failure Sketch

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:

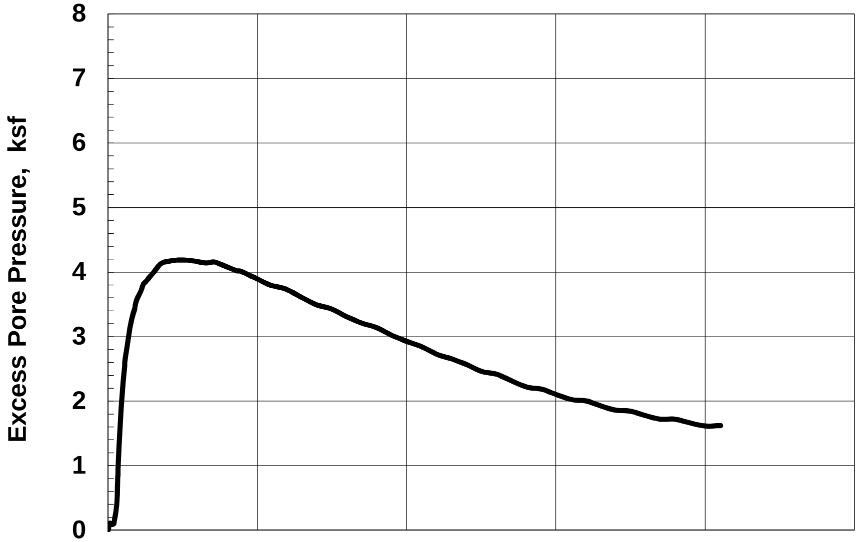




Test by: BB

Checked by: GET

Project No. T60428794	AECOM Dynegy CCR - Joppa	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION with Pore Pressure Measurements Boring: JOP-B023 Sample: ST-1B	September-15
TerraSense, LLC			



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)

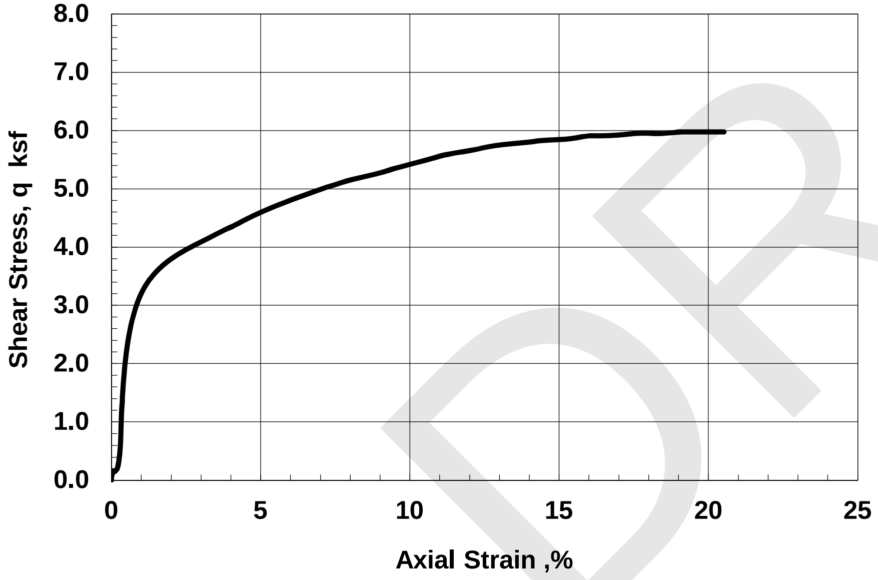
Height: 6.06 inch Diameter: 2.87 inch Area: 6.49 in²
Water Content: 18.1 % Total Unit Weight: 132.1 pcf

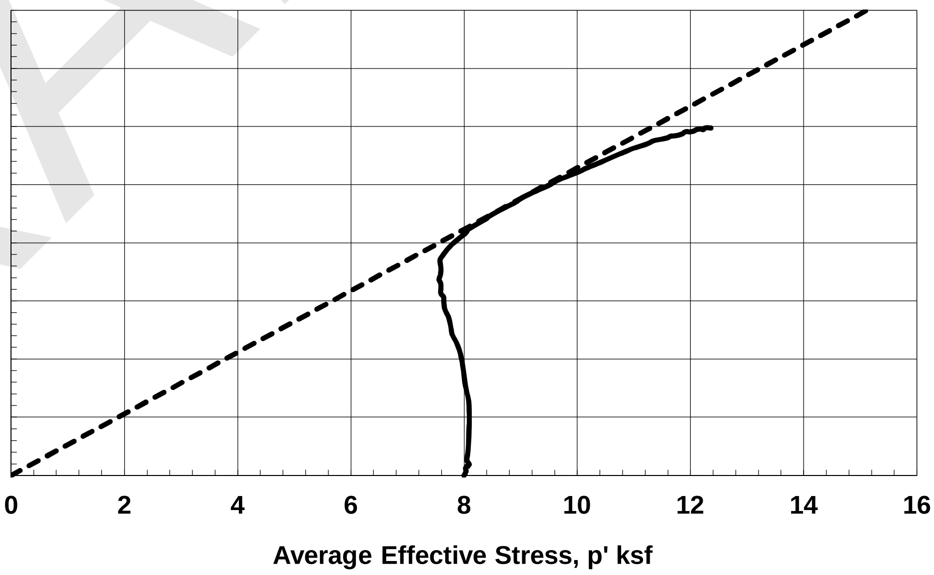
TEST SUMMARY

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	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-2B	October-15

DIRECT SHEAR TEST (ASTM D 3080): Setup / Take Down

Project Number: 04.11150035
Apparatus No.: DS-S02
File Name: P-B001_ST-2a
Task Number:
Assign. Units: ☒ ksf; or Other:
Ring No.: FL1
Project Name:
Series $\sigma'_{v,c}$ or $\sigma'_{n,c}$: 3 , 5
" 8 &
Area - Shear Box, A_{sb} (cm^2): 31.703
Height - Shear Box, H_{sb} (mm):
This Test $\sigma'_{v,c}$ or $\sigma'_{n,c}$: 3 ; 5 ; & 8
Shear Box: ☒ Circular ☐ Square
Induced OCR: NA ; Max. $\sigma'_{v,max}$: NA
Specific Gravity: 2.7 ☒ Assumed; ☐ Measured
Multistage: ☐ No; ☒ Yes
Residual/Multishearing: ☒ No; ☐ Yes
Precut Failure Plane ☒ No; ☐ Yes
Assign. Remarks:

☒ 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 Top (W1)	Bottom (W2)	Sides (W3)	Final, W_{at} (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 ; ☒ 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 ; ☒ No: ; Shear Box Free to Move Up & Down: ☐ Yes ; ☒ No:
Porous Inserts: ☒ Stone; ☐ Metal; **Do not use filter paper over porours inserts.** ; Free to Rotate: ☐ Yes ; ☒ No:
Porous Inserts with Additional Shear Transfer Features: ☐ None; ☐ Pins; ☐ Grid Plate; ☒ Waffle Stone; ☐ Other:
Apparatus deformation under consolidation load determined: ☐ Yes ; ☒ No

Sketch of Specimen

Photo taken of Sliced Test Specimen: ☐ Yes ; ☒ No
Final Visual Description: Sandy Clay, brown and greenish gray, with ferrous stains and small gravel
Trimming/Etc. Remarks:

Method of trimming periphery: ☒ "Casagrande" Lathe ; ☐ Cutting Shoe ; ☐ Wire Saw; ☐ Other
Method of trimming ends: ☐ Wire Saw & Sharp (knife) Straight Edge; ☒ 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): ☒ 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 × ρ_w × A_{sb}	
Estimated	0.11704
Final Selected	0.11704

Soil Height: Final by Dial Change During Test (mm)		For Multistage Testing 2nd Stage	3rd Stage
Initial Height, H_o	24.67		
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　☒ Assumed　☐ Measured
Mass Dry Soil, Md (g): 112.65　☒ 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
Task No.:
Project Name:
File Name: JOP-B001_ST-2a
Shear Box Dia./Width: 63.5 (mm)
Shear Box: ☒ Circular ☐ Square

App. No.: DS-S02
Consol. Stress, $\sigma'_{v,c}$: 3 (ksf)
Induced OCR: NA
$\sigma'_{v,max}$: NA (ksf)
Specimen Ht.: 23.88 (mm)
Vert. Strain During Consol.: 3.18 (%)

Boring No.: JOP-B001
Sample No.: ST-2
Specimen No.: a
Depth (ft): 10.00

Part of Test Series: ☒ No; ☐ Yes   If yes, Test: NA of NA
Multistage: ☐ No; ☒ Yes   If yes, Test Stage No.: 1
Residual/Multishearing: ☒ No; ☐ Yes   Precut Failure Plane ☒ 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:
☒ 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
Task No.:
Project Name:
File Name: JOP-B001_ST-2a
Shear Box Dia./Width: 63.5 (mm)
Shear Box: ☒ Circular ☐ Square

App. No.: DS-S02
Consol. Stress, $\sigma'_{v,c}$: 5 (ksf)
Induced OCR: NA
$\sigma'_{v,max}$: NA (ksf)
Specimen Ht.: 23.51 (mm)
Vert. Strain During Consol.: 0.73 (%)

Boring No.: JOP-B001
Sample No.: ST-2
Specimen No.: a
Depth (ft): 10.00

Part of Test Series: ☒ No; ☐ Yes If yes, Test: NA of NA
Multistage: ☐ No; ☒ Yes If yes, Test Stage No.: 2
Residual/Multishearing: ☒ No; ☐ Yes Precut Failure Plane ☒ 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:
☒ 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: ☒ Circular ☐ Square Vert. Strain During Consol.: 0.69 (%)

Part of Test Series: ☒ No; ☐ Yes If yes, Test: NA of NA
Multistage: ☐ No; ☒ Yes If yes, Test Stage No.: 3
Residual/Multishearing: ☒ No; ☐ Yes Precut Failure Plane ☒ 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:
☒ 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)

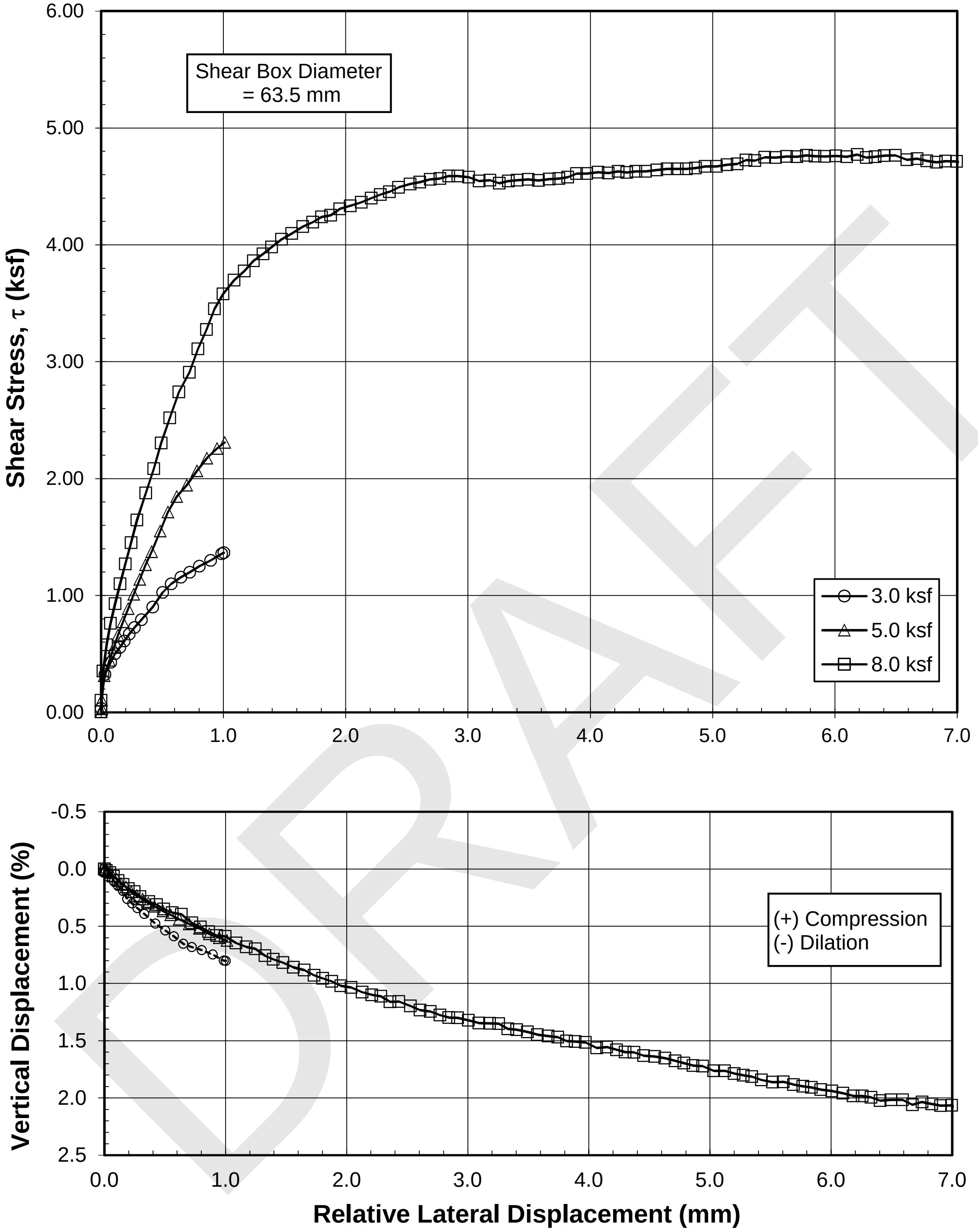
Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
0.00	0.0000	0.12	0.00	0.00
10.00	-0.0009	0.25	0.00	0.01
20.00	-0.0020	0.39	-0.01	0.01
33.00	-0.0022	0.70	-0.01	0.02
48.00	-0.0020	1.11	0.00	0.03
63.00	0.0002	3.55	0.00	0.10
78.00	0.0164	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

Sign Convention:
(+) Compression or Fowards
(-) Dilation or Backwards

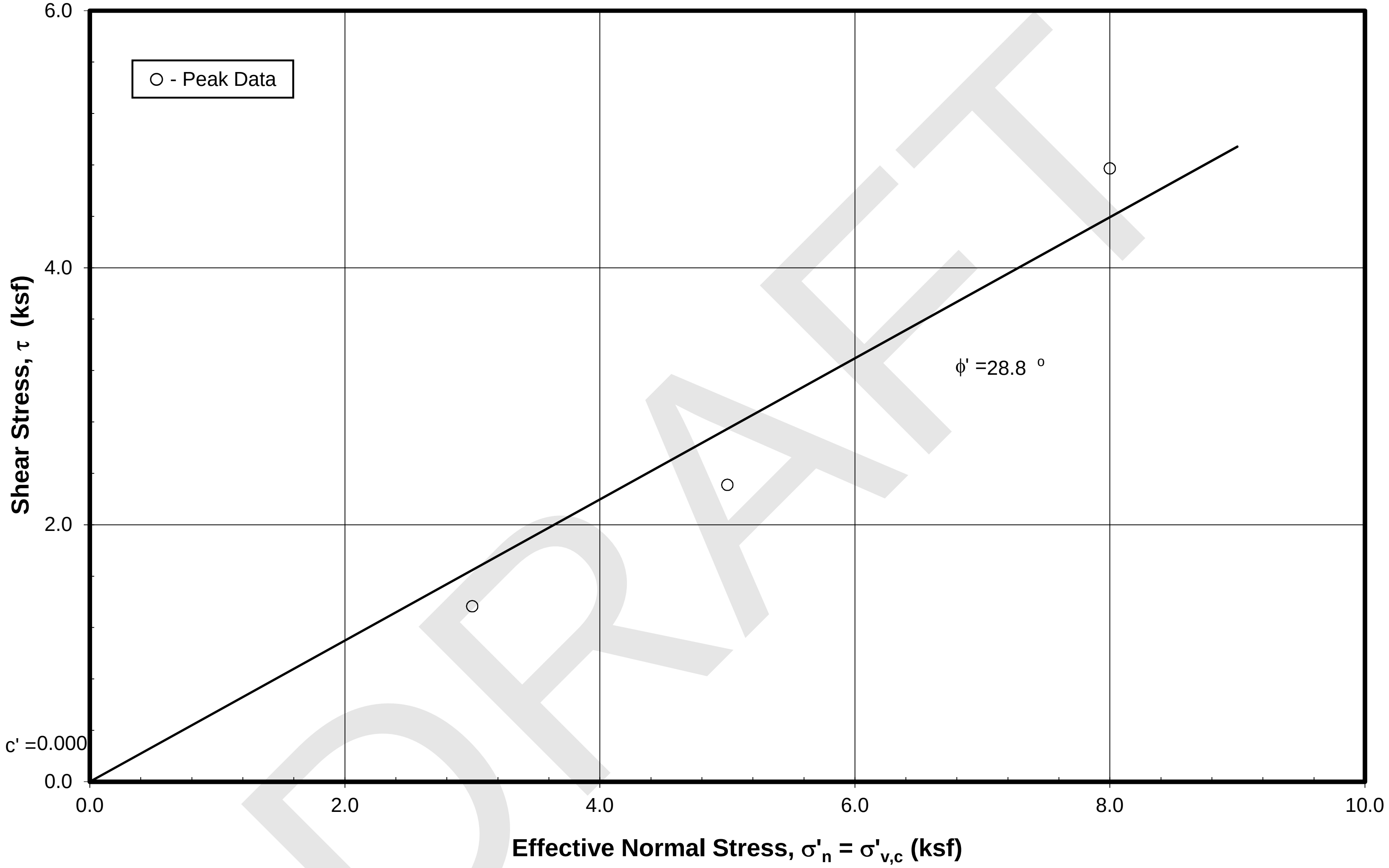
Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
785.00	2.1287	148.94	1.08	4.36
810.00	2.2088	150.11	1.10	4.40
835.00	2.2835	151.21	1.11	4.43
860.00	2.3587	151.94	1.16	4.45
885.00	2.4318	153.23	1.16	4.49
910.00	2.5268	154.20	1.20	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



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.; ☒ Assumed

☒ Tube ☐ Field Extruded ☐ Liner ☐ Remolded
Boring No.: JOP-B001 ☐ LPC Core
Sample No.: ST-2 Compostite No.:
Depth (ft): 9.75 Specimen No.: b
☐ Spec. Selection by X-ray; ☐ Geomarine Sample

☐ Tamping
☐ Impact/Rammer
☐ Pluviated:
☐ Kneading

☐ Constant Effort: Blows/Tamps per Layer =
Rammer Wgt.(lbf)= No. Layers =
Tamper Force (lbf)= Drop (in.) =
☐ Undercompaction: U_{ni} (%) = Dia. (in.) =
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 ☐ Post Cyclic ☒ Const. Vol./Ht ☐ Drained ☒ Without - Water ☐ With - Bath ☒ Cyclic (Hz) Rate: ☐ 0.1; ☒ 1; Other: ☐ Strain ☒ Stress

Water Content (WC);	Initial - Trimming Location Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	Final, W_{at} (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}:	☒ 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, $M_{t,o}$ $M_{t,at}$ (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 #
☒ 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:

☒ **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}: ☒ Yes; ☐ No Plattens with Pins: ☐ Yes; ☒ 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: ☒ Spec. removed right after shearing Remarks:
☐ Spec. unloaded to zero stress with access to water

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; ☒ Assumed

Type Test: CyDSS ta=0 Specimen: ☒ "Intact"; ☐ Reconstituted; ☐ Remolded

Calculations Corr. for Salt (dissolved solids): ☒ 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)

☒ 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	87.93

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 Consol.: to $\sigma'_{v,c}$	17.995	62.95	34.98	34.4	117.2	87.2	100.0		NA
After 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: JJR

Reviewed By: HP

Remarks:

RESULTS OF CYCLIC DSS STRENGTH TEST

Project Number: 4.11150035
Task Number
Project Name:

Boring/Exploration No.: JOP-B001
Sample No.: ST-2b
Specimen No: b
Depth : 9.75 (ft)

Test Type: CyDSS ta=0
Test Sequence Number:
File Name: JOP-B001_ST-2b

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

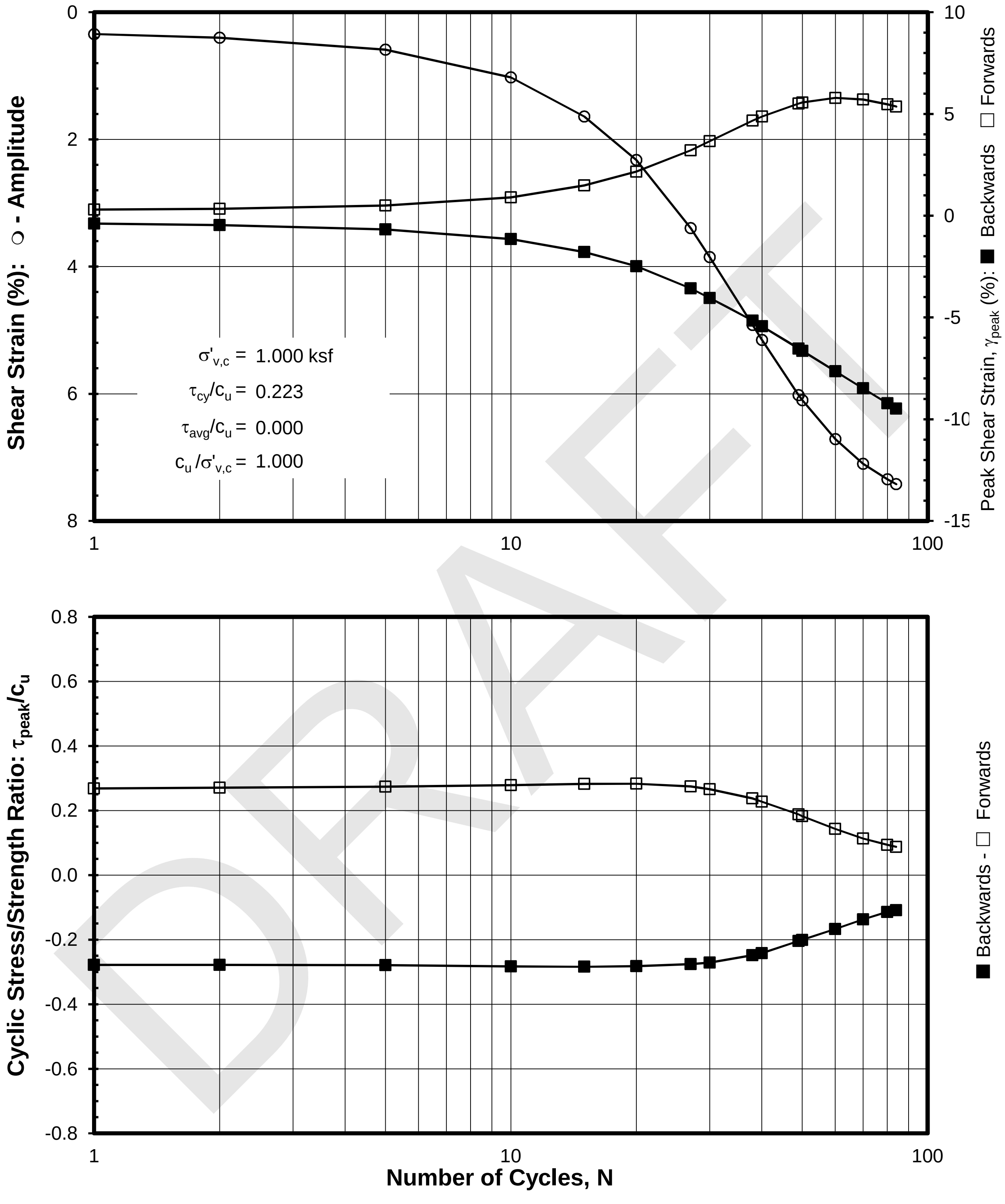
Static DSS $c_u/\sigma'_{v,c}$: 1.000
τ_{avg}/c_u: 0.000
τ_{cy}/c_u : 0.223
Ψ'_{DSS} : (degree)
$\gamma_{hf,max}$ (%) : 5.79
$\gamma_{hb,max}$ (%) : -9.48

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 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)	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 (%)	Backwards [1] γ_b (%)	Cyclic Shear Strain Amp. γ_{cy} (%)	Average Shear Strain γ_{avg} (%) [2]	Shear Modulus $(\tau_{cy} / \gamma_{cy})$ 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

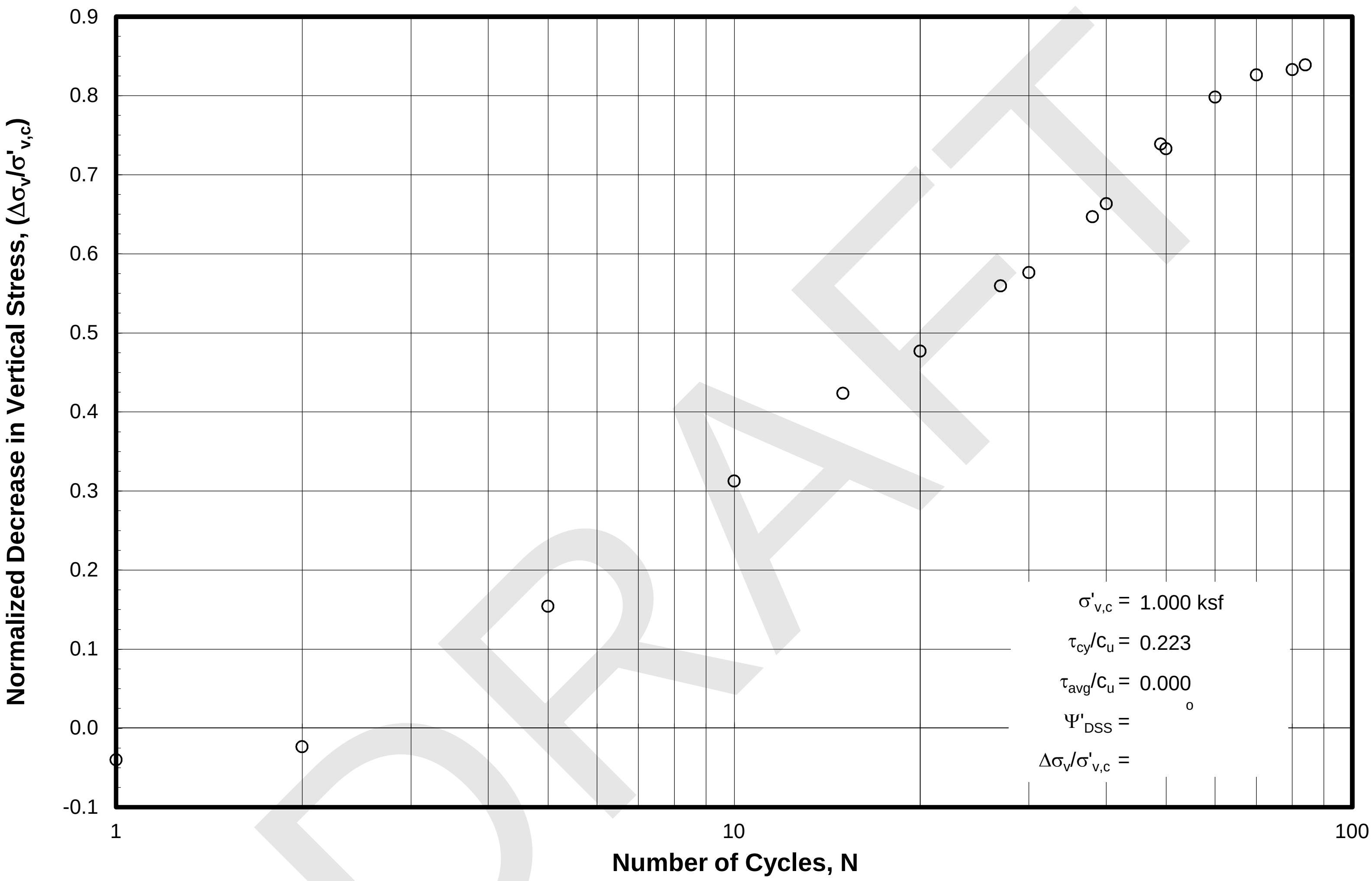


CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-2b - Depth: 9.75 ft

Boring JOP-B001

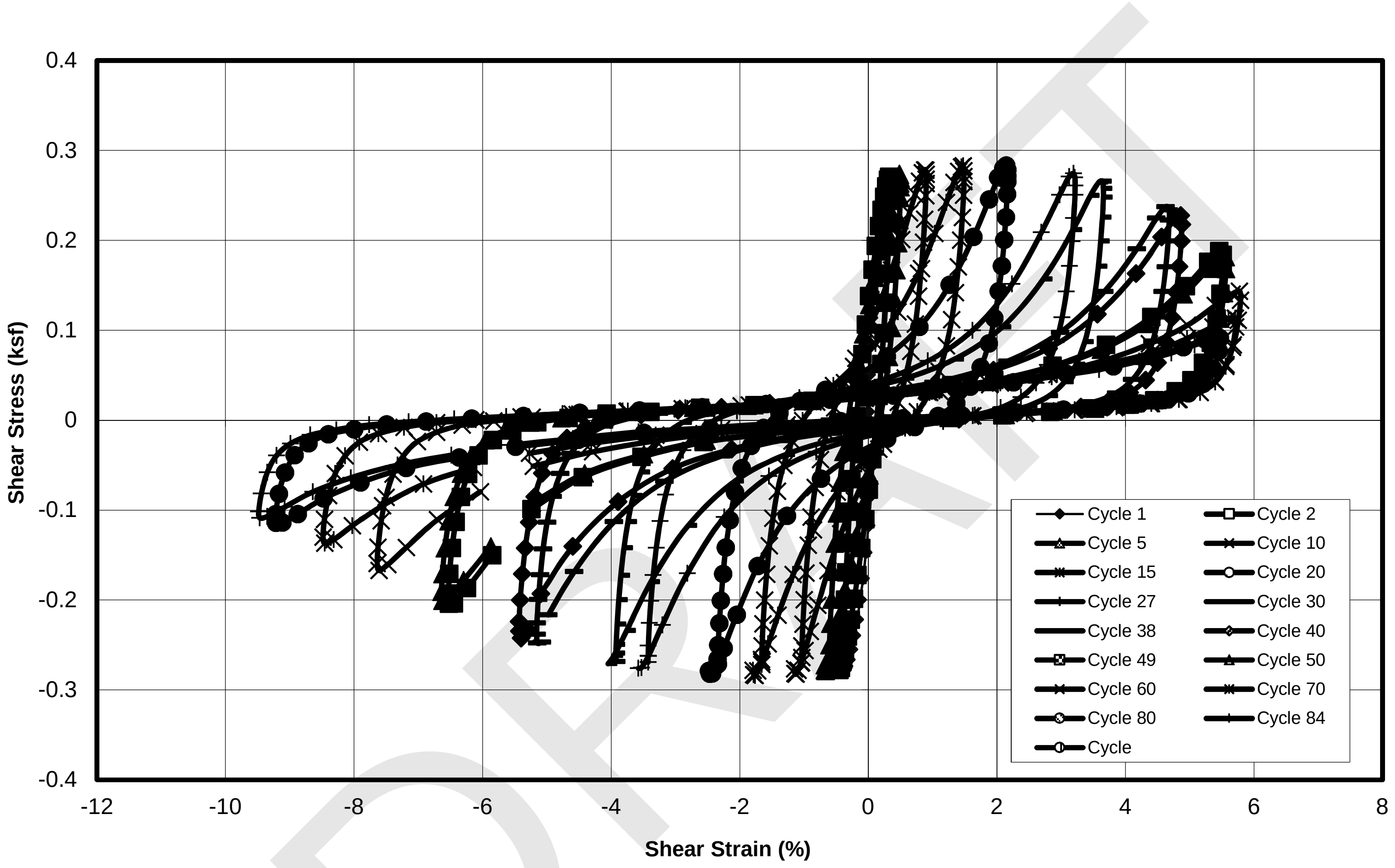


CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

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.; ☒ Assumed

☒ 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: ☐ 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 ☐ Post Cyclic ☐ Const, Vol./Ht ☐ Drained ☐ Without - Water ☐ With - Bath ☐ Cyclic (Hz) Rate: ☐ 0.1; ☐ Strain ☐ Stress 1; Other:

Water Content (WC);	Initial - Trimming Location Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	Final, W_{at} (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}: ☒ 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, $M_{t,o}$ $M_{t,at}$ (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 #
☒ 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

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:

☒ **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)=

Note: NA-Indicates not applicable. Top Cap No. 16 Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf

F or G in the Sta. No. indicates Fugro or GEOTAC apparatus. Data corr. for M_{tc}: ☒ Yes; ☐ No Plattens with Pins: ☐ Yes; ☒ 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: ☒ Spec. removed right after shearing Remarks:

☐ Spec. unloaded to zero stress with access to water

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; ☒ Assumed
Type Test: Post Cyclic DSS Specimen: ☒ "Undisturbed"; ☐ Reconstituted; ☐ Remolded
Calculations Corr. for Salt (dissolved solids): ☒ 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	ΔV_c (cm^3) =	1.14	ΔH_c (mm) =	0.323	$\varepsilon_{a,c}$ (%) =	1.76	$\Delta V_{c,max}$ (cm^3) =	NA
& Preshear	V_c (cm^3) =	62.95	H_c (mm) =	17.995	$\varepsilon_{v,c}$ (%) =	1.78	$\varepsilon_{ac,max}$ (%)=	NA
Conclusions	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
Project Name:
Test Number:

Task Number:
Test Type: Post Cyclic DSS
Test Series No.:

Boring No.: JOP-B001
Sample No.: ST-2
Specimen No.: b
Depth (ft.): 9.75

Horiz. Load Factor (lbf/V/V): 29.983
Horiz. Load, Test Floating Zero (V/V): 3.494E-03
Horiz. Deform. Factor (mm/V/V): -0.394

Vert. Load Factor (lbf/V/V): 144.426
Vert. Load, Test Floating Zero (V/V): 7.854E-03
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:

☒ 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 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 ☐ Stress ☐ 1; Other:

Summary of Specimen Physical Properties

Specific Gravity: G_s = 2.700	Height	Volume	Area	Water Content	Unit Weight Total	Unit Weight Dry	Saturation	LL PL PI		
Condition:	(mm)	(cm^3)	(cm^2)	(%)	(pcf)	(pcf)	(%)			
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}: ☒ Yes; ☐ No Plattens with Pins: ☐ Yes; ☒ No

☒ Wire Reinforced Membrane, Model: C=1.5 Data corr. for Membr. strength

☐ Regular Membrane with Rings ☐ Yes ☒ No

Data Normalization: ☒ Yes ☐ No Value: 1.000 (ksf)

Using Effective Vertical Stress:

☒ 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

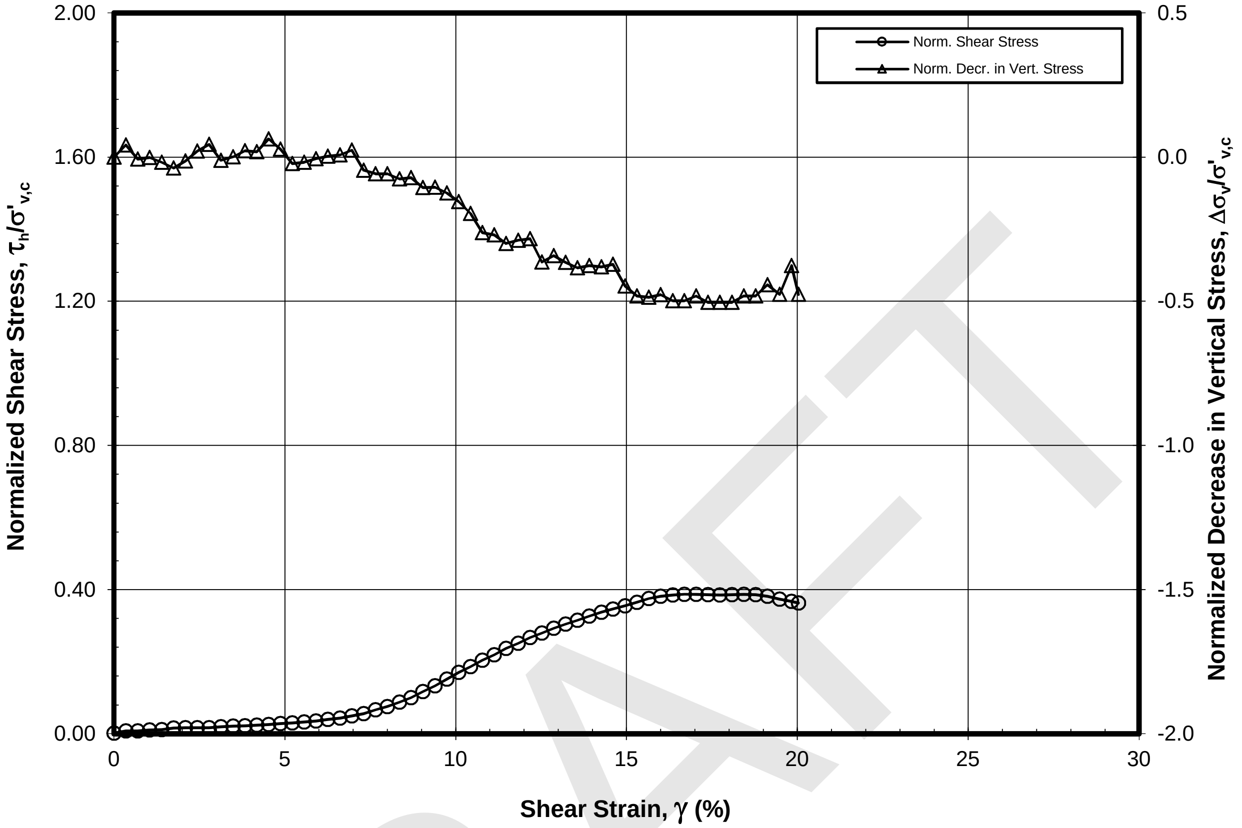
Final Visual Description and Remarks: Clay Sandy, Brown gray, with Silty Pockets

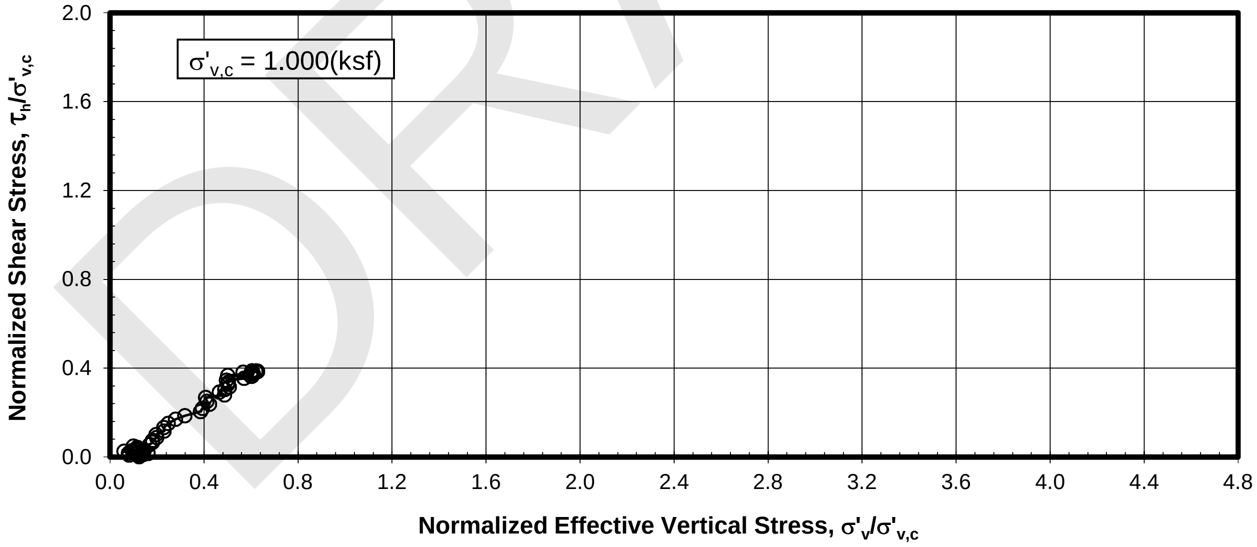
Loading Summary

	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: OP-B002_ST-1a

Task Number: ______ Assign. Units: ☒ 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: ☒ Circular ☐ Square

Induced OCR: NA ; Max. $\sigma'_{v,max}$: NA Specific Gravity: 2.7 ☒ Assumed;

Multistage: ☐ No; ☒ Yes Residual/Multishearing: ☒ No; ☐ Yes Precut Failure Plane ☒ No; ☐ Yes ☐ Measured

Assign. Remarks: ______

☒ 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 ; ☒ 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 ; ☒ No: Shear Box Free to Move Up & Down: ☐ Yes ; ☒ No:
	Porous Inserts: ☒ Stone; ☐ Metal; **Do not use filter paper over porours inserts.** Free to Rotate: ☐ Yes ; ☒ No:
	Porous Inserts with Additional Shear Transfer Features: ☐ None; ☐ Pins; ☐ Grid Plate; ☒ Waffle Stone; ☐ Other:
	Apparatus deformation under consolidation load determined: ☐ Yes ; ☒ No

Sketch of Specimen

Photo taken of Sliced Test Specimen: ☐ Yes ; ☒ No

Final Visual Description: Sandy Clay, brown, with ferrous stains

Trimming/Etc. Remarks:

Method of trimming periphery: ☒ "Casagrande" Lathe ; ☐ Cutting Shoe ; ☐ Wire Saw; ☐ Other

Method of trimming ends: ☐ Wire Saw & Sharp (knife) Straight Edge; ☒ 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): ☒ 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		Input Data for Back Calculation	
Item	Value	$S_{o,n}$ (%)	
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 2nd Stage	3rd Stage
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	☒ Assumed	☐ Measured				
Mass Dry Soil, Md (g)	131.99	☒ 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
Task No.:
Project Name:
File Name: JOP-B002_ST-1a
Shear Box Dia./Width: 63.5 (mm)
Shear Box: ☒ Circular ☐ Square

App. No.: DS-S01
Consol. Stress, $\sigma'_{v,c}$: 2 (ksf)
Induced OCR: NA
$\sigma'_{v,max}$: NA (ksf)
Specimen Ht.: 23.95 (mm)
Vert. Strain During Consol.: 3.61 (%)

Boring No.: JOP-B002
Sample No.: ST-1
Specimen No.: a
Depth (ft): 5.00

Part of Test Series: ☒ No; ☐ Yes If yes, Test: NA of NA
Multistage: ☐ No; ☒ Yes If yes, Test Stage No.: 1
Residual/Multishearing: ☒ No; ☐ Yes Precut Failure Plane ☒ 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:
- ☒ 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
Task No.:
Project Name:
File Name: JOP-B002_ST-1a
Shear Box Dia./Width: 63.5 (mm)
Shear Box: ☒ Circular ☐ Square

App. No.: DS-S01
Consol. Stress, $\sigma'_{v,c}$: 4 (ksf)
Induced OCR: NA
$\sigma'_{v,max}$: NA (ksf)
Specimen Ht.: 23.61 (mm)
Vert. Strain During Consol.: 0.94 (%)

Boring No.: JOP-B002
Sample No.: ST-1
Specimen No.: a
Depth (ft): 5.00

Part of Test Series: ☒ No; ☐ Yes If yes, Test: NA of NA
Multistage: ☐ No; ☒ Yes If yes, Test Stage No.: 2
Residual/Multishearing: ☒ No; ☐ Yes Precut Failure Plane ☒ 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:
☒ 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
Task No.:
Project Name:
File Name: JOP-B002_ST-1a
Shear Box Dia./Width: 63.5 (mm)
Shear Box: ☒ Circular ☐ Square

App. No.: DS-S01
Consol. Stress, $\sigma'_{v,c}$: 8 (ksf)
Induced OCR: NA
$\sigma'_{v,max}$: NA (ksf)
Specimen Ht.: 23.25 (mm)
Vert. Strain During Consol.: 0.98 (%)

Boring No.: JOP-B002
Sample No.: ST-1
Specimen No.: a
Depth (ft): 5.00

Part of Test Series: ☒ No; ☐ Yes If yes, Test: NA of NA
Multistage: ☐ No; ☒ Yes If yes, Test Stage No.: 3
Residual/Multishearing: ☒ No; ☐ Yes Precut Failure Plane ☒ 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:
☒ 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)

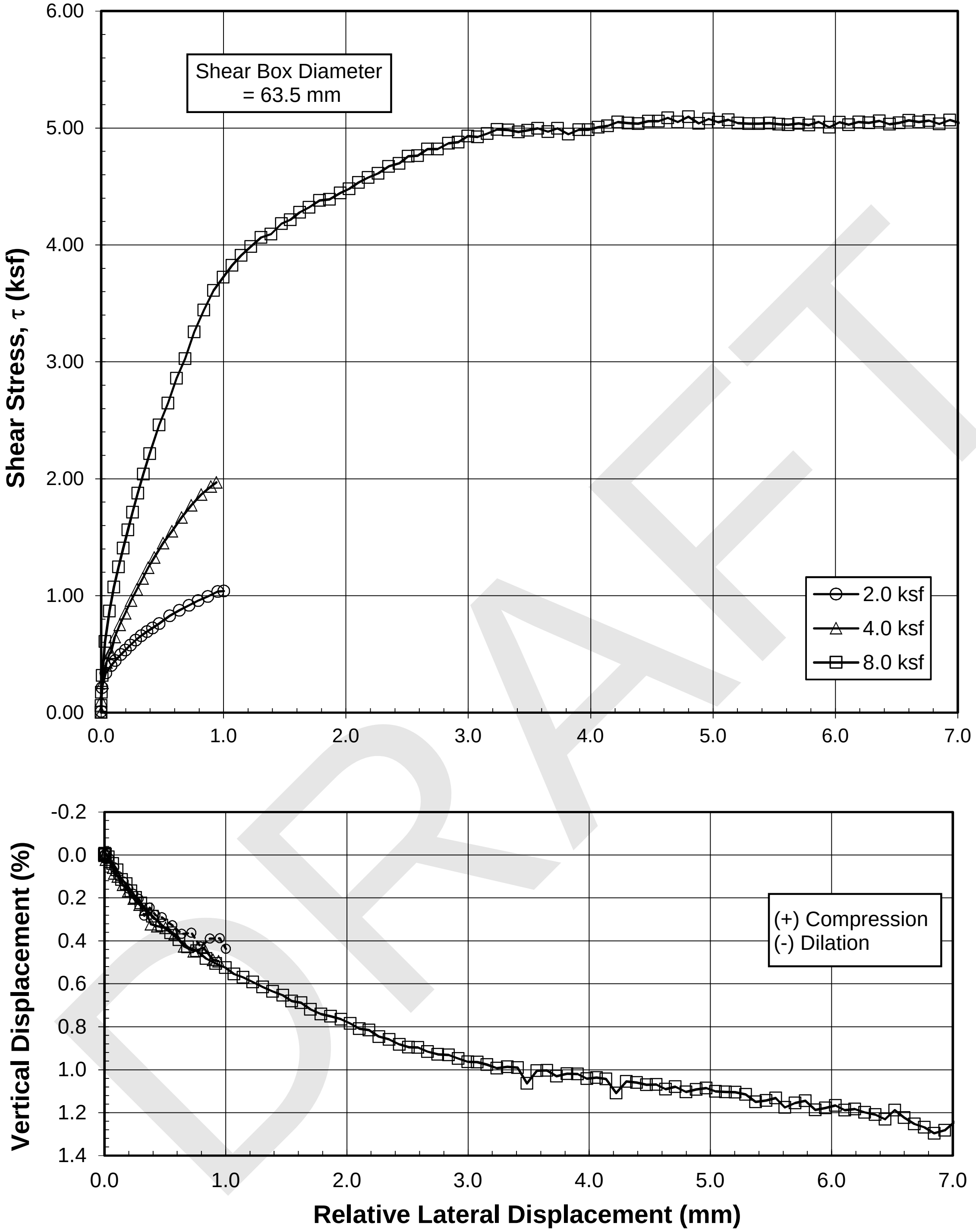
Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
0.00	0.0000	0.07	0.00	0.00
10.00	0.0001	2.04	0.00	0.06
20.00	0.0033	5.91	-0.01	0.17
33.00	0.0098	10.84	0.00	0.32
48.00	0.0325	20.76	0.01	0.61
63.00	0.0673	29.59	0.04	0.87
78.00	0.1040	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

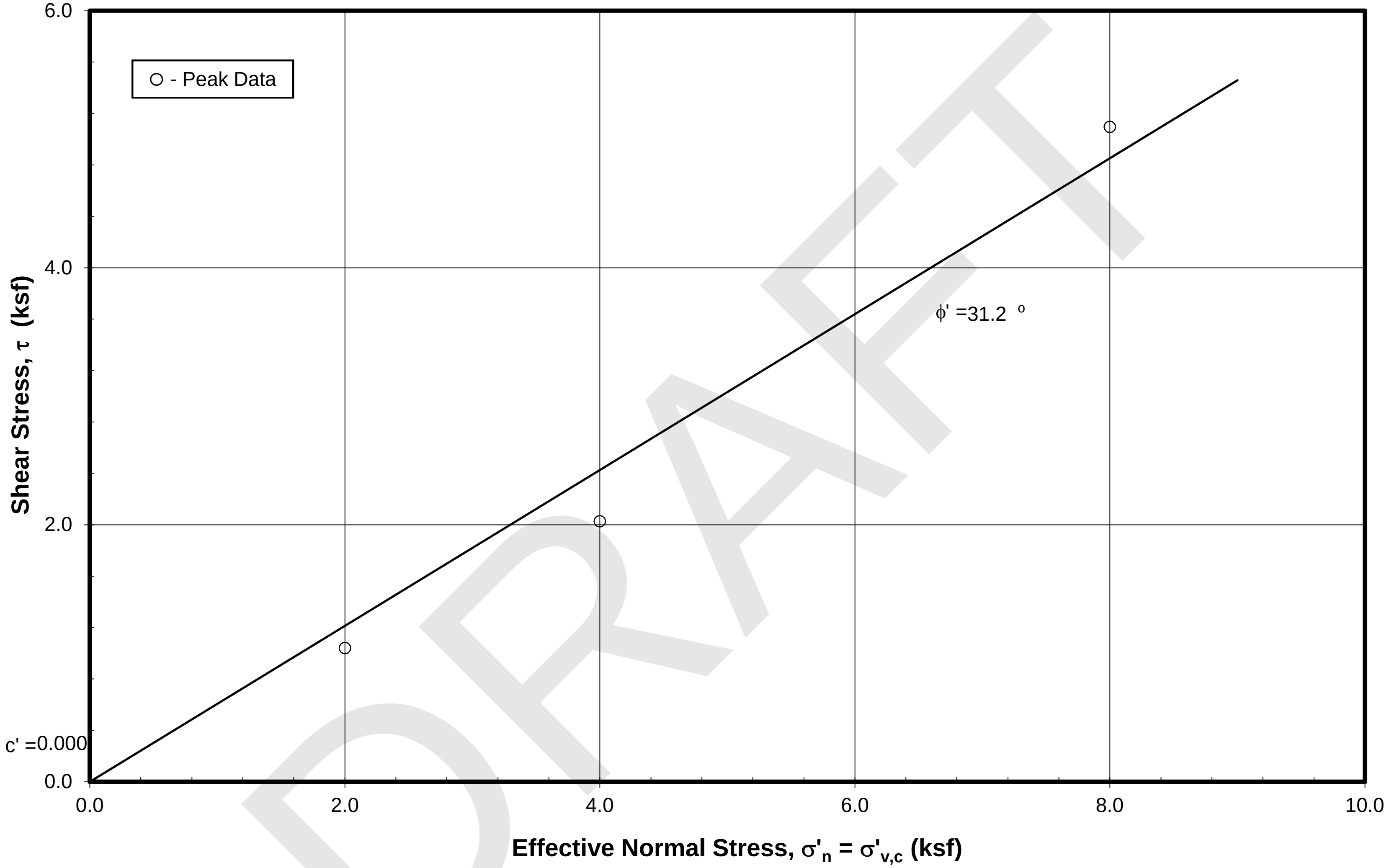
Elapsed Time (min)	Rel. Lateral Displacement (mm)	Horiz. Force (lbf)	Vert. Displacement (%)	Shear Stress, τ (kips/ft^2)
785.00	2.2644	157.41	0.85	4.61
810.00	2.3500	159.35	0.86	4.67
835.00	2.4345	160.28	0.88	4.70
860.00	2.5096	162.37	0.90	4.76
885.00	2.5858	162.56	0.90	4.76
910.00	2.6668	164.45	0.92	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.; ☒ Assumed

☒ Tube ☐ Field Extruded ☐ Liner ☐ Remolded
Boring No.: JOP-B002 ☐ LPC Core
Sample No.: ST-1 Compostite No.:
Depth (ft): 4.75 Specimen No.: b
☐ Spec. Selection by X-ray; ☐ Geomarine Sample

☐ Tamping
☐ Impact/Rammer
☐ Pluviated:
☐ Kneading

☐ Constant Effort: Blows/Tamps per Layer =
Rammer Wgt.(lbf)= No. Layers =
Tamper Force (lbf)= Drop (in.) =
☐ Undercompaction: U_{ni} (%) = Dia. (in.) =
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 ☐ Post Cyclic ☒ Const, Vol./Ht ☐ Drained ☒ Without - ☐ With - Water Bath ☒ Cyclic (Hz) Rate: ☐ 0.1; ☒ 1; Other: ☐ Strain ☒ Stress

Water Content (WC);	Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	Final, W_{at} (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}:	☒ 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, $M_{t,o}$ $M_{t,at}$ (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 #
☒ 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

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:

☒ **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)=

Note: NA-Indicates not applicable. Top Cap No. 16
Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf
F or G in the Sta. No. indicates Fugro or GEOTAC apparatus.
Data corr. for M_{tc}: ☒ Yes; ☐ No Plattens with Pins: ☐ Yes; ☒ No

Sketch of Specimen

Final Visual Description: Silty Clay, Tan & Gray, with Few Ferrous Stains

Other Remarks :

Trim./ Recon. By: HC Set Up By: HC Taken Down By: HC
Date: 12/14/2015 Date: 12/16/2015 Date: 12/17/2015
Prelim. Calc. By: HC Final Calc. By: JJR Reviewed By: HP

Specimen Take Down: ☒ Spec. removed right after shearing Remarks:
☐ Spec. unloaded to zero stress with access to water

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; ☒ Assumed

Type Test: CyDSS ta=0 Specimen: ☒ "Intact"; ☐ Reconstituted; ☐ Remolded

Calculations Corr. for Salt (dissolved solids): ☒ No or, ☐ Yes, with concentration = ______ ppm

Consolidation Stress Summary and Loading Summary

Test Stage:	Max. Stress	Pre-Cyclic	Post Cyclic	☐ Static Strain Rate = NA (%/hr or)		
Nominal Vertical Stress, σ'_v (ksf)	NA	0.5		☒ Cyclic Rate (Hz): ☐ 0.1; ☒ 1; Other =		
Axial/Vertical Force, $P_{vr,n}$ (lbf)	NA	NA		During/End of Loading	Static	Cyclic
Horizontal Force, $P_{hr,n}$ (lbf)	NA	0		Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Nominal OCR	NA	1		Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
t_c,(ON,days,hrs)	NA	0.18 days		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	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 Spec. Unloaded to 0 Stress**	
By Cal. Ht. & Init. Spec. Area			
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 Consol.: to $\sigma'_{v,c}$	17.650	61.67	34.94	23.8	127.4	103.0	100.0		NA
After 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
Task Number:
Project Name:
Boring/Exploration No.: JOP-B002
Sample No.: ST-1b
Specimen No: b
Depth : 4.75 (ft)
Test Type: CyDSS ta=0
Test Sequence Number:
File Name: JOP-B002_ST-1b
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

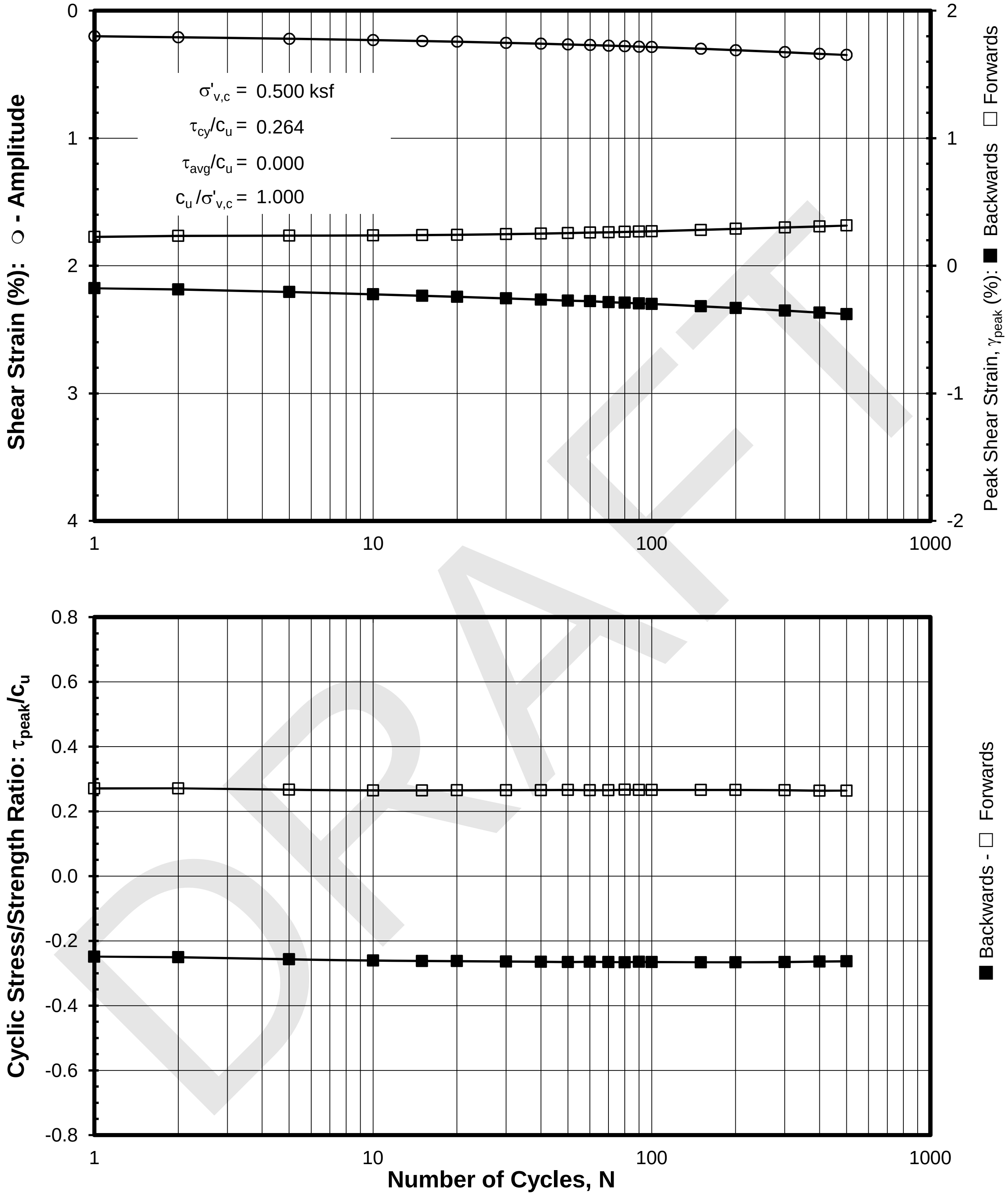
Summary of Specimen Physical Properties:

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 Consol.: to $\sigma'_{v,c}$	17.650	61.67	34.94	23.8	127.4	103.0	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	0.135	-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)	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 (%)	Backwards [1] γ_b (%)	Cyclic Shear Strain Amp. γ_{cy} (%)	Average Shear Strain γ_{avg} (%) [2]	Shear Modulus $(\tau_{cy} / \gamma_{cy})$ 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

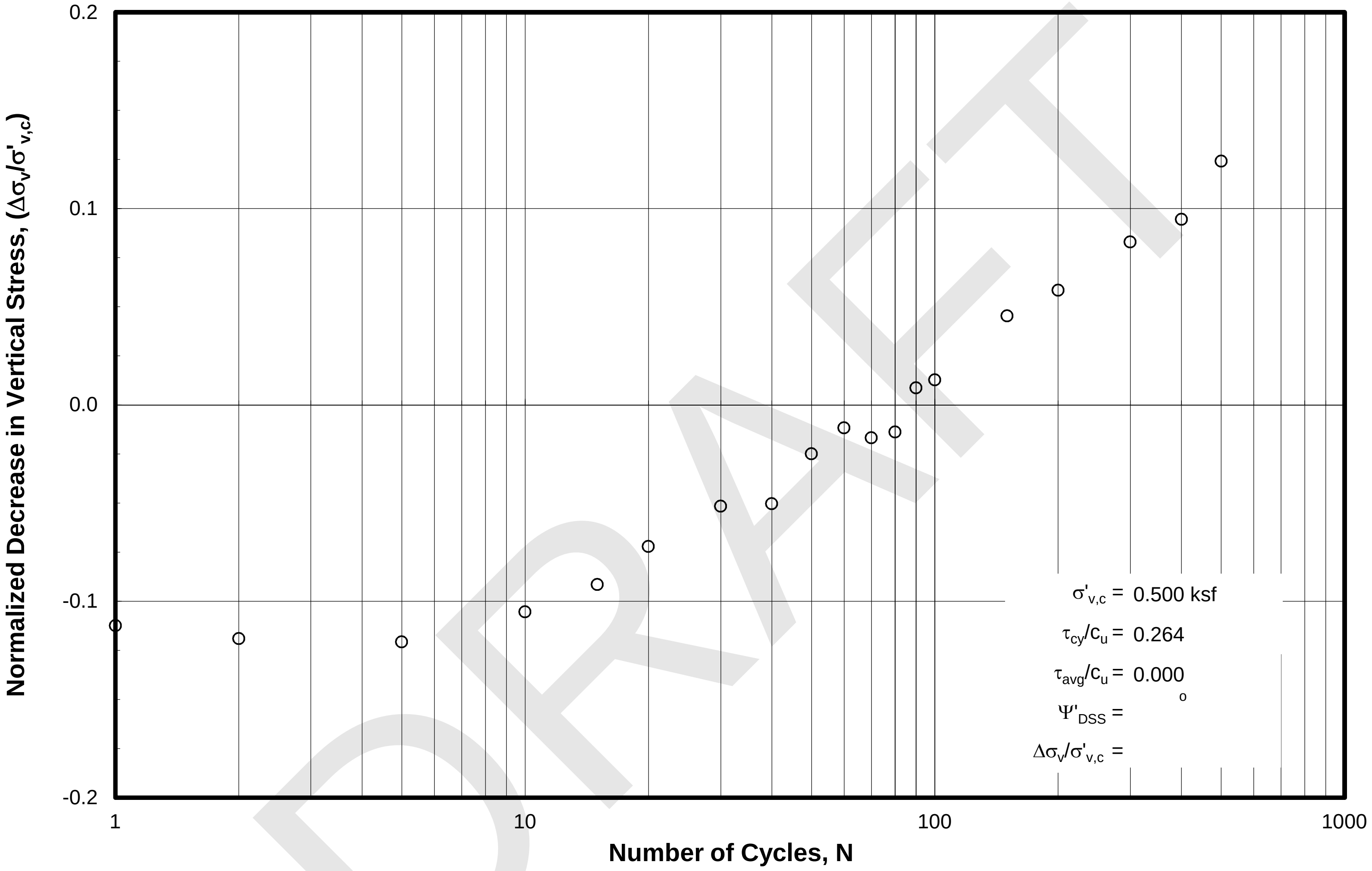


CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-1b - Depth: 4.75 ft

Boring JOP-B002

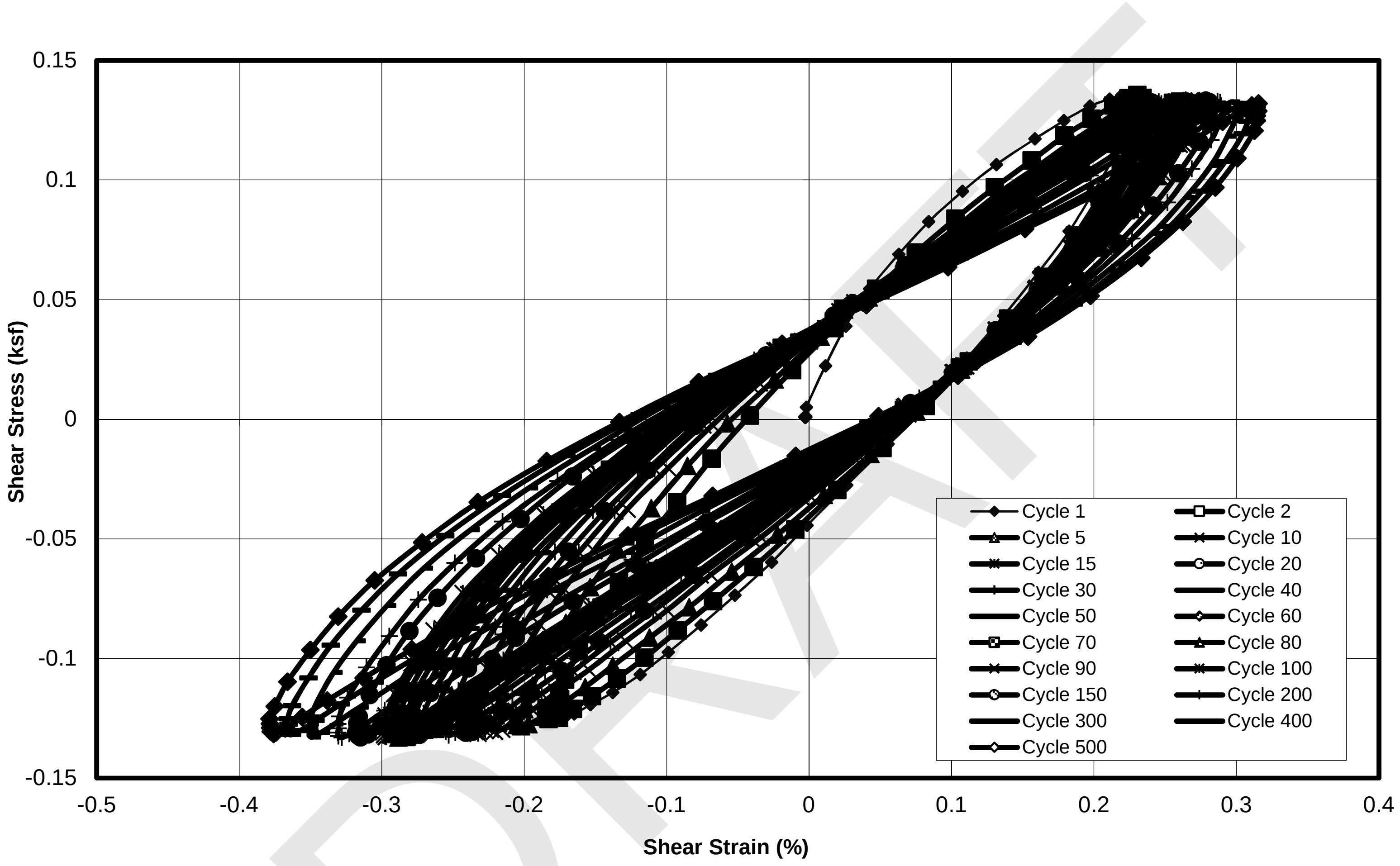


CYCLIC DSS STRENGTH TEST: Without Undrained Bias Shear Stress

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.; ☒ Assumed

☒ 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:	☐ 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 ☒ Post Cyclic	☐ Const, Vol./Ht ☐ Drained	☐ Without - Water ☐ With - Bath	☐ Cyclic (Hz) Rate: ☐ 0.1;	☐ Strain ☐ Stress ☐ 1; Other:

Water Content (WC);	Initial - Trimming Location Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	Final, W_{at} (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}:	☒ 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 #
☒ Trimming Ring for NGI Apparatus			Small-ring ID #
$H_{s,t}$ (mm):	17.91	$A_{s,t}$ (cm²):	34.98
$D_{s,t}$ (mm) :	66.73	$V_{s,t}$ (cm³):	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} (cm²):	NA
=	17.914	Avg	NA	V_{tr} (cm³):	NA

Estimated Initial Unit Weight

Total, $\gamma_{t,o}$ (lb/ft³)= 123.80 Dry, $\gamma_{d,o}$ (lb/ft³)= 101.97

Specimen Lateral Confinement by:

☒ **Wire Reinforced, Model:** C=1.5 Thickness (mm) = 0.72

Stress Level	Dia. by PiTape (mm) Meas.	Corr.	Area, $A_{c,n}$ (cm²)	(in²)
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 (cm²) ; (in²)=

Note: NA-Indicates not applicable. Top Cap No. 16
F or G in the Sta. No. indicates Fugro or GEOTAC apparatus.

Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf
Data corr. for M_{tc}: ☒ Yes; ☐ No Plattens with Pins: ☐ Yes; ☒ No

Sketch of Specimen

Final Visual Description: Silty Clay, Tan & Gray, with Few Ferrous Stains

Other Remarks :

Trim./ Recon. By: HC Set Up By: HC Taken Down By: HC
Date: 12/14/2015 Date: 12/16/2015 Date: 12/17/2015
Prelim. Calc. By: HC Final Calc. By: JJR Reviewed By: HP

Specimen Take Down: ☒ Spec. removed right after shearing Remarks:
☐ Spec. unloaded to zero stress with access to water

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; ☒ Assumed

Type Test: Post Cyclic DSS　Specimen: ☒ "Undisturbed"; ☐ Reconstituted; ☐ Remolded

Calculations Corr. for Salt (dissolved solids): ☒ 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 Spec. Unloaded to 0 Stress**	
By Cal. Ht. & Init. Spec. Area			
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 Consol.: to $\sigma'_{v,c}$	17.650	61.67	34.94	23.8	127.4	103.0	100.0	
After 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
Project Name:
Test Number:
Task Number:
Test Type: Post Cyclic DSS
Test Series No.:
Boring No.: JOP-B002
Sample No.: ST-1
Specimen No.: b
Depth (ft.): 4.75

Horiz. Load Factor (lbf/V/V): 29.983
Horiz. Load, Test Floating Zero (V/V): 3.494E-03
Horiz. Deform. Factor (mm/V/V): -0.394
Vert. Load Factor (lbf/V/V): 144.426
Vert. Load, Test Floating Zero (V/V): 1.443E-02
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:

☒ 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 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 ☐ Stress ☐ 1; Other:

Summary of Specimen Physical Properties

Specific Gravity: G_s = 2.720 **Condition:**	Height (mm)	Volume (cm^3)	Area (cm^2)	Water Content (%)	Unit Weight Total (pcf)	Unit Weight Dry (pcf)	Saturation (%)	LL PL PI		
Initial	17.91	62.66	34.98	22.18	123.8	101.3	89.7			
After Consol.: to $\sigma'_{v,c}$	17.65	61.67	34.94	23.76	127.4	103.0	100.0			
After 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}: ☒ Yes; ☐ No Plattens with Pins: ☐ Yes; ☒ No
☒ Wire Reinforced Membrane, Model: C=1.5 Data corr. for Membr. strength
☐ Regular Membrane with Rings ☐ Yes ☒ No

Data Normalization: ☒ Yes ☐ No Value: 0.500 (ksf)
Using Effective Vertical Stress:
☒ Pre-Shear Conditions ☐ Post-Cyclic Conditions
☐ Maximum Stress during Consol. ☐

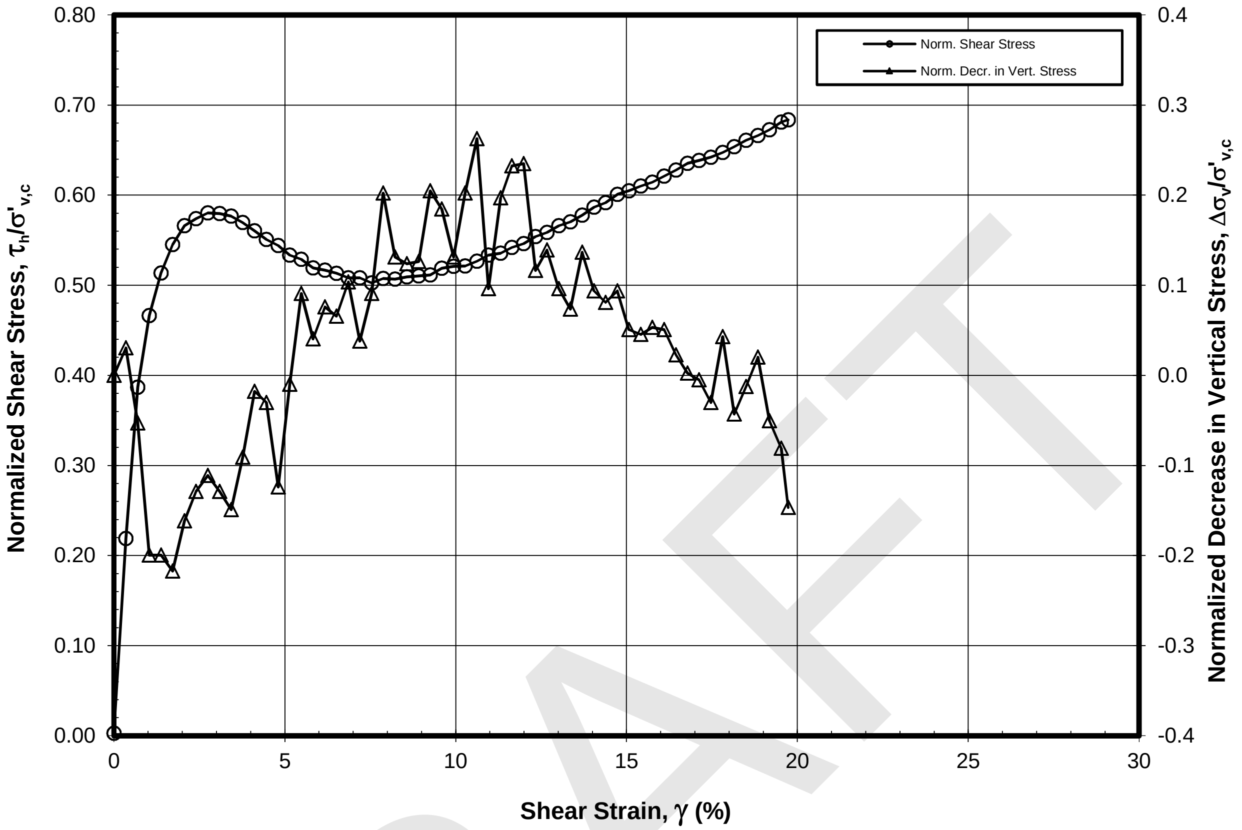
Notes: See Fugro South, Inc. Notation Listing for definition of symbols and acronyms. F or G in the Test Sta. No. indicates Fugro or GEOTAC apparatus.
NA - Not Applicable
Final Visual Description and Remarks: Silty Clay, Tan & Gray, with Few Ferrous Stains

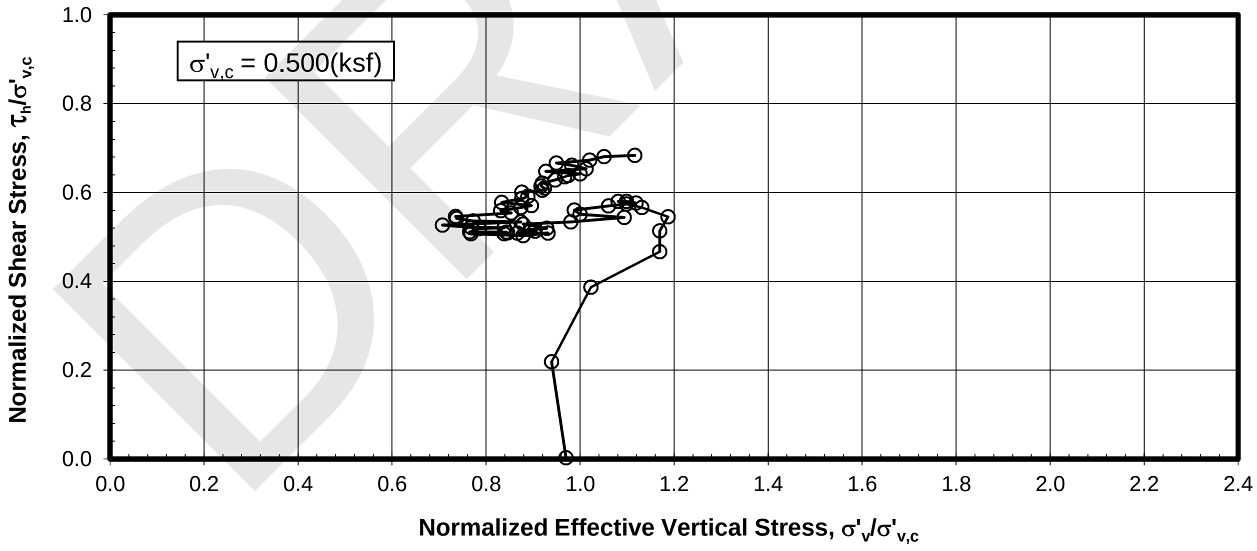
Loading Summary

	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**

5-23-2016

Project Manager (or Designee) Signature — **Date**

DISTRIBUTION	Project Central File – Quality File Folder Other – Specify:

AECOM

CALCULATION SHEET

Calculation No. 01

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.		$\sigma'_{fc} < 0.5$ 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 deg -5° ≤ α ≤ 5°: 29 deg α < -5°: 33 deg	$S_u/\sigma'_{fc} = 0.41$ $c_o = 700$ psf	
Foundation Sand	130	0	35	DRAINED	DRAINED
Ash	106	0	α > -5°: 33 deg -5° ≤ α ≤ 5°: 29 deg α < -5°: 33 deg	$S_u/\sigma'_{fc} = 0.44$	$S_u/\sigma'_{vc} = 0.07$[3]
Soft Clay (Miscellaneous Fill)[4]	125	0	24	$S_u/\sigma'_{fc} = 0.25$, min Su = 500 psf	$S_u/\sigma'_{fc} = 0.18$, 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

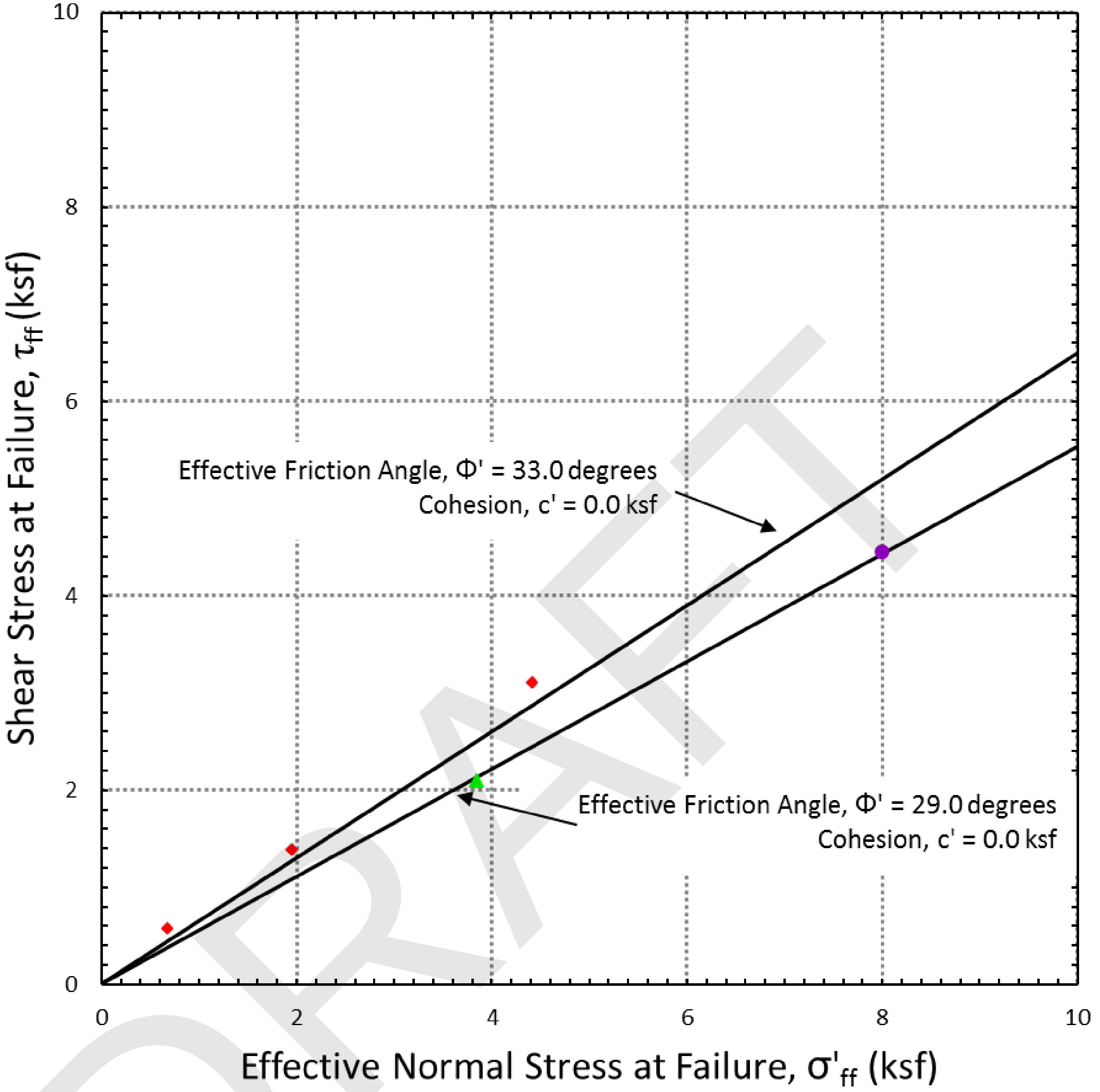
The shear strengths for the foundation sand and miscellaneous fills were either correlated or estimated based on available field data and soil descriptions.

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.



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 ASH	FIGURE 1
AECOM	JOPPA, ILLINOIS		

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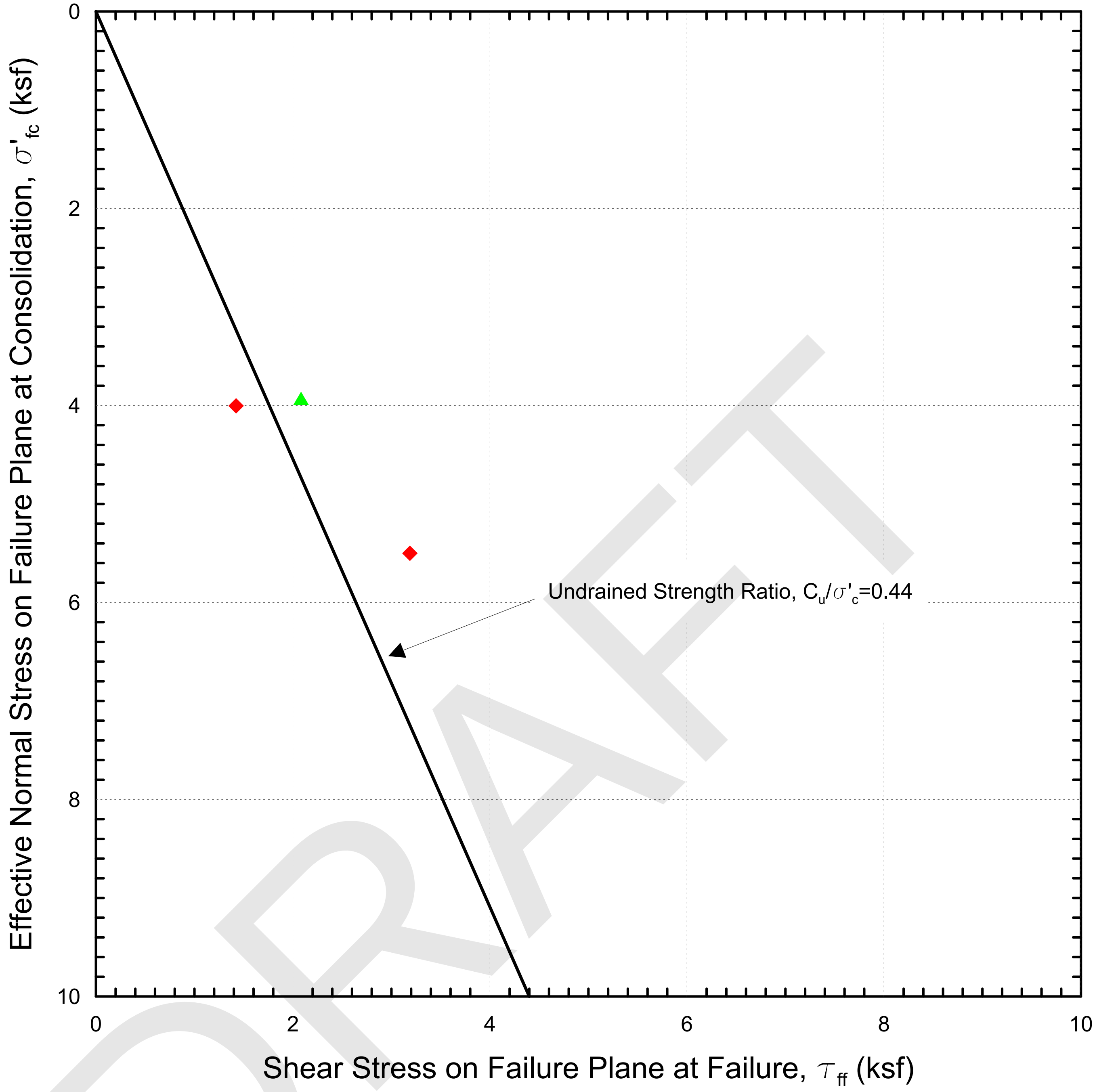


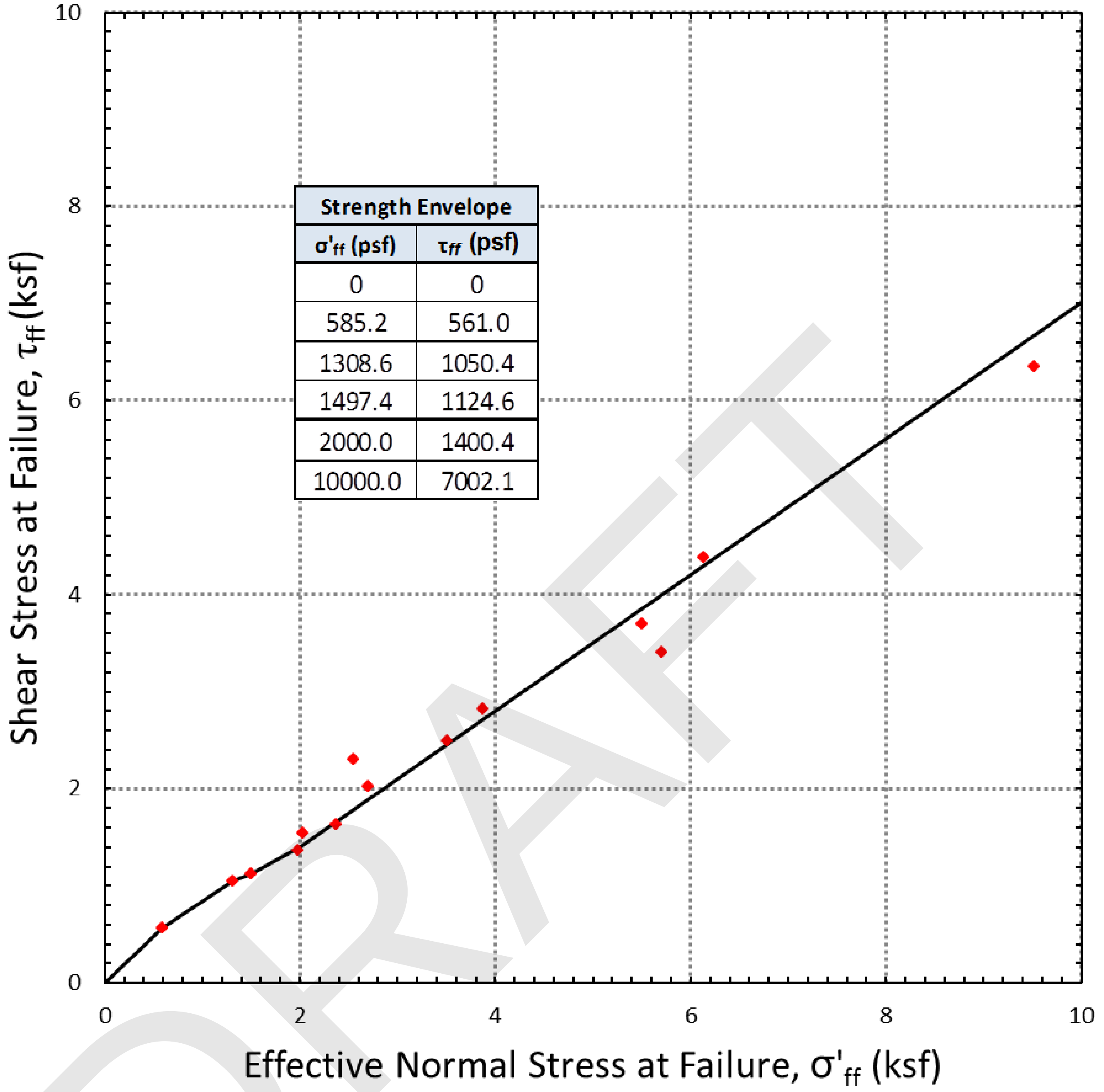
◆ 2015 AECOM (CIU)
▲ 2015 AECOM (DSS)

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		

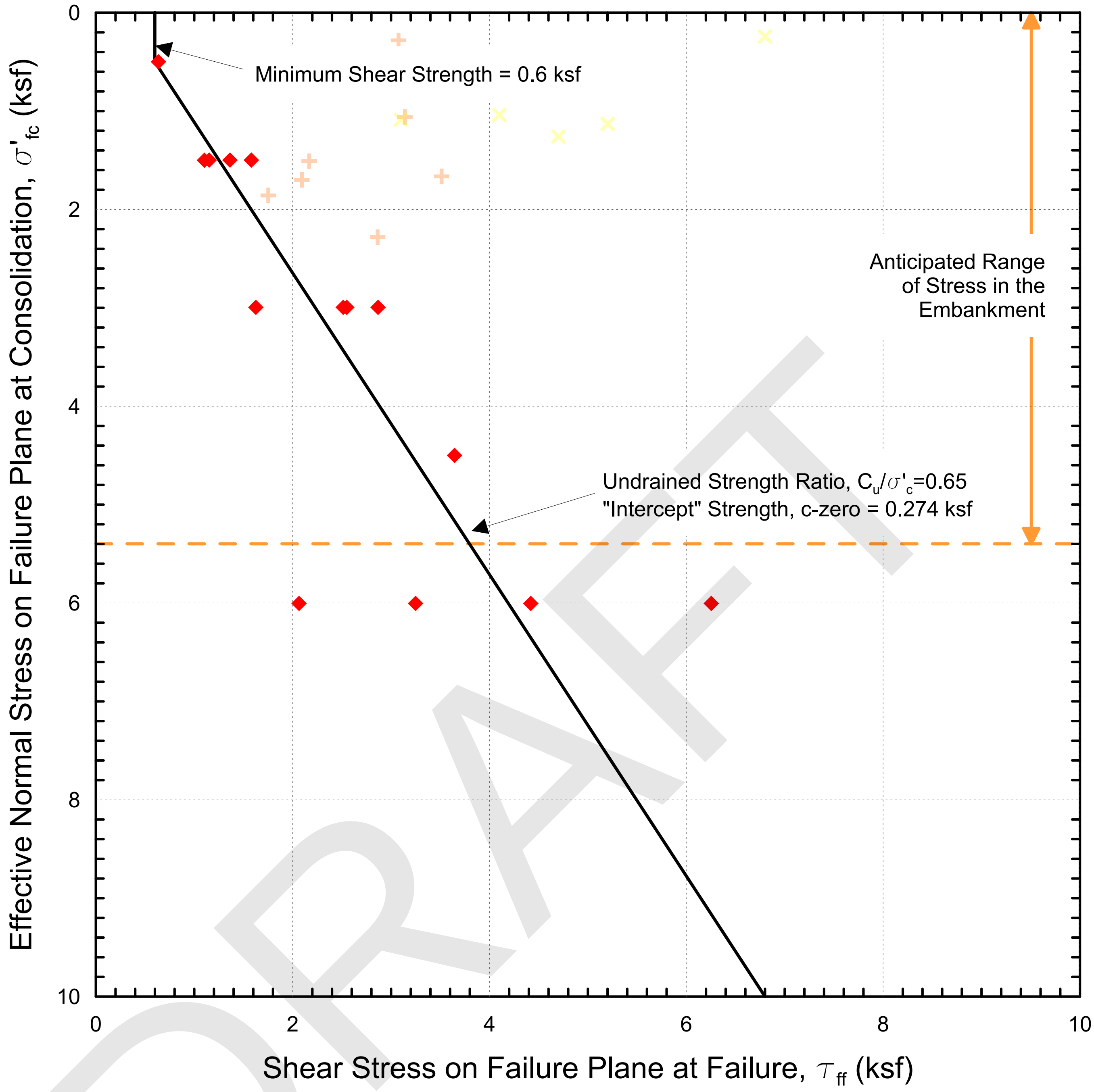


Strength Envelope	
σ'_{ff} (psf)	τ_{ff} (psf)
0	0
585.2	561.0
1308.6	1050.4
1497.4	1124.6
2000.0	1400.4
10000.0	7002.1

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		



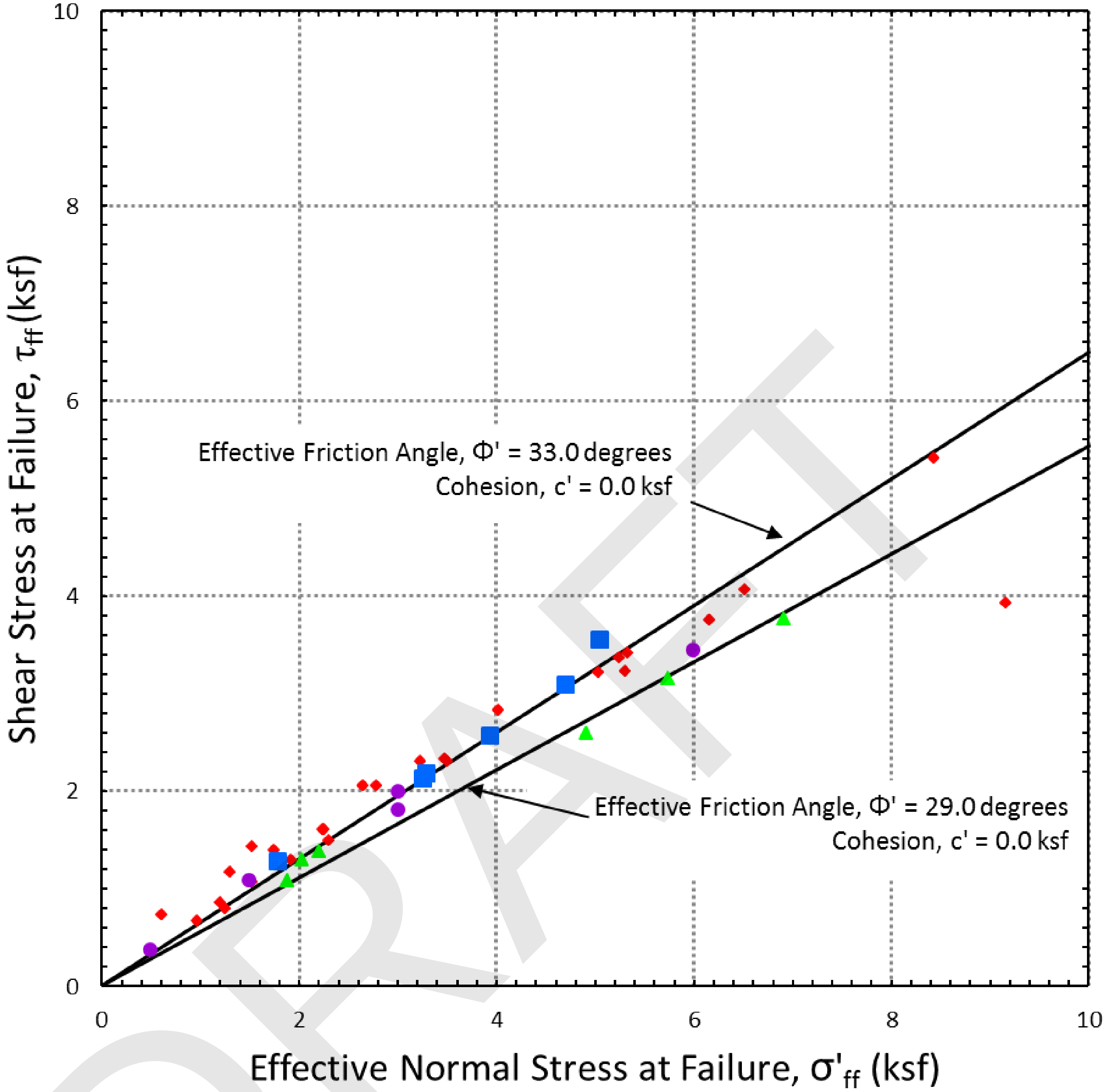
Notes:

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		



🟦 2010 Geotechnology (CIU)
♦ 2015 AECOM (CIU)
▲ 2015 AECOM (DSS)
● 2015 AECOM (DS)

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		

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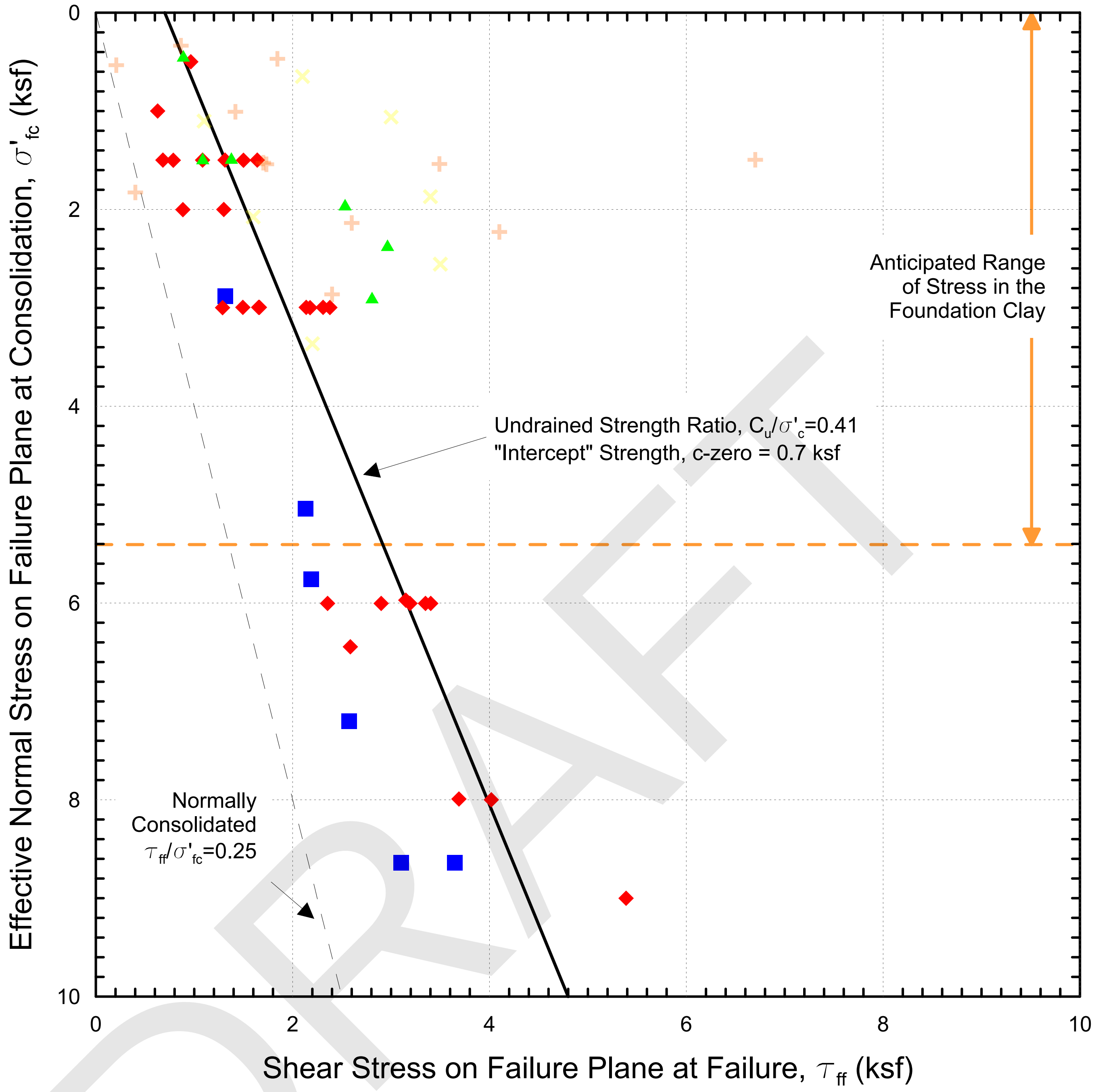


🟦 2010 Geotechnology (CIU)
◆ 2015 AECOM (CIU)
▲ 2015 AECOM (DSS)
+ 2015 AECOM (UU)
× 2015 AECOM (LV)

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)

PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND UNDRAINED SHEAR STRENGTH FOUNDATION CLAY	FIGURE 6
AECOM	JOPPA, ILLINOIS		

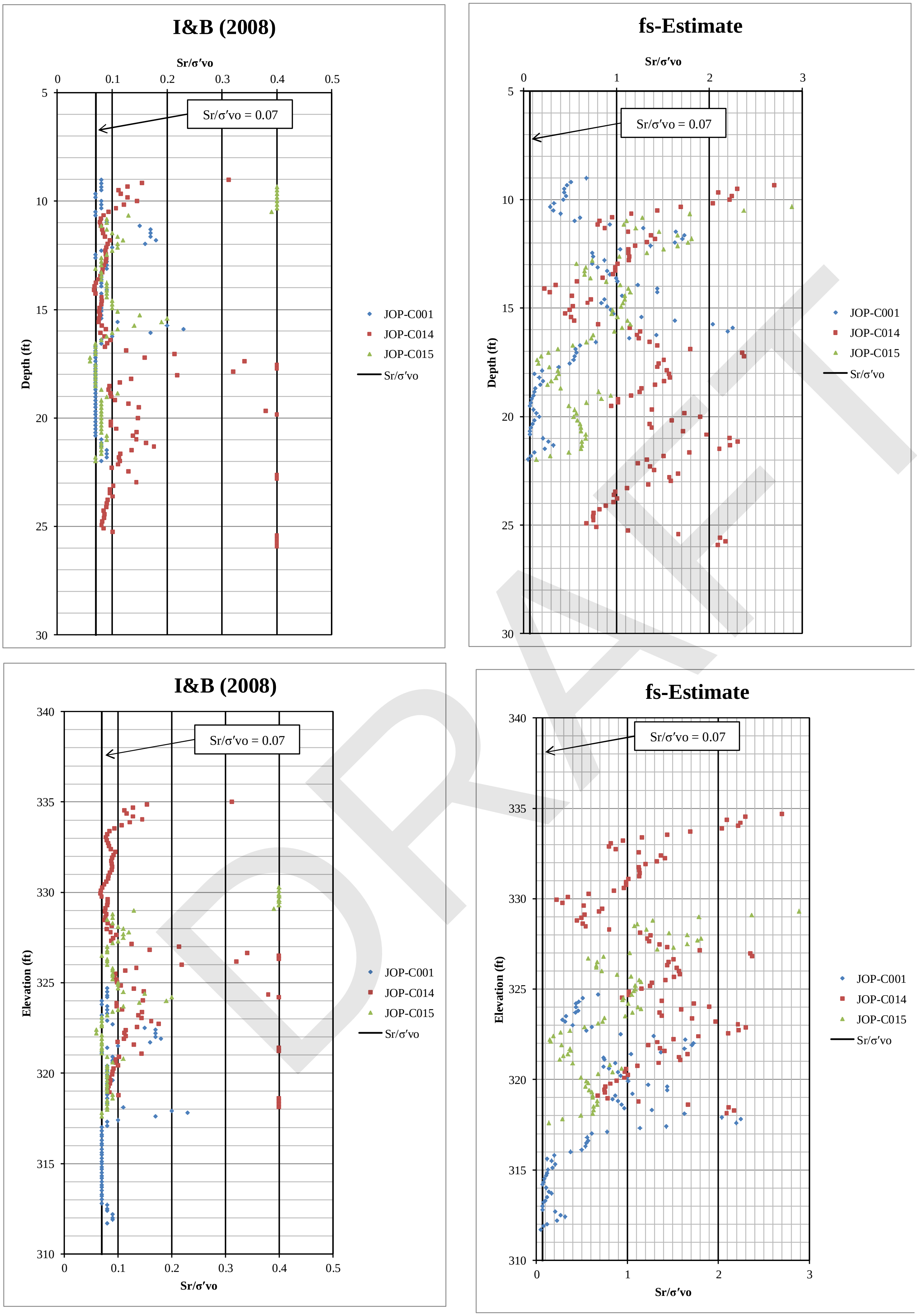
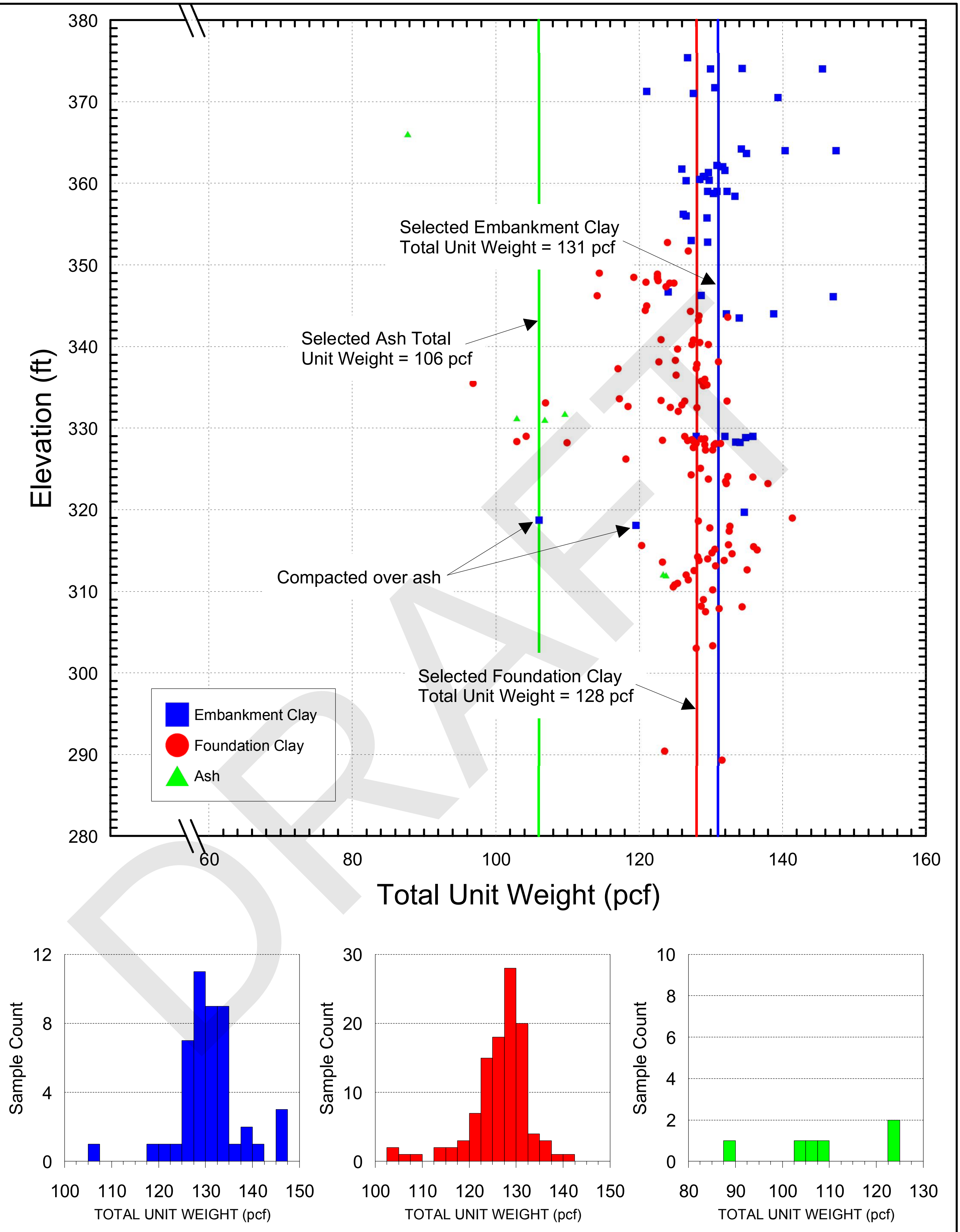


Figure 7 - Evaluation of Post-Liquefaction Shear Strength of Ash



PROJECT NO. 60440155	DYNEGY JOPPA POWER STATION	EAST ASH POND	FIGURE 8
AECOM	JOPPA, ILLINOIS	TOTAL UNIT WEIGHT	

ATTACHMENT A

CYCLIC DSS STRENGTH TEST (ASTM D 6528 & D 5311): Specimen Setup / Take Down

Project Number: 04.11150035
Task No.:
Project Name:
Sequence No.: of
Failure Criterion: ☐ Peak Obliquity, or ☐ Shear Strain (%) =

Test Type: CyDSS ta=0
Assign, $\sigma'_{v,c}$ = 1.00 ksf
Induced OCR = 1.00
Assig. Remarks: See Other Remarks

Sta. No.: CSS-S04 File Name: OP-B001_ST-2
Static DSS $c_u/\sigma'_{v,c}$ = 1.000
Cyclic Ratios: τ_{cy}/c_u = 0.300 τ_{avg}/c_u = NA
$\tau_{cy}/\sigma'_{v,c}$ = 0.300 $\tau_{avg}/\sigma'_{v,c}$ =
Specific Gravity: 2.700 ☐ Meas.; ☒ Assumed

☒ 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:	☒ 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 ☐ Post Cyclic	☒ Const, Vol./Ht ☐ Drained	☒ Without - Water ☐ With - Bath
					☒ Cyclic (Hz) ☐ Strain ☒ Stress Rate: ☐ 0.1; ☒ 1; Other:

Water Content (WC);	Initial - Trimming Location: Top ($W_{o,1}$)	Bottom ($W_{o,2}$)	Sides ($W_{o,3}$)	Final, W_{at} (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}:	☒ 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, $M_{t,o}$ $M_{t,at}$ (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 #
☒ 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.

Top Cap No. 16

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:

☒ **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}: ☒ Yes; ☐ No Plattens with Pins: ☐ Yes; ☒ 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: ☒ Spec. removed right after shearing
☐ Spec. unloaded to zero stress with access to water

Remarks:

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; ☒ Assumed

Type Test: CyDSS ta=0 Specimen: ☒ "Intact"; ☐ Reconstituted; ☐ Remolded

Calculations Corr. for Salt (dissolved solids): ☒ 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)

☒ 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	87.93

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	$\sim(M_{t,o} - M_{tat,c})/\rho_w + \Delta V_L + \Delta V_{uL}$	
By Cal. Height & App. Area		ΔV_c (cm^3)	3.87
ΔV_c (cm^3)	1.13	By Saturation = 100% and Spec. Unloaded to 0 Stress	
By Cal. Ht. & Init. Spec. Area			
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 Consol.: to $\sigma'_{v,c}$	17.995	62.95	34.98	34.4	117.2	87.2	100.0		NA
After 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: JJR

Reviewed By: HP

Remarks: ________

RESULTS OF CYCLIC DSS STRENGTH TEST

Project Number: 4.11150035
Task Number
Project Name:

Boring/Exploration No.: JOP-B001
Sample No.: ST-2b
Specimen No: b
Depth : 9.75 (ft)

Test Type: CyDSS ta=0
Test Sequence Number:
File Name: JOP-B001_ST-2b

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

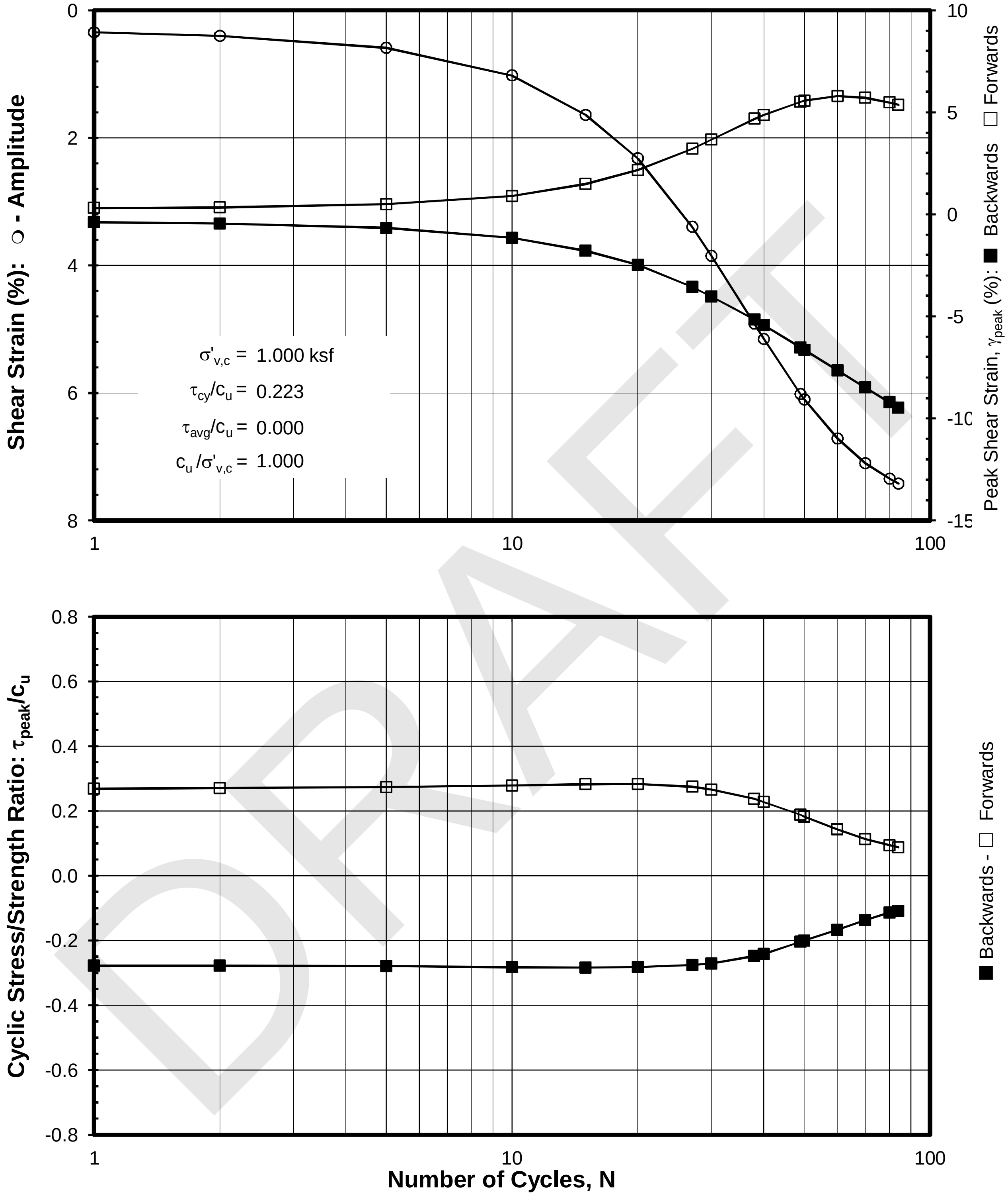
ATTACHMENT A

Summary of Specimen Physical Properties:										
Specific Gravity: G_s = 2.700		Height	Volume	Area	Water Content	Total Unit Weight	Dry Unit Weight	Saturation		LL PL
Condition:		(mm)	(cm^3)	(cm^2)	(%)	(pcf)	(pcf)	(%)		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.

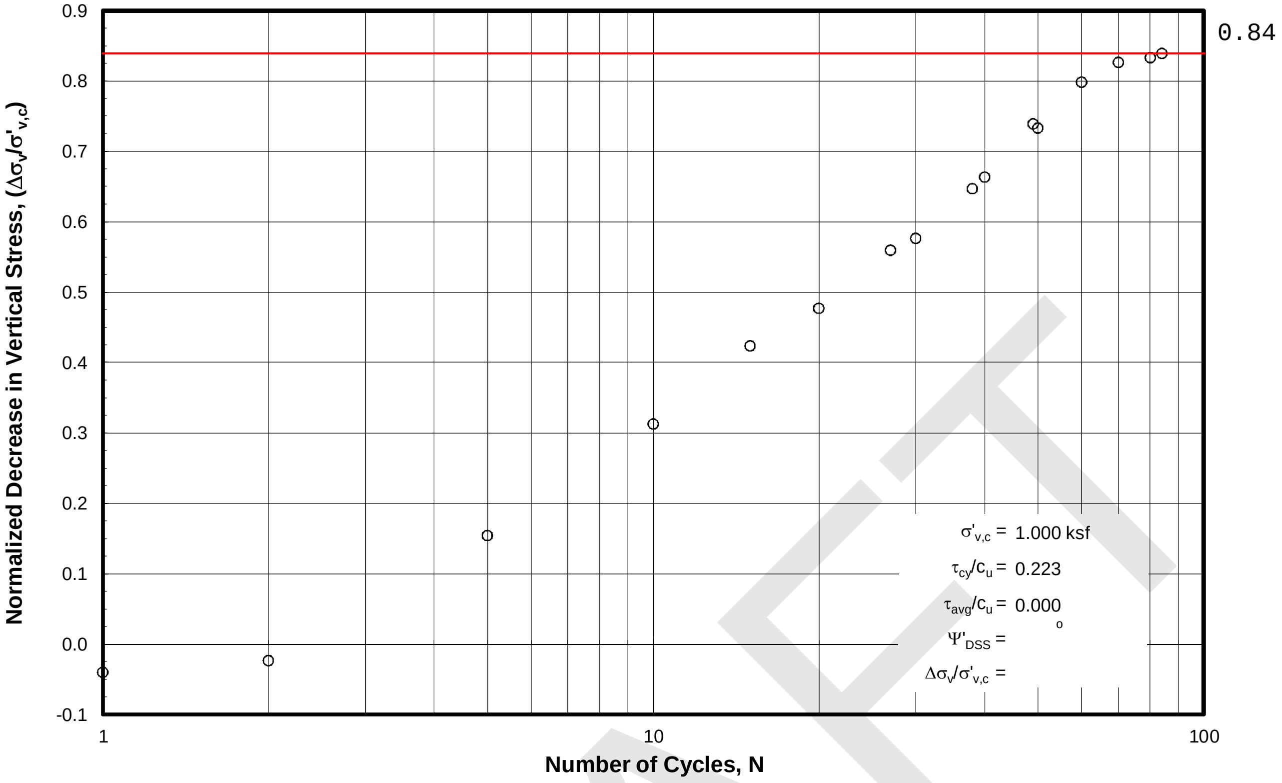
Cycle No.	Shear Stress: Forwards $\tau_{h,f}$ (ksf)	Backwards (1) $\tau_{h,b}$ (ksf)	Cyclic Shear Stress Amp. τ_{cy} (ksf)	Avg. Cyclic or Bias Stress τ_{avg} (2) (ksf)	Cyclic Stress Ratio $\tau_{cy} / \sigma'_{v,c}$	Average Cyclic Stress Ratio $(\tau_{cy} / \sigma'_{v,c})_{avg}$	Max. Decr. in Vert. Stress $\Delta\sigma'_{v,max}$ (ksf)	Normalized Decr. in Vert. Stress $\Delta\sigma'_{v,max} / \sigma'_{v,c}$	Shear Strain: Forwards γ_f (%)	Backwards (1) γ_b (%)	Cyclic Shear Strain Amp. γ_{cy} (%)	Average Shear Strain γ_{avg} (%) (2)	Shear Modulus $(\tau_{cy} / \gamma_{cy})$ 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



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

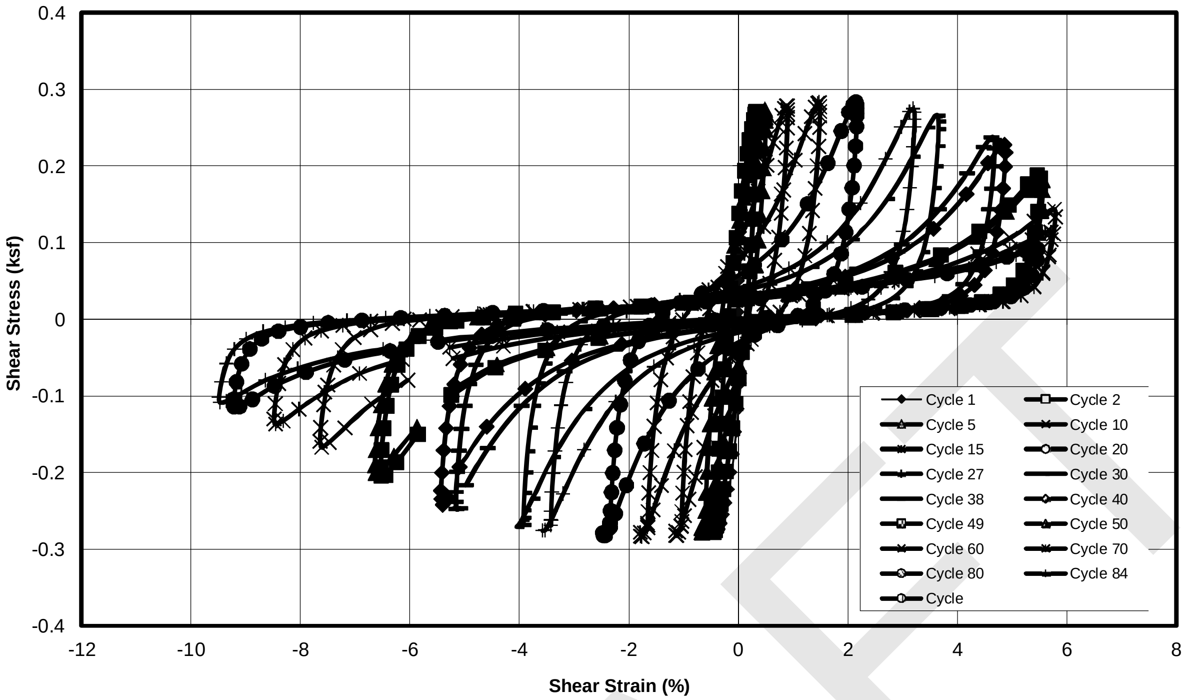
OCR = 1 - Cyclic Rate: 1.0 Hz

Sample: ST-2b - Depth: 9.75 ft

Boring JOP-B001

ATTACHMENT A

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

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.; ☒ Assumed

☒ 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:	☐ 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 ☐ Post Cyclic	☐ Const, Vol./Ht ☐ Drained	☐ Without - Water ☐ With - Bath	☐ Cyclic (Hz) Rate: ☐ 0.1;	☐ Strain ☐ Stress ☐ 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}: ☒	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 #
☒ Trimming Ring for NGI Apparatus			Small-ring ID #
$H_{s,t}$ (mm):	18.32	$A_{s,t}$ (cm²):	34.99
$D_{s,t}$ (mm) :	66.75	$V_{s,t}$ (cm³):	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} (cm²):	NA
=	18.318	Avg	NA	V_{tr} (cm³):	NA

Estimated Initial Unit Weight

Total, $\gamma_{t,o}$ (lb/ft³)= 115.36	Dry, $\gamma_{d,o}$ (lb/ft³)= 85.93

Specimen Lateral Confinement by:

☒ **Wire Reinforced, Model:** C=1.5 Thickness (mm) = 0.72

Stress Level	Dia. by PiTape (mm)		Area, $A_{c,n}$	
	Meas.	Corr.	(cm²)	(in²)
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 (cm²) ; (in²)=

Note: NA-Indicates not applicable. Top Cap No. 16 Mass Top Cap, etc., M_{tc} = 492.6 g, 1.09 lbf

F or G in the Sta. No. indicates Fugro or GEOTAC apparatus. Data corr. for M_{tc}: ☒ Yes; ☐ No Plattens with Pins: ☐ Yes; ☒ 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: ☒ Spec. removed right after shearing Remarks:

☐ Spec. unloaded to zero stress with access to water

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; ☒ Assumed

Type Test: Post Cyclic DSS Specimen: ☒ "Undisturbed"; ☐ Reconstituted; ☐ Remolded

Calculations Corr. for Salt (dissolved solids): ☒ No or, ☐ Yes, with concentration = ________ ppm

Consolidation Stress Summary and Loading Summary

Test Stage:	Max. Stress	Pre-Shear	Post Cyclic	0 Static Strain Rate =	NA	(%/hr or)
Nominal Vertical Stress, σ'_v (ksf)	NA	1.00		☐ Cyclic Rate (Hz):	☐ 0.1;	☐ 1; Other =
Axial/Vertical Force, $P_{vr,n}$ (lbf)	NA	NA		During/End of Loading	Static	Cyclic
Horizontal Force, $P_{hr,n}$ (lbf)	NA	0		Change in Height, $\Delta H_{L,n}$ (mm)	NA	NA
Nominal OCR	NA	1		Change in Vol., $\Delta V_{L,n}$ (cm^3)	NA	NA
t_c,(ON,days,hrs)	NA	0.11 days		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 $= \Delta V_{uL}$
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!	$\sim M_{t,o} - (M_{tat,c} + \Delta V_L + \Delta V_{uL})$	
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.

& 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: ________

ATTACHMENT A

DIRECT SIMPLE SHEAR TEST

Project Number: 04.11150035
Project Name:
Test Number:
Task Number:
Test Type: Post Cyclic DSS
Test Series No.:
Boring No.: JOP-B001
Sample No.: ST-2
Specimen No.: b
Depth (ft.): 9.75

Horiz. Load Factor (lbf/V/V): 29.983
Horiz. Load, Test Floating Zero (V/V): 3.494E-03
Horiz. Deform. Factor (mm/V/V): -0.394
Vert. Load Factor (lbf/V/V): 144.426
Vert. Load, Test Floating Zero (V/V): 7.854E-03
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:

☒ 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 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 ☐ Stress ☐ 1; 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 Normalization: ☒ Yes ☐ No Value: 1.000 (ksf)
Data corr. for M_{tc}: ☒ Yes; ☐ No	Plattens with Pins: ☐ Yes; ☒ No	Using Effective Vertical Stress:
☒ Wire Reinforced Membrane, Model: C=1.5	Data corr. for Membr. strength	☒ Pre-Shear Conditions ☐ Post-Cyclic Conditions
☐ Regular Membrane with Rings	☐ Yes ☒ No	☐ 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

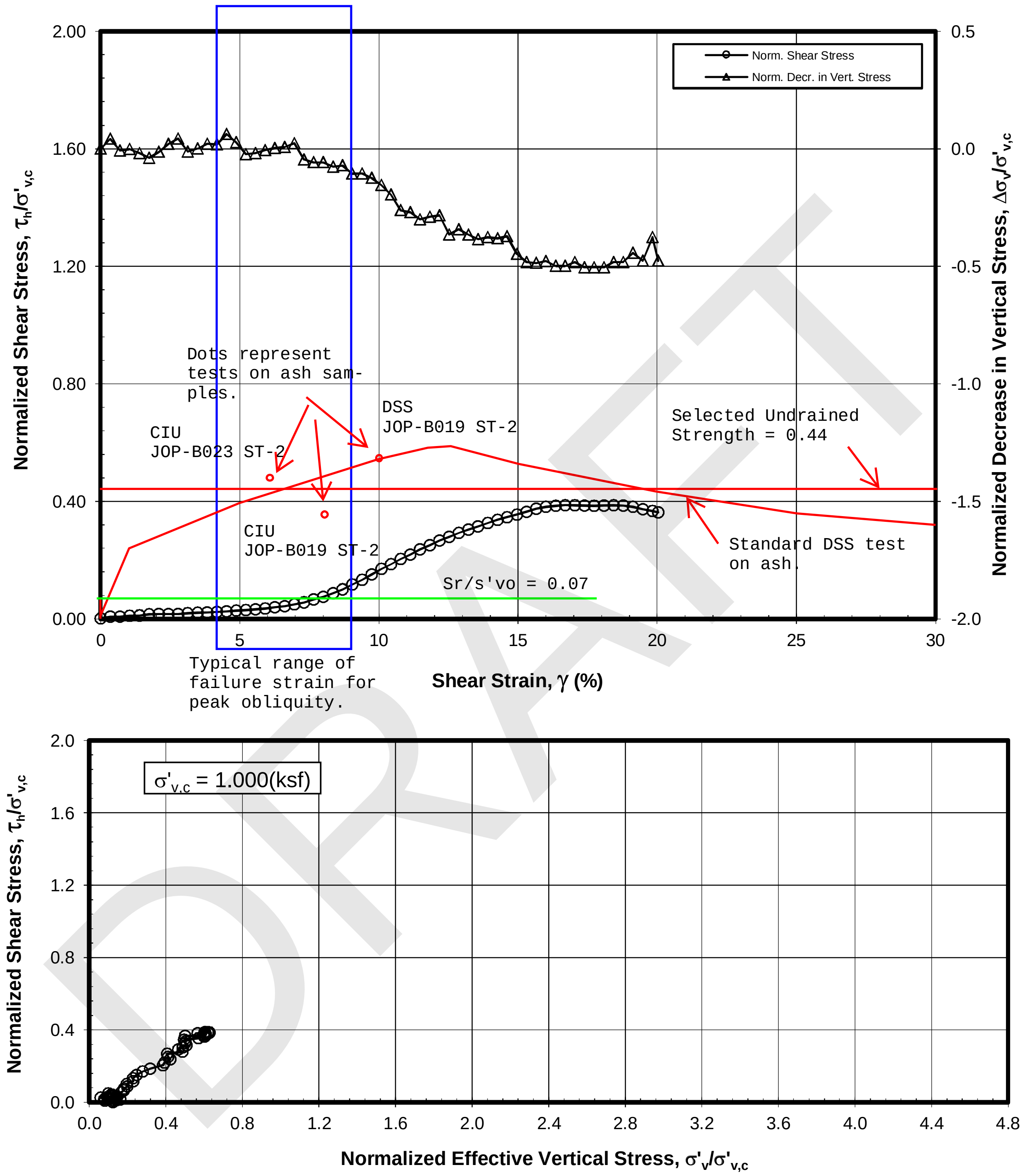
	τ_h (ksf)	γ (%)	σ'_v (ksf)	τ_h/σ'_v -	$\Delta\sigma'_v/\sigma'_{v,c}$ -	$c_u/\sigma'_{v,c}$
at Peak Shear Stress	0.387	16.69	0.621	0.623	-0.498	0.387
at Maximum Strain	0.363	20.03	0.600	0.605	-0.476	

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.

	4-19-2016
Originator Signature	**Date**
	4/26/16
Checker Signature	**Date**
Douglas F. Cauble	4-27-2016
Reviewer Signature	**Date**
	4/27/16
Project Manager (or Designee) Signature	**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 and 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.

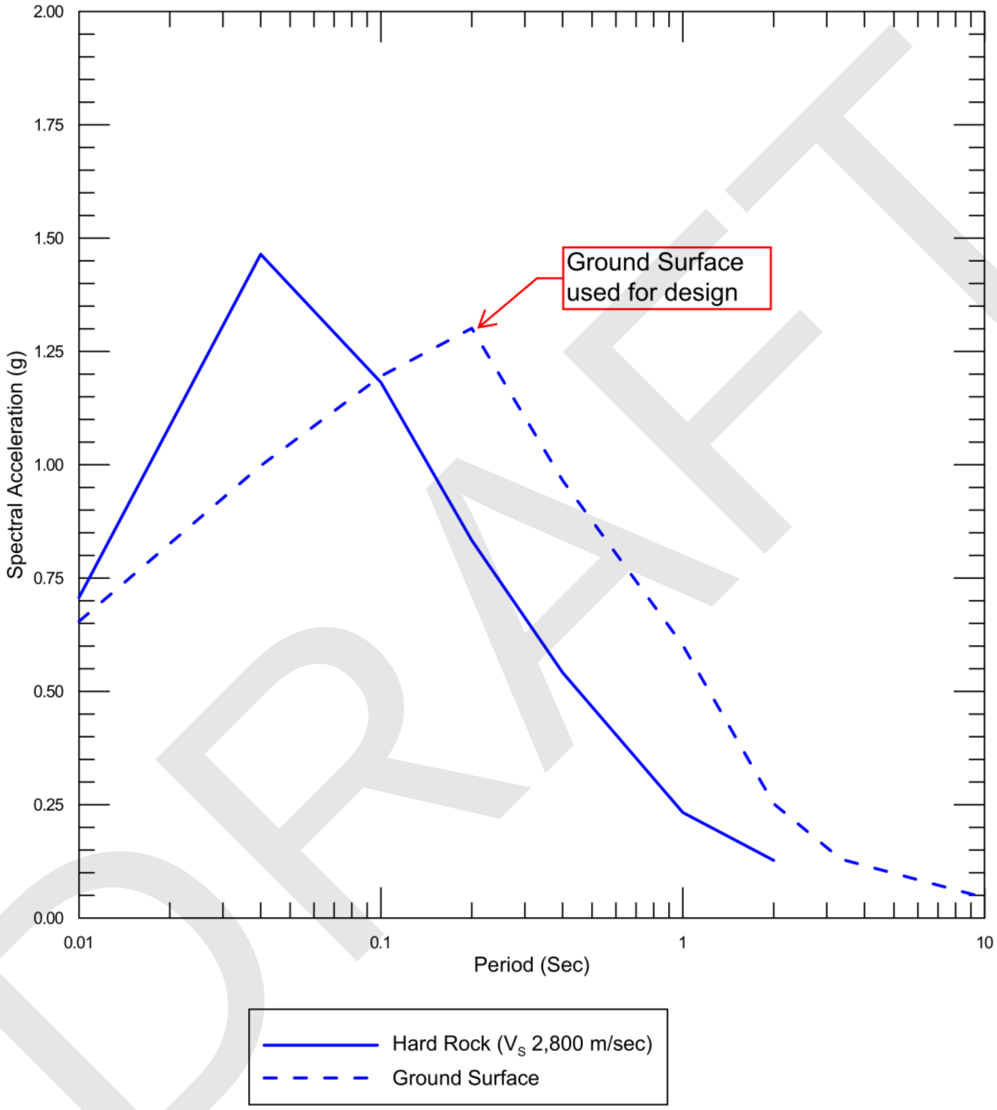


Figure 1: Joppa Uniform Hazard Spectrum (UHS)

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	Pseudostatic	Max Storage	Max Surcharge	Temp Const. with Rig	Temp Const. w/o Rig	Local Work Pad Long-Term
	Min FS = 1.20	Min FS = 1.00	Min FS = 1.50	Min FS = 1.40	Min FS = 1.30[1]	Min FS = 1.30[1]	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

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

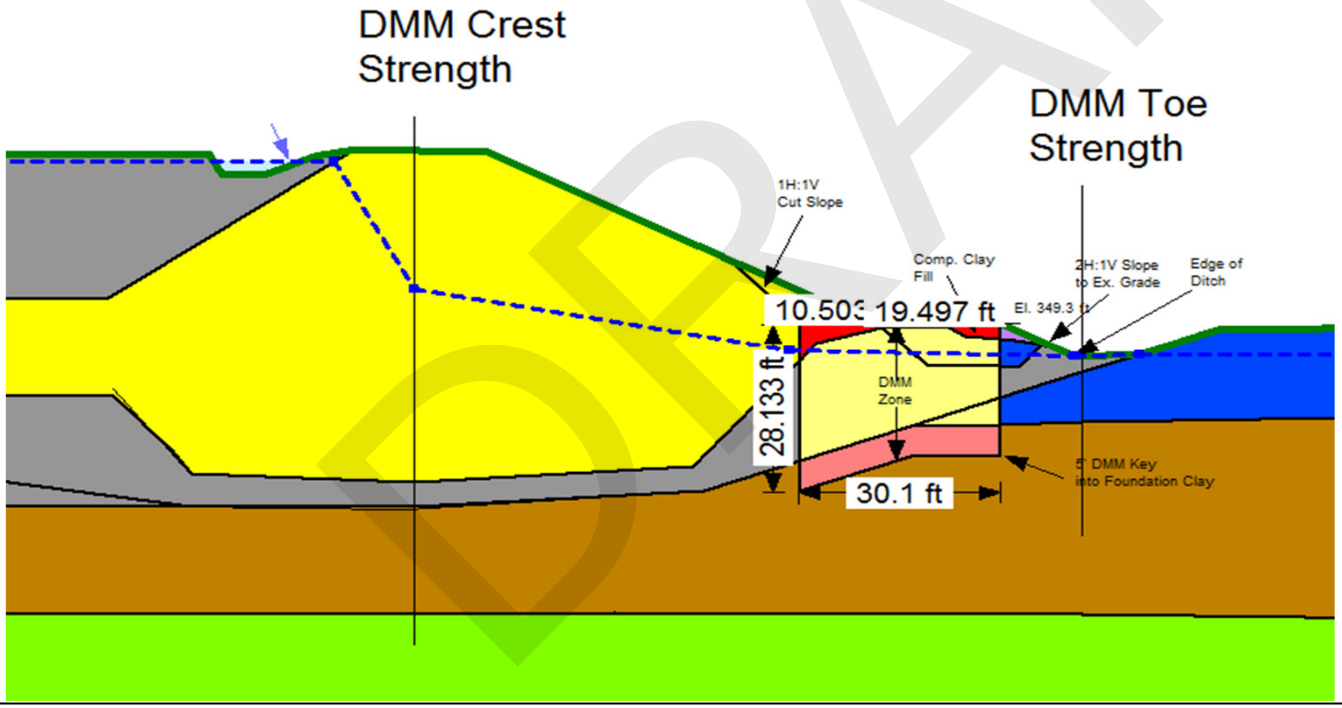
Composite DMM Strengths at Embankment Toe (x=400 ft)

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

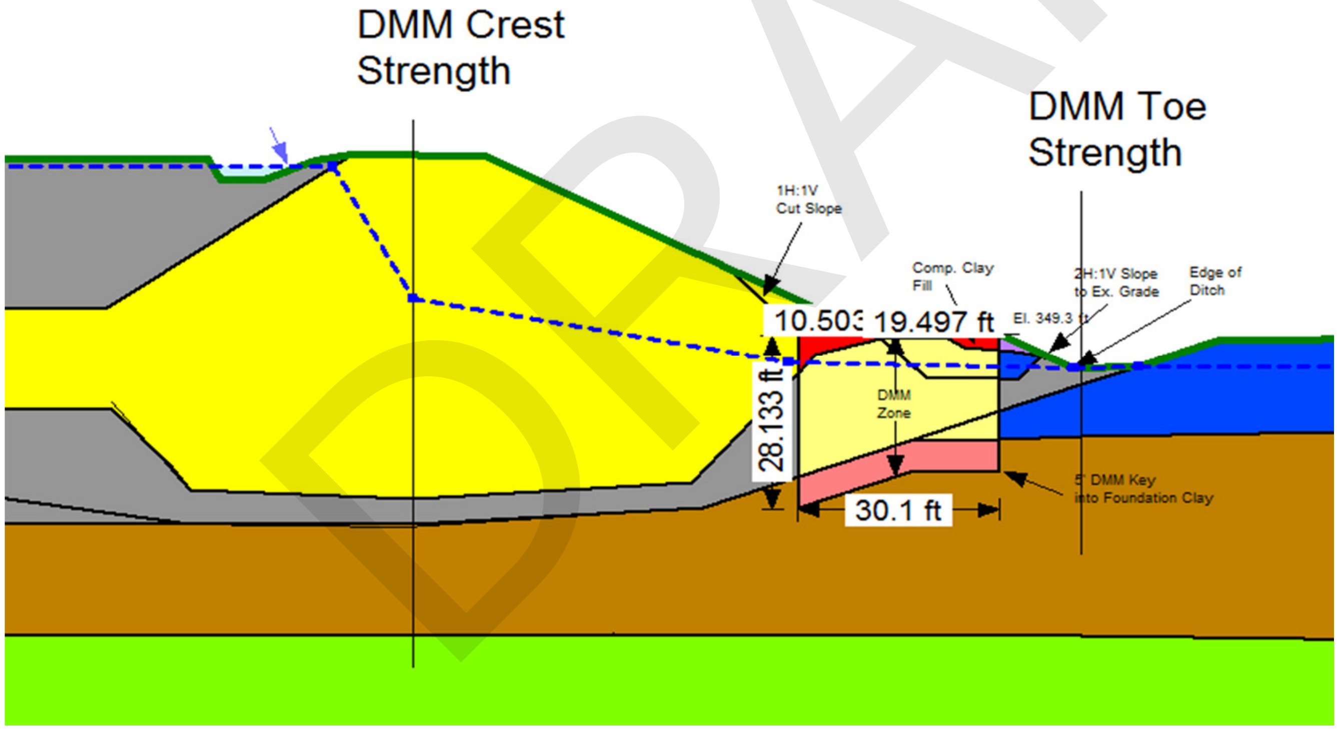
Composite DMM Strengths at Embankment Toe (x=400 ft)

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

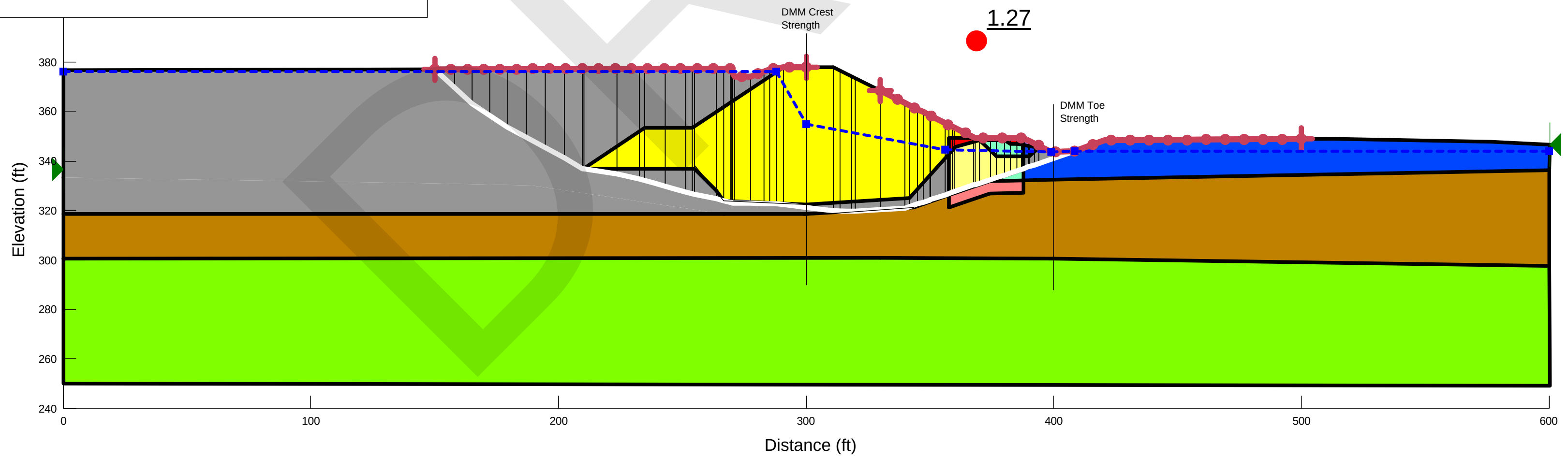
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Fly Ash (Post-Liquefaction) Unit Weight: 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

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

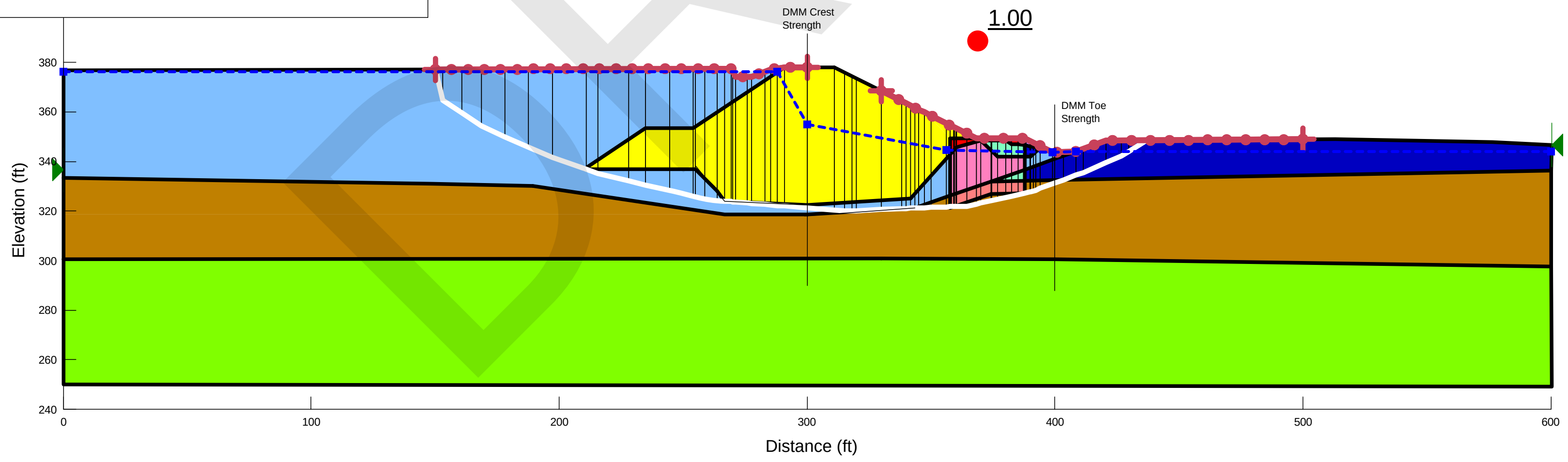
Materials

- 🟨 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 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

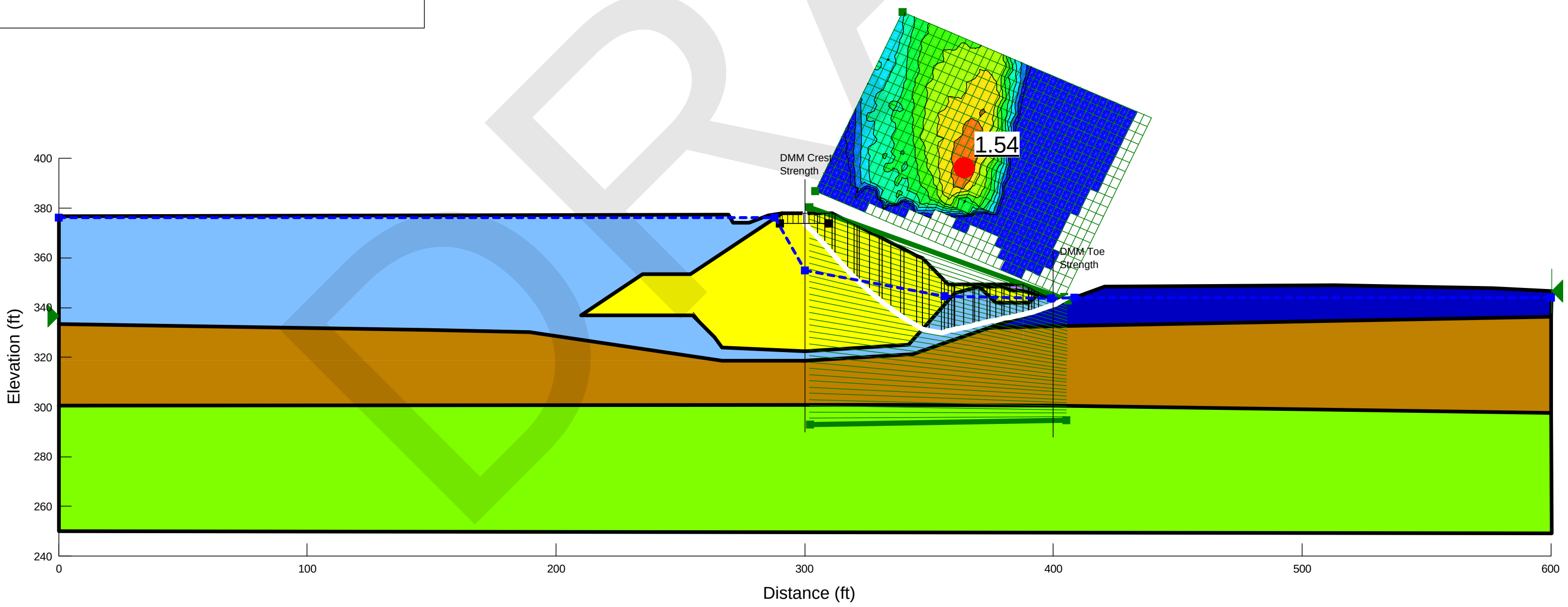
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

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

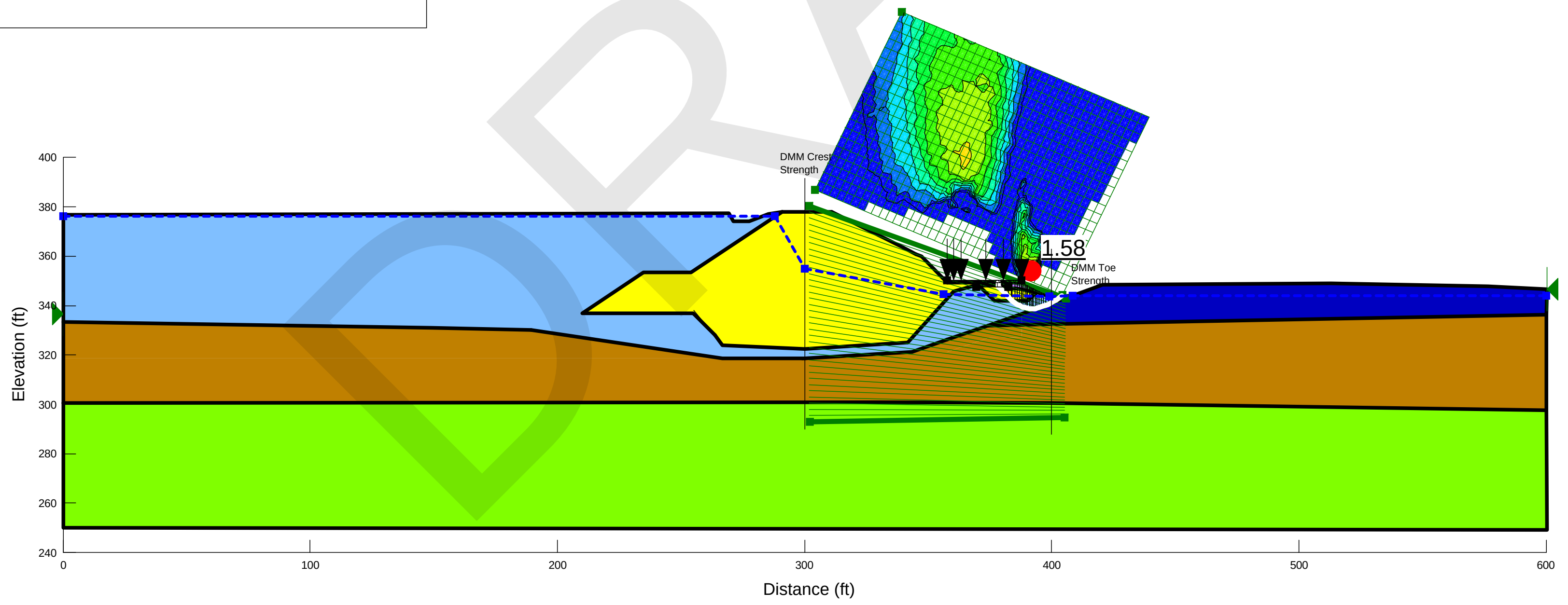
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

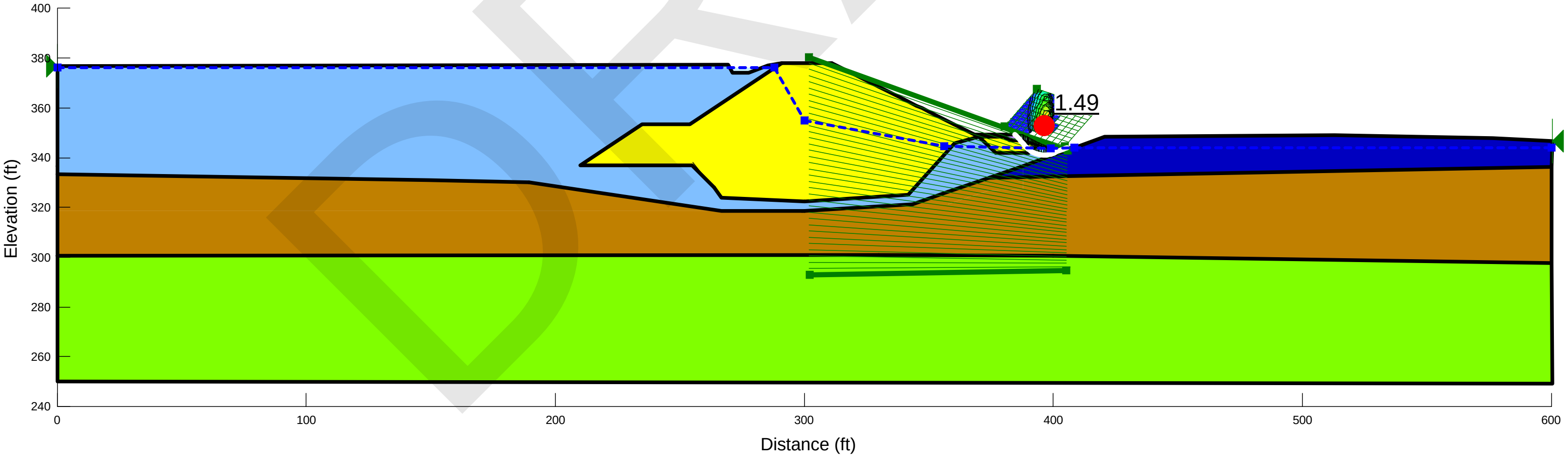
Name: Embankment Fill (Peak Drained)   Unit Weight: 131 pcf   Cohesion': 0 psf   Phi': 35 °   Piezometric Line: 1
Name: Foundation Clay (Peak Drained)   Unit Weight: 128 pcf   C-Horizontal: 0 psf   C-Vertical: 0 psf   Phi-Horizontal: 29 °   Phi-Vertical: 33 °   Piezometric Line: 1
Name: Foundation Sand (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

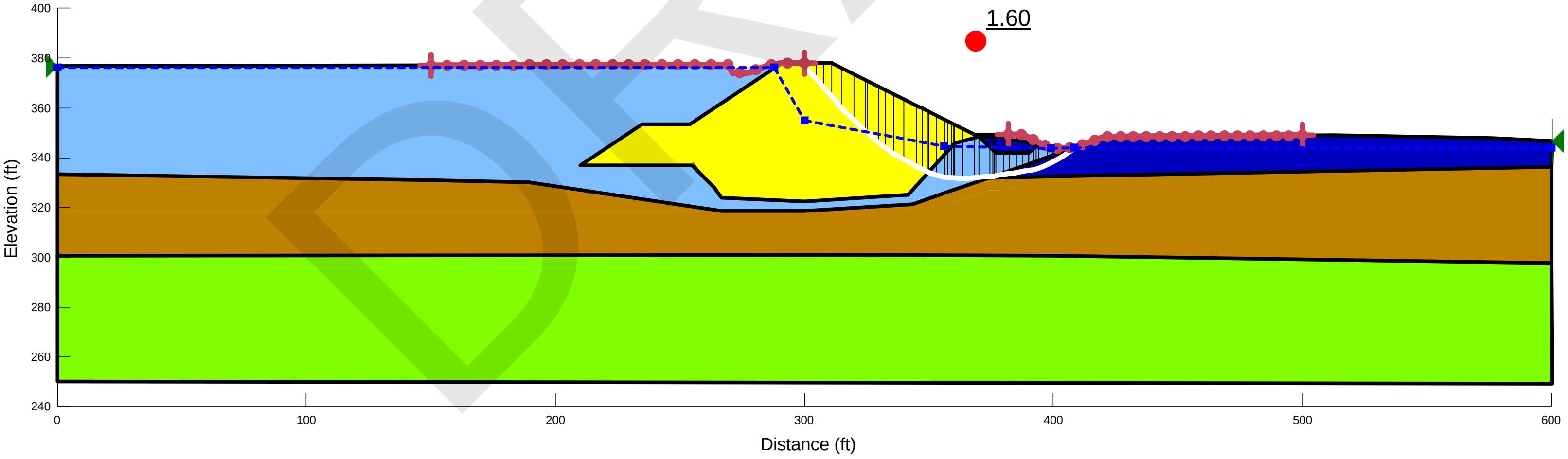
Name: Embankment Fill (Peak Drained)   Unit Weight: 131 pcf   Cohesion': 0 psf   Phi': 35 °   Piezometric Line: 1
Name: Foundation Clay (Peak Drained)   Unit Weight: 128 pcf   C-Horizontal: 0 psf   C-Vertical: 0 psf   Phi-Horizontal: 29 °   Phi-Vertical: 33 °   Piezometric Line: 1
Name: Foundation Sand (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

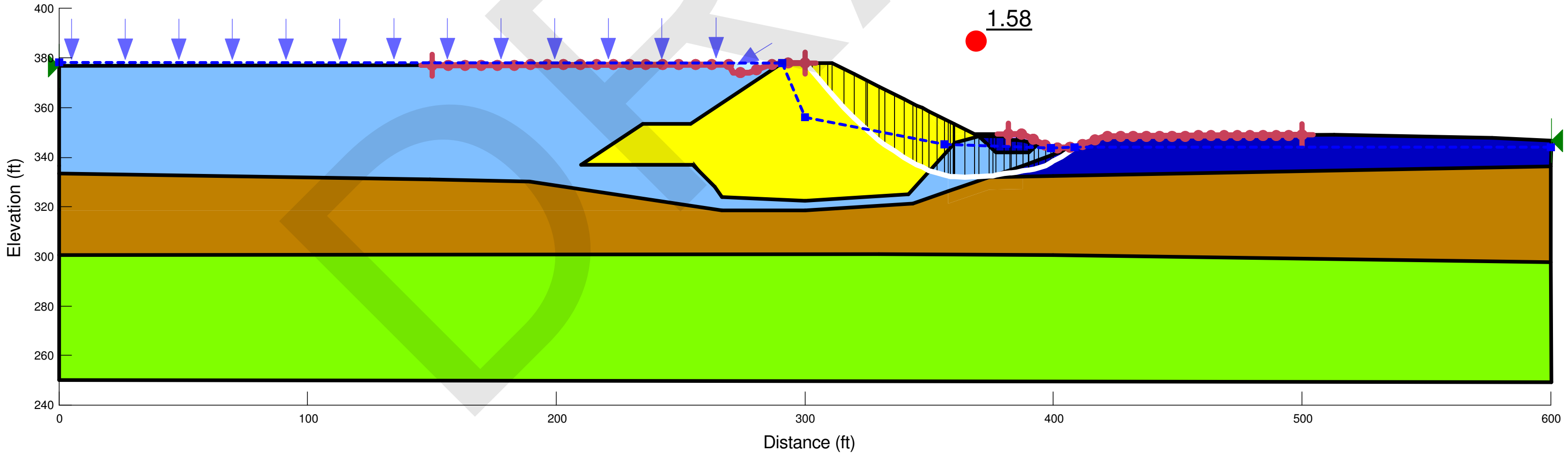
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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	

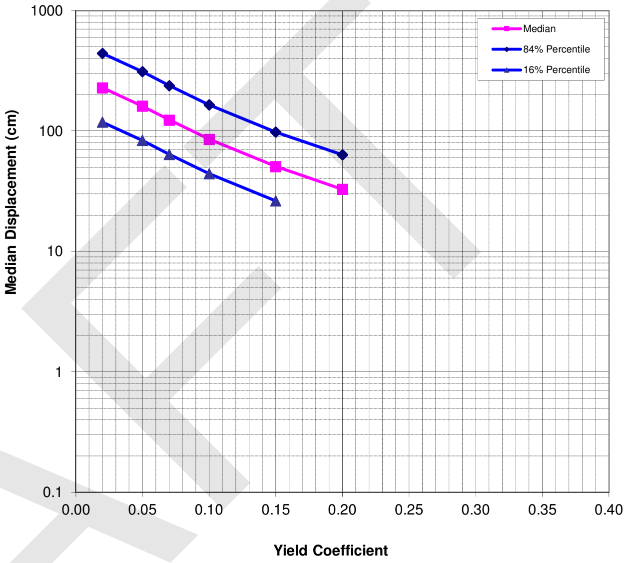
Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	91.44	cm

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)

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



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)

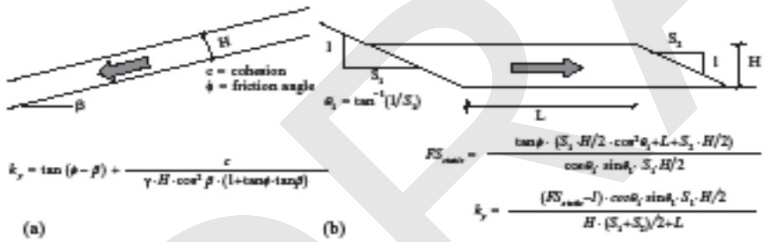


Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

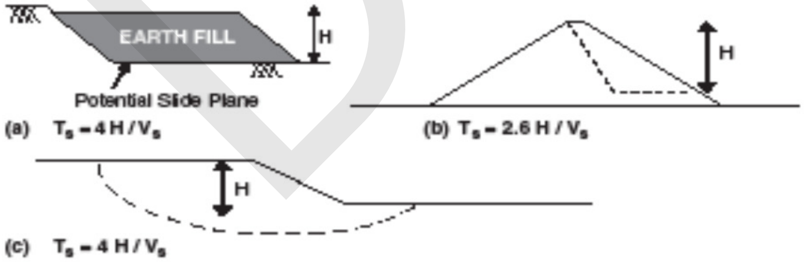


Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

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

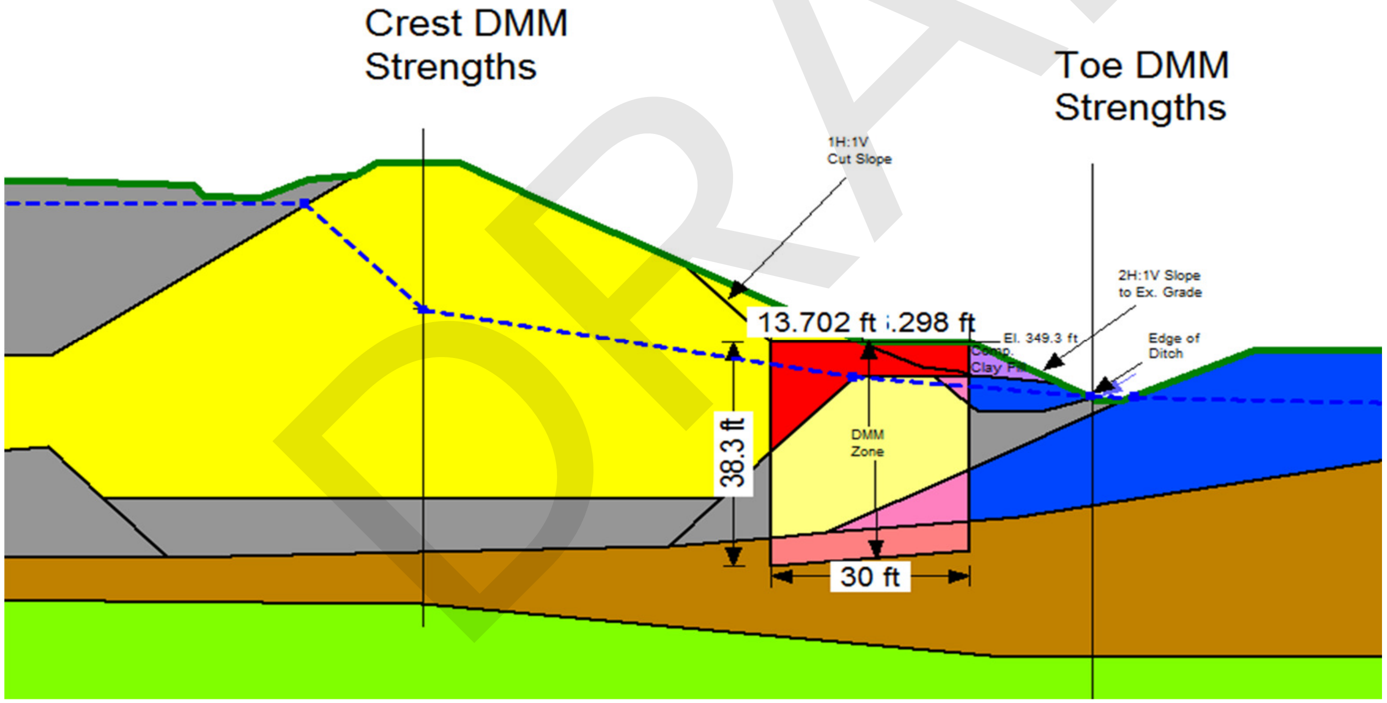
337.0	380.1	3575
337.0	355.0	4772
337.0	322.7	5654
337.0	322.7	4722
337.0	313.4	4835
337.0	313.4	5150
337.0	304.6	5276
337.0	304.6	6058
337.0	200.0	9085

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

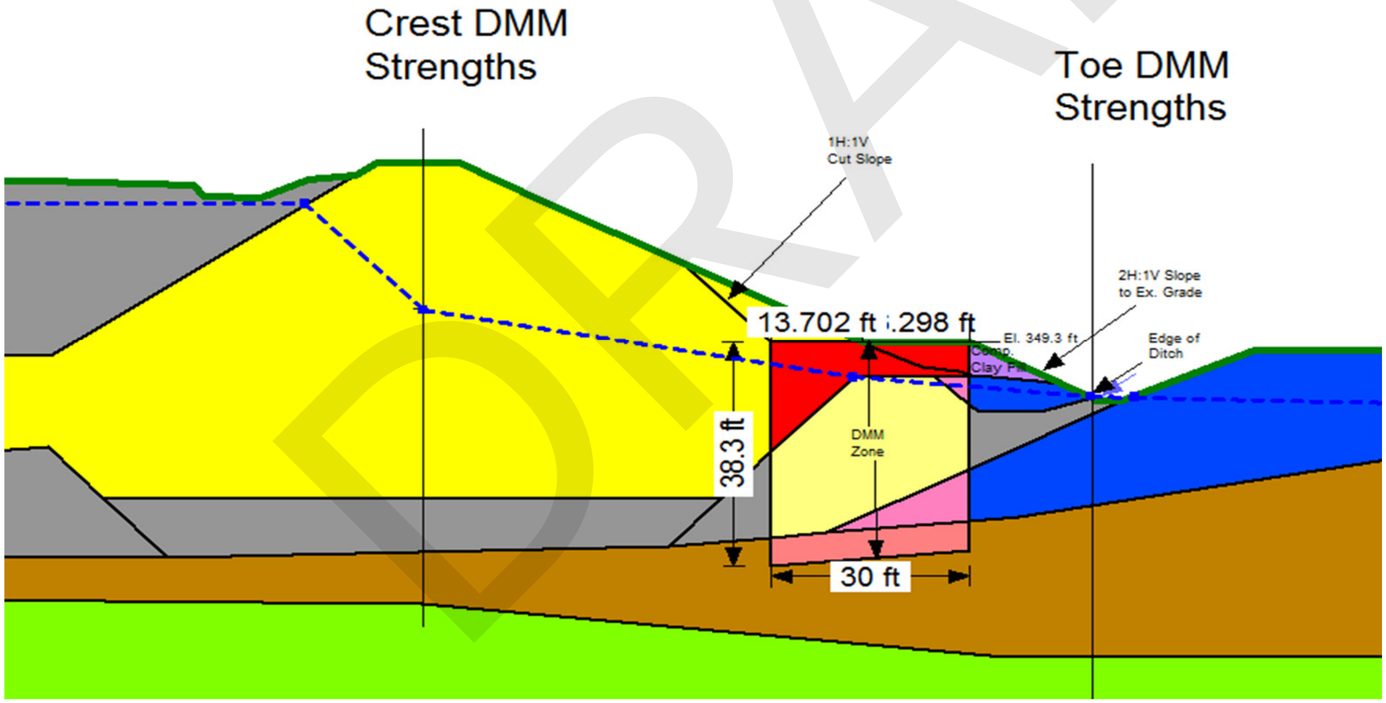
337.0	380.1	3575
337.0	355.0	4772
337.0	322.7	5654
337.0	322.7	3440
337.0	313.4	3457
337.0	313.4	5150
337.0	304.6	5276
337.0	304.6	6058
337.0	200.0	9085

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	-	-	-	-	-	-	600	8640	3197	3575
Fill	-	-	-	-	-	-	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

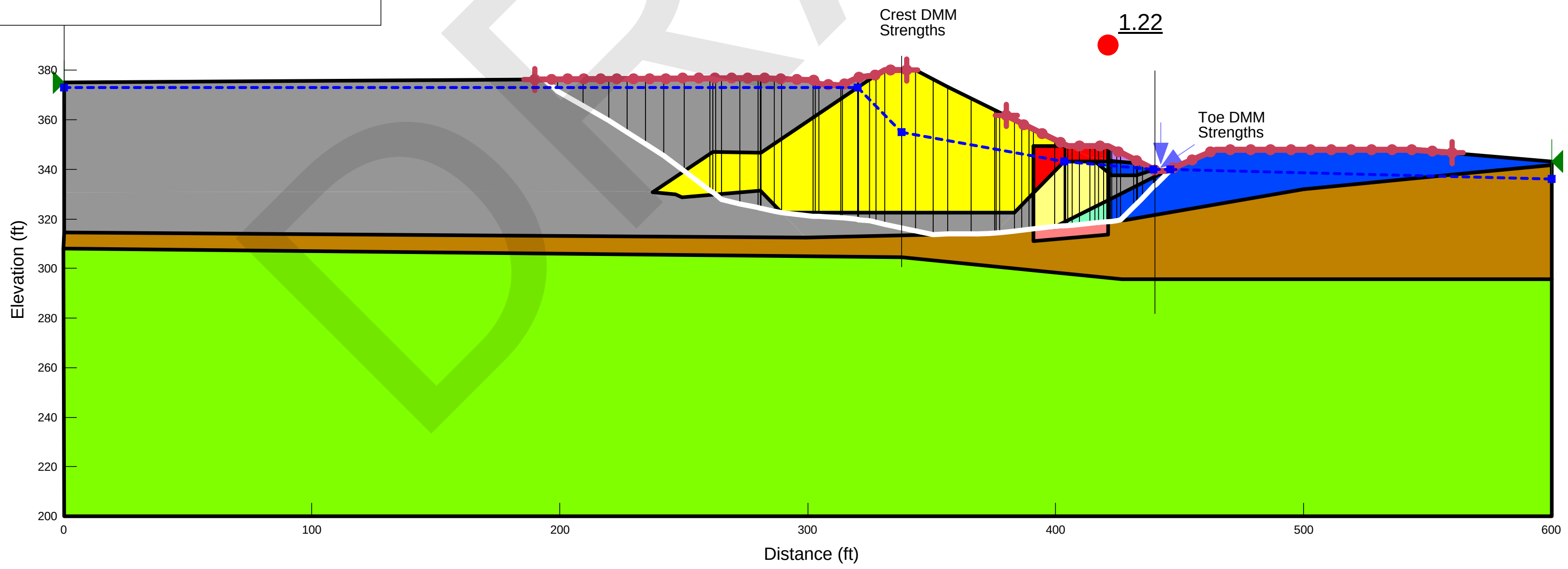
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Fly Ash (Post-Liquefaction) Unit Weight: 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

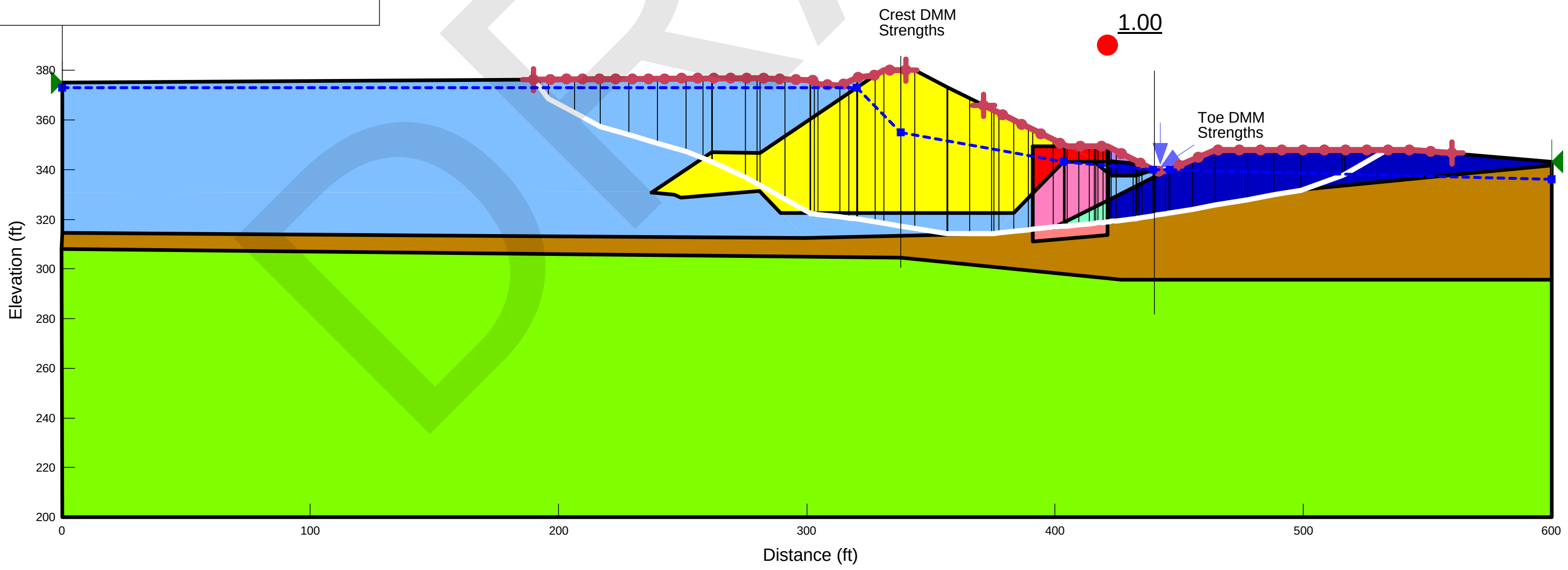
Materials

- 🟨 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

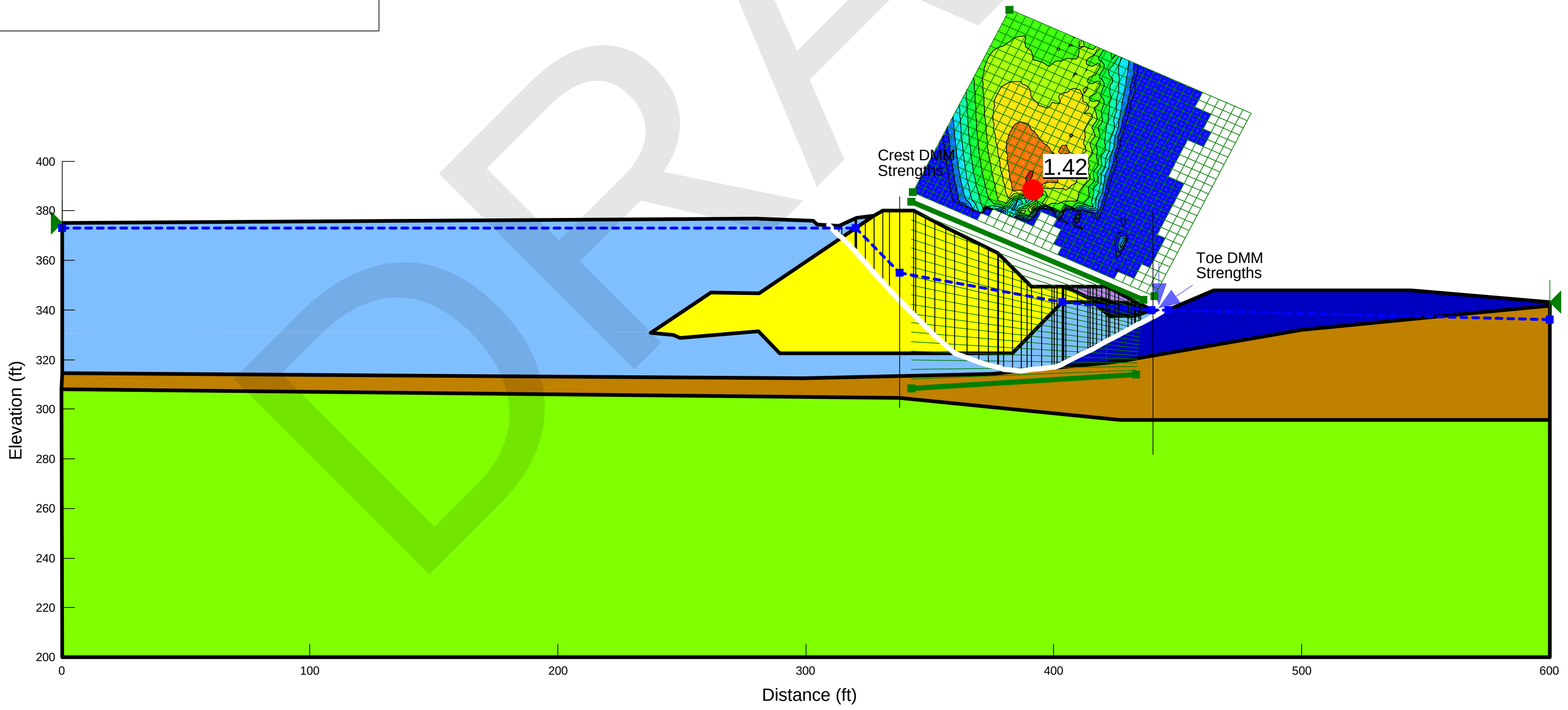
Name: Embankment Fill (Peak Undrained)   Unit Weight: 131 pcf   Strength Function: Embankment Fill Peak Undrained   Piezometric Line: 1
Name: Foundation Clay (Peak Undrained)   Unit Weight: 128 pcf   Strength Function: Foundation Clay Peak Undrained   Piezometric Line: 1
Name: Foundation Sand (Peak Drained)   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

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

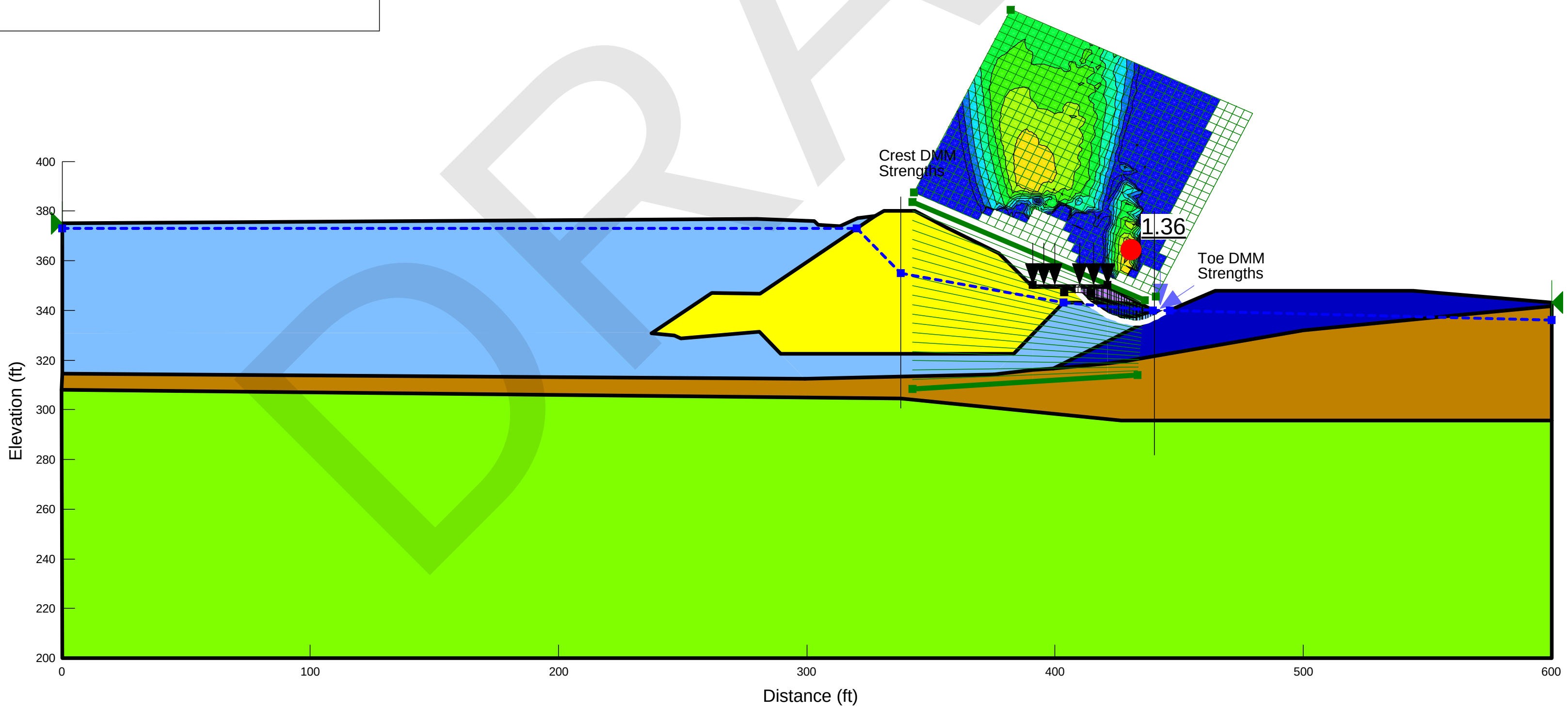
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

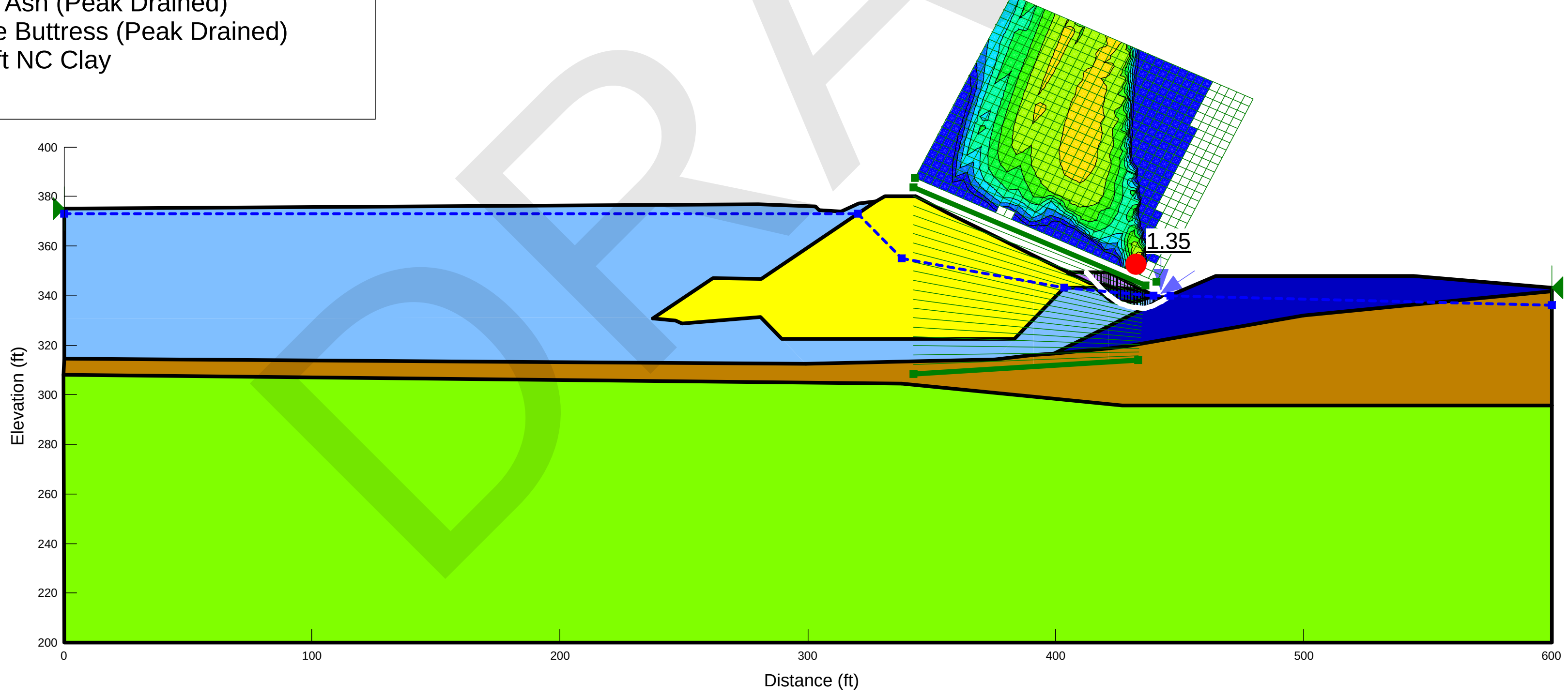
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

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 Local Stability

Kind: SLOPE/W
Method: Spencer
F of S: 1.35



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Joppa Section K DMM Design
Long-Termed Drained Stability

Computed By: LPC
Date: 4/13/2016

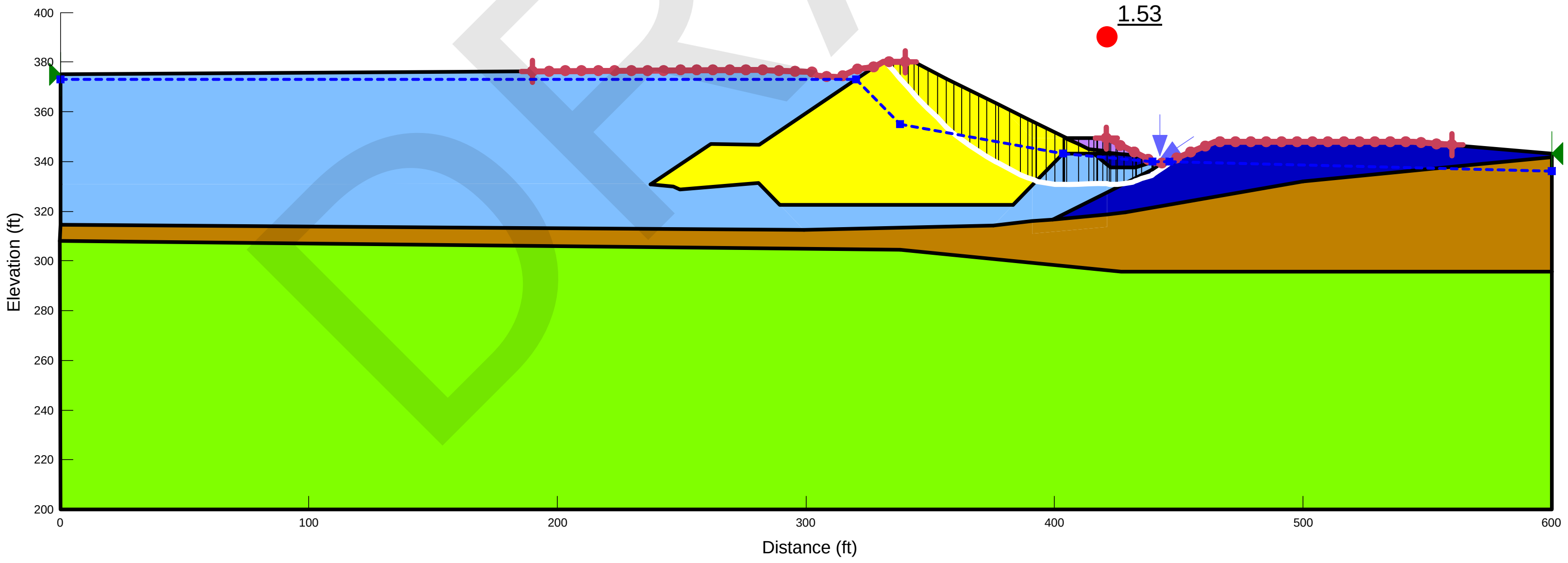
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

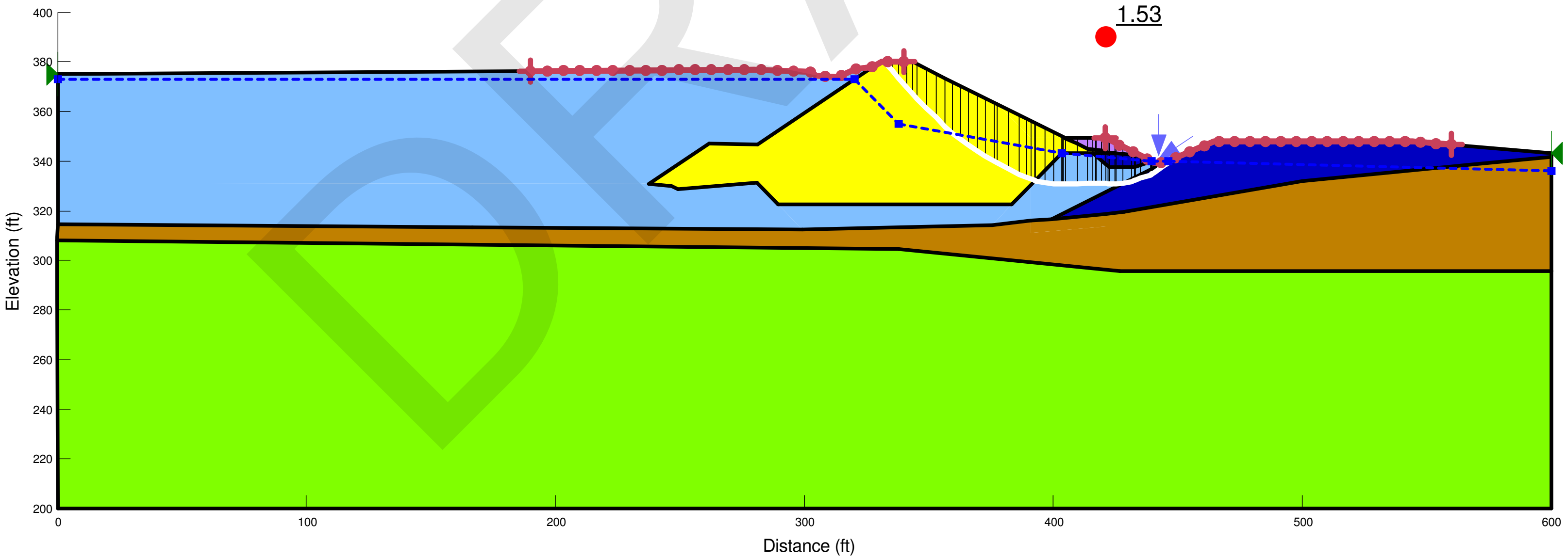
Name: Embankment Fill (Peak Drained)   Unit Weight: 131 pcf   Cohesion': 0 psf   Phi': 35 °   Piezometric Line: 1
Name: Foundation Clay (Peak Drained)   Unit Weight: 128 pcf   C-Horizontal: 0 psf   C-Vertical: 0 psf   Phi-Horizontal: 29 °   Phi-Vertical: 33 °   Piezometric Line: 1
Name: Foundation Sand (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 (M_W)	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		

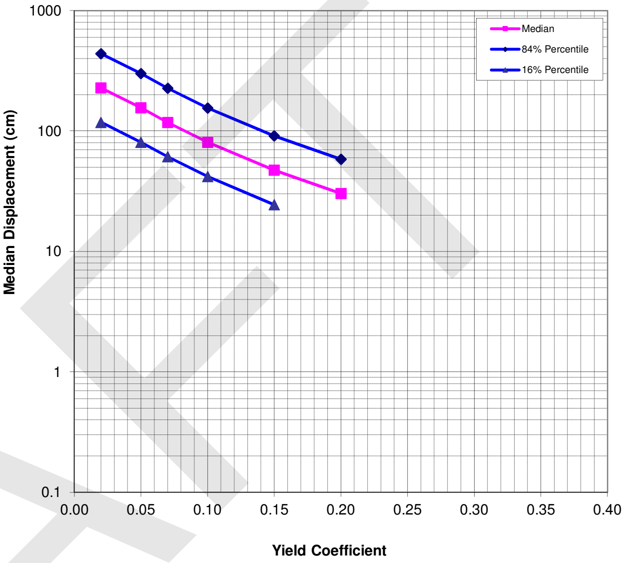
Results			
Probability of Negligible Displ. (P(D=0))	0.00		eq. (3)
D1	11.1	cm	calc. using eq. (7)
D2	21.4	cm	calc. using eq. (7)
D3	41.2	cm	calc. using eq. (7)
P(D>d_threshold)	0.01		eq. (7)

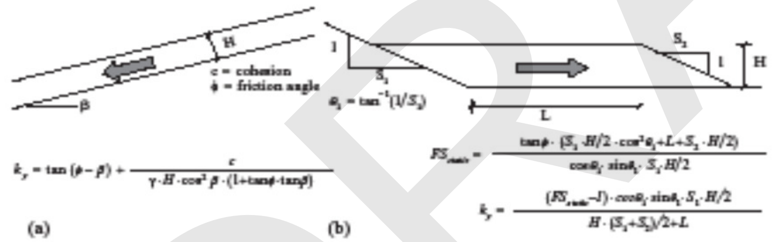
Notes

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





$$k_y = \tan(\phi - \beta) + \frac{c}{\gamma \cdot H \cdot \cos^2\beta \cdot (1 + \tan\phi \cdot \tan\beta)}$$

$$FS_{static} = \frac{\tan\phi \cdot (S_1 \cdot H/2 \cdot \cos^2\theta_1 + L + S_2 \cdot H/2)}{\cos\theta_1 \cdot \sin\theta_1 \cdot S_1 \cdot H/2}$$

$$k_y = \frac{(FS_{static} - 1) \cdot \cos\theta_1 \cdot \sin\theta_1 \cdot S_1 \cdot H/2}{H \cdot (S_1 + S_2)/2 + L}$$

Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

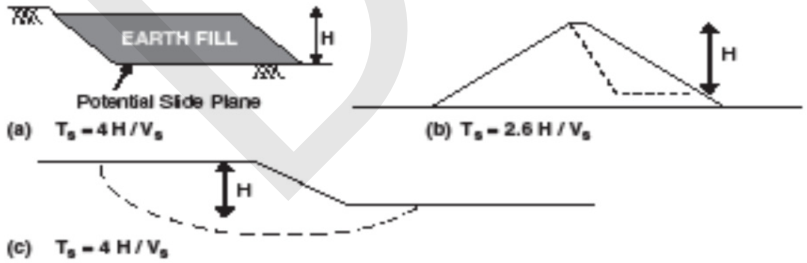


Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

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

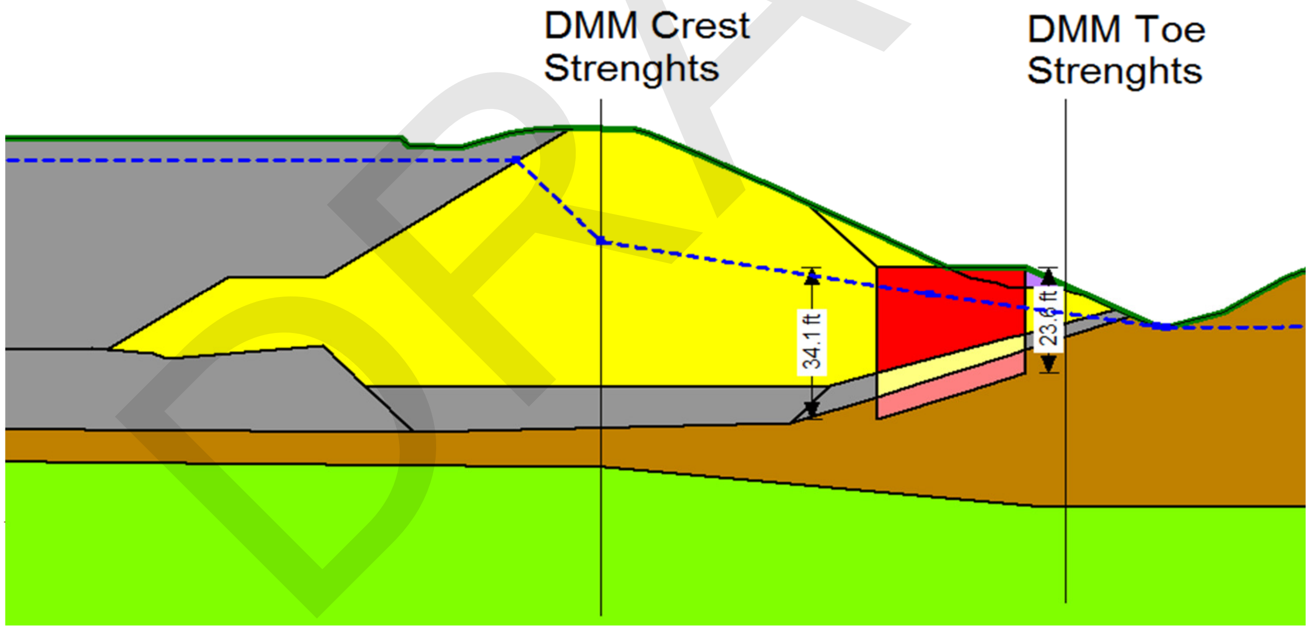
335.0	380.1	3575
335.0	355.1	4756
335.0	322.7	5654
335.0	322.7	4721
335.0	313.4	4833
335.0	313.4	5162
335.0	304.6	5307
335.0	304.6	6056
335.0	200.0	9082

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

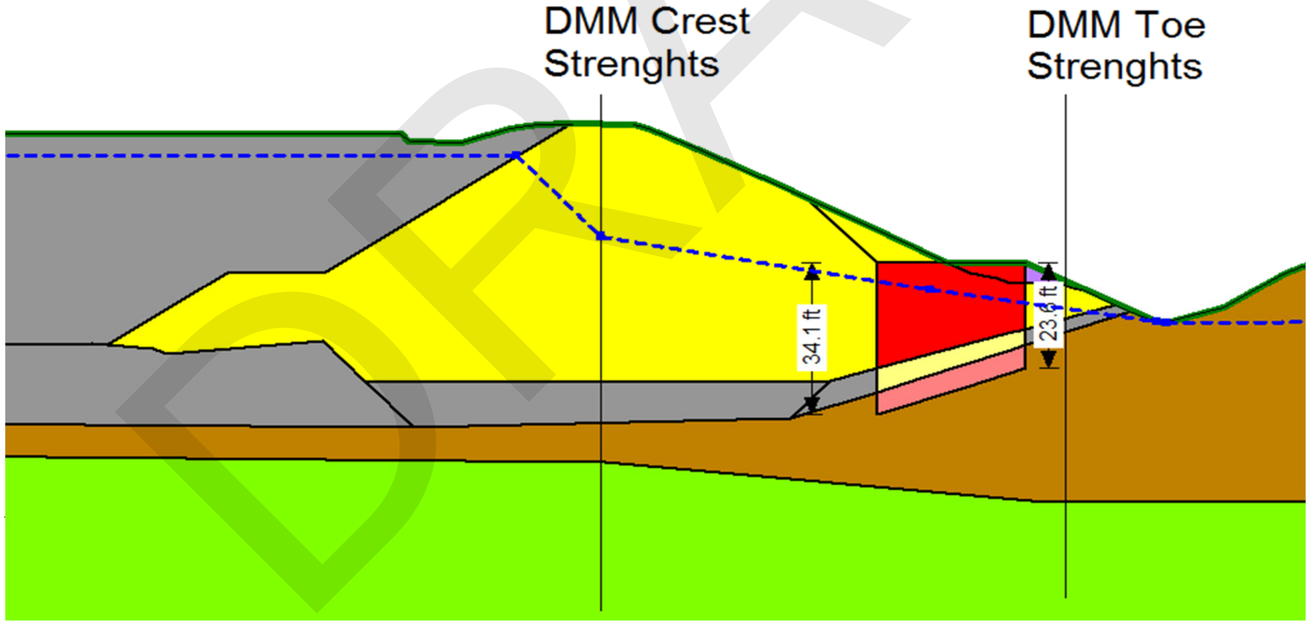
335.0	380.1	3575
335.0	355.1	4756
335.0	322.7	5654
335.0	322.7	3439
335.0	313.4	3457
335.0	313.4	5162
335.0	304.6	5307
335.0	304.6	6056
335.0	200.0	9082

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

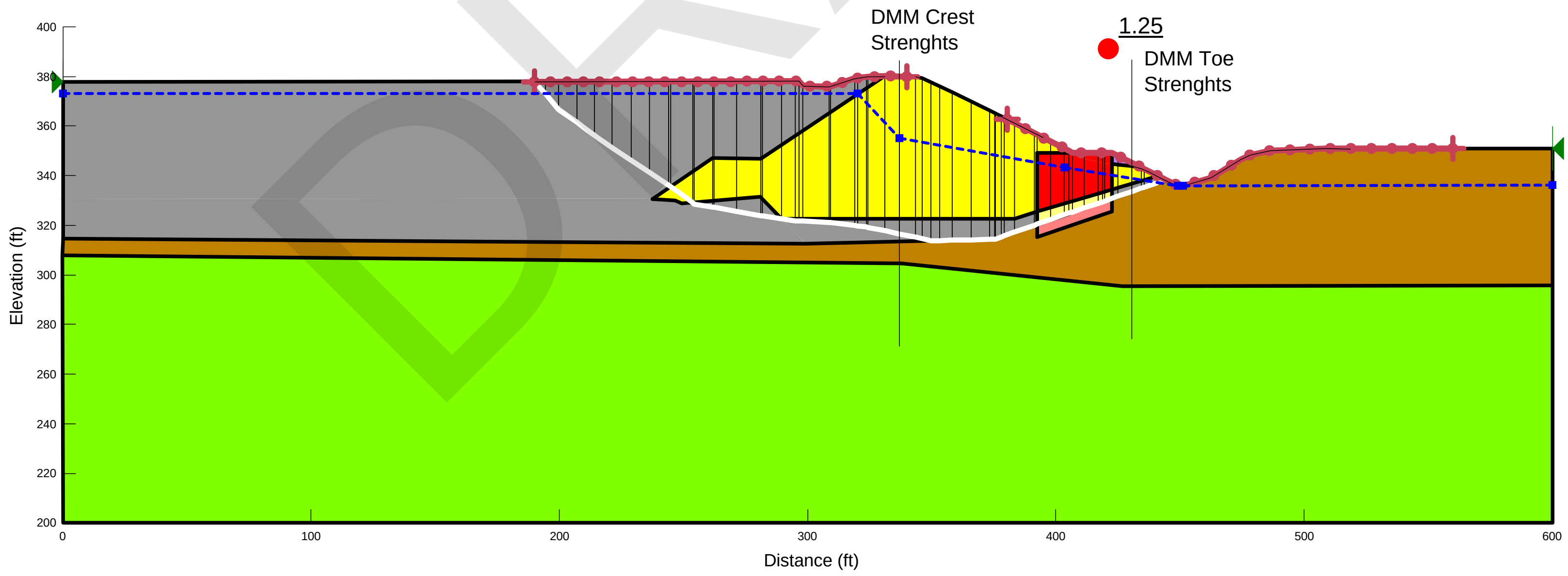
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Fly Ash (Post-Liquefaction) Unit Weight: 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

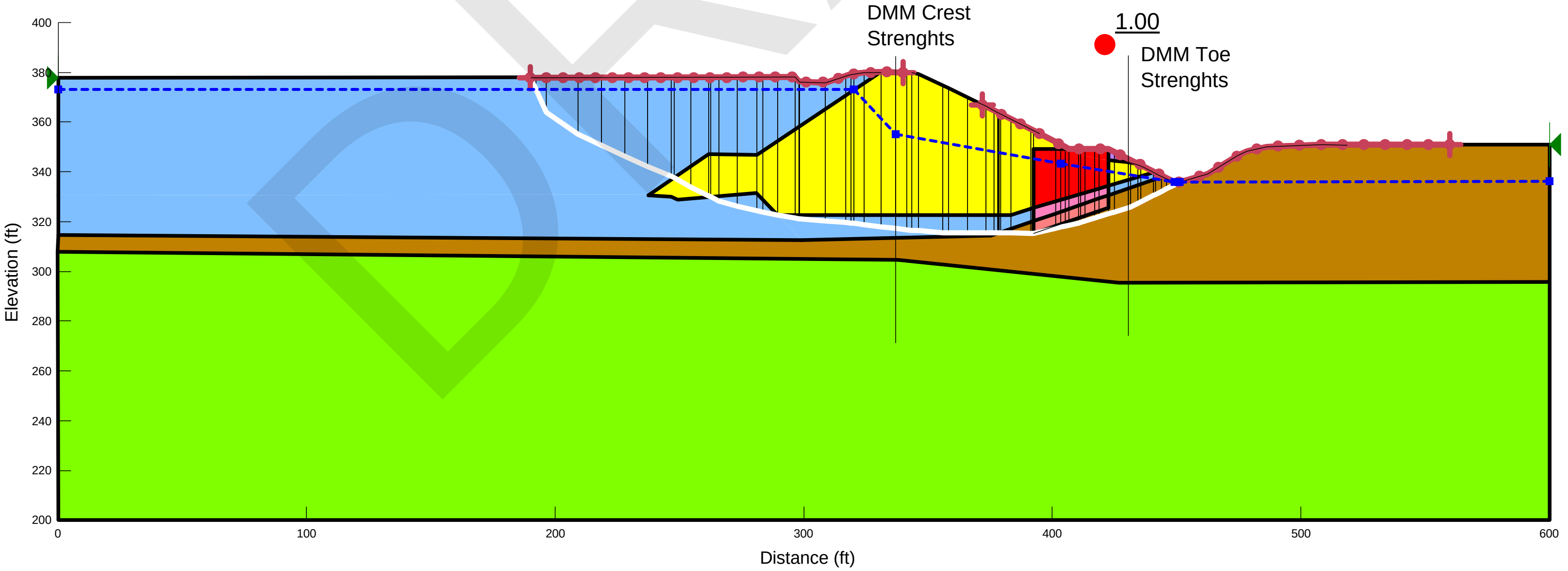
Materials

- 🟨 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

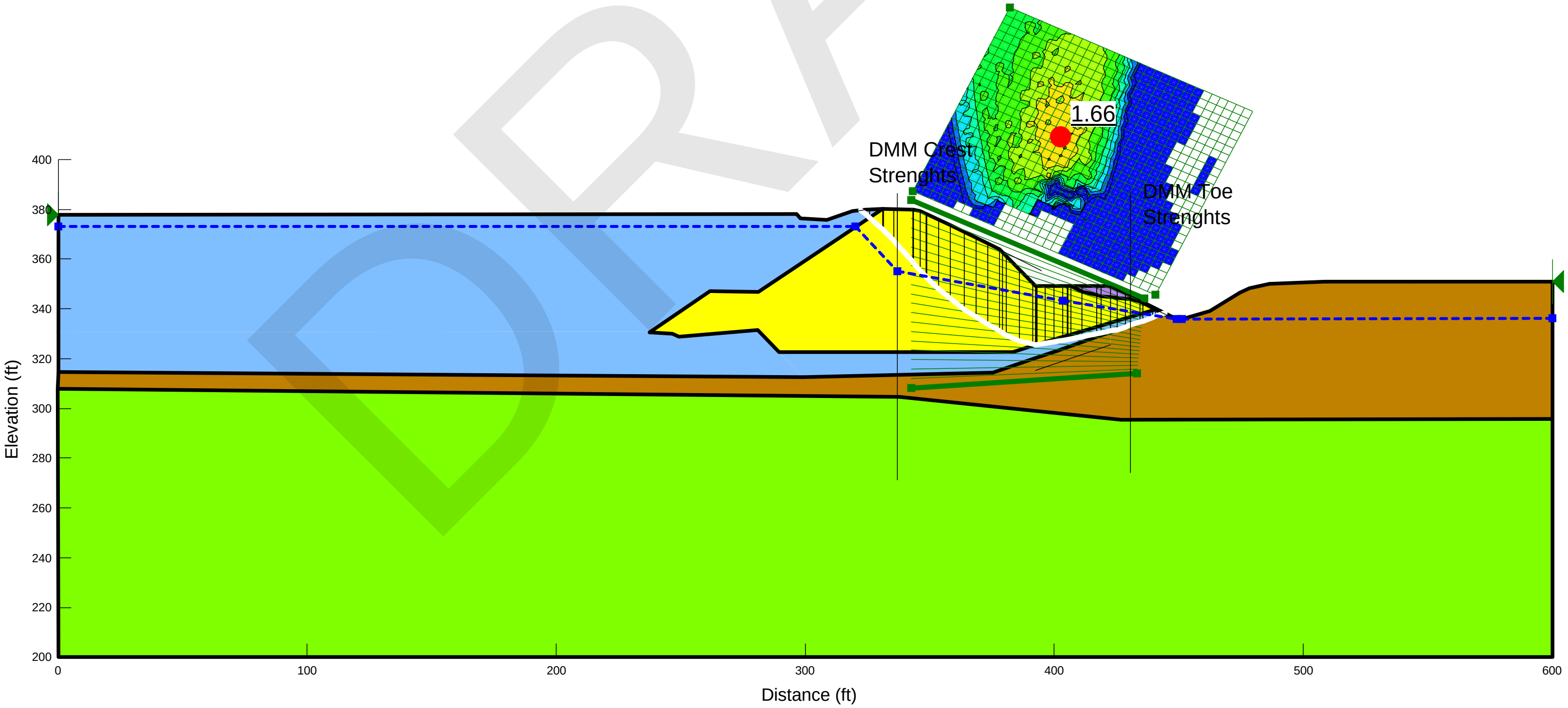
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

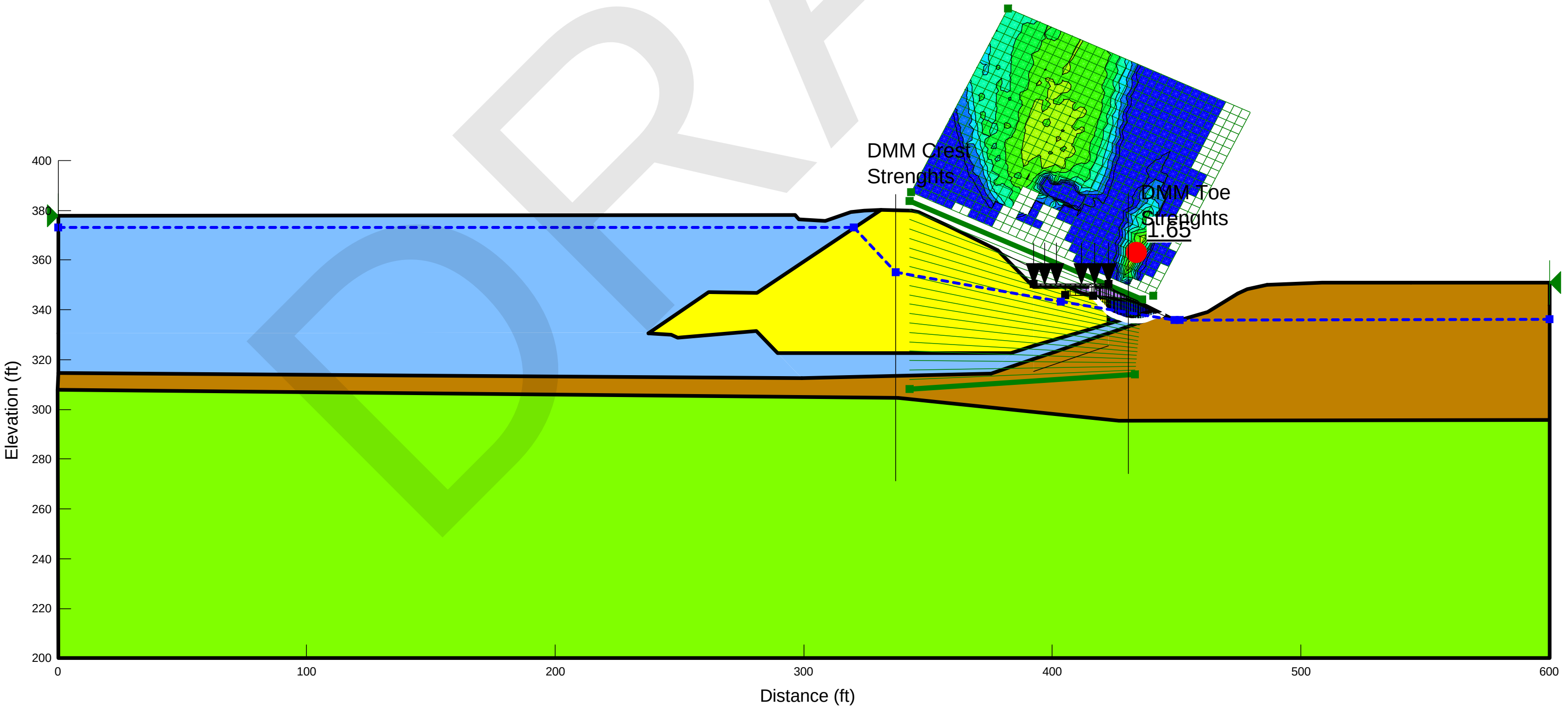
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

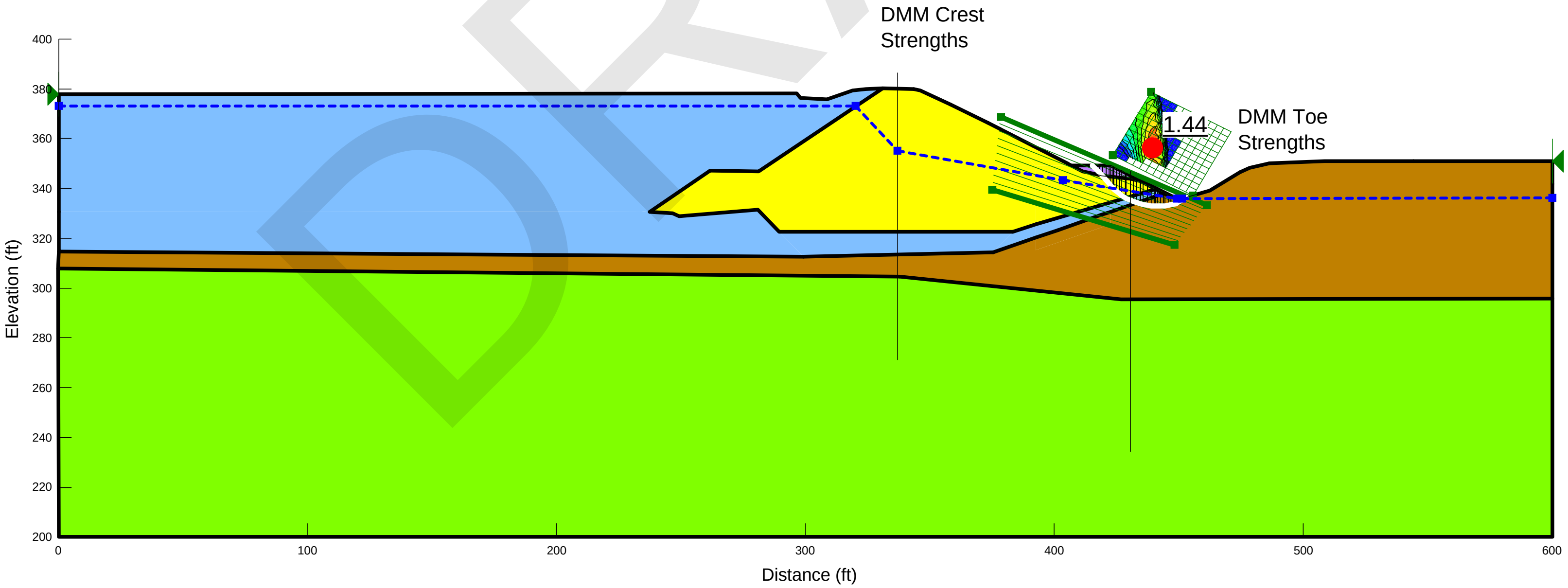
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

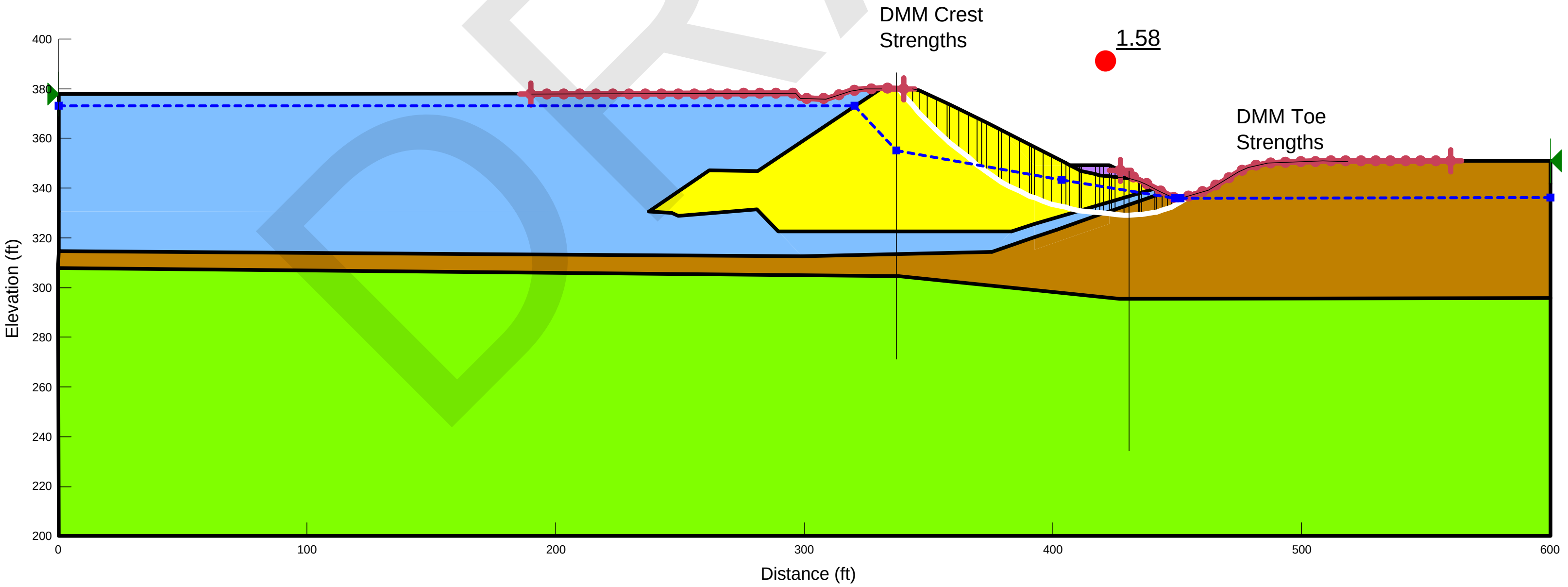
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

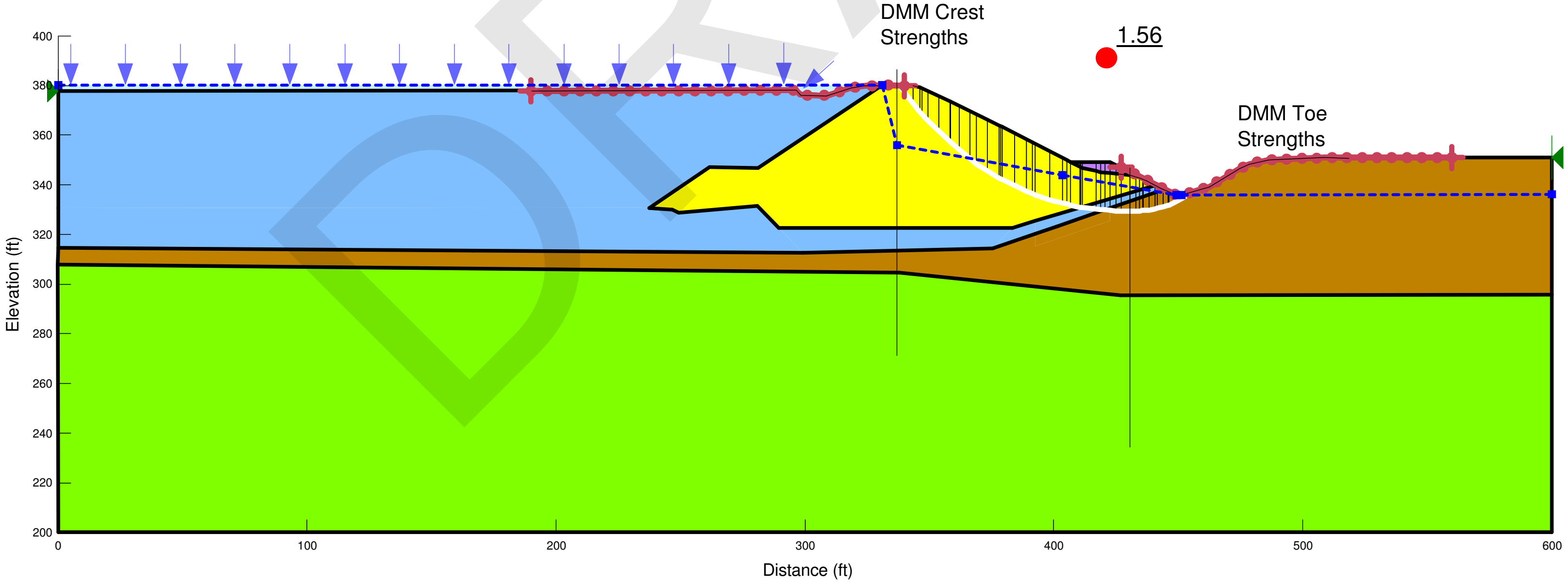
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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		

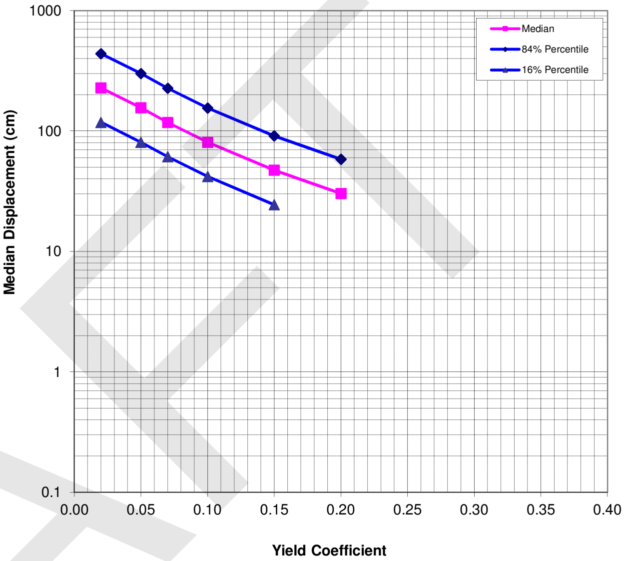
Results			
Probability of Negligible Displ. (P(D=0))	0.00		eq. (3)
D1	9.5	cm	calc. using eq. (7)
D2	18.4	cm	calc. using eq. (7)
D3	35.5	cm	calc. using eq. (7)
P(D>d_threshold)	0.01		eq. (7)

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



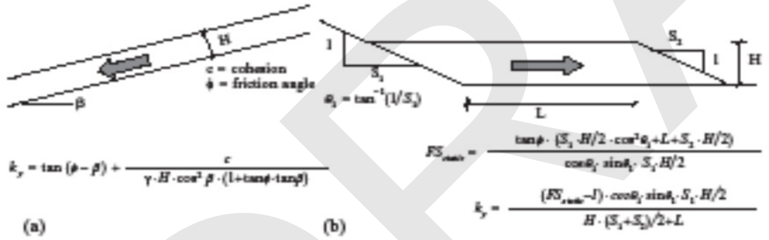


Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

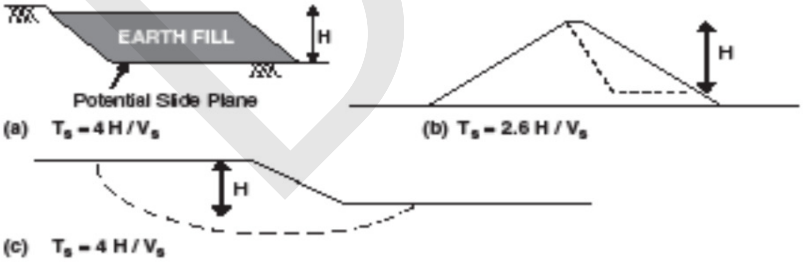


Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

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

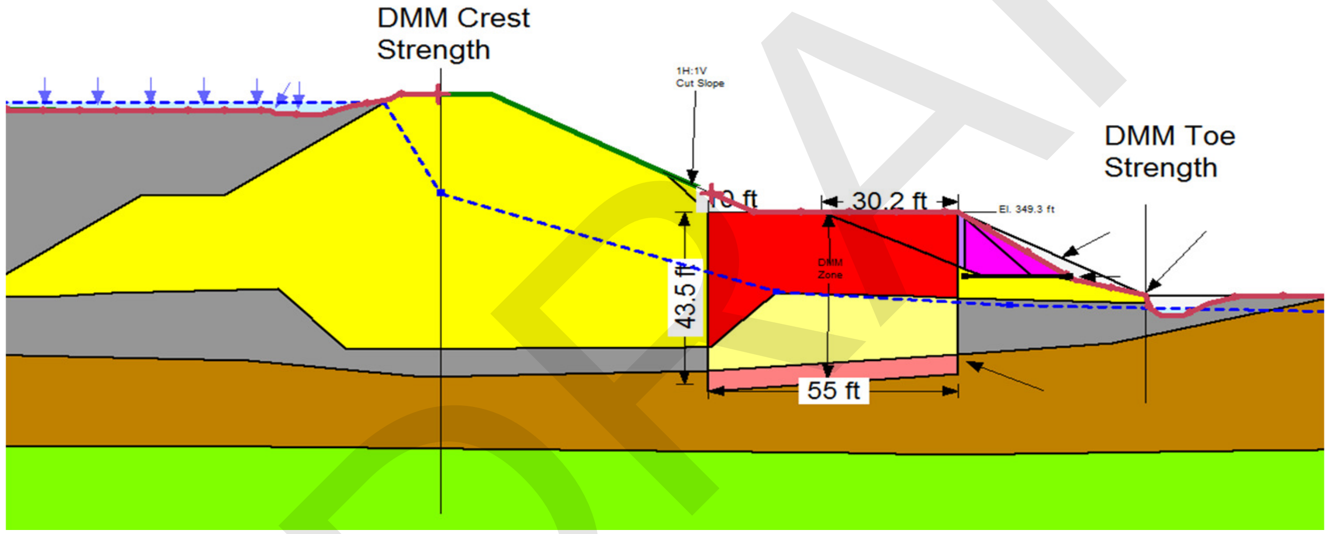
620.0	379.1	3575
620.0	354.1	4740
620.0	314.7	5859
620.0	314.7	4854
620.0	307.6	4940
620.0	307.6	5276
620.0	289.5	5559
620.0	289.5	6494
620.0	200.0	9084

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

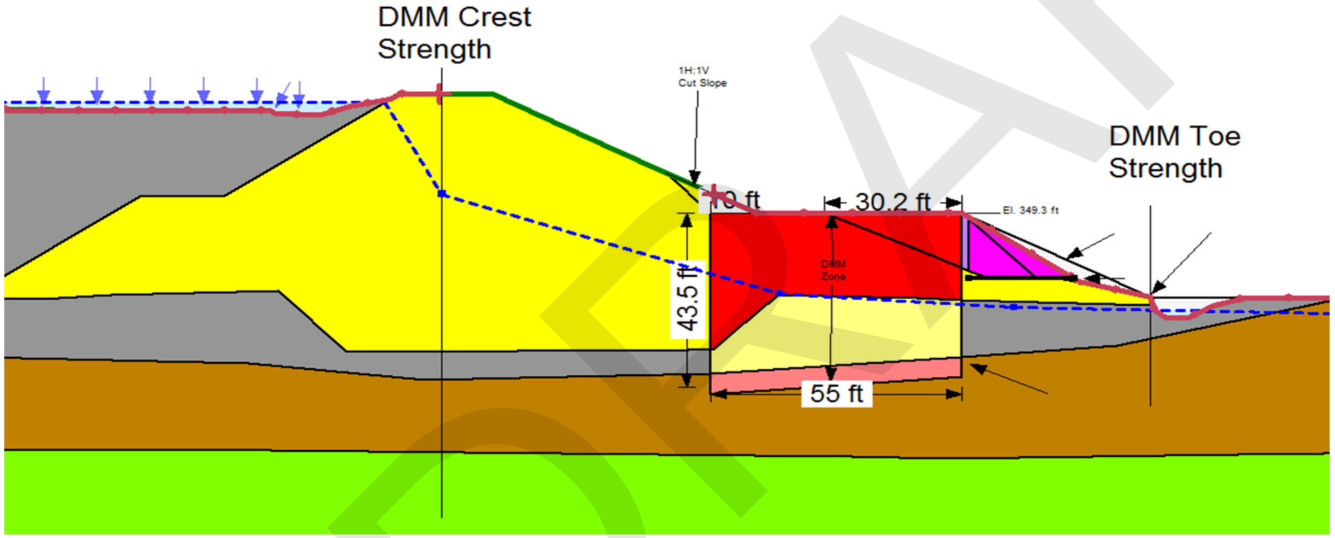
620.0	379.1	3575
620.0	354.1	4740
620.0	314.7	5859
620.0	314.7	3460
620.0	307.6	3474
620.0	307.6	5276
620.0	289.5	5559
620.0	289.5	6494
620.0	200.0	9084

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

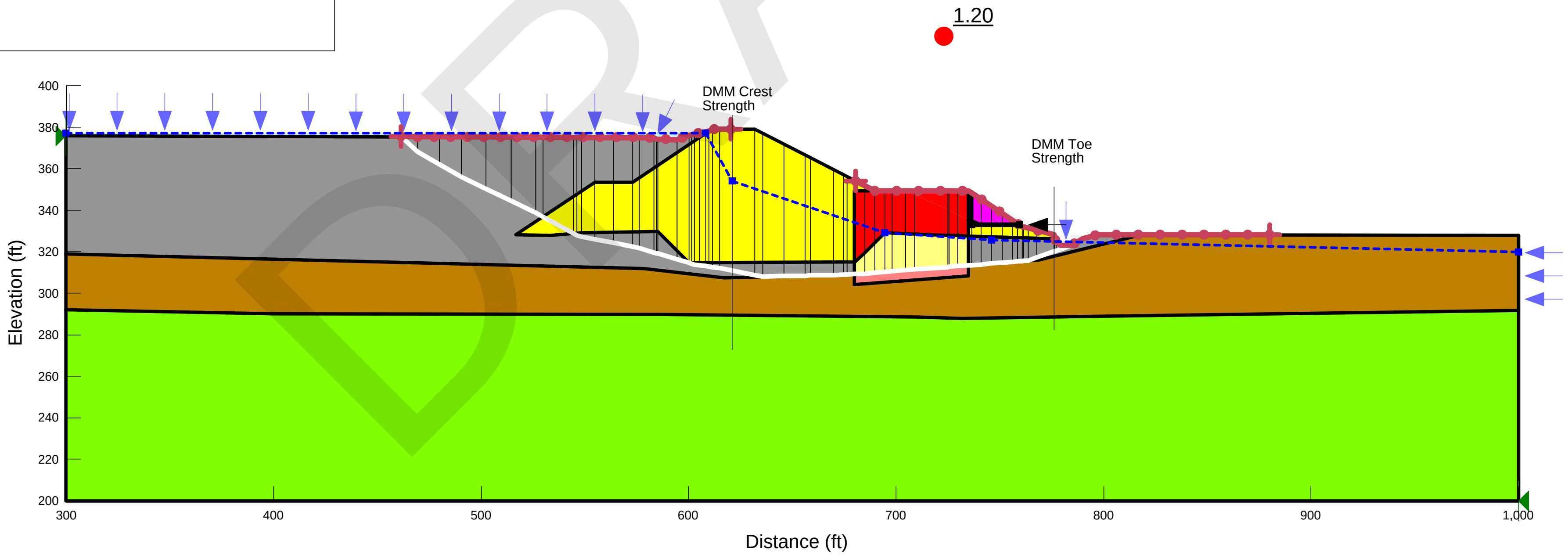
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Fly Ash (Post-Liquefaction) Unit Weight: 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

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 (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

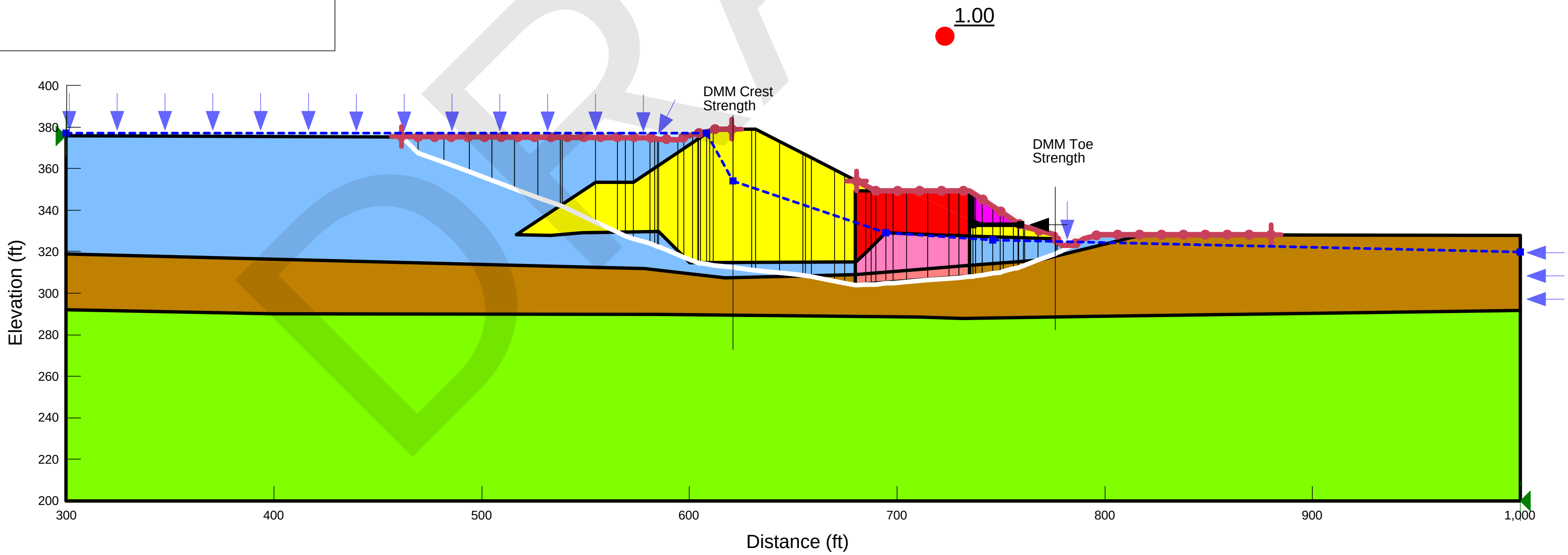
Materials

- 🟨 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

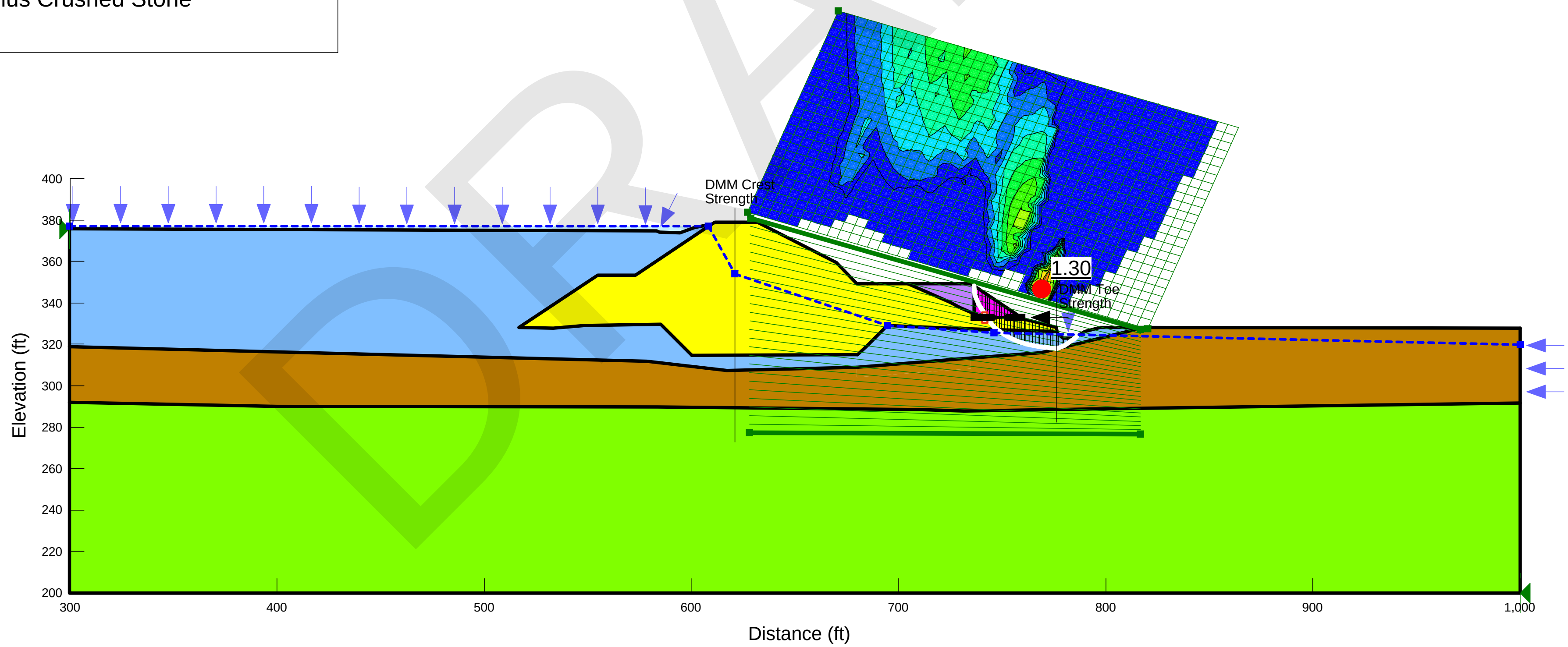
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

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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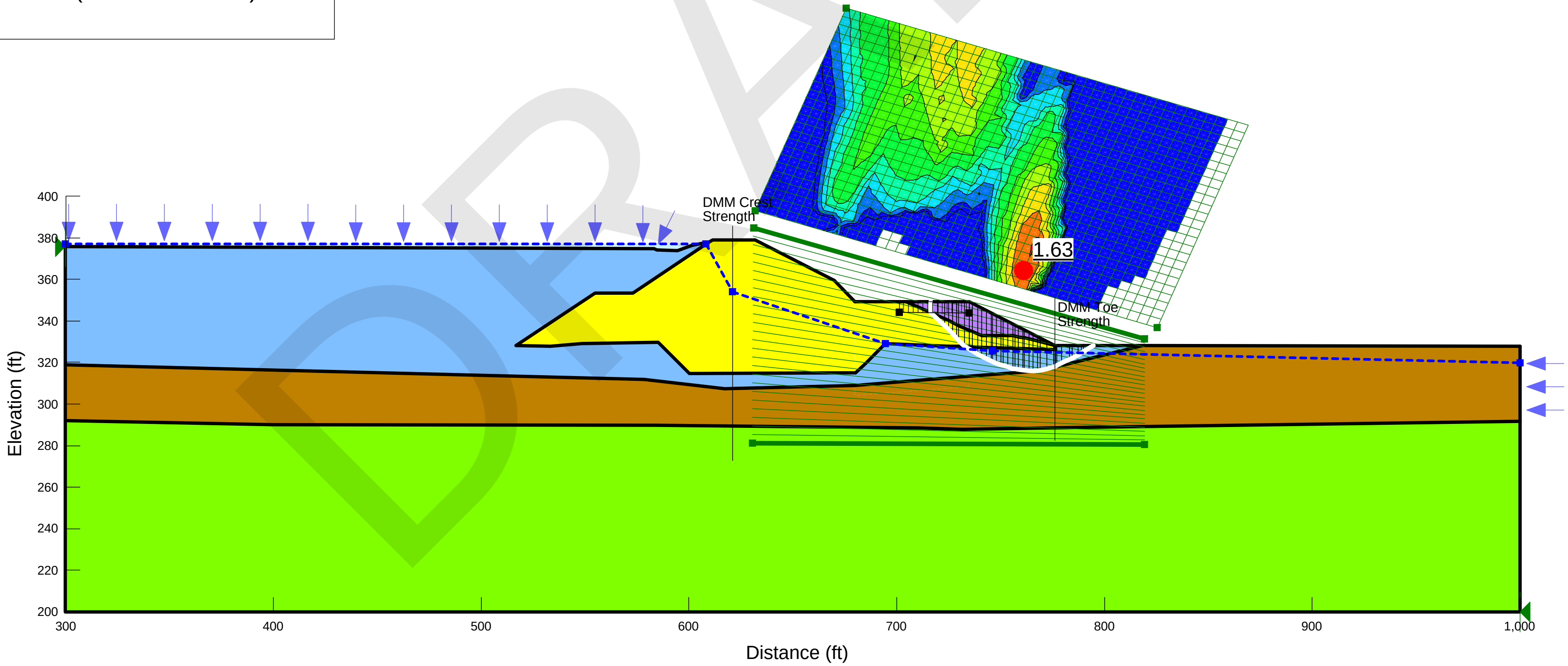
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit Weight: 128 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Fly Ash (Peak Undrained) Unit Weight: 106 pcf Tau/Sigma Ratio: 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

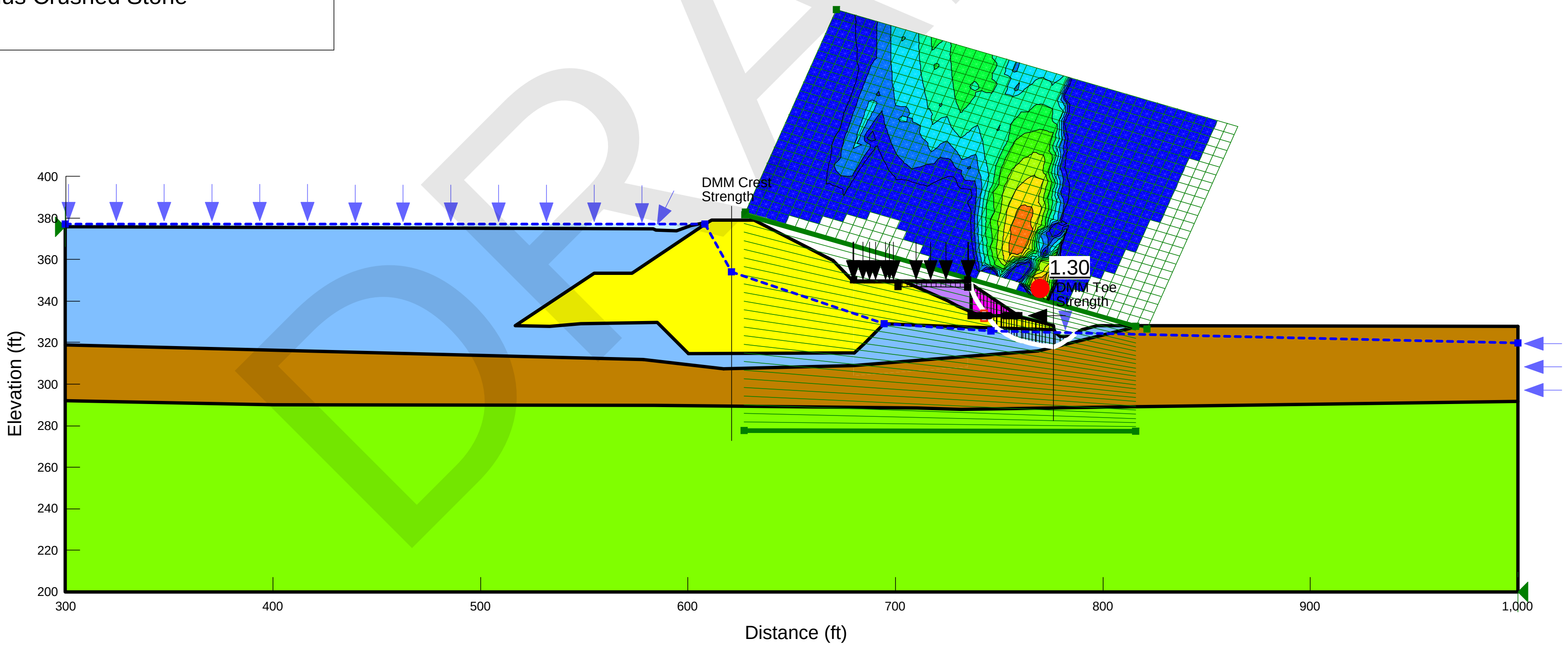
Name: Embankment Fill (Peak Undrained) Unit Weight: 131 pcf Strength Function: Embankment Fill Peak Undrained Piezometric Line: 1
Name: Foundation Clay (Peak Undrained) Unit Weight: 128 pcf Strength Function: Foundation Clay Peak Undrained Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

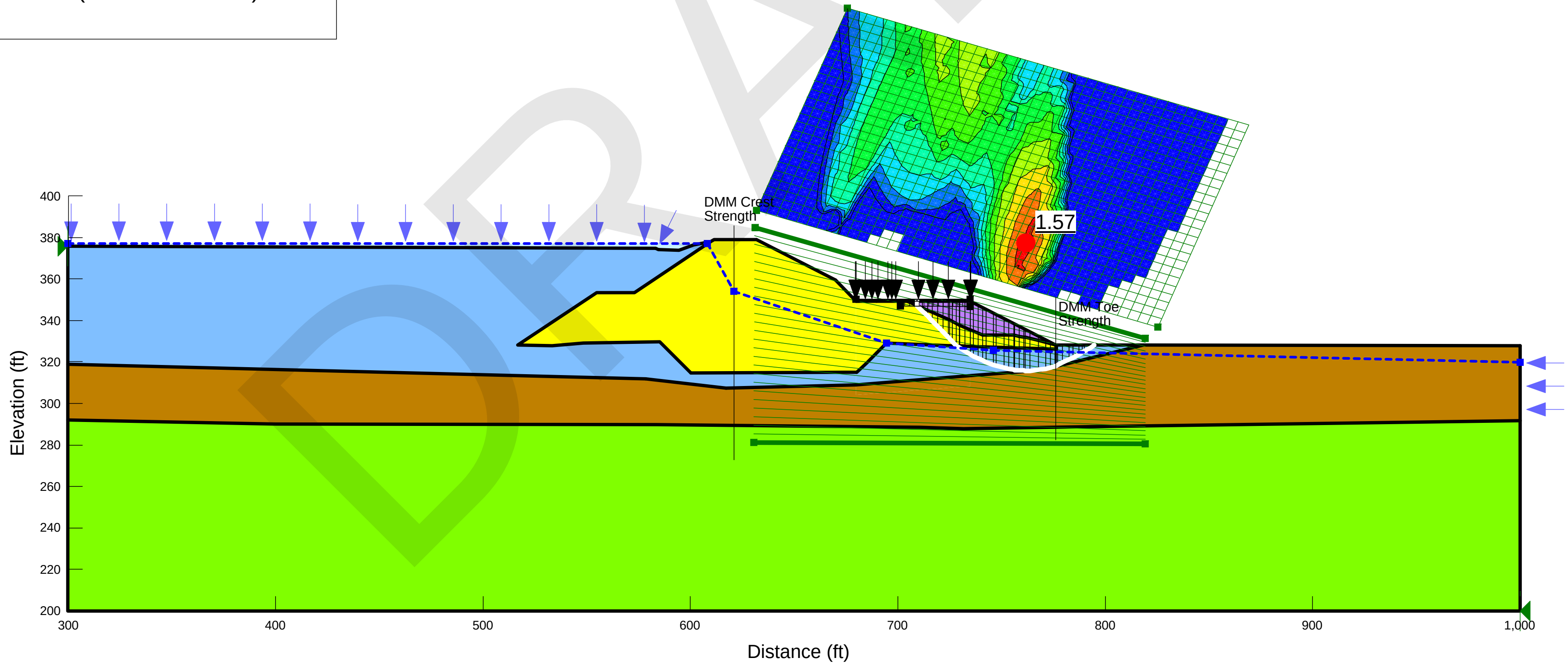
Name: Embankment Fill (Peak Undrained)   Unit Weight: 131 pcf   Strength Function: Embankment Fill Peak Undrained   Piezometric Line: 1
Name: Foundation Clay (Peak Undrained)   Unit Weight: 128 pcf   Strength Function: Foundation Clay Peak Undrained   Piezometric Line: 1
Name: Foundation Sand (Peak Drained)   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

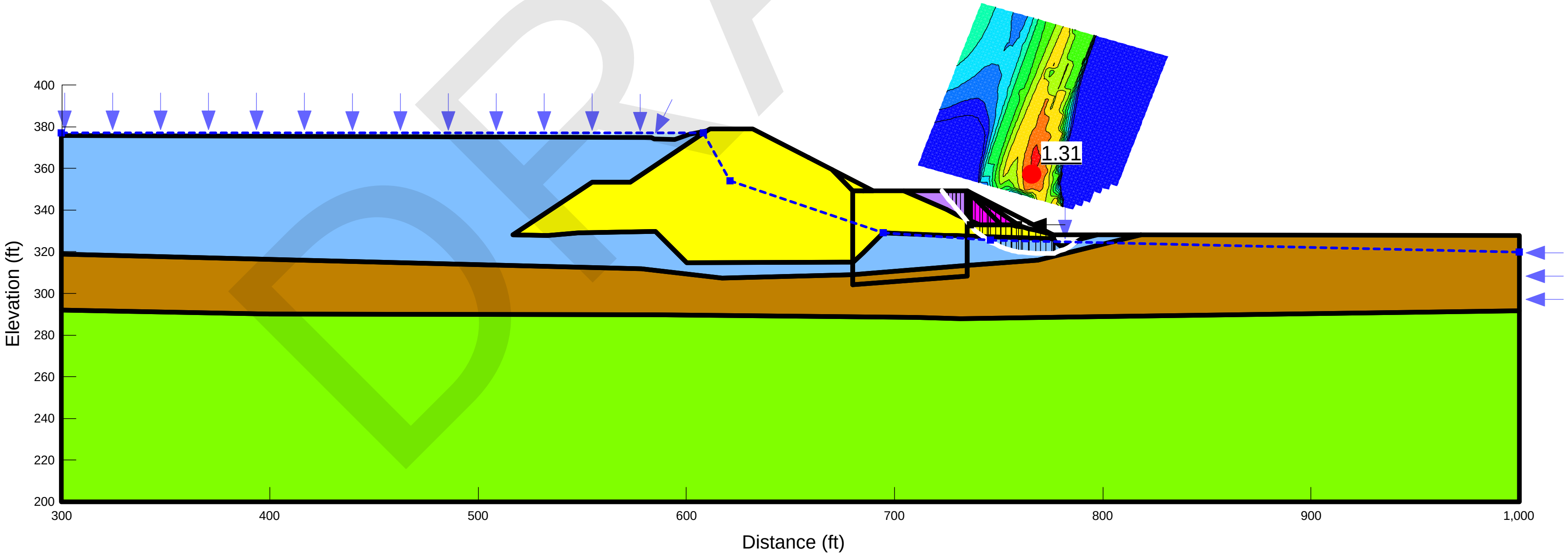
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

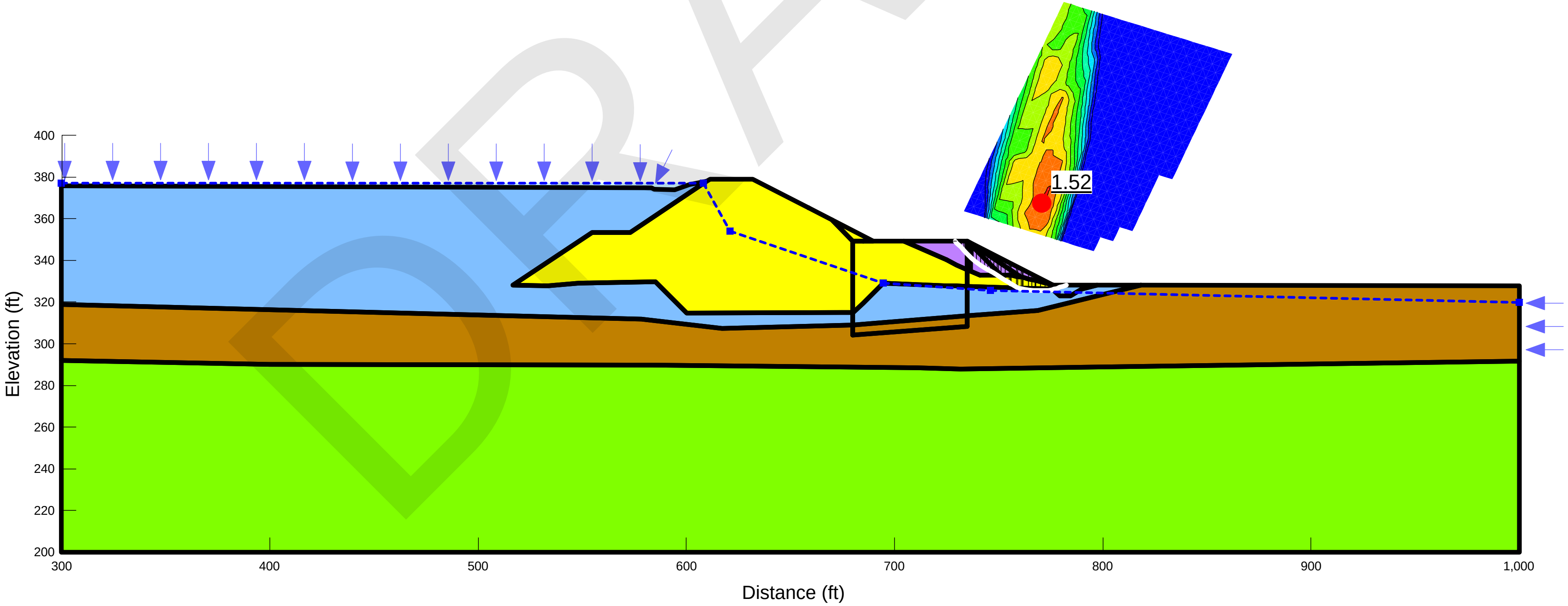
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

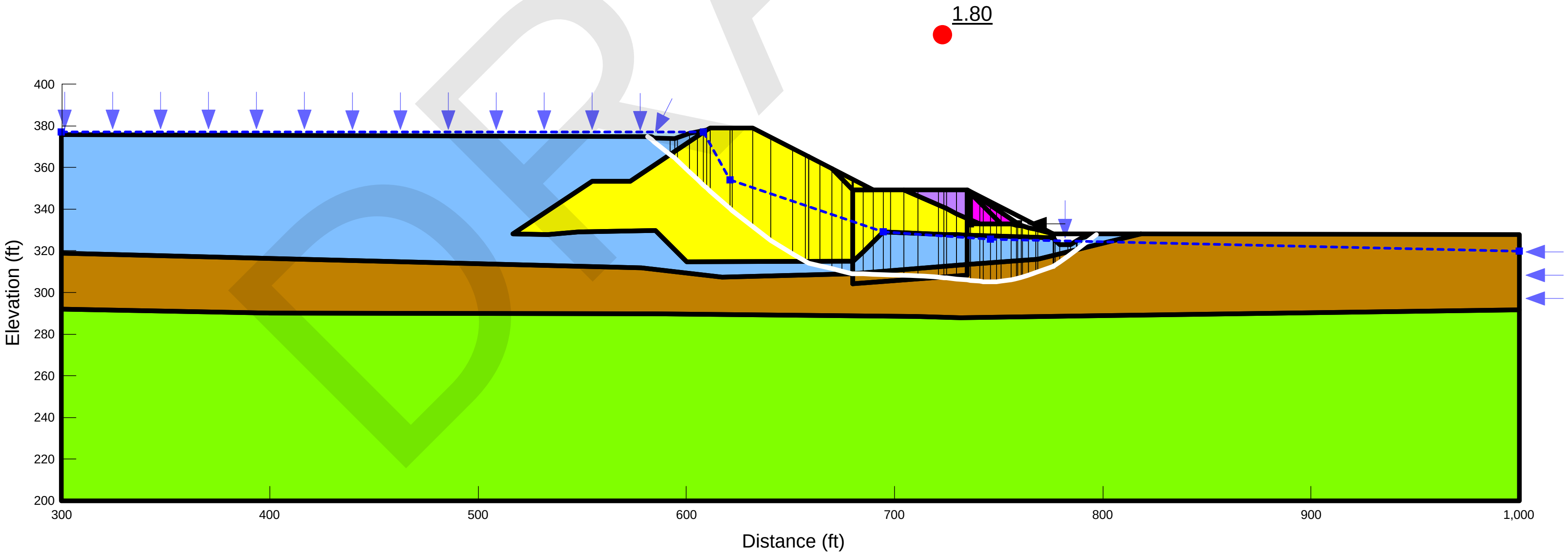
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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

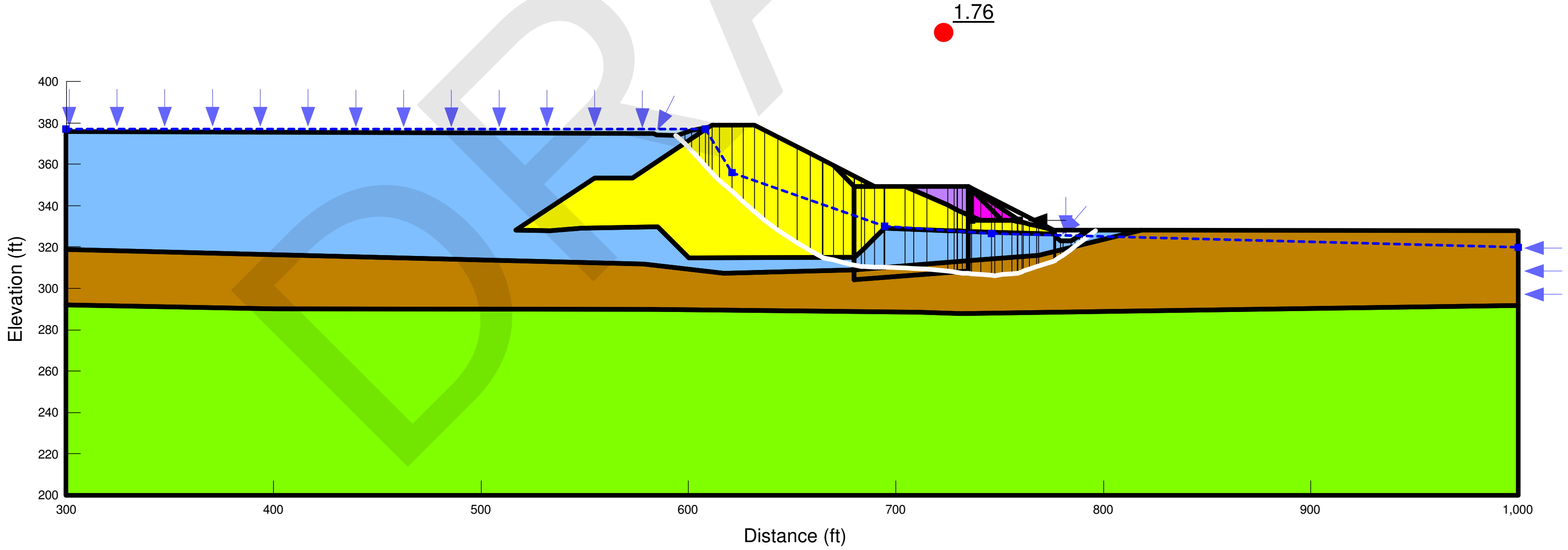
Name: Embankment Fill (Peak Drained) Unit Weight: 131 pcf Cohesion': 0 psf Phi': 35 ° Piezometric Line: 1
Name: Foundation Clay (Peak Drained) Unit Weight: 128 pcf C-Horizontal: 0 psf C-Vertical: 0 psf Phi-Horizontal: 29 ° Phi-Vertical: 33 ° Piezometric Line: 1
Name: Foundation Sand (Peak Drained) Unit 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		

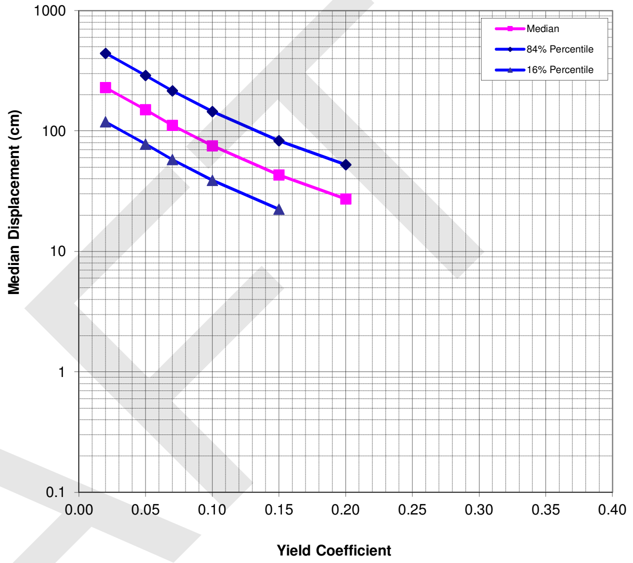
Results			
Probability of Negligible Displ. (P(D=0))	0.00		eq. (3)
D1	11.6	cm	calc. using eq. (7)
D2	22.4	cm	calc. using eq. (7)
D3	43.2	cm	calc. using eq. (7)
P(D>d_threshold)	0.02		eq. (7)

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



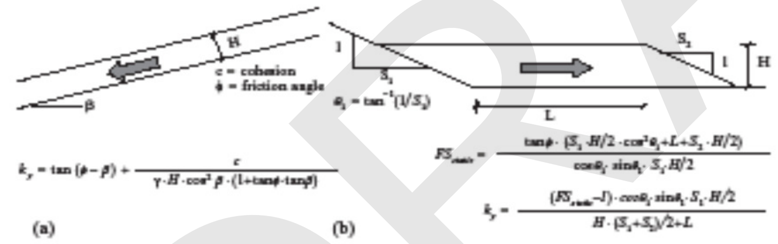


Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

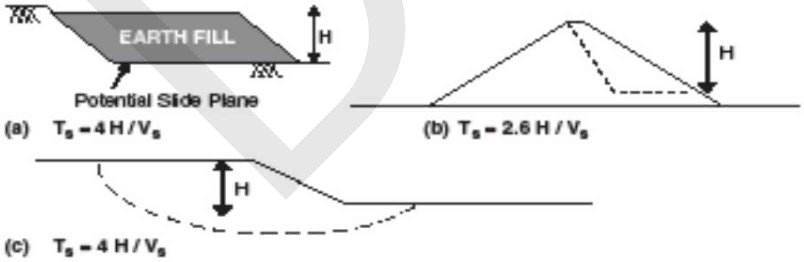


Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

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

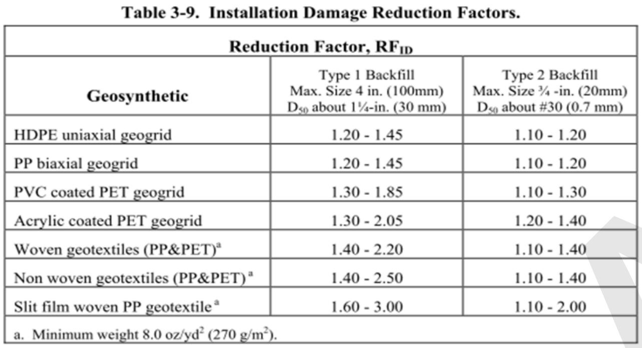


Table 3-9. Installation Damage Reduction Factors.

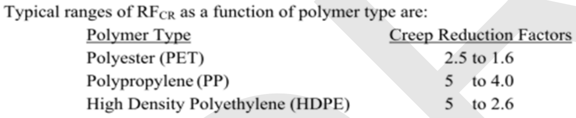
Geosynthetic	Reduction Factor, RF_{ID} Type 1 Backfill Max. Size 4 in. (100mm) D_{50} about 1¼-in. (30 mm)	 Type 2 Backfill Max. Size ¾ -in. (20mm) D_{50} about #30 (0.7 mm)
HDPE uniaxial geogrid	1.20 - 1.45	1.10 - 1.20
PP biaxial geogrid	1.20 - 1.45	1.10 - 1.20
PVC coated PET geogrid	1.30 - 1.85	1.10 - 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/yd² (270 g/m²).

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

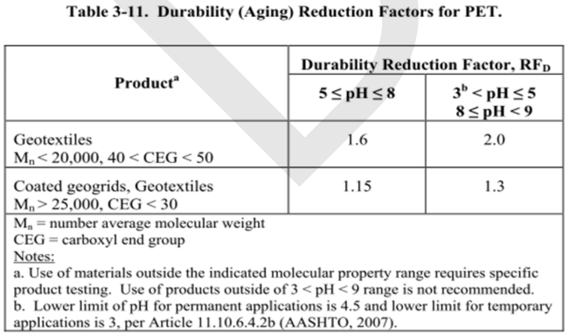


Table 3-11. Durability (Aging) Reduction Factors for PET.

Product[a]	Durability Reduction Factor, RF_D $5 \leq pH \leq 8$	 $3^b < pH \leq 5$ $8 \leq pH < 9$
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

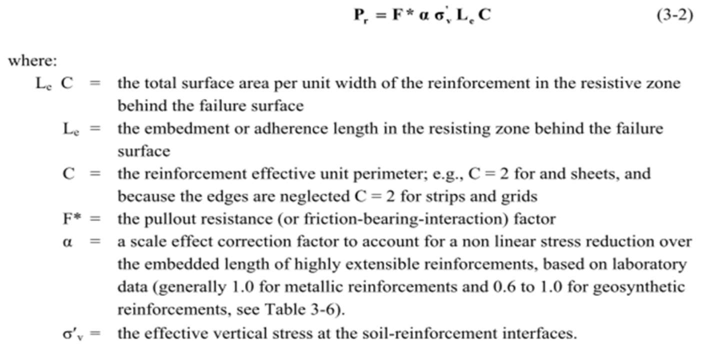
Product	Ultimate Tensile Strength (lbs/ft)	Tensile Strength @ 5% Strain (lbs/ft)	Long-Term Design Strength (lbs/ft)	T_{al} (lbs/ft)
PET70/70	4800	1080	2280	1043
PET100	7200	2700	3420	1565
PET150	10283	3600	4877	2235
PET200	13800	6000	6545	3000
PET300	20580	8400	10205	4474
PET 400/50	27417	9594	13590	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:



$$P_r = F^* \alpha \sigma'_v L_e C \quad (3\text{-}2)$$

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

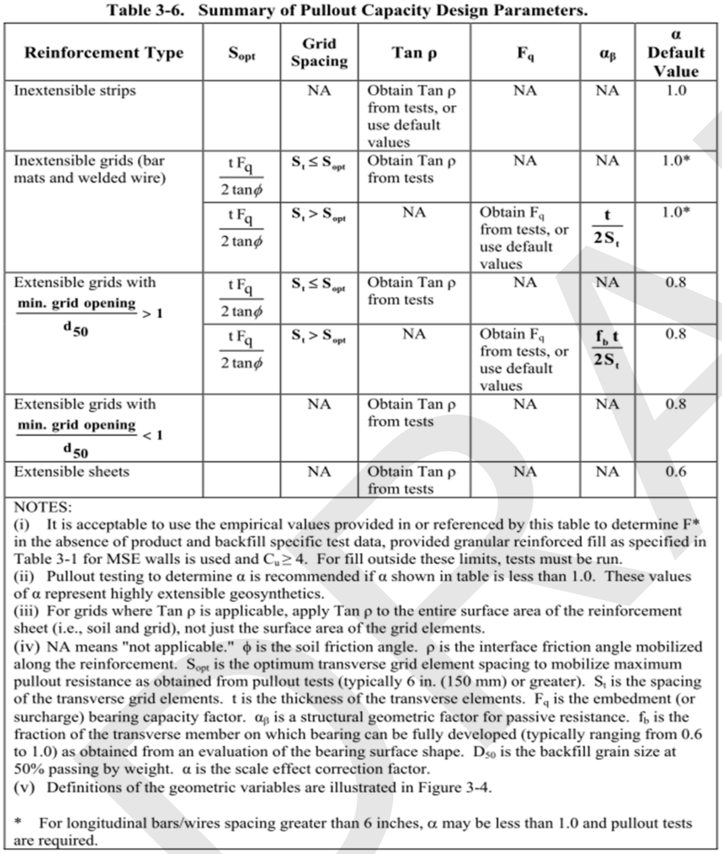


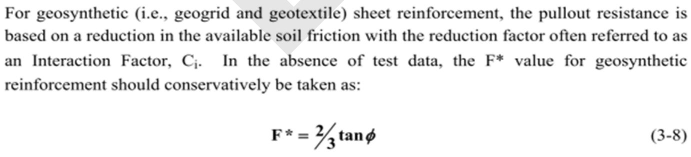
Table 3-6. Summary of Pullout Capacity Design Parameters.

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:

$$F^* = \frac{2}{3}\tan\phi \quad (3\text{-}8)$$

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.

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Mirafi® PET70/70

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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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Mirafi® PET100

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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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Mirafi® PET150

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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)

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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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.

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)	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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Mirafi® PET300

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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
			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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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

TENCATE
Mirafi®

TENCATE GEOSYNTHETICS
Americas

SEPARATION

SOIL REINFORCEMENT

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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TENCATE Mirafi

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Mirafi® PET 1000/100

SEPARATION
SOIL REINFORCEMENT

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	yd² (m²)	598 (500)
Estimated Roll Weight	lbs (kg)	2519 (1143)

TENCATE GEOSYNTHETICS
Americas

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)

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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Testing Lab 1291.01 & 1291.02

TENCATE Mirafi®

TENCATE GEOSYNTHETICS
Americas

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.

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)	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)

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
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)

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[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.

Made in USA

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.

TENCATE GEOSYNTHETICS
Americas

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)

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 Mirafi®

TENCATE GEOSYNTHETICS
Americas

Miragrid® 10XT

SOIL REINFORCEMENT

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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GAI-LAP-25-97

GMA Geosynthetic Materials Association

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TENCATE GEOSYNTHETICS
Americas

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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TENCATE GEOSYNTHETICS
Americas

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)

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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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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Testing Lab 1291.01 & 1291.02

Calculation Notes

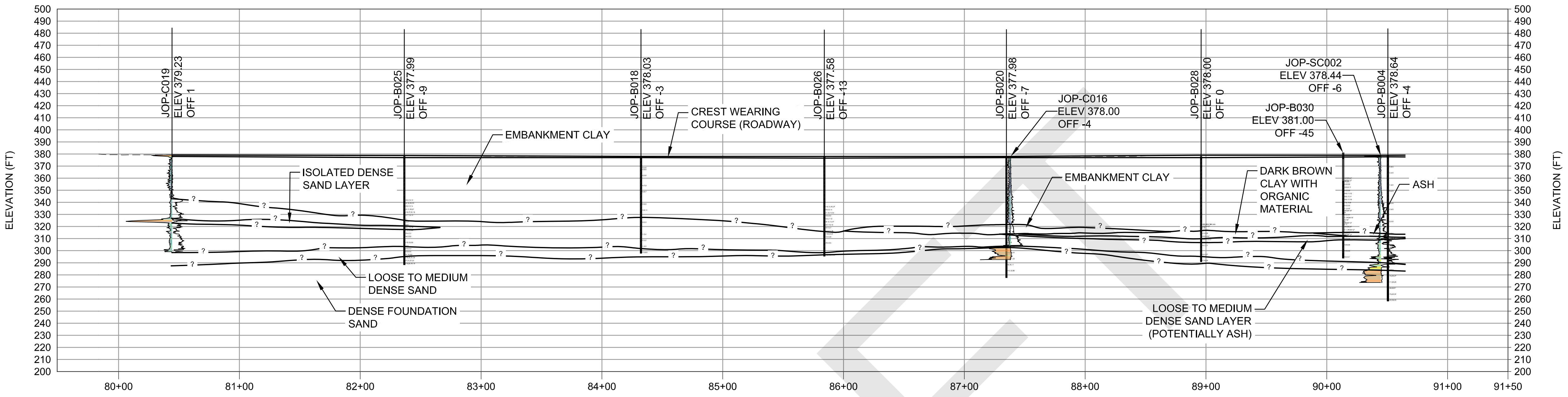
Subject: Joppa DMM Global Stability (Sta. 83+00 to 91+50)
Project Name: Dynegy CCR
By: Lucas Carr
Date: 4/14/2016
Project No: 60440155
Checked By: Andy Wilding
Date: 4/26/2016
Task No.: 01

Attachment 3

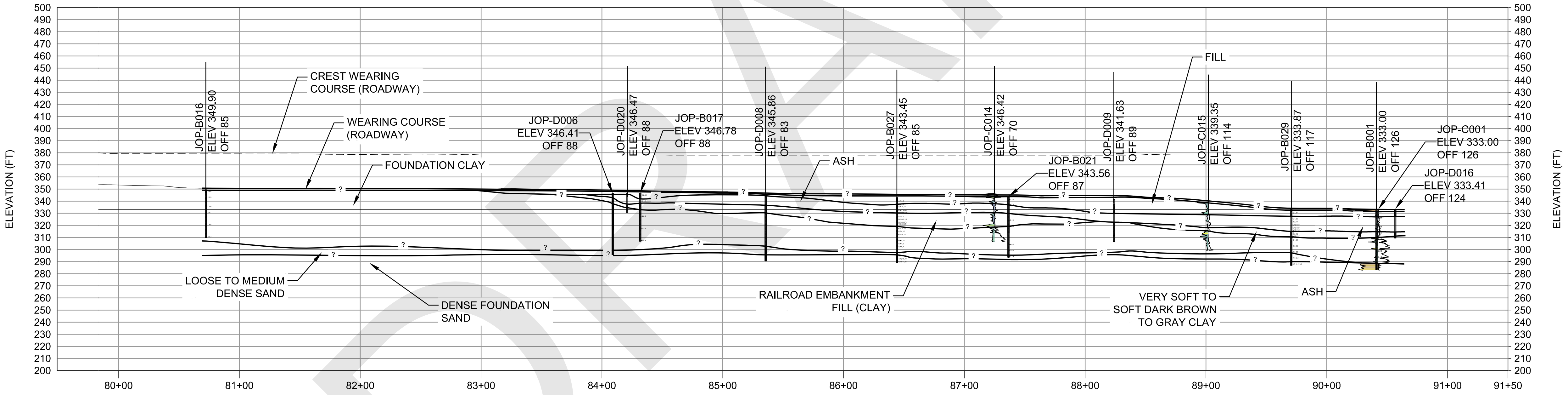
Section and Profile Drawings

RAU, MICHAEL, 4/22/2016 1:44 PM

CREST PROFILE



TOE PROFILE



NOTES:

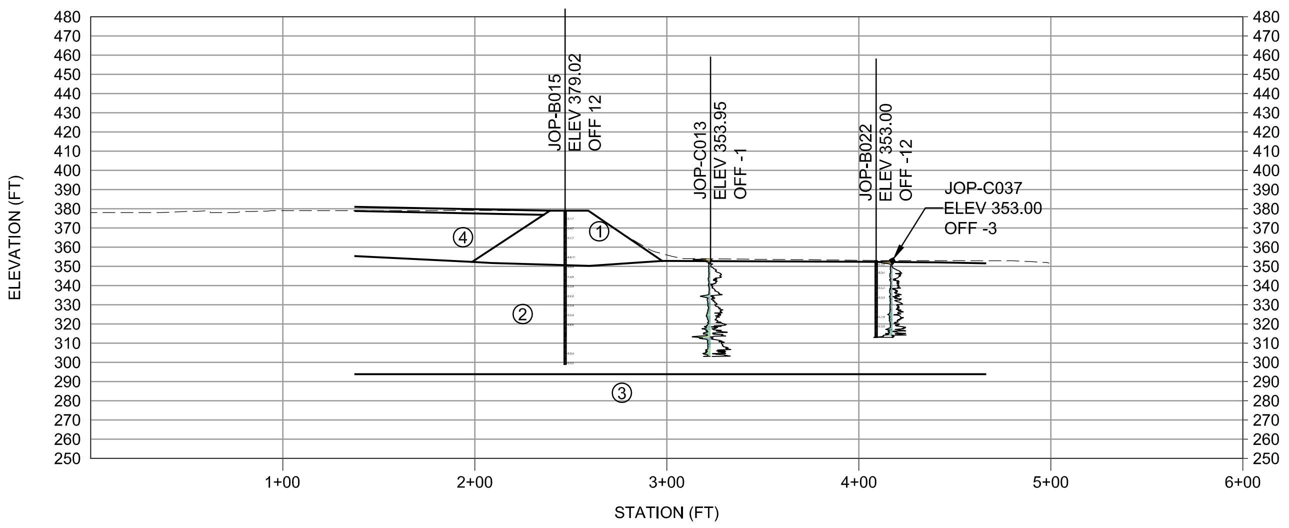
1. GROUND SURFACE: 2012 LIDAR DATA FROM THE ILLINOIS GEOSPATIAL DATA CLEARINGHOUSE - ILLINOIS GEOSPATIAL DATA CLEARINGHOUSE [IGDC]. (2015). LIDAR DATA FOR MASSAC COUNTY.
2. BORING LOCATIONS: 2015 POINTS LOCATED IN 2015 TOPOGRAPHIC AND BATHYMETRIC SURVEY 2016 POINTS WERE ESTIMATED LOCATIONS IN THE FIELD 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

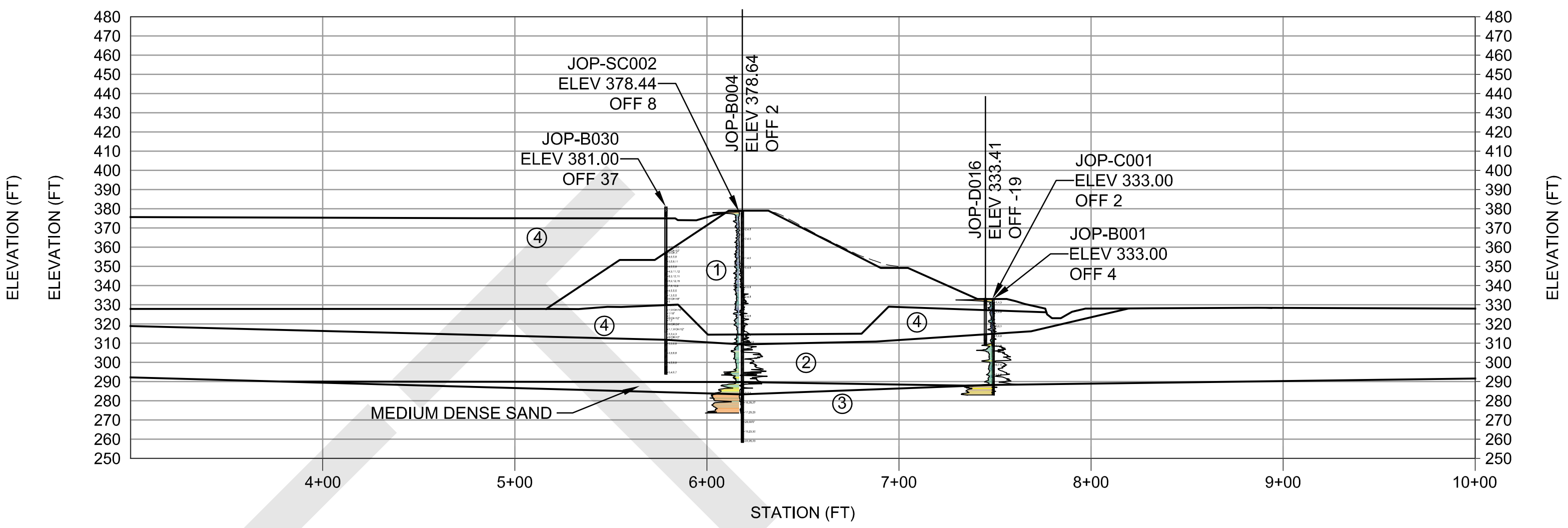
Job No. :	60440155	JOPPA ASH POND DMM DESIGN PROFILES
Prepared By :	RS	
Date :	04/22/2016	

RAU, MICHAEL, 4/22/2016 1:44 PM

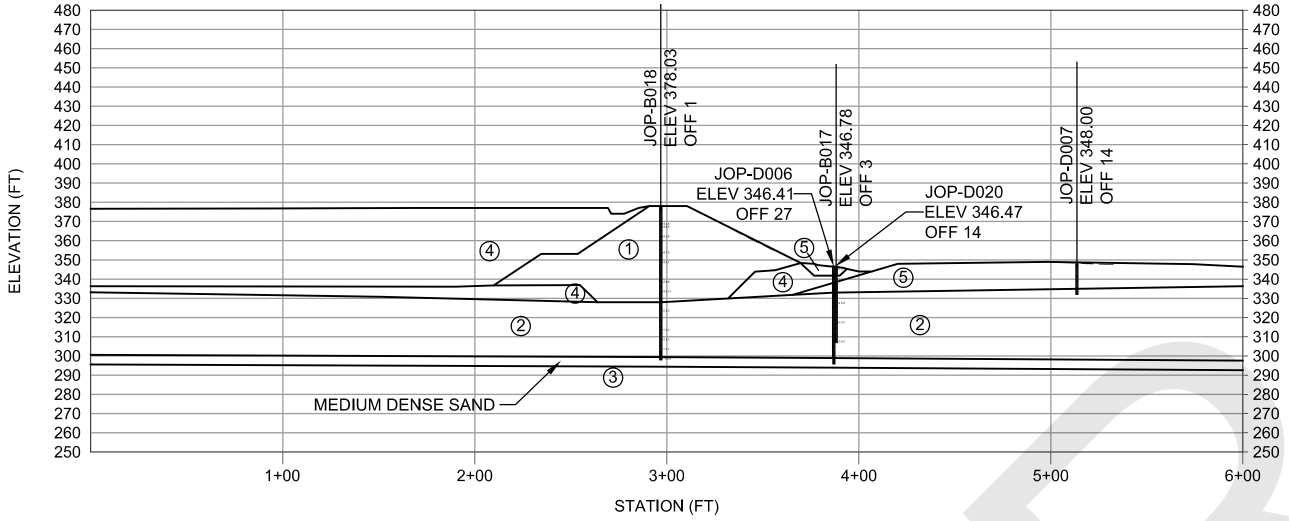
SECTION G



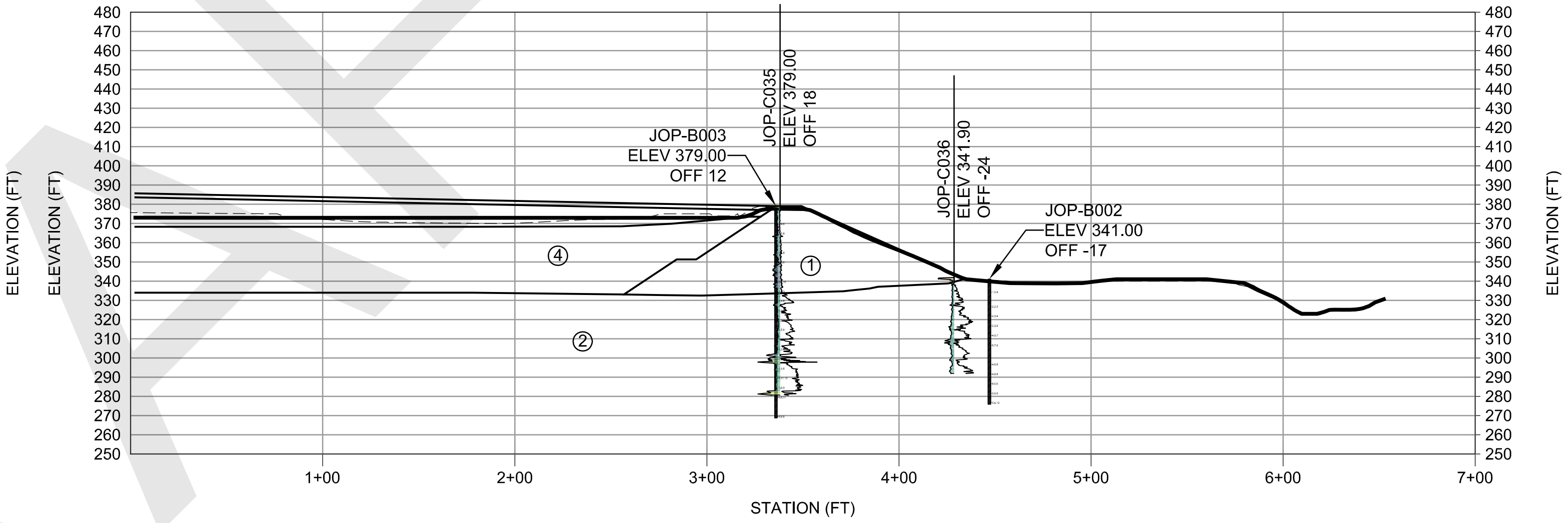
SECTION A



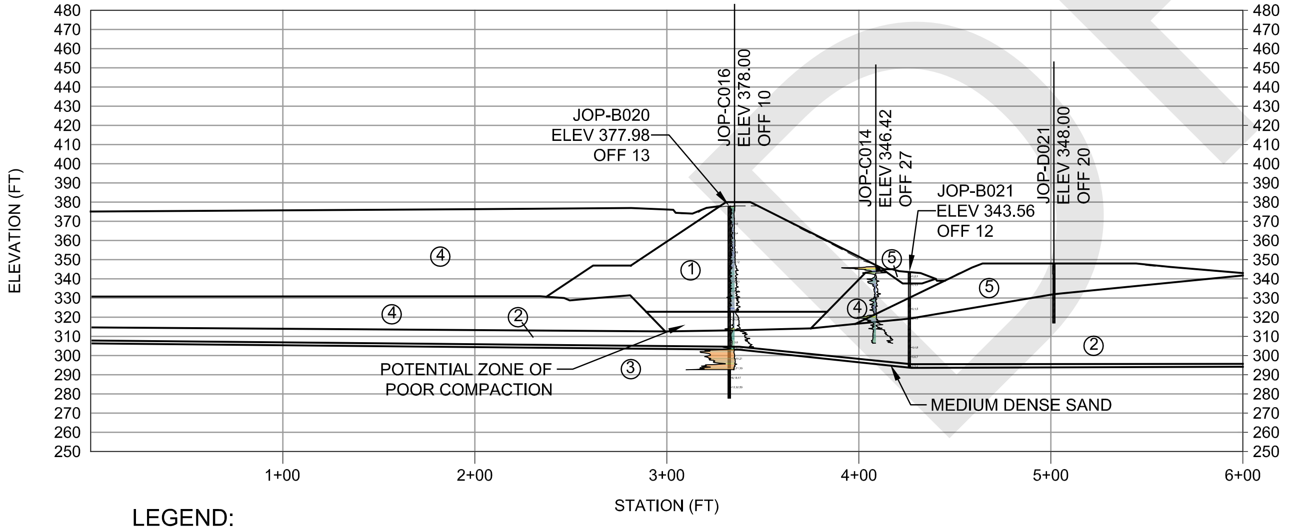
SECTION H



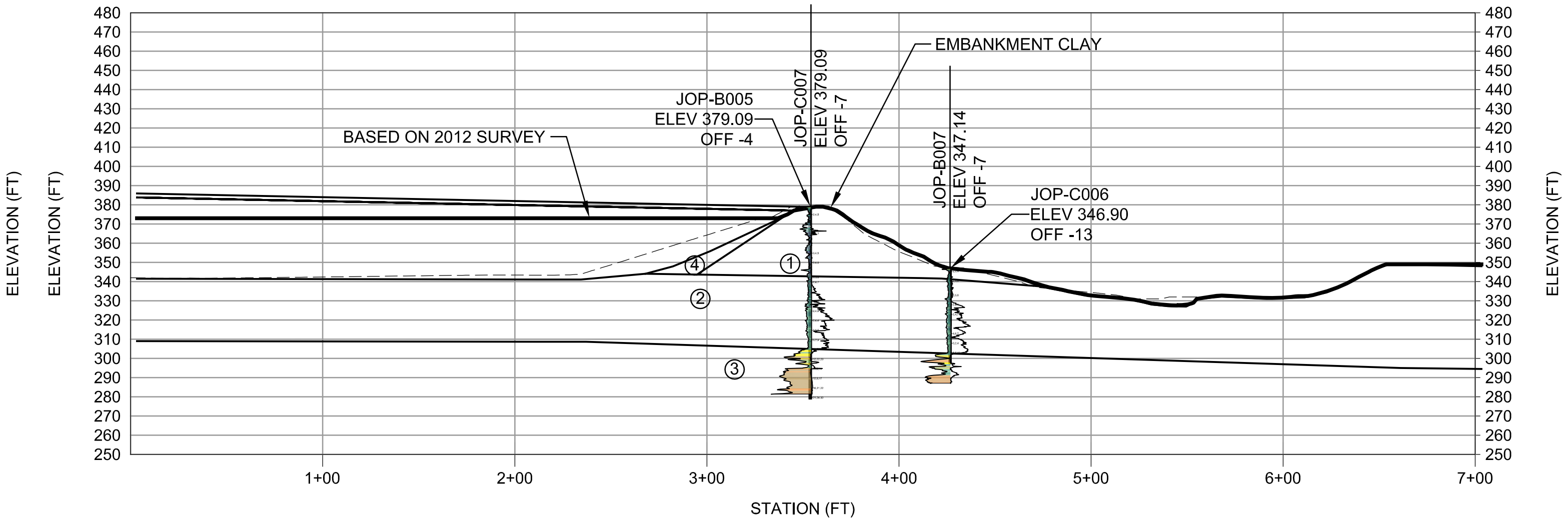
SECTION I



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\GeoCivil\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 25-Aug-16

Originator Signature Date

8/30/16

Checker Signature Date

Douglas F. Cauble 9-7-16

Reviewer Signature Date

Project Manager (or Designee) Signature Date

DISTRIBUTION	Project Central File – Quality File Folder Other – Specify:

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

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

JOP-C034
STA 34+77.68, 141.01' R
STA 34+84.87, 5.73' L
STA 34+79.05, 4.14' L
ELEV 380.00
STA 42+99.14, 0.02' R
JOP-C033
STA 30+71.59, 1.72' L
JOP-C032
STA 45+05.92, 229.82' L
JOP-C029
STA 49+50.04, 67.80' R
JOP-B012
STA 49+11.94, 3.44' L
STA 27+23.96, 306.37' L
STA 49+79.24, 304.94' L
JOP-C028
STA 24+75.63, 0.24' R
JOP-C031
JOP-C024
JOP-B027
JOP-C026
STA 20+55.21, 2.37' L
ELEV 376.00
STA 20+39.67, 2.67' L
ELEV 378.01
STA 20+08.45, 96.98' R
ELEV 354.97
STA 57+47.17, 512.55' L
JOP-C023
STA 60+52.31, 135.81' R
JOP-B014
STA 60+60.09, 6.49' L
JOP-B013
JOP-C012
STA 60+67.66, 1.27' L
C
JOP-C025
STA 14+34.03, 1.34' L
JOP-C022
STA 10+45.00, 17.75' R
STA 10+15.60, 71.58' R
JOP-B005
JOP-B007
STA 10+09.08, 71.65' R
ELEV 347.14
G
JOP-C037
JOP-B015
JOP-B019
JOP-C018
STA 7+99.07, 88.76' R
JOP-C005
B
STA 6+16.84, 53.96' R
ELEV 356.52
STA 6+25.45, 5.71' L
ELEV 380.00
JOP-B006
JOP-C020
STA 76+94.24, 20.23' L
STA 77+05.66, 15.92' L
STA 4+25.13, 105.35' R
ELEV 348.03
JOP-C003
STA 83+06.91, 226.77' L
JOP-C017
STA 80+44.23, 1.02' R
STA 80+72.23, 84.97' R
JOP-B016
STA 82+36.48, 9.46' L
STA 1+51.16, 2.15' R
ELEV 379.00
STA 1+44.57, 4.24' R
ELEV 379.00
STA 1+85.74, 95.23' R
ELEV 341.90
STA 1+79.10, 113.50' R
STA 0+84.91, 13.77' R
ELEV 341.00
STA 84+32.32, 3.00' L
JOP-B018
STA 90+13.52, 11.73' L
ELEV 375.00
STA 90+50.59, 3.99' L
ELEV 378.64
STA 90+44.73, 6.16' L
ELEV 378.44
STA 88+95.98, 0.15' L
ELEV 379.00
JOP-B026
JOP-B020
JOP-D008
JOP-B027
JOP-C014
JOP-B021
JOP-D009
JOP-C015
JOP-D007
JOP-D021
JOP-D010
JOP-D016
JOP-C001
JOP-B029
VF - (3)
ML (2)
I
A
H
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

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

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

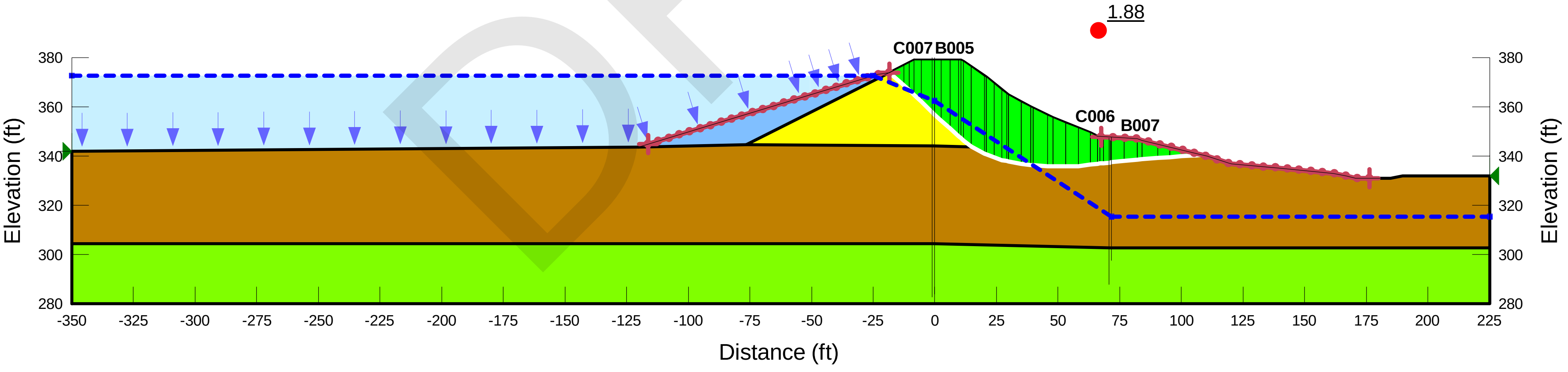
Kind: SLOPE/W
Method: Spencer
F of S: 1.88

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

Materials

- 🟨 Embankment Fill (Peak Drained)
- 🟫 Foundation Clay (Peak Drained)
- 🟩 Foundation Sand (Peak Drained)
- 🟦 Fly Ash (Peak Drained)



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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

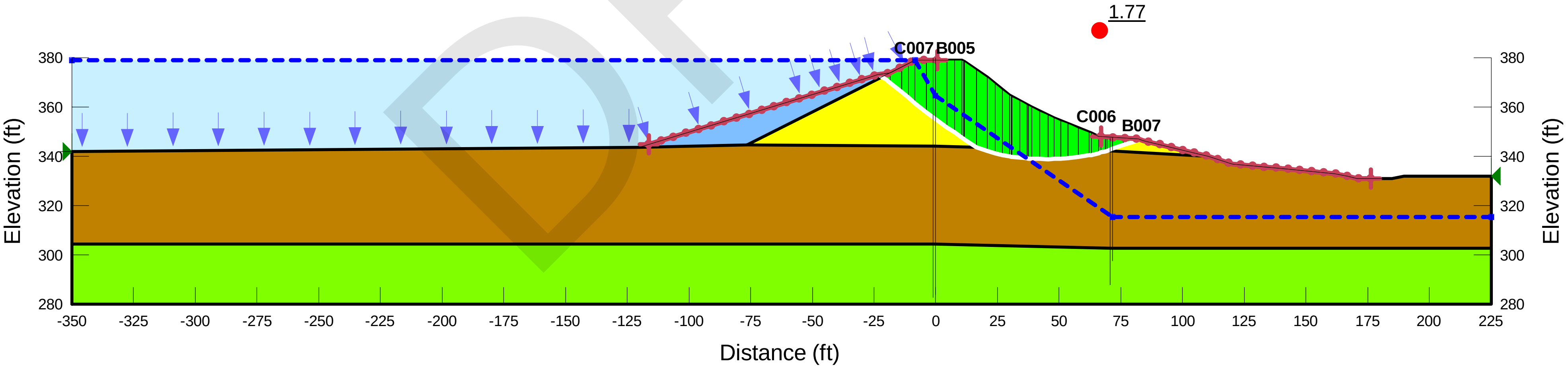
Kind: SLOPE/W
Method: Spencer
F of S: 1.77

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

Materials

- 🟨 Embankment Fill (Peak Drained)
- 🟫 Foundation Clay (Peak Drained)
- 🟩 Foundation Sand (Peak Drained)
- 🟦 Fly Ash (Peak Drained)



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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

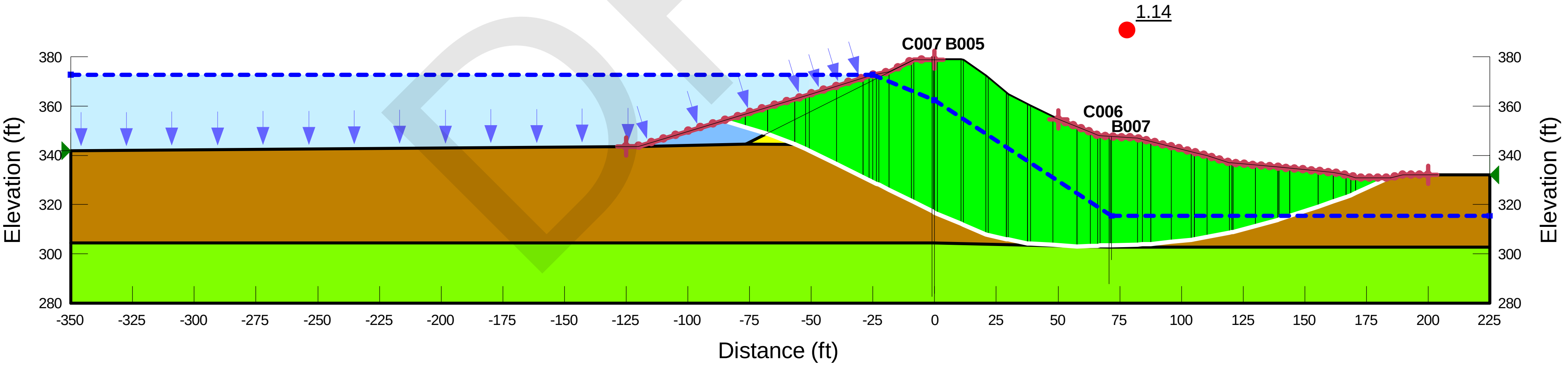
Section B Pseudostatic (kh)

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

Materials

- 🟨 Embankment Fill (Peak Undrained)
- 🟫 Foundation Clay (Peak Undrained)
- 🟩 Foundation Sand (Peak Drained)
- 🟦 Fly Ash (Peak Undrained)



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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

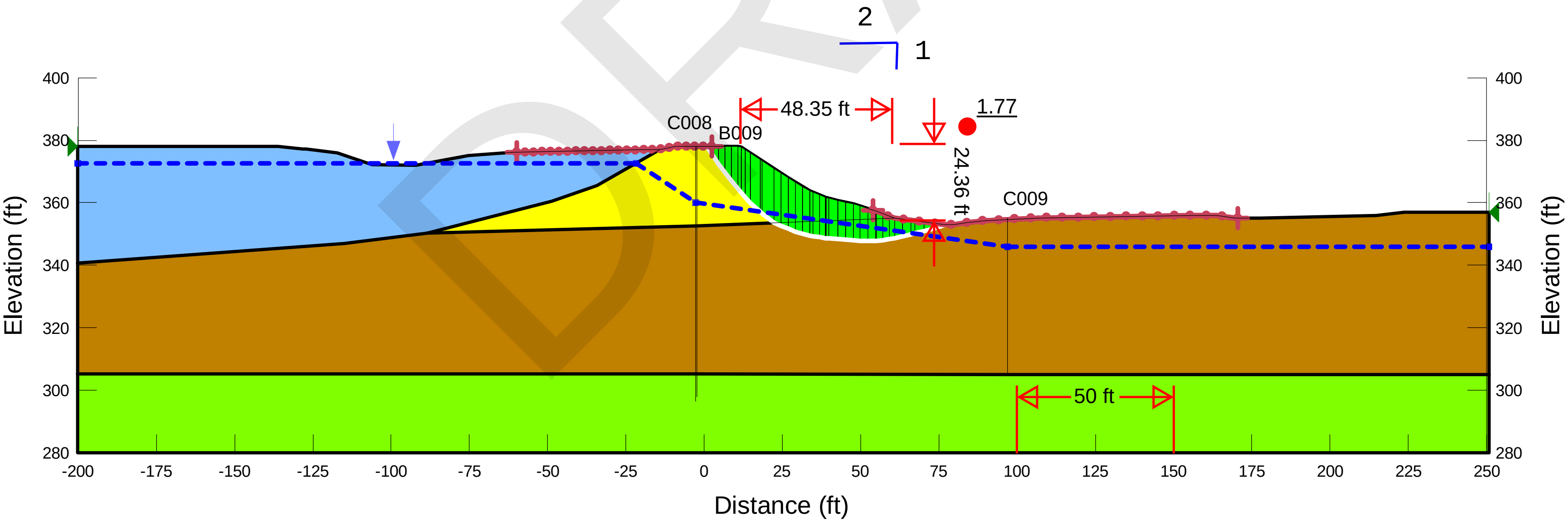
Section C Normal Pool

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

Materials

- 🟨 Embankment Fill (Peak Drained)
- 🟫 Foundation Clay (Peak Drained)
- 🟩 Foundation Sand (Peak Drained)
- 🟦 Fly Ash (Peak Drained)



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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

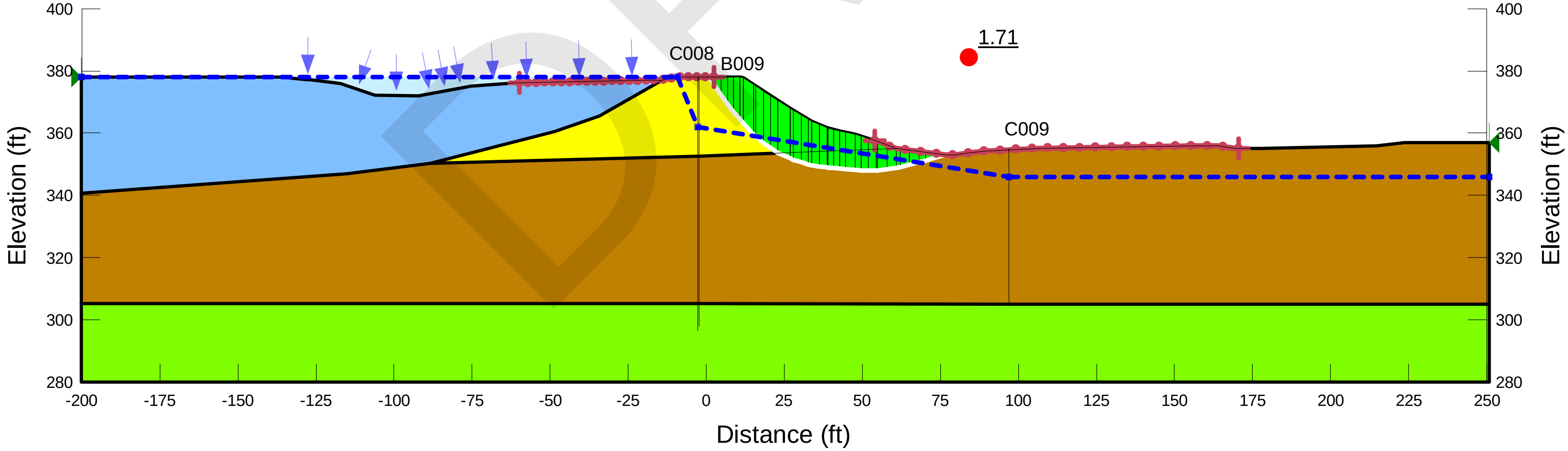
Section C Surchage Pool

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

Materials

- 🟨 Embankment Fill (Peak Drained)
- 🟫 Foundation Clay (Peak Drained)
- 🟩 Foundation Sand (Peak Drained)
- 🟦 Fly Ash (Peak Drained)



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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)

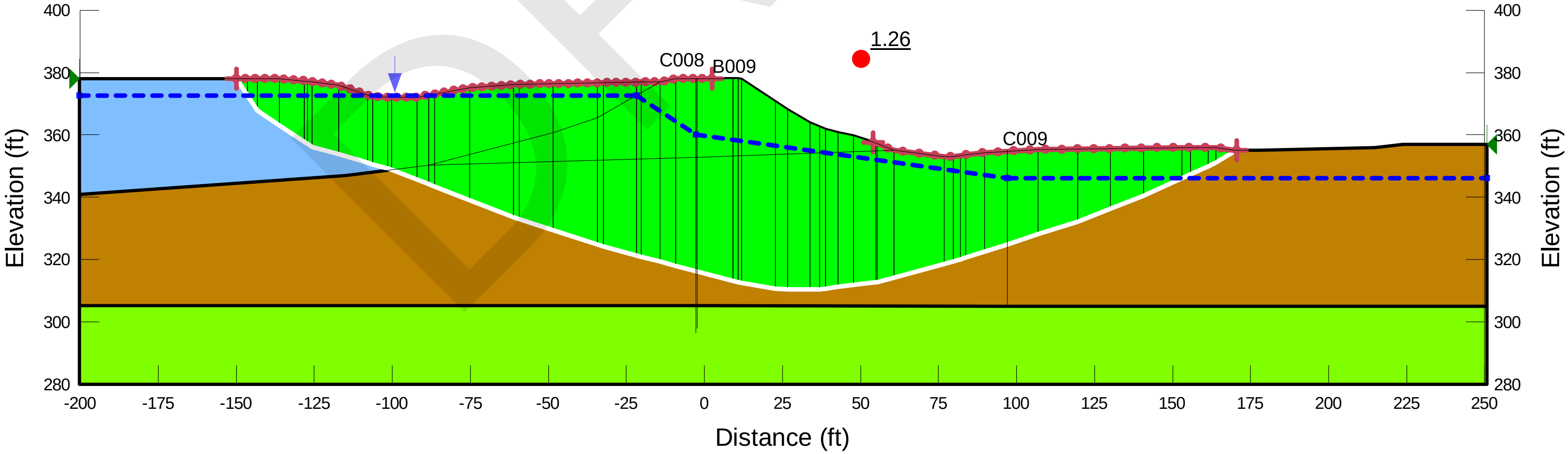
Kind: SLOPE/W
Method: Spencer
F of S: 1.26

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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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

Figure

2

GLP 8021

March 2021

\\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

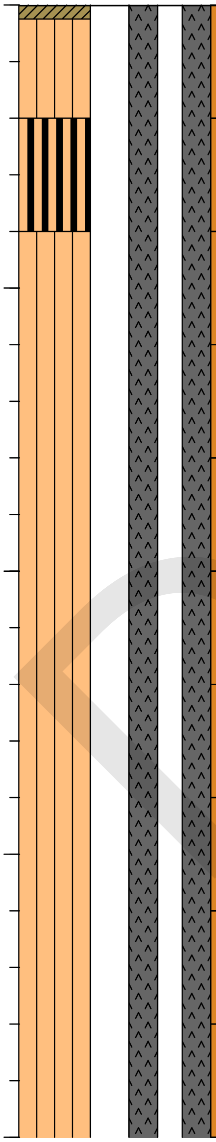
Geosyntec consultants
engineers | scientists | innovators

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**

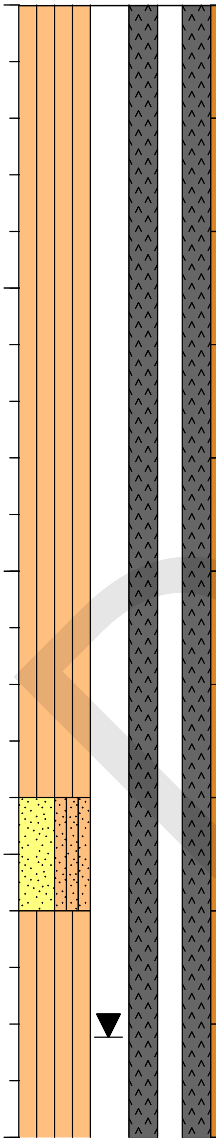


DEPTH (ft)	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0	SS	14/24	2 2 3 6	5	(0') CLAY (CL); some silt, high organics/roots, brown (10YR 4/3). (0.25') CLAYEY SILT (ML); brownish yellow (10YR 6/6), 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).		
15	SS	24/24	2 3 5 5	8	(14') As above: more light gray (10YR 7/2) mottling.		
	SS	24/24	2 3 5 6	8	(16') As above: trace sand.		
20	SS	24/24	3 4 5 9	9	(18') As above: light gray (10YR 7/2) becomes dominant.		

NOTES:

Geosyntec consultants engineers | scientists | innovators	**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)	WATER LEVEL	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	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

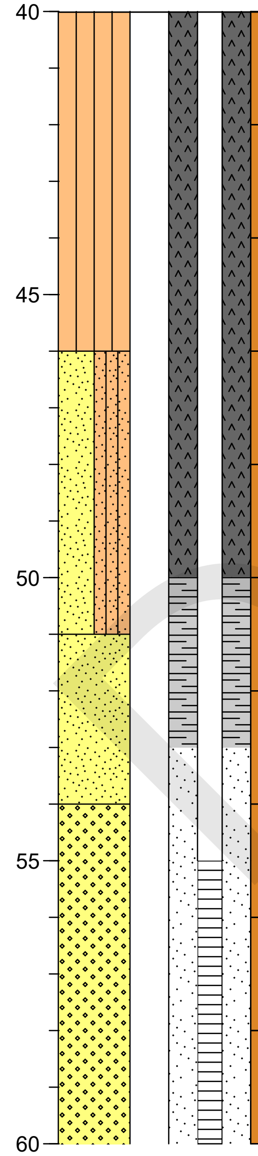
Client:	**Dynegy**
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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)	COLLECT: Sample Type	Recovery (in)	Blow Counts	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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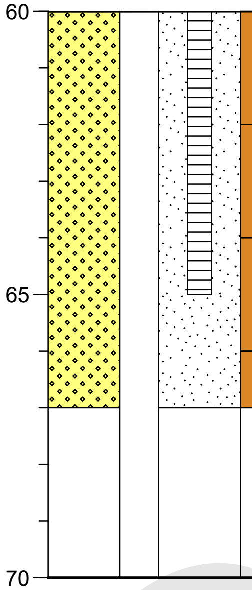
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	
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	
62	SS	24/24	1 3 13 12	16	(62') As above: reddish yellow (7.5YR 6/6).		
64	SS	24/24	1 15 14 13	29	(64') GRAVELLY SAND (SW); reddish yellow (7.5YR 6/8), wet, loose.		
66	SS	8/12	1 4		(66') As above: brownish yellow (10YR 6/6).		
67					(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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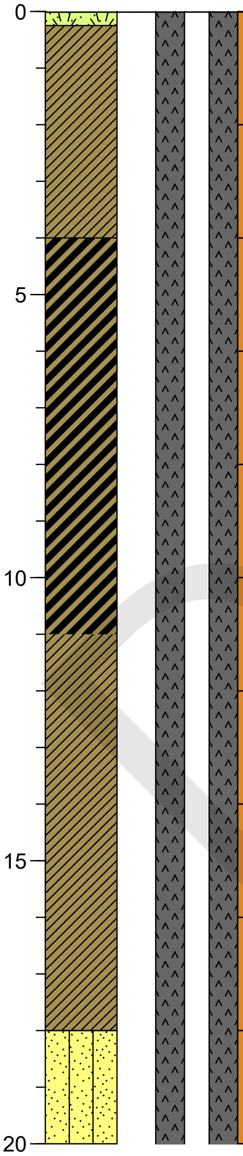
Client:	**Dynegy**
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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**



COLLECT					MEASURE	
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
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.		
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.		
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.		
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.		
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**
Drilling End Date: **02/02/2021**
Drilling Company: **Geotechnology**
Drilling Method: **Hollow Stem Auger**
Drilling Equipment: **CME 55LC**
Driller:
Logged By: **BA**

Boring Depth (ft): **62**
Boring Diameter (in): **7.25**
DTW During Drilling (ft):
DTW After Drilling (ft):
Top of Casing Elev. (ft): **359.53**
Ground Elev. (ft): **356.15**
Location (Lat/Long): **37.21902, -88.8494**

Well Depth (ft): **60**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Sch 40 PVC Slotted**
Seal Material(s): **Grout & Bentonite**
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 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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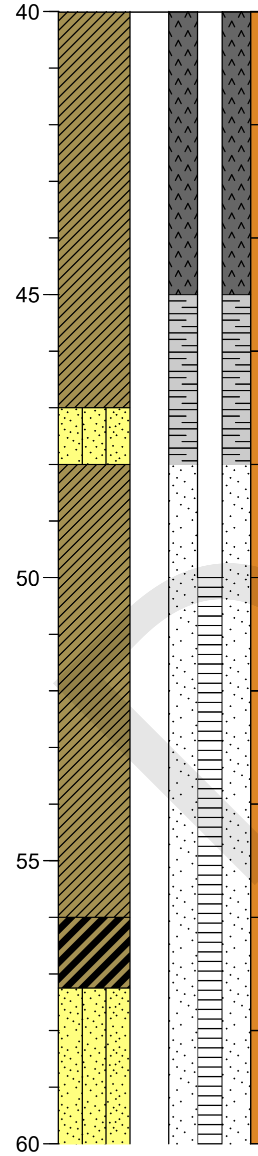
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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**



			COLLECT				MEASURE	
DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
40	SS	24/24	5 7 9 12	16	(40') As above: all clay, moderate plasticity, gray dominant (8/1).		
42	SS	24/24	3 5 7 8	12	(42') As above: brown dominant (5YR 5/8).		
44	SS	24/24	5 5 7 11	12	(44') As above: sandy clay, some black splotches.		
46	SS	24/24	19 33 15 11	48	(46') As above: wet.		
47					(47') SILTY SAND (SM); mostly silt, very fine to fine grained sand, poorly graded, dry, very tight, light gray (8/1).		
48	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.		
52	SS	24/24	3 4 6 8	14	(52') As above: moist, stiff to medium stiff.		
54	SS	24/24	4 5 8 8	13	(54-55') As above: soft. (55-56') As above: trace coarse gravel, stiff.		
56	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.		
58	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**

				COLLECT					MEASURE	
DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
60				SS	24/24	8 9 12 20	21	(60') As above.		
								(62') End of Boring.		
65										

NOTES:

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Client: **Dynegy**
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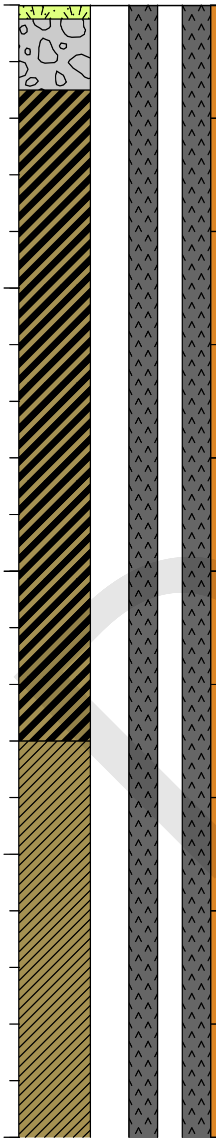
Address: **Unnamed Road, Metropolis, IL 62960**

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 4	11	(0') TOPSOIL. (0.25') POORLY GRADED GRAVEL (GP) (1.5') CLAY (CL); light brown (10YR 7/3), very stiff, low plasticity, dry.		
	SS	12/24	2 3 4 4	7	(2') As above.		
	SS	24/24	3 3 7 7	10	(4') As above: medium stiff.		
5	SS	24/24	3 6 7 9	13	(6') As above: mottled light brown (10YR 7/3) and light gray (8/1).		
	SS	24/24	3 5 5 7	10	(8') As above: trace coarse gravel.		
10	SS	24/24	3 4 5 6	9	(10') As above: stiff.		
	SS	24/24	2 3 5 6	8	(12') As above. (13') CLAY (CL); mostly same as above with some very fine to fine grained sand and silt.		
15	SS	24/24	4 5 8 9	13	(14') As above: slightly moist.		
	SS	24/24	2 3 5 7	8	(16') As above: dry.		
	SS	24/24	2 3 4 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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Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

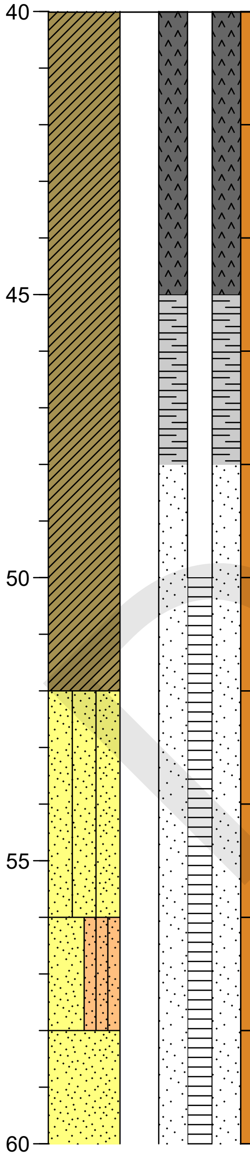
WELL LOG

Well No. G05
Page: 3 of 4

Drilling Start Date: **02/01/2021**
Drilling End Date: **02/01/2021**
Drilling Company: **Geotechnology**
Drilling Method: **Hollow Stem Auger**
Drilling Equipment: **CME 55LC**
Driller:
Logged By: **BA**

Boring Depth (ft): **66**
Boring Diameter (in): **7.25**
DTW During Drilling (ft):
DTW After Drilling (ft):
Top of Casing Elev. (ft): **361.68**
Ground Elev. (ft): **358.45**
Location (Lat/Long): **37.21716, -88.84883**

Well Depth (ft): **60**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Sch 40 PVC Slotted**
Seal Material(s): **Grout & Bentonite**
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.	
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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Client:	**Dynegy**
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

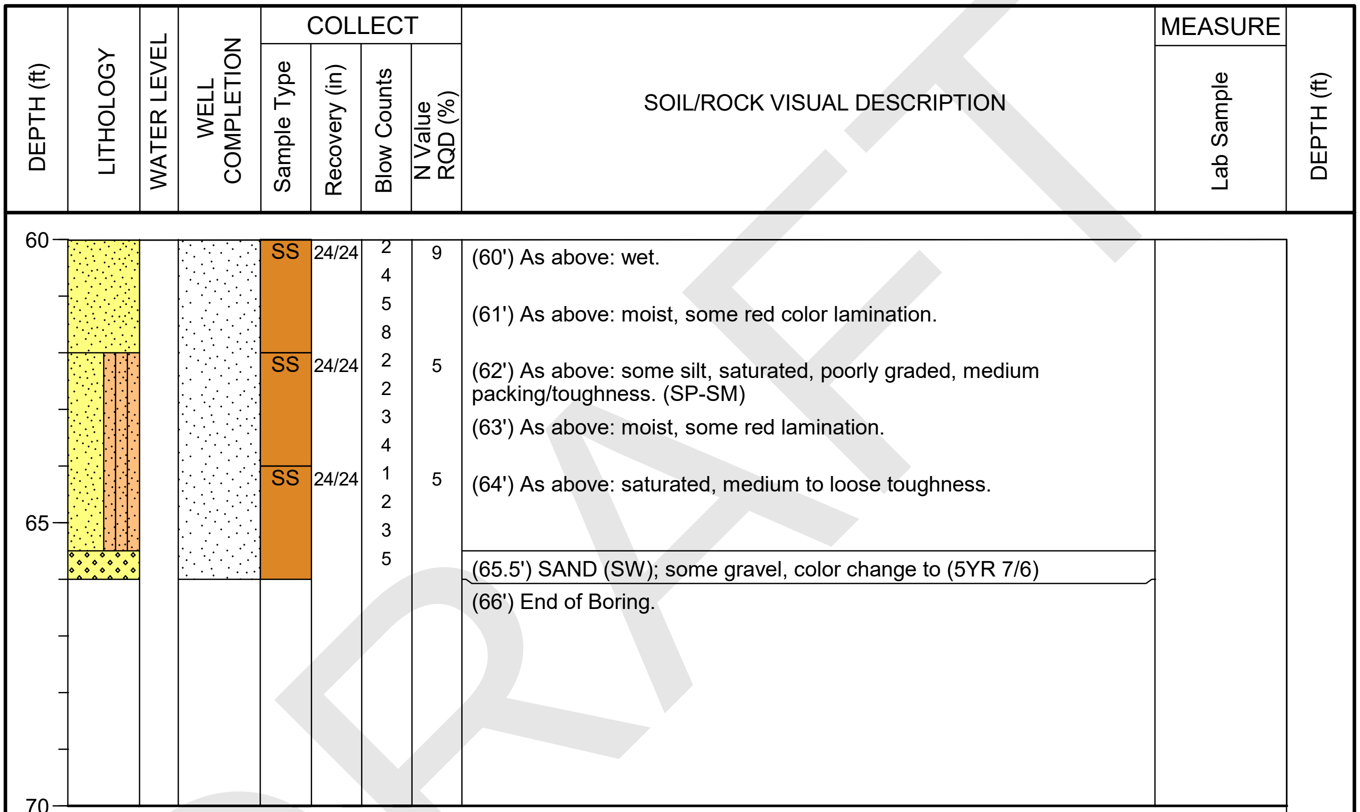
WELL LOG

Well No. **G05**
Page: **4 of 4**

Drilling Start Date:	**02/01/2021**
Drilling End Date:	**02/01/2021**
Drilling Company:	**Geotechnology**
Drilling Method:	**Hollow Stem Auger**
Drilling Equipment:	**CME 55LC**
Driller:	
Logged By:	**BA**

Boring Depth (ft):	**66**
Boring Diameter (in):	**7.25**
DTW During Drilling (ft):	
DTW After Drilling (ft):	
Top of Casing Elev. (ft):	**361.68**
Ground Elev. (ft):	**358.45**
Location (Lat/Long):	**37.21716, -88.84883**

Well Depth (ft):	**60**
Well Diameter (in):	**2**
Screen Slot (in):	**0.010**
Riser Material:	**Sch 40 PVC**
Screen Material:	**Sch 40 PVC Slotted**
Seal Material(s):	**Grout & Bentonite**
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	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.		
				SS	24/24	1 2 3 5	5	(64') As above: saturated, medium to loose toughness.		
65								(65.5') SAND (SW); some gravel, color change to (5YR 7/6)		
								(66') End of Boring.		
70										

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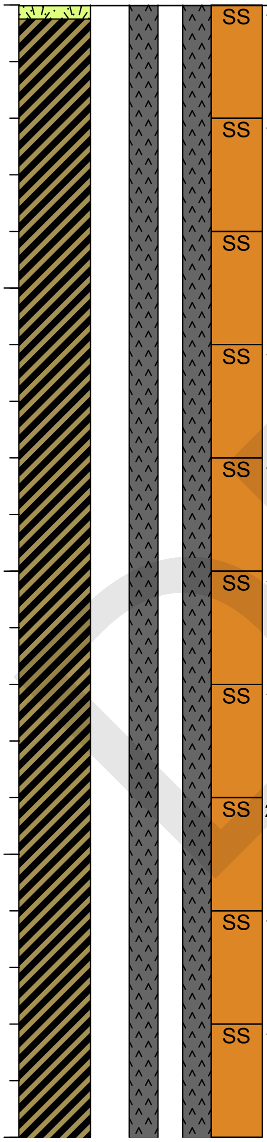
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	COLLECT Sample Type	Recovery (in)	Blow Counts	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.		
	SS	6/24	2 2 3 3	5	(4') CLAY (CH); brown (5YR 6/8), high plasticity, dry, soft. ~2" coal seam.		
5							
	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. (9') CLAY (CH); brown (5YR 6/8), high plasticity, moist, soft.		
10	SS	12/24	2 2 3 4	5	(10') As above: trace fine gravel.		
	SS	12/24	1 1 2 3	3	(12') As above: dry.		
	SS	24/24	3 3 4 4	7	(14') CLAY (CH); mottle (brown and light gray), high plasticity, soft, dry.		
15							
	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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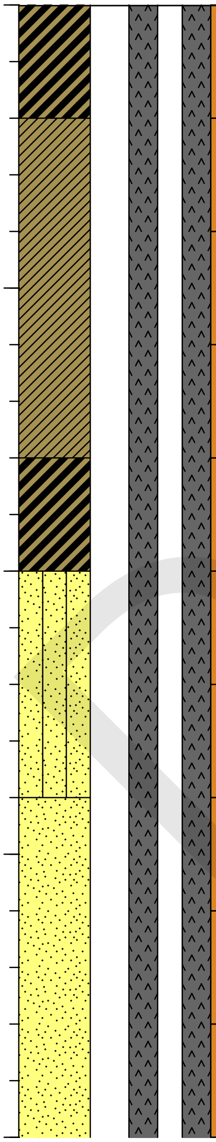
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	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.		
35	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.		
	SS	18/24	4 4 9 12	13	(36') As above: moist.		
40	SS	18/24	6 7 12 14	19	(38') As above: dry.		

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Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	
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.		
45				SS	18/24	7 11 12 12	23	(44') As above. (45') As above: wet.		
				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".		
55				SS	24/24	4 18 18 15	36	(54') As above: sand with 1-2" gravel at bottom.		
				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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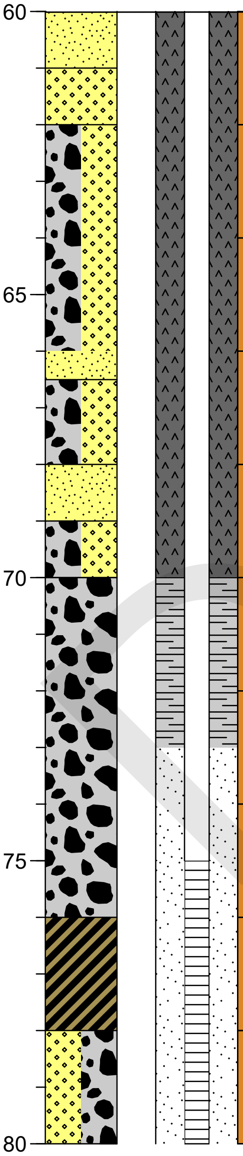
WELL LOG

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) | LITHOLOGY | WATER LEVEL | WELL COMPLETION



COLLECT					MEASURE	
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
SS	18/24	8 11 36 23	47	(5YR 7/6). (60') POORLY GRADED SAND (SP); reddish yellow (5YR 7/6), tight, wet. (61') WELL-GRADED SAND (SW); lots of coarse gravel (orange chert), loose.		
SS	18/24	7 18 29 31	47	(62') DIAMICTON - mostly fine-coarse grained GRAVEL AND SAND (GW-SW); (orange chert), wet, very loose, reddish yellow (5YR 7/6).		
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)		
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.		
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.		

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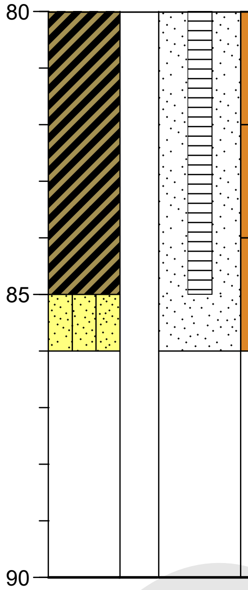
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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	Recovery (in)	Blow Counts	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.		
				SS	6/24	50/20	15	(84') As above.		
85								(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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Client: **Dynegy**
Project: **GLP0821, Joppa Ash Pond**
Address: **Unnamed Road, Metropolis, IL 62960**

WELL LOG

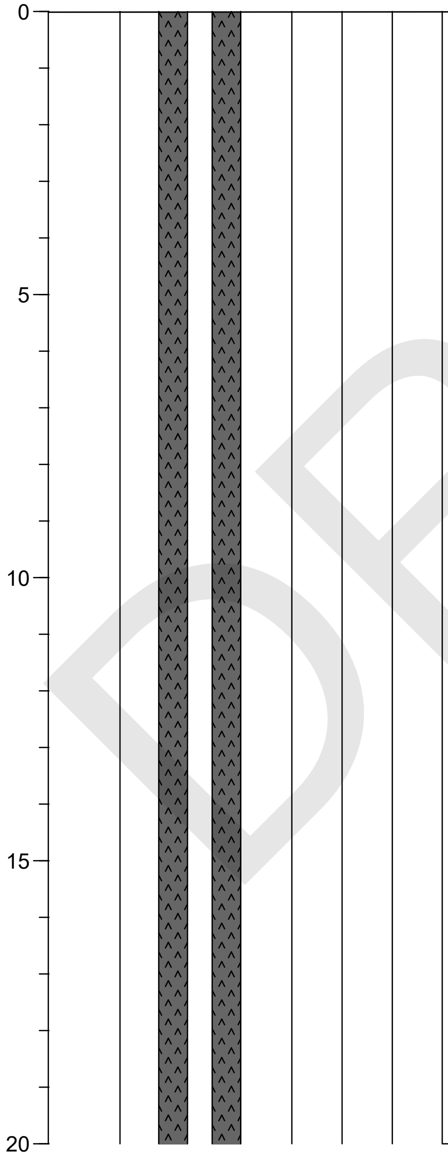
Well No. **G06S**
Page: **1 of 3**

Drilling Start Date: **02/01/2021**
Drilling End Date: **02/01/2021**
Drilling Company: **Geotechnology**
Drilling Method: **Hollow Stem Auger**
Drilling Equipment: **CME 55LC**
Driller:
Logged By: **BA**

Boring Depth (ft): **44**
Boring Diameter (in): **7.25**
DTW During Drilling (ft):
DTW After Drilling (ft):
Top of Casing Elev. (ft): **355.92**
Ground Elev. (ft): **352.47**
Location (Lat/Long): **37.22187, -88.84904**

Well Depth (ft): **40**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Sch 40 PVC Slotted**
Seal Material(s): **Grout & Bentonite**
Filter Pack: **Sand**

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



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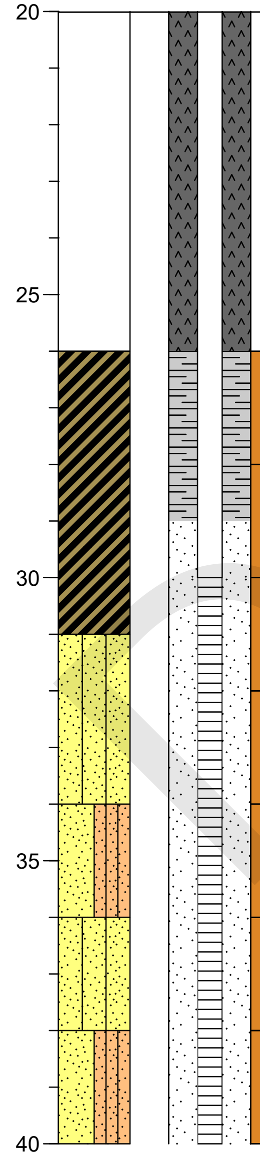
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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**	DTW 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**



COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	DEPTH (ft)
				(20') Blind drill.		
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.		
SS	24/24	3 7 14 24	21	(30') As above.		
				(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.		
SH	24/24	4 1 8 11	9	(32') As above.		
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)		

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Project: GLP0821, Joppa Ash Pond
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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**		DTWell 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	 Recovery (in)	 Blow Counts	 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.		
								(44') End of Boring.		
45										

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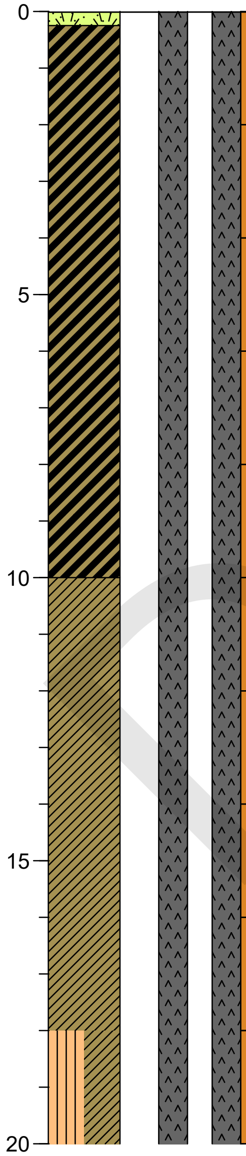
WELL LOG

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**



COLLECT					MEASURE	
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
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.		
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.		
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.		
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)		

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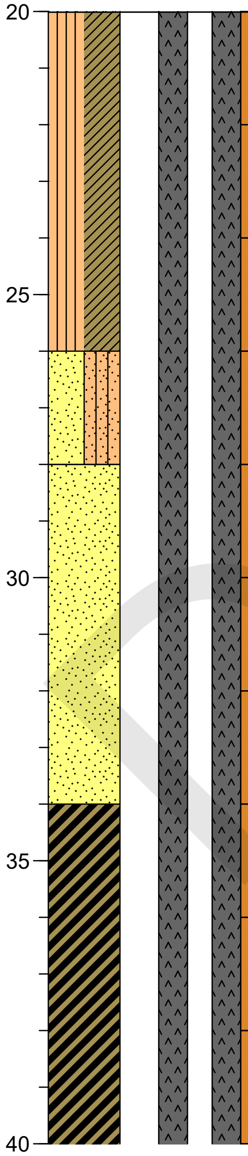
Address: Unnamed Road, Metropolis, IL 62960

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)	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	3 4 6 7	10	(20') As above: rust spots.		
22	SS	24/24	3 3 4 6	7	(22') As above: moist.		
24	SS	24/24	3 3 4 5	7	(24') As above: mottled (10R 8/1).		
25							
26	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.		
28	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).		
32	SH	18/24	10 6 9 9	15	(32') As above: color change to orange (5YR 6/8), clay at bottom.		
34	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							
36	SS	24/24	3 3 5 5	8	(36') As above: medium stiffness.		
38	SS	24/24	2 2 2 3	4	(38') As above.		
40							

NOTES:

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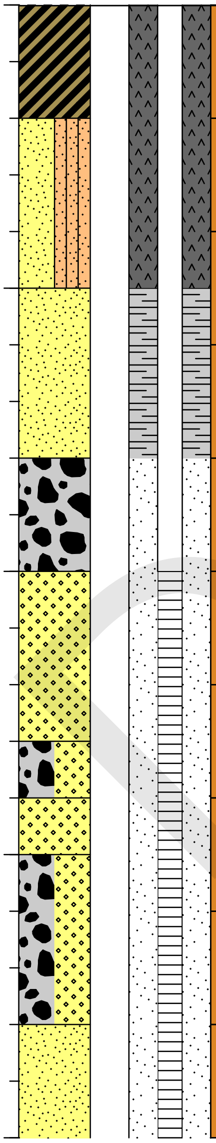
Client:	**Dynegy**
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	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					(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.		
	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).		
50	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).		
55					(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.		
	SS	24/24	7 21 14 8	35	(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).		
60							

COLLECT / MEASURE

NOTES:

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Client:	**Dynegy**
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**
Drilling End Date:	**01/29/2021**
Drilling Company:	**Geotechnology**
Drilling Method:	**Hollow Stem Auger**
Drilling Equipment:	**CME 55LC**
Driller:	
Logged By:	**BA & CL**

Boring Depth (ft):	**62**
Boring Diameter (in):	**7.25**
DTW During Drilling (ft):	
DTW After Drilling (ft):	
Top of Casing Elev. (ft):	**353.86**
Ground Elev. (ft):	**352.47**
Location (Lat/Long):	**37.21116, -88.8492**

Well Depth (ft):	**60**
Well Diameter (in):	**2**
Screen Slot (in):	**0.010**
Riser Material:	**Sch 40 PVC**
Screen Material:	**Sch 40 PVC Slotted**
Seal Material(s):	**Grout & Bentonite**
Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	
60	▨		▨	SS	24/24	32 48 38 8	86	(60') As above. (62') DIAMICTON (GW-SW); same as above.		
								(62') End of Boring.		
65										

NOTES:

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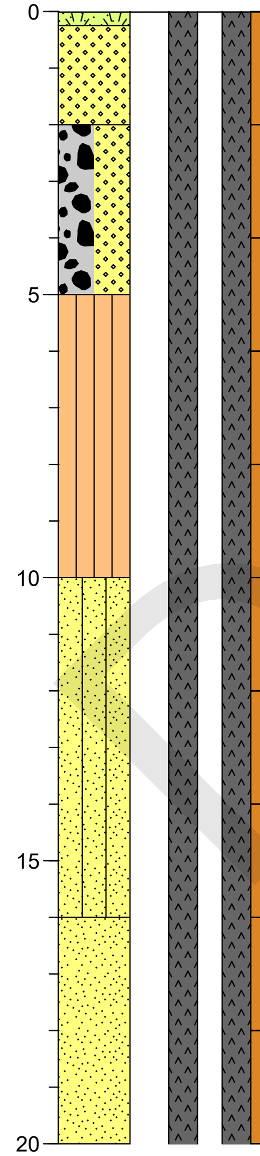
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	
0				SS		7 3 4 6	7	(0') TOPSOIL. (0.25') WELL-GRADED SAND (SW); light brown/gray, loose, dry.		
				SS		14 11 7 6	18	(2') GRAVELLY SAND (GW-SW); loose, dry, mostly fine to coarse grained gravel and sand.		
				SS		4 3 4 4	7			
5								(5') SILT (ML); low plasticity, dark gray, dry, trace coarse gravel.		
				SS		3 2 2 4	4	(6') As above.		
				SS		2 2 2 2	4	(8') As above: trace fine gravel.		
10				SS		3 4 4 4	8	(10') SILTY SAND (SM); dark gray, loose, dry, well-graded.		
				SS		2 2 3 3	5	(12') As above.		
				SS		2 3 2 4	5	(14') As above: clay seam at 15' (1-2").		
15										
				SS		2 2 2 2	4	(16') POORLY GRADED SAND and CLAY (SP/CL); dark gray interbedded with dark gray, medium stiff, clay - 2" beds alternating.		
				SS		1 2 1 1	3			
20										

NOTES:

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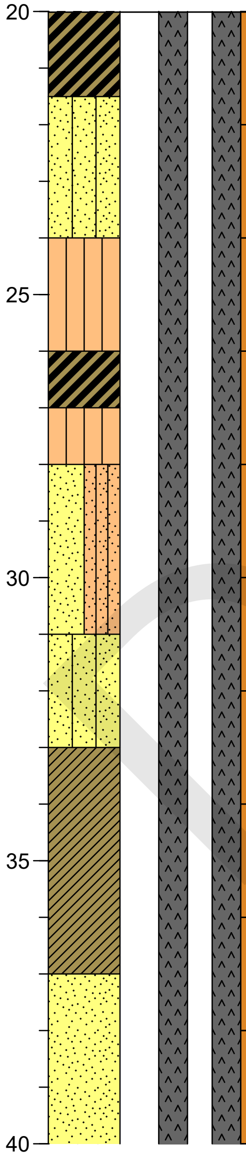
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G08
Page: 2 of 5

Drilling Start Date: **01/27/2021**
Drilling End Date: **01/28/2021**
Drilling Company: **Geotechnology**
Drilling Method: **Hollow Stem Auger**
Drilling Equipment: **CME 55LC**
Driller:
Logged By: **BA**

Boring Depth (ft): **86**
Boring Diameter (in): **7.25**
DTW During Drilling (ft):
DTW After Drilling (ft):
Top of Casing Elev. (ft): **344.22**
Ground Elev. (ft): **341.72**
Location (Lat/Long): **37.20984, -88.85066**

Well Depth (ft): **85**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Sch 40 PVC Slotted**
Seal Material(s): **Grout & Bentonite**
Filter Pack: **Sand**



COLLECT					MEASURE
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
SS		1 1 1 2	2	(20') CLAY (CH); high plasticity, soft, moist, gray to green.	
				(21.5') SILTY SAND (SM); wet, loose, gray to green.	
SS		1 1 1 1	2	(22') As above.	
SS		3 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.	
SS		3 2 3 4	5	(30') As above.	
				(31') SILTY SAND (SM); tight, light gray, poorly graded, fine to medium grained sand.	
SS		3 3 4 4	7	(32') As above.	
				(33') CLAY (CL); light gray, hard, low plasticity, dry.	
SS		4 4 3 3	7		
				(35') As above: some fine grained sand.	
SS		3 4 4 5	8	(36') As above: gradually grades to fine to medium sand.	
				(37') POORLY GRADED SAND (SP); fine to medium grained sand, tight, trace gravel, mottled with rusty red color.	
SS		3 3 3 3	6	(38') As above.	

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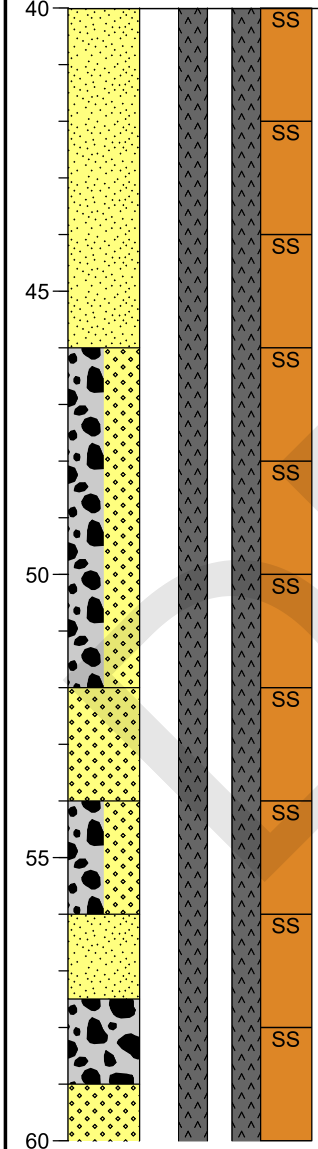
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	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.		
55	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.		
	SS		17 19 17 17	36	(56') POORLY GRADED SAND (SP); fine to medium grained, wet, loose, dark tan. (57.5') WELL-GRADED GRAVELLY SAND (GW); dark tan, loose.		
60	SS		6 8 11 12	19	(58') As above. (59') WELL-GRADED SAND (SW); dark tan, wet, loose, trace fine gravel.		

NOTES:

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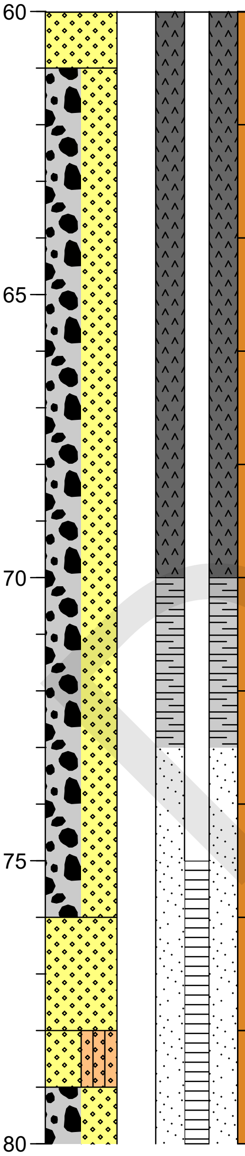
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
60	SS	24/24	14 10 14 11	24	(60') As above.		
					(61') GRAVELLY SAND (GW-SW); dark tan, well-graded, coarse chert nodules, wet, loose.		
	SS	18/24	5 3 4 5	7	(62') As above.		
	SS	12/24	4 8 5 8	13	(64') As above.		
65	SS	18/24	5 8 8 7	16	(66') As above.		
	SS	18/24	5 7 7 8	14	(68') As above: saturated.		
70	SS	12/24	5 6 7 7	13	(70') As above.		
	SS	18/24	7 9 9 11	18	(72') As above.		
	SS	24/24	7 7 8 9	15	(74') As above: mostly silt and gravel, (5YR 6/8).		
75	SS	18/24	10 16 17 25	33	(76') WELL-GRADED SAND (SW); mostly medium to coarse grained sand, wet, loose, (5YR 6/8).		
	SS	24/24	8 15 39 42	54	(78') DIAMICTON (SW-SM); mostly coarse grained gravel, fine sand, silt, wet, medium density, (5YR 6/8).		
80					(79') Same fine to coarse gravel, more coarse gravel, (5YR 6/8). (GW-SW)		

NOTES:

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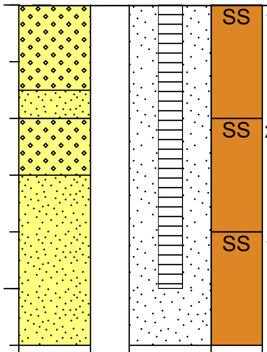
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
80	SS	18/24	6 11 12 14	23	(80') As above. (SW)		
					(81.5') 1/2" seam - orangish sand, medium packing, moist, (7.5YR 8/6). (SP)		
	SS	24/24	7 14 19 21	33	(82') Same as above. (SW)		
					(83') Same as above, top 3" (10R 6/6), tight, moist. (SP)		
	SS	12/24	19 27 15 5	42	(84') As above.		
85					(85') 2cm seam of reddish/oxidized fine grained sand, dry.		
					(86') End of Boring.		
90							

NOTES:

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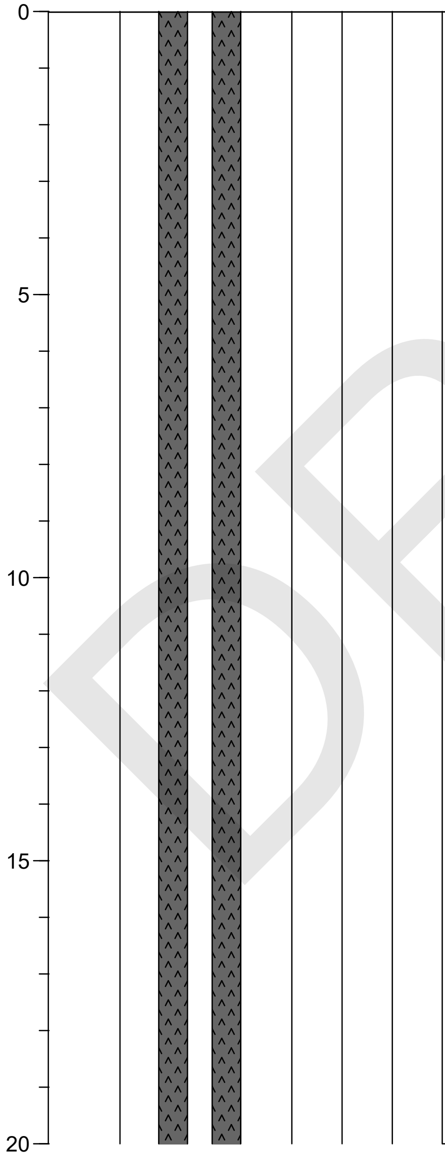
Client:	**Dynegy**
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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**

				COLLECT					MEASURE	
DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)



(0') Blind drilled.

NOTES:

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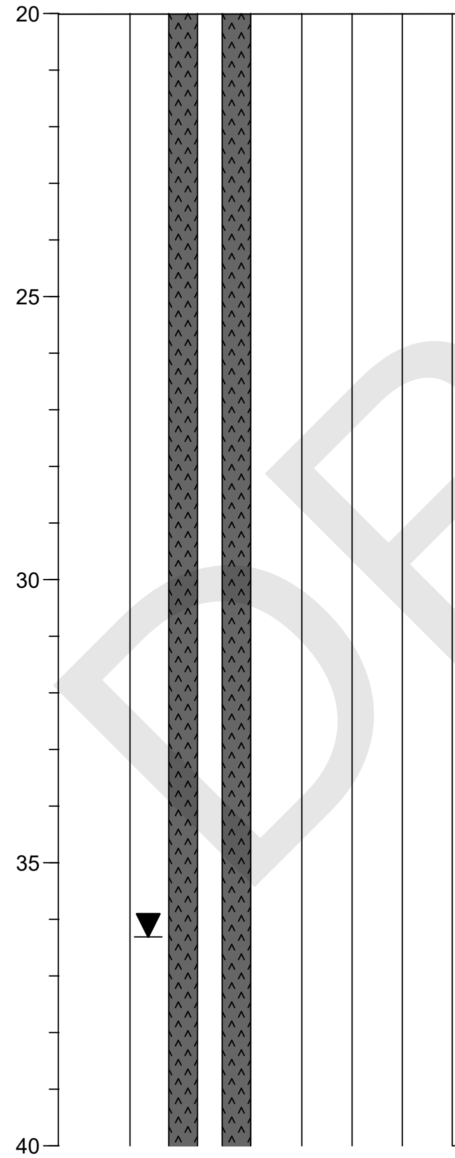
Drilling Start Date:	**01/31/2021**	Boring Depth (ft):	**72**	Well Depth (ft):	**70**
Drilling End Date:	**01/31/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	



(20') Blind drilled.

NOTES:

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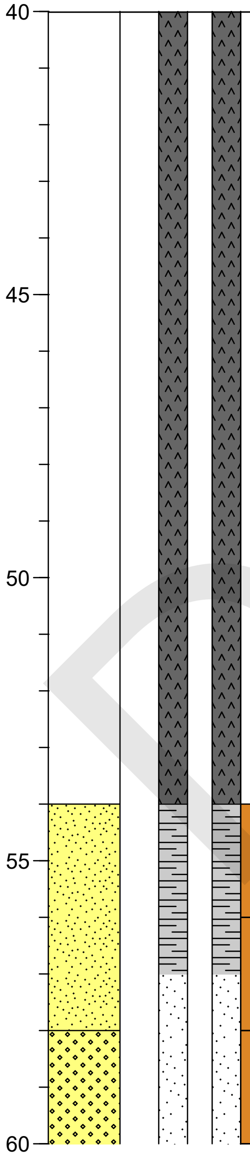
Client:	**Dynegy**	**WELL LOG**	
Project:	**GLP0821, Joppa Ash Pond**	**Well No.**	**G09**
Address:	**Unnamed Road, Metropolis, IL 62960**	**Page:**	**3 of 4**

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					MEASURE	
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
				(40') Blind drilled.		
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.		

NOTES:

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Client: **Dynegy**
Project: **GLP0821, Joppa Ash Pond**
Address: **Unnamed Road, Metropolis, IL 62960**

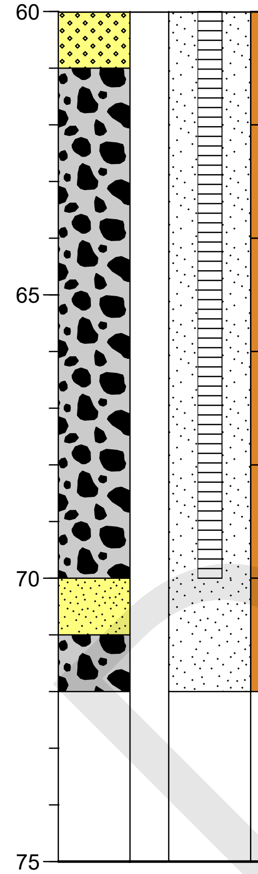
WELL LOG

Well No. **G09**
Page: **4 of 4**

Drilling Start Date: **01/31/2021**
Drilling End Date: **01/31/2021**
Drilling Company: **Geotechnology**
Drilling Method: **Hollow Stem Auger**
Drilling Equipment: **CME 55LC**
Driller:
Logged By: **SK**

Boring Depth (ft): **72**
Boring Diameter (in): **7.25**
DTW During Drilling (ft):
DTW After Drilling (ft): **36.31**
Top of Casing Elev. (ft): **351.99**
Ground Elev. (ft): **348.69**
Location (Lat/Long): **37.21039, -88.54247**

Well Depth (ft): **70**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Sch 40 PVC Slotted**
Seal Material(s): **Grout & Bentonite**
Filter Pack: **Sand**



DEPTH (ft)	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE
	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample
60	SS	19/24	13 24 48 25	72		
61					(61') SANDY GRAVEL (GW); yellow (10YR 7/8), loose, wet.	
62	SS	11/24	9 17 17 22	34	(62') Becomes sandier.	
64	SS	13/24	4 18 19 16	37		
65					(65') As above: brownish yellow (10YR 6/8).	
66	SS	13/24	4 17 23 50	40		
67					(67') As above.	
68	SS	2/24	50/5			
69					(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					(71') SANDY GRAVEL (GW); yellowish brown (10YR 5/6), loose, wet, well-graded.	
72					(72') End of Boring.	

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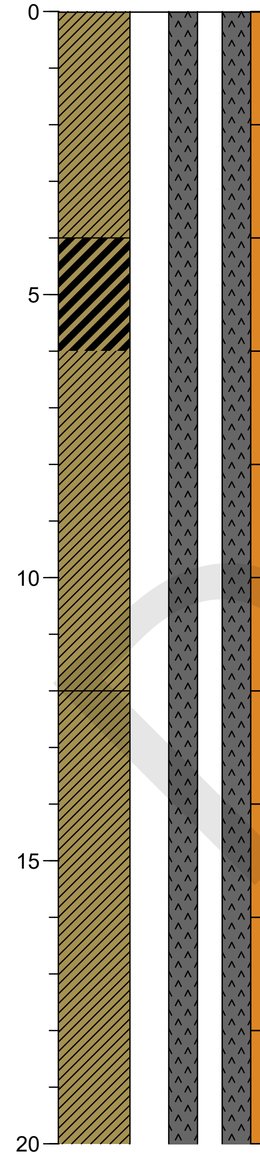
WELL LOG
Well No. G09M
Page: 1 of 8

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)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample
0	SS	6/24	6 4 5 6	9	(0') LEAN CLAY (CL); brown (7.5YR 5/3), stiff, dry, some reddish brown mottling, trace sand.	
2	SS	22/24	4 5 6 4	11		
4	SS	24/24	2 3 3 4	6	(4') FAT CLAY (CH); light brown (7.5YR 6/4), medium dense, moist.	
6	SS	24/24	0 3 3 4	6	(6') As above: lean clay, moist. (CL)	
8	SS	24/24	2 3 5 5	8	(8') As above: brown (7.5YR 5/4), some reddish brown mottling.	
10	SS	20/24	2 3 4 5	7	(10') As above.	10-12 Chem
12	SS	22/24	2 4 5 5	9	(12') CLAY (CL); gray to light brown (7.5YR 6/1) mottled, medium dense, dry, few sand.	
14	SS	21/24	2 3 5 5	8	(14') As above: brown (7.5YR 5/4).	
16	SH	24/24			(16') As above: light brown (7.5YR 6/3).	16-18 Geotech
18	SS	23/24	2 5 6 7	11	(18') CLAY (CL); gray to light brown (7.5YR 6/1) mottled, very stiff, moist, few sand.	

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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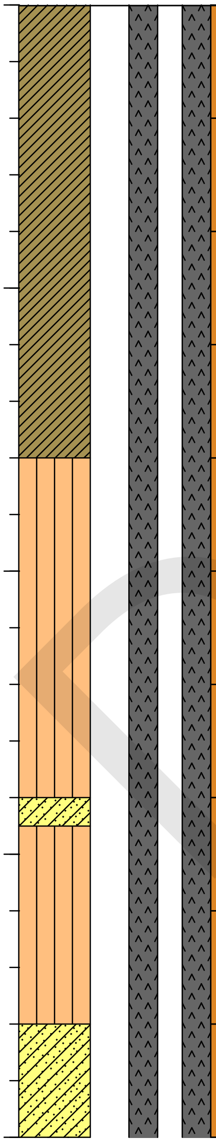
WELL LOG

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)	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).		
25	SS	24/24	2 5 7 8	12	(24') As above: fewer brown mottling.		
	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.		
30	SS	24/24	4 8 6 8	14	(30') As above: moist.		
	SS	24/24	4 5 6 7	11	(32') As above.		
35	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.		
	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							

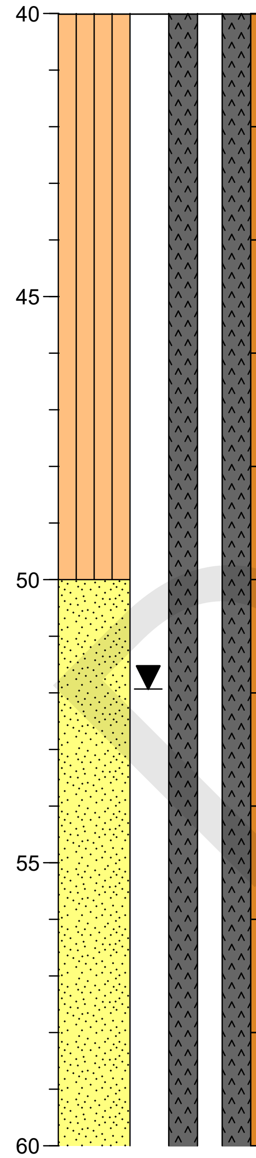
NOTES:

Client: **Dynegy**
Project: **GLP0821, Joppa Ash Pond**
Address: **Unnamed Road, Metropolis, IL 62960**

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**



DEPTH (ft)	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample
40	SS	24/24	3 6 8 7	14	(40') SILT WITH SAND (ML); few clay, gray (7.5YR 6/1), moist.	
	SS	24/24	5 3 4 5	7	(42') As above: some reddish brown mottling.	
45	SS	24/24	2 3 5 6	8	(44') As above: fewer clay, more sand.	
	SH	24/24				46-48 Geotech
	SS	24/24	5 8 18 12	26	(48') SILT WITH CLAY (ML); gradationally sandier, becomes moist, stiff to medium dense, gray (7.5YR 6/1).	48-50 Chem
50	SS	20/24	18 8 15 23	23	(50') POORLY GRADED SAND (SP); light gray (7.5YR 7/1), moist, loose.	
	SS	16/24	16 22 28 32	50	(52') POORLY GRADED SAND (SP); fine grained, with gravel up to cobble size, light gray (10YR 7/1), medium dense to loose, moist.	
55	SS	20/24	25 45 49 49	94	(54') POORLY GRADED SAND (SP); fine to medium grained, light gray (7.5YR 7/1), moist, loose. (55') As above: few coarse gravel, reddish yellow (7.5YR 7/6).	
	SS	23/24	27 33 20 20	53	(56') POORLY GRADED SAND (SP); fine to coarse grained, with coarse gravel, moist, gray (7.5YR 7/1) to reddish yellow (7.5YR 7/8).	
	SS	18/24	8 33 47 34	80	(58') As above: fine gray sand contains trace silt.	
60						

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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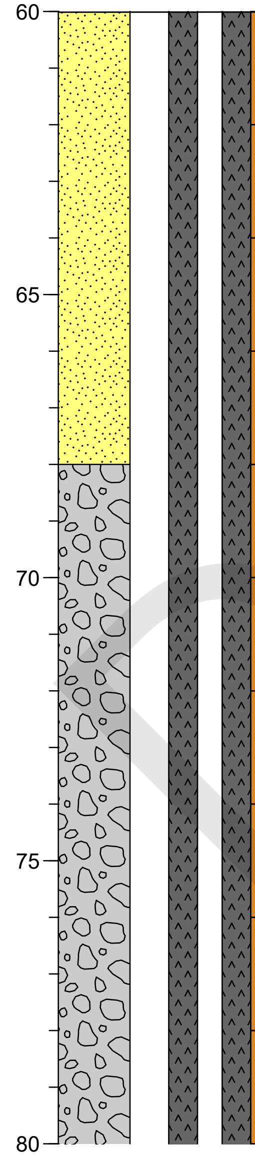
WELL LOG

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)	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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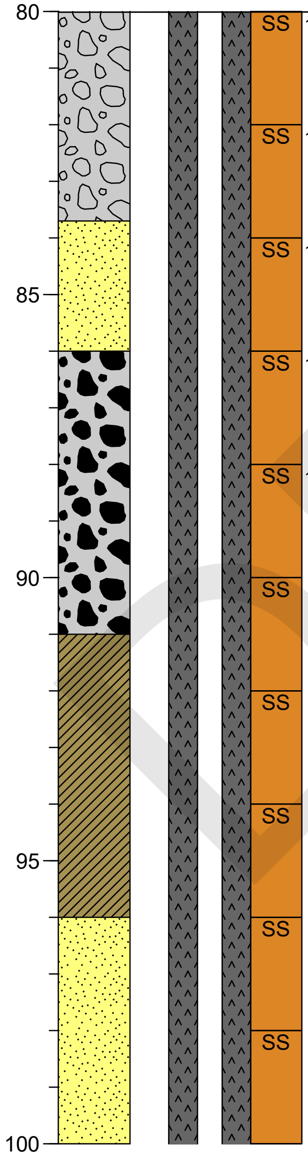
WELL LOG

Well No. G09M

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)	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample
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
82	SS	10/24	5 18 13 14	31		82-84 Geotech
84	SS	14/24		19	(83.7') POORLY GRADED SAND (SP); medium grained, trace gravel, reddish brown (7.5YR 6/8), loose, moist.	
86	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.	
88	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.	
92	SS		2 3 3 4	6	(92') CLAY (CL); trace gravel, gray (7.5YR 6/1), medium dense.	
94	SS		2 1 3 3	4	(94') As above: gray (10YR 5/1).	
96	SS		1 6 23 23	29	(96') POORLY GRADED SAND (SP); fine grained, strong brown (7.5YR 5/8), loose.	
98	SS		5 14 25 23	39	(98') As above.	
100						

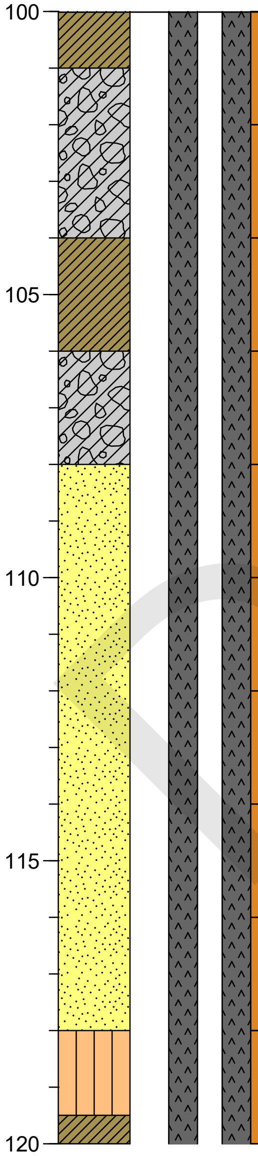
NOTES: SBG09M- (82-84)-20210127: 7.6% moisture content, 740 U mg/kg total organic carbon, 100.0 pcf dry unit weight, 2.686 specific gravity, 22.7% gravel, 75.4% sand, 1.9% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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**



Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
SS	14/24	14 14 13 15	27	(100') CLAY (CL); (10YR 6/1), very soft, trace gravel. (101') CLAYEY GRAVEL (GC); (7.5YR 5/8), moist, loose.	
SS	15/24	14 12 8 15	20	(102') As above: some sand, brown (7.5YR 4/4).	
SS	9/24	12 12 9 14	21	(104') GRAVELLY CLAY (CL); light gray (2.5Y 7/2), stiff, moist.	
SS	15/24	12 12 12 20	24	(106') CLAYEY GRAVEL (GC); pinkish gray (7.5YR 7/2), medium dense, moist.	
SS	14/24	9 28 11 11	39	(108') POORLY GRADED SAND (SP); fine grained, yellow (10YR 7/6) to white (10YR 8/1) at 109.8' bgs, moist, loose.	
SS	15/24	8 12 8 12	20	(110') As above: light gray (10YR 7/1).	110-112 Chem
SH	8/24				112-114 Geotech
SS	13/24	10 11 9 10	20	(114') As above: yellow (10YR 7/6), trace gravel.	
SS	12/24	7 9 9 12	18	(116') As above: light gray (10YR 7/2), no gravel.	116-118 Geotech (not tested)
SS	22/24	7 1 2 3	3	(118') SILT WITH SAND (ML); gray (10YR 6/1) with some light brown mottling, soft, moist. (119.5') CLAY (CL); little silt, gray (10YR 6/1), stiff, moist.	

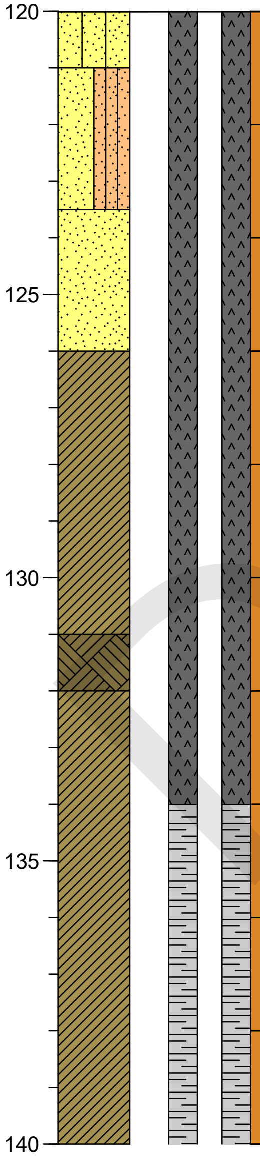
NOTES: SBG09M- (110-112)-20210127: 25.5% moisture content, 760 U mg/kg total organic carbon, 87.0 pcf dry unit weight, 2.675 specific gravity, 0.7% gravel, 84.1% sand, 15.2% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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
120	SS	21/24	2 3 4 14	7	(120') SAND WITH SILT (SM); light gray (10YR 7/1), medium dense, moist. (121') As above: less silty. (SP-SM)	
122	SS	16/24	7 7 22 31	29		
124	SS	11/24	13 14 16 14	30	(123.5') As above: yellow (2.5Y 7/6). (SP) (124') POORLY GRADED SAND (SP); fine to medium grained, red (2.5YR 5/6), loose, dry.	
126	SS	16/24	3 5 8 10	13	(126') CLAY (CL); few silt and sand, light brownish gray (10YR 6/2), very stiff, dry.	
128	SS	15/24	3 8 9 13	17	(128') As above.	128-130 Chem
130	SS	15/24	8 13 17 6	30	(130') Crushed SAPROLITE, dark yellowish brown (10YR 3/4) to black (10YR 2/1).	
132	SS	16/24	6 4 6 6	10	(132') CLAY (CL); few gravel, few sand, yellowish brown (10YR 5/4), moist, stiff.	132-134 Chem
134	SS	22/24	1 2 6 7	8	(134') As above: light brownish gray (10YR 6/2), no sand.	
136	SS	20/24	2 5 5 6	10	(136') As above: very pale brown (10YR 7/3).	
138	SS	13/24	4 8 7 21	15	(138') As above: light yellowish brown (5YR 6/4).	

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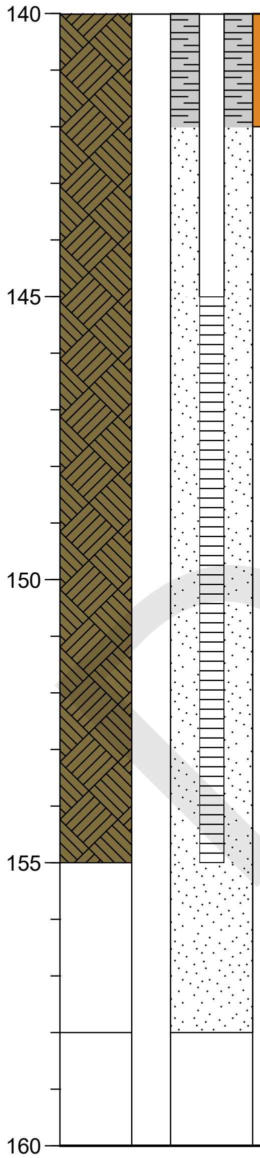
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample
140	SS	6/24	70/1		(140') CALCARENITE, very pale brown (10YR 7/3), dry.	140-142 Chem
155					(155') End of Boring.	
158					(158') Redrilled to 158' due to well installation difficulties.	

NOTES:

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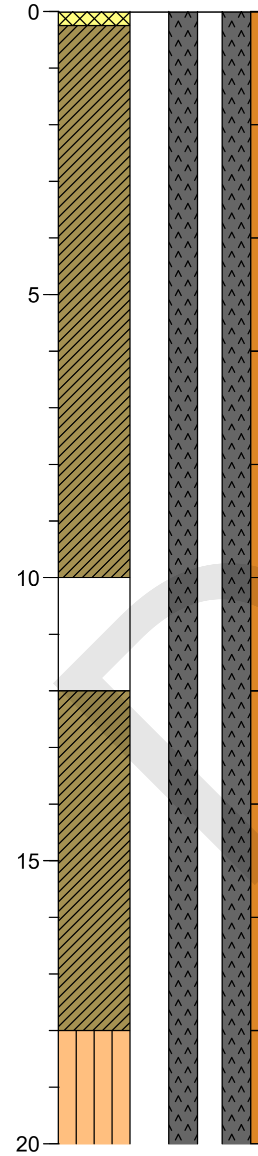
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	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 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.		
	SS	21/24	2 3 3 5	6	(4') As above: strong brown (7.5YR 5/6), little light gray mottling.		
5	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							

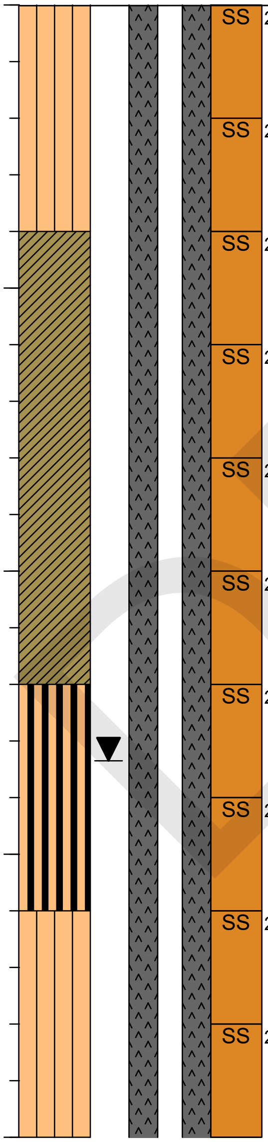
NOTES:

Client:	**Dynegy**
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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)		
40	SS	21/24	3 8 27 32	35	(38') SANDY SILT (ML); pale brown (10YR 6/3), very stiff, wet.		

NOTES:

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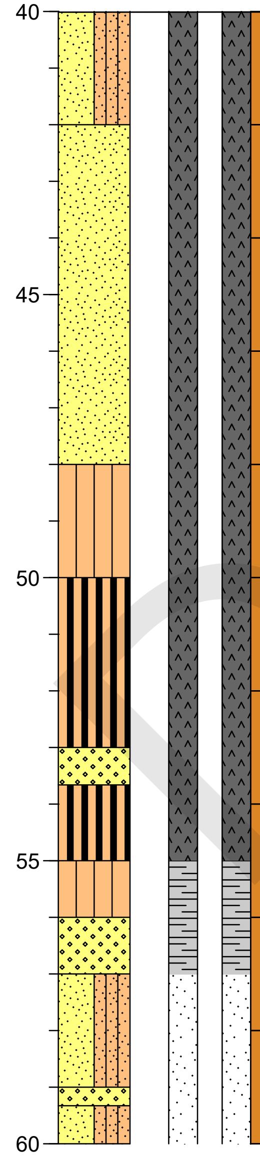
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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.	
42	SS	20/24	8 13 15 21	28	(42') As above: few silt. (SP)	
44	SS	19/24	10 14 14 11	28	(44') As above: light brownish gray (10YR 6/2), moist to dry, medium dense.	
46	SS	22/24	4 8 9 10	17	(46') As above: gray (10YR 6/1).	
48	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.	
52	SS	23/24	1 5 8 18	13		
53					(53') 8" GRAVELLY SAND lens (SW); loose, wet, yellowish red (5YR 5/6). (53'8") Returns to SILT as above. (MH)	
54	SS	22/24	1 3 4 8	7		
55					(55') CLAYEY SILT (ML); brownish yellow (10YR 6/6), moist, medium dense.	
56	SS	18/24	8 10 7 4	17	(56') WELL-GRADED GRAVELLY SAND (SW); reddish yellow (7YR 6/8), loose, wet.	
57					(57') POORLY GRADED SAND (SP-SM); fine grained, little silt, light gray (10YR 7/1), medium dense, moist.	
58	SS	24/24	2 28 3 7	31		
59					(59') 4" GRAVELLY SAND layer (SW); wet.	

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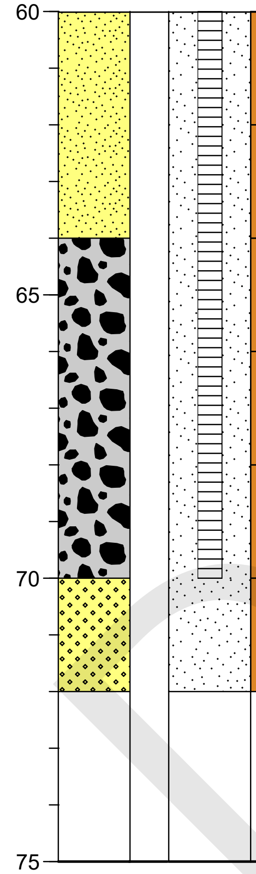
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
					(59'4") Returns to fine sand as above. (SP-SM)		
60	SS	19/24	6 7 7 6	14	(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.		
	SS	5/24	50/5		(64') SANDY GRAVEL (GW); brownish yellow (10YR 6/8), wet, loose.		
65					(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.		
					(72') End of Boring.		
75							

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Project: GLP0821, Joppa Ash Pond
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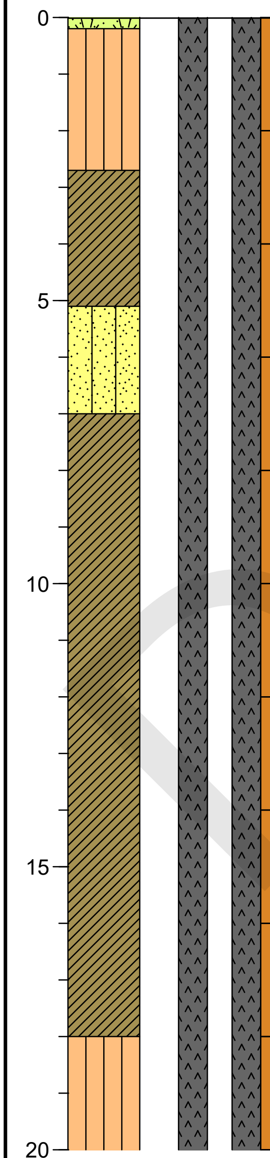
WELL LOG

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**



COLLECT

Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)
SS	24/24	6 4 9 7	13
SS	17/24	1 1 2 4	3
SS	16/24	5 21 50/6	71
SS	17/24	5 7 5 5	12
SS	24/24	1 3 5 6	8
SS	24/24	2 5 8 6	13
SS	23/24	2 4 5 7	9
SS	24/24	2 5 6 8	11
SS	24/24	2 4 5 6	9
SS	24/24	3 7 9 10	16

SOIL/ROCK VISUAL DESCRIPTION

(0') TOPSOIL.

(0.2') ASH (ML)

(0.8') LEAN SILT (ML); trace fine sand, stiff, moist, tan (2.5Y 7/4).

(2.7') LEAN CLAY (CL); some orange fine sand, soft, wet, brown (2.5Y 3/3).

(5.1') SILTY SAND (SM); fine to medium grained, with coal, some organics, very dense, gray (N3), moist, well-graded.

(7.0') LEAN CLAY (CL); stiff, moist, tan (5Y 7/2) with gray (N8) mottles.

(8') As above: becomes medium stiff, orange (10YR 7/12) mottles.

(10') As above: becomes stiff, black inclusions, trace organics.

(12') As above.

(14') As above.

(16') As above.

(18') LEAN SILT (ML); trace sand, stiff, moist, tan (5Y 7/2) with orange (10YR 7/12) and black mottling.

MEASURE

Lab Sample

DEPTH (ft)

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				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	
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	
25				SS	27/24			(24') As above.	24-26 ST	
				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.		
35				SS	25/24	4 5 8 7	13	(34') As above: with fine sand.		
				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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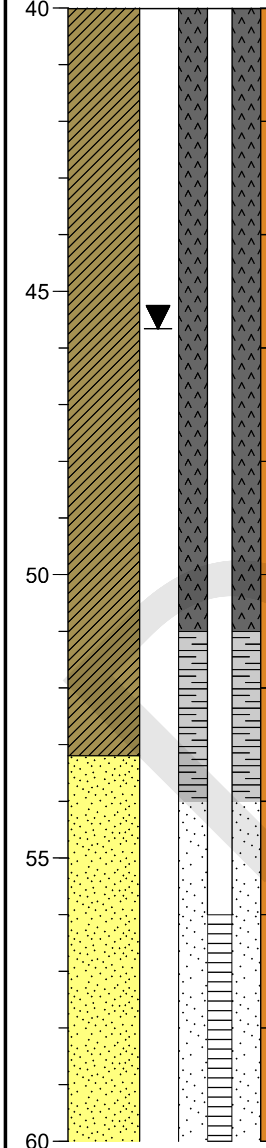
Client: **Dynegy**
Project: **GLP0821, Joppa Ash Pond**
Address: **Unnamed Road, Metropolis, IL 62960**

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**



DEPTH (ft)	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample
40	SS	25/24	2 3 4 4	7	(40') As above: becomes medium stiff.	
42	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).	
44	SS	25/24	2 4 5 6	9	(44') As above: stiff.	
46	SS	25/24	3 6 9 10	15	(46') As above: seams are silt only.	
48	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 0 3	3	(50') As above: increased moisture.	
52	SS	27/24	2 3 3 6	6	(52') As above: gray (N9) sand layer.	
53.2					(53.2') POORLY GRADED SAND (SP); fine to medium grained, trace silt, loose, gray (N9), wet.	
54	SS	27/24	3 8 26 26	34	(54') As above: becomes dense, trace clay, trace orange (10YR 7/6) silt inclusions.	
56	SS	8/24			(56') As above.	56-58 Geotech
58	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

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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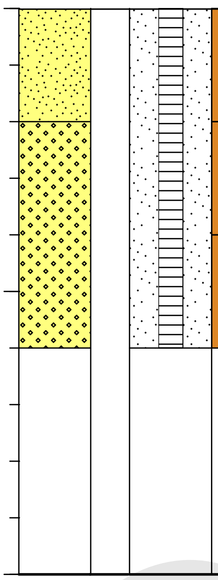
Client:	**Dynegy**	**WELL LOG**	
Project:	**GLP0821, Joppa Ash Pond**	**Well No.**	**G11**
Address:	**Unnamed Road, Metropolis, IL 62960**	**Page:**	**4 of 4**

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				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	
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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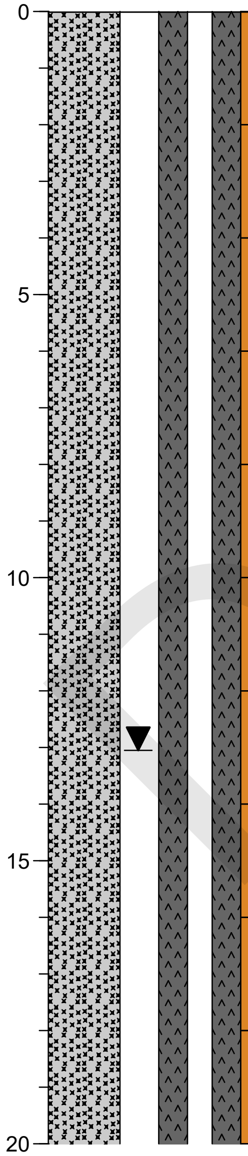
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE 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.	
	SS	18/24	3 2 2 4	4	(4') As above.	4-6 Chem
5	SS	24/24			(6') As above.	6-8 Geotech
	SS	15/24	4 4 3 2	7	(8') As above.	
					(9.6') LEAN SILT (ML); some fine sand, very soft, wet, grayish brown (N4) with white speckling. [FLY ASH MIXTURE]	
10	SS	18/24	1 1 1 1	2	(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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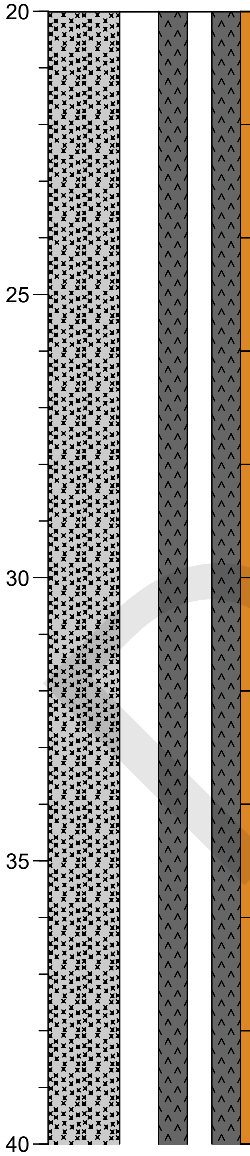
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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**

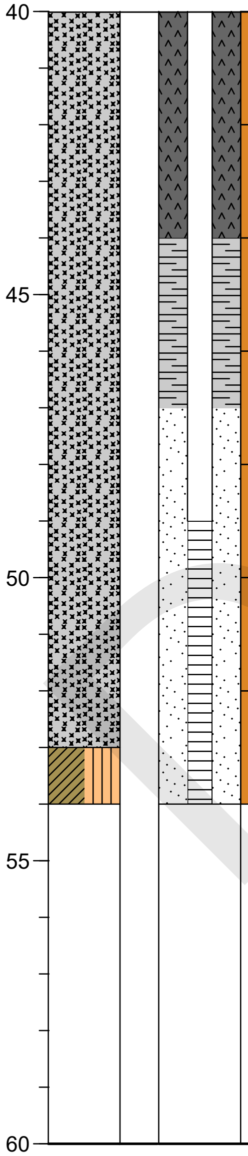


DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
20	SS	10/24	0 0 0 1	0	(20') As above. (21.3') LEAN SILT (ML); very soft, wet, grayish brown (N4) with white and orange speckling. [FLY ASH MIXTURE]	
22	SS	1/24	0 0 0 0	0	(22') As above: little fine sand, trace coal.	
24	SS	24/24	0 0 0 0	0	(24') LEAN SILT (ML); very soft, wet, grayish brown (N4). [FLY ASH]	
26	SS	24/24	0 0 0 0	0	(26') As above.	
28	SS	26/24	0 0 0 0	0	(28') As above.	
30	SS	26/24	0 0 0 0	0	(30') As above.	
32	SS	26/24	0 0 0 0	0	(32') As above.	
34	SS	26/24	0 0 0 0	0	(34') As above.	
36	SS	24/24	0 0 0 0	0	(36') As above.	
38	SS	25/24	0 0 0 0	0	(38') As above.	

NOTES: Well could not get down augers, augers were washed out using water, rig pump, tremie pipe.

Geosyntec consultants engineers | scientists | innovators	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)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample
40	SS	26/24	0 0 0 0	0	(40') As above: infrequent fine sand layers.	
42	SS	26/24	0 0 0 0	0	(42') As above.	
44	SS	20/24	0 0 0 0	0	(44') As above.	
46	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
48	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.	
52	SS	26/24	0 0 3 2	3	(52') As above.	
53					(53') LEAN CLAY WITH GRAVEL (CL-ML); some sand, some ash, soft, wet, gray (N4). [TRANSITIONAL]	
54					(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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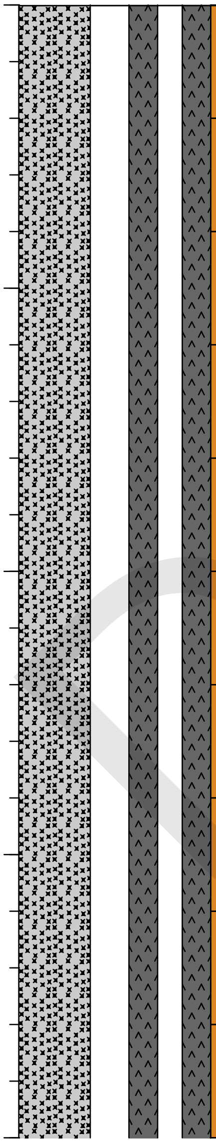
WELL LOG

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)	COLLECT Sample Type	 Recovery (in)	 Blow Counts	 N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample
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).	
15	SS	10/24	1 2 2 2	4	(14') As above: with gravel, white speckles.	
	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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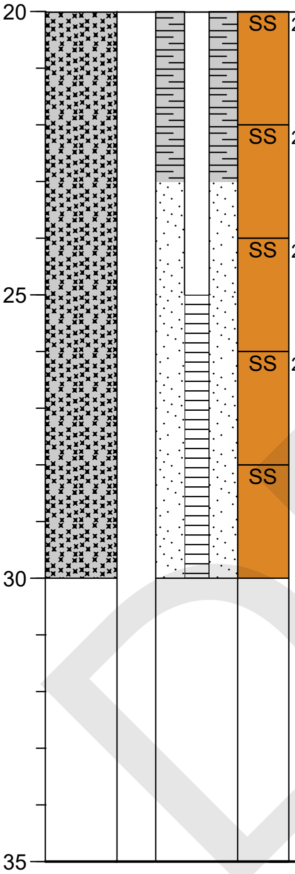
WELL LOG

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**



COLLECT					MEASURE
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
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.	
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.	
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.	

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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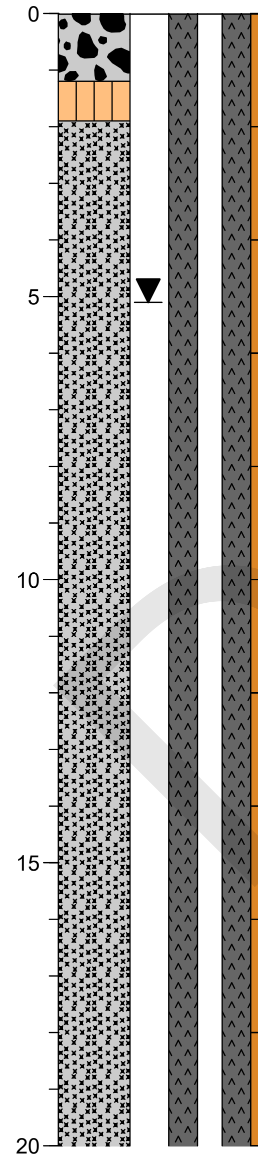
WELL LOG

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**



COLLECT					MEASURE
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
SS	22/24	4 14 7 3	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	1 0 1 1	1	(1.9') LEAN SILT (ML); frequent tan (2.5YR 9/2) silt layers, very soft, wet, brown (2.5YR 9/2). [FLY ASH]	
SS	26/24	1 4 4 1	8	(4') As above: becomes medium stiff, no tan silt layers, gravelly layer (coal fragments).	
SS	20/24	0 1 1 2	2	(6') As above: becomes very soft.	6-8 Chem
SS	26/24	2 1 1 1	2	(8') As above: some fine sand and white and black speckles.	
SS	23/24	0 0 0 0	0	(10') As above: no gravelly layers.	
SS	26/24	0 0 0 1	0	(12') As above: frequent black sandy layers	
SS	3/24			(14') As above.	
SS	0/24				
SS	0/24			(18') As above.	

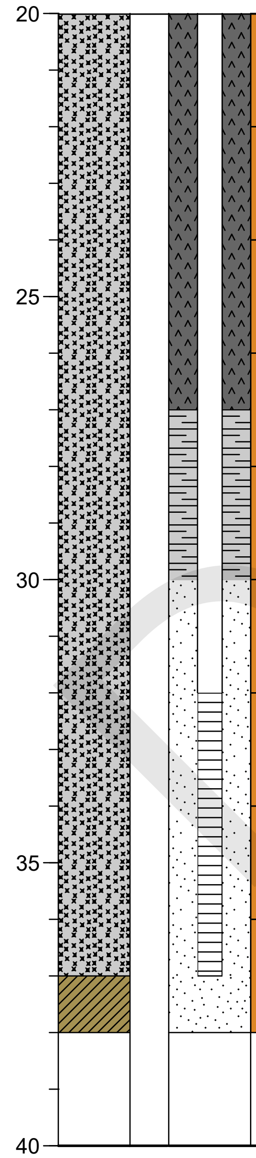
NOTES:

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**



DEPTH (ft)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample
20	SS	0/24			(20') As above.	
22	SS	26/24	0 0 0 0	0	(22') As above: no gravel or sand.	22-24 Geotech
24	SS	26/24	0 0 0 0	0	(24') As above.	
26	SS	26/24	0 0 0 0	0	(26') As above: infrequent black fine sand seams.	
28	SS	26/24	0 0 0 0	0	(28') As above.	
30	SS	26/24	0 0 0 0	0	(30') As above.	
32	SS	26/24	0 0 0 0	0	(32') As above.	
34	SS	26/24	0 0 0 0	0	(34.3') LEAN SILT (ML); very soft, wet, dark brown (N2). [LOWER ASH]	34-36 Chem
36	SS	24/24	0 0 0 0	0	(36') As above. (37') LEAN CLAY (CL); stiff, moist, tan (10YR 7/8) and gray (N8).	36-38 Geotech
38					(38') End of Boring.	

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, 1.8x10^{-7} cm/s vertical hydraulic conductivity, 46 LL, 31 PL, 15 PI, 0.0% gravel,9.4% sand, 90.6% fines.

GEOTECHNOLOGY INC
FROM THE GROUND UP

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

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

Sheet 1 of 1

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 (20ºC)
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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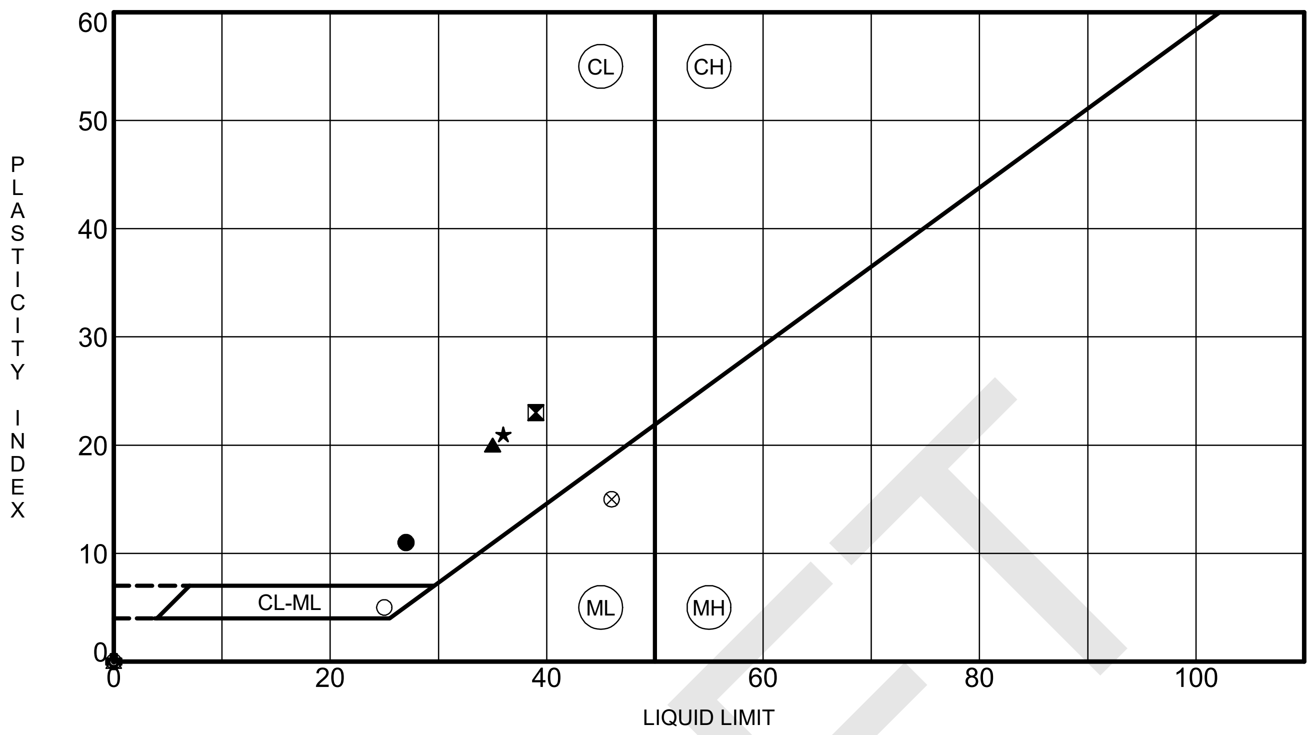
Summary of Laboratory Results

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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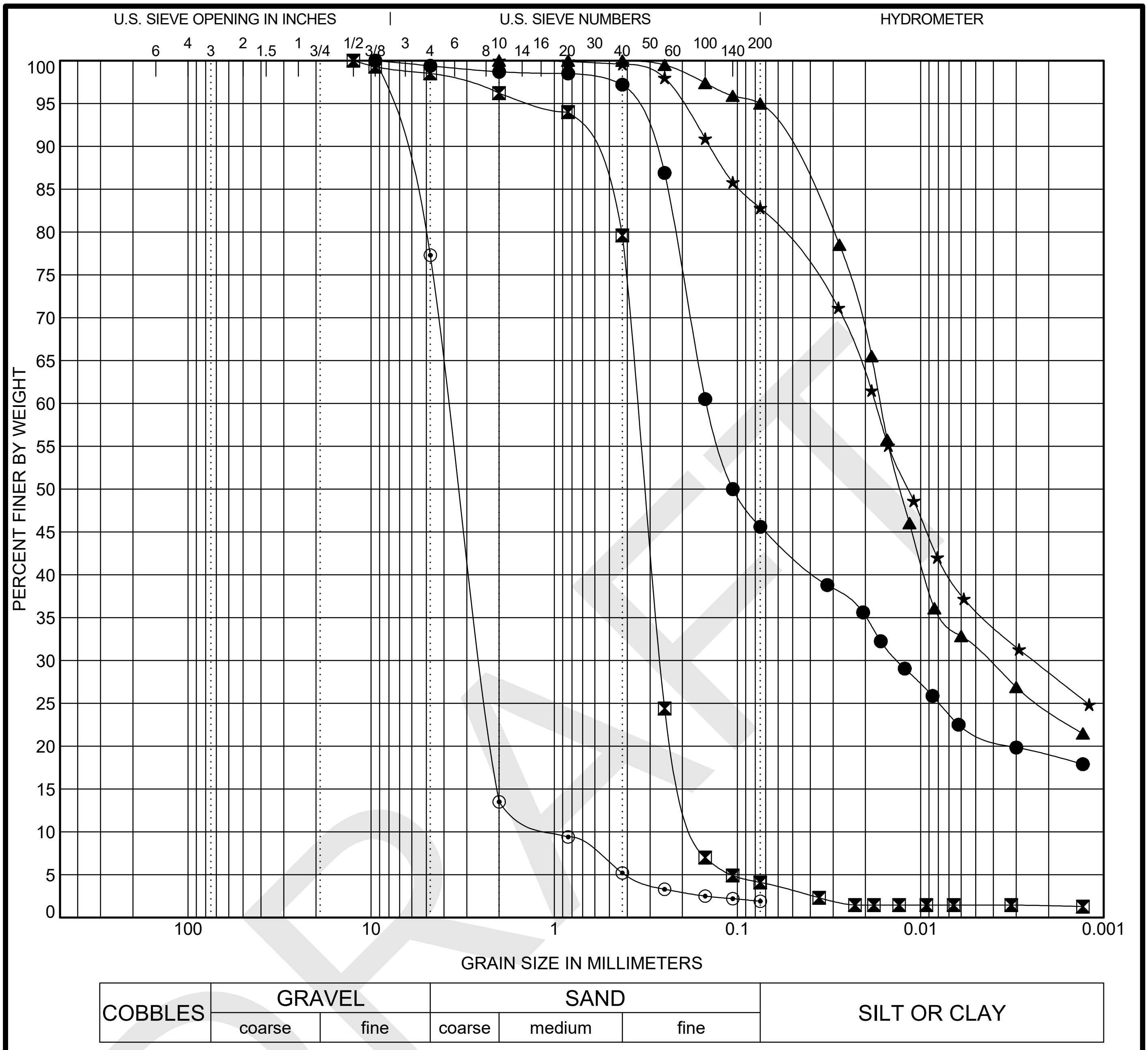
APPENDIX C

Grain Size Distribution



	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**	

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GRAIN SIZE DISTRIBUTION

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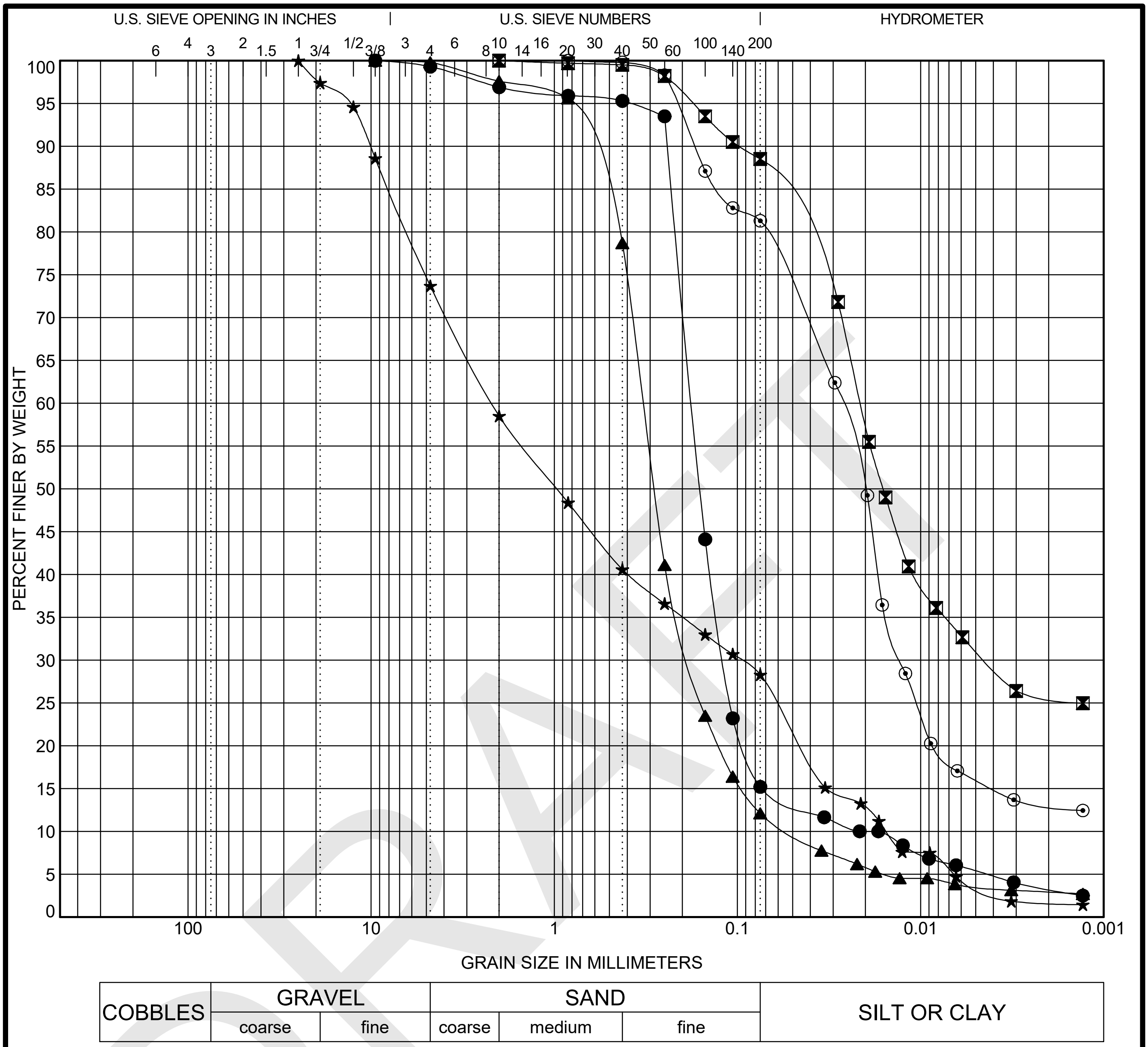


	Boring	Depth (ft.)	Sample Description	LL	PL	PI	Cc	Cu
●	**G09M**	**112.0**					**4.69**	**10.42**
⊠	**G11**	**24.0**	**LEAN CLAY(CL)**	**36**	**15**	**21**		
▲	**G11**	**56.0**	**SILTY SAND(SM)**	**NP**	**NP**	**NP**	**1.94**	**6.30**
★	**XPW01**	**6.0**	**SILTY SAND with GRAVEL(SM)**	**NP**	**NP**	**NP**	**0.28**	**142.34**
⊙	**XPW01**	**48.0**	**SILTY CLAY with SAND(CL-ML)**	**25**	**20**	**5**		

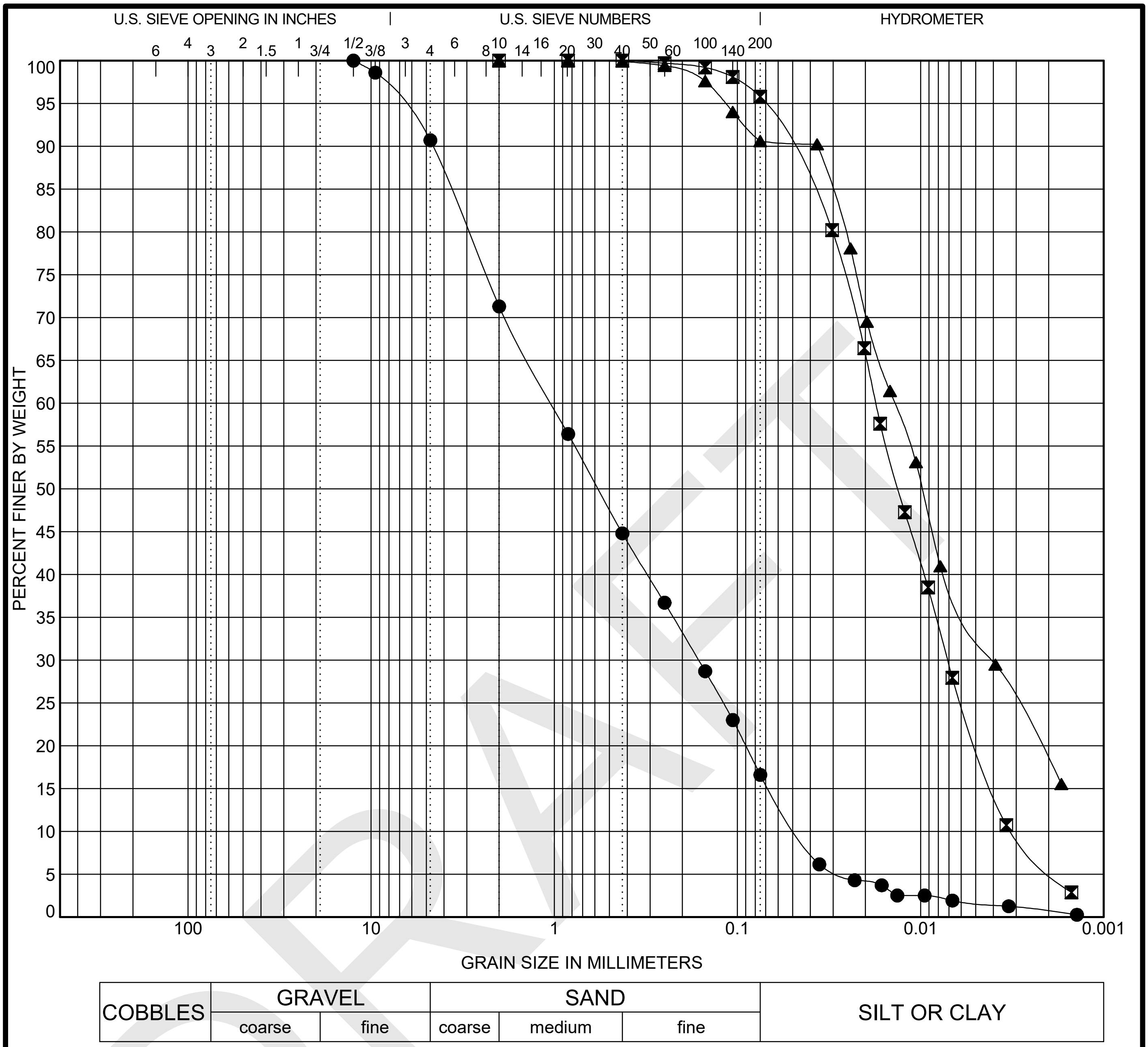
	Boring	Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**G09M**	**112.0**	**9.5**	**0.18**	**0.12**	**0.017**	**0.7**	**84.1**	**9.8**	**5.4**
⊠	**G11**	**24.0**	**2**	**0.02**	**0**		**0.0**	**11.5**	**57.4**	**31.1**
▲	**G11**	**56.0**	**9.5**	**0.33**	**0.18**	**0.052**	**0.2**	**87.7**	**8.5**	**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



	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

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.

ATTACHMENT C

Excerpts from 2022 Geosyntec Investigation

Geosyntec
consultants

Joppa East Ash Pond
Electric Energy Inc.
2022 SE Investigation
Hand Auger Location Plan
Developed By: PK **Date:** 4/19/22

FIGURE
1

Boring HA-01

Drilling Start Date:	3/2/2022	**Boring Depth (ft):**	4.25 ft
Drilling End Date:	3/2/2022	**Boring Diameter (in.)**	3.5 inches
Drilling Company:	Geosyntec	**Sampling Method(s):**	Hand Auger (HA)
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	0 ft bgs
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	0 ft bgs
Driller Name:	-	**Ground Surface Elev. (ft):**	333
Logged By:	Zachary Fallert / Pourya Kargar	**Northing, Easting:**	335579.79 4119704.73

Note: Survey data approximated using My Elevation app on Android

DEPTH (ft)	**SAMPLE TYPE/NUMBER**	**RECOVERY (ft)**	**BLOW COUNTS**	**MATERIAL DESCRIPTION**	**N-VALUE**	**MOISTURE CONTENT (%)**	**FINES (%)**	**REMARKS**
0				Loose, wet, black, silty fine SAND [COAL FINES]				
1				SAA, with trace brown coarse sand and clay				
2				SAA, becomes predominantly natural clayey well-graded SAND with organics				
3				SAA, with gravel trace				
4				SAA, with coarser gravel				
				Boring Terminated - Hole Collapse				
5								
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.)**	3.5 inches
Drilling Company:	Geosyntec	**Sampling Method(s):**	Hand Auger (HA)
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	0 ft bgs
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	0 ft bgs
Driller Name:	-	**Ground Surface Elev. (ft):**	326
Logged By:	Zachary Fallert / Pourya Kargar	**Northing, Easting:**	335647.60 4119676.77

Note: Survey data approximated using My Elevation app on Android

DEPTH (ft)	**SAMPLE TYPE/NUMBER**	**RECOVERY (ft)**	**BLOW COUNTS**	**MATERIAL DESCRIPTION**	**N-VALUE**	**MOISTURE CONTENT (%)**	**FINES (%)**	**REMARKS**
0				Soft, wet, black, silty CLAY- clayey SILT [COAL FINES-CLAY MIXTURE]				
1								
2				SAA, with more grey plastic fines and organics SAA				
3				SAA, with pockets of gray, loose SILT [Possible CCR]				
4				Loose, wet, grey/brown/black, SILT, with some sand, coal chunks, trace clay [CCR]				
5				Soft, wet, grey with black mottling, lean CLAY [ALLUVIUM]				
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.)**	3.5 inches	
Drilling Company:	Geosyntec	**Sampling Method(s):**	Hand Auger (HA)	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	0 ft bgs	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	0 ft bgs	
Driller Name:	-	**Ground Surface Elev. (ft):**	326	
Logged By:	Zachary Fallert / Pourya Kargar	**Northing, Easting:**	335811.16	4119868.92
		Note: Survey data approximated using My Elevation app on Android		

DEPTH (ft)	**SAMPLE TYPE/NUMBER**	**RECOVERY (ft)**	**BLOW COUNTS**	**MATERIAL DESCRIPTION**	**N-VALUE**	**MOISTURE CONTENT (%)**	**FINES (%)**	**REMARKS**
0				Moist, tan with grey & brown mix, silty CLAY [FILL]				
1								
2				Loose, wet, grey, SILT [CCR]				
3				Soft,wet, brown & grey, silty CLAY [CLAY-CCR MIXTURE]				
4				Soft, wet, brown & tan, fat CLAY [ALLUVIUM] SAA with grey 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.)**	3.5 inches	
Drilling Company:	Geosyntec	**Sampling Method(s):**	Hand Auger (HA)	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	0 ft bgs	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	0 ft bgs	
Driller Name:	-	**Ground Surface Elev. (ft):**	329	
Logged By:	Zachary Fallert / Pourya Kargar	**Northing, Easting:**	335826.55	4120020.69
		Note: Survey data approximated using My Elevation app on Android		

DEPTH (ft)	**SAMPLE TYPE/NUMBER**	**RECOVERY (ft)**	**BLOW COUNTS**	**MATERIAL DESCRIPTION**	**N-VALUE**	**MOISTURE CONTENT (%)**	**FINES (%)**	**REMARKS**
0				Moist, tan, lean CLAY [FILL]				
1				SAA, becomes wet				
2				SAA				
3				Loose, wet, grey, clayey SILT, [CLAY-CCR MIXTURE]				
4								No recovery from approximately 3.5 ft - 6 ft bgs.
5								
6				SAA, without clay Wet, tan & grey, fine silty SAND [ALLUVIUM]				
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.)**	3.5 inches	
Drilling Company:	Geosyntec	**Sampling Method(s):**	Hand Auger (HA)	
Drilling Method:	Hand Auger (HA)	**GW During Drilling (ft bgs):**	0 ft bgs	
Drilling Equipment:	Hand Auger (HA)	**GW After Drilling (ft bgs):**	0 ft bgs	
Driller Name:	-	**Ground Surface Elev. (ft):**	333	
Logged By:	Zachary Fallert / Pourya Kargar	**Northing, Easting:**	335861.70	4120093.26

At

DEPTH (ft)	**SAMPLE TYPE/NUMBER**	**RECOVERY (ft)**	**BLOW COUNTS**	**MATERIAL DESCRIPTION**	**N-VALUE**	**MOISTURE CONTENT (%)**	**FINES (%)**	**REMARKS**
0				Moist, tan, lean CLAY [Fill]				
1								
				SAA				
2				SAA				
				Boring Terminated - Gravel Refusal				
3								
4								
5								
6								
7								
8								
9								
10								

ATTACHMENT D

Summary of 2022 Geosyntec Subsurface Characterization

EAST ASH POND
Joppa Power Plant, Illinois
Summary of All Lab Data
GLP8025

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)	τ_{ff} (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

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 applicable.

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

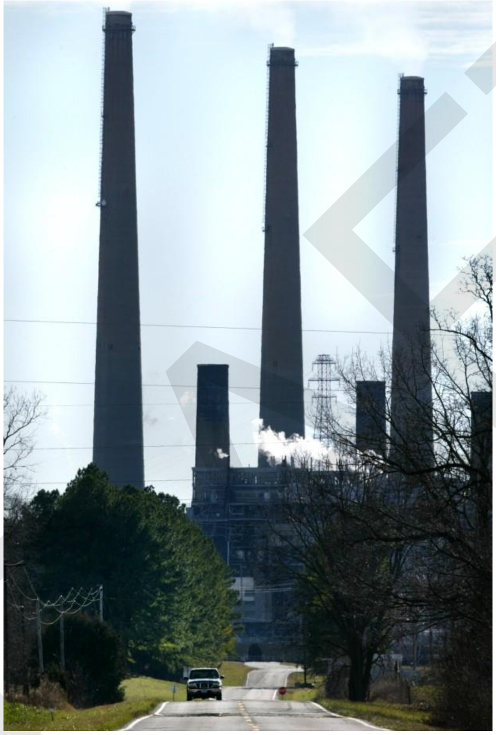


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TABLE OF CONTENTS

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

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:

$$p(Z > z) = 1 - e^{-\nu(z) \cdot t} \qquad (2\text{-}1)$$

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:

$$\dot{M}_o = \mu \, A \, S \qquad (2\text{-}6)$$

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):

$$\mathbf{M} = 2/3 \log M_o - 10.7 \qquad (2\text{-}7)$$

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):

$\mathbf{M} = -0.39 + 0.98\mathrm{Mn}$ for magnitudes ≤ 5.5

$$\mathbf{M} = 2.715 - 0.277\text{Mn} + 0.127(\text{Mn}^2) \text{ for magnitudes} > 5.5$$

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 ~R^{-1} geometrical spreading (0.31/0.383)	Silva *et al*. (2002) – DC-Sat Atkinson (2008) with 2011 modifications (A08′)
3	Complex/Empirical Source ~$R^{-1.3}$ 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:

$$P[A_S>z] = \iiint P\left[AF > \frac{z}{a}\middle| m,r,a\right] f_{M,R|A}\ (m,r;a) f_A(a)\, dm\, dr\, da \qquad (6\text{-}1)$$

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 y^{th} 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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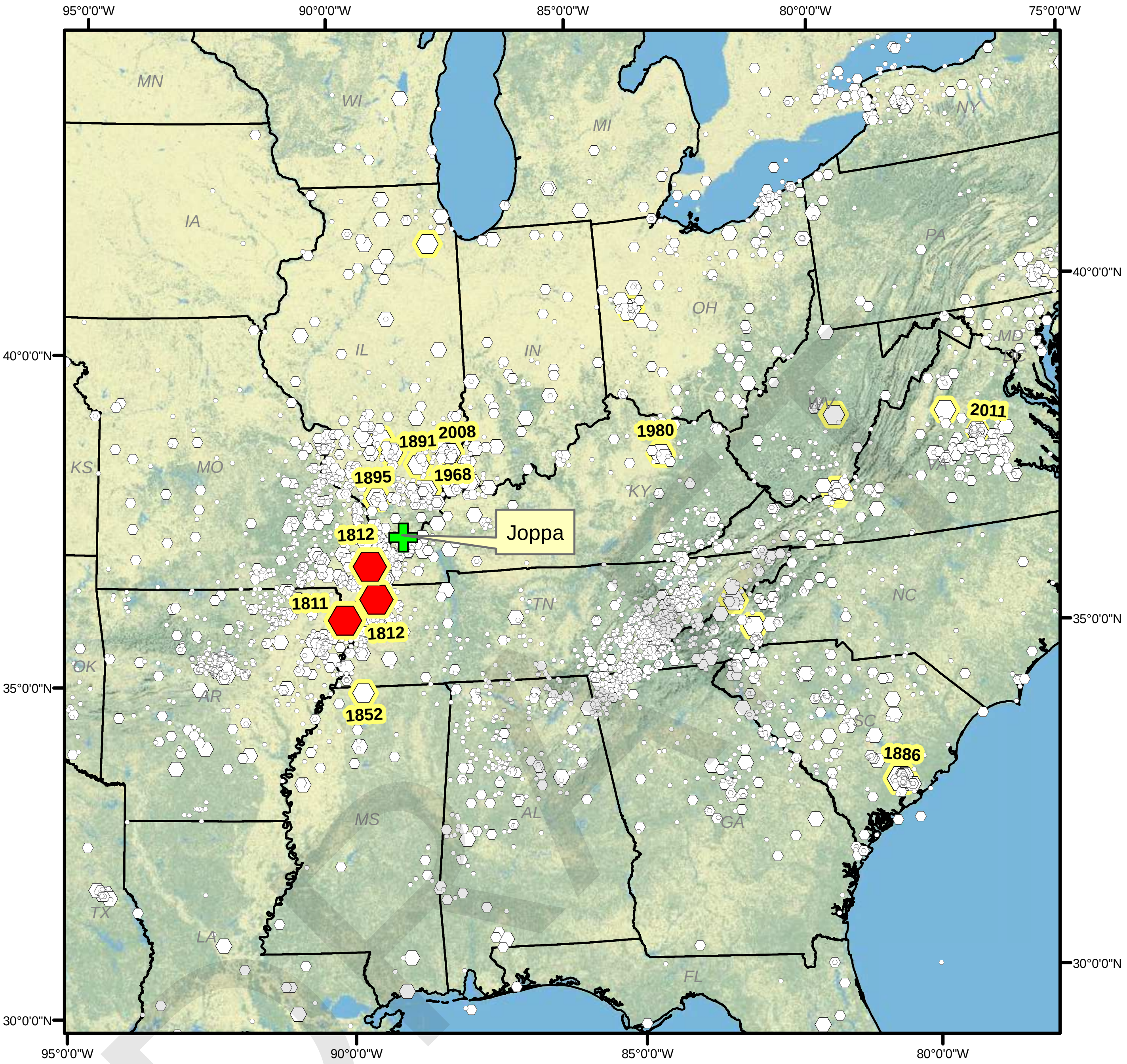
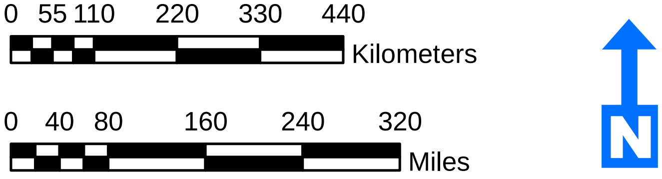


Magnitude Mw

◦	<= 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



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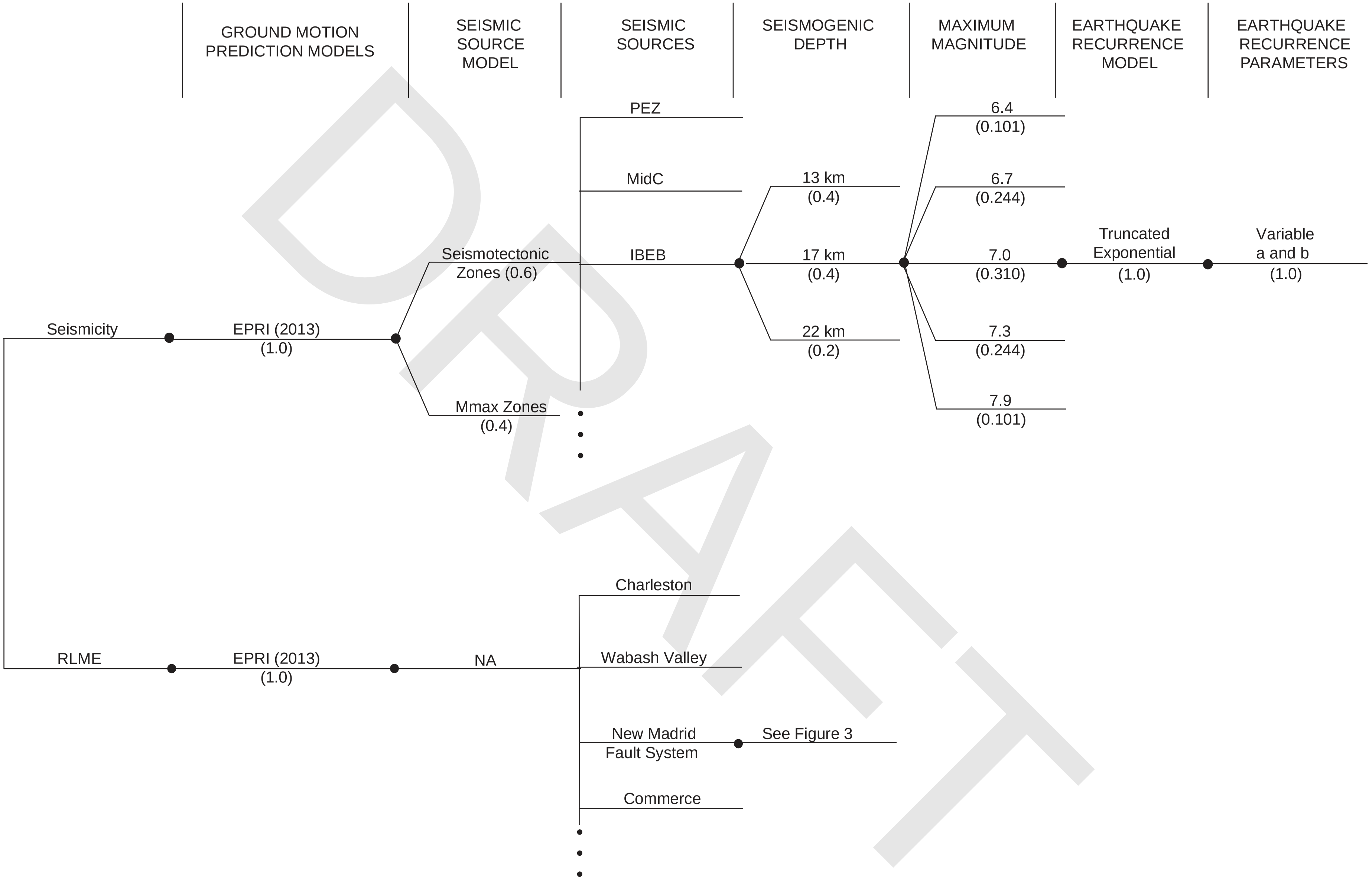
HISTORICAL SEISMICITY OF THE CENTRAL
AND EASTERN UNITED STATES
(1699 - 2015)

Figure

1



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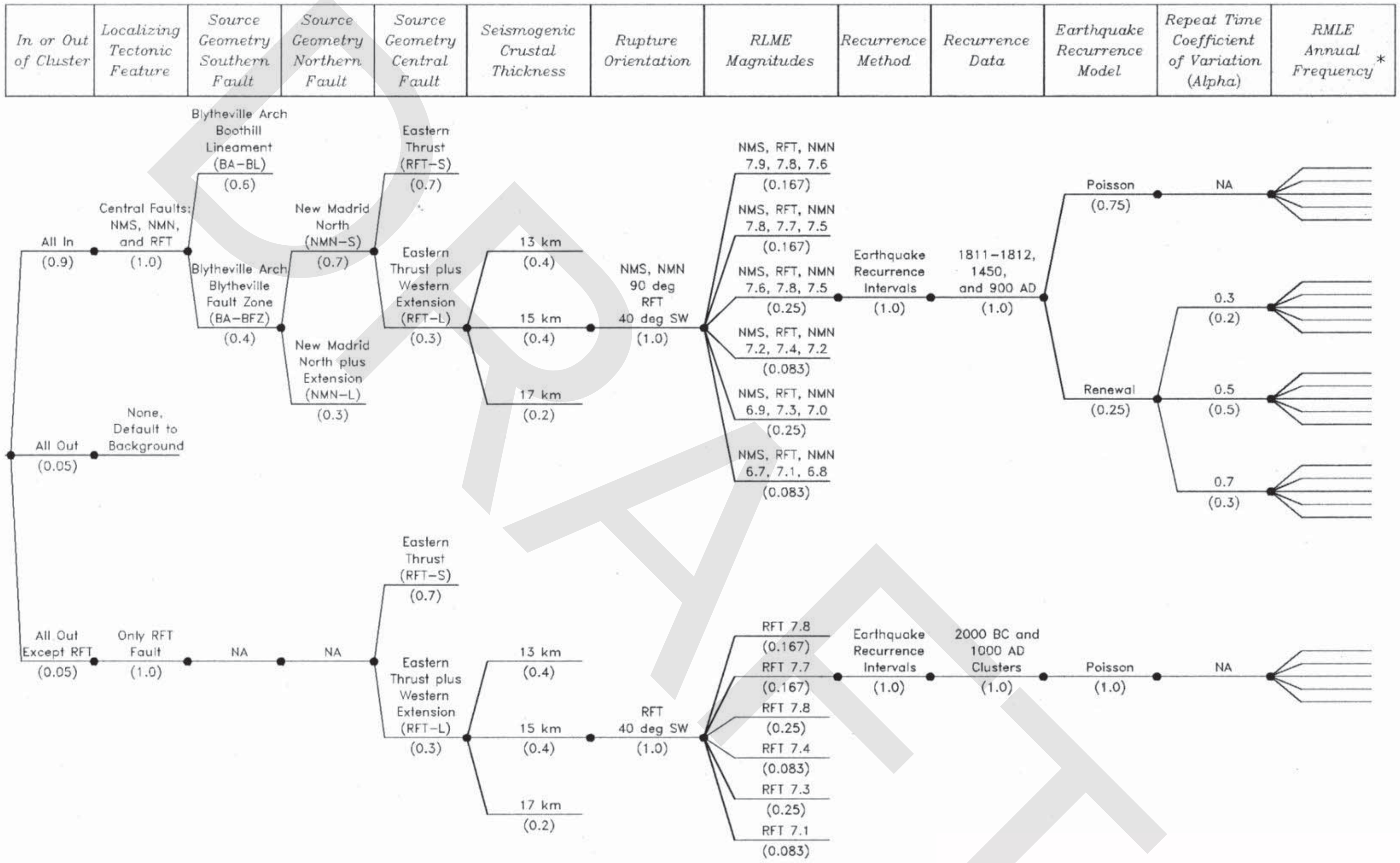
EXAMPLE SEISMIC HAZARD
MODEL LOGIC TREE

Figure
2



* See EPRI/DOE/NRC (2012)

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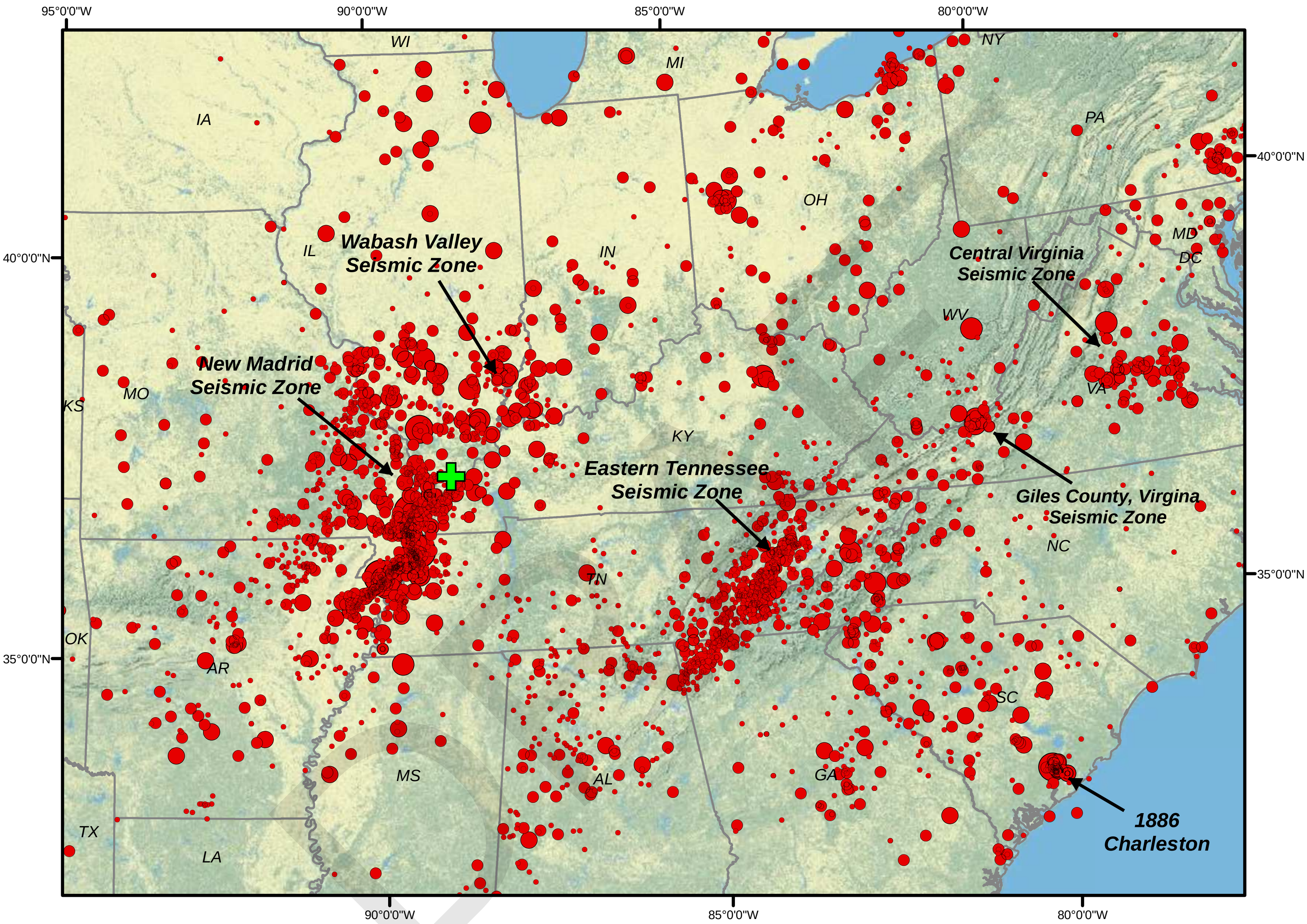
NEW MADRID RLME LOGIC TREE

Figure
3



✚ Project Site

● Earthquake Epicenters

Seismicity from:
EPRI/DOE/NRC (2012)

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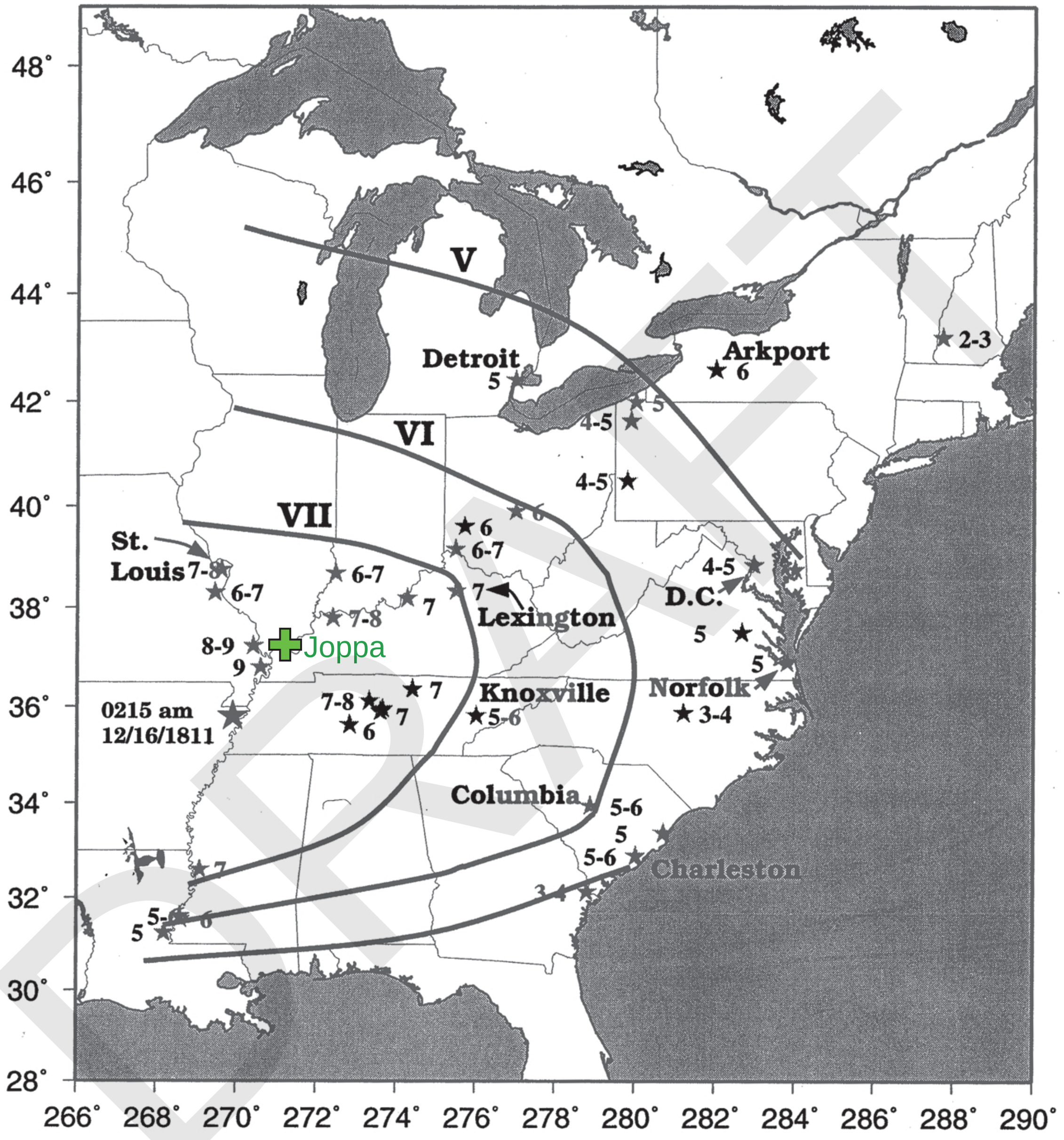
HISTORICAL SEISMICITY AND SEISMIC ZONES IN EASTERN U.S.

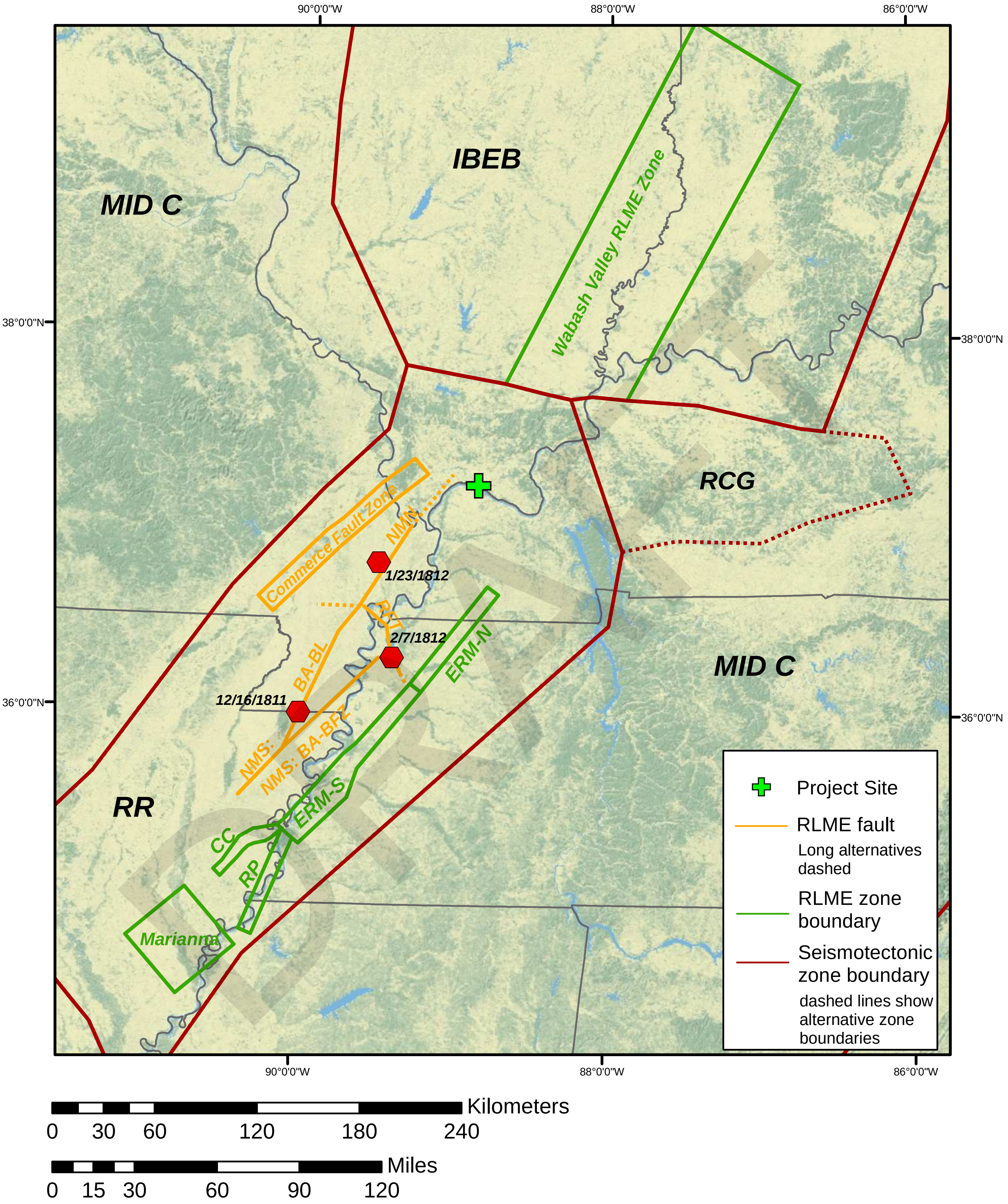
Figure

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



Project No. 60440155

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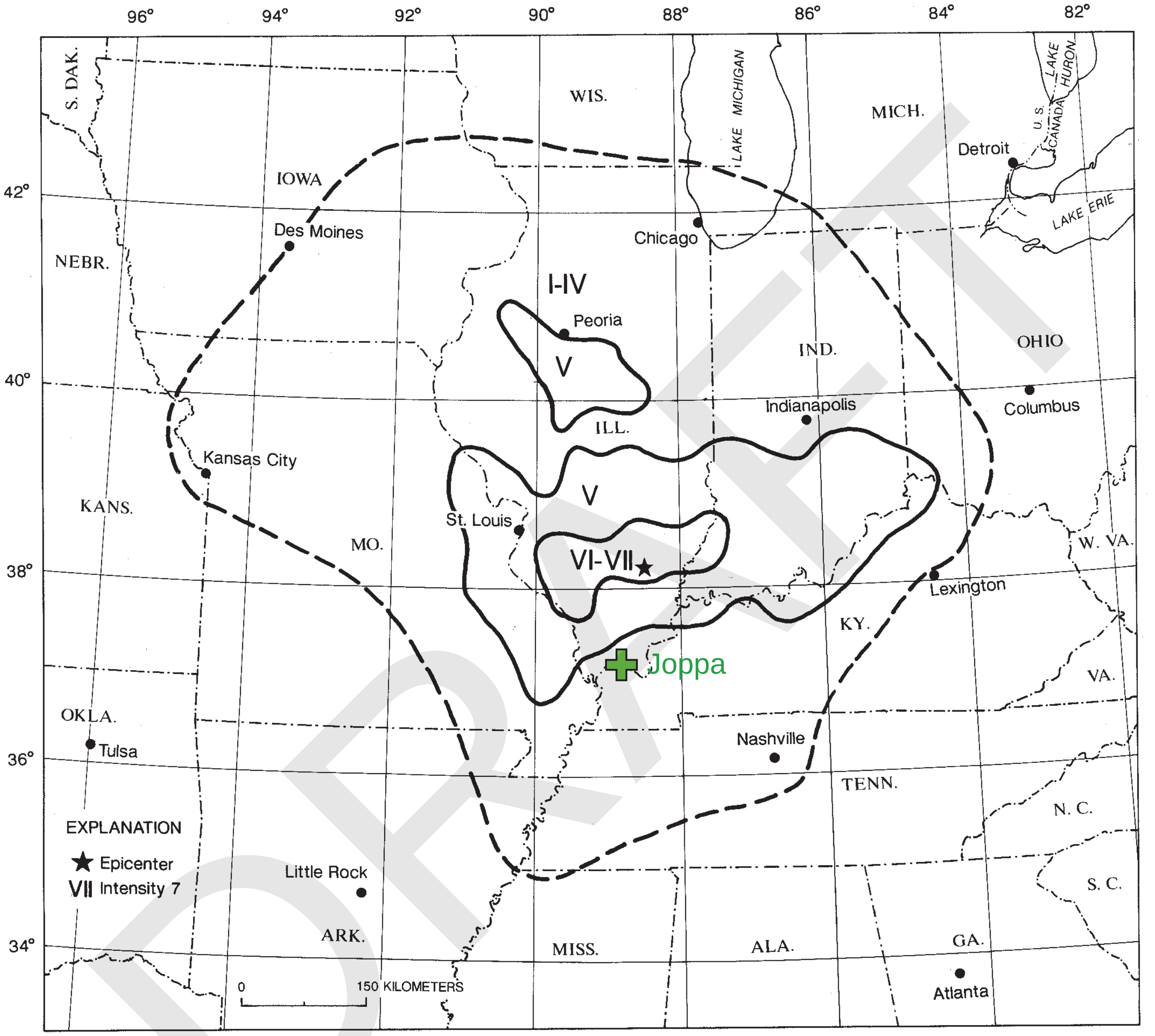
Dynegy

NEW MADRID FAULT SYSTEM, 1811-1812 NMFS EARTHQUAKES, AND NEIGHBORING RLMEs

Figure

6



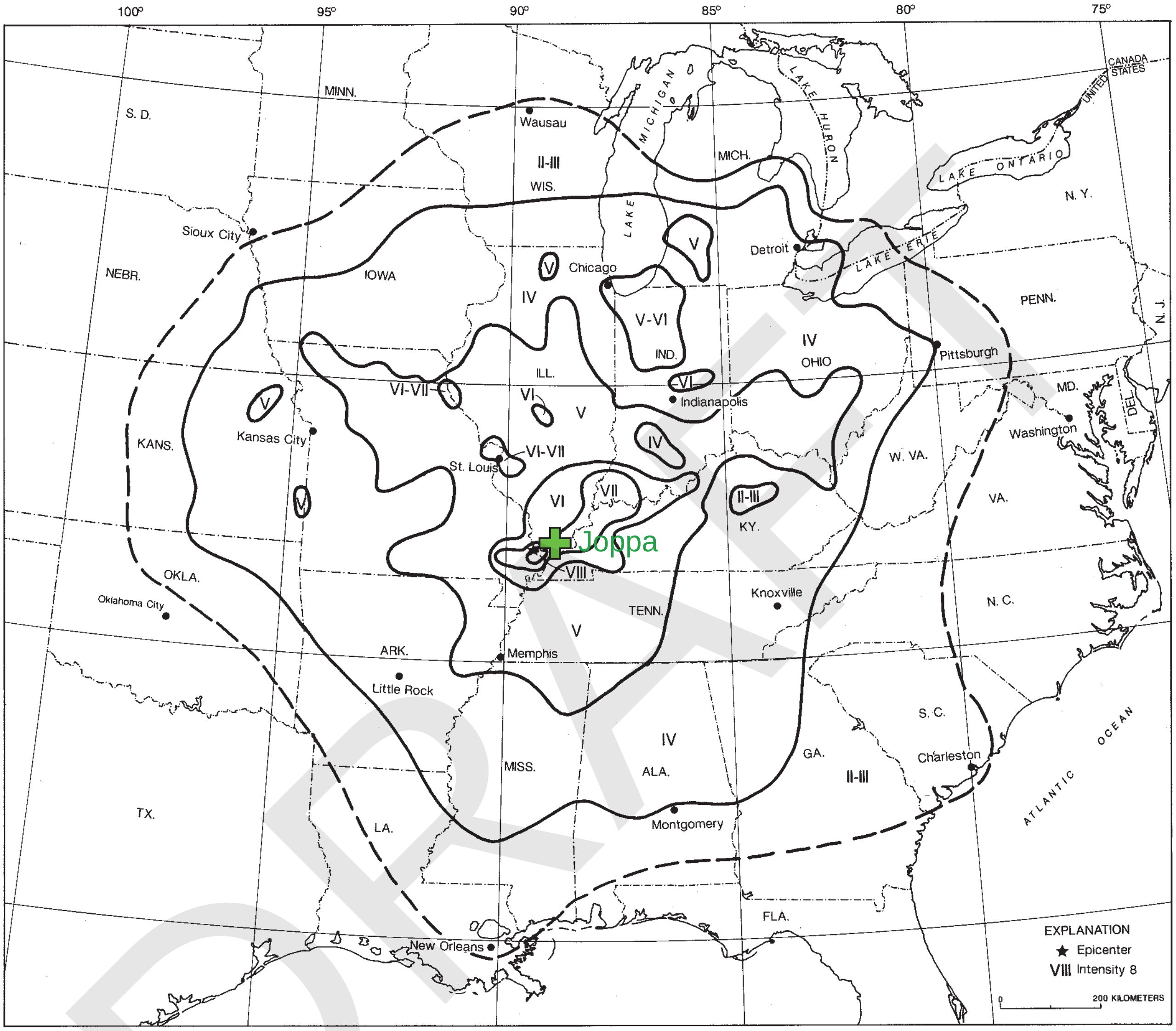
Source: Stover and Coffman (1993)

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)

Project No. 60440155

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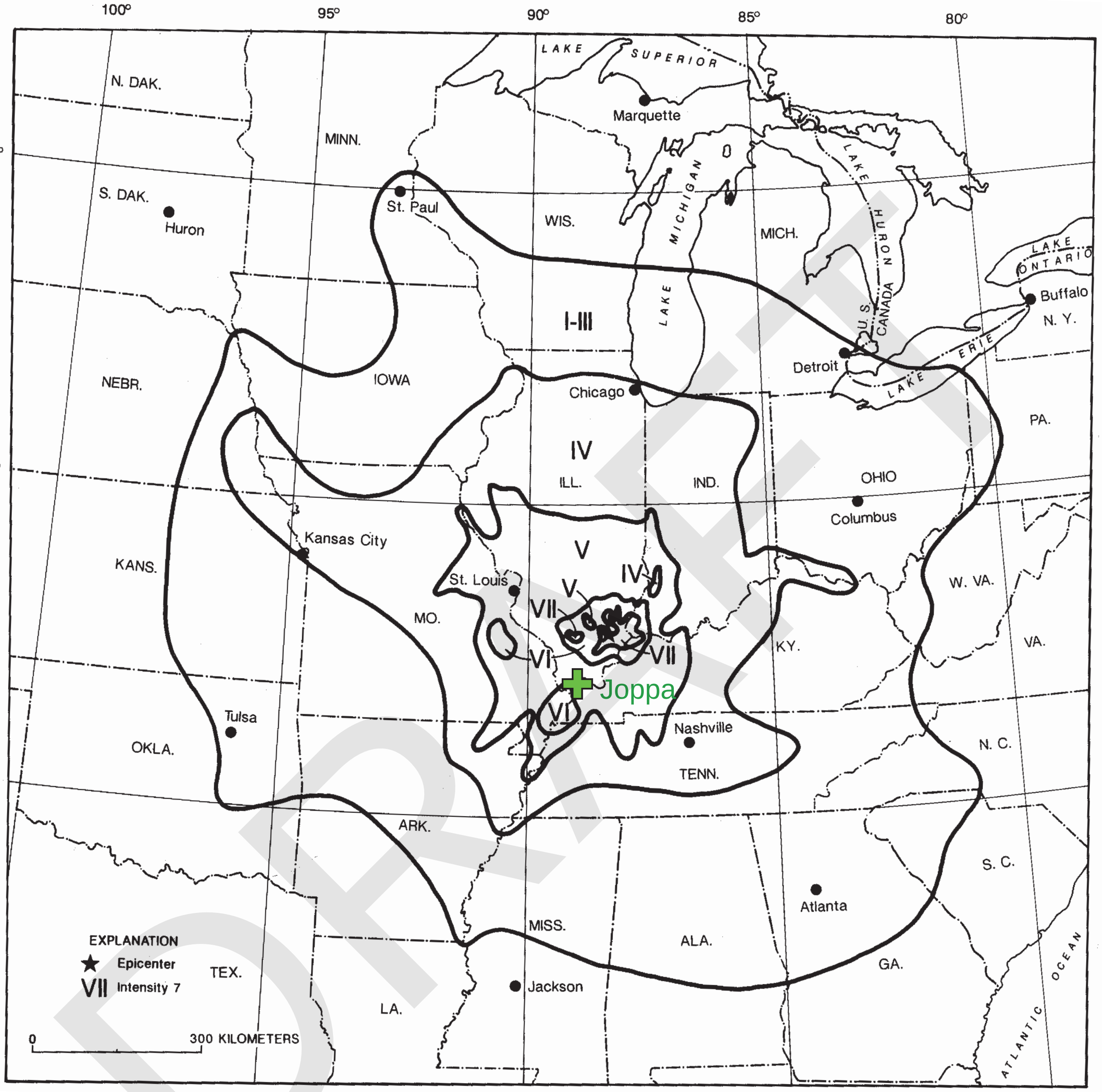
ISOSEISMAL MAP OF THE
31 OCTOBER 1895 M_S 6.7
CHARLESTON, MISSOURI EARTHQUAKE

Figure
8



Source: Stover and Coffman (1993)

Project No. 60440155

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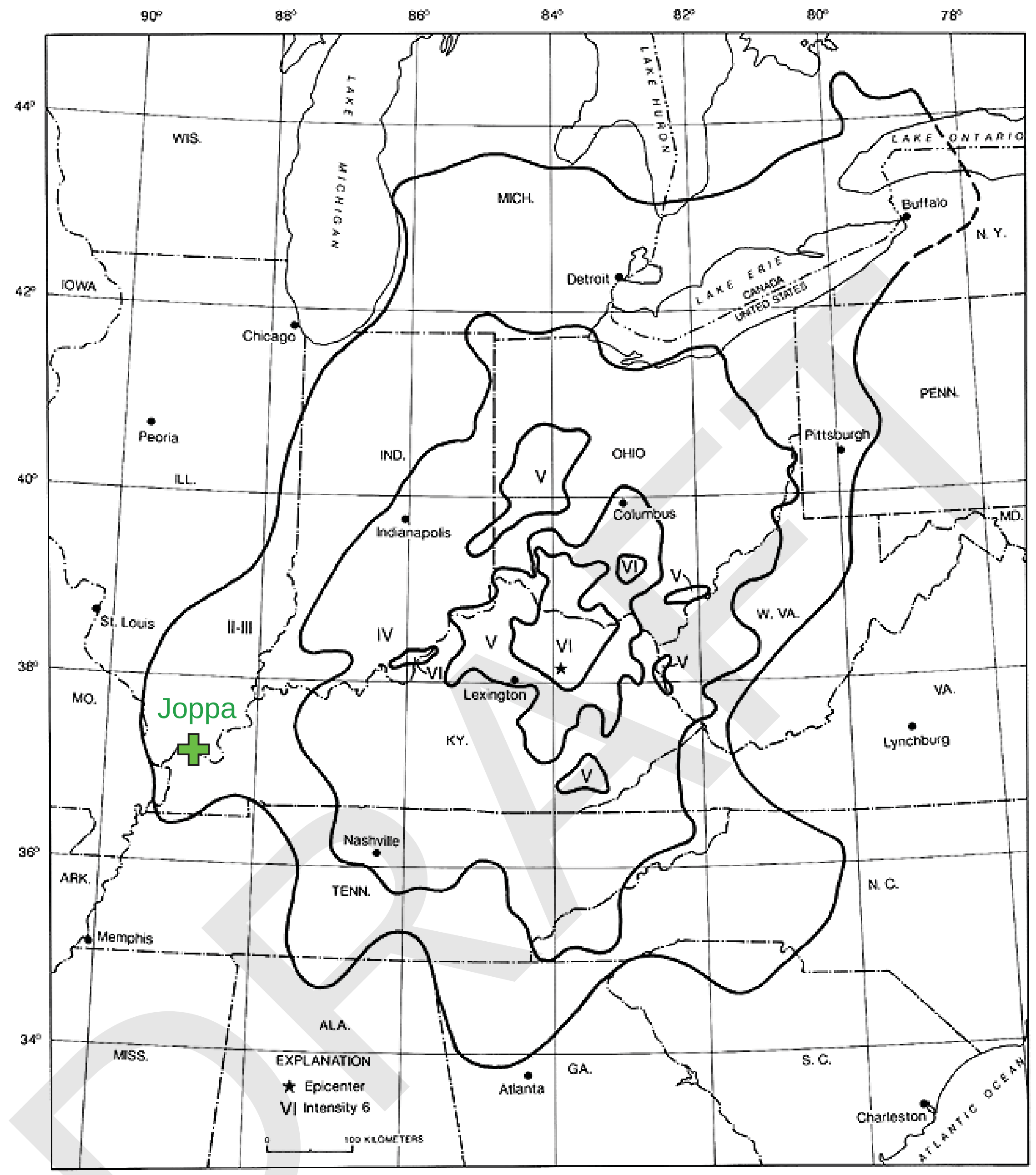
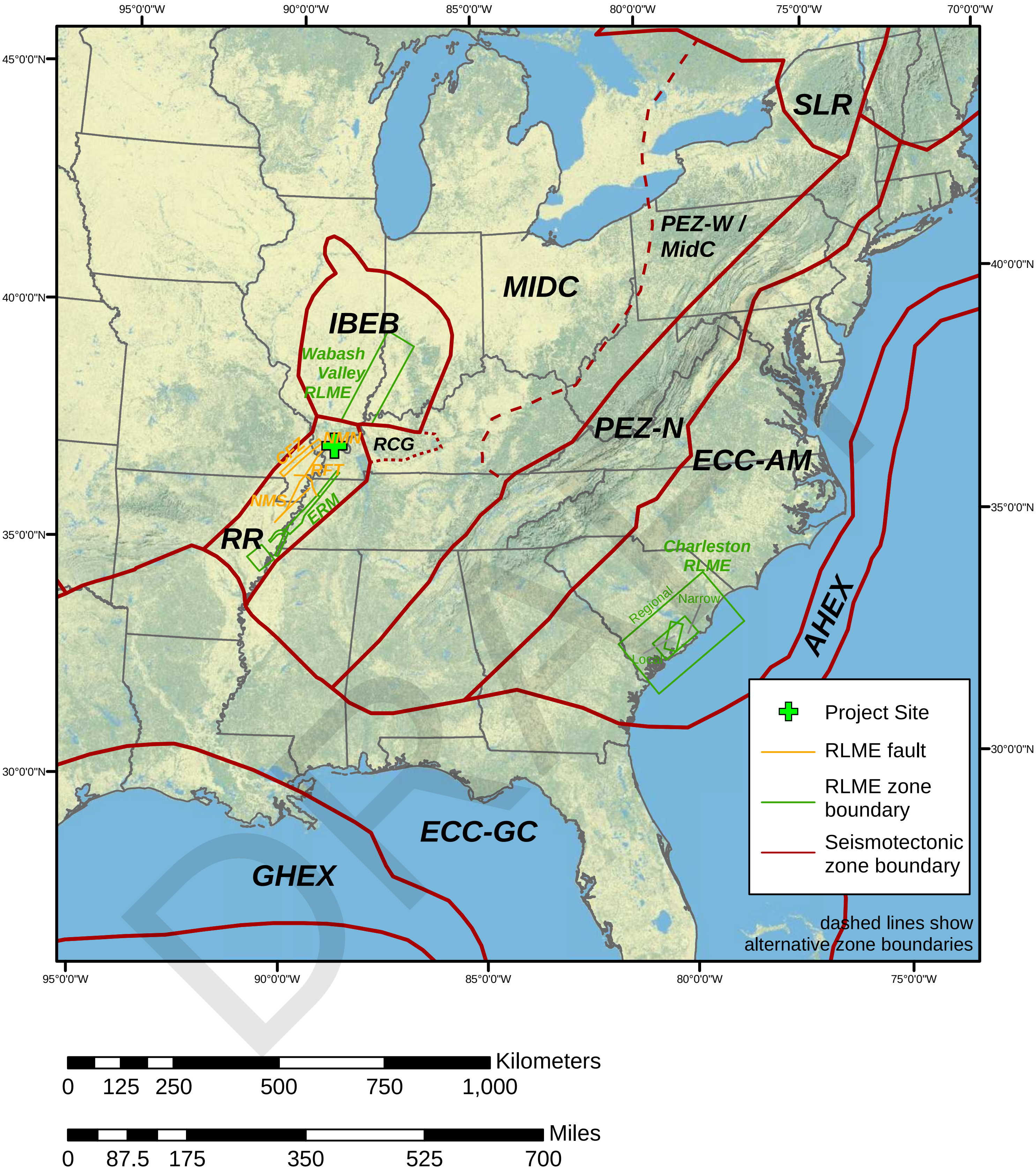
ISOSEISMAL MAP OF THE
9 NOVEMBER 1968 m_b 5.5
SOUTHERN ILLINOIS EARTHQUAKE

Figure
9



Source: Stover and Coffman (1993)

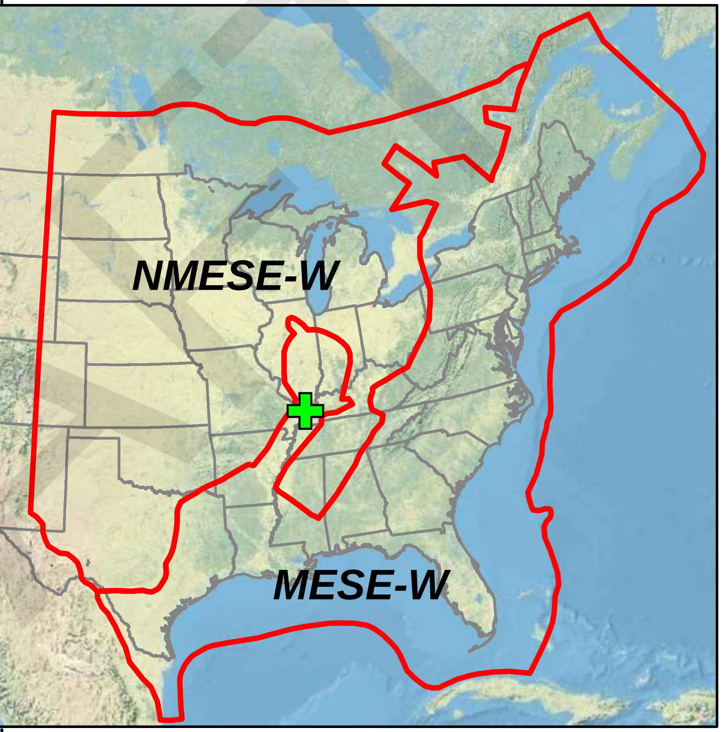
AECOM	Project No. 60440155	ISOSEISMAL MAP FOR THE 27 JULY 1980 M 5.1 SHARPSBURG, KENTUCKY EARTHQUAKE	Figure 10
	Joppa Power Station Dynegy		

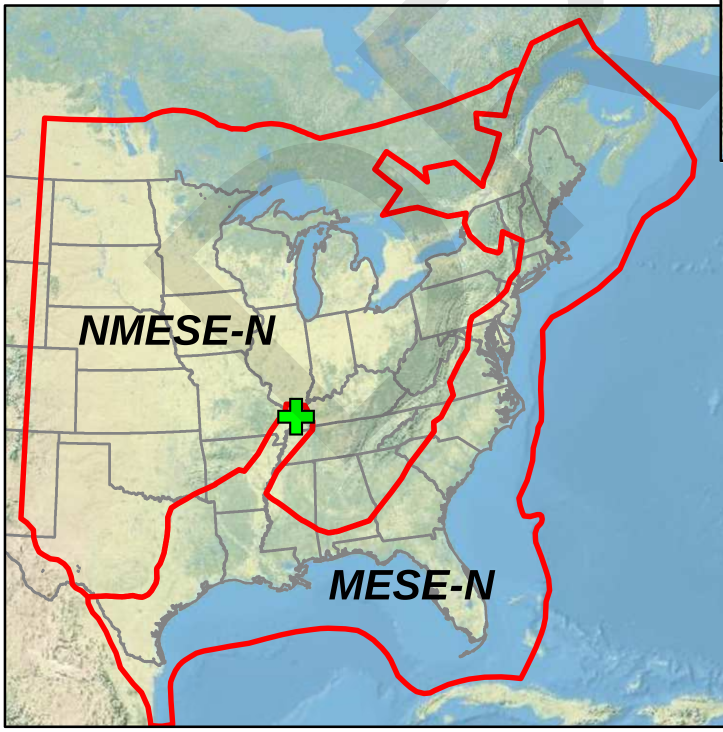


Project No. 60440155	SEISMOTECTONIC ZONES AND RLMES	Figure
Joppa Power Station Dynegy		11

1-Zone Mode

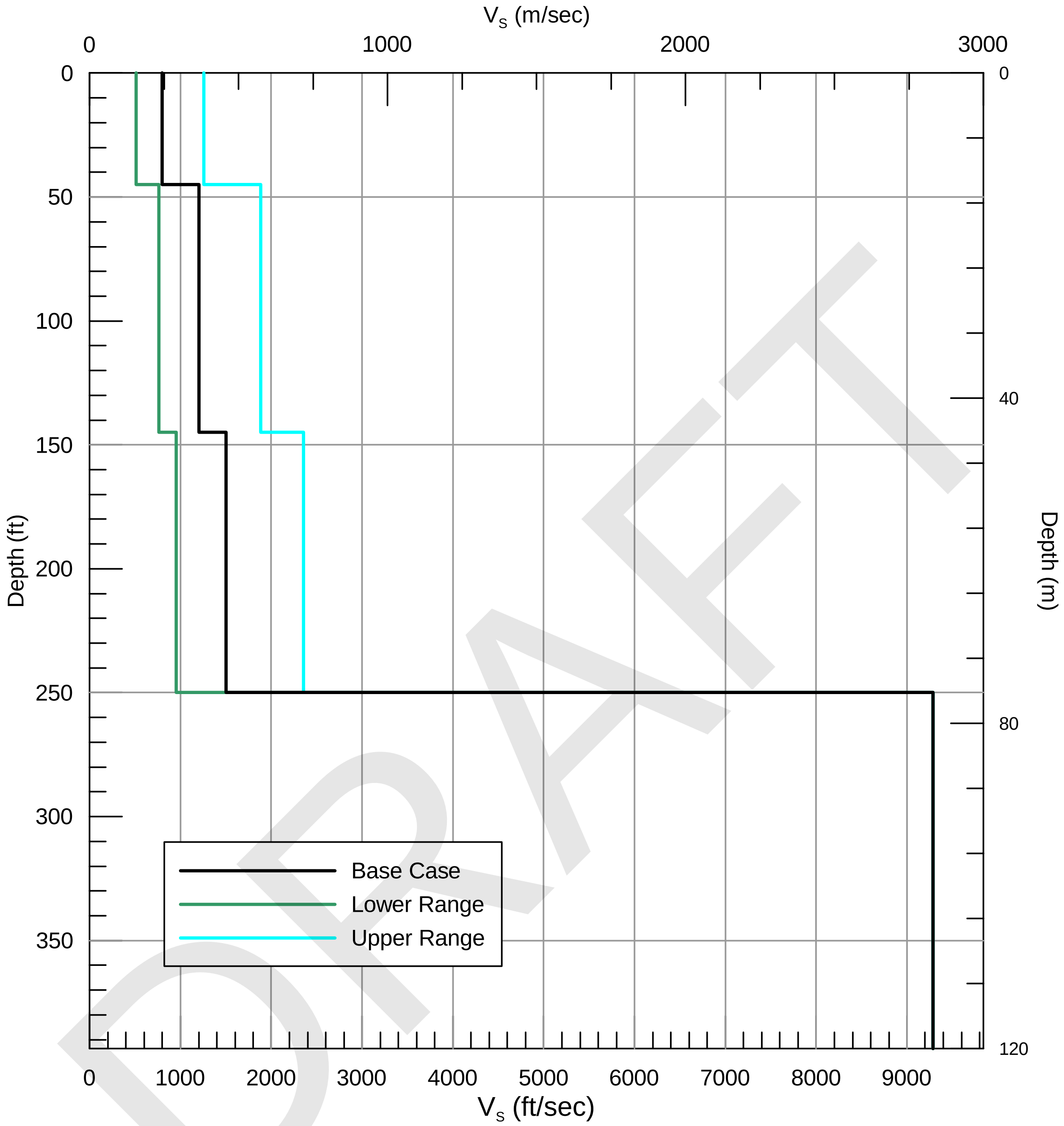
**2-Zone Model
MESE-Wide**



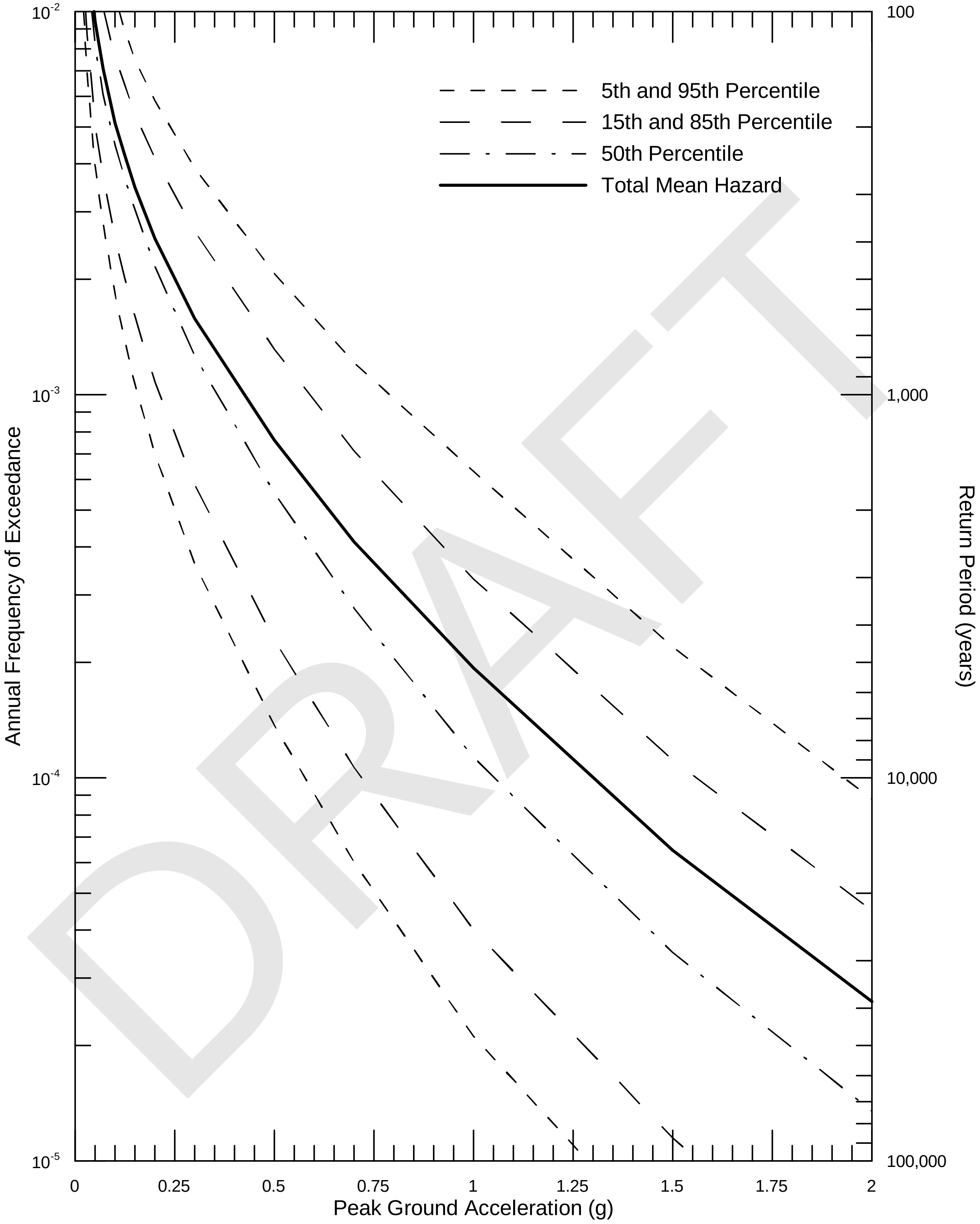


**2-Zone Model
MESE-Narrow**

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



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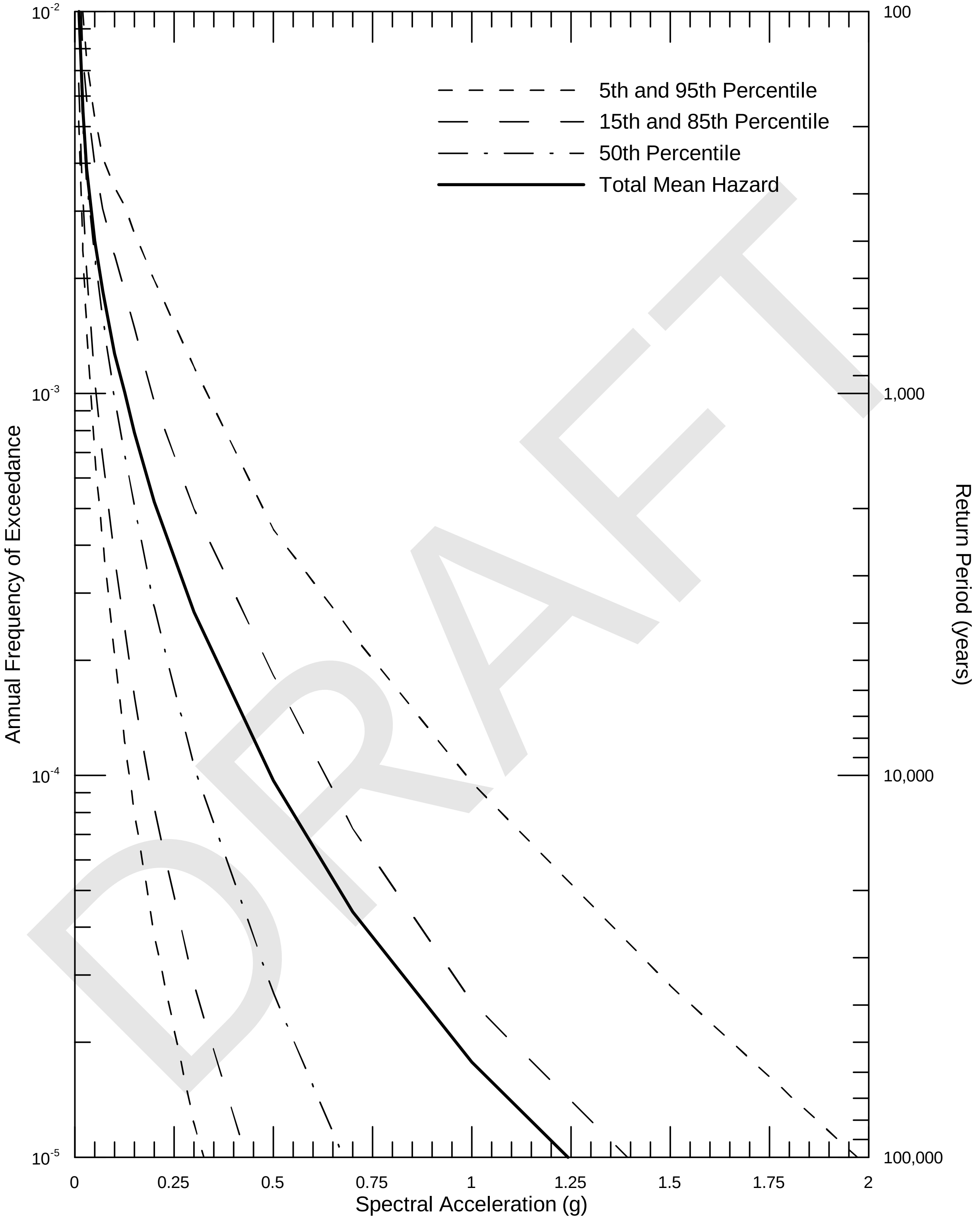
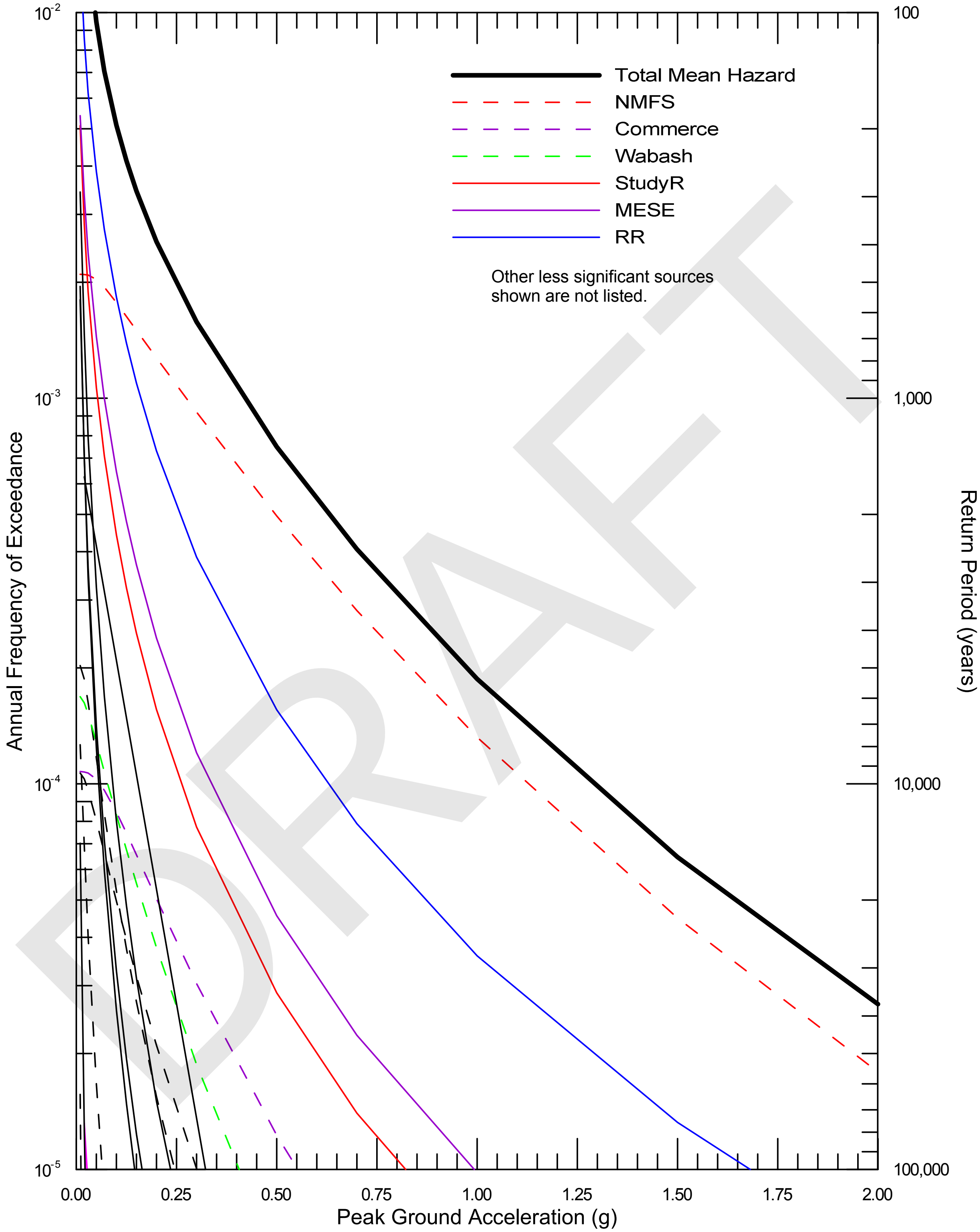
Dynegy

SEISMIC HAZARD CURVES FOR
PEAK HORIZONTAL ACCELERATION
ON HARD ROCK

Figure
14



AECOM	Project No. 60440155	SEISMIC HAZARD CURVES FOR 1.0 SEC HORIZONTAL SPECTRAL ACCELERATION ON HARD ROCK	Figure 15
	Joppa Power Station Dynegy		



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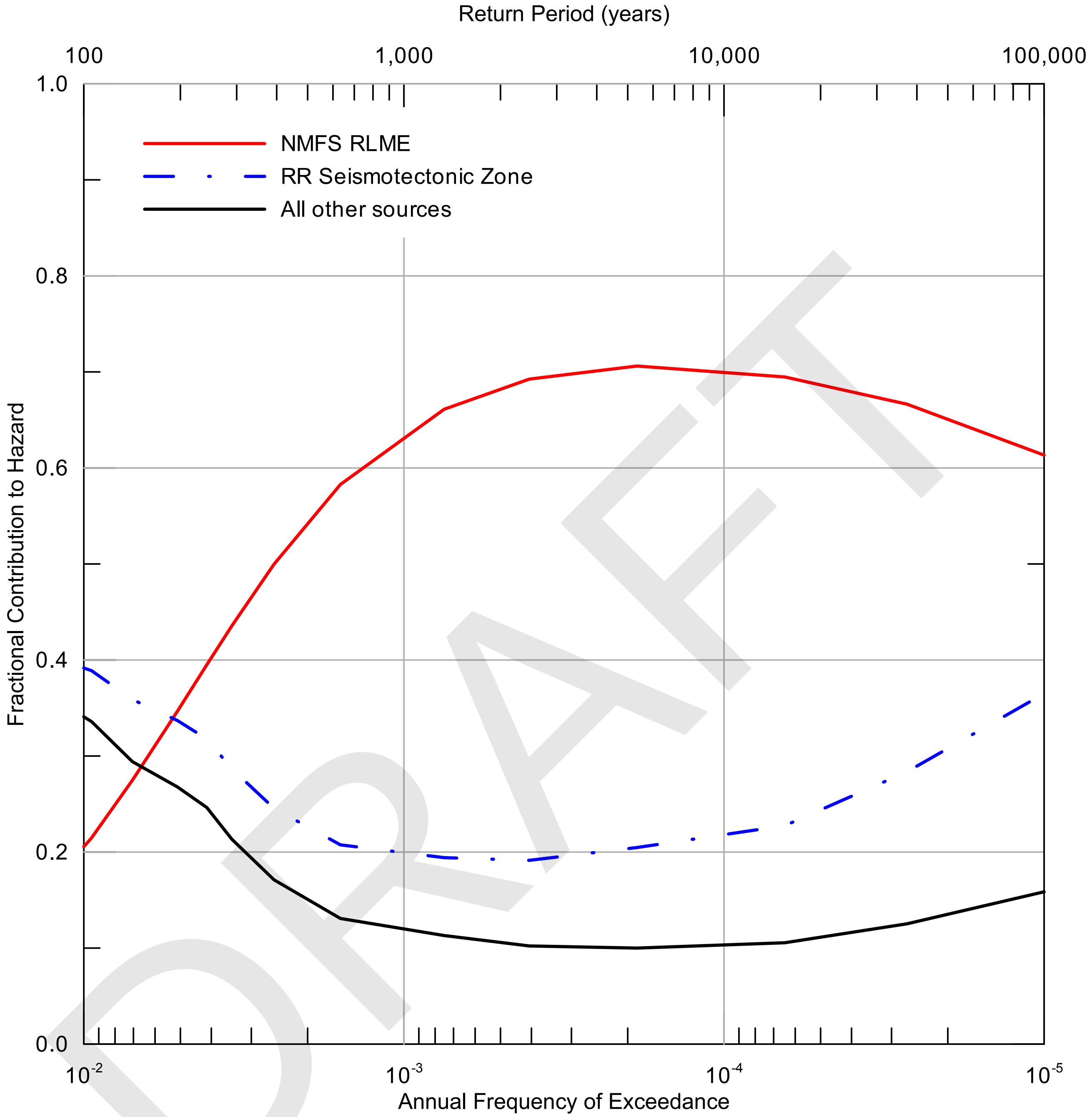
Project No. 60440155

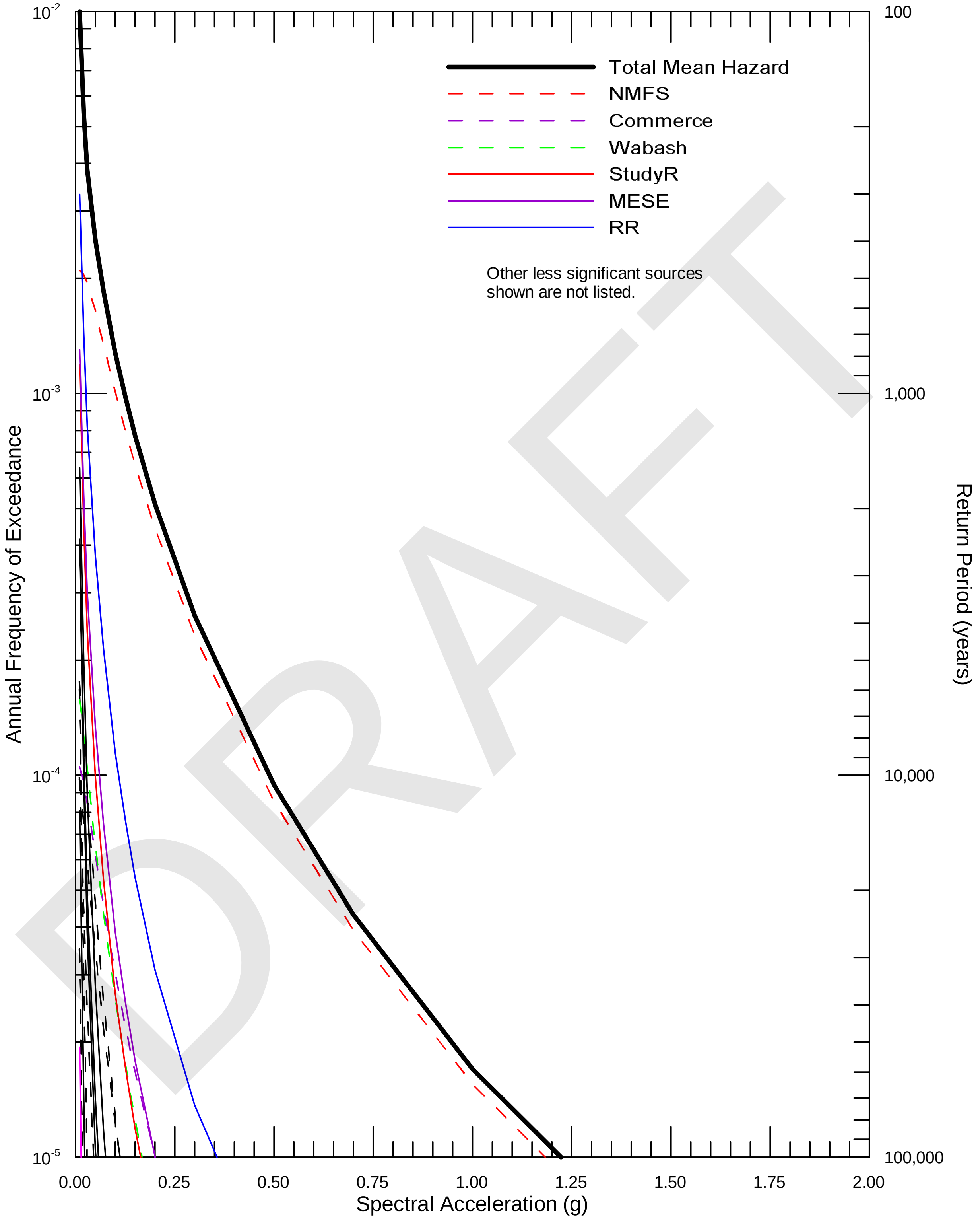
Joppa Power Station
Dynegy

SEISMIC SOURCE CONTRIBUTIONS TO MEAN PEAK HORIZONTAL ACCELERATION HAZARD ON HARD ROCK

Figure 16



AECOM	Project No. 60440155	SEISMIC SOURCE FRACTIONAL CONTRIBUTION TO MEAN PEAK HORIZONTAL ACCELERATION HAZARD ON HARD ROCK	Figure 17
	Joppa Power Station Dynegy		



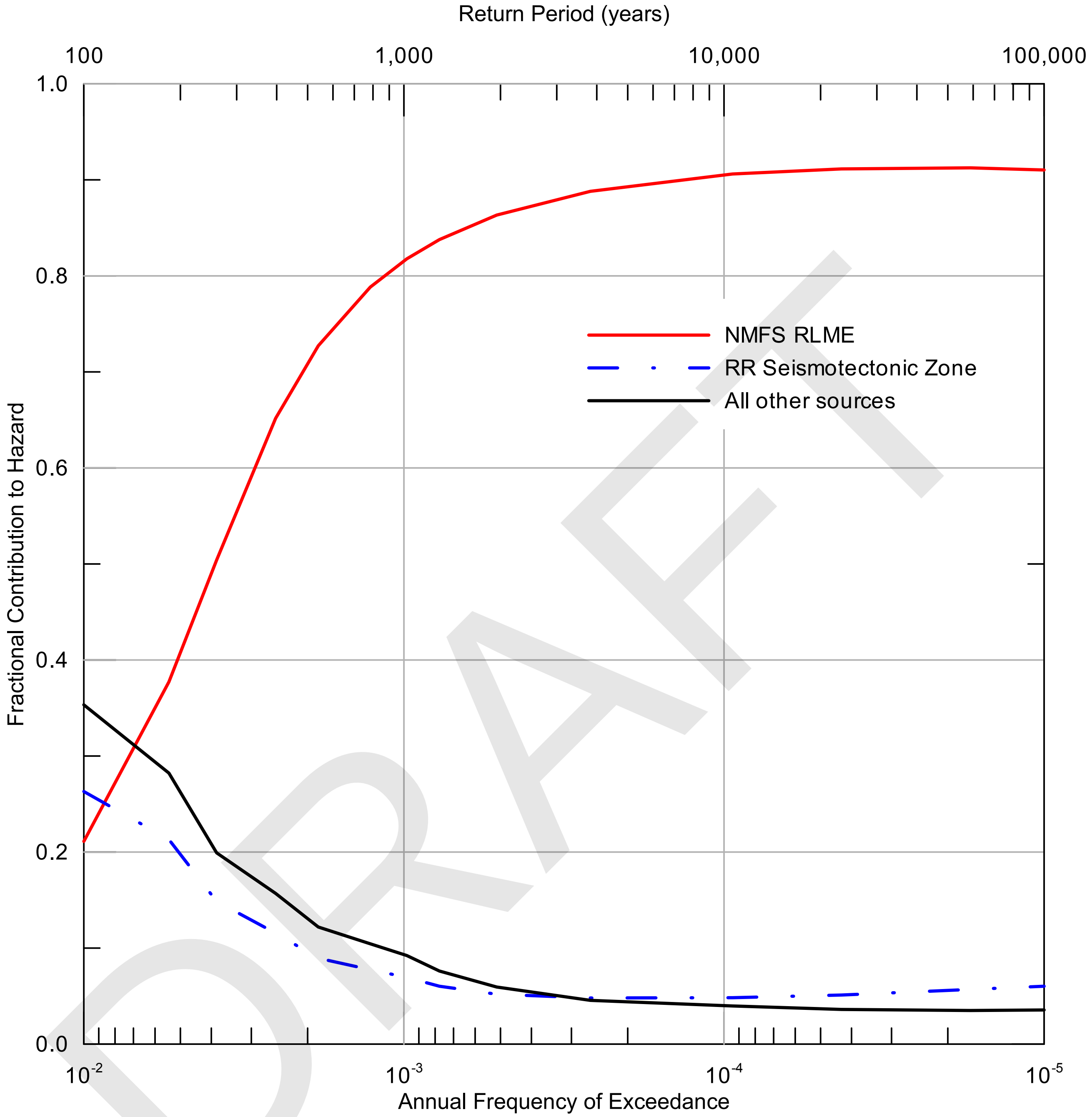
AECOM

Project No. 60440155

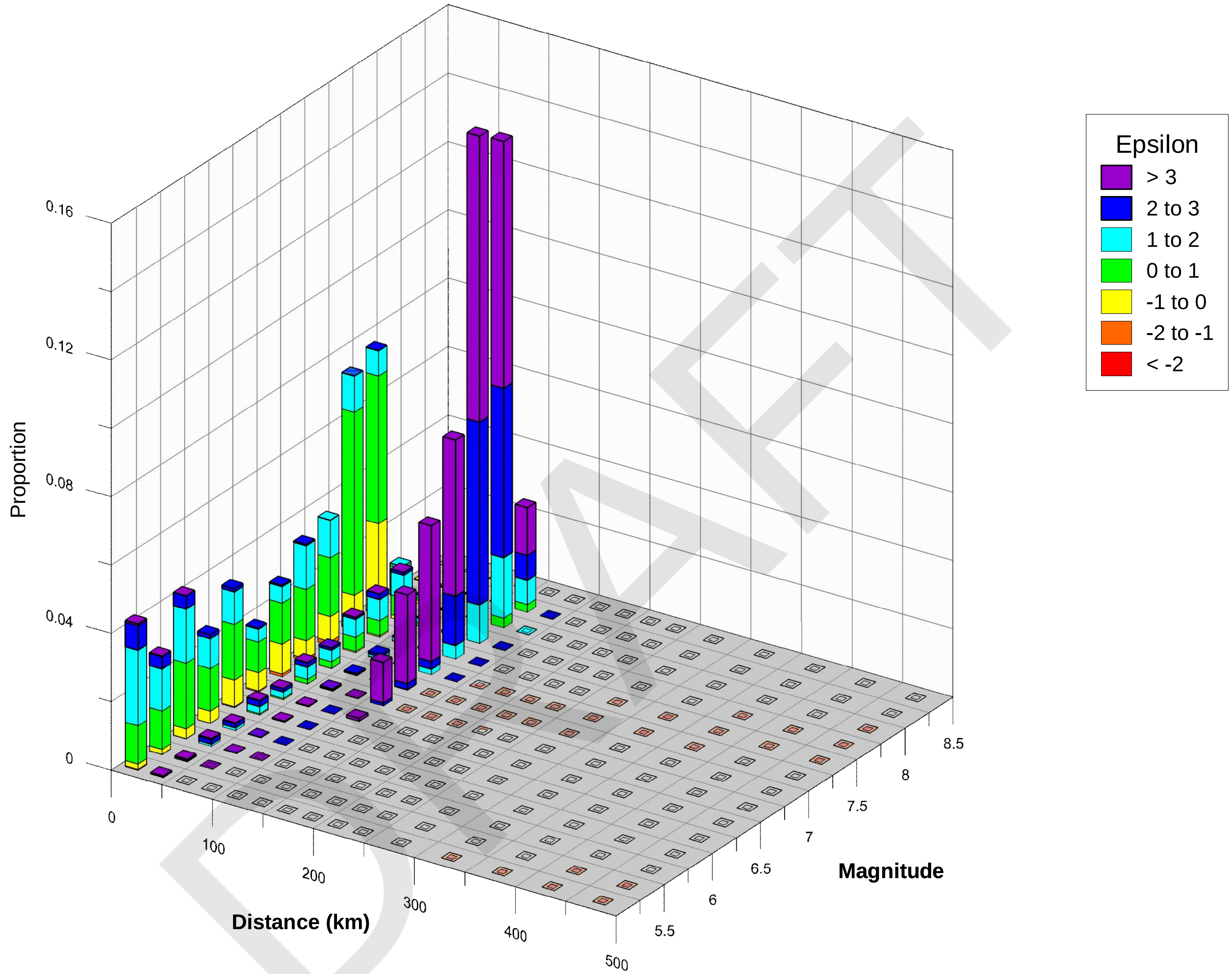
Joppa Power Station
Dynegy

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



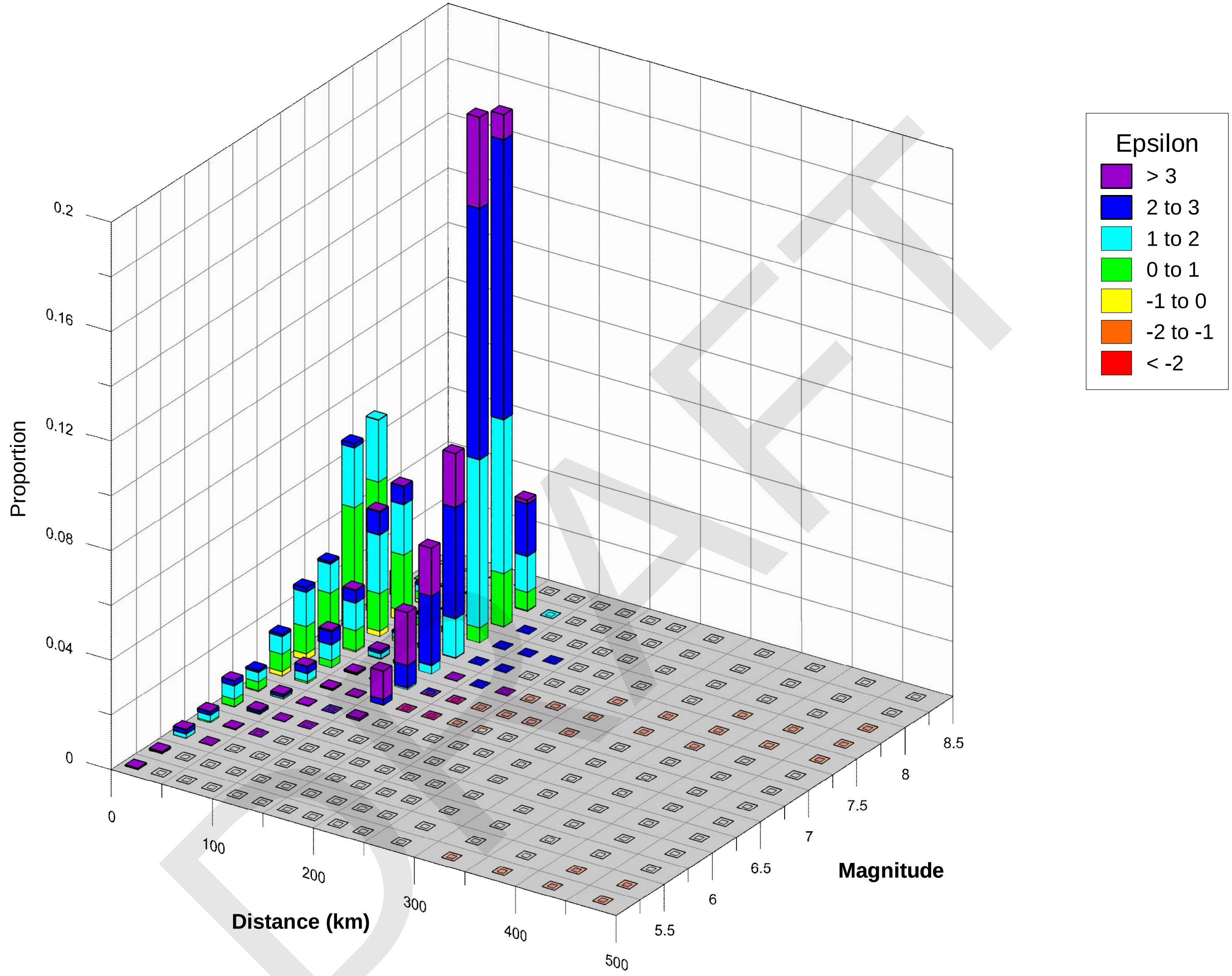
AECOM

Project No. 60440155

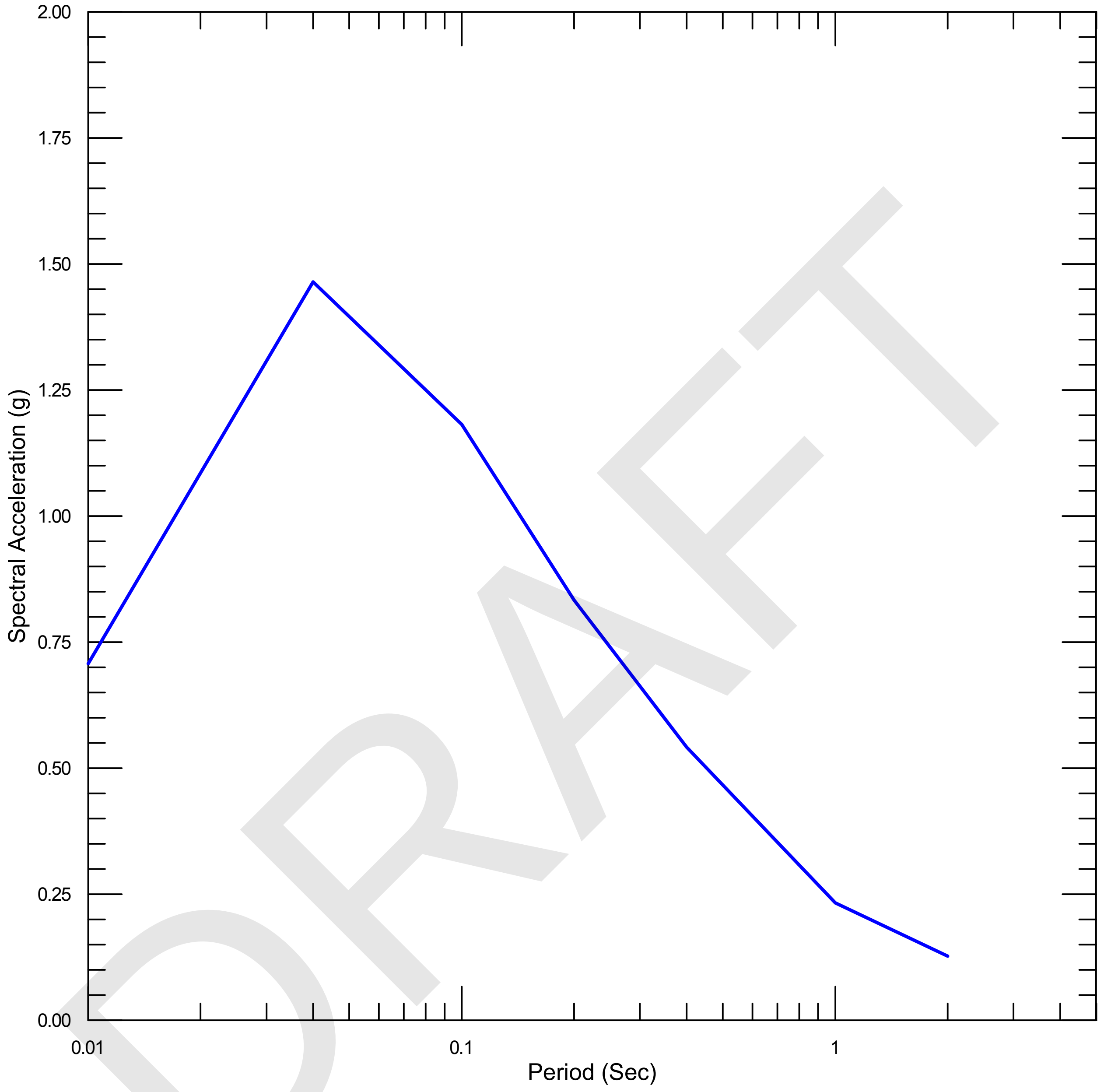
Joppa Power Station
Dynegy

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



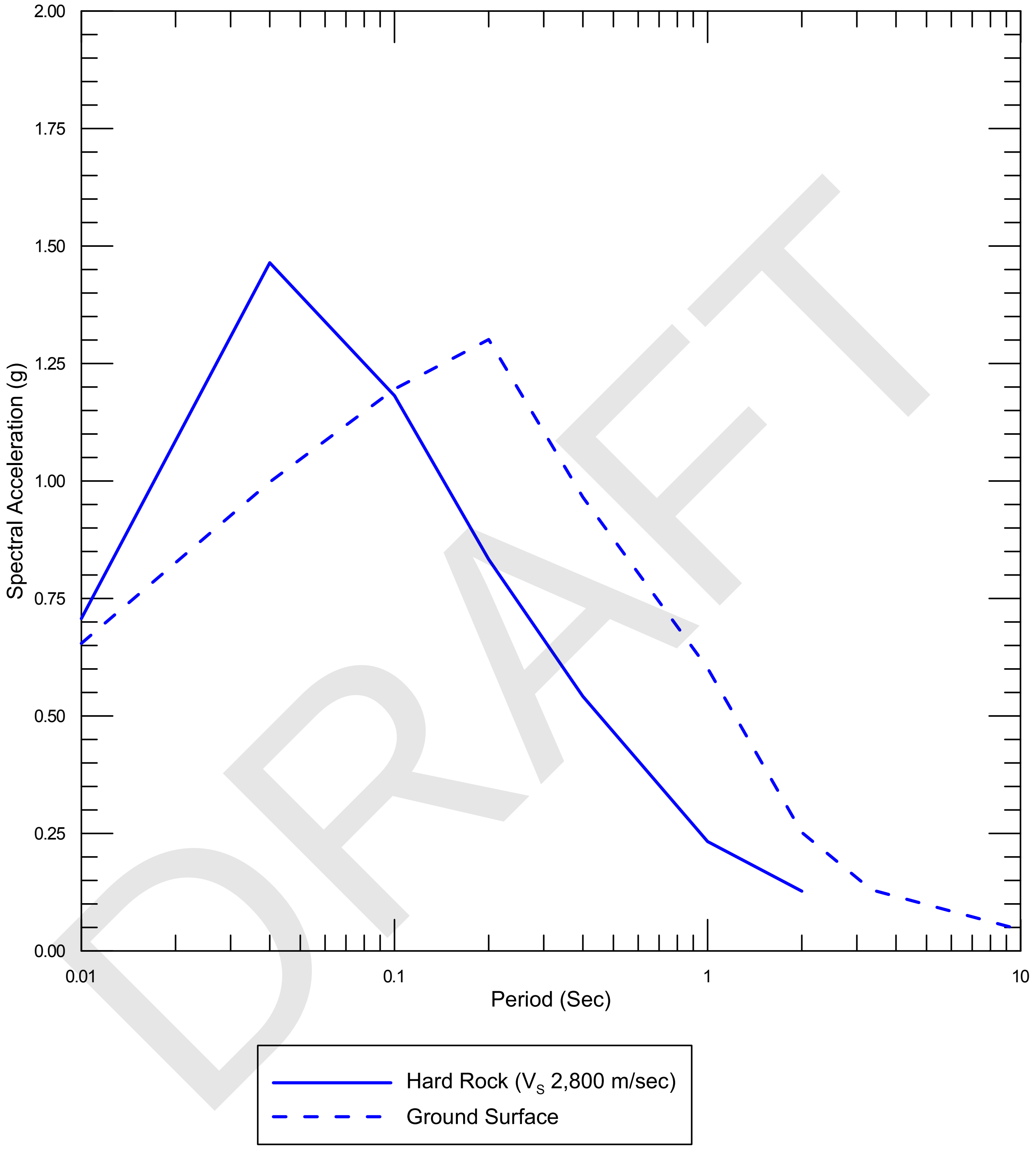
AECOM

Project No. 60440155

Joppa Power Station
Dynegy

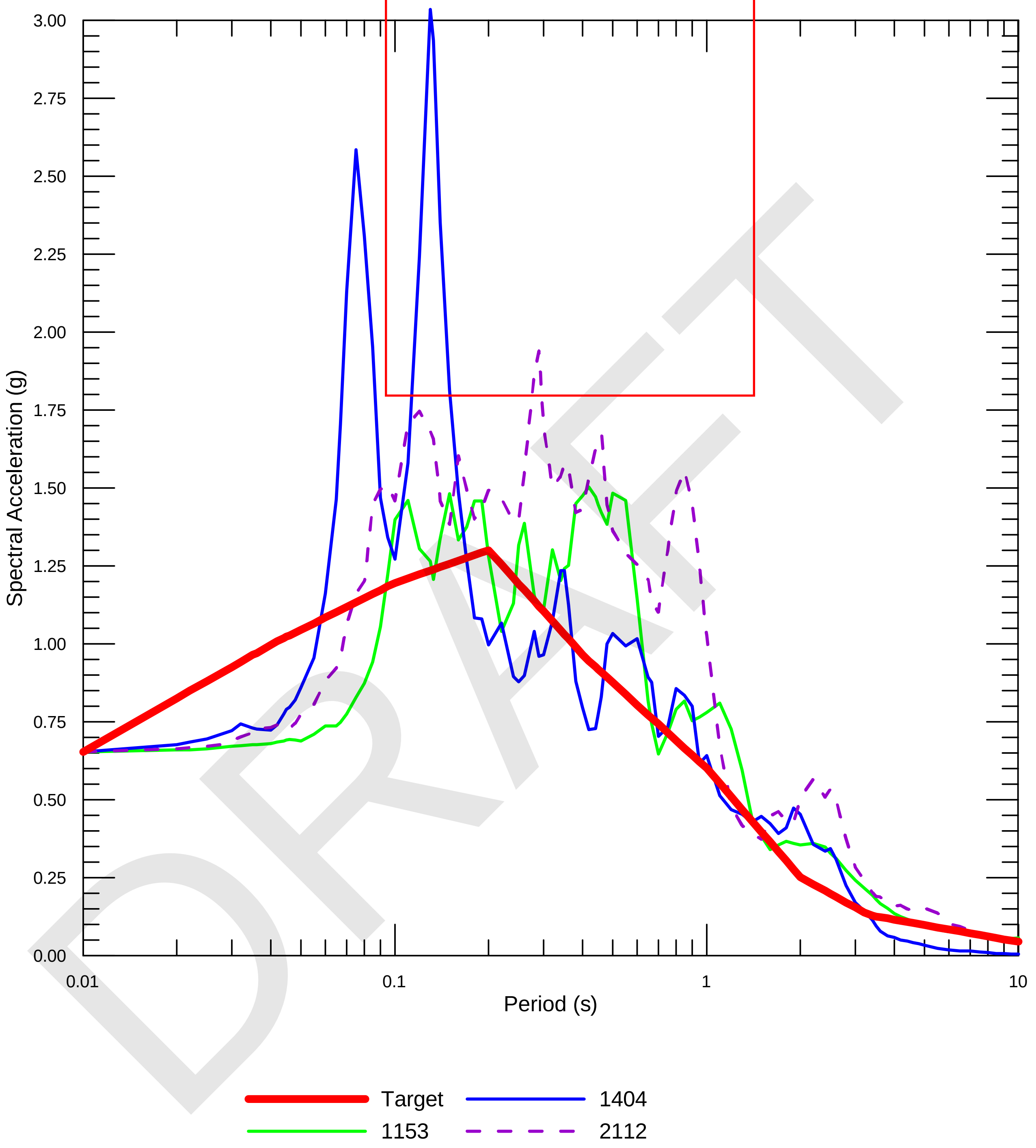
5%-DAMPED MEAN HORIZONTAL UHS
ON HARD ROCK
AT 2,500-YEAR RETURN PERIOD

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

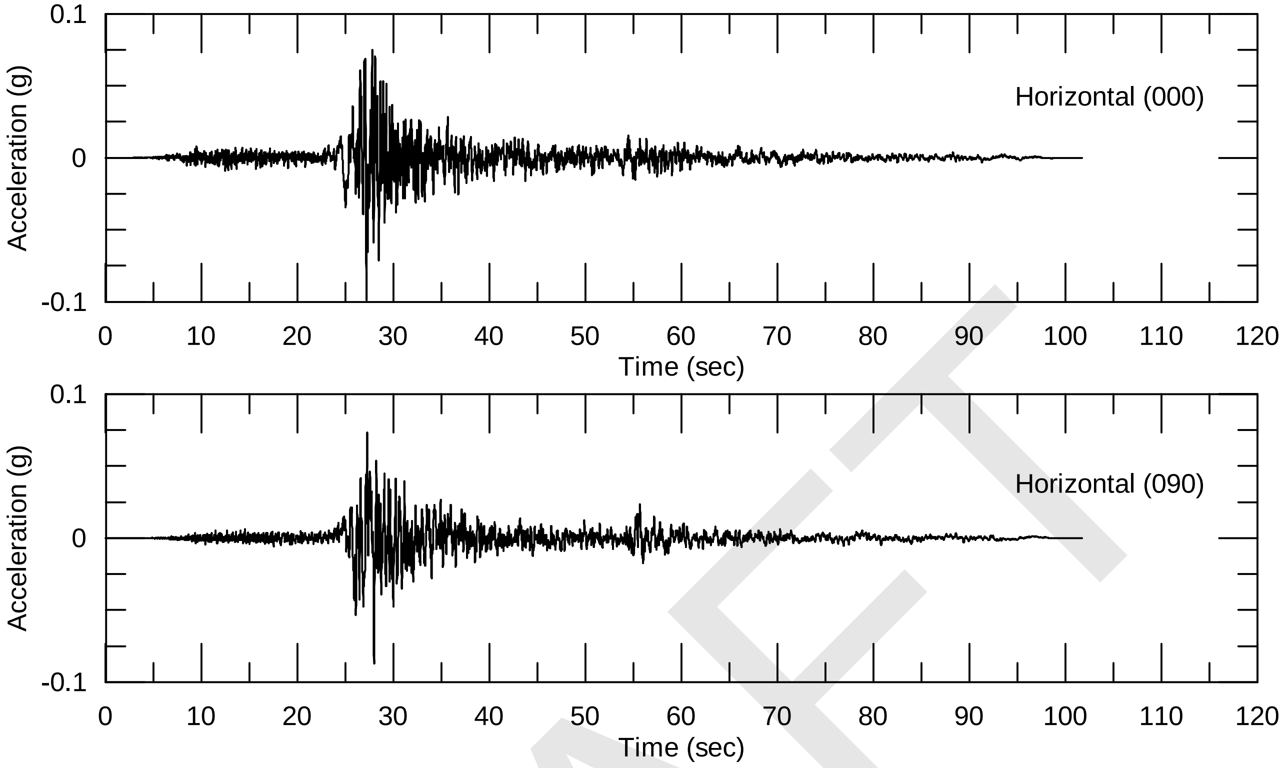


Project No. 60440155

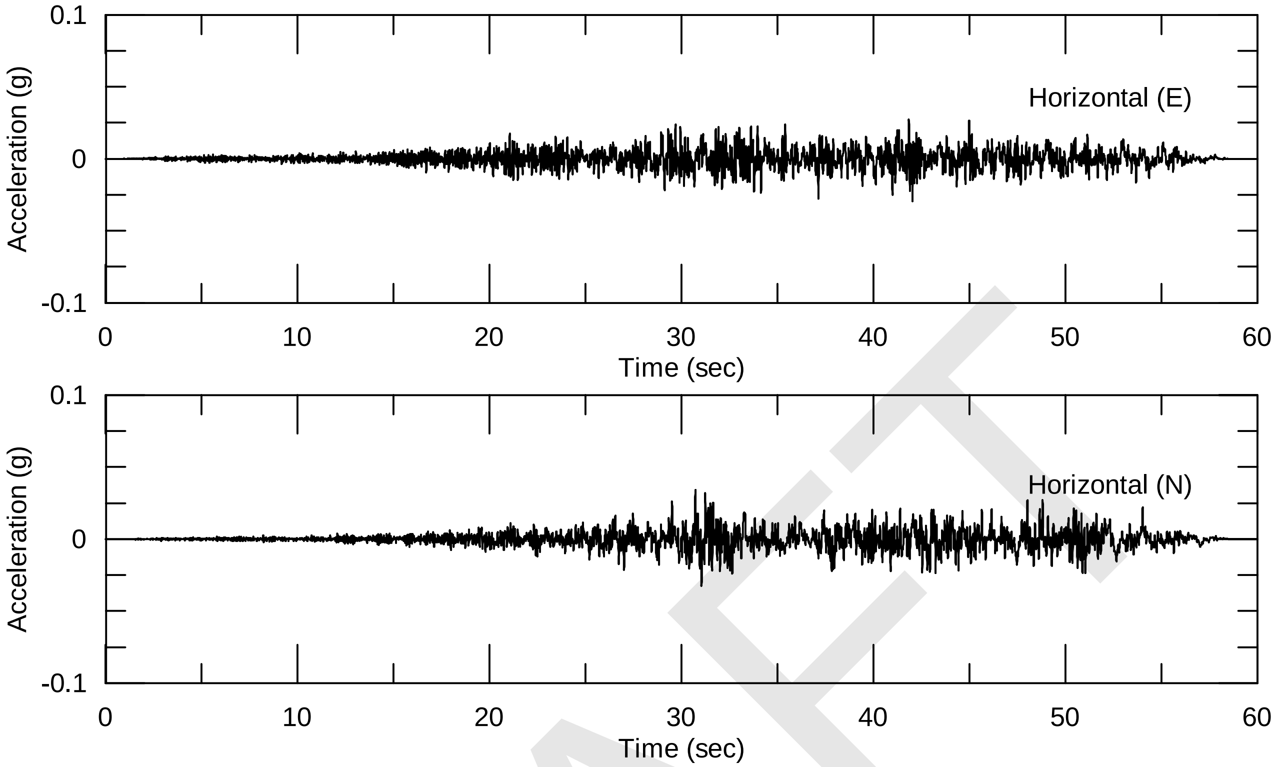
Joppa Power Station
Dynegy

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

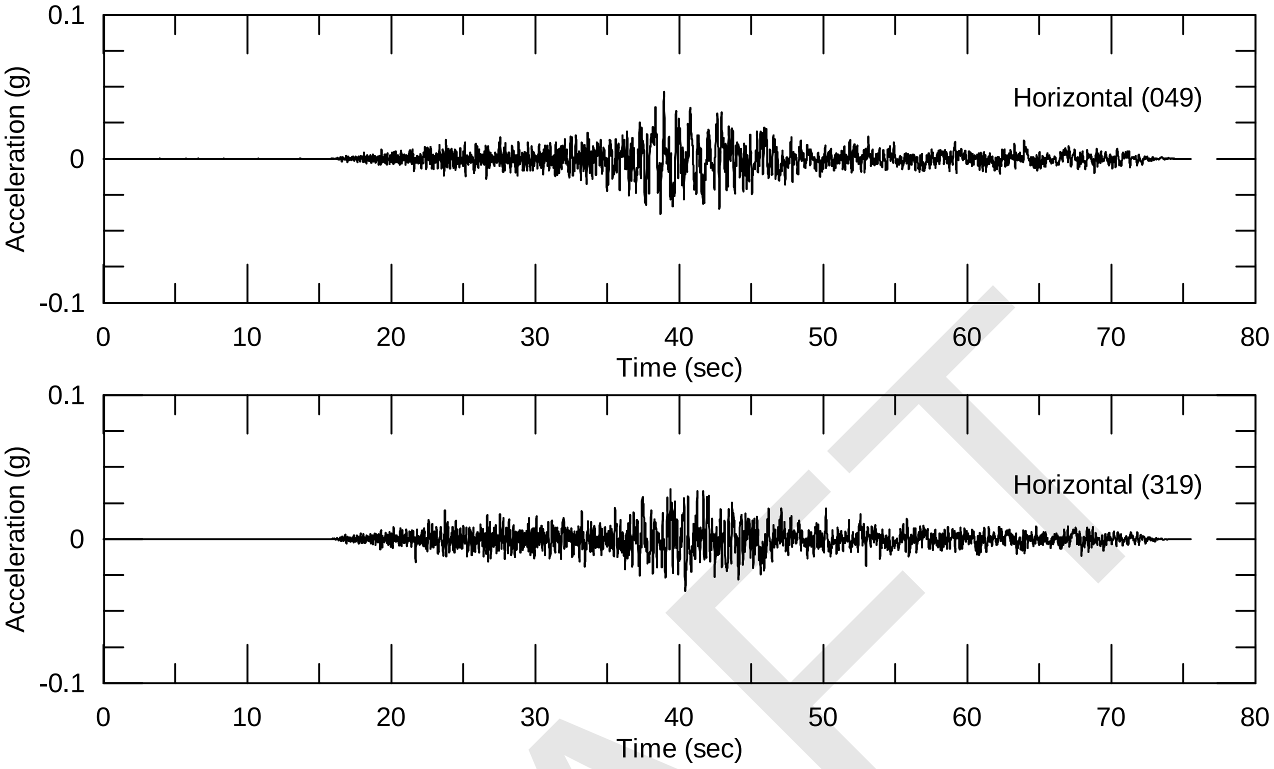


Project No. 60440155

Joppa Power Station
Dynegy

SEED TIME HISTORIES
RSN1404 - 1999 CHI CHI
PNG

Figure
26



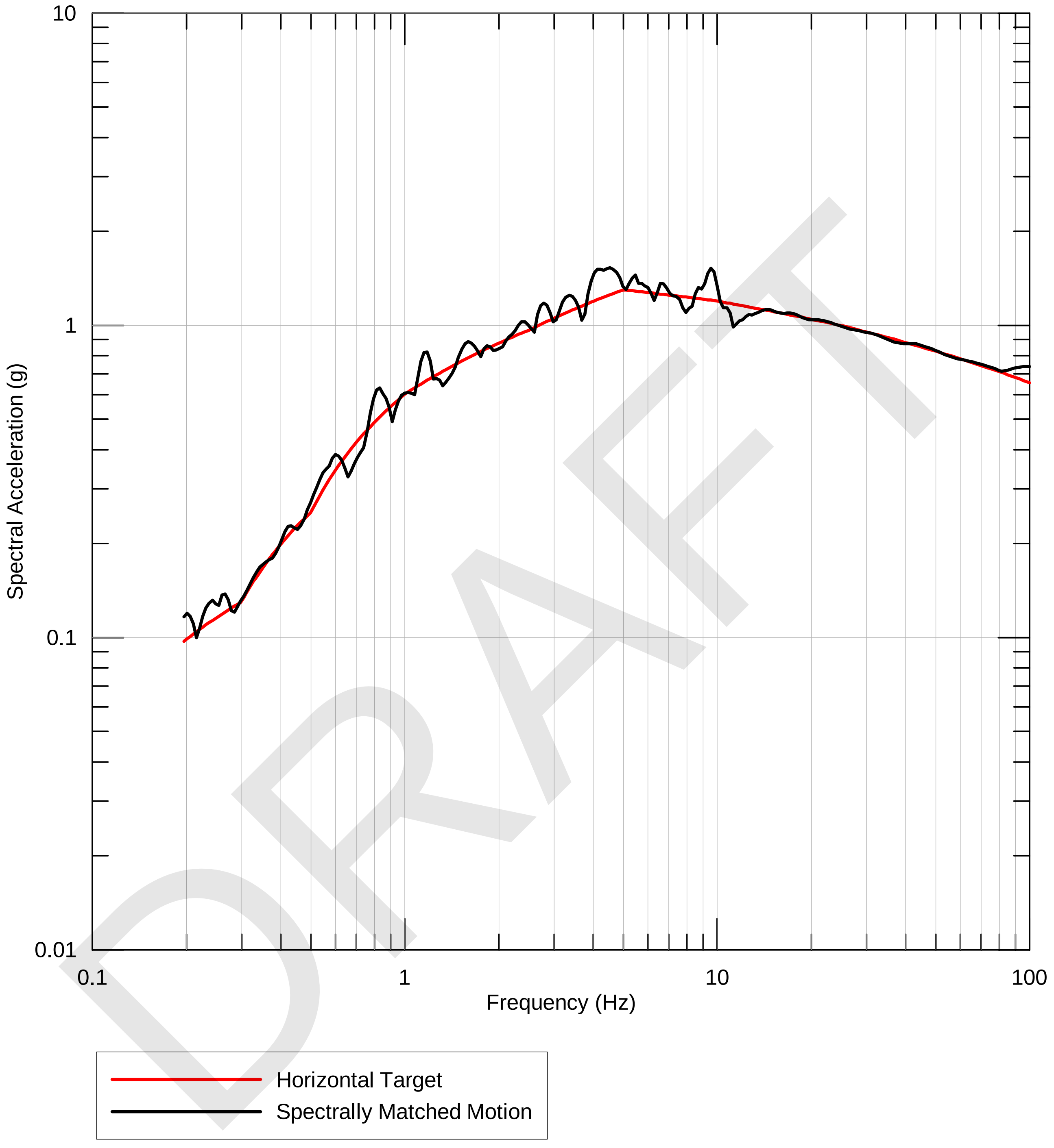
AECOM

Project No. 60440155

Joppa Power Station
Dynegy

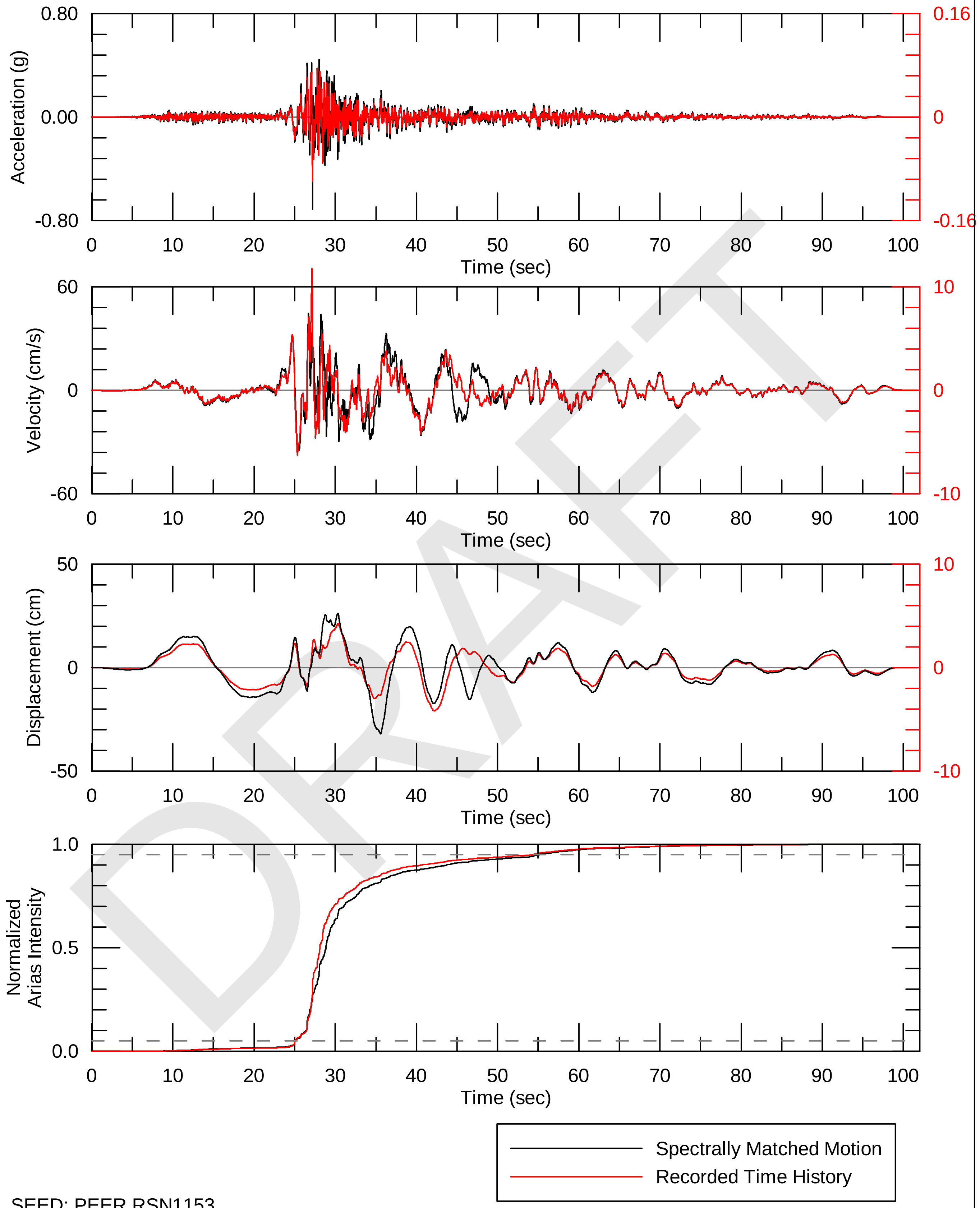
SEED TIME HISTORIES
RSN2112 - 2002 DENALI
TAPS PUMP STATION #08

Figure
27



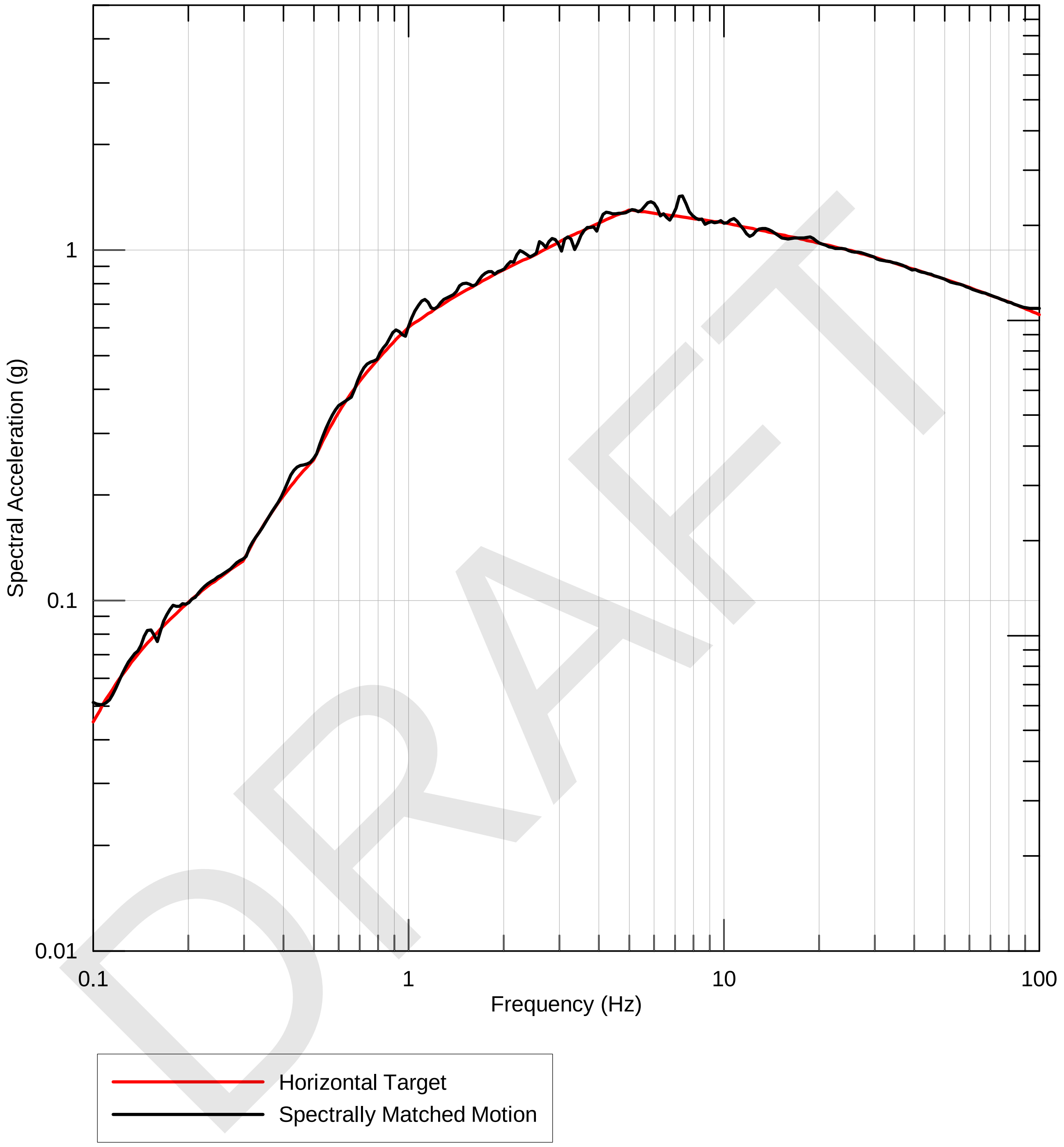
SEED: PEER RSN1153

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



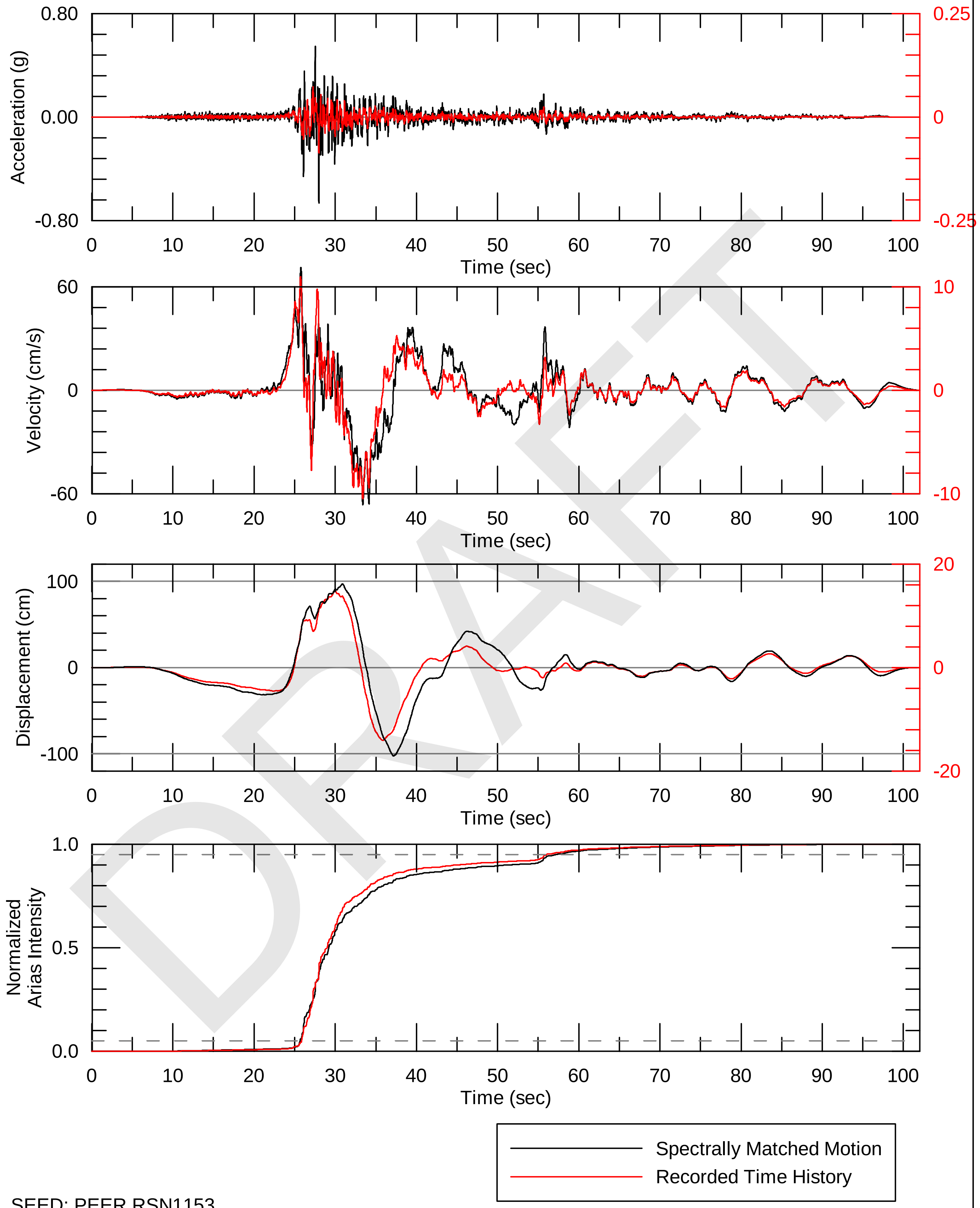
SEED: PEER RSN1153

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



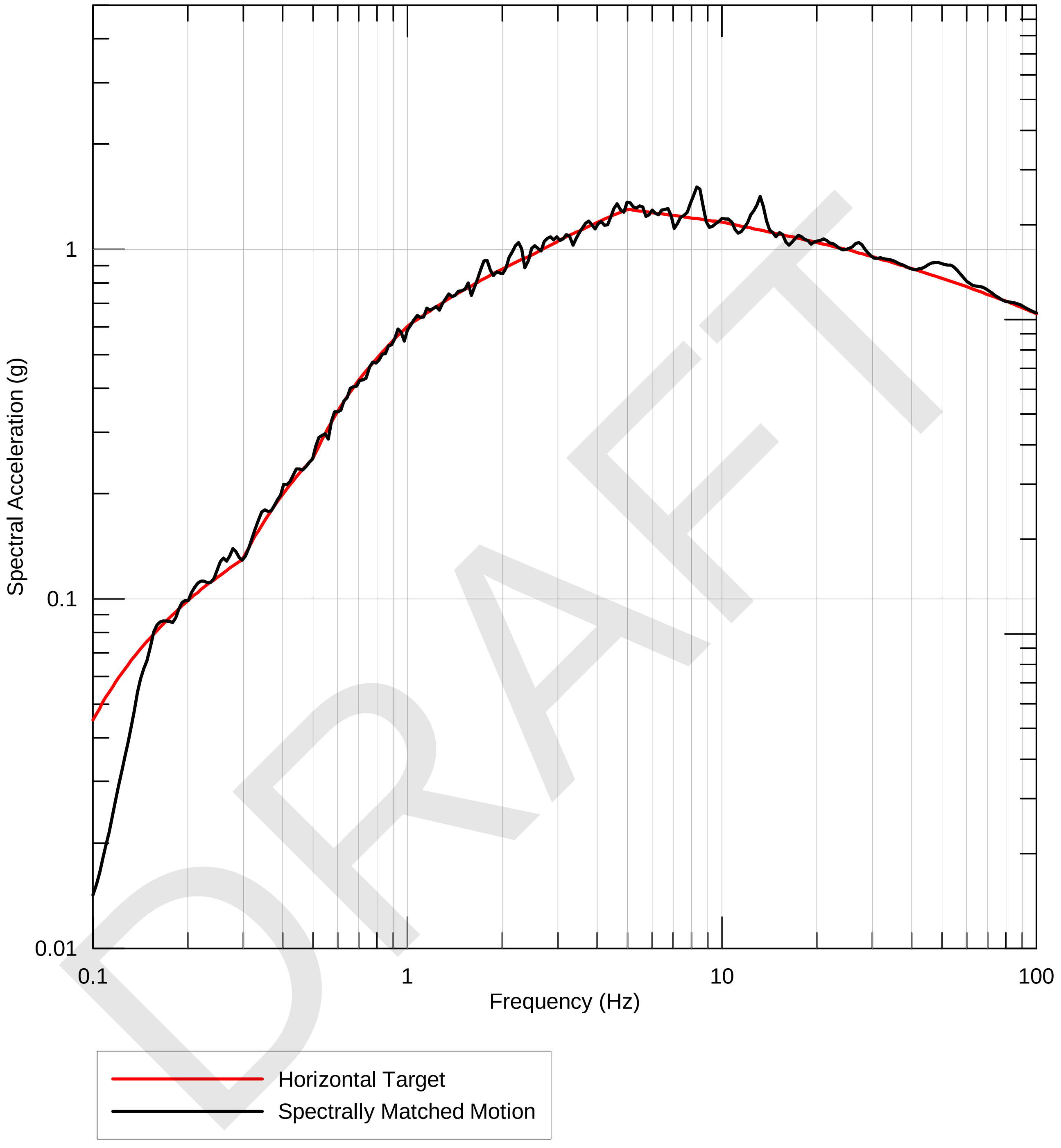
SEED: PEER RSN1153

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



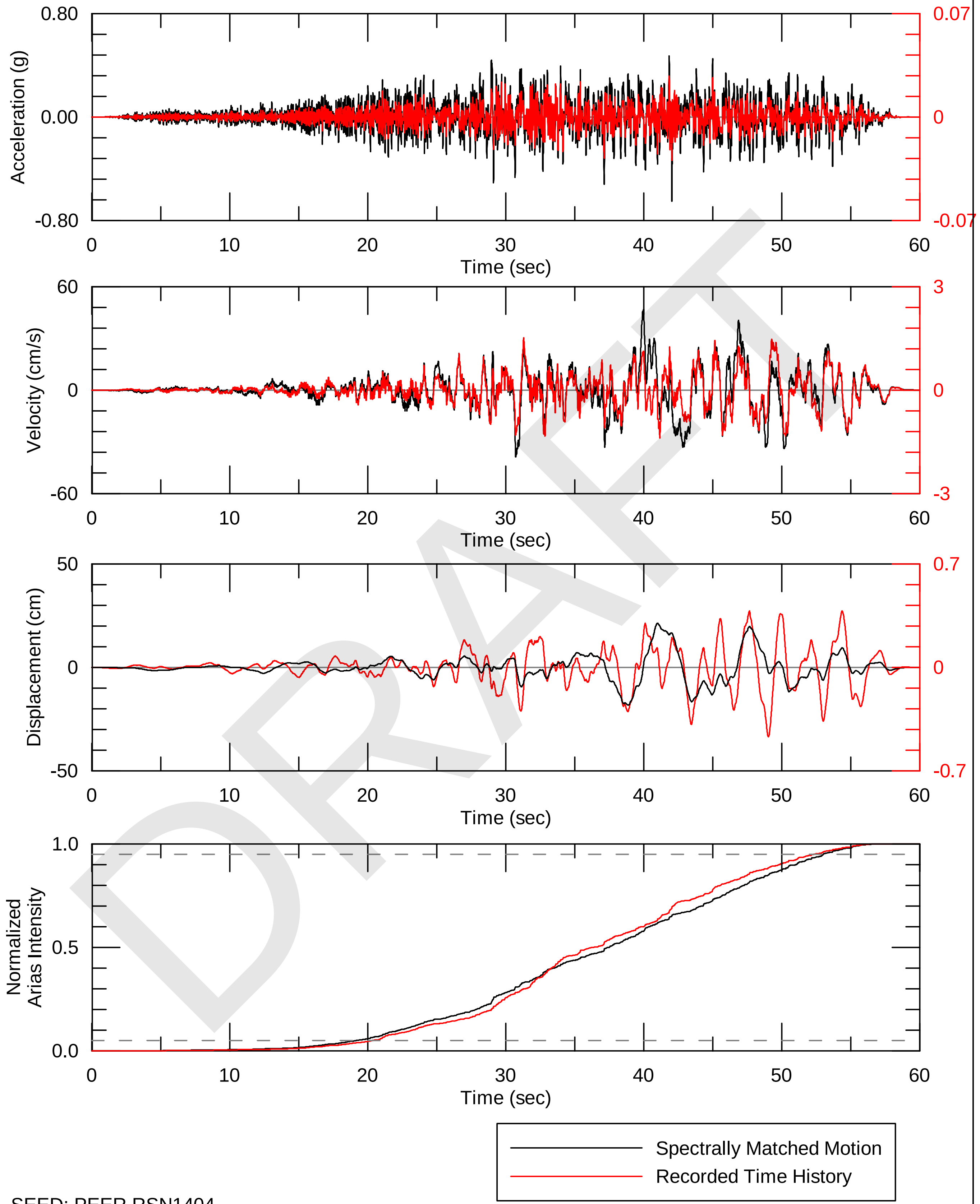
SEED: PEER RSN1153

	Project No. 60440155	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 KOCAELI - BOTAS (090) SEED	Figure 31
AECOM	Joppa Power Station Dynegy		



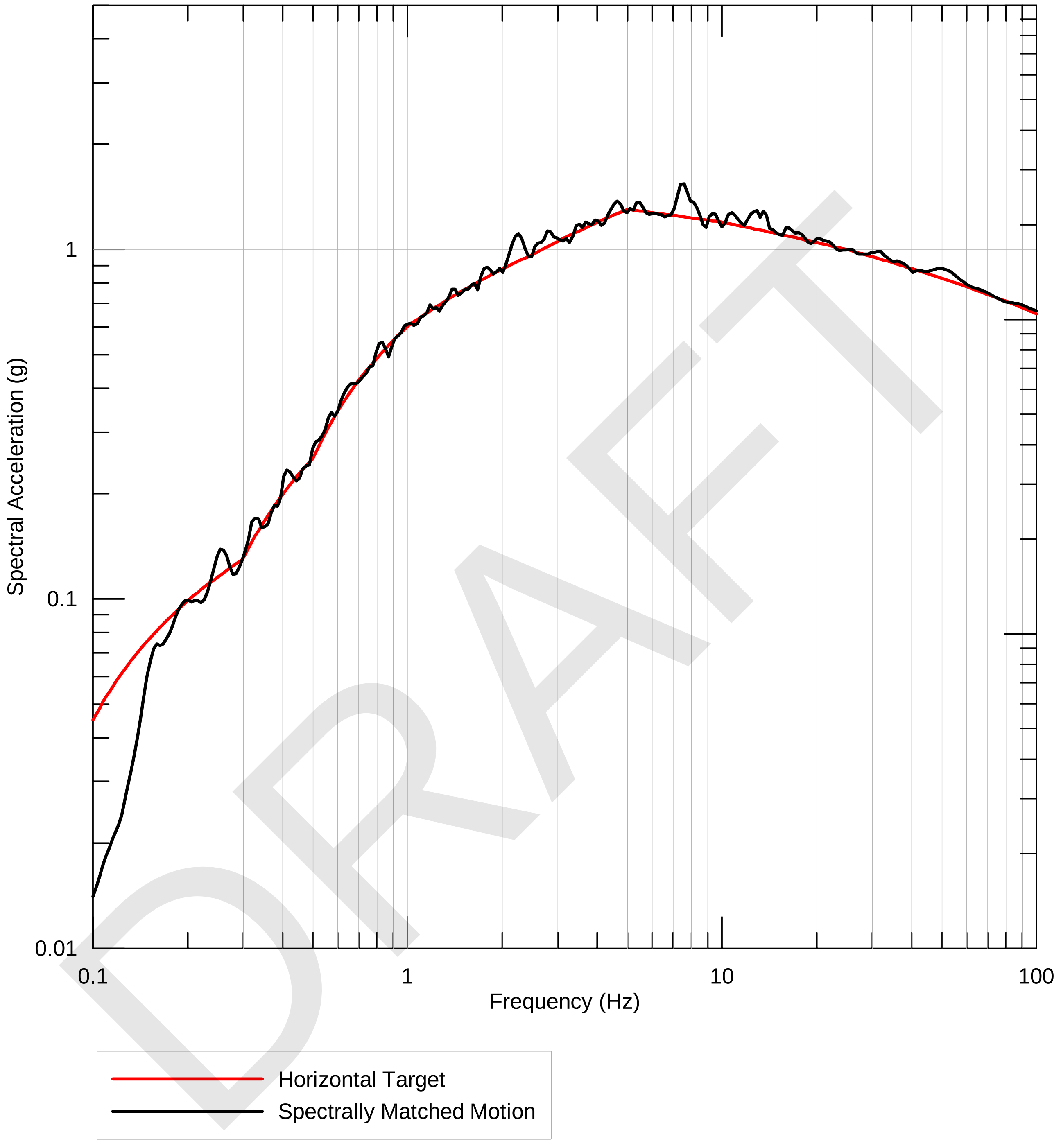
SEED: PEER RSN1404

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



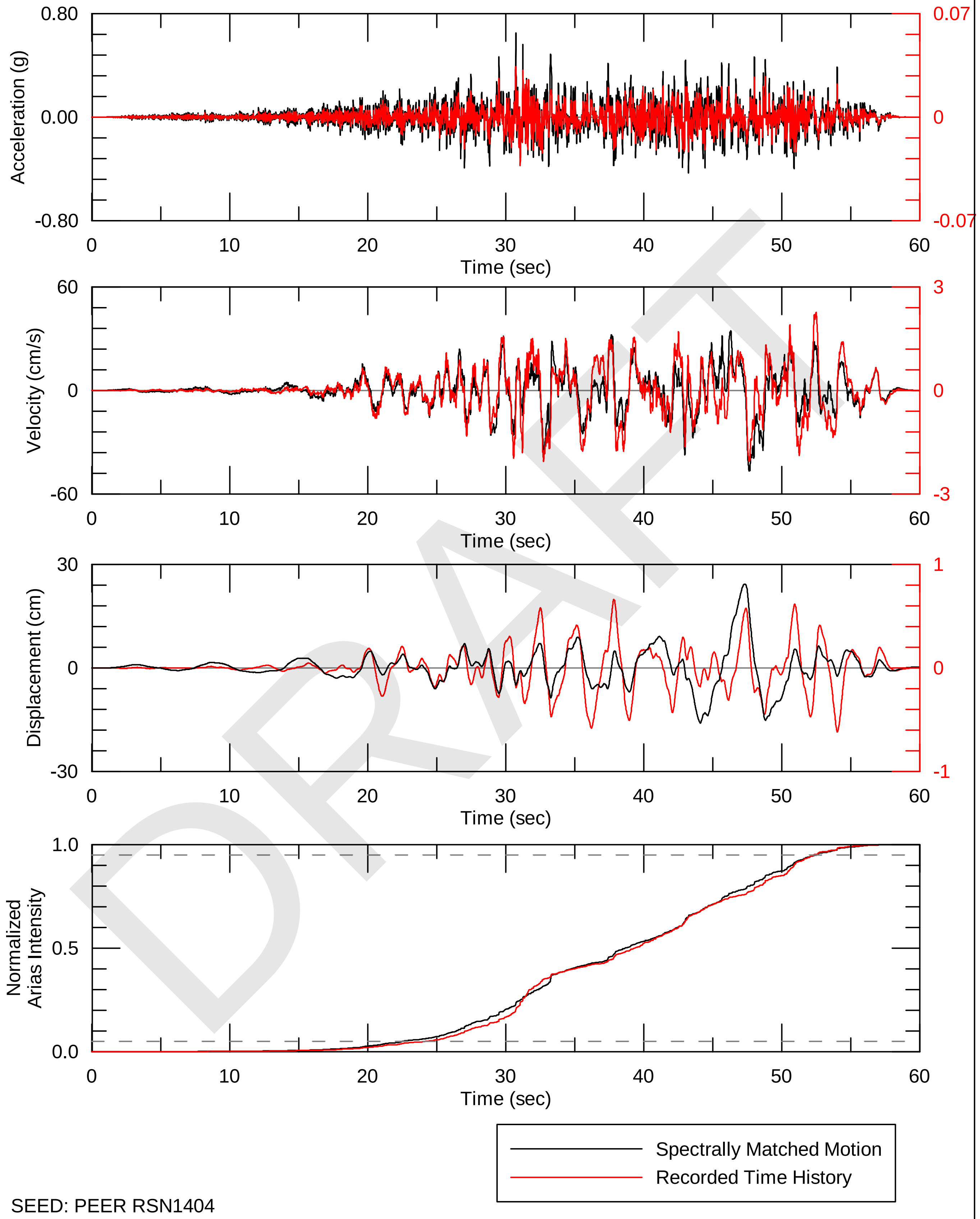
SEED: PEER RSN1404

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



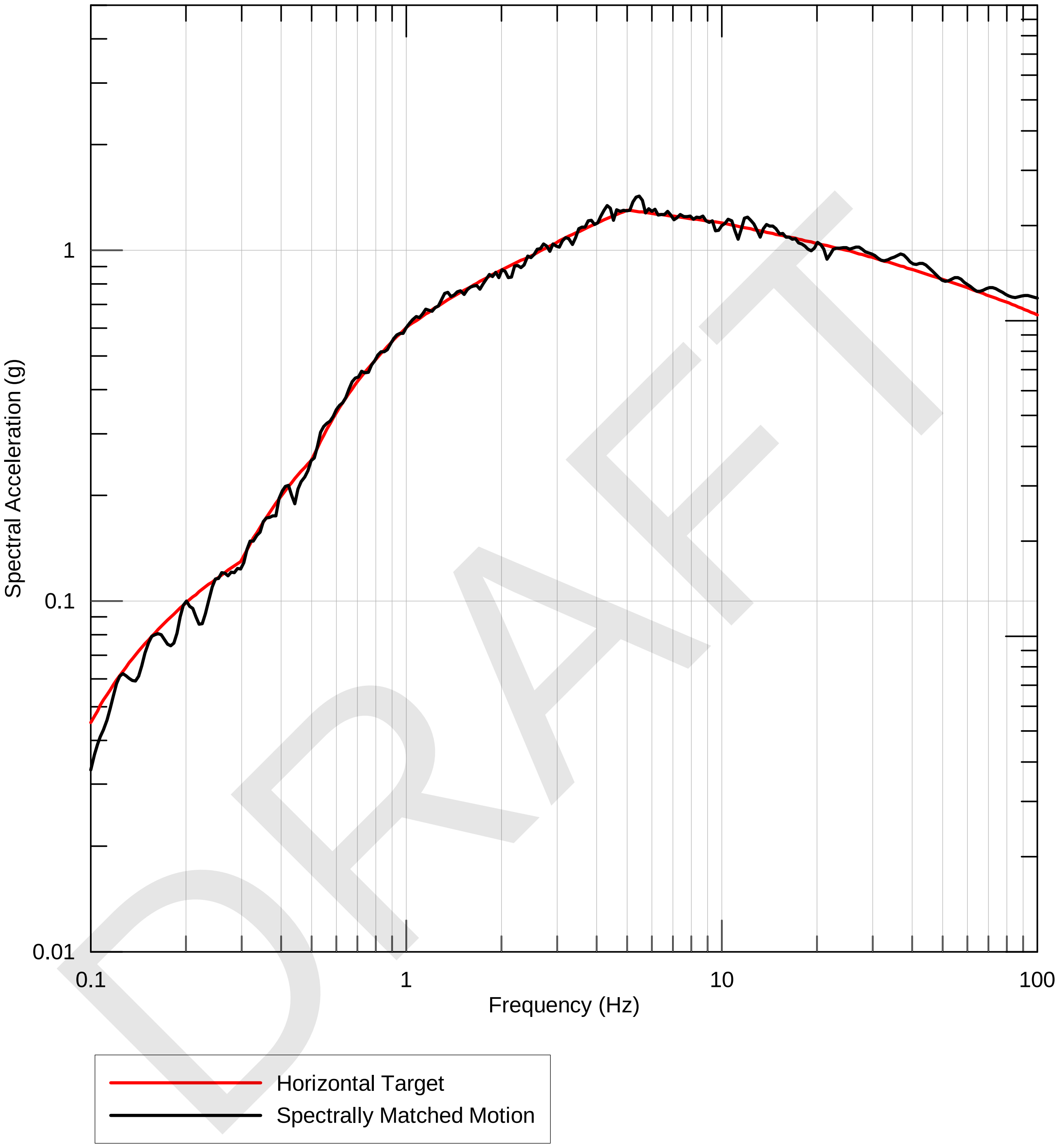
SEED: PEER RSN1404

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



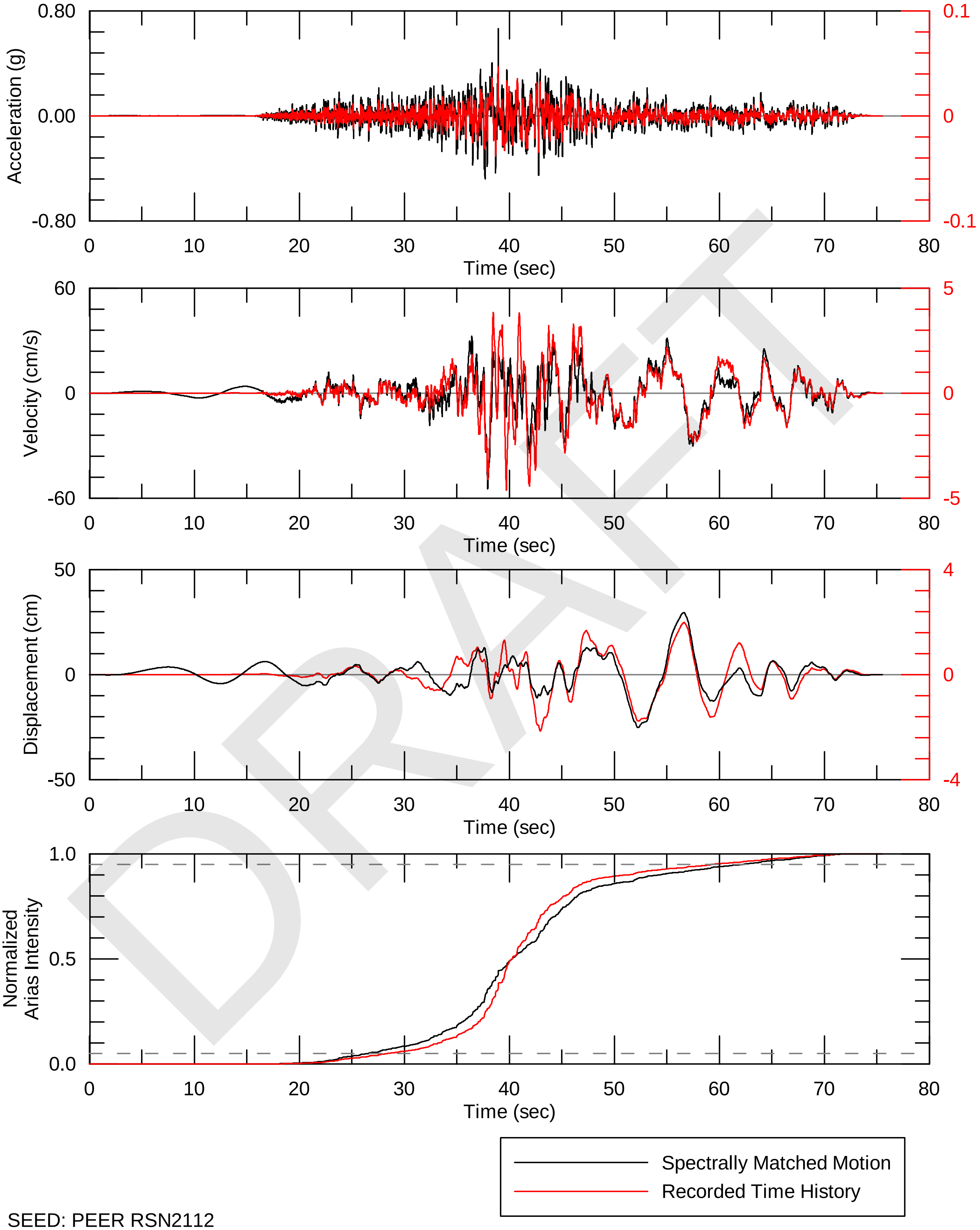
SEED: PEER RSN1404

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

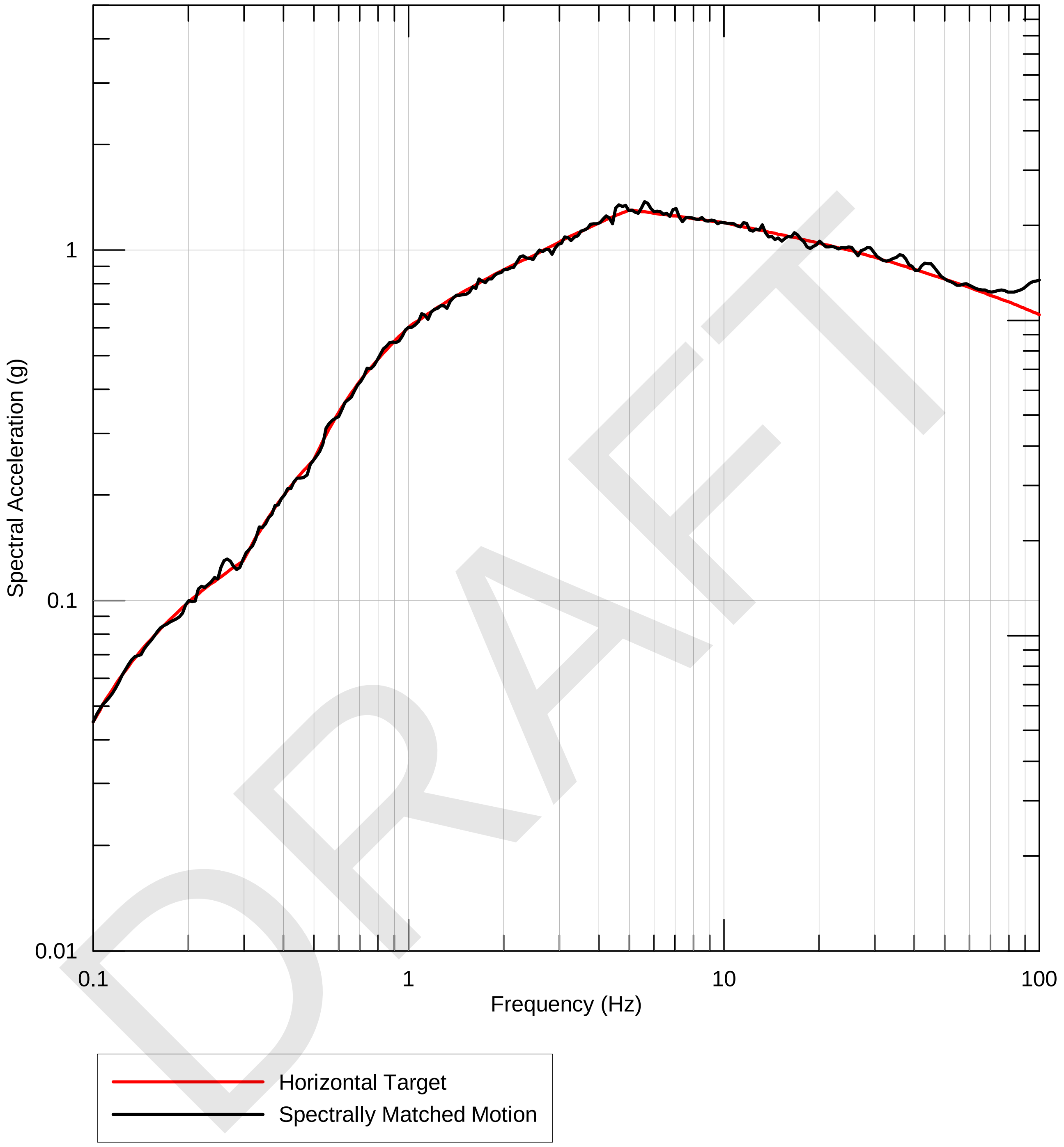
AECOM

Project No. 60440155

Joppa Power Station
Dynegy

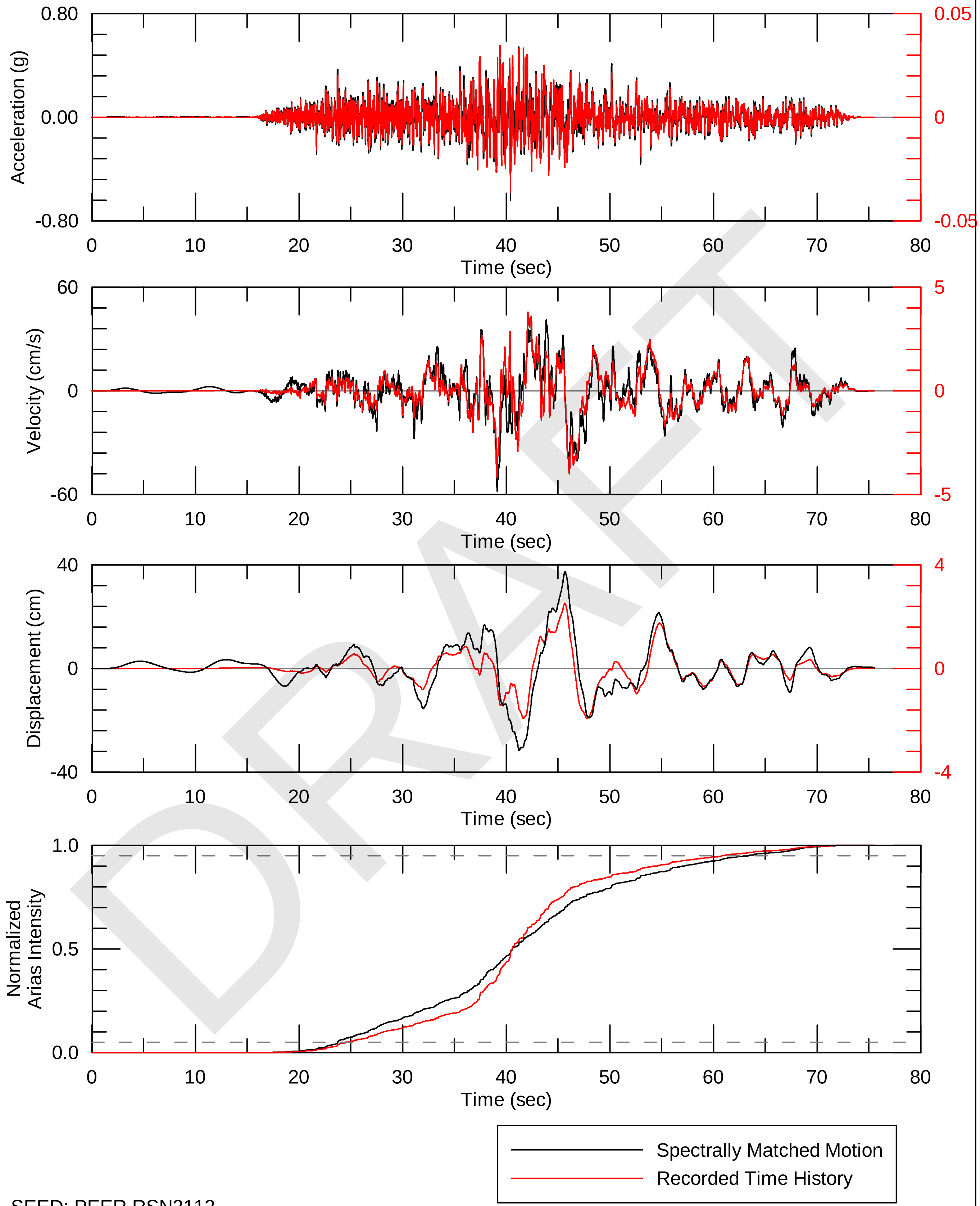
TIME HISTORY SPECTRALLY MATCHED TO
2,500-YEAR RETURN PERIOD UHS
HORIZONTAL TARGET
2002 DENALI - TAPS PUMP STATION #8 (049) SEED

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

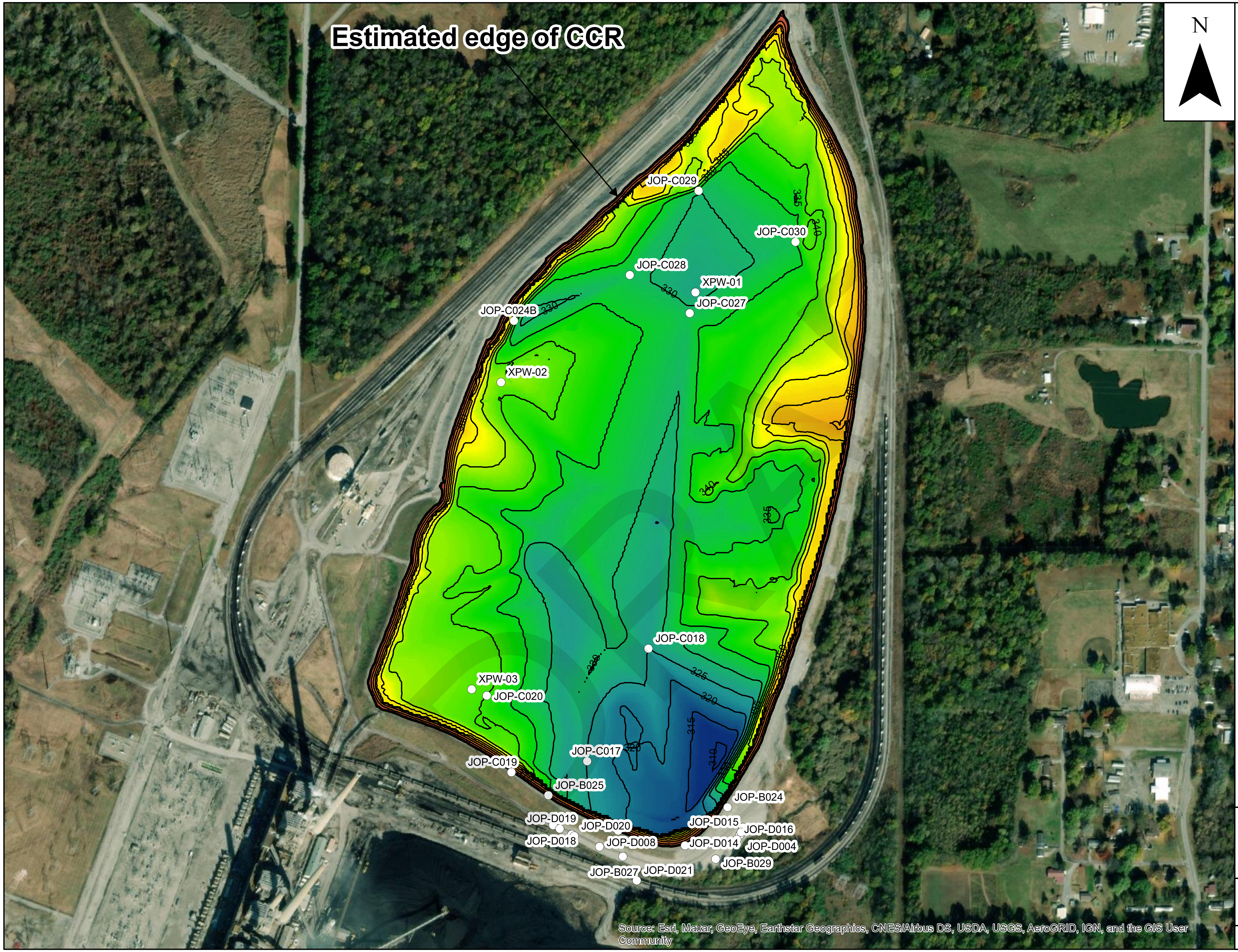
TIME HISTORY SPECTRALLY MATCHED TO
2,500-YEAR RETURN PERIOD UHS
HORIZONTAL TARGET
2002 DENALI - PUMP STATION #8 (319) SEED

Figure
39

Geosyntec
consultants

ATTACHMENT F

EAP Subsurface Layer Interface Maps



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Estimated High : 377.2 ft

Estimated Low : 308.8 ft

○ Bottom of CCR Measured from Boring or CPT

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.EXISTING CONTOURS TAKEN FROM "ELECTRIC ENERGY, INC., JOPPA POWER STATION, DECEMBER 2020 TOPOGRAPHY" DRAWING, DATED APRIL 1, 2021, PREPARED BY INEGNAE, LLC.

3.THE BOTTOM CCR CONTOURS SHOWN WERE DEVELOPED UTILIZING THE FOLLOWING DATA SOURCES:

3.1.UNITED STATES GEOLOGIC SURVEY (USGS) L.A. CENTER KENTUCKY-ILLINOIS QUANDRANGLE (1932).

3.2.INGENAE, LLC, "ELECTRIC ENERGY, INC., JOPPA POWER STATION, DECEMBER 2020 TOPOGRAPHY" DRAWING, DATED APRIL 20, 2021.

3.3.HISTORICAL DESIGN DRAWINGS FROM EAST ASH POND BERM CONSTRUCTION ACTIVITIES INCLUDING:

3.3.1.WAPORA, INC., “ELECTRIC ENERGY, INC., EAST ASH POND PLAN, SECTIONS AND DETAILS” DRAWING DATED JUNE 22, 1973.

3.3.2.“ELECTRIC ENERGY, INC., JOPPA, IL., EAST ASH POND, “4229-8211” DRAWING DATED AUGUST 4, 1982.

3.4.THE 1932 TOPOGRAPHY AND HISTORIC DESIGN DRAWINGS WERE SUPPLEMENTED USING BORING DATA SHOWING THE BOTTOM OF CCR ELEVATIONS FROM THE FOLLOWING SORUCES:

3.4.1. GEOTECHNICAL INVESTIGATION PERFORMED BY AECOM, AS PRESENTED IN “CCR CERTIFICAITON REPORT: INITIAL STRUCTURAL STABILITY ASSESSMENT, INTITIAL FACTOR OF SAFETY ASSESSMENT, AND INITIAL INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN FOR EAST CCR POND AT JOPPA POWER STATION” (2016).

3.4.2. SUBSRUFACE INVESTIGATION PERFORMED BY GEOSYNTEC, AS PRESENTED IN “ILLINOIS ADMINISTRATIVE CODE PART 845 DATA GAP ANALYSIS – SITE: JOPPA EAST POND-CCR UNIT 401” (2021).

4.THREE-DIMENSIONAL SURFACES WERE DEVELOPED FOR EACH OF THE ABOVE-MENTIONED DATASETS USING CAD AND GIS SOFTWARE. WHERE GIS WAS USED, AVAILABLE DATA WAS INTERPOLATED USING A COMBINATION OF THE KRIGING METHOD WITHIN EARTH VOLUMETRIC STUDIO 2021.4.3 AND THE TOPO TO RASTER METHOD WITHIN ARCMAP 10.8.1. THE COMPOSITE BOTTOM OF CCR CONTOURS WERE CHOSEN AS THE LOWEST ELEVATION OF EACH OF THE SURFACES DEVELOPED FROM THE DATA SOURCES LISTED IN NOTE 3.

5.WHERE THE CCR IS ADJACENT TO THE EARTHEN EAP PERIMTER DIKES, THE INTERIOR SLOPES OF THE DIKE/CCR INTERFACE WERE SET AT 1.5H:1V BASED ON: WAPORA, INC., “ELECTRIC ENERGY, INC., EAST ASH POND PLAN, SECTIONS AND DETAILS” DRAWING DATED JUNE 22, 1973 .

6.THE SURFACE PRESENTED IN THESE DRAWING SHOULD BE CONSIDERED APPROXIMATE, DUE TO LIMITED RECENT INVESTIGATION DATA TO CONFIRM THE BOTTOM OF CCR WHILE THE HISTORICAL USGS TOPOGRAPHIC MAP AND DESIGN DRAWINGS REPRESENT THE BEST-AVAILABLE ESTIMATE OF PRE-CONSTRUCTION SITE TOPOGRAPHY AND GRADES USING INFORMATION THAT IS AVAILABLE AS OF FEBRUARY 2022.

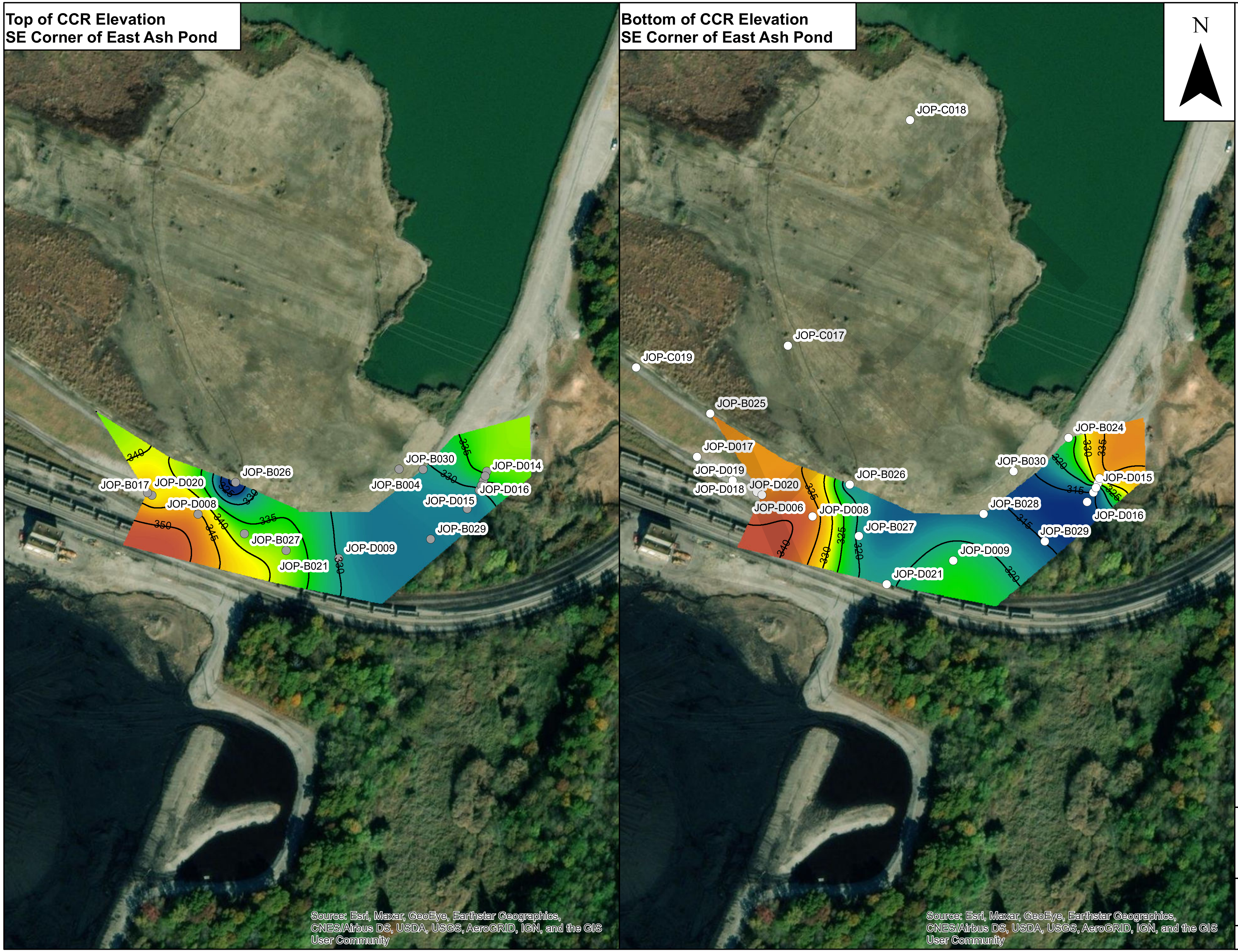
0 425 850 Feet

**Estimated Bottom of CCR Elevation,
Pond Interior, East Ash Pond
Joppa Power Plant
Joppa, Illinois**

Geosyntec consultants

Figure 1

GLP8025 2/16/2022



Top of CCR Elevation
SE Corner of East Ash Pond

Bottom of CCR Elevation
SE Corner of East Ash Pond

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Top of CCR (SE)

Estimated High : 352.5 ft

Estimated Low : 316.5 ft

Bottom of CCR (SE)

Estimated High : 340.5 ft

Estimated Low: 313.2 ft

● Top of CCR Measured from Boring or CPT

○ Bottom of CCR Measured from Boring or CPT

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 AND TOP OF CCR CONTOURS SHOWN WERE DEVELOPED UTILIZING THE FOLLOWING DATA SOURCES:

2.1.UNITED STATES GEOLOGIC SURVEY (USGS) L.A. CENTER KENTUCKY-ILLINOIS QUANDRANGLE (1932).

2.2.THE 1932 TOPOGRAPHY WAS SUPPLEMENTED USING BORING DATA SHOWING THE BOTTOM OF CCR AND TOP OF CCR ELEVATIONS FROM THE FOLLOWING SORUCES:

2.2.1. GEOTECHNICAL INVESTIGATION PERFORMED BY AECOM, AS PRESENTED IN "CCR CERTIFICAITON REPORT: INITIAL STRUCTURAL STABILITY ASSESSMENT, INTITIAL FACTOR OF SAFETY ASSESSMENT, AND INITIAL INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN FOR EAST CCR POND AT JOPPA POWER STATION" (2016).

2.2.2. SUBSRUFACE INVESTIGATION PERFORMED BY GEOSYNTEC, AS PRESENTED IN "ILLINOIS ADMINISTRATIVE CODE PART 845 DATA GAP ANALYSIS – SITE: JOPPA EAST POND-CCR UNIT 401" (2021).

3.THREE-DIMENSIONAL SURFACES WERE DEVELOPED FOR EACH OF THE ABOVE-MENTIONED DATASETS USING CAD AND GIS SOFTWARE. WHERE GIS WAS USED, AVAILABLE DATA WAS INTERPOLATED USING THE SPLINE METHOD WITHIN ARCMAP 10.8.1. THE COMPOSITE BOTTOM OF CCR CONTOURS WERE CHOSEN AS THE LOWEST ELEVATION OF EACH OF THE SURFACES DEVELOPED FROM THE DATA SOURCES LISTED IN NOTE 2. TOP OF CCR ELEVATIONS WERE BASED SOLEY ON INVESTIGATION DATA.

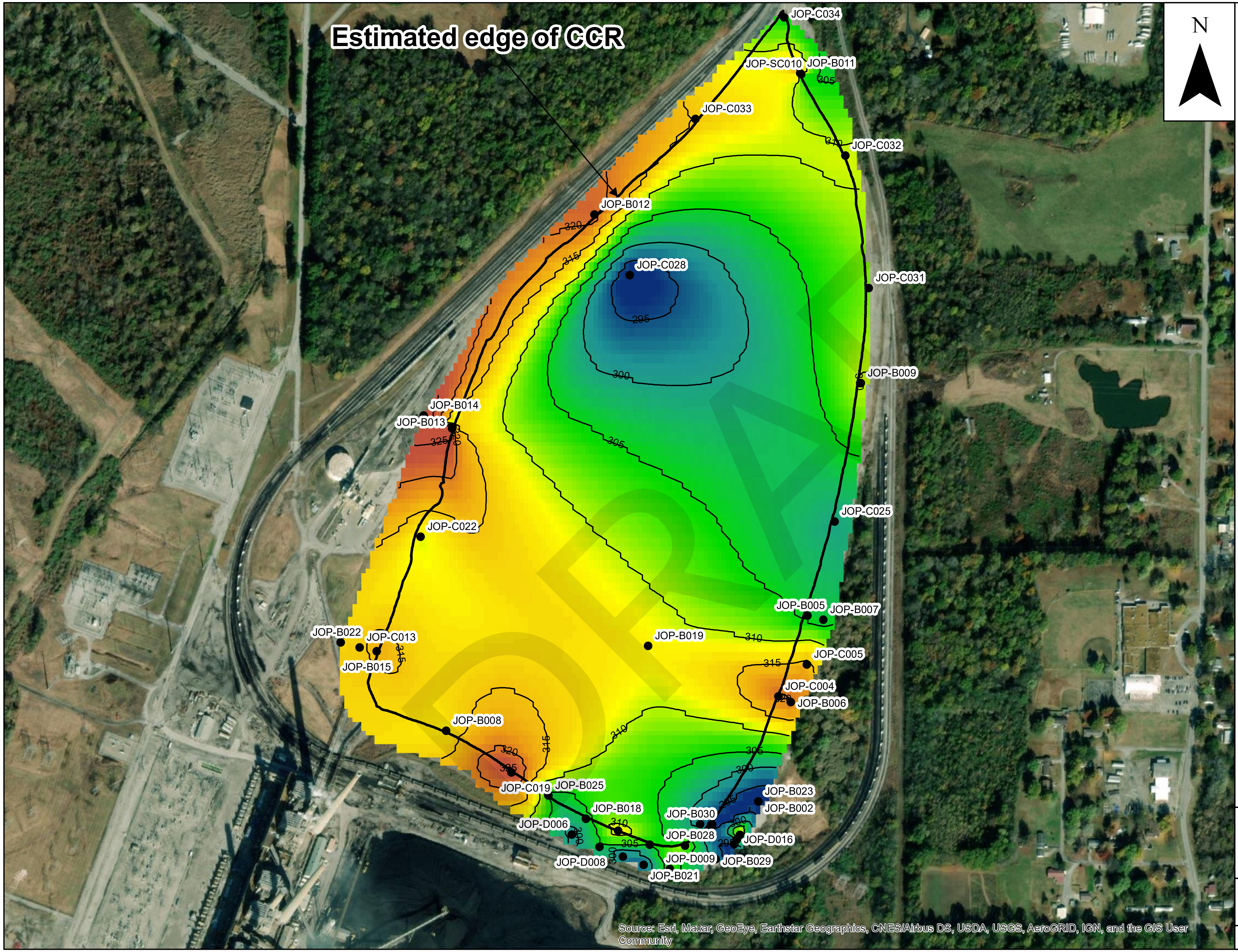
4.THE SURFACES PRESENTED IN THESE DRAWINGS SHOULD BE CONSIDERED APPROXIMATE, DUE TO LIMITED RECENT INVESTIGATION DATA TO CONFIRM THE BOTTOM AND TOP OF WHILE THE HISTORICAL USGS TOPOGRAPHIC MAP AND DESIGN DRAWINGS REPRESENT THE BEST-AVAILABLE ESTIMATE OF PRE-CONSTRUCTION SITE TOPOGRAPHY AND GRADES USING INFORMATION THAT IS AVAILABLE AS OF FEBRUARY 2022.

0 200 400
Feet

Estimated Bottom and Top
of CCR Elevations
Southeast Corner, East Ash Pond
Joppa Power Plant, Joppa, Illinois

Geosyntec
consultants

GLP8025	2/16/2022	Figure 2



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Estimated High : 329.5 ft

Estimated Low : 290.2 ft

● Bottom of Clay Measured from Boring or CPT

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 CONTOURS SHOWN WERE DEVELOPED UTILIZING THE FOLLOWING DATA SOURCES:

2.1.GEOTECHNICAL INVESTIGATION PERFORMED BY AECOM, AS PRESENTED IN “CCR CERTIFICAITON REPORT: INITIAL STRUCTURAL STABILITY ASSESSMENT, INTITIAL FACTOR OF SAFETY ASSESSMENT, AND INITIAL INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN FOR EAST CCR POND AT JOPPA POWER STATION” (2016).

2.2.SUBSRUFACE INVESTIGATION PERFORMED BY GEOSYNTEC, AS PRESENTED IN “ILLINOIS ADMINISTRATIVE CODE PART 845 DATA GAP ANALYSIS – SITE: JOPPA EAST POND-CCR UNIT 401” (2021).

3.THREE-DIMENSIONAL SURFACES WERE DEVELOPED FOR EACH OF THE ABOVE-MENTIONED DATASETS USING CAD AND GIS SOFTWARE.

4.AVAILABLE DATA WAS INTERPOLATED USING THE KRIGING METHOD WITHIN EARTH VOLUMETRIC STUDIO 2021.4.3.

5.THE SURFACE PRESENTED IN THIS DRAWING SHOULD BE CONSIDERED APPROXIMATE, DUE TO LIMITED RECENT INVESTIGATION DATA TO CONFIRM THE BOTTOM OF CLAY.

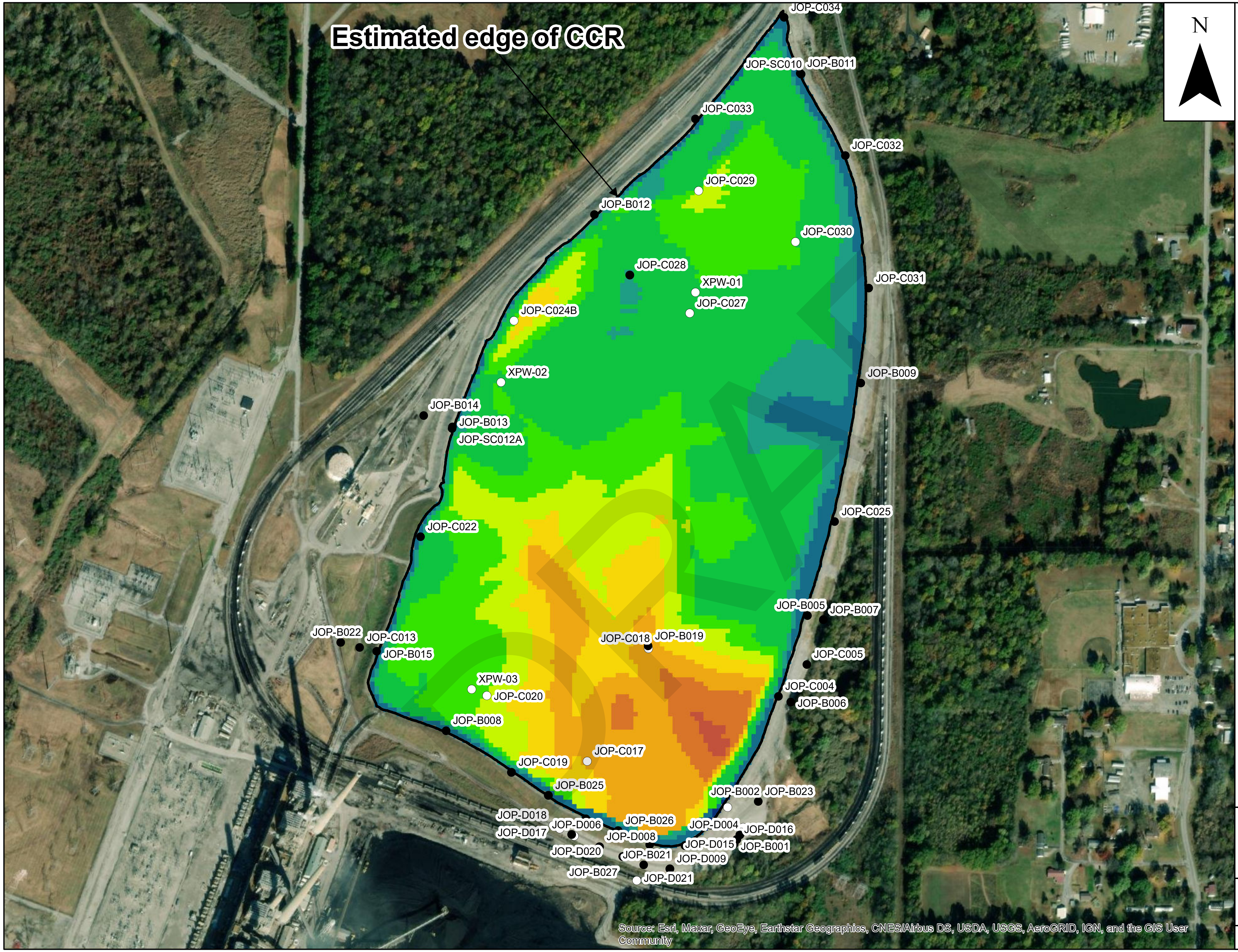
0 425 850 Feet

Estimated Bottom of Clay Elevation
East Ash Pond
Joppa Power Plant
Joppa, Illinois

Geosyntec consultants

Figure 3

GLP8025 2/16/2022



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

🟥 <5 ft
🟧 5 - 10 ft
🟧 10 - 15 ft
🟨 15 - 20 ft
🟨 20 - 25 ft
🟩 25 - 30 ft
🟩 30 - 40 ft
🟩 40 - 50 ft
🟦 50 - 75 ft
🟦 >75 ft

● Bottom of Clay Measured from Boring or CPT

○ Bottom of CCR Measured from Boring or CPT

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.ISOPACH THICKNESSES WERE GENERATED USING RASTER MATH TOOLS WITHIN ARCMAP 10.8.1. THE ELEVATION OF THE BOTTOM OF CLAY (FIGURE 3) WAS SUBTRACTED FROM THE ELEVATION OF THE BOTTOM OF CCR (FIGURE 1) TO PRODUCE THE ISOPACH THICKNESS.

3.THE ISOPACH PRESENTED IN THIS DRAWING SHOULD BE CONSIDERED APPROXIMATE, DUE TO LIMITED RECENT INVESTIGATION DATA TO CONFIRM THE BOTTOM OF CCR AND BOTTOM CLAY WHILE THE HISTORICAL USGS TOPOGRAPHIC MAP AND DESIGN DRAWINGS REPRESENT THE BEST-AVAILABLE ESTIMATE OF PRE-CONSTRUTION SITE TOPOGRAPHY AND GRADES USING INFORMATION THAT IS AVAIALBLE AS OF FEBRUARY 2022.

0 425 850 Feet

Estimated Clay Thickness Map
East Ash Pond
Joppa Power Plant
Joppa, Illinois

Geosyntec consultants

Figure 4

GLP8025 2/16/2022

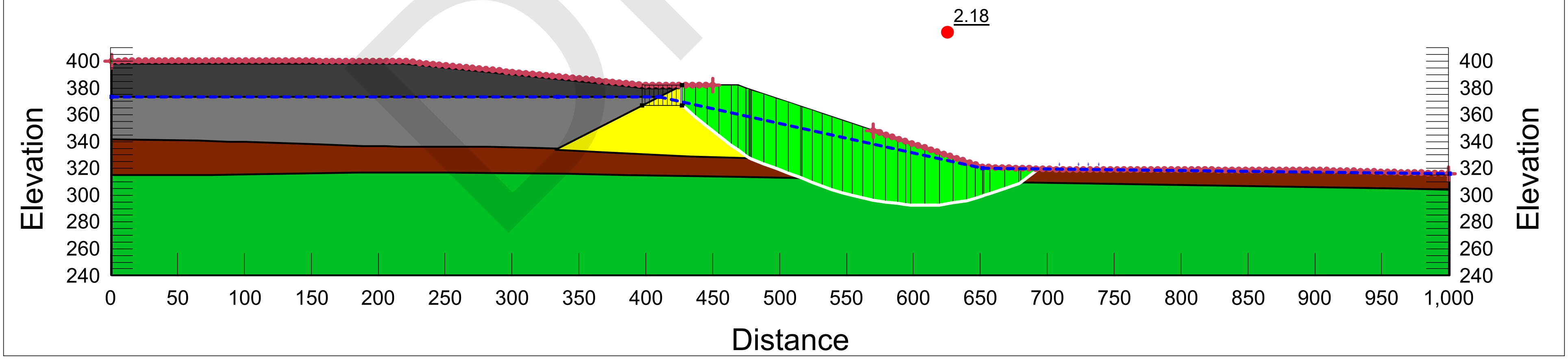
ATTACHMENT G

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

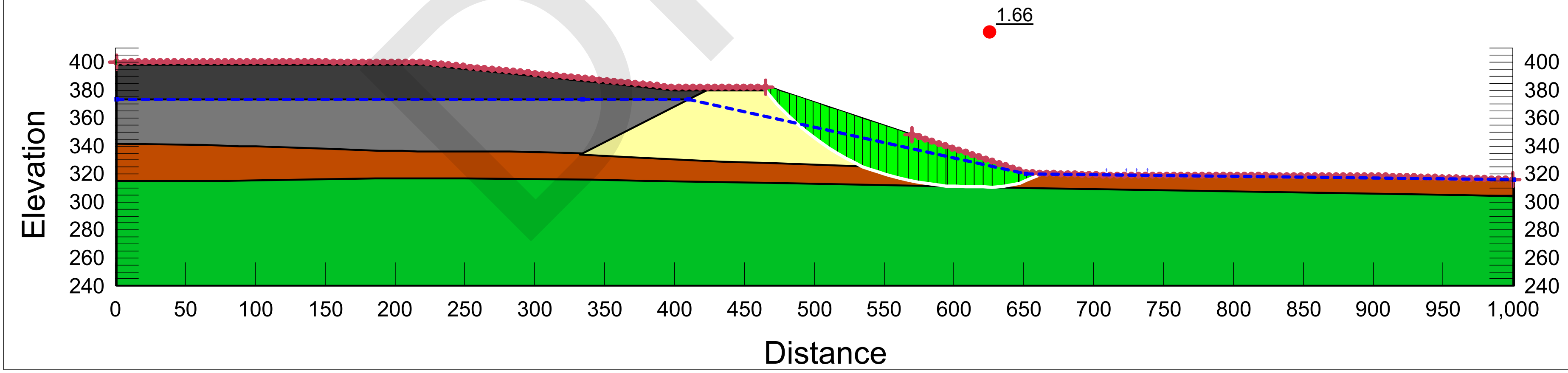


\\stlouismo-01\data\Company\Projects_post_2014\GLP8025_JOP_845_Const_Permit\500_Technical\540_Geotech\Slope Stability Analysis\Section A\ Section A_PK_04012022.gsz

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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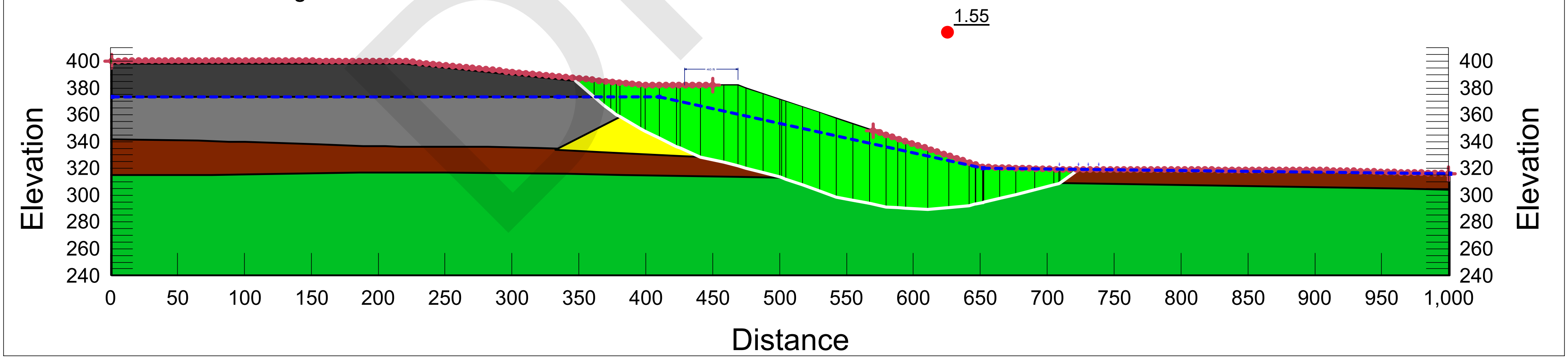
Joppa_East Ash Pond
Section A_Pseudostatic Seismic

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

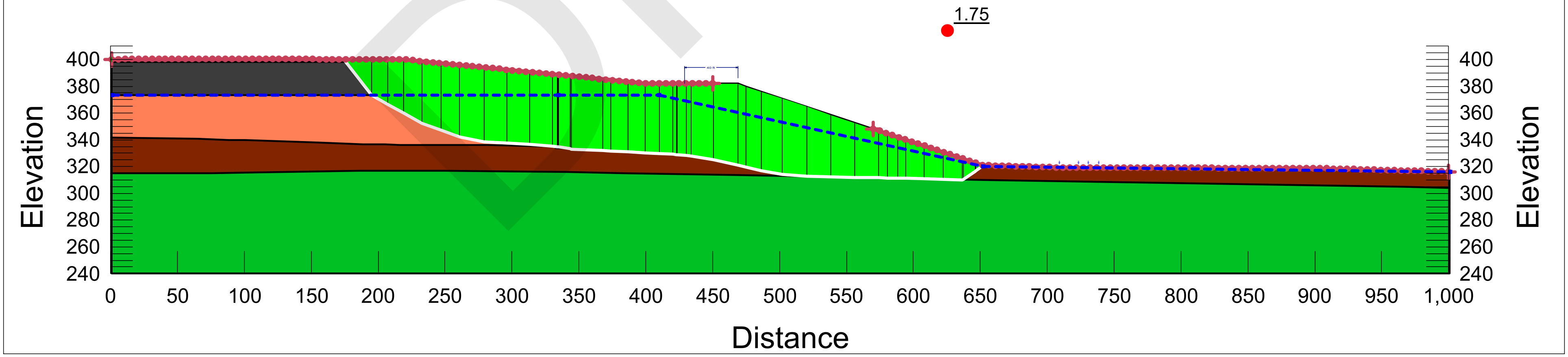
Pseudostatic k value	
k =	**0.108**

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)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0			1
🟩	Foundation Sands	Mohr-Coulomb	130			0	35	0			1



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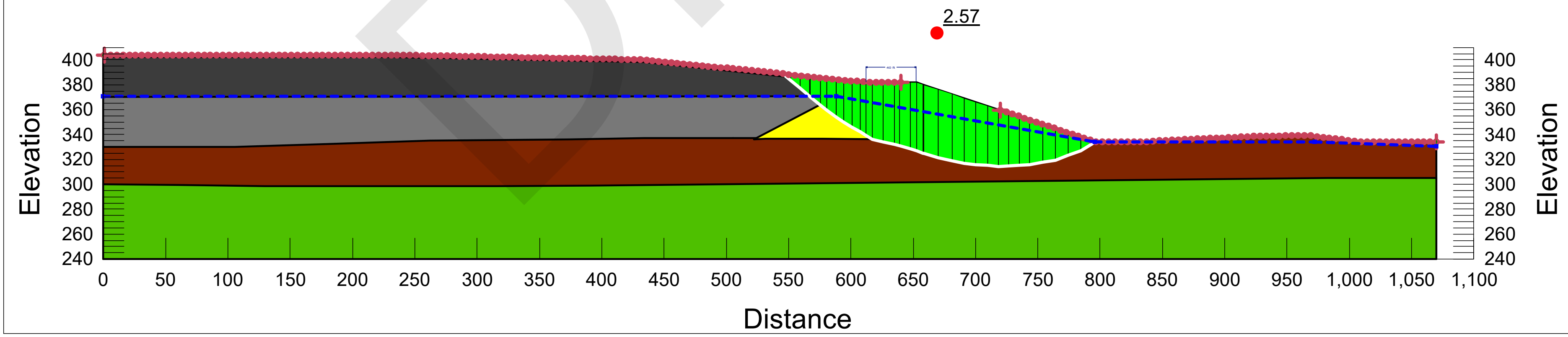
Joppa_East Ash Pond

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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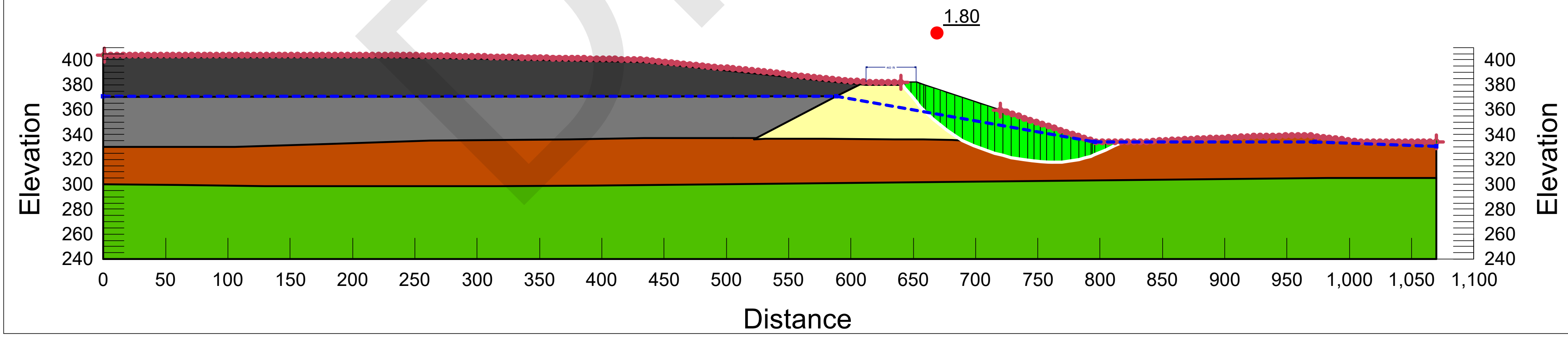
Joppa_East Ash Pond

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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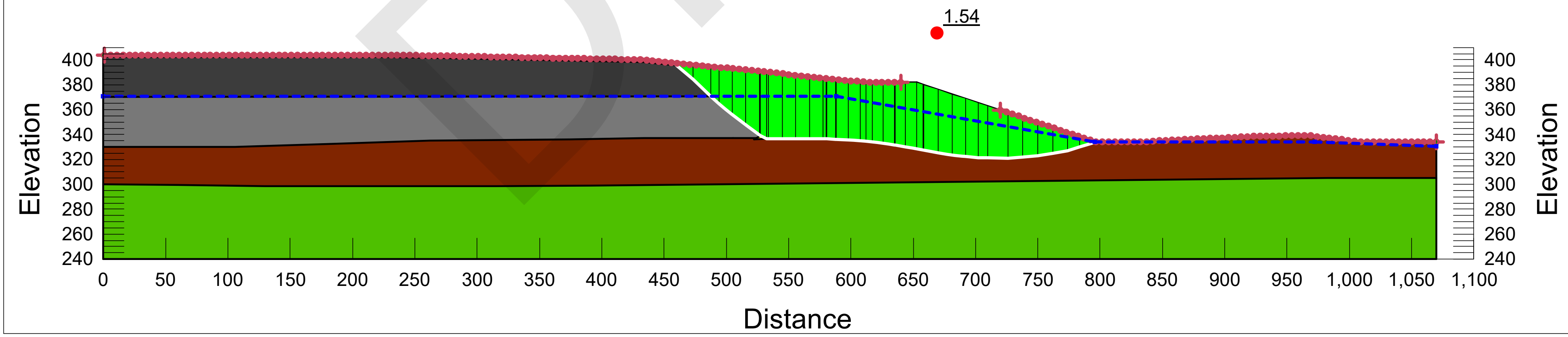
Joppa_East Ash Pond

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



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**

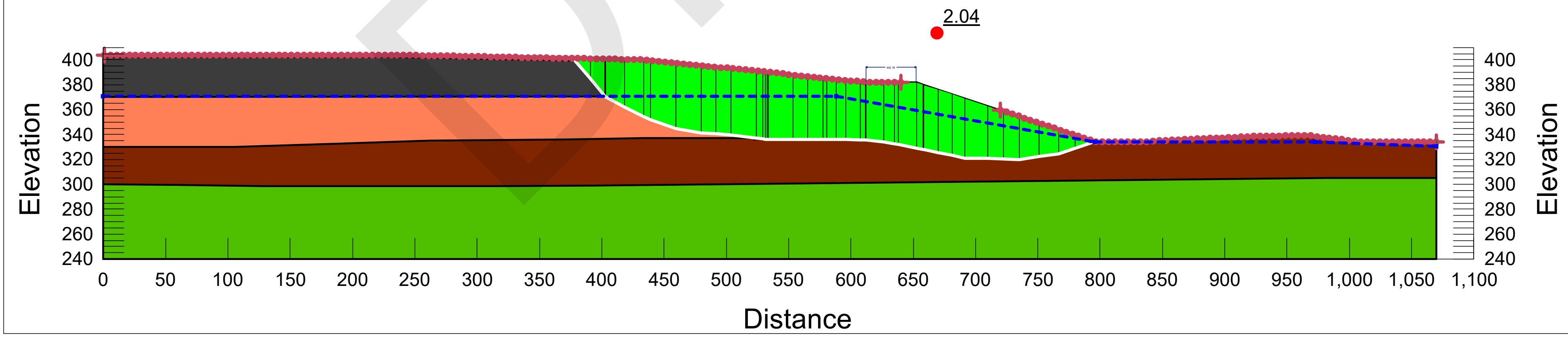
With this **k** value, if the pseudostatic FS >= 1.0, then the displacement will be less than 46 cm at the 50% or 16% probability of exceedance level (i.e., ε = 0 or 0.74, respectively).

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)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0			1
🟩	Foundation Sands	Mohr-Coulomb	130			0	35	0			1



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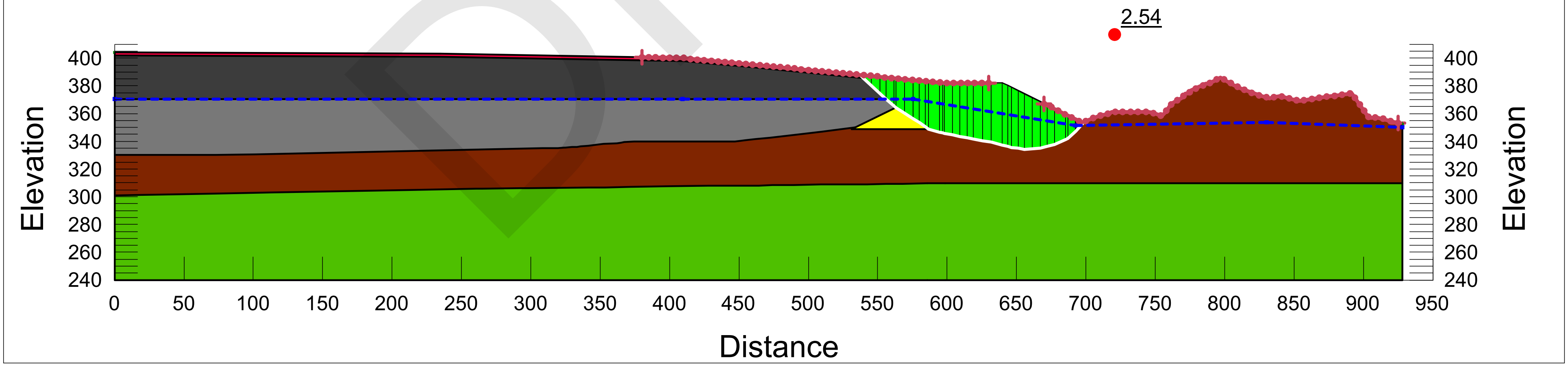
Joppa_East Ash Pond

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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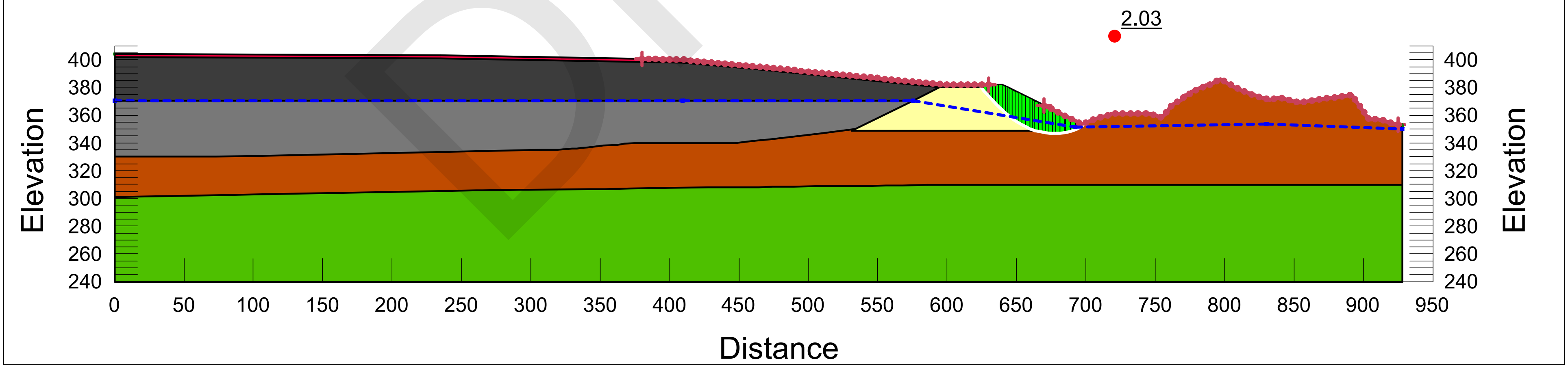
Joppa_East Ash Pond

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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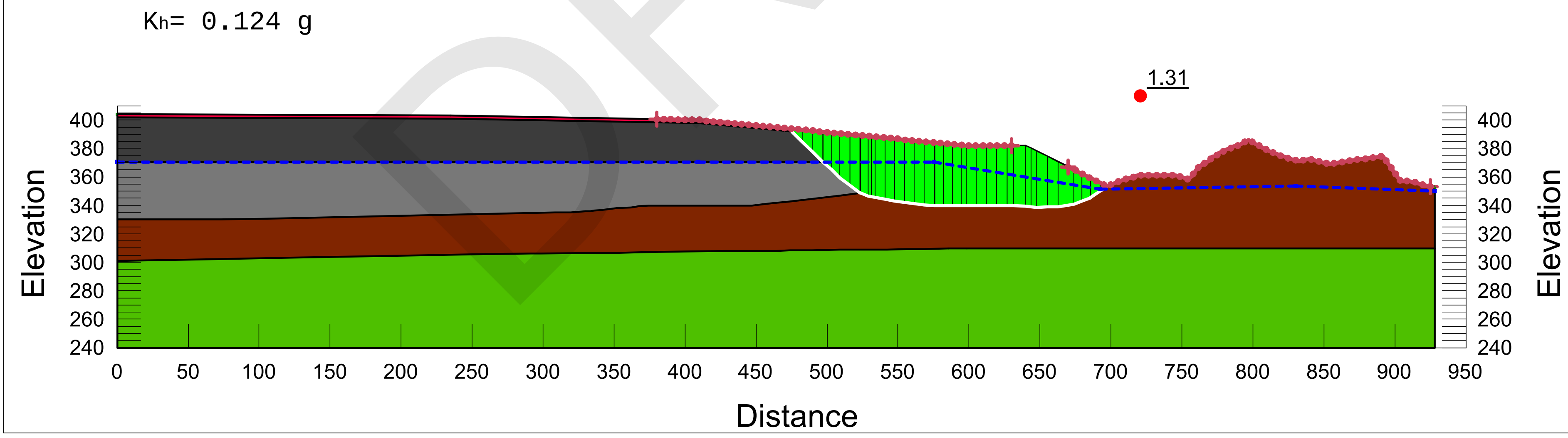
Joppa_East Ash Pond
Section C_Pseudostatic Seismic

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



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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

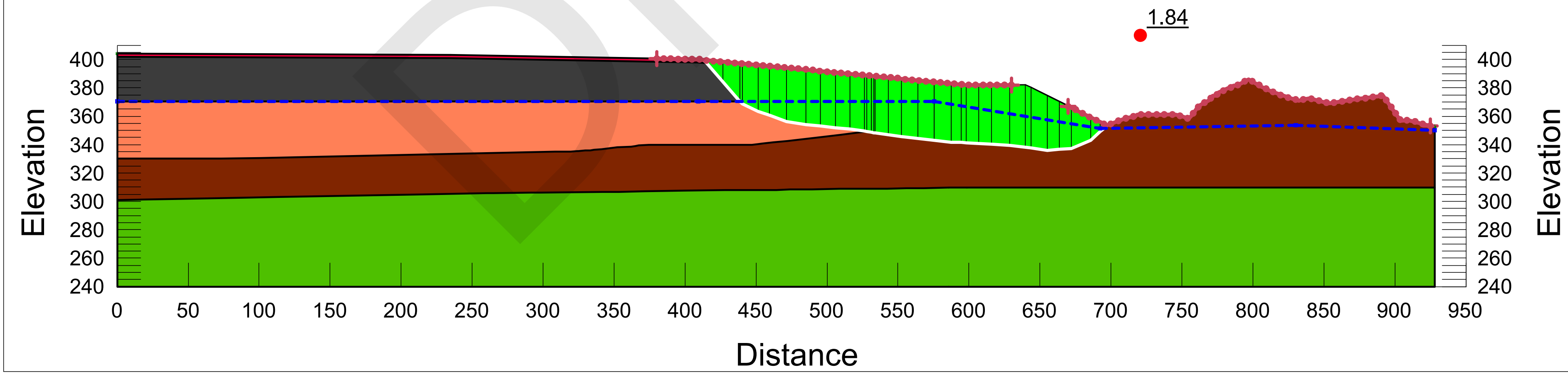
Pseudostatic k value	
k =	**0.124**

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

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)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0			1
🟩	Foundation Sands	Mohr-Coulomb	130			0	35	0			1



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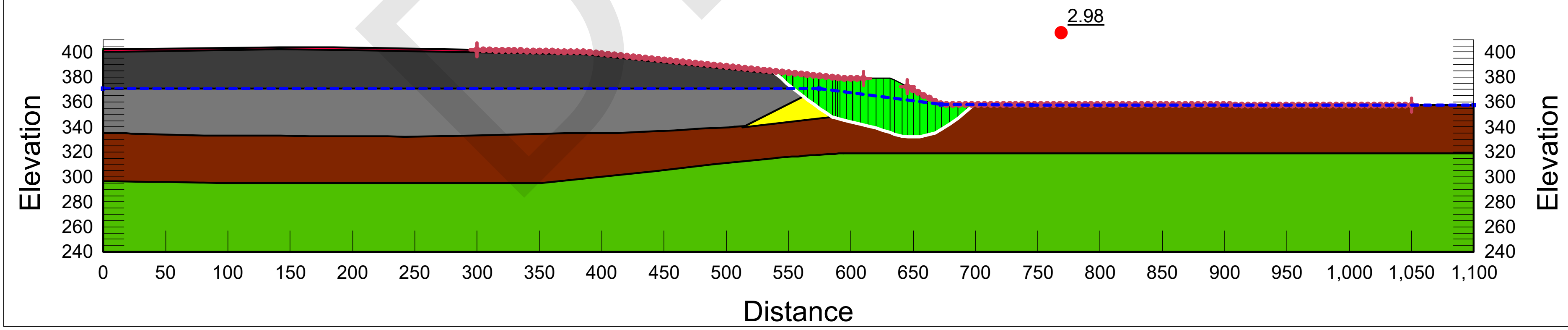
Joppa_East Ash Pond
Section D_End of Construction

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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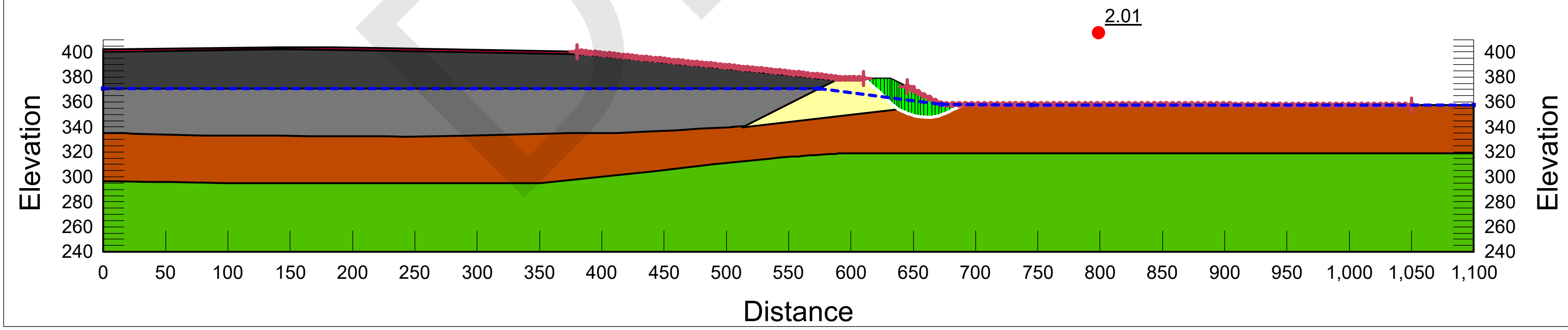
Joppa_East Ash Pond
Section D_Long Term

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

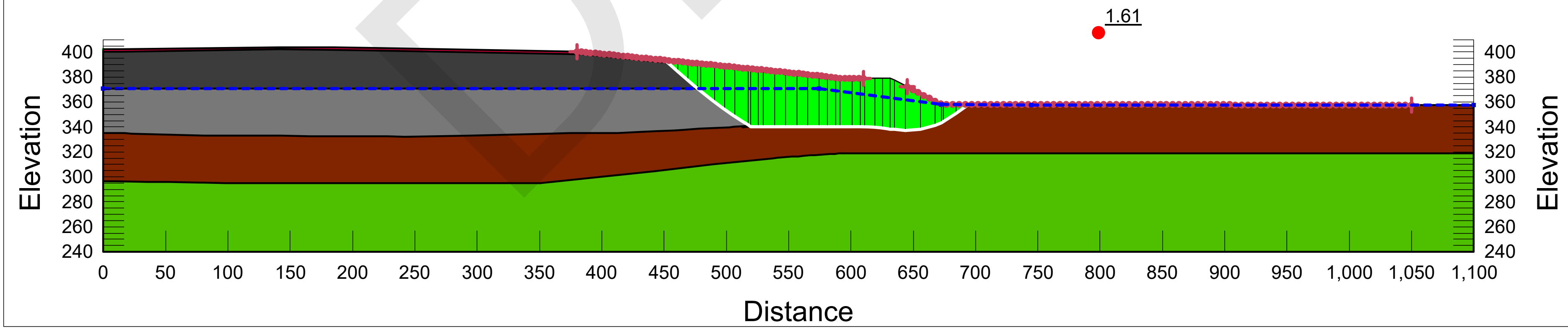


Joppa_East Ash Pond
Section D_Pseudostatic Seismic

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

Kh= 0.110 g



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

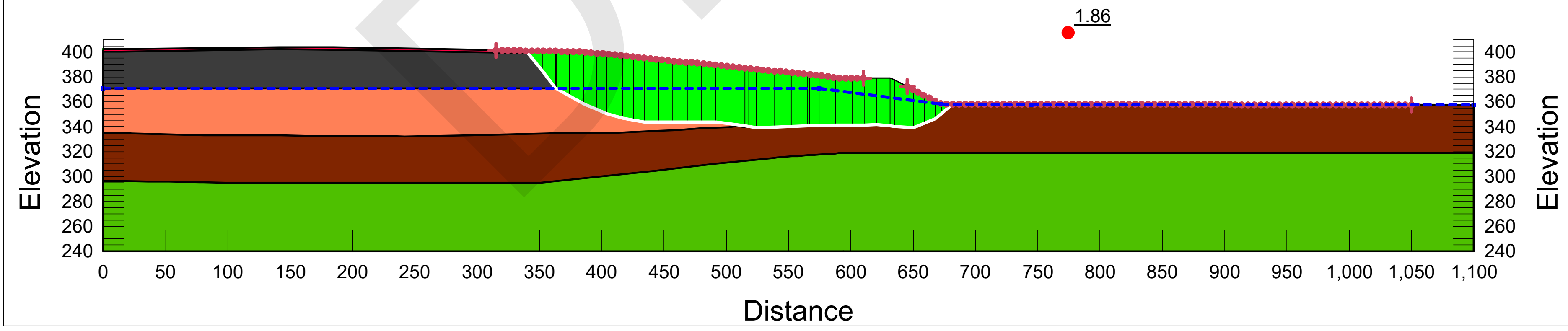
Pseudostatic k value	
k =	**0.110**

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

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)	Spatial Mohr-Coulomb	127	Foundation Clay			0	0			1
🟩	Foundation Sands	Mohr-Coulomb	130			0	35	0			1



\\stlouismo-01\data\Company\Projects_post_2014\GLP8025_JOP_845_Const_Permit\500_Technical\540_Geotech\Slope Stability Analysis\Section D\ Section D_PK_04062022.gsz

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	-				

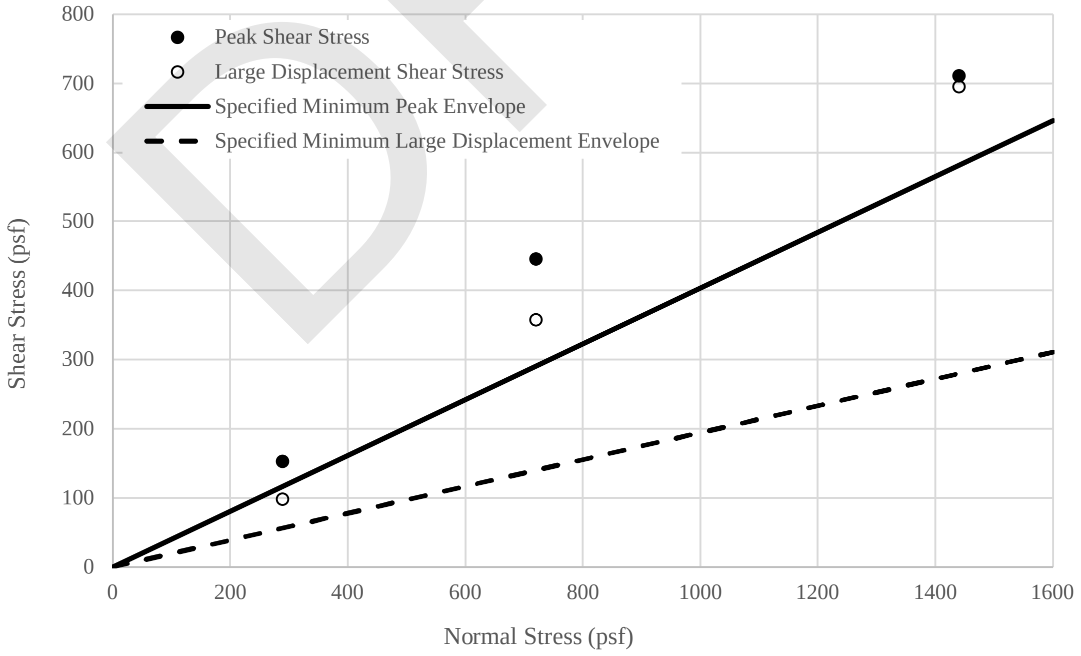
* Minimum Secant Angle results reported.

[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.

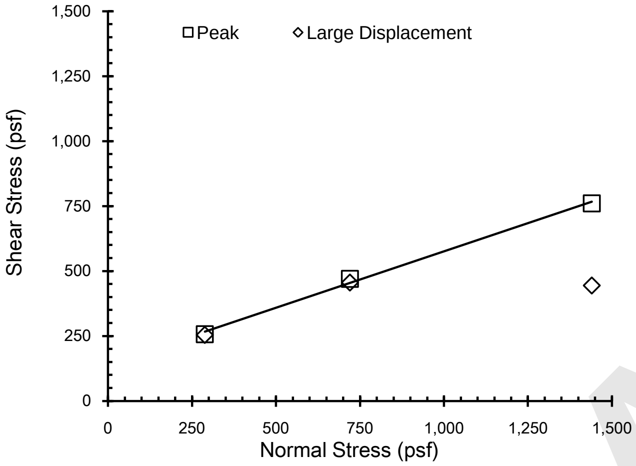
Figure K.1 - Interface Friction Testing Results Plot

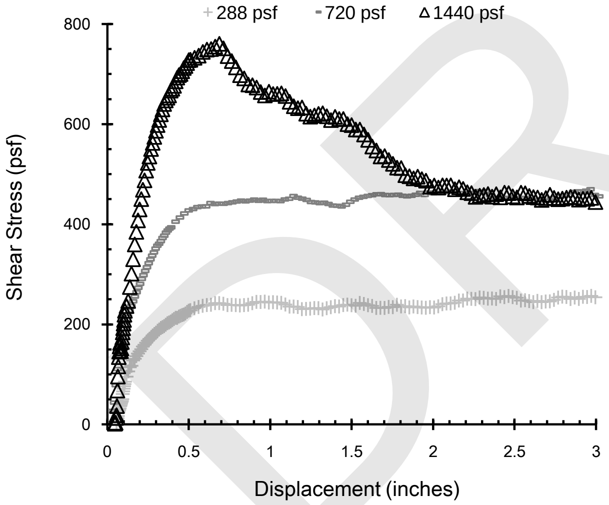


Multi-Layered Interface Friction Test (ASTM D5321 Modified)

Client:	Geosyntec Consultants	TRI Log #:	53888-3
Project:	Dynegy Energy	Richard S. Lacey, P.E.	3/9/2020
	Hennepin West Ash Pond System Closure	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

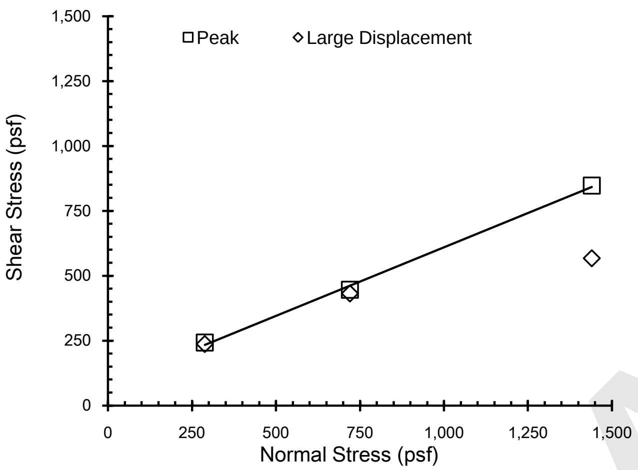
Shearing occurred at the TXGM vs Ash interface at 288 psf and 720 psf, and at the NWGT vs. TXGM interface at 1,440 psf.

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

Multi-Layered Interface Friction Test (ASTM D5321 Modified)

Client:	Geosyntec Consultants	TRI Log #:	53888-1
Project:	Dynegy Energy	Richard S. Lacey, P.E.	3/10/2020
	Hennepin West Ash Pond System Closure	Analysis & Quality Review/Date	

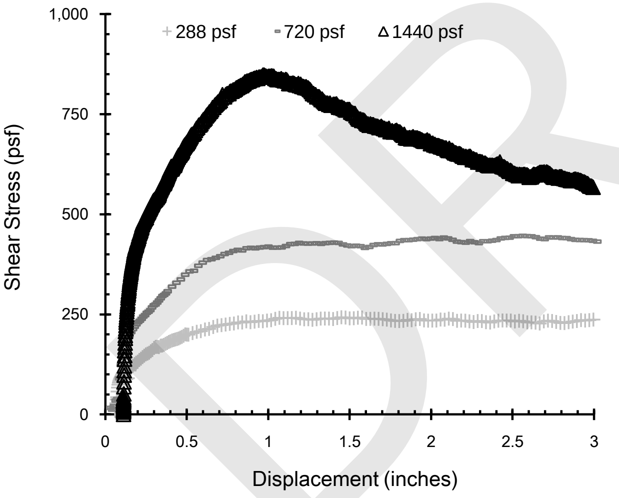
CB-03 (Clay) vs. Skaps NWGT GE116 (60771.1) vs. Skaps 40 mil LLDPE TXGM (3111002301) vs. CCR-1(coal ash) - Tamp



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

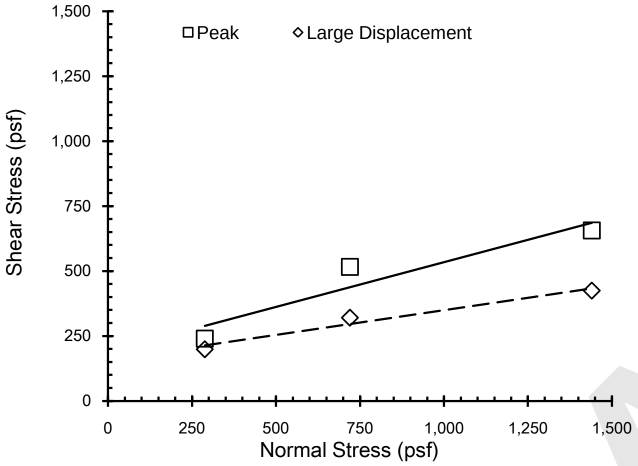
Shearing occurred at the TXGM vs Ash interface at 288 psf and 720 psf, and at the NWGT vs. TXGM interface at 1,440 psf.

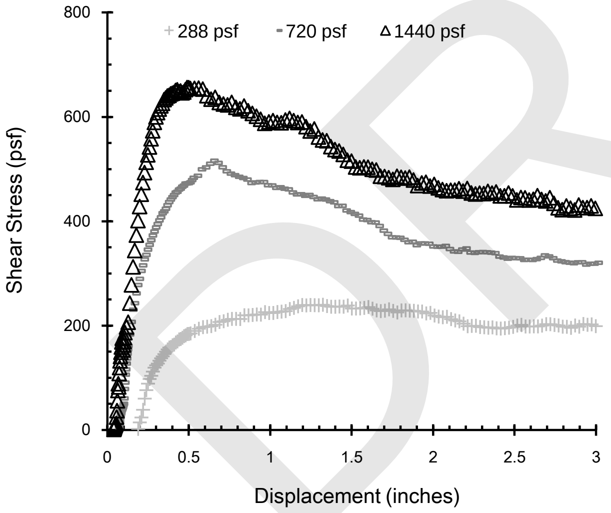
Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	243	446	847
	Secant Angle	deg.	40.1	31.8	30.5
Large Displacement	Shear Stress	psf	237	432	567
	Secant Angle	deg.	39.4	30.9	21.5
Asperity Height, Avg. of 5 Meas.		mils	32	32	31

Multi-Layered Interface Friction Test (ASTM D5321 Modified)

Client:	Geosyntec Consultants	TRI Log #:	53888-4
Project:	Dynegy Energy - Hennepin West Ash Pond System C	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

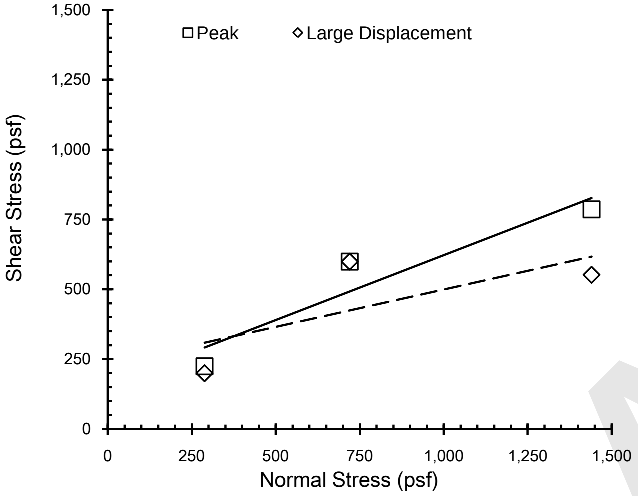
Shearing occurred at the DSGC vs. TXGM interface at all stresses.

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

Multi-Layered Interface Friction Test (ASTM D5321 Modified)

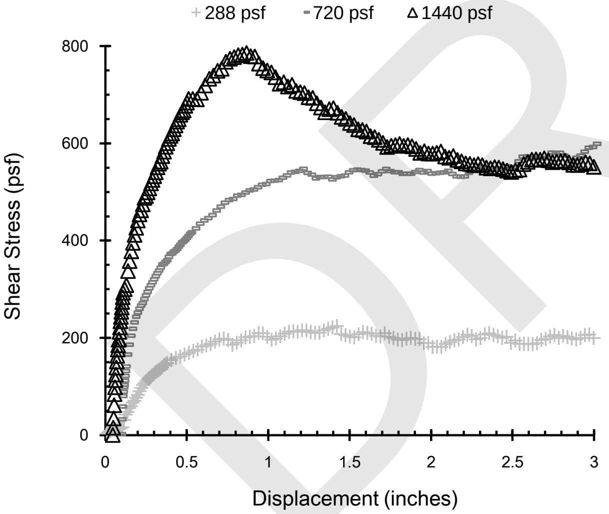
Client:	Geosyntec Consultants	TRI Log #:	53888-2
Project:	Dynegy Energy	Richard S. Lacey, P.E.	3/3/2020
	Hennepin West Ash Pond System Closure	Analysis & Quality Review/Date	

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

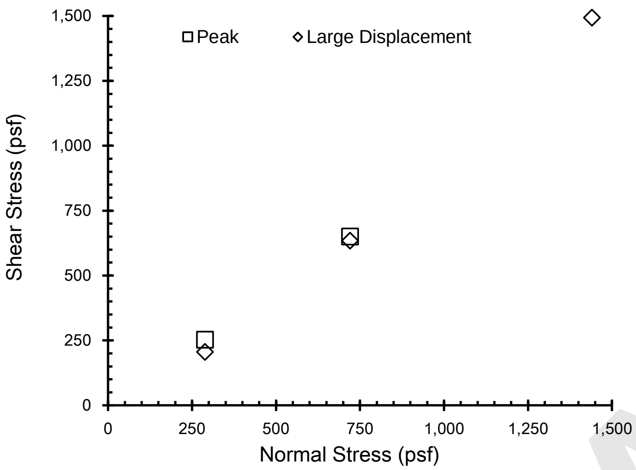
Shearing occurred at the Clay vs. NWGT interface at all stresses.

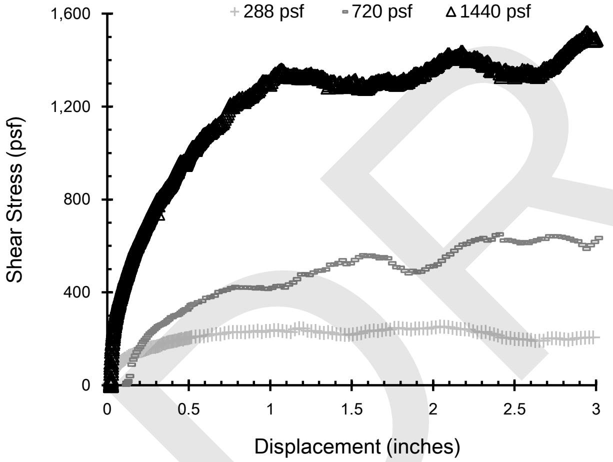
Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	224	599	786
	Secant Angle	deg.	37.9	39.8	28.6
Large Displacement	Shear Stress	psf	200	599	552
	Secant Angle	deg.	34.7	39.8	21.0
Asperity Height, Avg. of 5 Meas.		mils	32	33	31

Shear Strength of Geosynthetic-Geosynthetic Interface by Direct Shear (ASTM D5321)

Client:	Geosyntec Consultants	TRI Log #:	53888-7
Project:	Dynegy Energy - Hennepin	Richard S. Lacey, P.E.	5/26/2020
	West Ash Pond System Closure	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

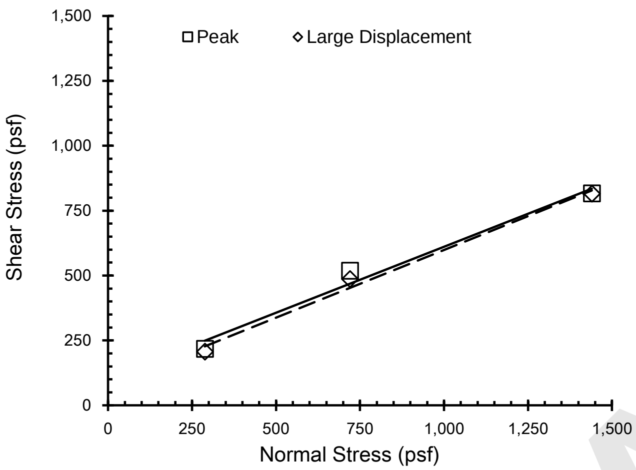
Shearing occurred at the interface at all stresses.

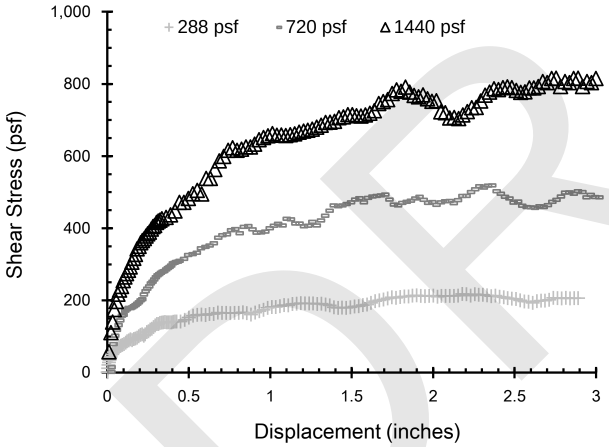
Specimen No.		-	1	2	3
Normal Stress		psf	288	720	1,440
Box Edge Dimension		in	12	12	12
Bearing Slide Resistance		lbs	11	15	22
Peak	Shear Stress	psf	253	649	1,517
	Secant Angle	deg.	41.3	42.1	46.5
Large Displacement	Shear Stress	psf	206	634	1,493
	Secant Angle	deg.	35.5	41.4	46.0

Shear Strength of Soil-Geosynthetic Interface by Direct Shear (ASTM D5321)

Client:	Geosyntec Consultants	TRI Log #:	53888-5
Project:	Dynegy Energy - Hennepin West Ash Pond System Closure	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

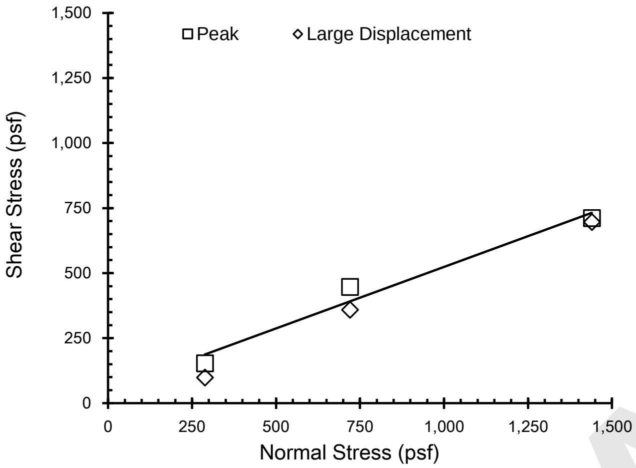
Shearing occurred at the interface at all stresses.

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

Shear Strength of Soil-Geosynthetic Interface by Direct Shear (ASTM D5321)

Client:	Geosyntec Consultants	TRI Log #:	53888-6
Project:	Dynegy Energy - Hennepin	Richard S. Lacey, P.E.	5/28/2020
	West Ash Pond System Closure	Analysis & Quality Review/Date	

SCS-03 vs.
Skaps 40 mil LLDPE TXGM (3111002301) - shiny side up



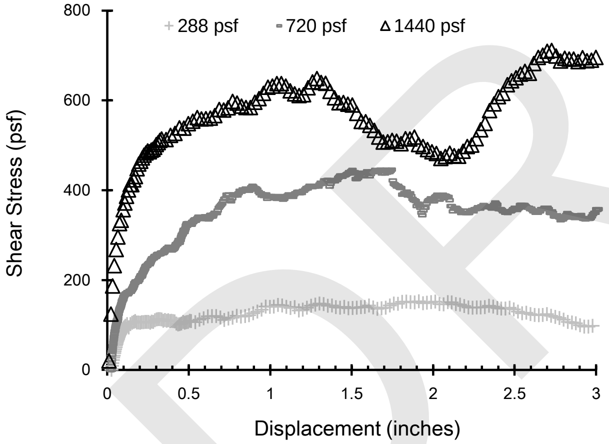
Test Results, Linear Regression

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

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		
$[a/\sin\beta]$	**D/B**	
2550.510	**11.58217133**	

E	***F***	***G***	
$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	**$[\tan\phi/(2\sin\beta\cos^2\beta)]/(1-\tan\beta\tan\phi)$**	**t/h**	**E x F x G**
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***	
$[\gamma_t$ x $(t-t_w) + \gamma_b$ x $t_w]$	**$[\gamma_t$ x $(t-t_w) + \gamma_{sat}$ x $t_w]$**	**tanδ/tanβ**	**[A/B] x C**
115.200	240.000	23.635	11.345

D	
[a/sinβ]	**D/B**
2550.510	**10.62712479**

E	***F***	***G***	
γ_t x $(t-t_w{}^*) + \gamma_b$ x $t_w{}^*]$/B	**[tanϕ/(2sinβcos$^2\beta$)]/(1-tanβtanϕ)**	**t/h**	**E x F x G**
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/$[\gamma_t$ x t x $\cos^2(\beta)]$	**tanϕ x $[1-(\gamma_w$ x $t_w)/(\gamma_t$ 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***	
[γ_t x (t-t_w) + γ_b x t_w]	**[γ_t x (t-t_w) + γ_{sat} x t_w]**	**tanδ/tanβ**	**[A/B] x C**
218.900	220.210	23.635	23.494

D	
[a/sinβ]	**D/B**
2550.510	**11.58217133**

E	***F***	***G***	
γ_t x (t-t_w*) + γ_b x t_w*]/B	**[tanϕ/(2sinβcos$^2\beta$)]/(1-tanβtanϕ)**	**t/h**	**E x F x G**
0.994	12.877	0.263	3.369

H	***I***	***J***	
1/B	**[1/(sinβcosβ)]/[1-tanβtanϕ]**	**ct/h**	**H x I x J**
0.005	50.535	0.000	0.000

A'	***B'***	***C'***	***D'***	**[A'+B'-C']/D'**
a/[γ_t x t x cos^2(β)]	**tanϕ x [1-(γ_w x t_w)/(γ_t x t)]**	**n_q x tanβ x tanϕ**	**n_q + tanβ**	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	
$[a/\sin\beta]$	**D/B**
0.000	**0**

E	***F***	***G***	
$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	**$[\tan\phi/(2\sin\beta\cos^{2}\beta)]/(1-\tan\beta\tan\phi)$**	**t/h**	**E x F x G**
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***	
$[\gamma_t$ x $(t-t_w) + \gamma_b$ x $t_w]$	**$[\gamma_t$ x $(t-t_w) + \gamma_{sat}$ x $t_w]$**	**$\tan\delta/\tan\beta$**	**[A/B] x C**
218.900	220.210	4.727	4.699

D	
$[a/\sin\beta]$	**D/B**
512.544	**2.327522168**

E	***F***	***G***	
γ_t x $(t-t_w^*) + \gamma_b$ x $t_w^*]/B$	**$[\tan\phi/(2\sin\beta\cos^2\beta)]/(1-\tan\beta\tan\phi)$**	**t/h**	**E x F x G**
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'**
$a/[\gamma_t$ x t x $\cos^2(\beta)]$	**$\tan\phi$ x $[1-(\gamma_w$ x $t_w)/(\gamma_t$ x t)]**	**n_q x $\tan\beta$ x $\tan\phi$**	**$n_q + \tan\beta$**	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*	
$[\gamma_t$ x $(t-t_w) + \gamma_b$ x $t_w]$	**$[\gamma_t$ x $(t-t_w) + \gamma_{sat}$ x $t_w]$**	**$\tan\delta/\tan\beta$**	**[A/B] x C**
115.200	240.000	4.727	2.269

D	
$[a/\sin\beta]$	**D/B**
512.544	**2.135598569**

E	*F*	*G*	
γ_t x $(t-t_w^*) + \gamma_b$ x $t_w^*]/B$	**$[\tan\phi/(2\sin\beta\cos^2\beta)]/(1-\tan\beta\tan\phi)$**	**t/h**	**E x F x G**
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'*
$a/[\gamma_t$ x t x $\cos^2(\beta)]$	**$\tan\phi$ x $[1-(\gamma_w$ x $t_w)/(\gamma_t$ x $t)]$**	**n_q x $\tan\beta$ x $\tan\phi$**	**$n_q + \tan\beta$**	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	
$[a/\sin\beta]$	**D/B**
512.544	**2.327522168**

E	***F***	***G***	
$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	**$[\tan\phi/(2\sin\beta\cos^2\beta)]/(1-\tan\beta\tan\phi)$**	**t/h**	**E x F x G**
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	
$[a/\sin\beta]$	**D/B**
0.000	**0**

E	***F***	***G***	
$\gamma_t \times (t-t_w^*) + \gamma_b \times t_w^*]/B$	**$[\tan\phi/(2\sin\beta\cos^2\beta)]/(1-\tan\beta\tan\phi)$**	**t/h**	**E x F x G**
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