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

Date
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Project No.
1940110241-004

CORRECTIVE ACTION PLAN

ELECTRIC ENERGY INC, JOPPA POWER PLANT, EAST ASH POND, IEPA ID NO. W1270100004-02

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CORRECTIVE ACTION PLAN ELECTRIC ENERGY INC, JOPPA POWER PLANT, EAST ASH POND, IEPA ID NO. W1270100004-02

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ACRONYMS AND ABBREVIATIONS

%	percent
35 I.A.C.	Title 35 of the Illinois Administrative Code
40 C.F.R.	Title 40 of the Code of Federal Regulations
amp	amperage
ASD	alternative source demonstration
bgs	below ground surface
CA	Corrective Action
CAAA	Corrective Action Alternatives Analysis
CAAA-SIR	Corrective Action Alternatives Analysis Supporting Information Report
CAP	Corrective Action Plan
CCA	compliance commitment agreement
CCR	coal combustion residuals
CIP	closure-in-place
CMA	Corrective Measures Assessment
COC	constituent of concern
CP	Construction Permit
CY	cubic yards
EAP	East Ash Pond, also referred to as Site
EEI	Electric Energy, Inc.
EQ	equalization
GMM	Geochemical Modeling Memorandum
gpm	gallons per minute
CA GMP	Corrective Action Groundwater Monitoring Plan
Gradient	Gradient Corporation
GWE	groundwater extraction
GWP	groundwater polishing
GWPS	groundwater protection standard(s)
HCR	Hydrogeologic Site Characterization Report
HDPE	high-density polyethylene
HP	horsepower
ID	identification
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
ISGS	Illinois State Geological Survey
ISWS	Illinois State Water Survey
JPP	Joppa Power Plant
LAU	lower aquifer unit
LCU	lower confining unit
NAVD88	North American Vertical Datum of 1988
No.	number
NPDES	National Pollutant Discharge Elimination System
OMM	Operation, Maintenance, and Monitoring
OP	Operating Permit
PCA	Preliminary Corrective Action
PWS	public water system

Ramboll	Ramboll Americas Engineering Solutions, Inc.
UA	uppermost aquifer
UCU	upper confining unit
USEPA	United States Environmental Protection Agency
VAC	volt alternating current

1. INTRODUCTION

1.1 Plant and Site Information

Electric Energy, Inc. (EEI) is the owner of the inactive coal-fired Joppa Power Plant (JPP), also referred to as the Joppa Power Station, in Joppa, Massac County, Illinois. This Corrective Action Plan (CAP) has been prepared for the East Ash Pond (EAP) at the JPP (Site). The EAP was present and operational prior to the promulgation of Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments [1]. The EAP is identified by Illinois Environmental Protection Agency (IEPA) identification (ID) number (No.) W1270100004-02, coal combustion residuals (CCR) Unit ID No. 401, and National Inventory of Dams No. of IL50714.

1.2 Organization of the Corrective Action Plan

This CAP is organized in the following manner:

- **Section 1** includes an introduction to the EAP, lists the status of other 35 I.A.C. § 845 permit applications submitted to IEPA, identifies the selected remedy, and provides a narrative of remedy construction;
- **Section 2** includes an overview of the Corrective Action process, including the results of the Corrective Measures Assessment (CMA) and Corrective Action Alternatives Analysis (CAAA);
- **Section 3** provides the CAP requirements, the selected remedy, an evaluation of effectiveness and an implementation schedule, as required by 35 I.A.C. § 845.670; and
- **Section 4** includes reference documents used in the development of this CAP.

This CAP was prepared as an attachment to a modification of the submitted Operating Permit (OP) application for the EAP as required by 35 I.A.C. § 845.200(a)(3).

1.3 Permit Status

The following 35 I.A.C. § 845 permit applications have previously been submitted to IEPA by EEI for the EAP:

- An OP application, as required by 35 I.A.C. § 845.230, was submitted on October 25, 2021 [2].
- A Construction Permit (CP) application for final closure of the EAP, as required by 35 I.A.C. § 845.220, including a CCR Surface Impoundment Final Closure Plan, as required by 35 I.A.C. § 845.720, was submitted on July 28, 2022 [3].
    - The Final Closure Plan selected closure-in-place (CIP) with a consolidate-and-cap approach as the most appropriate closure method for the EAP.

As of the date of this CAP, EEI's OP and final closure CP applications for the EAP are pending with IEPA.

1.4 Selected Corrective Action Remedy

Groundwater extraction (GWE) combined with the source control presented within the Final Closure Plan [4], has been identified as the most appropriate remedy for the EAP, based on the

CAAA provided in **Appendix A**. Potential remedies evaluated in the CAAA included Source Control with Groundwater Polishing (GWP), Source Control with GWE, and Source Control with a Deep Cutoff Wall.

The CAAA, which was prepared by Gradient Corporation (Gradient), was based on a CAAA Supporting Information Report (CAAA-SIR) that was prepared by Ramboll Americas Engineering Solutions, Inc. (Ramboll) and is attached to the CAAA. The CAAA-SIR includes the results of groundwater modeling and feasibility-level design information for each remedy.

A Groundwater Polishing Evaluation Report [5] is also attached to the CAAA. This report presents results from geochemical modeling of exceedance parameters addressed at the EAP by the CAP. Geochemical modeling supports the assessment of groundwater polishing as a component of the proposed corrective action by evaluating the potential for chemical attenuation of constituents of concern (COCs) before and after source control as a means of contextualizing the times to meet GWPS estimated in the flow and transport model.

1.4.1 Narrative Description of Selected Corrective Action Remedy

Corrective action will consist of the source control, as outlined in the Final Closure Plan for the EAP [4] and the operation of a GWE system, which will serve as a hydraulic containment system.

The proposed closure exceeds the minimum Closure Performance Standards listed in 35 I.A.C. § 845.750. The closure will include removing free liquids in accordance with the performance standard in 35 I.A.C. § 845. The closure will control infiltration in accordance with the performance standard in 35 I.A.C. § 845, thus removing the hydraulic head that can force leachate into subsurface soils and is the mechanism that can drive risk (United States Environmental Protection Agency [USEPA], 2015a, p. 21342):

> *EPA's risk assessment shows that the highest risks are associated with CCR surface impoundments due to the hydraulic head imposed by impounded water. Dewatered CCR surface impoundments will no longer be subjected to hydraulic head so the risk of releases, including the risk that the unit will leach into the groundwater, would be no greater than those from CCR landfills.*

The EAP will be closed using a consolidate-and-cap approach consisting of excavating nearly 1.8 million cubic yards of CCR [3] and placing it in a consolidated CCR footprint at an elevation greater than 15 to 50 feet above the uppermost aquifer (UA) and above the estimated post-closure water table. The consolidated CCR will be covered with an alternate geomembrane final cover system having performance that exceeds the 35 I.A.C. § 845.750(c)(2) minimum final cover requirements. The proposed source control is predicted to reduce water flux into and out of the EAP by greater than 99.9% and allow the GWPS to be achieved within approximately 11 years (**Appendix A**).

A GWE system is currently being implemented at the site as a preliminary corrective action (PCA), in accordance with the Compliance Commitment Agreement (CCA), dated May 21, 2024 [6]. The PCA system is expected to become operational in mid-2025 and will consist of a total of eight extraction wells situated along the eastern boundary of the site, east of the EAP. The wells will be utilized to contain and control easterly migration of COCs off site and towards the Village of Joppa, prior to the implementation of source control for the EAP. The eight extraction wells will pump groundwater to a system enclosure located in the middle of the extraction well transect. Extracted groundwater will be totalized, filtered (as necessary) and transferred from the system enclosure to the Settling Lagoon for discharge to the Ohio River via JPP Outfall 010 under a National Pollutant Discharge Elimination System (NPDES) permit for the site [7].

The GWE system will be installed as a PCA and it will continue to operate in accordance with this CAP. Few, if any, physical changes to the PCA are expected to occur post-EAP closure.

The GWE system will be continuously operated during the corrective action period, outside of routine shutdowns for system maintenance and/or power outages. Groundwater corrective action performance will be monitored in accordance with the Corrective Action Groundwater Monitoring Plan (CA GMP). The system operation will cease when concentrations in monitoring wells upgradient of the GWE do not exceed the GWPS and other considerations have been evaluated as described in the CA GMP Section 3.1.

Estimated timelines for GWE system operations and times to reach the GWPS will be periodically reviewed and updated based on observed corrective action performance via an adaptive site management strategy. These periodic, updated estimates will be communicated to IEPA and the public within annual corrective action monitoring reports, in accordance with the CA GMP.

Corrective action will be considered complete when a demonstration that GWPS compliance beyond the waste boundary has been achieved for at least three years after remedy operations have ceased and a corrective action completion report and certification have been submitted to IEPA in accordance with 35 I.A.C. § 845.680(e).

1.4.1.1 Narrative Discussion of Remedy Design and Function

The GWE design includes a total of eight extraction wells installed along a 2,700-foot alignment which generally runs from north to south along the existing site access road immediately east (hydrogeologically downgradient) of the JPP EAP and supporting infrastructure. Permit-level engineering drawings depicting the proposed remedy, which are the same as the in-progress PCA, are provided in **Appendix B**. Engineering calculations used to support the permit-level design of the remedy are provided in **Appendix C**.

- The groundwater extraction wells are spaced approximately 380 feet apart and advanced into the uppermost aquifer (UA).
- The UA typically ranges between 40 and 90 feet below ground surface (bgs) and is the most transmissive saturated zone capable of transporting CCR-derived constituents such as boron.
- Groundwater fate and transport modeling indicate an extraction flow rate of approximately 40 gallons per minute (gpm) will be needed at each extraction well to fully capture boron -impacted groundwater migrating towards the eastern boundary of the site.
- Extraction wells were constructed using pre-packed stainless steel well screens with carbon steel riser pipes joined using a di-electric union.
- Aquifer pump testing was conducted at each extraction well following installation to confirm groundwater recovery rates are sufficient to meet the design extraction rates.

Electrical infrastructure to support the GWE system will be installed prior to delivery and placement of the GWE system. System infrastructure will include:

- A 480-volt alternating current (VAC), 600-amperage (amp) power service, including supporting transformers and other infrastructure provided by Ameren Electric to power the GWE system.
- At each extraction well the following equipment will be installed:
    - Submersible pumps ranging from 2 horsepower (HP) to 10 HP that extract and deliver groundwater to the GWE system enclosure.
    - Extraction well pump control stations adjacent to each extraction well to power and control the submersible extraction well pumps.
- GWE system conveyance piping will be installed to route groundwater from the extraction wells to the system and outflow from the GWE system to the Settling Lagoon as follows:
    - 2-inch high-density polyethylene (HDPE) conveyance pipe will be buried in trenches between each extraction well and the GWE system gravel pad.
    - 6-inch HDPE conveyance piping will be buried in between the GWE system gravel pad and the Settling Lagoon.

A GWE system enclosure will be placed within the limits of a central gravel pad. The GWE system consists of two 40- by 8- by 8-foot shipping containers that will be merged together in the field. The system enclosure will contain the following equipment:

- An influent manifold consisting of control valves and flow meters to totalize extracted groundwater from each extraction well.
- Two 12,500-gallon cone bottom equalization (EQ) tanks, two 60-HP transfer pumps, four bag filter units, and miscellaneous electrical controls that allow for continuous automated operation, data collection and remote telemetry.

1.4.2 Narrative Description of Proposed Remedy Operations

The system will be operated in accordance with this Corrective Action Plan, and other applicable permits and regulations. OMM will be conducted on the GWE system on a routine basis. OMM will consist of system wide data collection to track groundwater recovery and discharge rates, filter changeouts (as needed), and to optimize the individual well extraction rates as needed under an adaptive site management strategy. Waste streams associated with the GWE system and their management may include:

- Spent bag filters will be allowed to air dry and will be disposed of as municipal waste in on-site dumpsters.
- Accumulated sediment/solids that collect at the bottom of the EQ tanks will be intermittently removed, dried, and disposed of at a non-hazardous landfill, as needed based on accumulation rates.
- The 2-inch and 6-inch HDPE conveyance piping will be flushed on an as-needed basis if solids accumulation is observed on the inner wall of the conveyance pipe during routine OMM inspections. Flush water will be placed in the Settling Lagoon.

Routine equipment maintenance will be conducted per recommendations provided by the GWE system manufacturer. Additionally, faulty equipment will be replaced as needed to keep the GWE system operating within design specifications. Equipment maintenance and/or replacements may require temporary shutdown of the GWE system.

1.4.3 Narrative Description of Proposed Groundwater Monitoring

Corrective action groundwater monitoring will be conducted in accordance with the CA GMP during remedy operation to evaluate the effectiveness of the corrective action remedy and whether groundwater concentrations are achieving the GWPS as predicted by the groundwater model. Groundwater data collected as part of the monitoring program will be analyzed to determine if the remedy is on track to meet GWPS and to inform adaptive management decisions if performance metrics are not achieved. Information associated with each of these activities is described below.

- Regular groundwater monitoring will be conducted utilizing a corrective action groundwater monitoring network designed in accordance with 35 I.A.C. § 845.680(c), which specifies that wells must be installed in the plume of contamination that lies beyond the waste boundary.
- Samples will be collected for each constituent required by 35 I.A.C. § 845.600(a)(1). Samples will be collected on a quarterly basis initially and potentially reduced to a semiannual basis once five years of monitoring have occurred, in accordance with 35 I.A.C. § 845.650(b)(4). Monitoring results will be submitted to IEPA for each monitoring event, in addition to an annual groundwater monitoring and corrective action report, in accordance with 35 I.A.C. § 845.610(e).
- Routine maintenance of the monitoring well network will include inspecting the wells, making repairs to the wells (as needed) and rehabilitating and/or replacing wells to improve performance (as needed).
- Adaptive Site Management will include updates to geochemical models for each location with GWPS exceedances.
    - The available solid-phase data from the aquifer and these models will be used to identify potential mobilization of other COCs as groundwater returns to background conditions.
    - Groundwater monitoring results will be evaluated for consistency with modeled concentrations and documented in the monitoring reports submitted to IEPA, in accordance with 35 I.A.C. § 845.610(e)
    - If groundwater does not match expected conditions, additional methods or techniques to achieve compliance with GWPS will be evaluated and, if feasible, implemented in accordance with 35 I.A.C. § 845.680(b). These actions could include, for example, an increase or decrease in individual extraction well flow rates, the installation of additional extraction wells to enhance groundwater recovery, and the installation of additional monitoring wells to obtain groundwater data necessary to support decisions made under the adaptive management strategy.
- Corrective Action Confirmation Monitoring and Completion
    - Per 35 I.A.C. § 845.680(c), corrective action is considered complete when compliance with the GWPS has been demonstrated for at all points within the plume of contamination that lies beyond the waste boundary […] for a period of

three consecutive years. At that time, an attainment evaluation will be implemented. This will include monitoring each well for three additional years to confirm that GWPS have been achieved, in accordance 35 I.A.C. § 845.680(c).

  - It should be noted that post-closure care groundwater monitoring required for a 30-year period by 35 I.A.C. § 845.780(c) will continue to occur after corrective action groundwater monitoring is expected to be completed.

- After completion of the corrective action confirmation monitoring period, a Corrective Action Completion Report and Certification will be prepared and submitted to IEPA, in accordance with 35 I.A.C. § 845.680(e).

2. CORRECTIVE ACTION OVERVIEW

This CAP is based on the tiered assessment and analysis of alternative remedial technologies and remedies that were completed via the CMA and CAAA (**Appendix A**). The objective of these assessments was to determine the optimal alternative for the EAP that, when coupled with the source control proposed in the Final Closure Plan [4], would remediate groundwater and provide compliance with the GWPS specified under 35 I.A.C. § 845.600.

2.1 Integration of Corrective Action with Source Control (Final Closure)

All documents, assessments, and analyses performed as part of this CAP assume that the source control presented in the Final Closure Plan [4] for the EAP will also be implemented. Source control is the primary corrective action for the EAP and will consist of removing free liquids from the CCR and completing CIP with a consolidate-and-cap approach. This is estimated to include moving a total of 1.8 million cubic yards (CY) of CCR and reducing the final footprint of the EAP from 128 to 74 acres. Source control will also include removing approximately 580,000 CY of CCR from a 32-acre area outside of the limits of the EAP for beneficial use for contouring and grading beneath the final cover system. When source control is completed, the remaining CCR in the EAP is expected to be located at least 10 feet above the groundwater table and 15 feet above the UA under post-closure conditions, in addition to being fully encapsulated on all sides by underlying native soils, low-permeability embankment dikes, and a low-permeability final cover system.

Source control alone, without other supplemental corrective action, has been estimated via groundwater modeling to reduce the infiltration of liquids into the EAP by 99.9 percent (%) and the hydraulic flux out of the EAP by 99.9%, relative to pre-closure conditions. Groundwater modeling performed to support the Final Closure Plan estimates that source control activities are expected to result in GWPS being achieved approximately 10 years after closure completion, without implementing other forms of corrective action [8].

The remedy presented in this CAP is supplemental to the removal of free liquids, completion of source control via closure, and placing the CCR above the groundwater table and UA, which when combined, are the primary remedial action that will be performed at the site.

2.2 Corrective Measures Assessment

The CMA [9] was performed for the EAP and submitted to the IEPA on April 18, 2024, after the exceedances of the GWPS were identified. The CMA considered four corrective measures for the EAP, including:

- Source Control with GWP
- Source Control with GWE
- Source Control with Groundwater Cutoff Wall
- Source Control with In-Situ Chemical Treatment

Based on the CMA, three corrective measures, including Source Control-GWP, Source Control-GWE, and Source Control-Deep Cutoff Wall, were identified as potentially viable corrective measures for the EAP and were included for further evaluation, design advancement, and comparative assessment within the CAAA for the EAP. The other corrective measure was determined by the CMA to be unlikely to be viable for the EAP and was not evaluated further within the CAAA.

2.3 Analysis of Corrective Action Alternatives

2.3.1 Corrective Action Alternatives Analysis Supporting Information Report

The CAAA for the EAP was prepared by Gradient based on the CAAA-SIR prepared by Ramboll. The CAAA-SIR, which is included as Attachment B of the CAAA provided in **Appendix A**, included additional evaluation, design advancement, and comparative assessment of the Source Control-GWP, Source Control-GWE, and Source Control-Deep Cutoff Wall corrective measures identified as potentially viable for the EAP by the CMA. The evaluation included the completion of feasibility-level design activities for each alternative and incorporated the following tasks:

- Performing predictive groundwater modeling to evaluate the scope (*i.e.,* location and extents) of each alternative and the corresponding estimated time to achieve GWPS;
- Developing feasibility-level design drawings showing the extents in plan and elevation view of each engineered remedy;
- Estimating the time required to design, construct, and implement each remedy, in addition to ongoing operational and maintenance requirements;
- Developing conceptual plans for the storage, treatment, and discharge of extracted groundwater for applicable remedies;
- Identifying future tasks required to implement each alternative, including permitting, investigation, and design efforts; and
- Estimating relevant material quantities, labor hours, delivery miles, equipment miles, and daily commuting miles associated with constructing each remedy.

2.3.2 Corrective Action Alternatives Analysis

The CAAA (**Appendix A**) included a detailed analysis of each of the corrective action alternatives presented in the CAAA-SIR, including an evaluation of:

- Long and short-term effectiveness and protectiveness;
- Ease or difficulty of implementation;
- Degree to which community concerns are addressed; and,
- Relative amount of contamination removed from the environment.

Based on the CAAA, the Source Control-GWE was identified as the most appropriate corrective action for the EAP and was selected for further design development as part of this CAP.

It should be noted that the permit-level engineering assessments, groundwater modeling, and other information contained within this CAP were developed to a higher level of design and detail than those assessments performed in the CAAA; therefore, information on items such as permitting, remedy scope, estimated time to reach GWPS, implementation schedule, etc. may differ between this CAP and the information included in the CAAA-SIR and CAAA. Information for the Source Control-GWE contained within the CAP should be considered to superseded information contained within the CAAA and CAAA-SIR.

3. CORRECTIVE ACTION PLAN

The 35 I.A.C. § 845 requirements for the CAP and corresponding demonstrations that the proposed corrective measures meet these requirements are discussed individually in this section. Many of the CAP requirements are discussed within the CMA and CAAA documents that have been prepared to support the CAP. Therefore, the demonstrations will also refer to those documents.

3.1 General Requirements

35 I.A.C. § 845.670(c): The corrective action plan must meet the following requirements:

> *(1) Be based on the results of the corrective measures assessment conducted under 35 I.A.C. § 845.660;*
>
> *(2) Identify a selected remedy that at a minimum, meets the standards listed in subsection (d);*
>
> *(3) Contain the corrective action alternatives analysis specified in subsection (e); and*
>
> *(4) Contain proposed schedules for implementation, including an analysis of the factors in subsection (f).*

This CAP is based on the results of the CMA and CAAA, which are included within **Appendix A**. The proposed schedule for implementing Source Control-GWE is provided in **Table 1**.

3.2 Remedy Selection

35 I.A.C. § 845.670(d): The selected remedy in the corrective action plan must:

(1) Be protective of human health and the environment;

Current conditions at the EAP pose no risk to human health or the environment. Concentrations of CCR-derived constituents are anticipated to decline once the EAP is closed and the GWE remedy is in place as presented in the CAAA [10] **Appendix A**. The GWE system will provide hydraulic control and prevent easterly migration of groundwater as CCR-derived constituent concentrations decline below the GWPS.

(2) Attain the groundwater protection standards specified in 35 I.A.C. § 845.600;

Groundwater modeling used to support design of the GWE system (Appendix B of the CAAA-SIR) indicates the selected remedy of source control with GWE will attain the GWPS.

(3) Control the sources of releases to reduce or eliminate, to the maximum extent feasible, further releases of constituents listed in 35 I.A.C. § 845.600 into the environment;

The EAP will be closed using a consolidate-and-cap approach which will act as the main source control mechanism to prevent further releases of CCR-derived constituents. The GWE system will prevent further off-site migration of CCR-derived constituents in groundwater until the GWPS are achieved.

The main source of CCR-derived constituent release occurred as a result of surface water infiltration coming into contact with EAP CCR. The GWE system was designed to achieve hydraulic containment to prevent off-site migration of CCR-derived constituents. If the remedy is found to be unsuccessful in meeting remediation goals adaptive site management actions will be taken as described within the CA GMP (Appendix B).

(4) Remove from the environment as much of the contaminated material that was released from the CCR surface impoundment as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and

No known releases of CCR due to a structural integrity issue have occurred at the EAP. However, CCR is present in a 32-acre area outside of the limits of the EAP, which has been identified as the Southeast Area. This area will be addressed as part of source control (e.g., final closure) activities for the EAP and will include removing the CCR and up to one foot of underlying soils from this area and beneficially using the materials as compacted subgrade fill below the final cover system within the closure-in-place area of the EAP. The Southeast Area and corresponding source control activities are discussed in more detail in the Final Closure Plan [4].

(5) Comply with standards for management of wastes as specified in 35 I.A.C. § 845.680(d).

The CCR managed as part of the closure will be done in accordance with all 845 requirements and the submitted closure plan [4].

3.3 Schedule for Implementation

GWE is effective as an engineered control as it provides hydraulic containment at the site boundary, will protect the value of the upper aquifer during remedy operation, and has been demonstrated as a reliable and applicable ex-situ remedial technology by the USEPA **[11]**. GWE will be implemented as both a PCA and the final CA. The purpose of GWE as a PCA is to protect human and ecological receptors until source control is in place. GWE will continue to operate as the CA following source control until GWPS have been met.

The GWE remedy was evaluated to determine if it can be successfully implemented to achieve GWPS compliance in a timely manner in accordance with 35 I.A.C. § 845.670. Timeframes to attain GWPS in the CA monitoring network wells are estimated in **Table A**:

Table A. Estimated Timeframes to Attain GWPS in Groundwater Monitoring Wells

Description	1 years**	3 years**	5 years**	8 years**	10 years**
Percentage of Wells predicted to attain GWPS*	17 %	33%	58 %	83 %	100 %

*: 12 wells, part of current monitoring network, were used in 2025 Groundwater Modeling Technical Memorandum.
‡** Years counted starting from completion of source control.

<u>35 I.A.C. § 845.670(f)</u>: The owner or operator must specify, as part of the corrective action plan, a schedule for implementing, of and completing, remedial activities. The schedule must require the completion of remedial activities within a reasonable time, taking into consideration the factors in this subsection (f). The owner or operator of the CCR surface impoundment must consider the following factors in determining the schedule of remedial activities:

The schedule implementing and completing the Source Control-GWE remedy at the EAP is included in **Table B**. The GWE system remedy will already be implemented as a PCA and will be continuously operated during the corrective action period.

The schedule will result in completion of remedial activities within a reasonable timeframe considering the factors specified by 35 I.A.C. §§ 845.670(f)(1) through (5), as summarized below.

35 I.A.C. § 845.670(f)(1): Extent and nature of contamination, as determined by the characterization required under 35 I.A.C. § 845.650(d);

The Nature and Extent Report [12] which was submitted to the IEPA on April 18, 2024 and is included as an attachment to the CAAA provided as **Appendix A**, details exceedances of GWPS. Groundwater modeling and geochemical analysis were performed by Ramboll as part of the CAAA-SIR to design the remedy, and the modeling considered the nature and extent of contamination.

35 I.A.C. § 845.670(f)(2): Reasonable probabilities of remedial technologies achieving compliance with the GWPS established by 35 I.A.C. § 845.600 and other objectives of the remedy;

Several remedies were evaluated in the CAAA and it was determined that the selected remedy (Source Control–GWE) is expected to achieve compliance with 35 I.A.C. § 845.600. Groundwater modeling [13] was performed to evaluate future groundwater quality in the vicinity of the EAP impoundment. The results of the modeling indicate that groundwater will attain the GWPS for all constituents within approximately 10 years after closure.

As discussed in the CMA, source control and groundwater extraction are proven methods for addressing groundwater contamination [9]. The proposed consolidate-and-cap approach is consistent with the requirements of 40 CFR Section 257 and 35 I.A.C. § 845. The proposed cover has been demonstrated to be compliant by equivalency in the CP Application [3].

35 I.A.C. § 845.670(f)(3): Availability of treatment or disposal capacity for CCR managed during implementation of the remedy;

The selected remedy includes CIP and GWE. The CCR will be managed within the footprint of the existing CCR Unit as proposed in the Final Closure Plan [4]. The GWE system manages groundwater and, therefore, the treatment and disposal capacity of CCR is not an applicable consideration for the selected remedy.

35 I.A.C. § 845.670(f)(4): Potential risks to human health and the environment from exposure to contamination before completion of the remedy;

A Human Health and Ecological Risk Assessment was completed and included as an attachment to the CAAA (**Appendix A**). The overall conclusion is that groundwater from the EAP impoundment and potential groundwater contributions to surface water pose no unacceptable risks to human health or the environment. This conclusion is based on modeled and detected maximum concentrations of all COCs in surface water at the NPDES permitted discharge that were below conservative risk-based screening benchmarks. This conclusion was reached using methodology consistent with applicable IEPA and USEPA risk assessment principles. The assessment relied on conservative assumptions meant to overestimate possible exposures and risks and provide an additional level of certainty in the conclusions [10].

<u>35 I.A.C. § 845.670(f)(5):</u> Resource value of the aquifer, including:

The resource value of the aquifer is discussed in the Hydrogeologic Site Characterization Report (HCR) [14], which is included as Attachment B.3 in the closure Construction Permit application [3]. The EAP is located on the Southeastern Coastal Plain Aquifer System, which is designated as a principal aquifer. A principal aquifer is defined as a regionally extensive aquifer or aquifer system that has the potential to be used as a source of potable drinking water. The GWE remedy is being installed as a PCA in 2025 in order to protect the aquifer until source control is in place at which time the GWE remedy will operate until the GWPS are achieved. Paragraphs (A) through (F) from 35 I.A.C. § 845.670(f)(5) are further addressed, as summarized below.

<u>35 I.A.C. § 845.670(f)(5)(A)</u>: Current and future uses, including potential residential, agricultural, commercial industrial and ecological uses; and

Current uses and users of the groundwater are discussed in the HCR Section 5.1 and attachments and, were considered in the CAAA as part of the Human Health and Ecological Risk Assessment which concluded that groundwater from the EAP impoundment and potential groundwater contributions to surface water pose no unacceptable risks to human health or the environment. No changes in future residential, commercial, or ecological use are expected. In the absence of any changes to current and future uses there is no applicable scheduling consideration.

<u>35 I.A.C. § 845.670(f)(5)(B)</u>: Proximity and withdrawal rate of users;

A water well inventory was completed in 2021 utilizing federal and state databases to assess nearby pumping wells, drinking water receptors, and other uses of water in the vicinity of the EAP. The database survey was supplemented with a windshield survey, in-person inquiries, and distribution of a letter to all residents in the Village of Joppa inquiring about the presence of wells. No potable wells were identified from these activities. There are no known wells screened within the sand and gravel downgradient of the EAP [15].

Based on records obtained from IEPA, Illinois State Geological Survey (ISGS), and Illinois State Water Survey (ISWS); there is one result for a public water system (PWS) located within 1,000 meters of the EAP that is screened in the upper limestone bedrock. The Joppa PWS (ID IL1270100, Joppa CWS #2), which was reported to serve 462 people, was identified to be approximately 870 meters to the southeast and downgradient of the EAP. However, historical field verification has identified the actual location of the well at approximately 1,070 meters from the EAP. The Joppa PWS obtains groundwater sourced from the limestone bedrock and its capacity is approximately 190 gpm. Monitoring wells G13M, G20M, and G21M, in addition to Joppa CWS #2 were sampled in 2022 and 2023 to evaluate whether the EAP had impacted groundwater within the LAU. Results indicated there were no elevated concentrations of boron in the LAU and the measured water levels generally indicated upward gradients [16].

In response to the observed offsite migration of boron in groundwater, the GWE remedy is being installed as a PCA in 2025 to reduce off-site migration of groundwater toward the Village of Joppa in accordance with the CCA [5]. The GWE will also be continuously operated during the corrective action period.

<u>35 I.A.C. § 845.670(f)(5)(C)</u>: Groundwater quantity and quality;

Per 35 I.A.C. § 620.210, groundwater within the uppermost aquifer at the EAP meets the definition of Class I – Potable Resource Groundwater [14] . The Human Health and Ecological Risk Assessment [10]concluded that groundwater from the EAP impoundment and potential groundwater contributions to surface water pose no unacceptable risks to human health or the environment. The GWE system will be operational in 2025, extracted groundwater will be managed in accordance with this Corrective Action Plan, and other applicable permits (e.g., NPDES permit).

<u>35 I.A.C. § 845.670(f)(5)(D)</u>: The potential impact to the subsurface ecosystem, wildlife, other natural resources, crops, vegetation, and physical structures caused by exposure to CCR constituents;

Potential surface receptors are discussed in HCR Sections 5.2 and 5.3. A survey to identify surface water features, nature preserves, and historic sites was conducted for a 1,000-meter radius around the EAP. Section 3.5 of the Human Health and Ecological Risk Assessment included as Appendix A of the CAAA and CMA/CAAA Report discusses the ecological risk evaluation.

- Ecological receptors exposed to surface water include aquatic and marsh plants, amphibians, reptiles, and fish. The risk evaluation showed that none of the COIs in surface water exceeded protective screening benchmarks.
- Ecological receptors exposed to sediment include benthic invertebrates. The modeled sediment COIs did not exceed the 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). Based on US EPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update) [17], mercury and selenium were identified as bioaccumulative COIs. However, the maximum detected concentration for mercury and the maximum detection limit for selenium (which was undetected) in surface water were below benchmarks protective of bioaccumulative effects. In addition, modeled sediment concentrations were also below benchmarks protective of bioaccumulative exposures.

Overall, this evaluation demonstrated that none of the COIs evaluated are expected to pose an unacceptable risk to ecological receptors. However, in response to the observed off-site migration of boron in groundwater, the GWE remedy is being installed as a PCA in 2025 to reduce off-site migration of groundwater in accordance with the CCA [6]. In the absence of any unacceptable risks to ecological receptors there is no applicable scheduling consideration.

<u>35 I.A.C. § 845.670(f)(5)(E)</u>: The hydrogeologic characteristic of the facility and surrounding land; and

In addition to the CCR present in the EAP, there are five layers of unlithified material present above the bedrock, which were categorized into three hydrostratigraphic units. Underlying the constructed CCR unit, the four (including bedrock) hydrostratigraphic units in descending order are:

- Upper confining unit (UCU) - Low permeability silt and clay of the Equality Formation, silts of the Peoria/Roxana/Loveland, and clay and silt of the Metropolis Formation are considered the UCU. This unit was encountered in all borings advanced on-site and limits the vertical migration of CCR impacts into the UA.
- Uppermost aquifer (UA) **-** High permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation. The UA was encountered at elevations ranging from 222.6 to 318.6 feet North American Vertical Datum of 1988 (NAVD88).
- Lower confining unit (LCU) **-** Clay and silt of the Lower McNairy Formation that was encountered in all borings advanced to bedrock. Based on material description, continuous lateral extent, and observed vertical gradients, this unit is identified as the LCU.
- Lower aquifer unit (LAU) **-** Lowermost unit identified at the site and underlies all unlithified deposits. This unit is comprised of the Salem Limestone, which is the uppermost lithified unit at the Site, and used as a potable and non-potable water supply in the vicinity of the JPP.

The effects of these hydrostratigraphic units on schedule were considered by incorporating the geometry, hydraulic, and geochemical properties of these units into the groundwater modeling and groundwater polishing evaluation reports, attached to the CAAA-SIR and CAAA, respectively, included in **Appendix A**, which estimate the time to reach the GWPS for remedial alternatives.

The GWE remedy will provide hydraulic capture of groundwater migrating through the UA and reduce off-site migration. No off-site migration of CCR-derived constituents is expected to occur in the UCU or LCU due to the low transmissivity of these lithological units. No exceedances have been detected in the LAU. The GWE remedy is being installed as a PCA in 2025 until source control is in place at which time the GWE remedy will operate until the GWPS are achieved.

35 I.A.C. § 845.670(f)(5)(F): The availability of alternative water supplies.

As discussed in subsection 670(f)(5)(B) above, there is one PWS well within 1,000 meters of the EAP. There is currently no need for an alternative water supply well as there are no current unacceptable risks to any human or ecological receptors at the site and the GWE remedy will prevent off-site migration of EAP CCR-derived constituents.

35 I.A.C. § 845.670(f)(6): Other relevant factors.

No additional factors were identified for consideration.

3.4 Necessity of Interim Measures

Source control using the consolidate-and-cap approach is projected to be complete within four to six years after approval of the CP Application [3]. 35 I.A.C § 845.680(a)(3) states interim measures are required to reduce the constituents leaching from the CCR surface impoundment, and/or potential exposures to human or ecological receptors. GWE is being implemented in accordance with the CCA as a PCA prior to implementation of source control. Further, all subsections of this requirement are discussed as follows.

35 I.A.C. § 845.680(a)(3)(A): Time required to develop and implement a final remedy.

Source control-GWE has already been evaluated and a design was completed prior to the submittal of this CAP. The GWE portion of the remedy will be implemented as a PCA prior to implementation of source control.

35 I.A.C. § 845.680(a)(3)(B): Actual or potential exposure of nearby populations or environmental receptors to any of the constituents listed in 35 I.A.C. § 845.600.

There are no current unacceptable risks to human or ecological receptors at the site [10]. A windshield survey conducted in the Village of Joppa and subsequent in-person inquiries found no evidence to suggest any current residents rely on groundwater from the UA as their primary source of drinking water. A letter distributed to all residents within the Village of Joppa to identify wells that may not have been included in the original searches also did not result in identification of any existing wells. The Village Well was sampled on two occasions and no exceedances were identified. Additionally, the installation of the preliminary corrective action GWE system prevents off-site migration of groundwater towards Joppa Village. Because dissolved constituent concentrations are expected to decline due to source controls and corrective actions, there would also be no future risks to human and ecological receptors.

35 I.A.C. § 845.680(a)(3)(C): Actual or potential contamination of sensitive ecosystems or current or potential drinking water supplies.

As stated above, there are no current unacceptable risks to human or ecological receptors at the site. Additionally, an ecological risk assessment was completed [10] and no unacceptable risks were identified for ecological receptors exposed to surface water and sediment.

35 I.A.C. § 845.680(a)(3)(D): Further degradation of the groundwater that may occur if remedial action is not initiated expeditiously.

GWE will be implemented as a PCA prior to implementation of source control which consists of the consolidate and cap approach. The GWE system is designed to prevent off-site migration of groundwater within the UA.

35 I.A.C. § 845.680(a)(3)(E): Weather conditions that may cause any of the constituents listed in 35 I.A.C. § 845.600 to migrate or be released.

As stated above, the GWE system will prevent off-site migration of CCR-impacted groundwater in the UA which includes CCR leachate caused by infiltration from weather related phenomena.

35 I.A.C. § 845.680(a)(3)(F): Potential for exposure to any of the constituents listed in 35 I.A.C. § 845.600 as a result of accident or failure of a container or handling system.

As stated above, the GWE system is designed to prevent off-site migration of CCR-impacted groundwater in the UA which includes any potential accident or failure of a container or handling system resulting in impacts to groundwater.

35 I.A.C. § 845.680(a)(3)(G): *Other situations that may pose threats to human health and the environment.*

No other situations have been identified where EAP CCR leachate poses threats to human health and the environment.

4. REFERENCES

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[14] I. Ramboll Americas Engineering Solutions, "Hydrogeologic Site Characterization Report, Joppa Power Plant East Ash Pond," October 2021.

[15] Ramboll, "Village of Joppa Well Survey and Community Water Supply Results," June 2022.

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[17] USEPA, "Region 4 Ecological Risk Assessment Supplemental Guidance," 2018.

TABLES

Table 1. Proposed Milestone Schedule for Implementing Corrective Action Remedy (Groundwater Extraction)

Corrective Action Plan
Joppa Power Plant
East Ash Pond
Joppa, IL

Implementation Phase	Implementation Task	Timeframe* (Preliminary Estimates)
Corrective Action O&M and Closeout	Corrective Action O&M (Time to Meet GWPS)	120 months
	Corrective Action Confirmation Monitoring	36 months
	Corrective Action Completion	6 months
	Timeframe to Complete Corrective Action O&M and Closeout	162 months
	Total Timeline to Complete Corrective Action (after completion of source control)	162 months (14 years)

*All timeframes are assumed to start after source control (e.g., final closure of the surface impoundment) is complete and a corrective action plan permit has been issued by IEPA, whichever is longer.

APPENDIX A
CORRECTIVE ACTION ALTERNATIVES ANALYSIS (845.670(E)), INCLUDING CORRECTIVE MEASURES ASSESSMENT (845.660)

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

February 13, 2025

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Abbreviations

BMP	Best Management Practice
CAA	Closure Alternatives Analysis
CAAA	Corrective Action Alternatives Analysis
CA GMP	Corrective Action Groundwater Management Plan
CCR	Coal Combustion Residual
CIP	Closure-in-Place
cm/s	Centimeters per Second
CMA	Corrective Measures Assessment
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CY	Cubic Yard
EAP	East Ash Pond
EEI	Electric Energy Inc.
GHG	Greenhouse Gas
GMP	Groundwater Monitoring Plan
GWE	Groundwater Extraction
GWP	Groundwater Polishing
GWPS	Groundwater Protection Standard
IAC	Illinois Administrative Code
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
JPP	Joppa Power Plant
LAU	Lower Aquifer Unit
LCU	Lower Confining Unit
LLDPE	Linear Low-Density Polyethylene
N_2O	Nitrous Oxide
NID	National Inventory of Dams
NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
PCB	Polychlorinated Biphenyl
PCA	Preliminary Corrective Action
PM	Particulate Matter
PMP	Potential Migration Pathway
QA	Quality Assurance
QC	Quality Control
SFWA	State Fish and Wildlife Area
Source Control-Deep Cutoff Wall	Source Control with a Deep Cutoff Wall
Source Control-GWE	Source Control with Groundwater Extraction
Source Control-GWP	Source Control with Groundwater Polishing
TSS	Total Suspended Solids
UA	Uppermost Aquifer
UCU	Upper Confining Unit

US DOT	United States Department of Transportation
US EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

Summary of Findings

Title 35, Part 845 of the Illinois Administrative Code (IAC) (IEPA, 2021) requires that a Corrective Action Alternatives Analysis (CAAA) be performed as part of the remedy selection, prior to undertaking any corrective actions at certain coal combustion residual (CCR)-containing impoundments where exceedances of groundwater protection standards (GWPSs) have been identified. This report presents a CAAA for the East Ash Pond (EAP) at the Joppa Power Plant (JPP) pursuant to the requirements under IAC Section 845.670. The goal of performing a CAAA is to holistically evaluate the potentially viable corrective actions identified in the Corrective Measures Assessment (CMA; Appendix C; Ramboll, 2024) in order to remediate groundwater and achieve compliance with GWPSs specified under IAC Section 845.600 (IEPA, 2021). These analyses assess potentially viable corrective action alternatives based on a wide range of factors, including the efficiency, reliability, and ease of implementation of a corrective action; its potential positive and negative short- and long-term impacts on human health and the environment; and its ability to address concerns raised by the community (IEPA, 2021).

It is important to note that many CCR sites are complex groundwater environments where remedial actions would 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 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 the United States Environmental Protection Agency (US EPA) refused to specify what is a reasonable *versus* an unreasonable timeframe for groundwater corrective actions at CCR sites, stating that it "was truly unable to establish an outer limit on the necessary timeframes – including even a presumptive outer bound" (US EPA, 2015a).

In this CAAA, all corrective actions that have been evaluated consist of source control and residual plume management. Source control 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). US EPA has also stated that source control is the most effective means of ensuring the timely attainment of remediation objectives (US EPA, 2015). As a result, the implementation of source control often has a substantial and immediate effect on groundwater quality improvements.

The specific source control method that is the central component of all the corrective action alternatives evaluated in this CAAA is closure-in-place (CIP) using a consolidate-and-cap approach. Specifically, this includes the removal of free liquids, excavation and consolidation of CCR into the western portion of the EAP, and the installation of a low-permeability final cover system. These activities are designed to control, minimize, or eliminate post-closure infiltration of liquids into the impounded CCR. This source control approach would consolidate CCR at least 15 feet (ft) above the uppermost aquifer (UA) and would physically separate CCR from the current and predicted post-closure water table within the upper confining unit by 10 ft and include a cover system consisting of a 40milliliter (mil) linear low-density polyethylene (LLDPE) geomembrane layer, a geotextile protective layer, and 24 inches (in) of protective soil cover. These measures (installation of a geosynthetic cap and consolidation of CCR) will control to the maximum extent feasible the migration of CCR constituents to groundwater, thus facilitating the achievement of the GWPSs in accordance with IAC Section 845.600. As demonstrated by the groundwater modeling in support of the Closure Alternatives Analysis (CAA) (Gradient, 2022a), this source control approach would result in a reduction of the migration of water into the EAP by 99.9% compared to pre-closure conditions. Additionally, source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022a) demonstrating that source control will control, minimize or eliminate post-closure release of leachate.

Three potential corrective actions are evaluated in this CAAA: Source Control with Groundwater Polishing (Source Control-GWP), Source Control with Groundwater Extraction (Source Control-GWE), and Source Control with a Deep Cutoff Wall (Source Control-Deep Cutoff Wall). All alternatives consist of source control and residual plume management, and all alternatives were identified as a viable approach in the CMA (Appendix C; Ramboll, 2024). The residual plume management portions of these corrective action alternatives include groundwater polishing (GWP), groundwater extraction (GWE), and a deep cutoff wall.

Under the Source Control-GWP alternative, active groundwater monitoring would supplement source control to verify and document the attenuation by natural physical and geochemical mechanisms of constituent concentrations in groundwater. Site-specific evaluation demonstrated that groundwater polishing is appropriate at the EAP because site conditions are favorable for physical and geochemical processes of inorganic contaminants *via* adsorption (Appendix E; Geosyntec Consultants, Inc., 2024). Under the Source Control-GWE alternative, a groundwater extraction (GWE) system that was constructed in late 2024 as a preliminary corrective action (PCA) would begin to operate in 2025. The GWE system consists of eight extraction wells that contain and control the eastward migration of constituents in groundwater toward the Village of Joppa. This corrective action alternative would involve transitioning the PCA GWE into a final corrective action remedy after implementing source control. Under the Source Control-Deep Cutoff Wall alternative, a groundwater flow barrier consisting of bentonite and either soil or cement would be constructed to reduce or prevent the horizontal migration of potentially impacted groundwater toward the Village of Joppa. As part of all three corrective action alternatives, an adaptive site management plan would be implemented in order to optimize the selected remedy based on real-time data that are collected.

Table S.1 evaluates the three potentially viable corrective actions evaluated in this CAAA (Source Control-GWP, Source Control-GWE, and Source Control-Deep Cutoff Wall) with regard to each of the factors specified under IAC Section 845.670(d) and IAC Section 845.670(e) (IEPA, 2021a). Based on this evaluation and the details provided in Section 2 of this report, the most appropriate corrective action for this Site is Source Control-GWE. The Source Control-GWE alternative was predicted to achieve GWPSs under the shortest amount of time. The expected impacts on workers, nearby communities, and the environment under the Source Control-GWE alternative are lower than those under the Source Control-Deep Cutoff Wall alternative. Furthermore, Source Control-GWE controls off-Site migration of groundwater into the Village of Joppa more than Source Control-GWP and, thus, result in less impact on the Village of Joppa than Source Control-GWP. Thus, Source Control-GWE is the most appropriate corrective action alternative for the EAP.

Table S.1 Comparison of Proposed Corrective Action Alternatives with Respect to Factors Specified in IAC Section 845.670(d) and IAC Section 845.670(e)

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-GWE	Source Control-Deep Cutoff Wall
Magnitude of Reduction of Existing Risks/Be Protective of Human Health and the Environment (Section 2.2.1; IAC Section 845.670(e)(1)(A)/ IAC Section 845.670(d)(1))	Because current conditions do not present a risk to human health or the environment at the EAP, there would be no unacceptable risk to human health or the environment for future conditions when the unit has been closed and source control has been implemented. Concentrations of CCR-related constituents would decline over time and, consequently, potential exposures to CCR-related constituents in the environment would also decline. The magnitude of the reduction of existing risks is the same for all of the potential corrective action alternatives, and all three corrective action alternatives are equally protective of human health and the environment.	Because current conditions do not present a risk to human health or the environment at the EAP, there would be no unacceptable risk to human health or the environment for future conditions when the unit has been closed and source control has been implemented. Concentrations of CCR-related constituents would decline over time and, consequently, potential exposures to CCR-related constituents in the environment would also decline. The magnitude of the reduction of existing risks is the same for all of the potential corrective action alternatives, and all three corrective action alternatives are equally protective of human health and the environment.	Because current conditions do not present a risk to human health or the environment at the EAP, there would be no unacceptable risk to human health or the environment for future conditions when the unit has been closed and source control has been implemented. Concentrations of CCR-related constituents would decline over time and, consequently, potential exposures to CCR-related constituents in the environment would also decline. The magnitude of the reduction of existing risks is the same for all of the potential corrective action alternatives, and all three corrective action alternatives are equally protective of human health and the environment.
Effectiveness of the Remedy in Controlling the Source (Section 2.2.2; IAC Section 845.670(e)(2))			
Extent to Which Containment Practices Will Reduce Further Releases/Control the Sources of Releases to Reduce or Eliminate, to the Maximum Extent Feasible (IAC Section 845.670(e)(2)(A)/ IAC Section 845.670(d)(3))	All three alternatives include source control (which is the primary remedial measure) and residual plume management. Modeling results (see the CAA; Gradient, 2022a) indicate that source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions. Source control is	All three alternatives include source control (which is the primary remedial measure) and residual plume management. Modeling results (see the CAA; Gradient, 2022a) indicate that source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions. Source control is	All three alternatives include source control (which is the primary remedial measure) and residual plume management. Modeling results (see the CAA; Gradient, 2022a) indicate that source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions.

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-GWE	Source Control-Deep Cutoff Wall
	thus effective at controlling the source. Under the residual plume management for this alternative, physical and geochemical attenuation mechanisms would mitigate impacts to downgradient groundwater quality and control the residual plume (Appendix E; Geosyntec Consultants, Inc., 2024). If necessary, remedy optimizations would be implemented under the adaptive site management program.	thus effective at controlling the source. Under the residual plume management for this alternative, groundwater extraction wells would remove impacted groundwater and control migration of impacted groundwater off-Site towards Village of Joppa. Physical and geochemical attenuation mechanisms would also help mitigate impacts to the downgradient groundwater quality and control the residual plume (Appendix E; Geosyntec Consultants, Inc., 2024). If necessary, remedy optimizations would be implemented under the adaptive site management program.	Under the residual plume management for this alternative, a cutoff wall would be constructed to reduce potential CCR-constituents in groundwater from migrating off-Site towards Village of Joppa. Physical and geochemical attenuation would also help control impacts to downgradient groundwater quality (Appendix E; Geosyntec Consultants, Inc., 2024). If necessary, remedy optimizations would be implemented under the adaptive site management program.
Extent to Which Treatment Technologies May Be Used (IAC Section 845.670(e)(2)(B))	Source Control-GWP would rely on physical and geochemical attenuation processes. If necessary, remedy optimizations would be implemented under the adaptive site management program.	Under the Source Control-GWE alternative, groundwater extracted from the GWE wells would be filtered and treated prior to discharge. Total suspended solids (TSS) would be treated *via the* existing settling lagoon. If necessary, bag filtration would be used as a pre-treatment upstream of the settling lagoon. The remedy also relies on physical and geochemical attenuation processes. If necessary, remedy optimizations would be implemented under the adaptive site management program.	The Source Control-Deep Cutoff Wall alternative focuses on preventing groundwater from flowing off-Site using an engineered physical barrier. The remedy also relies on physical and geochemical attenuation processes. If necessary, remedy optimizations would be implemented under the adaptive site management program.

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
Likelihood of Future Releases of CCR (Section 2.2.3; IAC Section 845.670(e)(1)(B))	All three corrective action alternatives include source control using CIP with a consolidate-and-cap approach. A new cover system, which consists of a 40-mil LLDPE geomembrane layer, a geotextile protective layer, and 24 in of protective soil cover, as well as new stormwater control structures, would be installed. 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 release of CCR. As a result, there would be minimal risk of accidental CCR releases occurring post-closure.	All three corrective action alternatives include source control using CIP with a consolidate-and-cap approach. A new cover system, which consists of a 40-mil LLDPE geomembrane layer, a geotextile protective layer, and 24 in of protective soil cover, as well as new stormwater control structures, would be installed. 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 release of CCR. As a result, there would be minimal risk of accidental CCR releases occurring post-closure.	All three corrective action alternatives include source control using CIP with a consolidate-and-cap approach. A new cover system, which consists of a 40-mil LLDPE geomembrane layer, a geotextile protective layer, and 24 in of protective soil cover, as well as new stormwater control structures, would be installed. 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 release of CCR. As a result, there would be minimal risk of accidental CCR releases occurring post-closure.
Type and Degree of Long Term Management, Including Monitoring, Operation, and Maintenance (Section 2.2.4; IAC Section 845.670(e)(1)(C))	Minimal long-term O&M efforts would be required under Source Control-GWP, because it would not require the installation, operation, or maintenance of any engineered systems or structures other than maintenance of the monitoring wells. Corrective action groundwater monitoring would continue until GWPSs have been achieved. Post-closure care groundwater monitoring would continue for a minimum of 30 years as required by IAC Section 845.780(c). Additionally, corrective action groundwater monitoring would continue for 3	No additional installation of any new engineered systems or structures would be required, because the extraction wells have already been installed. Long-term O&M efforts required under Source Control-GWE would include the maintenance of the GWE system and discharge of extracted groundwater. Groundwater collected at the GWE wells would be filtered and treated and sent to the settling lagoon. The settling lagoon would provide further clarification to remove remaining solids before discharging *via* the NPDES permitted outfall. Corrective action groundwater sampling would	Construction of the cutoff wall would occur simultaneously with the EAP closure. Once the cutoff wall has been installed, no O&M efforts would be required, because it is a passive and below-grade structure. However, post-construction quality assurance (QA) programs may be required to validate the quality of the constructed cutoff wall. Corrective action groundwater sampling would continue until GWPSs have been achieved. Post-closure care groundwater monitoring would continue for a minimum of 30 years as required by

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
	years after GWPS have been achieved. Based on the adaptive site management approach, remedy optimizations may be implemented to ensure achievement of the GWPSs.	continue until GWPSs have been achieved. Post-closure care groundwater monitoring would continue for a minimum of 30 years as required by IAC Section. 845.780(c). Additionally, corrective action groundwater monitoring would continue for 3 years after GWPS have been achieved. Based on the adaptive site management approach, remedy optimizations might be implemented to ensure achievement of the GWPSs.	IAC Section. 845.780(c). Additionally, corrective action groundwater monitoring would continue for 3 years after GWPS have been achieved. Based on the adaptive site management approach, remedy optimizations might be implemented to ensure achievement of the GWPSs, such as installing a secondary GWE system.
Short-Term Risks to the Community or the Environment During Implementation of Remedy (Section 2.2.5; IAC Section 845.670(e)(1)(D))			
Safety Impacts	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. While appropriate controls would be established to prevent accidents and injuries from occurring, the risks of accidents and injuries occurring during source control would be the same for all three corrective action alternatives. These source control risks were evaluated in the CAA (Gradient, 2022a).	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. While appropriate controls would be established to prevent accidents and injuries from occurring, the risks of accidents and injuries occurring during source control would be the same for all three corrective action alternatives. These source control risks were evaluated in the CAA (Gradient, 2022a).	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. While appropriate controls would be established to prevent accidents and injuries from occurring, the risks of accidents and injuries occurring during source control would be the same for all three corrective action alternatives. These source control risks were evaluated in the CAA (Gradient, 2022a).

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-GWE	Source Control-Deep Cutoff Wall
	Overall, no worker accidents or injuries would be expected under the Source Control-GWP alternative because no installation, operation, and maintenance of engineered systems or structures would be required.	Overall, considering worker accidents occurring during residual plume management both on- and off-Site, 0.092 worker injuries and 1.1×10^{-3} worker fatalities would be expected to occur on-Site and off-Site under the Source Control-GWE alternative. In total, an estimated 0.019 injuries and 3.0×10^{-4} fatalities would be expected to occur among community members due to off-Site activities under the Source Control-GWE alternative.	Overall, considering worker accidents occurring during residual plume management both on- and off-Site, 0.32 worker injuries and 7.1×10^{-3} worker fatalities would be expected to occur on-Site and off-Site under the Source Control-Deep Cutoff Wall alternative, which is the highest of the three alternatives. Off-Site impacts on nearby residents, including injuries or fatalities, would be the highest under the Source Control-Deep Cutoff Wall alternative. In total, an estimated 0.11 injuries and 1.2×10^{-3} fatalities would be expected to occur among community members due to off-Site activities under the Source Control-Deep Cutoff Wall alternative.
Cross-Media Impacts to Air	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Air impacts occurring during source control would be the same for all three corrective action alternatives. These source control risks were evaluated in the CAA (Gradient, 2022a). Cross-media impacts to air can include air pollutants and GHG emissions, which are proportional to the potential impact of each	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Air impacts occurring during source control would be the same for all three corrective action alternatives. These source control risks were evaluated in the CAA (Gradient, 2022a). Cross-media impacts to air can include air pollutants and GHG emissions, which are proportional to the potential impact of each	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Air impacts occurring during source control would be the same for all three corrective action alternatives. These source control risks were evaluated in the CAA (Gradient, 2022a). Cross-media impacts to air can include air pollutants and GHG emissions, which are proportional to the potential impact of each

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
	alternative on other emissions from construction vehicles and equipment. Residual plume management for the Source Control-GWP alternative would be expected to have minimal air impacts, because it would not require the construction of any engineered systems or structures.	alternative on other emissions from construction vehicles and equipment. Residual plume management for the Source Control-GWE alternative would have greater air impacts than the Source Control-GWP alternative due to the operation of the GWE system.	alternative on other emissions from construction vehicles and equipment. Residual plume management for the Source Control-Deep Cutoff Wall alternative would have greatest air impacts among the three alternatives due to the greatest vehicle and equipment miles resulted from increased construction activity required for this alternative.
Cross-Media Impacts to Surface Water and Sediments	Groundwater modeling was performed in support of the CAA (Gradient, 2022a). The modeling predicted that source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022a). Under residual plume management for the Source Control-GWP alternative, minimal surface water and sediment impacts would be expected, because it would not require the construction of any engineered systems or structures.	Groundwater modeling was performed in support of the CAA (Gradient, 2022a). The modeling predicted that source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022a). Under residual plume management for the Source Control-GWE alternative, groundwater collected by the extraction wells would be filtered and treated before discharge to the Ohio River *via* one of the facility's NPDES-permitted outfalls. No surface water or sediment impacts are expected under this alternative.	Groundwater modeling was performed in support of the CAA (Gradient, 2022a). The modeling predicted that source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022a). Under residual plume management for the Source Control-Deep Cutoff Wall alternative, erosion and runoff may be a potential concern during construction of the cutoff wall. Thus, surface water and sediment impacts may be higher under the Source Control-Deep Cutoff Wall alternative than the other two alternatives. Any associated impacts would be addressed through best management practice (BMP) in accordance with site land disturbance permits.
Control of Exposure to Any Residual Contamination During Implementation of the Remedy	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-GWE	Source Control-Deep Cutoff Wall
	potential corrective action alternatives. While appropriate controls would be established to prevent exposures of CCR during source control, the risks of CCR exposure during source control would be the same for all three corrective action alternatives. Risks to workers arising from potential contact with residual contamination during construction activities associated with residual plume management would be minimal under the Source Control-GWP alternative, which would not involve exposure to soil or groundwater waste streams.	potential corrective action alternatives. While appropriate controls would be established to prevent exposures of CCR during source control, the risks of CCR exposure during source control would be the same for all three corrective action alternatives. Risks to workers arising from potential contact with residual contamination during construction, operation, and maintenance activities associated with residual plume management would be higher for the Source Control-GWE alternative than for the Source Control-GWP alternative, because Source Control-GWE would involve the production, management, and potential treatment of extracted groundwater. Any potential CCR exposures during the Source Control-GWE alternative would be managed through the use of rigorous safety protocols and personal protective equipment.	potential corrective action alternatives. While appropriate controls would be established to prevent exposures of CCR during source control, the risks of CCR exposure during source control would be the same for all three corrective action alternatives. Risks to workers arising from potential contact with residual contamination during construction, operation, and maintenance activities associated with residual plume management would be higher for the Source Control-Deep Cutoff Wall alternative than for the Source Control-GWP alternative, because Source Control-Deep Cutoff Wall would involve the excavation and subsequent disposal of Site soils. Any potential CCR exposures during the Source Control-GWE and Source Control-Deep Cutoff Wall alternatives would be managed through the use of rigorous safety protocols and personal protective equipment.
Other Identified Impacts	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, impacts during source control would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a).	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, impacts during source control would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a).	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, impacts during source control would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a).

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-GWE	Source Control-Deep Cutoff Wall
	The energy demands of construction equipment and vehicles associated with residual plume management would be lowest under the Source Control-GWP alternative, because this alternative would not require any significant construction or maintenance activity. Similarly, traffic and noise impacts associated with residual plume management are also expected to be higher under the Source Control-Deep Cutoff Wall alternative than the other two alternatives, due to there is no construction activities required to construct the barrier wall. Traffic and noise impacts associated with residual plume management from the Source Control-GWP are expected to be minimal because no construction is required under this alternative. There are no notable scenic, historic, or recreational areas located within 1,500 ft of the EAP. Therefore, there would be no impacts to natural resources and habitat under the Source Control-GWP alternative because no additional construction activities would be required.	The energy demands of construction equipment and vehicles associated with residual plume management would also be minimal under the Source Control-GWE alternative, because this alternative would not require any significant construction or maintenance activity. However, energy would be required for the operation of the GWE system under the Source Control-GWE alternative. Similarly, traffic and noise impacts associated with residual plume management are also expected to be higher under the Source Control-Deep Cutoff Wall alternative than the other two alternatives, due to the construction activities required to construct the barrier wall. Traffic and noise impacts associated with residual plume management from the Source Control-GWE are expected to be minimal because no construction is required under this alternative. There are no notable scenic, historic, or recreational areas located within 1,500 ft of the EAP. Therefore, there would be no impacts to natural resources and habitat under the Source Control-GWE alternative because no additional construction activities would be required.	The energy demands of construction equipment and vehicles associated with residual plume management would be greatest under the Source Control-Deep Cutoff Wall alternative, while the energy demands under the Source Control-GWP and Source Control-GWE alternatives are expected to be lower, because these two alternatives would not require any significant construction activity. Similarly, traffic and noise impacts associated with residual plume management are also expected to be higher under the Source Control-Deep Cutoff Wall alternative than the other two alternatives, due to the construction activities required to construct the barrier wall. There are no notable scenic, historic, or recreational areas located within 1,500 ft of the EAP. Therefore, construction activities under the Source Control-Cutoff Wall alternative at the Site are not expected 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 corrective action alternatives.

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
Time Until Groundwater Protection Standards Are Achieved/Attain the Groundwater Protection Standards Specified in Section 845.600 (Section 2.2.6; IAC Section 845.670(e)(1)(E); IAC Section 845.670(d)(2))	Groundwater modeling performed in support of the CAA (Gradient 2022a) concluded that source control alone would result in a 99.9% reduction in mass flux from the EAP into the underlying groundwater. Additional modeling was conducted to evaluate future groundwater quality in the vicinity of the EAP under each of the proposed source control and corrective action alternatives. The results indicate that groundwater would attain the GWPSs for all constituents identified as having potential exceedances within 11 years at all monitoring wells under the Source Control-GWP alternative (Appendix B, Ramboll, 2024a).	Groundwater modeling performed in support of the CAA (Gradient, 2022a) concluded that source control alone would result in a 99.9% reduction in mass flux from the EAP into the underlying groundwater. Additional modeling was conducted to evaluate future groundwater quality in the vicinity of the EAP under each of the proposed source control and corrective action alternatives. The results indicate that groundwater would attain the GWPSs for all constituents identified as having potential exceedances within approximately 10 years at all monitoring wells after closure under the Source Control-GWE alternative (Appendix B; Ramboll, 2024a).	Groundwater modeling performed in support of the CAA (Gradient, 2022a) concluded that source control alone would result in a 99.9% reduction in mass flux from the EAP into the underlying groundwater. Additional modeling was conducted to evaluate future groundwater quality in the vicinity of the EAP under each of the proposed source control and corrective action alternatives. The results indicate that groundwater would attain the GWPSs for all constituents identified as having potential exceedances within approximately 12 years at all monitoring wells after closure under the Source Control-Deep Cutoff Wall alternative (Appendix B; Ramboll, 2024a).
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 (Section 2.2.7; IAC Section 845.670(e)(1)(F))	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Therefore, all three corrective action alternatives would be equally and fully protective with regard to exposure to residual CCR. As a result of the source control, there would be no risk of CCR releases post-closure. While physical and geochemical attenuation mechanisms would be	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Therefore, all three corrective action alternatives would be equally and fully protective with regard to exposure to residual CCR. As a result of the source control, there would be no risk of CCR releases post-closure. Under Source Control-GWE, the flow of groundwater into the Village of	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Therefore, all three corrective action alternatives would be equally and fully protective with regard to exposure to residual CCR. As a result of the source control, there would be no risk of CCR releases post-closure. Under Source Control-Deep Cutoff Wall, the flow of groundwater into

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
	relied upon to address the downgradient plume, no engineered controls would be implemented under the Source Control-GWP alternative to prevent groundwater from flowing into the Village of Joppa.	Joppa would be mitigated through operation of the extraction system. Thus, Source Control-GWE would be more protective of residents in the Village of Joppa than the Source Control-GWP alternative. Potential risks to workers that come in contact with residual contamination of CCR-related constituents during groundwater extraction and treatment would be managed through the use of rigorous safety protocols and personal protective equipment. Some changes in groundwater flow (*i.e.*, reduction in groundwater flow into the river) may occur under the Source Control-GWE alternative, due to the operation of the GWE wells. However, changes to groundwater flow would not be expected to have an effect on the potential for the exposure of humans and environmental receptors to remaining wastes.	the Village of Joppa would be mitigated through installation of a physical barrier. Thus, Source Control-Deep Wall Cutoff would be more protective of residents in the Village of Joppa than the Source Control-GWP alternative. Potential risks to workers that come in contact with residual contamination of CCR-related constituents during the installation of the cutoff wall would be managed through the use of rigorous safety protocols and personal protective equipment. Hydrogeological changes would be expected under the Source Control-Deep Cutoff Wall alternative, such as altering flow patterns in the Uppermost Aquifer (UA), redirecting groundwater flow around the cutoff wall, and causing changes in hydraulic gradients. However, changes to groundwater flow would not be expected to have an effect on the potential for the exposure of humans and environmental receptors to remaining wastes.
Long-Term Reliability of the Engineering and Institutional Controls (Section 2.2.8;	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-GWE	Source Control-Deep Cutoff Wall
IAC Section 845.670(e)(1)(G))	alternatives. Thus, long-term reliability during source control would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-GWP alternative would be reliable because it would rely on physical and geochemical attenuation processes and active monitoring. If necessary, remedy optimizations would be implemented under the adaptive site management program.	alternatives. Thus, long-term reliability during source control would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). GWE is a proven remedy that has been implemented at many sites. Thus, residual plume management under the Source Control-GWE alternative would be reliable, as long as the GWE wells and pumps are maintained and operated appropriately. If necessary, remedy optimizations would be implemented under the adaptive site management program.	alternatives. Thus, long-term reliability during source control would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Cutoff walls are a proven remedy and have been implemented at many sites. Thus, residual plume management under the Source Control-Deep Cutoff Wall alternative would be reliable because the cutoff wall is a passive, below-grade structure, which would not require any O&M activities once it is installed. Quality control (QC) and QA programs would be required during and after the construction phase to ensure the effectiveness of the cutoff wall. If necessary, remedy optimizations would be implemented under the adaptive site management program.
Potential Need for Replacement of the Remedy (Section 2.2.9; IAC Section 845.670(e)(1)(H))	Replacement of the residual plume management remedy under the Source Control-GWP alternative would likely be unnecessary, because it would not require the installation, operation, and maintenance of engineered systems or structures. Adaptive site management strategies would be used to implement remedy optimizations, if necessary, to ensure that remedial goals are achieved.	Replacement of the residual plume management remedy under the Source Control-GWE alternative would likely be unnecessary as long as the GWE system is maintained and serviced appropriately. Adaptive site management strategies would be used to implement remedy optimizations, if necessary, to ensure that remedial goals are achieved.	Replacement of the residual plume management remedy under the Source Control-Deep Cutoff Wall alternative would likely be unnecessary, because the cutoff wall is a robust, engineered, and maintenance-free subsurface structure. Adaptive site management strategies would be used to implement remedy optimizations, if necessary, to ensure that remedial goals are achieved.

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
Degree of Difficulty Associated with Constructing the Remedy (Section 2.3.1; IAC Section 845.670 (e)(3)(A)	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, construction difficulties would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-GWP alternative would rely on physical and geochemical attenuation processes and therefore would not pose any significant construction challenges.	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, construction difficulties would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-GWE alternative would rely on continued operation of the existing GWE system to prevent off-Site migration of impacted groundwater, as well as physical and geochemical attenuation processes. Therefore, no significant construction challenges would be expected.	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, construction difficulties would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-Deep Cutoff Wall alternative would rely on the barrier wall to prevent off-Site migration of impacted groundwater, as well as physical and geochemical attenuation processes. Some challenges may be encountered during the construction of the cutoff wall, including the following: (1) Specialized equipment, including large cranes, clamshells, slurry cutters, or potentially one-pass trenching equipment may be needed to construct the cutoff wall. (2) Construction challenges, such as encountering highly permeable layers leading to slurry loss, facing obstructions that necessitate specialized techniques and/or equipment for progression, or experiencing sidewall instability, may arise.

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
			(3) Ongoing QC is essential during construction, as part of QA activities, to prevent defective features. Additionally, post-construction QA programs, such as coring and testing, may be necessary to validate the quality of the constructed barrier. (4) Ongoing monitoring and QA/QC testing for slurry mixing, placement, or soil-bentonite mixing are critical to ensure the performance of the cutoff wall.
Expected Operational Reliability of the Remedy (Section 2.3.2; IAC Section 845.670 (e)(3)(B))	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, the operational reliability of the remedy would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-GWP alternative would have high operational reliability because this alternative would rely on natural processes and active monitoring. Adaptive site management strategies would be used to implement remedy optimizations, if necessary.	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, the operational reliability of the remedy would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-GWE alternative would have high operational reliability because it is an established technology, as long as the GWE system is maintained and operated appropriately. Adaptive site management strategies would be used to implement remedy optimizations, if necessary.	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, the operational reliability of the remedy would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-Deep Cutoff Wall alternative would have high operational reliability because it is an established technology, as long as the cutoff wall is constructed in accordance with standard design and specifications. Adaptive site management strategies would be used to implement remedy optimizations, if necessary.

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies (Section 2.3.3; IAC Section 845.670 (e)(3)(C))	Source Control-GWP would require regulatory approval, but no additional permits would be needed other than those issued by IEPA for source control and the Corrective Action Plan.	Source Control-GWE would require regulatory approvals. Groundwater extracted from the GWE would be sent to the southern settling lagoon and discharged *via* the NPDES-permitted outfall. The NPDES permits are already in place as part of the preliminary corrective action (PCA) and would likely require renewals depending on the timeline of the corrective action implementation.	Source Control-Deep Cutoff Wall would require regulatory approval, such as permits from IEPA for the construction of stormwater controls and BMPs. An amendment to the submitted EAP Closure Plan and Construction Permit Application would be required to allow the disposal of deep cutoff wall spoils beneath the EAP's final cover system.
Availability of Necessary Equipment and Specialists (Section 2.3.4; IAC Section 845.670 (e)(3)(D)	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, equipment and specialist needs would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-GWP alternative would require standard environmental monitoring equipment and groundwater professionals. Specialists such as geologists, hydrogeologists, statisticians, and geochemists would be available to collect and evaluate the data.	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, equipment and specialist needs would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-GWE alternative would require standard environmental monitoring equipment, as well as specialists to manage the GWE system throughout its operational period, including maintenance of specialized components and non-routine O&M tasks. Certain more complex equipment, like the transfer pumps and transfer pump controllers, may involve longer lead times for replacement or servicing.	Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, equipment and specialist needs would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a). Residual plume management under the Source Control-Deep Cutoff Wall alternative would require standard environmental monitoring equipment. In addition, building the deep cutoff wall requires the expertise of a specialized contractor with a background in constructing similar types of walls in comparable geologic environments. Specialized equipment, including large cranes, clamshell buckets, slurry cutters, batch plants, or one-pass construction equipment, would be

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-GWE**	**Source Control-Deep Cutoff Wall**
			required for the construction of the cutoff wall. Specialists, such as design engineers, construction managers, and contractor staff, involved in the design and construction of cutoff walls would be essential during both phases.
Available Capacity and Location of Needed Treatment, Storage, and Disposal Services/Comply with Standards for Management of Wastes as Specified in Section 845.680(d) (Section 2.3.5; IAC Section 845.670 (e)(3)(D)/ IAC section 845.670(d)(5))	No treatment, storage, or disposal services would be required with the source control with GWP alternative, as GWP would not generate any significant volume of waste or wastewater.	Residual plume management under the Source Control-GWE alternative would not require new treatment, storage, or disposal services outside of the existing services already utilized by the Site as part of the PCA. Groundwater extracted from the GWE system would be filtered and treated, and sent to the settling lagoon prior to be discharged *via* a NPDES permitted outfall. TSS would be treated *via* the existing settling lagoon. If necessary, bag filtration would be used as a pre-treatment upstream of the settling lagoon.	Residual plume management under the Source Control-Deep Cutoff Wall alternative would generate waste such as spoils during the cutoff wall construction phase. These waste materials would be disposed of appropriately, such as on-Site disposal during the closure construction as compacted contouring fill beneath the final cover system for the EAP.
The Degree to Which Community Concerns Are Addressed by the Remedy (Section 2.4; IAC Section 845.670(e)(4))	The combination of source control (*i.e.*, CIP using a consolidate-and-cap approach) and residual plume management would cause groundwater concentrations to decline over time under all of the corrective action alternatives (Ramboll, 2023), thus addressing community concerns. A public meeting would be held on March 19, 2025, pursuant to requirements under IAC Section	The combination of source control (*i.e.*, CIP using a consolidate-and-cap approach) and residual plume management would cause groundwater concentrations to decline over time under all of the corrective action alternatives (Ramboll, 2023), thus addressing community concerns. A public meeting would be held on March 19, 2025, pursuant to requirements under IAC Section	The combination of source control (*i.e.*, CIP using a consolidate-and-cap approach) and residual plume management would cause groundwater concentrations to decline over time under all of the corrective action alternatives (Ramboll, 2023, thus addressing community concerns. A public meeting would be held on March 19, 2025, pursuant to requirements under IAC Section

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-GWE	Source Control-Deep Cutoff Wall
	845.710(e). Questions raised by attendees would be answered at the meeting; subsequently, a written summary of all questions and responses would be made available to interested parties.	845.710(e). Questions raised by attendees would be answered at the meeting; subsequently, a written summary of all questions and responses would be made available to interested parties.	845.710(e). Questions raised by attendees would be answered at the meeting; subsequently, a written summary of all questions and responses would be made available to interested parties.
Remove from the Environment as Much of the Contaminated Material That Was Released from the CCR Surface Impoundment as Is Feasible, Taking into Account Factors such as Avoiding Inappropriate Disturbance of Sensitive Ecosystems (Section 2.5; IAC Section 845.670(d)(4))	There have been no documented releases of CCR from the unit. All three potential corrective action alternatives would include significant source control and residual plume management efforts. Groundwater modeling performed in support of the CAA (Gradient, 2022a) concluded that source control alone would result in a 99.9% reduction in mass flux from the EAP into the underlying groundwater (Ramboll, 2022a). Additionally, residual plume management under the Source Control-GWP alternative would address impacted groundwater by relying on site-specific evaluations demonstrated that conditions are favorable for the attenuation of inorganic contaminants *via* adsorption. Attenuation *via* sorption onto mineral surfaces should remain stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS (Appendix E; Geosyntec Consultants, Inc., 2024). No ecosystems would be disturbed because no construction	There have been no documented releases of CCR from the unit. All three potential corrective action alternatives would include significant source control and residual plume management efforts. Groundwater modeling performed in support of the CAA (Gradient, 2022a) concluded that source control alone would result in a 99.9% reduction in mass flux from the EAP into the underlying groundwater (Ramboll, 2022a). Additionally, residual plume management under the Source Control-GWE alternative would utilize an engineered system to actively remove constituent mass from the groundwater. Groundwater quality would also be improved as a result of physical and geochemical attenuation processes. Site-specific evaluation demonstrated that the site conditions are favorable for the attenuation of inorganic contaminants *via* adsorption. Attenuation *via* sorption onto mineral surfaces should remain	There have been no documented releases of CCR from the unit. All three potential corrective action alternatives would include significant source control and residual plume management efforts. Groundwater modeling performed in support of the CAA (Gradient, 2022a) concluded that source control alone would result in a 99.9% reduction in mass flux from the EAP into the underlying groundwater (Ramboll, 2022a). Additionally, residual plume management under the Source Control-Deep Cutoff Wall alternative w would utilize an engineered system to actively remove constituent mass from the groundwater. Groundwater quality would also be improved as a result of physical and geochemical attenuation processes. Site-specific evaluation demonstrated that the site conditions are favorable for the attenuation of inorganic contaminants *via* adsorption. Attenuation *via* sorption onto mineral

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-GWE	Source Control-Deep Cutoff Wall
	activities are expected under the Source Control-GWP alternative.	stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS (Appendix E; Geosyntec Consultants, Inc., 2024). No ecosystems would be disturbed because no additional construction activities are expected under the Source Control-GWE alternative, because the GWE system was already constructed in 2024.	surfaces should remain stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS (Appendix E; Geosyntec Consultants, Inc., 2024). The location of the cutoff wall was selected to avoid sensitive areas such as wetland and floodplains, and thus no significant disturbance to the ecosystems is expected. Some tree clearing is required and would be conducted consistent with Indiana regulations under the Source Control-Deep Cutoff Wall alternative, which may cause some temporary loss of habitat for species such as birds, insects, and plants.

Notes:

CAA = Closure Alternatives Analysis; CCR = Coal Combustion Residual; CIP = Closure-in-Place; EAP = East Ash Pond; GHG = Greenhouse Gas; GWE = Groundwater Extraction; GWPS = Groundwater Protection Standard; IAC = Illinois Administrative Code; IEPA = Illinois Environmental Protection Agency; NPDES = National Pollutant Discharge Elimination System; O&M = Operations and Maintenance; Source Control-Deep Cutoff Wall = Source Control with a Deep Cutoff Wall; Source Control-GWE = Source Control with Groundwater Extraction; Source Control-GWP = Source Control with Groundwater Polishing.

1 Introduction

1.1 Site Description and History

1.1.1 Site Location and History

The inactive coal-fired Joppa Power Plant (JPP), also known as the Joppa Power Station, is owned by Electric Energy Inc. (EEI). The facility is located in the Village of Joppa, Illinois, along one bank of the Ohio River and operated as a electrical generation plant from 1953 to 2022 (Ramboll, 2021; Vistra Corp., 2021).

1.1.2 CCR Impoundment

The JPP previously produced and currently 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.

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. Since electricity generation at the JPP ceased in 2022, the EAP no longer receives any ash, and is not currently operating (Appendix B; Ramboll, 2024a).

During typical operations at the former plant, CCRs from the power plant were sluiced to the southwest corner of the EAP. A third-party recycling company recovered a portion of the ash from the EAP for beneficial reuse. Decanted water discharged from the EAP was ultimately routed to the Ohio River *via* a National Pollutant Discharge Elimination System (NPDES)-permitted outfall (Geosyntec Consultants, 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 is located in the greater Lower Ohio River Watershed (8-digit Hydrologic Unit Code: 05140206) (AECOM, 2016a; Ramboll, 2021). The Ohio River is located approximately 1,600 ft south of the outer extent of the EAP and 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 (*i.e.*, JPP Outfall 010) (Geosyntec Consultants, 2021). According to the 2020 Kentucky Section 303(d) List, the segment of the Ohio River adjacent to the Site (Assessment Unit ID KY-108) is impaired, namely 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). Mermet Lake is the closest named freshwater lake and is located approximately 2 miles north of the EAP (Google LLC, 2022).

1.1.4 Hydrogeology

In the vicinity of the EAP, four hydrostratigraphic units define the geology underlying the Site (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 clay sand 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 JPP. The LAU is considered a potential migration pathway (PMP) at the Site.

Groundwater migrates downward through the UCU into the UA in the vicinity of the EAP. Further downward migration is limited by the LCU. Within the UA, groundwater flows generally to the south and southeast toward the Ohio River as well as towards the Village of Joppa. The primary receiving body of water in the vicinity of the Site is the Ohio River. 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 can also arise from other industrial sources and occur naturally in sediments and surface water. As a result, their presence in the sediments and/or surface water of the Ohio River does not necessarily signify contributions from the EAP.

1.1.5 Site Vicinity

The Ohio River bounds the Site to the south, the Village of Joppa bounds the Site immediately to the east, a Portland cement plant (LaFarge North America) bounds the Site to the west, and a compressor station for a natural gas pipeline system (Trunkline Gas Company-Joppa Compressor) bounds the Site to the north and to the west (Google LLC, 2022). 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). The Joppa Public Boat Ramp is located less than 1 mile upstream of the JPP, along the Ohio River.

According to a review of the Illinois State Archaeological Survey database, there are no historic sites located within 1,000 meters of the EAP (Ramboll, 2021). From a review of the Illinois Department of Natural Resources (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 Part 845 Regulatory Review and Requirements

Title 35, Part 845 of the Illinois Administrative Code (IAC) (IEPA, 2021) requires that a Corrective Action Alternatives Analysis (CAAA) be performed as part of the remedy selection, prior to undertaking any corrective actions at certain CCR-containing impoundments where exceedances of GWPSs have been identified. Because exceedances of GWPSs in groundwater associated with the EAP have been identified for boron, cobalt, and pH (Appendix D; Ramboll, 2024b, this report presents a CAAA for the EAP pursuant to the requirements under IAC Section 845.670.[1] The goal of a CAAA is to holistically evaluate a range of factors for the various corrective actions being considered at an impoundment, including the efficiency, reliability, and ease of implementation of the corrective action; its potential positive and negative short- and long-term impacts on human health and the environment; and its ability to address concerns raised by the community (IEPA, 2021). A CAAA is a decision-making tool that is designed to aid in the selection of a corrective action alternative.

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[1] Throughout this document, "exceedance" or "exceedances" is intended to refer only to potential exceedances of proposed applicable background statistics or Groundwater Protection Standards (GWPS) as described in the proposed groundwater monitoring program which was submitted to IEPA on April 26, 2022 as part of Electric Energy Inc.'s operating permit application for the EAP (Geosyntec, 2022). That operating permit application, including the proposed groundwater monitoring program, remains under review by IEPA and therefore Electric Energy Inc. has not identified any actual exceedances.

2 Corrective Action Alternatives Analysis

This section presents the CAAA pursuant to requirements under IAC Section 845.670 (IEPA, 2021). The goal of a CAAA is to fully evaluate proposed viable corrective measures that were identified in the CMA. The CAAA evaluates potential corrective actions with respect to a wide range of factors, including the performance, reliability, and ease of implementation of the corrective action; its potential impacts on human health and the environment; and its ability to address concerns raised by the community (IEPA, 2021a).

Per IAC Section 845.670(d) (IEPA, 2021), any corrective actions selected under a Corrective Action Plan must:

1. Be protective of human health and the environment;
2. Attain the groundwater protection standards specified in Section 845.600;
3. Control the sources of releases to reduce or eliminate, to the maximum extent feasible, further releases of constituents listed in Section 845.600 into the environment;
4. Remove from the environment as much of the contaminated material that was released from the CCR surface impoundment as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
5. Comply with standards for management of wastes as specified in Section 845.680(d).

At the EAP, a CAAA is required because groundwater monitoring associated with the EAP identified exceedances of the GWPSs. Groundwater monitoring was conducted in accordance with the proposed groundwater monitoring plan (GMP) between 2015 and 2023 (Appendix D; Ramboll, 2024b). The groundwater samples collected from groundwater compliance monitoring wells were used to monitor groundwater quality and evaluate compliance with the groundwater quality standards listed in IAC Section 845.600(a). As of the date of this report, boron, cobalt, and pH were identified as constituents/parameters detected in groundwater at concentrations in excess of their corresponding GWPSs (Appendix D; Ramboll, 2024b).

Three potentially viable corrective actions for the EAP were identified in the CMA for further consideration in this CAAA. The corrective actions alternatives that are considered in this CAAA are Source Control with Groundwater Polishing (Source Control-GWP), Source Control with Groundwater Extraction (Source Control-GWE), and Source Control with a Deep Groundwater Cutoff Wall (Source Control-Deep Cutoff Wall). Each of these corrective action alternatives is described below in Section 2.1.

2.1 Corrective Action Alternative Descriptions

For all three corrective actions evaluated in this CAAA, source control is the primary remedy. US EPA has stated that source control is the most effective means of ensuring the timely attainment of remediation objectives (US EPA, 2015). The source control for the EAP consists of closure-in-place (CIP) using a consolidate-and-cap approach. Specific elements of this approach include:

- 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 would be managed in accordance with the NPDES permit for the Site;

- Removal of free liquids prior to final cover installation *via* ditches, trenches, drains and pumps. Water would be managed in accordance with the NPDES discharge requirements;
- Excavation of approximately 1.2 million cubic yards (CY) of CCRs from a 54-acre area in the eastern portion of the EAP and consolidation into a 74-acre area in the western portion of the EAP;
- Excavation of approximately 0.6 million CY of CCRs and soils from a 32-acre area outside EAP, which would be used for contouring and grading as a beneficial use beneath the final cover system;
- Construction of a new soil containment berm to separate the 54-acre excavated portion of the EAP from the 74-acre consolidate-and-cap portion of the EAP; and
- Construction of an alternative cover system consisting of a 40-mil linear low-density polyethylene (LLDPE) geomembrane layer, a geotextile protective layer, and 24 in of protective soil cover suitable for supporting vegetative growth.

These source control activities include the removal of free liquids, excavation and consolidation of CCR into the western portion of the EAP, and the installation of a low-permeability final cover system. These activities are designed to control, minimize or eliminate, post closure infiltration of liquids into the impounded CCR. This source control approach would consolidate CCR at least 15 ft above the UA and would physically separate CCR from the current and predicted post-closure water table within the upper confining unit by 10 ft, and include a cover system consisting of a 40-mil linear low-density polyethylene (LLDPE) geomembrane layer, a geotextile protective layer, and 24 in of protective soil cover. These measures (installation of a geosynthetic cap and consolidation of CCR) will control to the maximum extent feasible the migration of CCR constituents to groundwater, thus facilitating the achievement of the GWPSs in accordance with IAC Section 845.600. As demonstrated by the groundwater modeling in support of the Closure Alternatives Analysis (CAA) (Gradient, 2022a), this source control approach would result in a reduction of the migration of water into the EAP by 99.9% compared to pre-closure conditions. Additionally, source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022a) demonstrating that source control will control, minimize or eliminate post-closure release of leachate.

In addition to source control, the corrective actions evaluated in this CAAA include residual plume management. Three potential corrective actions, identified as viable in the CMA, are evaluated in this CAAA for the EAP:

- **Alternative 1:** Source Control with Groundwater Polishing (Source Control-GWP);
- **Alternative 2:** Source Control with Groundwater Extraction (Source Control-GWE); and
- **Alternative 3:** Source Control with a Deep Groundwater Cutoff Wall (Source Control-Deep Cutoff Wall).

For all three potential corrective action alternatives, adaptive site management strategies would be integrated into residual plume management. This approach ensures the timely incorporation of new site information throughout the corrective action process in order to optimize the remediation and expedite achievement of the GWPSs. As part of the adaptive site management approach, system performance and residual plume conditions would be monitored throughout the implementation of the selected corrective action. If groundwater concentrations do not respond as expected to the corrective action, the adaptive site management approach would enable prompt adjustments, optimizations, or replacement of the remedy to ensure overall effectiveness.

2.1.1 Alternative 1: Source Control-GWP

The first corrective action alternative is Source Control-GWP. This remedy includes source control (CIP using a consolidate-and-cap approach) combined with residual plume management based on natural physical and geochemical processes that would reduce groundwater concentrations downgradient of the EAP. Groundwater polishing mechanisms were evaluated using geochemical speciation and reaction models. The primary objective of the geochemical model was to support the evaluation of groundwater polishing as a potential remedy for the site. The model focused on evaluating the dominant geochemical reactions that may occur at time scales relevant to groundwater flow, including adsorption and mineral dissolution/precipitation reactions (*i.e.*, iron and aluminum hydroxides, carbonates, and some sulfates) (Appendix E; Geosyntec Consultants, Inc., 2024). Model inputs included geochemically reactive solid mineral phases, downgradient groundwater composition, and background groundwater composition derived from site-specific data. Speciation models analyzed the distribution of chemical constituents between solid and aqueous phases, while reaction models assessed how these distributions may shift in response to changing site conditions (US EPA, 2015).

Components of residual plume management for the Source Control-GWP alternative include:

- Groundwater concentrations would be reduced in the downgradient plume as a result of physical and geochemical attenuation processes. Site-specific evaluations have shown that groundwater polishing would reduce the groundwater concentrations and mobility of inorganic contaminants, especially after the implementation of source control. Specifically, chemical attenuation of contaminants is feasible *via* sorption to aquifer solids, particularly iron and aluminum oxides under current conditions. Attenuation *via* sorption onto mineral surfaces should remain stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS. Contaminant levels in groundwater are anticipated to drop below the GWPS at all compliance monitoring wells following the migration of background groundwater during the post-closure phase. This attenuation process would reduce the flux of CCR constituents in downgradient groundwater (Appendix E; Geosyntec Consultants, Inc., 2024).
- Corrective action groundwater monitoring using a groundwater monitoring system designed in accordance with IAC Section 845.680(c), which would be installed within the plume that lies beyond the waste boundary.
- Adaptive site management strategies for this alternative would include geochemical modeling. Groundwater monitoring results would be evaluated and compared to the model-predicted concentrations. In situations in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques to remove residual sources to achieve the GWPSs would be evaluated, and if viable, incorporated as per IAC Section 845.680(b).
- Corrective action confirmation groundwater sampling would be performed for 3 years after GWPSs have been achieved.
- Following the completion of the corrective action confirmation monitoring period, a report and certification for Corrective Action Completion would be prepared and submitted to IEPA as per IAC Section 845.680(e).

The overall corrective action implementation duration for this alternative is approximately 15 years (174 months) after source control has been completed (Appendix B; Ramboll, 2024c), including:

- Eleven years (132 months) of corrective action monitoring (*i.e.*, time to meet GWPSs);
- At least 3 years (36 months) of corrective action confirmation monitoring;[2] and
- Six months associated with post-closure reporting.

Although source control (*i.e.*, control-in-place [CIP]) is a primary component of the corrective action, the labor time, equipment usage, and mileage linked to source control were previously estimated in the Closure Alternative Analysis (CAA) (Gradient, 2022a) and are not repeated in this analysis. There is no labor and mileage incurred with the residual plume management under the Source Control and GWP alternative, because no construction would be required under this alternative. Mileage and labor associated with corrective action monitoring was not included in this analysis (Appendix B; Ramboll, 2024c).

2.1.2 Alternative 2: Source Control-GWE

The second corrective action alternative is Source Control-GWE. This remedy includes source control with groundwater extraction (GWE) as the residual plume management approach. The GWE system would include the operation of eight GWE wells located east of the EAP that were installed in late 2024 as a preliminary corrective action (PCA), and the system is anticipated to begin operation in 2025 (Appendix B). These wells were advanced into the UA and installed along a 2,700-ft alignment in the north-south direction along the existing site access road to the east of the EAP (*i.e.*, hydraulically downgradient). These wells will contain and control the eastward off-Site migration of constituents towards the Village of Joppa. Groundwater is pumped from the eight extraction wells to an enclosure system located approximately in the middle of the extraction well transect. The groundwater is then totalized, filtered (if necessary), and transferred from the enclosure to the settling lagoon located along the Ohio River. Water is discharged from the settling lagoon to the Ohio River *via* JPP Outfall 010 under a NPDES permit (IEPA, 2022). This corrective action alternative would involve the transitioning of the PCA GWE system into a final corrective action remedy. This transition is expected to involve minimal physical modifications to the GWE system.

The physical construction and initial implementation of the pre-closure use of GWE as a PCA began in 2024 with the installation of extraction wells. In 2025, construction will continue with the installation of mechanical, electrical, and piping infrastructure, and the remedy is expected to become operational the same year. The PCA is anticipated to operate continuously until EAP source control is complete, when the PCA will remain in place and transition from a PCA to a GWE final corrective action remedy. Long-term management of the GWE system would include periodic inspections and routine maintenance of the system, including the replacement of worn or damaged parts. Components of corrective action operation, maintenance (O&M), and closeout include the following.

- Continued operation of the GWE system.
- Routine and non-routine inspections and maintenance of extraction wells, transfer pumps, and other system components, which may include repair or replacement of system components.
- Monitoring of extracted groundwater under the NPDES permit at Outfall 010 to ensure compliance.
- Groundwater concentrations would be reduced in the downgradient plume as a result of physical and geochemical attenuation processes. Site-specific evaluations have shown that groundwater polishing would reduce the groundwater concentrations and mobility of inorganic contaminants,

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[2] It should be noted that post-closure care groundwater monitoring would continue for a minimum of 30 years as required by IAC Section. 845.780(c).

especially after the implementation of source control. Specifically, chemical attenuation of contaminants is feasible *via* sorption to aquifer solids, particularly iron and aluminum oxides under current conditions. Attenuation *via* sorption onto mineral surfaces should remain stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS. Contaminant levels in groundwater are anticipated to drop below the GWPS at all compliance monitoring wells following the migration of background groundwater during the post-closure phase. This attenuation process would reduce the flux of CCR constituents in downgradient groundwater (Appendix E; Geosyntec Consultants, Inc., 2024).

- Adaptive site management strategies would be employed to track remediation progress and incorporate new site information to assure the achievement of the GWPSs.
- Corrective O&M would be considered complete when boron concentrations drop below 2 mg/L at all monitoring wells located upgradient of the GWE, and other considerations outlined in the Corrective Action Groundwater Management Plan (CA GMP) have been evaluated. GWE system would be decommissioned at that time.
- Corrective action monitoring, which would be performed using a corrective action groundwater monitoring network designed in accordance with IAC Section 845.680(c), which would be installed within the plume contamination that lies beyond the waste boundary.
- Corrective action confirmation monitoring, which would be performed for 3 years after GWPSs have been achieved.
- Following the completion of the corrective action confirmation monitoring period, a report and certification for Corrective Action Completion would be prepared and submitted to IEPA as per IAC Section 845.680(e).

The overall corrective action implementation duration is approximately 14 years (162 months) after source control has been completed, including:

- Approximately 10 years (120 months) of corrective action operations and maintenance (O&M) (*i.e.*, time to meet GWPSs);
- At least 3 years (36 months) of corrective action confirmation monitoring,[3] and
- Approximately 6 months associated with post-closure reporting.

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[3] It should be noted that post-closure care groundwater monitoring would continue for a minimum of 30 years as required by IAC Section. 845.780(c).

Key parameters for the Source Control-GWE corrective action alternative are shown in Table 2.1, below.

Table 2.1 Key Parameters for the Source Control-GWE Corrective Action Alternative[a]

Parameter[b]	Value[c]
Labor Hours	
Total On-Site Labor	4,420 hours
Total Off-Site Labor	0 hours
40% Contingency	1,770 hours
Total Labor Hours:	6,190 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	6,630 miles
On-Site Haul Trucks (Unloaded + Loaded)	0 miles
Labor Mobilization	77,800 miles
Equipment Mobilization (Unloaded + Loaded)	0 miles
Off-Site Haul Trucks (Unloaded + Loaded)	560 miles
Material Deliveries (Unloaded + Loaded)	0 miles
Total On-Site Vehicle and Equipment Travel Miles:	6,630 miles
Total Off-Site Vehicle and Equipment Travel Miles:	78,400 miles
Total Vehicle and Equipment Travel Miles:	85,000 miles

Notes:

Source Control-GWE = Source Control with Groundwater Extraction.

(a) Although source control (*i.e.*, closure-in-place [CIP]) is a primary component of the corrective action, the labor time, equipment usage, and mileage linked to source control were previously estimated in the Closure Alternative Analysis (CAA) and are not repeated in this analysis.

(b) There are no mileage and labor estimates for construction for this corrective action alternative, because no additional construction activities are expected for this alternative. The wells previously installed as a preliminary corrective action (PCA) would be used. Site activities are only expected to occur during corrective action operation and maintenance phase.

(c) Values reported in this table were rounded to reflect 3 significant figures.

Source: Appendix B; Ramboll, 2024c.

2.1.3 Alternative 3: Source Control-Deep Cutoff Wall

The third corrective action alternative is Source Control-Deep Cutoff Wall. This remedy includes source control (CIP using a consolidate-and-cap approach) and a deep groundwater cutoff wall as the residual plume management approach. The residual plume management would include construction of a maintenance-free physical barrier that significantly reduces or prevents the horizontal migration of impacted groundwater towards the Village of Joppa. The cutoff wall would be constructed, starting from ground surface to an approximate depth of 100 ft, terminating in the UA (Appendix B; Ramboll, 2024c). The total length of the cutoff wall is expected to be approximately 4,000 ft. The cutoff wall would be constructed of a mixture of either bentonite and cement or bentonite and soil, with a thickness ranging from 2 to 3 ft, and would have a hydraulic conductivity of no higher than 1×10^{-7} centimeters per second (cm/s).

Implementation of the Source Control-Deep Cutoff Wall is expected to occur in parallel with source control to allow disposal of spoils generated during construction beneath the final cover system in the EAP closure. The residual plume management includes various tasks distributed across three major phases: pre-construction activities (Phase 1), corrective action construction (Phase 2), and corrective action O&M,

groundwater monitoring, and closeout (Phase 2). The activities associated with the Source Control-Deep Cutoff Wall alternative are summarized below.

- **Phase 1:** Pre-construction activities, including obtaining permits from agencies and completing site investigations and engineering designs.
- **Phase 2:** Construction of the deep cutoff wall and removal/decommissioning of the GWE system implemented as part of the PCA.
  - Mobilization of equipment and materials to the site, and preparation for site construction;
  - The wall would be constructed using conventional construction equipment (*i.e.,* clamshell and/or slurry cutter); although one-pass trenching/mixing or other innovative methods could be utilized if later determined to be appropriate based on site-specific subsurface conditions and constructability considerations.
  - Installation of the deep cutoff would occur concurrently with the EPA source control (*i.e.*, CIP) and excavated spoils would be used as contouring (*i.e.*, subgrade) fill beneath the final EAP cover system.
  - Site restoration would be completed following the construction of the cutoff wall, including repair of relocated or damaged site infrastructure during construction and minor regrading and seeding of disturbed areas.
- **Phase 3:** Corrective action operations, maintenance, and closeout. Details pertaining to each of these activities are outlined below.
  - Operation of the deep cutoff wall;
  - Corrective Action O&M: Because the deep cutoff wall is a passive, below-grade structure, no O&M would be needed following its installation.
  - Groundwater concentrations would also be reduced in the downgradient plume as a result of physical and geochemical attenuation processes. Site-specific evaluations have shown that groundwater polishing would reduce the groundwater concentrations and mobility of inorganic contaminants, especially after the implementation of source control. Specifically, chemical attenuation of contaminants is feasible *via* sorption to aquifer solids, particularly iron and aluminum oxides under current conditions. Attenuation *via* sorption onto mineral surfaces should remain stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS (Appendix E; Geosyntec Consultants, Inc., 2024).
  - Adaptive site management strategies would be employed to track remediation progress and incorporate new site information to assure the achievement of the GWPSs.
  - Corrective action monitoring, which would be performed using a corrective action groundwater monitoring network designed in accordance with IAC Section 845.680(c), which requires the monitoring of wells within the plume beyond the waste boundary.
  - Corrective action confirmation monitoring would be performed for 3 years after GWPSs have been achieved.
  - Following the completion of the corrective action confirmation monitoring period, a report and certification for Corrective Action Completion would be prepared and submitted to IEPA as per IAC Section 845.680(e).

The overall corrective action implementation duration is approximately 19-21 years (228-252 months) (Appendix B; Ramboll, 2024c), including:

- Approximately 2.5-4 years (30-48 months) of pre-construction activities (Phase 1; assumed to occur concurrently with source control);
- Approximately 1-1.5 years (12-18 months) of corrective action construction (Phase 2; assumed to occur concurrently with source control);
- Approximately 15.5 years (186 months) of corrective action O&M and closeout (Phase 3; assumed to start after the completion of source control);
    - It includes 12 years (144 months) of corrective action monitoring (*i.e.*, time to meet GWPSs), at least 3 years (36 months) of corrective action confirmation monitoring,[4] and 6 months associated with post-closure reporting.

Key parameters for the Source Control-Deep Cutoff Wall corrective action alternative are shown in Table 2.2, below.

Table 2.2 Key Parameters for the Source Control-Deep Cutoff Wall Corrective Action Alternative[a]

Parameter[b]	Value[c]
Labor Hours	
Total On-Site Labor	14,400 hours
Total Off-Site Labor	0 hours
40% Contingency	5,780 hours
Total Labor Hours:	20,200 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	42,300 miles
On-Site Haul Trucks (Unloaded + Loaded)	6,120 miles
Labor Mobilization	198,000 miles
Equipment Mobilization (Unloaded + Loaded)	84,100 miles
Off-Site Haul Trucks (Unloaded + Loaded)	46,900 miles
Material Deliveries (Unloaded + Loaded)	117,000 miles
Total On-Site Vehicle and Equipment Travel Miles:	48,500 miles
Total Off-Site Vehicle and Equipment Travel Miles:	445,000 miles
Total Vehicle and Equipment Travel Miles:	494,000 miles

Notes:
Source Control-Deep Cutoff Wall = Source Control with a Deep Cutoff Wall.
(a) Although source control (*i.e.*, control-in-place [CIP]) is a primary component of the corrective action, the labor time, equipment usage, and mileage linked to source control were previously estimated in the Closure Alternative Analysis (CAA) and are not repeated in this analysis.
(b) Site activities are only expected to occur during the corrective action construction phase for this alternative.
(c) Values reported in this table were rounded to reflect 3 significant figures.
Source: Appendix B; Ramboll, 2024c.

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[4] It should be noted that post-closure care groundwater monitoring will continue for a minimum of 30 years as required by IAC Section 845.780(c).

2.2 Long- and Short-term Effectiveness and Protectiveness of Corrective Action Alternative (IAC Section 845.670(e)(1))

2.2.1 Magnitude of Reduction of Existing Risks/Be Protective of Human Health and the Environment (IAC Section 845.670(e)(1)(A)/(IAC Section 845.670(d)(1))

There are no current unacceptable risks to human or ecological receptors at this Site (Appendix A; Gradient, 2022b). A potential risk was identified for residents in the Village of Joppa who may use groundwater from the UA as a source of drinking water (Appendix A; Gradient, 2022b). However, a well database search of ILWATER (a GIS-based tool managed by the Illinois State Geological Survey, part of the Prairie Research Institute) and windshield survey conducted in the Village of Joppa found no evidence to suggest that any current residents rely on groundwater from the UA as their primary source of drinking water. Subsequent outreach and in-person/mail inquiries confirmed that there are no active private wells located in the downgradient area of the residual plume (Ramboll, 2022b). Analytical test results from Joppa public supply well indicated that there are no impacts to the municipal water system related to EAP (Hennings and Tlachac, 2022). Additionally, the installation of the PCA GWE system prevents off-Site migration of groundwater in the vicinity of the EAP into the Village of Joppa.

Because current conditions do not present a risk to human health or the environment at the EAP, there would be no unacceptable risk to human health or the environment for future conditions when the unit has been closed and source control has been implemented. Concentrations of CCR-related constituents would decline over time and, consequently, potential exposures to CCR-related constituents in the environment would also decline. As a result of this, the magnitude of the reduction of existing risks is the same for all of the potential corrective action alternatives (IAC Section 845.670(e)(1)(A)), and three corrective action alternatives are equally protective of human health and the environment (IAC Section 84.670(d)(1)).

2.2.2 Effectiveness of the Remedy in Controlling the Source (IAC Section 845.670(e)(2)/IAC Section 845.670(d)(3))

Extent to Which Containment Practices Will Reduce Further Releases/Control the Sources of Releases to Reduce or Eliminate, to the Maximum Extent Feasible (IAC Section 845.670(e)(2)(A)/IAC Section 845.670(d)(3))

Source control would be implemented for each corrective action alternative. Source control includes the consolidation of CCR in the EAP into the western portion of the impoundment and the installation of a low-permeability final cover system designed to limit the infiltration of precipitation into the impounded CCR. Groundwater modeling performed in support of the CAA (Gradient, 2022a) concluded that source control alone would result in a 99.9% reduction in mass flux from the EAP into the underlying groundwater. Therefore, all three corrective action alternatives would be equally and fully protective with regard to source control (*i.e.*, of CCR in the EAP). The effectiveness of residual plume management for each of the corrective action alternatives with respect to residual source control is summarized below.

- Under the Source Control-GWP alternative, the attenuation of dissolved constituent concentrations remaining after source control would be achieved through natural physical and geochemical processes. Site-specific evaluations have shown that groundwater polishing would reduce the groundwater concentrations and mobility of inorganic contaminants, especially after the implementation of source control. Specifically, chemical attenuation of contaminants is feasible *via* sorption to aquifer solids, particularly iron and aluminum oxides under current conditions.

Attenuation *via* sorption onto mineral surfaces should remain stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS. Contaminant levels in groundwater are anticipated to drop below the GWPS at all compliance monitoring wells following the migration of background groundwater during the post-closure phase. This attenuation process would reduce the flux of CCR constituents in downgradient groundwater (Appendix E; Geosyntec Consultants, Inc., 2024). In cases in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques to achieve the GWPSs would be evaluated under the adaptive site management plan, and if viable, incorporated as per IAC Section 845.680(b).

- Under the Source Control-GWE alternative, residual plume management would be achieved by extracting impacted groundwater and preventing potential migration off-Site of groundwater through the operation of eight GWE wells located at the eastern boundary of the Site. GWE is a widely used corrective measure that has been effectively implemented at many sites to contain dissolved-phase groundwater plumes when off-Site migration is a concern. Physical and geochemical attenuation would also help control secondary sources and prevent downgradient migration. In cases in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques to achieve the GWPSs would be evaluated under the adaptive site management plan, and if viable, incorporated as per IAC Section 845.680(b).
- Under the Source Control-Deep Cutoff Wall alternative, residual plume management would be achieved by construction of a cutoff wall located east of the EAP to reduce or prevent the eastward migration of contaminants in groundwater. Cutoff walls are a frequently used corrective measure that have been determined to be an effective approach in preventing dissolved-phase groundwater plume migration at multiple sites. Physical and geochemical attenuation would also help control secondary sources and prevent downgradient migration. In cases in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques to achieve the GWPSs would be evaluated under the adaptive site management plan, and if viable, incorporated as per IAC Section 845.680(b).

Because all three corrective action alternatives include source control and residual plume management, all three of the potential corrective action alternatives would be equally effective at reducing, to the maximum extent feasible, releases from both primary and residual sources (IAC Section 845.670(e)(2)(A)/IAC Section 845.670(d)(3)).

Extent to Which Treatment Technologies May Be Used (IAC Section 845.670(e)(2)(B))

Because Source Control-GWP would rely on physical and geochemical processes, no additional treatment technologies would be required under this alternative. For the Source Control-GWE alternative, the extracted groundwater from the GWE wells would be treated and filtered before it is sent to the settling lagoon, which can provide further clarification to filter out remaining solids prior to discharge to the Ohio River (Appendix B; Ramboll, 2024c). No additional treatment technologies would be required for the Source Control-Deep Cutoff Wall alternative, because its approach focuses on preventing groundwater from flowing eastward off-Site using an engineered physical barrier. For all three corrective action alternatives, remedy optimizations would be implemented, if necessary, under the adaptive site management program.

2.2.3 Likelihood of Future Releases of CCR (IAC Section 845.670(e)(1)(B))

All three corrective action alternatives include source control using CIP with consolidate-and-cap approach. A new cover system would be installed over the EAP, which would a 40-mil LLDPE geomembrane layer, a geotextile protective layer, and 24 in of protective soil cover, 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 release of CCR. There would be minimal risk of accidental CCR releases occurring post-closure under any of the corrective action alternatives.

2.2.4 Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (IAC Section 845.670(e)(1)(C))

The type and degree of long-term residual groundwater plume management associated with each corrective action alternative is summarized below.

- Residual plume management for the Source Control-GWP alternative would not require the installation, operation, or maintenance of any engineered systems or structures, other than maintenance of the monitoring well network. The only long-term management activity required under this alternative would be regular groundwater monitoring and routine maintenance of the monitoring wells, which would continue for at least 3 years after GWPSs have been achieved for all wells, in accordance with IAC Section 845.680(c)(2). Post-closure care groundwater monitoring would continue for a minimum of 30 years as required by IAC Section 845.780(c). Based on the adaptive site management approach, remedy optimization (additional methods or techniques) may be implemented to ensure the achievement of the GWPSs.
- Residual plume management for the Source Control-GWE alternative would not require the installation of any new engineered systems or structures, because the extraction wells have already been installed (Appendix B; Ramboll, 2024c). Under this alternative, the GWE wells would continue to be operated and maintained appropriately. Groundwater extracted from the extraction wells would go through a water treatment and filtration process prior to reaching the settling lagoon; if necessary, treatment would entail bag filtration to manage and reduce total suspended solids (TSS) levels (Appendix B; Ramboll, 2024c). The settling lagoon would provide further clarification to remove remaining solids before discharging *via* the NPDES permitted outfall. Additionally, regular groundwater sampling and routine maintenance of the monitoring well network would continue for at least 3 years after GWPSs have been achieved at all wells, in accordance with IAC Section 845.680(c)(2). Post-closure care groundwater monitoring would continue for a minimum of 30 years as required by IAC Section 845.780(c). Based on the adaptive site management approach, remedy optimization (additional methods or techniques) may be implemented to ensure the achievement of the GWPSs.
- Residual plume management for the Source Control-Deep Cutoff Wall alternative would require multiple tasks to be completed over three phases: pre-construction activities (Phase 1), corrective action construction (Phase 2), and corrective action operations, maintenance, and closeout (Phase 3). Once pre-construction activities are completed, construction of the cutoff wall would occur simultaneously with EAP closure. The waste generated from the cutoff wall construction would be disposed on-Site beneath the final cover of the EAP (Appendix B; Ramboll, 2024c). After the installation of the deep cutoff wall, no O&M efforts would be required, because it is a passive, below-grade structure. However, quality assurance (QA) programs would be required as part of construction to validate the integrity of the constructed cutoff wall. Regular groundwater sampling

and routine maintenance of the monitoring well network would continue for at least 3 years after GWPSs have been achieved for all wells, in accordance with IAC Section 845.680(c)(2). Post-closure care groundwater monitoring would continue for a minimum of 30 years as required by IAC Section 845.780(c). Based on the adaptive site management approach, remedy optimization may be implemented to ensure the achievement of the GWPSs, such as installing a secondary GWE system.

2.2.5 Short-Term Risks to the Community or the Environment During Implementation of Remedy (IAC Section 845.670(e)(1)(D))

2.2.5.1 Safety Impacts

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 risks to workers during construction and/or other corrective action 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 associated with source control, which were evaluated in the CAA (Gradient, 2022a), are the same for all three corrective action alternatives. The safety impacts associated with residual plume management (*i.e.*, construction and O&M) for each corrective action alternative are described below.

- The Source Control-GWP alternative would not require the construction of any engineered systems or structures, and maintenance of engineered systems or structures, and therefore no safety impacts are expected.
- The Source Control-GWE alternative would not require any additional construction because the GWE system has already been installed. As a result, potential safety concerns are only associated with O&M of the GWE system.
- The Source Control-Deep Cutoff Wall would include the construction of a deep groundwater cutoff wall to prevent contaminant migration eastward. Because the cutoff wall is a passive, subsurface structure, no O&M would be needed following installation. Therefore, potential safety concerns are only associated with the construction of the cutoff wall.

Worker Risks

On-Site accidents include injuries and deaths arising from the use of heavy equipment and/or earthmoving operations during Site activities. Off-Site accidents include injuries and deaths due to vehicle accidents during labor and equipment mobilization/demobilization, as well as materials/supplies hauling and deliveries.

As discussed in section 2.1.1, there are no construction activities or operational requirements associated with residual plume management for the Source Control-GWP alternative. As shown in Tables 2.1-2.2, Ramboll estimates that residual plume management for the Source Control-GWE corrective action alternative would require 4,420 on-Site labor hours, and residual plume management for the Source Control-Deep Cutoff Wall corrective action alternative would require 14,400 on-Site labor hours (Appendix B; Ramboll, 2024c). 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 0.046 worker injuries and 4.0×10^{-4} worker fatalities would occur on-Site under the Source Control-GWE corrective action alternative; and approximately 0.15 worker injuries and 1.3×10^{-3} worker fatalities would occur on Site under the Source Control-Deep Cutoff Wall corrective action alternative (Table 2.3). No worker accidents would be expected under the Source Control-GWP alternative. The number of on-Site worker accidents is therefore expected to be highest under the Source Control-Deep Cutoff Wall alternative.

Table 2.3 Expected Number of On-Site Worker Accidents Under Each Corrective Action Alternative[a]

Corrective Action Alternative	Injuries	Fatalities
Source Control-GWP	0	0
Source Control-GWE	0.046	4.0×10^{-4}
Source Control-Deep Cutoff Wall	0.15	1.3×10^{-3}

Notes:

Source Control-Deep Cutoff Wall = Source Control with a Deep Cutoff Wall; Source Control-GWE = Source Control with Groundwater Extraction; Source Control-GWP = Source Control with Groundwater Polishing.

(a) Although source control (*i.e.*, control-in-place [CIP]) is a primary component of the corrective action, the worker accidents associated with source control were previously estimated in the Closure Alternative Analysis (CAA) and are not repeated in this analysis.

Off-Site, a greater number of haul truck miles, labor and equipment mobilization/demobilization miles, and material delivery miles would be required under the Source Control-Deep Cutoff Wall alternative than would be required under the Source Control-GWP and Source Control-GWE alternatives (Tables 2.1-2.2). For residual plume management under the Source Control-Deep Cutoff Wall alternative, a total of approximately 445,000 off-Site vehicle and equipment travel miles would be required. In contrast, residual plume management under the Source Control-GWE corrective action alternative, only 78,400 total off-Site vehicle and equipment travel miles would be required, and no worker accidents would be expected under the Source Control and GWP alternative (Appendix B; Ramboll, 2024c). The United States Department of Transportation (US DOT) provides estimates of the expected number of fatalities and injuries "per vehicle mile driven" for drivers and passengers of large trucks and passenger vehicles (US DOT, 2023). Table 2.4 shows the expected number of off-Site accidents under each corrective action alternative 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 0.046 worker injuries and 7.5×10^{-4} worker fatalities would be expected to occur due to off-Site activities under the Source Control-GWE alternative; and an estimated 0.17 worker injuries and 5.8×10^{-3} worker fatalities would be expected to occur due to off-Site activities under the Source Control-Deep Cutoff Wall alternative. No worker accidents would be expected under the Source Control and GWP alternative.

Table 2.4 Expected Number of Off-Site Worker Accidents Related to Off-Site Car and Truck Use Under Each Corrective Action Alternative[a]

Off-Site Vehicle Use Category	Source Control-GWP		Source Control-GWE		Source Control-Deep Cutoff Wall	
	Injuries	**Fatalities**	**Injuries**	**Fatalities**	**Injuries**	**Fatalities**
Hauling	0	0	1.2×10^{-4}	8.8×10^{-6}	9.9×10^{-3}	7.4×10^{-4}
Labor Mobilization/Demobilization	0	0	0.046	7.4×10^{-4}	0.12	1.9×10^{-3}
Equipment Mobilization/Demobilization	0	0	0	0	0.018	1.3×10^{-3}
Material Deliveries	0	0	0	0	0.025	1.8×10^{-3}
Total:	0	0	0.046	7.5×10^{-4}	0.17	5.8×10^{-3}

Notes:

Source Control-Deep Cutoff Wall = Source Control with a Deep Cutoff Wall; Source Control-GWE = Source Control with Groundwater Extraction; Source Control-GWP = Source Control with Groundwater Polishing.

(a) Although source control (*i.e.*, closure-in-place [CIP]) is a primary component of the corrective action, the worker accidents associated with source control were previously estimated in the Closure Alternative Analysis (CAA) and are not repeated in this analysis.

Overall, considering accidents occurring both on- and off-Site, no worker injuries and worker fatalities would be expected to occur for residual plume management under the Source Control and GWP alternative; 0.092 worker injuries and 1.1×10^{-3} worker fatalities would be expected to occur for residual plume management under the Source Control-GWE alternative; and 0.32 worker injuries and 7.1×10^{-3} worker fatalities would be expected to occur for residual plume management under the Source Control-Deep Cutoff Wall alternative. Thus, overall risks to workers would be highest under the Source Control-Deep Cutoff Wall alternative and lowest under Source Control-GWP alternative.

Community Risks

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 (2023) and the off-Site travel mileages reported in Appendix B (and summarized in Tables 2.1-2.2), off-Site vehicle accidents could result in an estimated 0.019 injuries and 3.0×10^{-4} fatalities among community members (*e.g.*, people involved in haul truck accidents that are neither haul truck drivers nor passengers, including pedestrians, drivers of other vehicles, *etc*.) for residual plume management under the Source Control-GWE alternative (Table 2.5). For residual plume management under the Source Control-Deep Cutoff Wall alternative, off-Site vehicle accidents could result in an estimated 0.11 community injuries and 1.2×10^{-3} community fatalities. No community risks are expected under the Source Control-GWP alternative. Therefore, off-Site impacts on nearby residents, including injuries or fatalities, would be highest under the Source Control-Deep Cutoff Wall alternative.

Table 2.5 Expected Number of Community Accidents Under Each Corrective Action Alternative

Off-Site Vehicle Use Category	Source Control-GWP		Source Control-GWE		Source Control-Deep Cutoff Wall	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	1.5×10^{-4}	1.1×10^{-6}	0.012	9.1×10^{-5}
Labor Mobilization/Demobilization	0	0	0.019	3.0×10^{-4}	0.048	7.6×10^{-4}
Equipment Mobilization/Demobilization	0	0	0	0	0.022	1.6×10^{-4}
Material Deliveries	0	0	0	0	0.031	2.3×10^{-4}
Total:	0	0	0.019	3.0×10^{-4}	0.11	1.2×10^{-3}

Notes:
Source Control-Deep Cutoff Wall = Source Control with a Deep Cutoff Wall; Source Control-GWE = Source Control with Groundwater Extraction; Source Control-GWP = Source Control with Groundwater Polishing.
(a) Although source control (*i.e.*, closure-in-place [CIP]) is a primary component of the corrective action, the community accidents associated with source control were previously estimated in the Closure Alternative Analysis (CAA) and are not repeated in this analysis.

2.2.5.2 Cross-Media Impacts to Air

Air pollution can occur both on-Site (*e.g.*, construction activities) and off-Site (*e.g.*, along transportation routes), potentially impacting workers as well as community members. Diesel emissions are a major source of air pollutants and GHG emissions at construction sites. Diesel exhaust contains 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). Construction equipment also emits greenhouse gases (GHGs), including carbon dioxide (CO_2) and possibly nitrous oxide (N_2O). The potential impact of each corrective action alternative on GHG emissions is proportional to the potential impact of each alternative on other emissions from construction vehicles and equipment.

Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Air impacts occurring during source control would be the same for all corrective action alternatives. Impacts associated with CIP using a consolidate-and-cap approach were evaluated in the CAA (Gradient, 2022a). On-Site emissions would be highest for residual plume management under the Source Control-Deep Cutoff Wall alternative due to the greatest amount of on-Site vehicle travel miles required under this corrective action alternative (48,500 total on-Site travel miles under the Source Control-Deep Cutoff Wall alternative *versus* 6,630 total on-Site travel miles under the Source Control-GWE alternative and no on-Site travel miles under the source Control-GWP alternative; Section 2.1.1, Tables 2.1-2.2). Off-Site emissions would similarly be highest for residual plume management under the Source Control–Deep Cutoff Wall alternative due to the greatest amount of off-Site vehicle and equipment travel miles required under this alternative (445,000 total off-Site travel miles under the Source Control-Deep Cutoff Wall alternative *versus* 78,400 under the Source Control-GWE alternative and no off-Site travel miles Source Control-GWP alternatives). In summary, air impacts would be highest for the Source Control-Cutoff Wall alternative due to greatest vehicle travel miles, and lowest for the Source Control-GWP alternative, because no construction activities would be expected under this alternative.

2.2.5.3 Cross-Media Impacts to Surface Water and Sediments

Under all three corrective action alternatives, the constituent mass flux from groundwater into surface water would decline over time after source control has been completed (Ramboll, 2023). Groundwater modeling was performed in support of the CAA (Gradient, 2022a). The modeling predicted that source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions

(Ramboll, 2022a). Due to the reduction in the hydraulic flux out of the EAP, the mass flux out of the EAP would also be controlled or minimized.

Under the Source Control-GWP alternative, minimal surface water and sediment impacts would be expected associated with residual plume management, because it would not require the construction of any engineered systems or structures (other than utilizing existing monitoring wells).

Under the Source Control-GWE alternative, groundwater collected by the extraction wells would be discharged to the Ohio River *via* one of the facility's NPDES-permitted outfalls. Collected groundwater would be treated and filtered prior to discharge to ensure compliance with water quality standards. Thus, minimal surface water or sediment impacts are expected under the Source Control-GWE alternative associated with residual plume management.

Under the Source Control-Deep Cutoff Wall alternative, surface water and sediment impacts would be higher than the other two alternatives due to the construction of the barrier wall. Construction can have short-term negative impacts on surface water and sediment quality immediately adjacent to a site due to erosion and sediment runoff. Any associated impacts would be addressed through best management practice (BMPs) in accordance with Site land disturbance permits.

2.2.5.4 Control of Exposure to Any Residual Contamination During Implementation of the Remedy

Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. While appropriate controls would be established to prevent exposures of CCR during source control, the risks of CCR exposure during source control would be the same for all three corrective action alternatives. For each of the other corrective action components for the three potential alternatives, no residual CCR exposures would be expected to occur. However, impacted soils and groundwater can be a source of CCR-related constituent exposure for workers. Risks to workers arising from potential contact with residual contamination during construction, operation, and maintenance activities associated with residual plume management would be higher for the Source Control-GWE and Source Control-Deep Cutoff Wall alternatives than for the Source Control-GWP alternative, because the Source Control-GWE would involve the production, management, and potential treatment of extracted groundwater and Source Control-Deep Cutoff Wall would involve the excavation and subsequent disposal of Site soils. The Source Control-GWP alternative would not involve exposure to either of these soil or groundwater waste streams. Any potential CCR-exposures during the Source Control-GWE and Source Control-Deep Cutoff Wall alternatives would be managed through the use of rigorous safety protocols and personal protective equipment.

2.2.5.5 Other Identified Impacts

Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, impacts during source control would be the same for all three corrective action alternatives (see the CAA; Gradient, 2022a).

In addition to safety impacts, cross-media impacts, and the potential for workers to be exposed to residual contamination, construction activities, and remedial operations can have significant energy demands and can cause nuisance impacts such as traffic and noise. 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 here include the burning of diesel fuel during construction equipment and vehicle travel miles. Because GHG emission impacts and energy consumption impacts both arise from the same sources at construction sites, the trends discussed in Section 2.2.5.2 with respect to GHG emissions also apply to the evaluation of energy demands. Specifically, the energy demands of construction equipment and vehicles associated with residual plume management would be greater under the Source Control-Deep Cutoff Wall, while the energy demands under the Source Control-GWP and Source Control-GWE alternatives associated with residual plume management are expected to be lower, because these two alternatives would not require any significant construction activity. However, energy would be required for the operation of the GWE system under the Source Control-GWE alternative, while there is no operational energy required under the Source Control-GWP and Source Control-Deep Cutoff Wall alternatives, because the Source Control-GWP alternative would rely on physical and geochemical processes and the Source Control Deep Cutoff Wall alternative would rely on the constructed deep barrier wall.

Similarly, traffic and noise impacts associated with residual plume management are also expected to be higher under the Source Control-Deep Cutoff Wall alternative than the other two alternatives, due to the construction activities required to construct the barrier wall. Traffic may increase temporarily around the Site under the Source Control-Deep Cutoff Wall alternative 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 workday (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). Traffic and noise impacts associated with residual plume management from the Source Control-GWP and Source Control-GWE alternatives are expected to be significantly less than those associated with the Source Control-Deep Cutoff Wall alternative.

Construction activities can negatively impact natural resources and habitat near the Site, as well as scenic, historical, and recreational value. There would be no impacts under the Source Control-GWP and Source Control-GWE alternatives because no additional construction activities would occur after implementation of source control. However, under the Source Control-Deep Cutoff Wall alternative, large cranes, batch plants, and other equipment would be utilized during construction of the wall. Part of the wall is situated within approximately 500 ft of off-Site residences and approximately 600 ft from the Joppa High School's baseball fields. Given the proximity between these areas and the wall, it is likely that these areas would experience adverse impacts such as visual disturbance, obstruction of view, and noise during the construction period. However, these impacts are expected to diminish once the construction is completed in 12 – 18 months.

In addition, the construction of the cutoff wall under the Source Control-Deep Cutoff Wall alternative is expected to use a significant amount of cement, which would be introduced into the UA and other hydrogeological units. The process would use bentonite-based drilling mud with various additives, similar to the methods employed in well drilling but on a notably larger scale. Adding substantial quantities of these materials into the subsurface environment may cause alteration in groundwater pH levels and affect geochemical conditions in the UA.

2.2.6 Time Until Groundwater Protection Standards Are Achieved/Attain the Groundwater Protection Standards Specified in Section 845.600 (IAC Section 845.670(e)(1)(E)/IAC Section 845.680(d)(2))

This section of the report evaluates the time required to achieve GWPSs, pursuant to requirements under IAC Section 845.670(e)(1)(E) (IEPA, 2021) and under IAC Section 845.680(d)(2).

Groundwater and dissolved constituents move 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 in a southern direction towards the Ohio River, with seasonal variations to the southeast and southwest. The Ohio River is the primary receiving water body 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 JPP 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 in the UA may fluctuate by approximately 10 ft in the vicinity of the Site (Ramboll, 2021).

Groundwater modeling was performed in support of the CAA (Gradient, 2022a). The modeling predicted that source control would result in a reduction of migration of water into the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022a). Additionally, source control would result in a reduction of hydraulic flux out of the EAP by 99.9% compared to pre-closure conditions (Ramboll, 2022a). Additional modeling was conducted for each of the corrective action alternatives to evaluate future groundwater quality in the vicinity of the EAP as a result of residual plume management (Appendix B; Ramboll, 2024c), and the results of the modeling indicate that groundwater would attain the GWPSs for all of the constituents[5] identified as having potential groundwater exceedances in the monitoring well network within approximately 11, 10, and 12 years, respectively, after source control has been implemented for the Source Control-GWP, Source Control-GWE, and Source Control-Deep Cutoff Wall alternatives (Appendix B; Ramboll, 2024c), and thus satisfy the GWPSs criteria in IAC Section 845.670(e)(1)(E) and IAC Section 845.680(d)(2)).

Table 2.6 Estimated Timeline and Implementation Schedule Under Each Corrective Action Alternative

Implementation Phase	Implementation Task	Timeframe		
		Source Control-GWP	**Source Control-GWE**	**Source Control-Deep Cut**
1: Pre-Construction Activities[a] (concurrent with Source Control)	Agency Coordination, Approvals, and Permitting	NA	NA	6 to 12 months
	Final Design and Bid Process			24 to 36 months
	Timeframe to Complete Corrective Pre-Construction Activities			30 to 48 months after CAP Approval (3 to 4 years)
2: Corrective Action Construction[a] (concurrent with Source Control)	Corrective Action Construction	NA	NA	12 to 18 months
	Timeframe to Complete Corrective Action Construction			12 to 18 months

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[5] Boron was selected as a surrogate for the contaminant fate and transport simulations to evaluate the effectiveness of each of the corrective action alternative. Boron was detected in the EAP groundwater at the highest concentrations relative to its GWPS and it is expected to take the longest time to achieve GWPS. Modeling all constituents that exceed GWPS or have been detected at lower concentrations relative to their GWPSs is unnecessary, as these constituents will likely achieve their GWPSs more quickly (Appendix B; Ramboll, 2024a).

3: Corrective Action O&M and Closeout[b] (after completion of Source Control)	Corrective Action Monitoring (Time to Meet GWPS)	132 months (11 years)	120 months (10 years)	144 months (12 years)
	Corrective Action Confirmation Monitoring	36 months	36 months	36 months
	Corrective Action Completion Reporting	6 months	6 months	6 months
Total Timeline to Complete Corrective Action (After Completion of Source Control)		174 months (15 years)	162 months (14 years)	186 months (15.5 years)

Notes:

CAP = Construction Application Permit; NA = Non-applicable; Source Control-Deep Cutoff Wall = Source Control with a Deep Cutoff Wall; Source Control-GWE = Source Control with Groundwater Extraction; Source Control-GWP = Source Control with Groundwater Polishing.

(a) Pre-construction Activities (Phase 1) and Corrective Action Construction (Phase 2) are assumed to occur concurrently with the source control (*i.e.*, closure-in-place or CIP) activities, to allow waste materials to be placed underneath the East Ash Pond (EAP) final cover system under the Source Control-Cutoff Wall alternative.

(b) Corrective Action O&M and Closeout (Phase 3) is assumed to start after the source control (*i.e.*, closure-in-place or CIP) is complete and approval of the corrective action construction permit application has been issued by Illinois Environmental Protection Agency (IEPA), whichever is longer.

Source: Appendix B; Ramboll, 2024c.

2.2.7 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 845.670(e)(1)(F))

Section 2.2.1 describes the magnitude of reduction of existing risks under each corrective action alternative. Section 2.2.2 describes the effectiveness of the remedy in controlling the source, including the extent to which containment practices would reduce further releases. Section 2.2.3 describes the likelihood of future releases of CCR occurring under each corrective action alternative, and Section 2.2.5 describes the short-term risks to workers, the community, and the environment during implementation of the remedy, including safety impacts and control of exposure to any residual contamination. In summary, source control measures (*i.e.*, CIP using a consolidate-and-cap approach) would be undertaken at the Site. Thus, all corrective action alternatives would completely eliminate the potential for a sudden CCR release to occur post-closure (due, *e.g.*, to flooding or a dike failure event). Similarly, due to the source control common to all of the corrective action alternatives, the three alternatives would all involve installing a new cover system over the EAP, and no residual CCR exposures would be expected to occur during the implementation of any of the alternatives. All three corrective action alternatives would therefore be equally and fully protective with regard to exposure to residual CCR. There are no current or future risks to any human or ecological receptors at the Site, and there would be no risk of CCR releases post-closure.

Under Source Control-GWE and Source Control-Deep Cutoff Wall alternatives, the flow of groundwater into the Village of Joppa would be prevented by the extraction wells and the barrier wall, respectively, whereas the eastward flow of groundwater into the Village of Joppa would not be controlled by engineered structures under the Source Control-GWP alternative. Thus, Source Control-GWE and Source Control-Deep Cutoff Wall alternatives would be more protective of residents in the Village of Joppa than the Source Control-GWP alternative.

For construction workers, risks arising from potential contact with residual contamination during construction, operation, and maintenance activities associated with residual plume management would be higher for the Source Control-GWE and Source Control-Deep Cutoff Wall alternatives than for the Source Control-GWP alternative, because the Source Control-GWE would involve the production, management, and potential treatment of extracted groundwater, and Source Control-Deep Cutoff Wall would involve the excavation and subsequent disposal of Site soils. The Source Control-GWP alternative would not involve exposure to either of these soil or groundwater waste streams. Any potential CCR exposures occurring under Source Control-GWE during groundwater extraction and treatment, and under Source Control-Deep Cutoff Wall during the installation of the cutoff wall, would be managed through the use of rigorous safety protocols, personal protective equipment, and appropriate disposal practice.

Some changes in groundwater flow (*i.e.*, reduction in groundwater flow into the river) may occur under the Source Control-GWE alternative, due to the operation of the GWE wells. However, changes to groundwater flow would not be expected to have an effect on the potential for exposure of humans and environmental receptors. Hydrogeological changes would also be expected under the Source Control-Deep Cutoff Wall alternative, such as altering flow patterns in the UA, redirecting groundwater flow around the cutoff wall, and causing changes in hydraulic gradients. However, changes to groundwater flow would not be expected to have an effect on the potential for the exposure of humans and environmental receptors to remaining wastes.

2.2.8 Long-term Reliability of the Engineering and Institutional Controls (IAC Section 845.670(e)(1)(G))

Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, the long-term reliability during source control would be the same for all three corrective action alternatives (Gradient, 2022). The long-term reliability of the engineering and institutional controls associated with residual plume management of each corrective action alternative are summarized below.

- Residual plume management under the Source Control-GWP alternative would be reliable because it would rely on natural physical and geochemical 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). Active groundwater monitoring would be in place to track the remediation progress. Should the predicted decrease in groundwater concentrations not occur, the adaptive site management approach would enable prompt adjustments or enhancements to the corrective action in accordance with IAC Section 845.680(b). This strategy would allow continuous improvement of the EAP groundwater remediation in response to new Site information and/or the performance of the corrective action alternative.
- GWE is a proven remedy that has been implemented at many sites. Thus, residual plume management under the Source Control-GWE alternative would be expected to be reliable. Under this alternative, no additional engineering structures, other than the extraction wells that have already been installed, would require design or installation. Routine maintenance of the GWE is required to ensure reliable operation of the extraction wells and pumps, as well as other system components. Active groundwater monitoring would be in place, similar to those required under the Source Control-GWP alternative.
- Cutoff walls are a proven remedy that have been implemented at many sites. Thus, residual plume management under the Source Control-Deep Cutoff Wall alternative would be reliable provided it is constructed in accordance with standard design and specifications. Some challenges are expected during construction, necessitating specialized equipment deployment. Common challenges include slurry loss, obstructions, and the risk of instability. The effectiveness of the cutoff wall relies on

precise construction techniques, demanding ongoing quality control (QC). Under this alternative, no O&M activities would be required to ensure the success of the alternative because the cutoff wall is a passive, below-grade structure. However, post-construction QA programs may be required to validate the quality of the constructed cutoff wall. Ongoing monitoring of the system may be required to ensure reliable operation. Active groundwater monitoring would be in place, similar to the monitoring required under the Source Control-GWP alternative.

- For all three corrective action alternatives, remedy optimizations would be implemented if necessary, under the adaptive site management program.

2.2.9 Potential Need for Replacement of the Remedy (IAC Section 845.670(e)(1)(H))

The potential need for the eventual replacement of the residual plume management remedy under each corrective action alternative is summarized as follows:

- Source Control-GWP would rely on natural geochemical processes to achieve reductions in groundwater concentrations to below GWPSs. Because no installation, operation, and maintenance of engineered systems or structures would be required, it would be unlikely that the residual plume management remedy under the Source Control-GWP alternative would need to be replaced. Adaptive site management strategies would be used to implement remedy optimizations or replacement, as necessary based on data that are collected, to ensure that remedial goals are achieved.
- Source Control-GWE would utilize a GWE system to extract impacted groundwater to achieve reductions in groundwater concentrations to below GWPSs. While the GWE system would need ongoing maintenance and potential replacement of system components over time, it is unlikely that the residual plume management remedy under the Source Control-GWE alternative would need to be replaced. Adaptive site management strategies would be used to implement remedy optimizations or replacement, as necessary based on data that are collected, to ensure that remedial goals are achieved.
- Source Control-Deep Cutoff Wall would rely on a cutoff wall as a physical barrier to reduce or prevent migration of impacted groundwater and achieve reductions in groundwater concentrations to below GWPSs. Because the deep cutoff wall is a robust, engineered, and maintenance-free subsurface structure, it is unlikely that the residual plume management remedy under the Source Control-Deep Cutoff Wall alternative would need to be replaced. Adaptive site management strategies would be used to implement remedy optimizations or replacement, as necessary based on data that are collected, to ensure that remedial goals are achieved.

2.3 The Ease or Difficulty of Implementing a Remedy (IAC Section 845.670 (e)(3))

2.3.1 Degree of Difficulty Associated with Constructing the Remedy (IAC Section 845.670(e)(3)(A)

Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, construction difficulties regarding source control would be the same for all three corrective action alternatives. Difficulties associated with implementing CIP using a consolidate-and-cap approach were evaluated in the CAA (Gradient, 2022a). The expected degree of difficulty associated with residual plume management for each of the corrective action alternatives is summarized below.

- Residual plume management under the Source Control-GWP alternative would rely on physical and geochemical attenuation processes and therefore would not pose any significant construction challenges. Therefore, there would be minimal difficulty in constructing the Source Control-GWP remedy.
- Residual plume management under the Source Control-GWE would utilize the existing GWE system along the eastern boundary of the EAP to extract impacted groundwater and rely on physical and geochemical attenuation processes to address downgradient groundwater quality impacts. Therefore, minimal additional construction challenges are expected. Groundwater monitoring would be conducted using a groundwater monitoring network designed in accordance with IAC Section 845.680(c).
- Residual plume management under the Source Control-Deep Cutoff Wall alternative would rely on the barrier wall to reduce or prevent migration of impacted groundwater and would rely on physical and geochemical attenuation processes to address downgradient groundwater quality impacts. However, it may have the following challenges during construction of the cutoff wall (Appendix B; Ramboll, 2024c):
    - Implementing the remedy entails the mobilization of specialized equipment to the site, including large cranes, clamshells, slurry cutters, or potentially one-pass trenching equipment. Supporting equipment such as batch plants, excavation, and grading equipment may also be used.
    - Although cutoff walls are commonly constructed to similar depths in comparable geologic environments, challenges during the cutoff wall's construction may still arise. These challenges may involve encountering highly permeable layers (leading to slurry loss), obstructions that necessitate specialized techniques and/or equipment for progression, or sidewall instability.
    - The effectiveness of the cutoff wall relies on the construction techniques employed to prevent gaps, voids, or other discontinuities in the structure. Ongoing QC is essential during construction as part of QA activities to prevent such defective features. Additionally, QA programs, such as coring and testing, may be necessary to validate the quality of the constructed barrier.
    - The performance of the wall is contingent on its actual hydraulic conductivity. This necessitates ongoing monitoring and QA/QC testing for slurry mixing, placement, or soil-bentonite mixing. The goal is to ensure adherence to the designed mix and involves routine testing of samples from the wall material.

- Groundwater monitoring would be conducted using a groundwater monitoring network designed in accordance with IAC Section 845.680(c).

2.3.2 Expected Operational Reliability of the Remedy (IAC Section 845.670(e)(3)(B))

Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, the operational reliability of the remedy would be the same for all three corrective action alternatives. The reliability associated with implementing CIP using a consolidate-and-cap approach was evaluated in the CAA (Gradient, 2022a). All three corrective action alternatives would likely be highly reliable with respect to operational controls associated with residual plume management; specific details for each corrective action alternative are discussed below.

- Residual plume management under the Source Control-GWP alternative would have high operational reliability because it would rely on natural processes and active monitoring, rather than the installation, operation, and maintenance of engineered systems or structures (other than monitoring wells). Under the Source Control-GWP alternative, engineering failure would not occur, and no O&M activities would be required to ensure the success of the alternative. Groundwater geochemical processes near ambient background conditions are unlikely to affect the chemical mechanisms of GWPS or delay the projected timeline for achieving GWPS compliance (Appendix B; Ramboll, 2024c).
- Residual plume management under the Source Control-GWE alternative would also have high operational reliability because it is an established and commonly used remedial technique. The GWE system would be initiated before implementation of source control as a PCA to control the easterly migration of CCR-impacted groundwater. However, the remedy operates as a mechanical system and would require the GWE system to be maintained appropriately in accordance with standard practices in order to reliably operate.
- Residual plume management under the Source Control-Deep Cutoff Wall alternative would also have high operational reliability, because it is an established remedial technology, as long as it is constructed in accordance with standard design and specifications for barrier walls. The deep cutoff wall is a passive, continuous, and low-permeability barrier to groundwater and no O&M would be required after its installation.

2.3.3 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies (IAC Section 845.670(e)(3)(C))

All three corrective action alternatives would require regulatory approvals. Specific permits and approvals associated with source control are the same for all three corrective action alternatives and are discussed in the CAA (Gradient, 2022a). The specific approvals and permits associated with residual plume management for all three corrective action alternatives are discussed below.

- The Source Control-GWP alternative would not need additional permits from other agencies, other than the permits issued by IEPA for source control (*i.e.*, Closure Plan and Construction Permit Application) and approval of the eventual Corrective Action Plan.
- The Source Control-GWE alternative would require a Site-specific NPDES permit, which is already in place as part of the PCA. The permit should remain in place during operation of the GWE into the post-closure final remedy. The NPDES permits would likely require renewals depending on the timeline of corrective action implementation.

- The Source Control-Deep Cutoff Wall alternative would require approvals and permits, such as permits from IEPA for construction of stormwater controls and BMPs. An amendment to the submitted EAP Closure Plan and Construction Permit Application would be required to allow the disposal of deep cutoff wall spoils beneath the EAP's final cover system.

2.3.4 Availability of Necessary Equipment and Specialists (IAC Sections 845.670(e)(3)(D) and 845.660(c)(1), "Ease of Implementation")

Source control (*i.e.*, CIP using a consolidate-and-cap approach) would be implemented for all three potential corrective action alternatives. Thus, equipment and specialist needs would be the same for all three corrective action alternatives. An assessment of necessary equipment and specialists associated with implementing CIP using a consolidate-and-cap approach was evaluated in the CAA (see the CAA; Gradient, 2022a). Specialized equipment and personnel are essential for field data collection and groundwater sampling for residual plume management under all three potential corrective action alternatives. Additionally, the assessment of groundwater concentrations for Site constituents would necessitate laboratory equipment and specialists for all three alternatives. The availability of equipment and specialists for each corrective action alternative is summarized below.

- Residual plume management under the Source Control-GWP alternative would require groundwater professionals, such as geologists, hydrogeologists, statisticians (*i.e.*, statistical analysis), and geochemists to evaluate all monitoring data, ensuring that physical and geochemical processes function as anticipated for this alternative. The equipment and specialists needed for Site groundwater monitoring and analysis are currently engaged in these tasks as part of the routine groundwater monitoring program outlined in accordance with IAC Section 845.220(c)(4).
- Residual plume management under the Source Control-GWE alternative would require specialists to manage the GWE system throughout its operational period.
    - Components that would require maintenance include totalizers, bag filter housings (if necessary), instrumentation, and the extraction well and transfer pumps. Moreover, specialists would be essential for nonroutine O&M tasks, such as flushing or jetting conveyance lines, replacing faulty system components, swapping out pumps or pump controllers, and updating malfunctioning system instrumentation.
    - Typically, specialists and replacement equipment are readily available in the vicinity (within 100-300 miles) of the Site. However, certain more complex equipment, like the transfer pumps and transfer pump controllers, may involve longer lead times for replacement or servicing.
    - This alternative would necessitate the use of equipment and the expertise of specialists for tasks such as field data collection, groundwater sampling, analysis, and periodic corrective action groundwater monitoring and reporting. Similar to those in the GWP alternative, these activities are already being conducted as part of routine groundwater monitoring in accordance with IAC Section 845.220(c)(4).
- Residual plume management under the Source Control-Deep Cutoff Wall alternative would require specialists for the construction phase of the cutoff wall.
    - Building the deep cutoff wall requires the expertise of a specialized contractor with a background in constructing similar types of walls in comparable geologic environments, like those found in the Mississippi and Ohio River Valleys. The contractor would probably need specialized equipment, including large cranes, clamshell buckets, slurry cutters, batch plants, or one-pass construction equipment.

- Specialists involved in the design and construction of cutoff walls would be essential during both phases. This team of specialists should involve design engineers, construction managers, and contractor staff with expertise in cutoff wall construction and equipment operation.
- The types of equipment and specialists should have been employed for projects similar to designing and building deep cutoff walls. However, there may be backlogs associated with the equipment and specialists, due to the high existing backlog for specialty ground improvement contractors and design specialists, who are engaged with similar projects in sectors like electric utilities, dams/levees, and other areas.
- This alternative would also require the use of equipment and the expertise of specialists for tasks such as field data collection, groundwater sampling, groundwater sample analysis, and periodic corrective action groundwater monitoring and reporting. Similar to those in the Source Control-GWP alternative, these activities are already being conducted as part of routine groundwater monitoring in accordance with IAC Section 845.220(c)(4).

2.3.5 Available Capacity and Location of Needed Treatment, Storage, and Disposal Services/Comply with Standards for Management of Wastes as Specified in Section 845.680(d) ((IAC Section 845.670(e)(3)(D)/IAC Section 845.670(d)(5))

The available capacity and location of needed treatment, storage, and disposal services associated with residual plume management under each corrective action alternative is summarized below. All the practices employed in the three alternatives would comply with standards for the management of wastes as specified in IAC Section 845.670(e)(3)(D) and IAC Section 845.680(d)(5).

- Residual plume management for the Source Control-GWP remedy would not require any treatment, storage, or disposal services, because GWP is not anticipated to produce a substantial amount of waste or wastewater, aside from minor purge water volumes generated during routine groundwater sampling activities for residual plume management. This could be managed by a standard waste management contractor.
- Residual plume management for the Source Control-GWE alternative would not require new treatment, storage, or disposal services outside of the existing services already utilized by the Site as part of the PCA, including:
  - The design of the GWE system may allow for the treatment and filtration of suspended or dissolved solids retrieved from extracted groundwater. The anticipated quantities of extracted solids are expected to be minimal, and they would be disposed of off-Site after condensation and drying of the solids.
  - The on-Site settling lagoon is expected to have enough capacity to receive treated groundwater before discharging it at NPDES Outfall 010. This assessment was confirmed through hydraulic and hydrologic calculations conducted during design of the GWE system.
- Residual plume management for the Source Control-Deep Cutoff Wall alternative would generate waste during the cutoff wall construction phase, and the types of waste would be limited to spoils. These waste materials would be disposed of on-Site during the closure construction as compacted contouring fill beneath the EAP final cover system. During the operation of the cutoff walls no wastes would be generated. Consequently, no additional treatment, storage, or disposal services would be necessary for this remedy.

2.4 The Degree to Which Community Concerns Are Addressed by the Remedy (IAC Section 845.670(e)(4))

Several nonprofits raised concerns regarding 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). The combination of source control (*i.e*., CIP using a consolidate-and-cap approach) and residual plume management would cause groundwater concentrations to decline over time under all of the corrective action alternatives, as suggested by the groundwater modeling (Ramboll, 2023), thus addressing community concerns.

A public meeting would be held on March 19, 2025, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees would be answered at the meeting; subsequently, a written summary of all questions and responses would be made available to interested parties.

2.5 Remove from the Environment as Much of the Contaminated Material that Was Released from the CCR Surface Impoundment as Is Feasible, Taking into Account Factors such as Avoiding Inappropriate Disturbance of Sensitive Ecosystems (IAC Section 845.670(d)(4))

There have been no documented releases of CCR from the unit. All three potential corrective action alternatives would have source control and residual plume management efforts. The source control would include the consolidation of CCR in the EAP into the western portion of the impoundment and the installation of a low-permeability final cover system designed to limit the infiltration of precipitation into the impounded CCR. Groundwater modeling performed in support of the CAA (Gradient, 2022a) concluded that source control alone would result in a 99.9% reduction in mass flux from the EAP into the underlying groundwater (Ramboll, 2022a). Therefore, this approach would prevent the release of contaminated material from the EAP to the extent that is feasible.

Moreover, residual plume management under each corrective action alternative will further result in the removal of contaminated material from the environment and/or the improvement of downgradient groundwater quality. Groundwater modeling has predicted that GWPSs would be achieved in all monitoring wells within approximately 11, 10, and 12 years, respectively, after source control has been implemented for the Source Control-GWP, Source Control-GWE, and Source Control-Deep Cutoff Wall alternative (Appendix B; Ramboll, 2024a). Specific considerations for residual plume management for each alternative are provided below.

- Residual plume management under the Source Control-GWP alternative would address impacted groundwater by relying on physical and geochemical attenuation processes to reduce the residual concentrations of CCR. Site-specific evaluation demonstrated conditions are favorable for the attenuation of inorganic contaminants *via* adsorption. Attenuation *via* sorption onto mineral surfaces should remain stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS. Contaminant levels in groundwater are anticipated to drop below the GWPS at all compliance monitoring wells following the migration of background groundwater during the post-closure phase (Appendix E; Geosyntec Consultants, Inc., 2024). In cases in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques to remove residual sources to achieve the GWPSs would be evaluated under the adaptive site management, and if viable, incorporated as per IAC

Section 845.680(b). No ecosystems would be disturbed because no construction activities are expected under the Source Control-GWP alternative.

- Residual plume management under the Source Control-GWE alternative would rely on the GWE system to reduce or prevent horizontal migration of impacted groundwater off-Site. Groundwater quality would also be improved as a result of physical and geochemical attenuation processes. No ecosystems would be disturbed because no additional construction activities are expected under the Source Control-GWE alternative, because the GWE system would begin operation prior to the implementation of source control.
- Residual plume management under the Source Control-Deep Cutoff Wall alternative would rely on an engineered system to prevent migration of impacted groundwater off-Site. Groundwater quality would also be improved as a result of physical and geochemical attenuation processes. The location of the cutoff wall was selected to avoid sensitive areas such as wetland and floodplains, and thus no significant disturbance to the ecosystems is expected. Some tree clearing is required and would be conducted consistent with Indiana regulations under the Source Control-Deep Cutoff Wall alternative, which may cause some temporary loss of habitat for species such as birds, insects, and plants.

2.6 Summary

This CAAA evaluates all three corrective action alternatives identified as potentially viable in the CMA with regard to each of the factors specified in IAC Section 845.670(d) and 845.670(e) (IEPA, 2021). Based on this evaluation, the most appropriate corrective action for this Site is Source Control-GWE. The Source Control-GWE alternative was predicted to achieve GWPSs under the shortest amount of time. The expected impacts on workers, nearby communities, and the environment under the Source Control-GWE alternative are lower than the Source Control-Deep Cutoff Wall alternative. Furthermore, Source Control-GWE controls off-Site migration of groundwater into the Village of Joppa more than Source Control-GWP and, thus, result in less impact on the Village of Joppa than Source Control-GWP. Thus, Source Control-GWE is the most appropriate corrective action alternative for the EAP.

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Appendix A

Human Health and Ecological Risk Assessment

Human Health and Ecological Risk Assessment
East Ash Pond
Joppa Power Plant
Joppa, Illinois

July 28, 2022

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Abbreviations

ADI	Acceptable Daily Intake
BCF	Bioconcentration Factor
BCG	Biota Concentration Guide
CAA	Closure Alternatives Assessment
CCR	Coal Combustion Residual
CEM	Conceptual Exposure Model
COI	Constituent of Interest
COPC	Constituent of Potential Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CWS	Community Water Supply
DWW	Drinking Water Watch
EAP	East Ash Pond
EEI	Electric Energy, Inc.
ESV	Ecological Screening Value
GWPS	Groundwater Protection Standard
GWQS	Groundwater Quality Standard
HTC	Human Threshold Criteria
HQ	Hazard Quotient
IAC	Illinois Administrative Code
IEPA	Illinois Environmental Protection Agency
ILWATER	Illinois Water and Related Wells
ISGS	Illinois State Geological Survey
JPP	Joppa Power Plant
K_d	Equilibrium Partition Coefficient
LAU	Lower Aquifer Unit
LOAEL	Lowest Observed Adverse Effect Level
LCU	Lower Confining Unit
MCL	Maximum Contaminant Level
NGWMN	National Groundwater Monitoring Network
NRWQC	National Recommended Water Quality Criteria
ORNL RAIS	Oak Ridge National Laboratory's Risk Assessment Information System
pCi	Picocurie
PMP	Potential Migration Pathway
PRG	Preliminary Remediation Goal
PWS	Public Water System
RAGS	Risk Assessment Guidance for Superfund
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SDWIS	Safe Drinking Water Information System
SI	Surface Impoundment
SWQS	Surface Water Quality Standards

TEC	Threshold Effect Concentration
UA	Uppermost Aquifer
UCU	Upper Confining Unit
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1 Introduction

Electric Energy, Inc. (EEI), a subsidiary of Vistra Corp., owns and operates the Joppa Power Plant (JPP), a coal-fired power generating facility in Joppa, Illinois. The facility began operations in 1955 and is currently in operation. EEI plans to retire the JPP by September 2022 (Vistra Corp, 2021). The JPP has two surface impoundments (SIs) for the storage of coal combustion residuals (CCR). The East Ash Pond (EAP), which is the subject of this report, is an "unlined CCR SI used to manage CCR and non-CCR waste streams at the JPP" (Ramboll, 2021). The West Ash Pond, known as Joppa West, is inactive (Ramboll, 2021).

This report presents the results of an evaluation that characterizes potential risk to human and ecological receptors that may be exposed to CCR constituents in environmental media potentially impacted by the EAP. This risk evaluation was performed to support the Closure Alternatives Assessment (CAA) for the EAP in accordance with the requirements outlined in Title 35, Part 845 of the Illinois Administrative Code (IAC) (IEPA, 2021). Human and ecological risks were evaluated for Site-specific constituents of interest (COIs). The conceptual site model (CSM) assumed that Site-related COIs may impact groundwater and migrate to the Ohio River and affect surface water and sediment in the vicinity of the Site.

Consistent with United States Environmental Protection Agency (US EPA) guidance (US EPA, 1989), this report used a tiered approach to evaluate potential risks, which included the following steps:

1. Identify complete exposure pathways and develop a conceptual exposure model (CEM).
2. Identify Site-related COIs: A constituent detected in groundwater was considered a COI if its maximum detected concentration over the period of 2015-2021 exceeded a groundwater protection standard (GWPS) identified in Section 845.600 (IEPA, 2021), or a relevant surface water quality standard (SWQS) (IEPA, 2019; US EPA Region IV, 2018).
3. Perform screening-level risk analysis: Compare maximum measured or modeled COI concentrations in surface water and sediment to conservative, health-protective benchmarks to identify constituents of potential concern (COPCs).
4. Perform refined risk analysis: If COPCs are identified, perform a refined analysis to evaluate potential risks associated with the COPCs.
5. Formulate risk conclusions and discuss any associated uncertainties.

This assessment relies on a conservative (*i.e.*, health-protective) approach and is consistent with the risk approaches outlined in US EPA guidance. Specifically, Gradient considered evaluation criteria detailed in Illinois Environmental Protection Agency (IEPA) guidance documents (*e.g.*, IEPA, 2013, 2019), incorporating principles and assumptions consistent with the Federal CCR Rule (US EPA, 2015a) and US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals," referred to herein as the US EPA CCR risk assessment (US EPA, 2014a).

US EPA has established acceptable risk metrics. Risks above these US EPA-defined metrics are termed potentially "unacceptable risks." Even though there are no known current risks associated with exposure to groundwater at the Site, an unacceptable risk was identified for the potential future residential use of shallow groundwater as source of drinking water. No other unacceptable risks to human or ecological receptors resulting from CCR exposures associated with the EAP were identified. Specific risk assessment results include the following:

- Residential use of groundwater from the Uppermost Aquifer (UA) as drinking water was identified as a potential human health risk. However, based on a windshield survey within the Village of Joppa, Gradient does not believe that there are any current residential users of groundwater from the UA.
- No unacceptable risks were identified for residents using groundwater for irrigation of homegrown produce.
- No unacceptable risks were identified for recreators swimming or boating in the Ohio River adjacent to the Site.
- No unacceptable risks were identified for recreators exposed to sediment in the Ohio River adjacent to the Site.
- No unacceptable risks were identified for anglers consuming locally caught fish.
- No unacceptable risks were identified for ecological receptors exposed to surface water or sediment at the Site.
- No bioaccumulative ecological risks were identified.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk. Moreover, due to the planned closure and corrective measures that will be implemented at the Site, future risks are anticipated to be lower than current risks for all receptors and exposure pathways, because potential releases of CCR-related constituents will decline over time and impacted groundwater will be intercepted before it can migrate off Site. Consequently, potential exposures to CCR-related constituents in the environment will also decline.

2 Site Overview

2.1 Site Description

The JPP is located in Massac County, Illinois, west of the Village of Joppa and northeast of the Ohio River, in a predominantly agricultural area (Ramboll, 2021). The JPP Site "is bordered by the LaFarge North America cement plant to the west, the Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south" (Ramboll, 2021) (Figure 2.1). The EAP is located on the eastern portion of the JPP property, "and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa" (Ramboll, 2021).

As stated in Ramboll (2021), "the EAP was built in two phases." The northern portion (Phase I) was completed in late 1973, while the southern portion (Phase II) was completed in late 1985. The northern and southern portions "are separated by a dividing dike (*i.e.*, Central Dike) and were referred to as the Northern and Southern Ponds" (Ramboll, 2021). Both the Northern and Southern Ponds are diked earthen embankment structures with dike heights varying "from approximately 15 to 45 ft above" their outboard toe, and the "Northern Pond is diked over the length of its perimeter" (Ramboll, 2021).

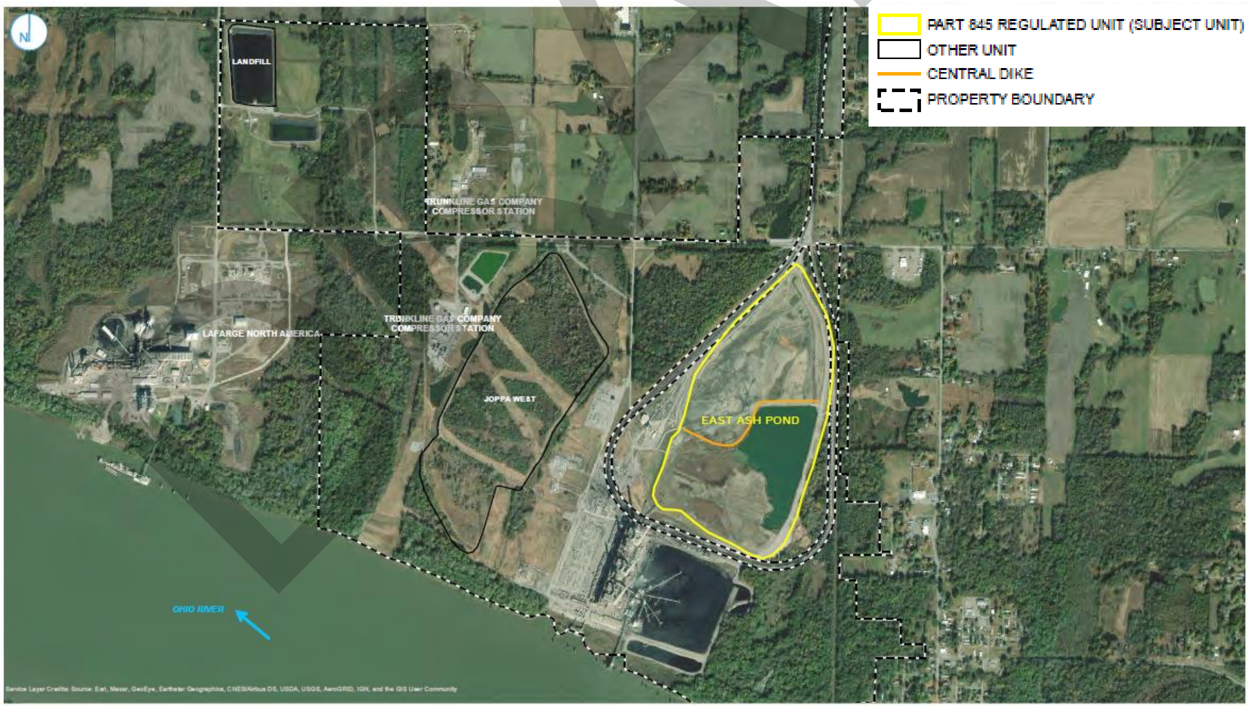

Figure 2.1 Site Location Map. Source: Ramboll (2021).

2.2 Geology/Hydrogeology

The geology underlying the Site in the vicinity of the EAP primarily consists of three hydrostratigraphic layers of unlithified deposits underlain by bedrock (Ramboll, 2021). From the top down, the three unlithified hydrostratigraphic units are the Upper Confining Unit (UCU), consisting of low-permeability silt and clay; the Uppermost Aquifer (UA), consisting of high-permeability sand with gravel and minor silt/clay; and the Lower Confining Unit (LCU), consisting of low-permeability clay and silt (Ramboll, 2021). The lowermost bedrock unit, or Lower Aquifer Unit (LAU), is comprised of limestone. The LAU is "used as a potable and non-potable water supply in the vicinity of the JPP" (Ramboll, 2021).

The UCU consists of the silt and clay of the Equality Formation (14-28 ft thick) and the Metropolis Formation (5-40 ft thick). The average thickness of the UCU is approximately 41 ft (Ramboll, 2021). The UA consists of the sands and gravels of the Upper McNairy Formation, with isolated lenses of silt and clay. Horizontal hydraulic conductivity for the Upper McNairy Formation at the Site is variable, with a geometric mean of 3.1×10^{-3} cm/sec (Ramboll, 2021). The UA is about 58 ft thick and is underlain by the LCU. The LCU overlies the bedrock and consists of the clay and silt of the Lower McNairy Formation, with a maximum thickness of about 14 ft. The LAU is composed of a 200- to 500-ft-thick limestone of the Salem Formation. The LAU was identified as a potential migration pathway (PMP) (Ramboll, 2021). The geometric mean horizontal hydraulic conductivity for the LAU at the Site is 4×10^{-4} cm/sec (Ramboll, 2021). The LAU is transmissive and can support production from the JPP wells.

As stated in Ramboll (2021), "The EAP is located upgradient of the Ohio River." Groundwater in the UA generally flows to the south and southeast toward the Ohio River (Figure 2.2; Ramboll, 2021). Some constituents in groundwater associated with the EAP may have migrated off Site into the areas east of the JPP property, including the Village of Joppa.

2.3 Conceptual Site Model

A CSM describes sources of contamination, the hydrogeological units, and the physical processes that control the transport of water and solutes. In this case, the CSM describes how groundwater underlying the EAP migrates and potentially interacts with surface water and sediment in the adjacent Ohio River. The CSM was developed using available hydrogeologic data specific to the EAP (Ramboll, 2021), including information on groundwater flow and surface water characteristics. Groundwater (and CCR-related constituents) originating from the EAP may migrate vertically downward through the silts and clays of the UCU into the sands and gravels of the UA and ultimately flow to the south and southeast toward the Village of Joppa and the Ohio River. Dissolved constituents in groundwater may partition between river sediments and Ohio River surface water.

2.4 Groundwater Monitoring

A total of 31 wells have been used to monitor groundwater quality near and downgradient of the EAP. Of these, 26 wells are screened in the UA, 4 are screened in the UCU, and 1 is screened in the LAU (Table 2.1) (Ramboll, 2021). The analyses presented in this report relied on all the available data from the 31 wells collected between 2015 and 2022, which is the period subsequent to the promulgation of the Federal CCR Rule. Groundwater samples were analyzed for a suite of total metals, specified in the Illinois CCR Rule, Section 845.600 (IEPA, 2021).[1] A summary of the groundwater data used in this risk evaluation is

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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.

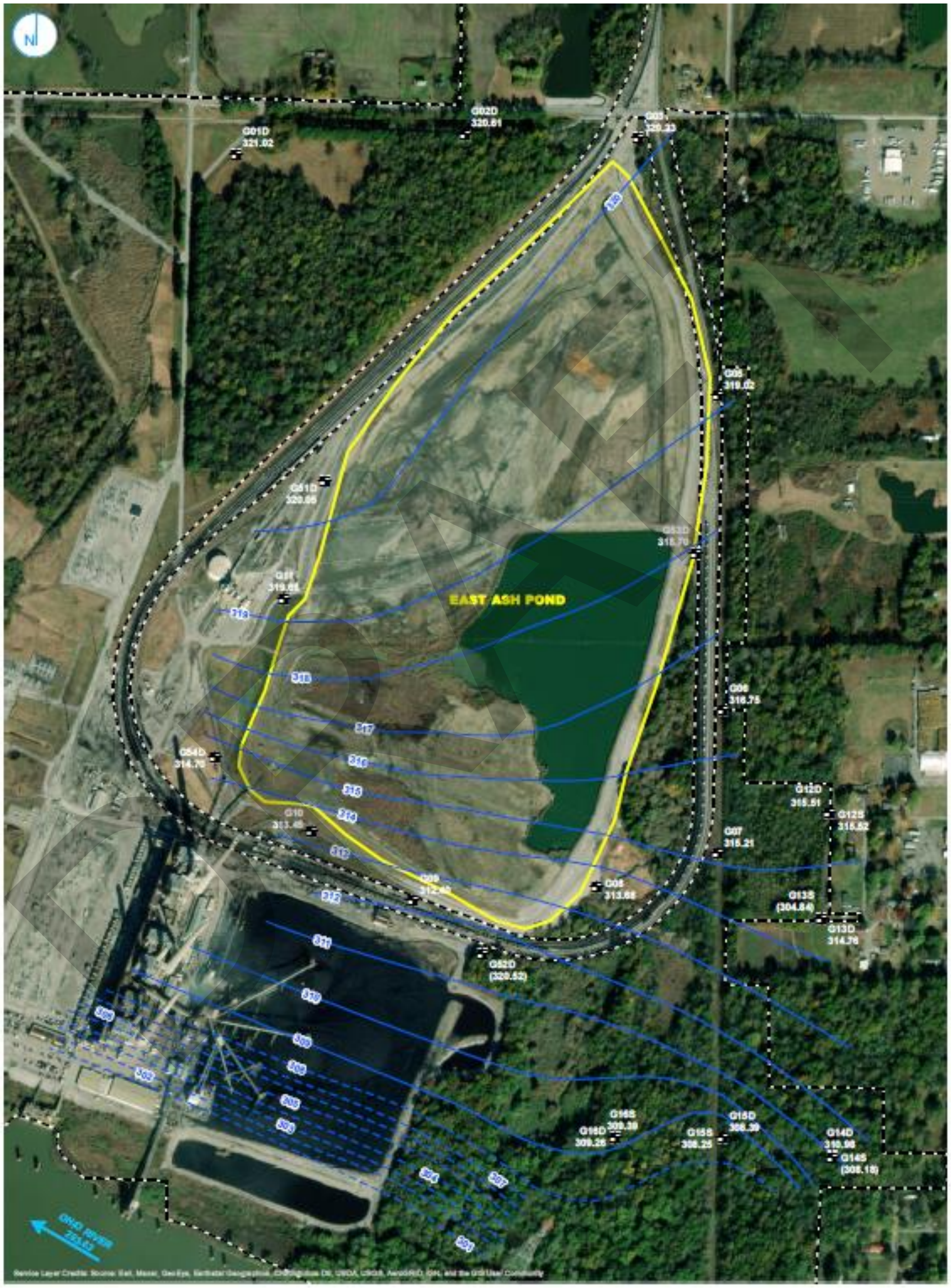

Figure 2.2 Monitoring Well Locations and Groundwater Elevation Contours for the UA.
Source: Ramboll (2022a).

Table 2.1 Groundwater Monitoring Wells Related to East Ash Pond

Well	Hydrogeologic Unit	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth (ft bgs)
G01D	UA	08/14/2015	54.2	63.9	64.4
G02D	UA	08/13/2015	62.2	71.8	72.4
G03	UA	02/02/2021	55.0	65.0	65.0
G04	UA	02/02/2021	50.0	60.0	60.0
G05	UA	02/01/2021	50.0	60.0	60.0
G06	UA	01/29/2021	75.0	85.0	85.0
G06S	UA	01/28/2021	30.0	40.0	40.0
G07	UA	01/29/2021	50.0	60.0	60.0
G08	UA	01/28/2021	75.0	85.0	85.0
G09	UA	01/31/2021	59.5	69.5	69.5
G09M	LAU	01/28/2021	145.0	155.0	155.0
G10	UA	02/01/2021	60.3	70.3	70.3
G11	UA	01/19/2021	55.7	65.7	65.7
G12D	UA	09/23/2021	80.0	90.0	90.0
G12S	UA	09/23/2021	60.0	70.0	70.0
G13D	UA	09/23/2021	80.0	90.0	90.0
G13S	UA	09/23/2021	50.0	60.0	60.0
G14D	UA	09/16/2021	120.0	130.0	130.0
G14S	UA	09/16/2021	53.0	63.0	63.0
G15D	UA	09/15/2021	83.0	93.0	93.0
G15S	UA	09/15/2021	50.0	60.0	60.0
G16D	UA	09/14/2021	98.0	108.0	108.0
G16S	UA	09/14/2021	50.0	60.0	60.0
G51D	UA	08/18/2015	49.6	59.3	59.9
G52D	UA	08/19/2015	69.9	79.6	80.0
G53D	UA	08/21/2015	47.3	56.9	57.3
G54S	UCU	01/22/2021	34.7	44.7	44.7
G54D	UA	08/11/2015	70.0	79.7	80.1
G151	UCU	06/19/2010	31.7	41.7	41.7
G152[a]	UCU	06/21/2010	14.7	24.7	24.7
G152B	UCU	01/30/2013	34.4	44.4	44.6
G153	UCU	06/18/2010	29.7	39.7	39.7

Notes:

ft bgs = Feet Below Ground Surface; LAU = Lower Aquifer Unit; UA = Uppermost Aquifer; UCU = Upper Confining Unit.

Sources: Ramboll (2021, 2022a).

(a) No analytical data were available for Well G152.

Table 2.2 Groundwater Data Summary

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	195	ND	ND	0.0010
Arsenic	72	219	0.0010	0.0098	0.0010
Barium	219	219	0.011	0.59	0.0040
Beryllium	2	195	0.0011	0.0012	0.0010
Boron	174	225	0.016	7.2	0.10
Cadmium	2	195	0.0010	0.0018	0.0010
Chromium	225	225	22	178	0.50
Cobalt	84	219	0.0011	0.023	0.0015
Lead	151	219	0.0010	0.0268	0.0010
Lithium	30	219	0.0010	0.0066	0.0010
Mercury	123	219	0.0011	0.010	0.0030
Molybdenum	0	195	ND	ND	0.00020
Selenium	59	195	0.0010	0.0062	0.0015
Thallium	4	195	0.0020	0.0033	0.0020
Radionuclides (pCi/L)					
Radium-226+228	219	219	0	5.9	2.0
Other (mg/L)					
Chloride	223	225	1.0	45	25
Fluoride	205	225	0.10	0.98	0.10
Sulfate	221	225	10	761	500
Total Dissolved Solids	225	225	146	1,200	20

Notes:
ND = Not Detected; pCi/L = Picocuries Per Liter.
Source: Ramboll (2021, 2022a).

3 Risk Evaluation

3.1 Risk Evaluation Process

A risk evaluation was conducted to determine whether constituents present in groundwater underlying and downgradient of the EAP have the potential to pose adverse health effects to human and ecological receptors. The risk evaluation is consistent with the principles of risk assessment established by US EPA and has considered evaluation criteria detailed in Illinois guidance documents (*e.g.*, IEPA, 2013, 2019).

The general risk evaluation approach is summarized in Figure 3.1 and discussed below.

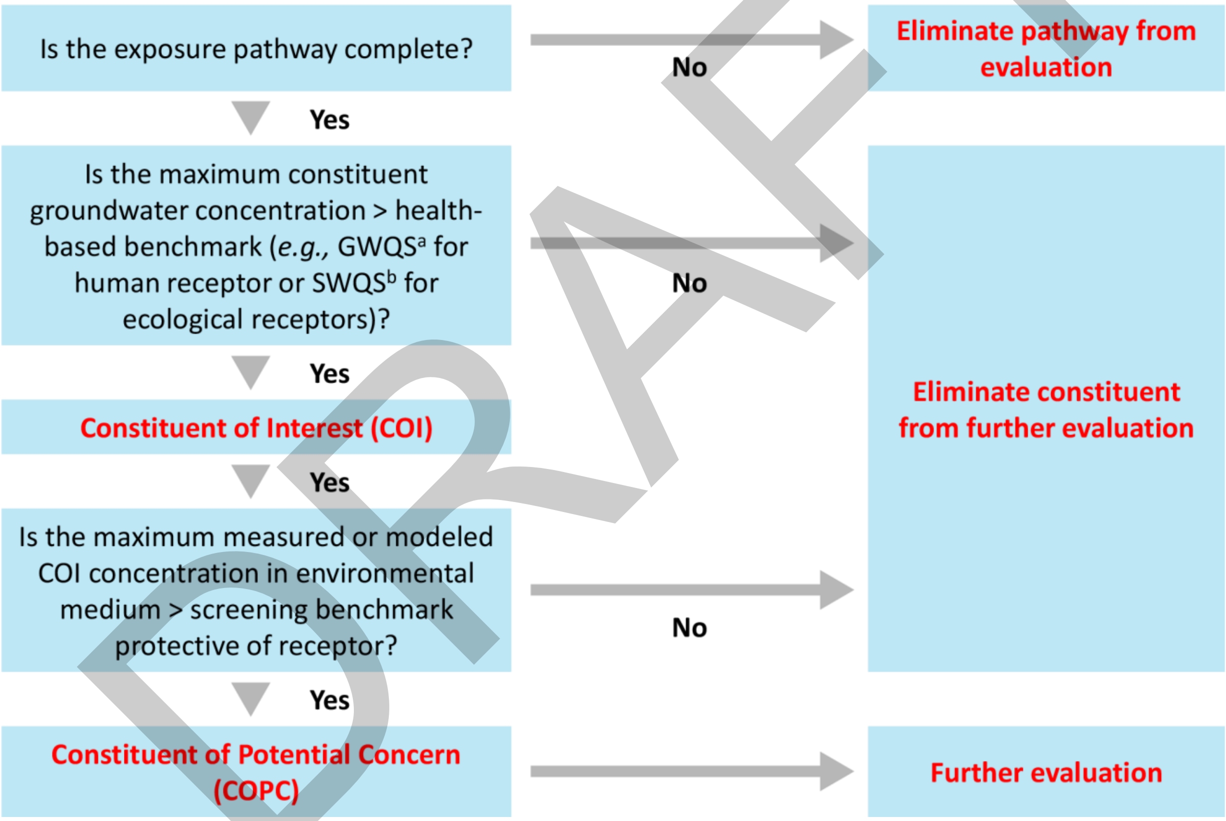

Figure 3.1 Overview of Risk Evaluation Methodology. GWQS = Groundwater Quality Standard; IEPA = Illinois Environmental Protection Agency; SWQS = Surface Water Quality Standard; US EPA = United States Environmental Protection Agency. (a) The IEPA Part 845 GWPS were used to identify COIs. (b) IEPA SWQS protective of chronic exposures to aquatic organisms were used to identify ecological COIs. In the absence of SWQSs, US EPA Region IV Ecological Screening Values (ESV) were used.

The first step in the risk evaluation was to develop the CEMs and identify complete exposure pathways. All potential receptors and exposure pathways based on groundwater use and surface water use in the vicinity of the Site were considered. Exposure pathways that are incomplete were excluded from the evaluation.

Groundwater data were used to identify COIs. COIs were identified as constituents with maximum concentrations in groundwater in excess of groundwater quality standards (GWQS)[2] for human receptors and SWQS for ecological receptors.

To evaluate the drinking water pathway, groundwater COI concentrations were compared to screening benchmarks for drinking water developed by US EPA. Concentrations that exceeded a conservative screening benchmark were identified as COPCs requiring further evaluation. To evaluate the use of groundwater for irrigation of homegrown produce, Gradient modeled the COI concentrations in soil resulting from irrigation with groundwater. The modeled soil concentrations were compared to soil screening benchmarks protective of consumption of homegrown produce. COIs with concentrations above the screening benchmark were identified as COPCs requiring further evaluation.

Surface water and sediment samples have not been collected from the Ohio River adjacent to the Site. Gradient modeled the potential migration of COIs from groundwater to surface water and sediment to evaluate potential risks to receptors (see Section 3.3.3). Gradient modeled the COI concentrations in surface water and sediment based on the groundwater data from the EAP-related wells. The modeled COI concentrations in surface water and sediment were compared to conservative, generic risk-based screening benchmarks for human health and ecological receptors. These generic screening benchmarks rely on default assumptions with limited consideration of site-specific characteristics. Human health benchmarks are receptor-specific values calculated for each pathway and environmental medium that are designed to be protective of human health. Ecological benchmarks are medium-specific values designed to be protective of all potential ecological receptors exposed to surface water. Ecological and human health screening benchmarks are inherently conservative because they are intended to screen out chemicals that are of no concern with a high level of confidence. Therefore, a modeled COI concentration exceeding a screening benchmark does not indicate an unacceptable risk; it only indicates that further risk evaluation is warranted. COIs with maximum concentrations exceeding a conservative screening benchmark are identified as COPCs requiring further evaluation.

As described in more detail below, the results of the screening assessment demonstrate that constituents present in groundwater underlying the EAP do not pose an unacceptable human health or ecological risk for exposure to surface water or sediment. The use of groundwater for irrigation of homegrown produce does not present an unacceptable risk. The residential use of groundwater from the UA as drinking water was identified as a potential human health risk for boron and cobalt, thus further assessment is warranted.

3.2 Human and Ecological Conceptual Exposure Models

A CEM provides an overview of the receptors and exposure pathways requiring risk evaluation. The CEM describes the source of the contamination, the mechanism that may lead to a release of contamination, the environmental media to which a receptor may be exposed, the route of exposure (exposure pathway), and the types of receptors that may be exposed to these environmental media.

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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.

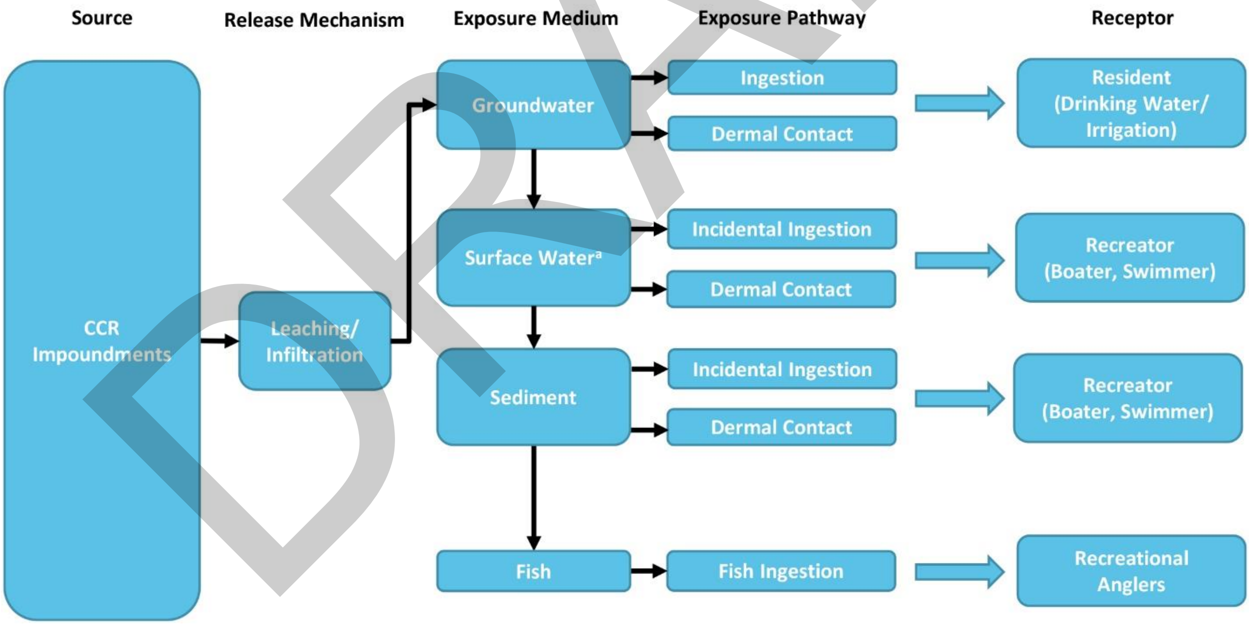

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residual. (a) Surface water is not used as a drinking water source adjacent to the Site.

3.2.1.1 Groundwater as a Drinking Water/Irrigation Source

Receptor surveys have been performed between 2013 and 2021 to identify potential users of groundwater in the vicinity of the EAP (Ramboll, 2021). Federal and state databases were reviewed as part of these surveys to identify nearby pumping wells and potential drinking water receptors in the vicinity of the EAP (Ramboll, 2021). Specific sources that were reviewed in these surveys include the United States Geological Survey (USGS) National Groundwater Monitoring Network (NGWMN),[3] the Illinois State Geological Survey (ISGS) Illinois Water and Related Wells (ILWATER) Map,[4] the US EPA Safe Drinking Water Information System (SDWIS),[5] and the IEPA Illinois Drinking Water Watch (DWW)[6] (Ramboll, 2021).

The most recent receptor survey, conducted in 2021 (Ramboll, 2021), identified six potential groundwater wells within 300 meters of the JPP property boundary. Three of the identified wells were located downgradient of the EAP, and three were located sidegradient of the EAP (Figure 3.3) (Ramboll, 2022b). The well survey results are presented in Appendix C, and are summarized as follows (Ramboll, 2022b):

- Two potential downgradient wells (121270005500 and 121270005400) have depths of 65 and 137 feet below ground surface (ft bgs), respectively. One of these wells (121270005400) is located on the JPP property.
- One potential downgradient well (121272094200) has a depth of 90 ft bgs. EEI is listed as the owner of this well.
- Three potential sidegradient wells (121270003100, 121270003000, and 121270005200) have depths ranging from 138 to 156 ft bgs.

A windshield survey (site visit) was completed in February 2022 to confirm the existence of the wells identified in the well survey, and to assess whether there may be other wells within the Village of Joppa (Ramboll, 2022b). No wells were identified at the potential locations cited in the 2021 receptor survey. Two other potential wells were identified during the windshield survey (located at 235 Main Street and 234 Pope Avenue). However, based on further in-person inquiries conducted in May and June 2022, it was confirmed that the features that were identified were not groundwater wells (Ramboll, 2022b). EEI also sent a letter to all residents of the Village of Joppa to request that residents "with a private irrigation or drinking water well contact EEI to have their well tested"; however, no responses have been received as of the end of June 2022 (Ramboll, 2022b). Based on the results of the windshield survey and the follow-up inquiries, and the fact that the Village of Joppa is serviced by a municipal water supply, Gradient has concluded that there are no current private users of groundwater within the Village of Joppa.

A search of the US EPA SDWIS and IEPA Illinois DWW databases for drinking water intakes in the vicinity of the EAP identified a community water supply (CWS) well for the Village of Joppa. The Joppa CWS Well #2 (Water System ID IL1270100) is located approximately 1,070 m to the southeast and downgradient of the EAP and provides drinking water supply for 462 residents (Figure 3.3). This well is screened at a depth of 240 ft within the LAU and separated from the UA by an approximately 14-ft-thick clay/silt layer of the LCU that prevents groundwater from flowing between the units. Furthermore, there is an upward flow gradient from the LAU toward the UA, so to the extent that there is any hydraulic

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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

connection between the LAU and the UA, flow would be going from the deeper unit to the shallower unit (Ramboll, 2022a).

The Joppa CWS Well #2 was sampled by Ramboll on May 23, 2022. The samples were analyzed for a range of inorganic constituents (antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, fluoride, iron, lead, lithium, mercury, molybdenum, selenium, sulfate, thallium, and total dissolved solids). The constituent concentrations did not exceed the Illinois Class I groundwater protection standards (35 Ill. Admin. Code Part 620.410) (Ramboll, 2022b); therefore, the results indicate there are no well impacts related to the EAP. The CWS well will be resampled in September 2022 to confirm these results. In addition, groundwater monitoring wells installed "as part of off-site plume delineation activities within the Village of Joppa are scheduled for testing in July, September, and October 2022" (Ramboll, 2022b).

In summary, the well survey did not identify any downgradient potable water wells, and sampling results indicate that the Joppa CWS well is not impacted by the EAP (Ramboll, 2022b). However, because there is a possibility that a resident of Joppa could install a private well in the UA and use the water for drinking water or irrigation, this exposure pathway was considered to be potentially complete and was retained for evaluation in this risk assessment.

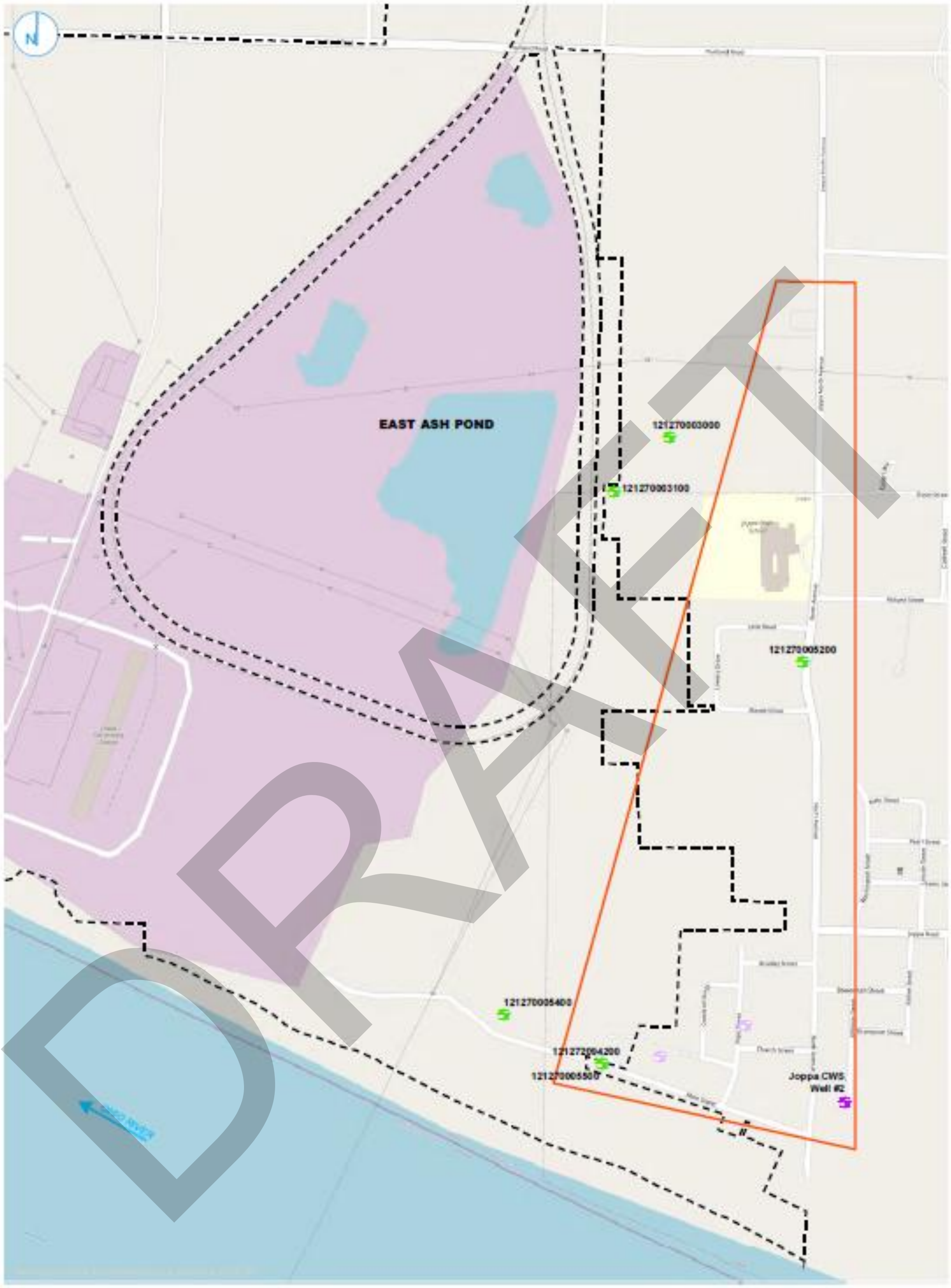

Figure 3.3. 2021 Well Survey Results. Source: Ramboll (2022b).

3.2.1.2 Surface Water as a Drinking Water/Irrigation Source

The Ohio River is not used as a public water supply adjacent to the Site. Gradient searched the US EPA SDWIS database to identify the public water systems for the four counties that border the Ohio River within 10 miles of the Site (*i.e.*, Massac County, Illinois; Pulaski County, Illinois; Ballard County, Kentucky; and McCracken County, Kentucky) (US EPA, 2022a). The public water systems in Massac, Pulaski, and Ballard Counties use groundwater as their water source, and thus do not obtain water from the Ohio River. In McCracken County, the city of Paducah, Kentucky, obtains a portion of its water supply from the Ohio River (Paducah Water, 2021); however, this location is approximately 15 miles upstream of the Site.

3.2.1.3 Recreational Exposures

The Site is located on the north bank of the Ohio River, which flows to the west past the Site. Recreational exposure to surface water and sediment may occur during activities such as swimming, boating, or fishing in the river. Exposure estimates for swimmers provide a health-protective means to evaluate exposure during other recreational activities. Recreational anglers may also consume locally caught fish from the Ohio River.

3.2.2 Ecological Conceptual Exposure Model

The ecological CEM for the Site depicts the relationships between off-Site environmental media (surface water and sediment) potentially impacted by COIs in groundwater and ecological receptors that may be exposed to these media. The ecological risk evaluation considered both direct toxicity as well as secondary toxicity *via* bioaccumulation. Figure 3.4 presents the ecological CEM for the Site.

The following ecological receptor groups and exposure pathways were considered:

- **Ecological Receptors Exposed to Surface Water:**
  - Aquatic plants, amphibians, reptiles, and fish.
- **Ecological Receptors Exposed to Sediment:**
  - Benthic invertebrates (*e.g.*, insects, crayfish, mussels).
- **Ecological Receptors Exposed to Bioaccumulative COIs:**
  - Higher-trophic-level wildlife (avian and mammalian) *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of prey (*e.g.*, plants, invertebrates, small mammals, fish).

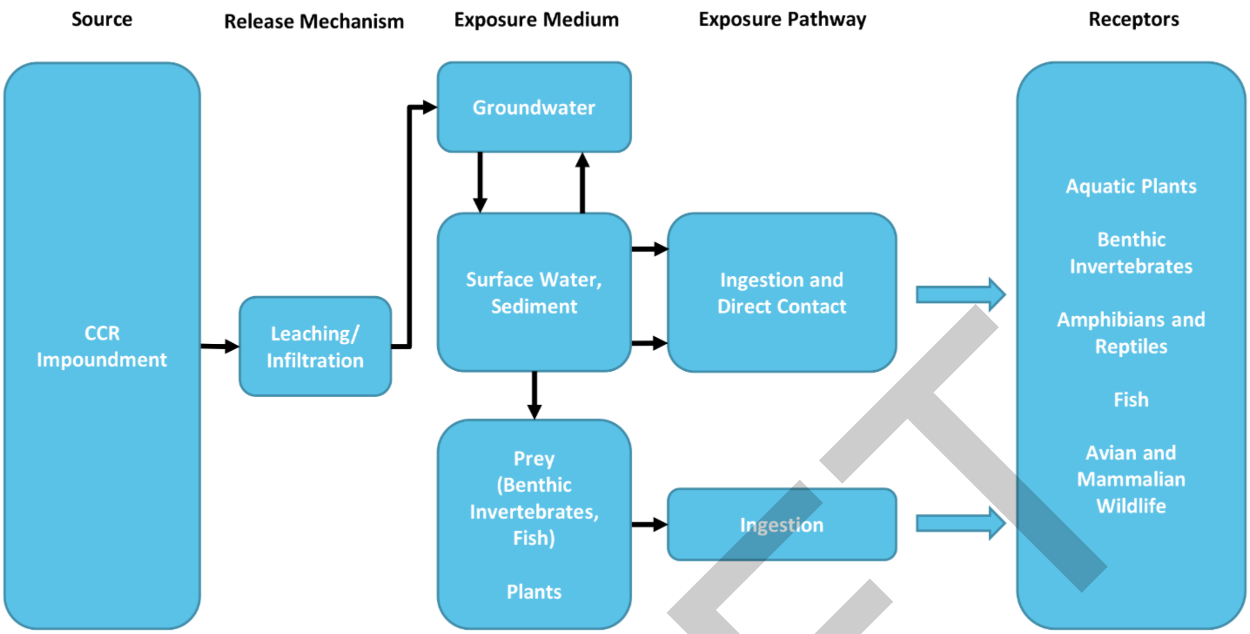

Figure 3.4 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residual.

3.3 Identification of Constituents of Interest

Risks were evaluated for COIs. A constituent was considered a COI if the maximum detected constituent concentration in groundwater exceeded a health-based benchmark. According to US EPA risk assessment guidance (US EPA, 1989), this screening step is designed to reduce the number of constituents carried through the risk evaluation that are anticipated to have a minimal contribution to the overall risk. Identified COIs are the constituents that are most likely to pose a risk concern in the surface water adjacent to the Site.

3.3.1 Human Health Constituents of Interest

For the human health risk evaluation, COIs were conservatively identified as constituents with maximum concentrations in groundwater above the GWPS listed in the Illinois CCR Rule Section 845.600 (IEPA, 2021). To determine the COIs for the surface water pathway, Gradient used the maximum detected concentrations from groundwater samples collected from all of the EAP-associated wells, regardless of hydrostratigraphic unit. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with the EAP. Using this approach, four COIs (boron, cobalt, thallium, and radium-226+228) were identified for the human health risk evaluation (Table 3.1). The maximum detected groundwater concentration of sulfate exceeded the GWPS; however, sulfate was not included in the risk evaluation, because the GWPS is based on aesthetic quality (*i.e.*, the US EPA secondary maximum contaminant level [MCL] for sulfate [250 mg/L] is based on salty taste; US EPA, 2021a). Given that sulfate is not likely to pose a human health risk concern, it was not considered to be a human health COI.

Table 3.1 Human Health Constituents of Interest

Constituent[a]	Maximum Concentration	GWPS[b]	Human Health COI[c]
Total Metals (mg/L)			
Antimony	ND	0.0060	No
Arsenic	0.0098	0.010	No
Barium	0.59	2.0	No
Beryllium	0.0012	0.0040	No
Boron	7.2	2.0	Yes
Cadmium	0.0018	0.0050	No
Chromium	0.023	0.10	No
Cobalt	0.027	0.0060	Yes
Lead	0.0066	0.0075	No
Lithium	0.010	0.040	No
Mercury	ND	0.0020	No
Molybdenum	0.0058	0.10	No
Selenium	0.033	0.050	No
Thallium	0.0033	0.0020	Yes
Radionuclides (pCi/L)			
Radium-226+228	5.9	5.0	Yes
Other (mg/L)			
Chloride	45	200	No
Fluoride	0.98	4.0	No
Sulfate	761	400	No[d]
Total Dissolved Solids	1,200	1,200	No

Notes:
COI = Constituent of Interest; GWPS = Groundwater Protection Standard; MCL = Maximum Contaminant Level; pCi/L = Picocuries Per Liter.
Shaded = Compound identified as a COI.
(a) The constituents are those listed in Illinois Section 845.600 (IEPA, 2021).
(b) The Illinois Section 845.600 GWPS (IEPA, 2021) were used to identify COIs.
(c) COIs are constituents for which the maximum detected concentration in groundwater exceeds the GWPS.
(d) This constituent is not likely to pose a human health risk concern due to the absence of studies regarding its toxicity to human health. Therefore, this constituent is not considered a COI.

3.3.2 Ecological Constituents of Interest

The Illinois GWPS, as defined in IEPA's guidance, were developed to protect human health but not necessarily ecological receptors. While ecological receptors are not exposed to groundwater, groundwater can potentially migrate into the adjacent surface water and impact ecological receptors. Therefore, to identify ecological COIs, the maximum concentrations of constituents detected in groundwater were compared to ecological surface water benchmarks protective of aquatic life.

The surface water screening benchmarks for freshwater organisms were obtained from the following hierarchy of sources:

- IEPA (2019) SWQS. IEPA SWQS are health-protective benchmarks for aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). The SWQS for several metals are hardness dependent (cadmium, chromium, copper, lead, manganese, nickel, and zinc). Screening benchmarks for these constituents were calculated assuming US EPA's default hardness of 100 mg/L (US EPA, 2022b).[7]

- US EPA Region IV (2018) surface water Ecological Screening Values (ESVs) for hazardous waste sites.

Benchmarks from a United States Department of Energy (US DOE) guidance document ("A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota") were used for radium (US DOE, 2019). US DOE presents benchmarks for radium-226 and radium-228 (4 and 3 picocuries per liter [pCi/L], respectively). Given that radium concentrations are expressed as total radium (radium-226+228, *i.e.*, the sum of radium-226 and radium-228), Gradient used the lower of the two benchmarks (3 pCi/L for radium-228) to evaluate total radium concentrations.

Consistent with the human health risk evaluation, Gradient used the maximum detected concentrations from groundwater samples collected from all of the EAP-associated wells (regardless of hydrostratigraphic unit) without considering spatial or temporal representativeness for ecological receptor exposures. The use of the maximum constituent concentrations in this evaluation is designed to conservatively identify COIs that warrant further investigation. Cadmium, cobalt, and radium-226+228 were identified as COIs for ecological receptors (Table 3.2).

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[7] Hardness data are available from the Ohio River at Olmsted, Illinois (USGS Station 03612600), about 12 miles downstream of the Site. Based on the available data (103 samples, collected from 2014 to 2021), hardness ranges from 91 to 171 mg/L, with a mean of 122 mg/L (USGS, 2022a). However, the US EPA (2022b) default hardness of 100 mg/L was used in this assessment. The use of a higher hardness value would result in less stringent screening values, thus the use of the US EPA default hardness value is conservative

Table 3.2 Ecological Constituents of Interest

Constituent[a]	Maximum Groundwater Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Metals (mg/L)				
Antimony	ND	0.19	US EPA R4 ESV	No
Arsenic	0.0098	0.19	IEPA SWQC	No
Barium	0.59	5.0	IEPA SWQC	No
Beryllium	0.0012	0.064	US EPA R4 ESV	No
Boron	5.3	7.6	IEPA SWQC	No
Cadmium	0.0018	0.0011	IEPA SWQC	Yes
Chromium	0.023	0.21	IEPA SWQC	No
Cobalt	0.027	0.019	US EPA R4 ESV	Yes
Lead	0.0066	0.020	IEPA SWQC	No
Lithium	0.010	0.44	US EPA R4 ESV	No
Mercury	ND	0.0011	IEPA SWQC	No
Molybdenum	0.0058	7.2	US EPA R4 ESV	No
Selenium	0.033	1.0	IEPA SWQC	No
Thallium	0.0033	0.0060	US EPA R4 ESV	No
Radionuclides (pCi/L)				
Radium-226+228	5.9	3.0	US DOE	Yes
Other (mg/L)				
Chloride	45	500	IEPA SWQC	No
Fluoride	0.98	4.0	IEPA SWQC	No
Sulfate	761	NA	NA	NA
Total Dissolved Solids	1,200	NA	NA	NA

Notes:
COI = Constituent of Interest; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; NA = Not Available; ND = Not Detected; pCi/L = Picocuries Per Liter; SWQC = Surface Water Quality Criteria; US DOE = United States Department of Energy; US EPA R4 = United States Environmental Protection Agency Region IV.
Shaded = Compound identified as a COI.
(a) The constituents are those listed in Illinois Section 845.600 (IEPA, 2021).
(b) Ecological benchmarks are from the hierarchy of sources discussed in Section 3.3.2: IEPA SWQC = IEPA (2019); US EPA R4 = US EPA Region IV "Ecological Risk Assessment Supplemental Guidance" (US EPA Region IV, 2018); and US DOE = US DOE guidance document "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).
(c) Constituents with maximum detected concentrations exceeding a benchmark protective of surface water exposure are considered ecological COIs.

3.3.3 Surface Water and Sediment Modeling

No surface water sampling has been conducted in the Ohio River adjacent to the Site. To estimate the potential contribution to surface water (and sediment) from groundwater specifically associated with the EAP, Gradient modeled concentrations in the Ohio River surface water and sediment from groundwater that may flow to the Ohio River for the detected human and ecological COIs (boron, cadmium, cobalt, thallium, and radium-226+228). The constituents detected in groundwater above a ecological or health-based benchmark are most likely to pose a risk concern in the adjacent surface water. Gradient modeled human health and ecological COI concentrations in the surface water and sediment using a mass balance calculation based on the surface water and groundwater mixing. The model assumes a well-mixed groundwater-surface water location.

The maximum detected concentrations in groundwater (regardless of well location) from 2015 to 2021 were conservatively used to model COI concentrations in surface water and sediment. The metals in groundwater were measured as total metals. Use of the total metal concentration for these COIs may overestimate surface water concentrations, because dissolved concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow to and mix with surface water.

The modeling approach does not account for geochemical transformations that may occur when groundwater mixes with surface water. Gradient assumed that predicted surface water concentrations were influenced only by the physical mixing of groundwater as it enters the surface water and were not further influenced by the geochemical reactions in the water and sediment, such as precipitation. In addition, the model only predicts surface water and sediment concentrations as a result of the potential migration of COI concentrations in EAP-related groundwater and does not account for background concentrations in surface water or sediment.

For this evaluation, Gradient adapted a simplified and conservative form of US EPA's indirect exposure assessment methodology (US EPA, 1998) that was used in US EPA's CCR risk assessment (US EPA, 2014a). The model is a mass-balance calculation based on surface water and groundwater mixing and the concept that the dissolved and sorbed concentrations can be related through an equilibrium partition coefficient (K_d). The model assumes a well-mixed groundwater-surface water location, with partitioning among total suspended solids, the dissolved water column, sediment pore water, and solid sediments.

Sorption to soil and sediment is highly dependent on the surrounding geochemical conditions. To be conservative, Gradient ignored the natural attenuation capacity of soil and sediment and estimated the surface water concentrations based only on the physical mixing of groundwater and surface water (*i.e.*, dilution).

The aquifer and surface water properties used to estimate the volume of groundwater flowing to the Ohio River and surface water COI concentrations are presented in Table 3.3. The COI concentrations in sediment were modeled using the COI-specific sediment-to-water partitioning coefficients and the sediment properties presented in Table 3.4. In the absence of Site-specific information for the Ohio River, Gradient used default assumptions (*e.g.*, depth of the upper benthic layer and bed sediment porosity) to model sediment COI concentrations. The modeled surface water and sediment COI concentrations are presented in Table 3.5. These modeled concentrations reflect conservative contributions from groundwater. A description of the modeling and the detailed results are presented in Appendix A.

Table 3.3 Groundwater and Surface Water Properties Used in Modeling

Parameter	Value	Unit	Notes/Source
Groundwater			
COI Concentration	Constituent specific	mg/L	Maximum detected concentration in groundwater.
Cross Section Area for the UA[a]	14,672	m^2	The length of the groundwater discharge zone was assumed to be equal to the maximum width of the EAP (*i.e.*, approximately 830 m). The thickness of the discharge zone was assumed to be equal to the maximum thickness of the UA (17.7 m) (Ramboll, 2021).
Hydraulic Gradient	0.0053	m/m	Maximum average horizontal hydraulic gradient determined for the UA (Ramboll, 2021).
Hydraulic Conductivity of the UA	0.0031	cm/s	Geometric mean horizontal hydraulic conductivity for all UA wells (Ramboll, 2021).
Surface Water			
Surface Water Flow Rate	9.6×10^{13}	L/year	Representative low-flow (10th percentile) discharge rate for the Ohio River at USGS Olmsted, Illinois gauging station (USGS Station 03612600) (USGS, 2022b).
Total Suspended Solids (TSS)	62	mg/L	Median of 2014-2021 suspended solids data for Ohio River at USGS Olmsted, Illinois gauging station (USGS 03612600) (USGS, 2022a).
Depth of the Water Column	8.23	m	Average water depth of Ohio River near JPP (Bist LLC, 2022).
Suspended Sediment to Water Partition Coefficient	Constituent specific	mg/L	Values based on US EPA (2014a).

Notes:

COI = Constituent of Interest; EAP = East Ash Pond; JPP = Joppa Power Plant; UA = Uppermost Aquifer; USGS = United States Geological Survey.

(a) The cross-sectional area represents the area through which groundwater flows from the UA to the Ohio River.

Table 3.4 Sediment Properties Used in Modeling

Parameter	Value	Unit	Notes/Source
Depth of Upper Benthic Layer	0.03	m	Default (US EPA, 2014a).
Depth of Water Body	8.26	m	Depth of water column (8.23 m) in Ohio River (Bist LLC, 2022) plus depth of upper benthic layer (0.03 m) (US EPA, 2014a).
Bed Sediment Particle Concentration	1	g/cm^3	Default (US EPA, 2014a).
Bed Sediment Porosity	0.6	–	Default (US EPA, 2014a).
Total Suspended Solids (TSS) Mass Per Unit Area	0.51	kg/m^2	Depth of water column × TSS × conversion factors (10^{-6} kg/mg and 1,000 L/m^3).
Sediment Mass Per Unit Area	30	kg/m^2	Depth of upper benthic layer × bed sediment particulate concentration × conversion factors (0.001 kg/g and 10^6 cm^3/m^3).
Sediment to Water Partitioning Coefficients	Constituent specific	mg/L	Values based on US EPA (2014a).

Table 3.5 Surface Water and Sediment Modeling Results

COI	Groundwater Concentration (mg/L or pCi/L)	Mass Discharge Rate (mg/year or pCi/year)	Total Water Column Concentration (mg/L or pCi/L)	Concentration Sorbed to Bottom Sediments (mg/kg or pCi/kg)
Metals				
Boron	7.24	5.5E+08	5.8E-06	2.4E-05
Cadmium	0.0018	1.4E+05	1.4E-09	4.8E-07
Cobalt	0.027	2.0E+06	2.1E-08	5.5E-06
Thallium	0.0033	2.5E+05	2.6E-09	3.0E-08
Radionuclides				
Radium-226+228	5.9	4.5E+08	4.7E-06	2.4E-02

Notes:
COI = Constituent of Concern; pCi/L = Picocuries Per Liter; pCi/kg = Picocuries Per Kilogram.

3.4 Human Health Risk Evaluation

The section below presents the results of the human health risk evaluation for residents using groundwater as drinking water, residents using groundwater for the irrigation of homegrown produce, and recreators (boaters, swimmers and anglers) along the Ohio River adjacent to the Site. Risks for recreators were assessed using the maximum modeled COI concentrations in surface water.

3.4.1 Residents Using Groundwater as Drinking Water

Screening Exposures: Although there are no known current residential users of groundwater, residents to the east of the JPP could be exposed to groundwater from the UA used as drinking water if they install a private well in the UA. The maximum COI concentrations in groundwater were used as conservative upper-end estimates of the COI concentrations to which a resident might be exposed through drinking water.

Screening Benchmarks: The US EPA Regional Screening Levels (RSLs) for tap water were used as the screening benchmarks values for the risk evaluation. US EPA developed the RSLs using generic default assumptions for a resident designed to identify constituents that warrant further investigation (US EPA, 2021b). The RSLs are based on a target hazard quotient (HQ) of 1, or a target cancer risk of 1×10^{-6}, based on US EPA's "Risk Assessment Guidance for Superfund" (RAGS; US EPA, 1989). The screening benchmarks for Ra-226 and Ra-228 were obtained from the US EPA Preliminary Remediation Goal (PRG) calculator (US EPA, 2020). The tap water PRG was 2.84E-02 for Ra-226, and 1.03E-02 for Ra-228. The PRG for Ra-228 was used as the screening benchmark because it is the lower of the two PRG values.

Screening Risk Evaluation: Risks from residential use of groundwater as drinking water were evaluated by comparing the maximum COI concentration to the US EPA tap water RSL (or PRG). The maximum detected concentrations of all four COIs were higher than their respective benchmarks, indicating they are COPCs that require further evaluation (Table 3.6).

Further Evaluation: Gradient evaluated data for the four COPCs from a subset of the EAP monitoring wells that included 10 monitoring wells (five nested pairs) along the eastern and southeastern JPP property boundary (G12S/D, G13S/D, G14S/D, G15S/D, and G16S/D). These wells are screened in the UA (Ramboll, 2022a). The data from these wells were used for this additional drinking water risk evaluation because this data could be representative of groundwater conditions in the UA if someone were to install a private well just east of the property boundary. In this dataset, boron and cobalt were the only constituents (of the four COPCs) that were considered COIs for the drinking water exposure pathway (Table 3.7). In the refined risk evaluation, maximum boron and cobalt concentrations exceeded the US EPA RSL benchmarks and were considered to be COPCs requiring further evaluation (Table 3.8). The boron concentration exceeded the RSL by a factor of 2, and the cobalt concentration exceeded the RSL by a factor of 4; thus, these constituents present a potential unacceptable risk for residents using groundwater as drinking water. However, it should be noted that the boron and cobalt levels in groundwater are well below levels that cause adverse health effects (see Section 3.6).

Although this risk evaluation includes some refinement, EEI is currently in the process of determining the nature and extent of COIs in any wells potentially used for drinking water east of the JPP. Once that information is available, the risk evaluation could be further refined.

Table 3.6 Risk Evaluation for Residents Using Groundwater as Drinking Water

COI	Maximum Concentration	Human Health Residential Benchmark[a] (mg/L)	COPC
Metals (mg/L)			
Boron	7.2	4	Yes
Cobalt	0.027	0.006	Yes
Thallium	0.0033	0.0002	Yes
Radionuclides (pCi/L)			
Radium-226+228	5.9	0.01	Yes

Notes:
COI = Constituent of Interest; PRG = Preliminary Remediation Goal; RSL = Regional Screening Level.
(a) Screening benchmark is the US EPA RSL for tap water (US EPA, 2021b) or the US EPA PRG (for radium) (US EPA 2020).

Table 3.7 Refined Screening Evaluation for Drinking Water Pathway

Constituent	Maximum Concentration	GWPS	Human Health COI
Metals (mg/L)			
Boron	7.2	2	Yes
Cobalt	0.024	0.006	Yes
Thallium	<0.002	0.002	No
Radionuclides (pCi/L)			
Radium-226+228	1.1	5	No

Notes:
COI = Constituent of Interest; GWPS = Groundwater Protection Standard; NA = Not Available.
< = The constituent was not detected, and the value reported is the detection limit.
Shaded = Compound identified as a COI.
This table includes data from 10 monitoring wells along the eastern and southeastern property boundary (G12S/D, G13S/D, G14S/D, G15S/D, and G16S/D).
Source: Ramboll (2022a).

Table 3.8 Refined Risk Evaluation for Residents Using Groundwater as Drinking Water

COI	Maximum Concentration	Human Health Residential Benchmark[a] (mg/L)	COPC
Metals (mg/L)			
Boron	7.2	4	Yes
Cobalt	0.024	0.006	Yes

Note:
(a) Screening benchmark is the US EPA Regional Screening Level (RSL) for tap water (US EPA, 2021b).

3.4.2 Residents Using Groundwater as an Irrigation Source

Screening Exposures: Gradient evaluated hypothetical risks to downgradient residents who may consume homegrown produce irrigated with water from a private well that could potentially be impacted by COIs related to the EAP. The exposure concentrations used for this risk evaluation were the maximum detected concentrations of the groundwater COIs. Gradient used the conservative assumption that there was no dilution or attenuation of COI concentrations between the monitoring wells on the JPP property and a potential downgradient private well.

The COI concentrations in soil resulting from irrigation with well water were estimated by modeling the equilibrium partitioning expected as CCR-impacted groundwater mixes with surface soil during irrigation. The K_d varies by source and soil characteristics (*e.g.*, soil pH, moisture content). The K_d values are from US EPA's CCR risk assessment (US EPA, 2014a). Gradient used 50th-percentile K_d values for unsaturated soils, which would be similar to the surface soil used for residential gardens. The maximum groundwater COI concentrations, K_d values, and modeled soil concentrations are presented in Table 3.9.

Screening Benchmarks: US EPA does not have a soil RSL protective of residents consuming homegrown produce. Therefore, screening benchmarks were calculated using the recommended approach described in US EPA's RAGS (US EPA, 1989) and US EPA's CCR risk assessment (US EPA, 2014a). As recommended by the CCR beneficial use risk assessments conducted by US EPA (2014b), benchmarks were calculated using a target HQ of 1 (US EPA, 2014b, 2015a). Soil screening levels were calculated for five types of homegrown produce (exposed fruit, exposed vegetables, protected fruit, protected vegetables, and root vegetables) that could be exposed to constituents in soil *via* root uptake when using groundwater as an irrigation source. Produce ingestion rates used by US EPA in its CCR risk assessment (US EPA, 2014a) were used in this analysis. Child residents were assumed to ingest 1.5, 1.2, 2.0, 1.2, and 0.5 g/kg-day of exposed fruit, exposed vegetables, protected fruit, protected vegetables, and root vegetables, respectively (US EPA, 2014a). Adult residents were assumed to ingest 0.9, 0.8, 1.5, 0.6, and 0.6 g/kg-day of exposed fruit, exposed vegetables, protected fruit, protected vegetables, and root vegetables, respectively (US EPA, 2014a). Soil benchmarks protective of the consumption of all five types of homegrown produce were calculated using US EPA-recommended assumptions (*i.e.*, exposure duration, body weight, averaging time) and toxicity reference values (*i.e.*, reference doses [RfDs]). Non-cancer benchmarks were calculated only for a child resident, because it is the most sensitive of the two age groups (*i.e.*, child and adult).

Appendix B, Table B.1 presents the calculations of soil screening benchmarks protective of residents consuming homegrown produce watered with potentially impacted groundwater. The soil screening benchmarks for this pathway are presented in Table 3.9.

Screening Risk Evaluation: The modeled soil concentrations of all COIs were lower than their respective soil benchmarks (Table 3.9). Thus, the residential use of groundwater from private wells potentially impacted by constituents related to the EAP as an irrigation source for homegrown produce does not pose a risk concern.

Table 3.9 Risk Evaluation for Residents Using Private Well Water as an Irrigation Source

COI	Maximum Groundwater Concentration (mg/L)	Soil-Water Partitioning Coefficient (K_d)[b] (L/kg)	Modeled Soil Concentration[c] (mg/kg)	Gardening Soil Benchmark[d] (mg/kg)	COPC
Boron	7.24	0.11	0.80	101	No
Cobalt	0.0238	3.7	0.088	38	No
Thallium	0.0033	0.2	0.00066	11	No
Radium-226+228	5.9	1.0	0.0059	0.13	No

Notes:

COI = Constituent of Interest; K_d = Equilibrium Partitioning Coefficient.

(b) K_d values are from US EPA (2014a).

(c) Modeled soil concentrations were calculated as the maximum groundwater concentration multiplied by the K_d value.

(d) The calculated soil benchmarks are protective of gardeners consuming homegrown produce watered with potentially impacted groundwater.

3.4.3 Recreators Exposed to Surface Water

Screening Exposures: Recreators could be exposed to surface water *via* incidental ingestion and dermal contact while swimming or boating. In addition, anglers could consume fish caught in the Ohio River. The maximum modeled COI concentrations in surface water were used as conservative upper-end estimates of the COI concentrations to which a recreator might be exposed directly (incidental ingestion of COIs in surface water while swimming) and indirectly (consumption of locally caught fish exposed to COIs in surface water).

Screening Benchmarks: The Illinois surface water criteria known as human threshold criteria (HTC) (IEPA, 2019) are based on incidental exposure through direct contact with or ingestion of small volumes of water while swimming or during other recreational activities, as well as the consumption of fish. HTC values are calculated using the following equation (IEPA, 2019):

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

where:

HTC = Human threshold criterion (mg/L)
ADI = Acceptable daily intake (mg/day)
W = Water consumption rate (L/day)
F = Fish consumption rate (kg/day)
BCF = Bioconcentration factor (L/kg-tissue)

Illinois defines the acceptable daily intake (ADI) as the "maximum amount of a substance which, if ingested daily for a lifetime, results in no adverse effects to humans" (IEPA, 2019). US EPA defines its chronic RfD as an "estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure for a chronic duration (up to a lifetime) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (US EPA, 2011a). Illinois lists methods to derive an ADI from the primary literature (IEPA, 2019). In accordance with Illinois guidance, Gradient derived an ADI by multiplying the MCL by the default water ingestion rate of 2 L/day (IEPA, 2019). In the absence of an MCL, Gradient applied the RfD used by US EPA to derive its Regional Screening Levels (RSLs) (US EPA, 2021b) as a conservative estimate of the ADI. The RfDs are given in mg/kg-day, while the ADIs are given in mg/day; thus, Gradient multiplied the RfD by a standard adult body weight of 70 kg to obtain the ADI in mg/day. The calculation of the HTC values is shown in Appendix B, Table B.2.

Gradient used bioconcentration factors (BCFs) from a hierarchy of sources. The primary BCFs were those that US EPA used to calculate the National Recommended Water Quality Criteria (NRWQC) for human health (US EPA, 2002). Other sources included BCFs used in the US EPA CCR risk assessment (US EPA, 2014a) and BCFs reported by Oak Ridge National Laboratory's Risk Assessment Information System (ORNL RAIS) (ORNL, 2020).[8]

Illinois recommends a fish consumption rate of 0.020 kg/day (20 g/day) for an adult weighing 70 kg (IEPA, 2019). Illinois recommends a water consumption rate of 0.01 L/day for "incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities" (IEPA, 2019). Appendix B, Table B.2 presents the calculated HTC for fish and water and for fish consumption only.

The HTC for fish consumption for radium-226+228 was calculated as follows:

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

where:

HTC = Human threshold criterion (pCi/L)
TCR = Target cancer risk (1×10^{-5})
SF = Food ingestion slope factor (risk/pCi)
BAF = Bioaccumulation factor (L/kg-tissue)
F = Fish consumption rate (kg/day)

The food ingestion slope factor (lifetime excess total cancer risk per unit exposure, in risk/pCi) used to calculate the HTC was the highest value of those for radium-226 (Ra-226), radium-228 (Ra-228), and "Ra-228+D" (US EPA, 2001). According to US EPA (2001), "+D" indicates that "the risks from associated short-lived radioactive decay products (*i.e.*, those decay products with radioactive half-lives less than or equal to 6 months) are also included."

Screening Risk Evaluation: The maximum modeled COI concentrations in surface water were compared to the calculated Illinois HTC values (Table 3.10). All the modeled surface water concentrations were below their respective benchmarks. The HTC are protective of recreational exposure *via* water and/or fish ingestion and do not account for dermal exposures to COIs in surface water while swimming. However, given that the modeled surface water concentrations are orders of magnitude below the HTC protective of water and/or fish ingestion, dermal exposures to COIs are not expected to pose a risk concern. Moreover, the dermal uptake of metals is considered to be minimal and represent only a small proportion of ingestion exposures. Thus, none of the COIs evaluated would be expected to pose an unacceptable risk to recreators exposed to surface water while swimming and anglers consuming fish caught in the Ohio River.

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[8] Although recommended by US EPA (2015b), US EPA Epi Suite version 4.1 (US EPA, 2019) was not used as a source of BCFs, because inorganic compounds are outside the estimation domain of the program.

Table 3.10 Risk Evaluation for Recreators Exposed to Surface Water

COI	Maximum Modeled Surface Water Concentration	HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC
Total Metals (mg/L)					
Boron	5.8E-06	467	1,400	700	No
Cobalt	2.1E-08	0.0035	2.1	0.0035	No
Thallium	2.6E-09	0.0017	0.40	0.0017	No
Radionuclides (pCi/L)					
Radium-226+228	4.7E-06	1,000	1,000	87,413	No

Notes:

COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; pCi/L = Picocuries Per Liter.

3.4.4 Recreators Exposed to Sediment

Recreational exposure to sediment may occur during boating and swimming activity along the Ohio River. Recreational exposure to sediment may occur through incidental ingestion and dermal contact.

Screening Exposures: COIs in impacted groundwater flowing into the river can sorb to sediments. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations.

Screening Benchmarks: There are no established recreator RSLs that are protective of recreational exposures to sediment (US EPA, 2021c). Therefore, benchmarks that are protective of recreational exposures to sediment *via* incidental ingestion and dermal contact were calculated using US EPA's RSL guidance (US EPA, 2021c). These benchmarks were calculated using the recommended assumptions (*i.e.*, oral bioavailability, body weights, averaging time) and toxicity reference values (*i.e.*, RfD and cancer slope factor [CSF]), with the following changes. Recreators were assumed to be exposed to sediment while recreating 60 days a year (or two weekend days per week for 30 weeks a year, from April to October). The exposure duration was assumed for a child 6 years of age and an adult 20 years of age, per US EPA guidance (US EPA, 2014c). The daily recommended residential soil ingestion rates are 200 mg/day for a child and 100 mg/day for an adult, based on an all-day exposure to residential soils (US EPA, 2014c, 2011b). Because recreational exposures to sediment are assumed to occur for less than 4 hours per day, one-third of the daily residential soil ingestion amount (*i.e.*, 67 mg/day for a child and 33 mg/day for an adult) was used as a conservative assumption. For dermal exposures, recreators were assumed to be exposed to sediment on their lower legs and feet (with a skin surface area 1,026 cm^2 for the child and 3,026 cm^2 for the adult, based on the age-weighted skin surface areas reported in US EPA, 2011b). While other body parts may be exposed to sediment, the contact time will likely be very short, as the sediment would wash off in the surface water. Gradient used US EPA's recommended soil adherence factor of 0.2 mg/cm^2 based on child exposure to wet soil (US EPA, 2004a, 2014c), which was used in the US EPA RSL user's guide for a child recreator exposed to soil or sediment (US EPA, 2021c). The sediment screening benchmarks were calculated based on a target HQ of 1 or a target cancer risk of 1×10^{-5}. Appendix B, Table B.3 presents the calculations of screening benchmarks protective of recreational exposures to sediment. The recreator sediment screening benchmark for radium-226+228 was based on soil PRGs calculated for radium-226 and radium-228 using US EPA's PRG calculator (US EPA, 2020). The lower of the two values was used as the recreator sediment screening benchmark for radium-226+228 (Appendix B, Table B.4).

Screening Risk Evaluation: The modeled sediment concentrations were all well below their respective recreator sediment screening benchmarks (Table 3.11). Therefore, exposure to sediment is not expected to pose an unacceptable risk to recreators while swimming or boating.

Table 3.11 Risk Evaluation for Recreators Exposed to Sediment

COI[a]	Modeled Sediment Concentration	Recreator Sediment Screening Benchmark	COPC
Total Metals (mg/kg)			
Boron	2.4E-05	2.7E+05	No
Cobalt	5.5E-06	4.1E+02	No
Thallium	3.0E-08	1.4E+01	No
Radionuclides (pCi/kg)			
Radium-226+228	2.4E-02	7.9E+03	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; pCi/kg = Picocuries Per Kilogram.

3.5 Ecological Risk Evaluation

Based on the ecological CEM (Figure 3.4), ecological receptors could be exposed to surface water and dietary items (*i.e.*, prey and plants) potentially impacted by identified COIs (cadmium, cobalt, and radium-226+228).

3.5.1 Ecological Receptors Exposed to Surface Water

Screening Exposures: The ecological evaluation considered aquatic communities in the Ohio River potentially impacted by the identified ecological COIs. Modeled surface water concentrations were compared to risk-based ecological screening benchmarks.

Screening Benchmarks: Surface water screening benchmarks protective of aquatic life were obtained from the following hierarchy of sources:

- IEPA SWQS (IEPA, 2019), which are regulatory standards that are intended to protect aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). For cadmium, the surface water benchmark is hardness dependent and was calculated using a default hardness of 100 mg/L (US EPA, 2022b).[9]
- US EPA Region IV (2018) surface water ESVs for hazardous waste sites.
- US DOE benchmarks from the guidance document, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).

Risk Evaluation: The maximum modeled COI concentrations in surface water were compared to the benchmarks protective of aquatic life (Table 3.12). The modeled surface water concentrations were below their respective benchmarks. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in the Ohio River.

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[9] Conservatisms associated with using a default hardness value are discussed in Section 3.6.

Table 3.12 Risk Evaluation for Ecological Receptors Exposed to Surface Water

COI	Maximum Modeled Surface Water Concentration	Ecological Freshwater Benchmark	Basis	COPC
Total Metals (mg/L)				
Cadmium	1.4E-09	0.0011	IEPA (2019)	No
Cobalt	2.1E-08	0.019	US EPA Region IV (2018)	No
Radionuclides (pCi/L)				
Radium-226+228	4.7E-06	3.0	US DOE (2019)	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; pCi/L = Picocuries Per Liter.

3.5.2 Ecological Receptors Exposed to Sediment

Screening Exposures: COIs in impacted groundwater flowing to the Ohio River can sorb to sediments *via* chemical partitioning. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations. Therefore, the modeled COI sediment concentrations reflect the potential maximum Site-related sediment concentration from groundwater.

Screening Benchmarks: Sediment screening benchmarks were obtained from US EPA Region IV (2018). The majority of the sediment ESVs are based on threshold effect concentrations (TECs) from MacDonald *et al.* (2000), which provide consensus values that identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. In the absence of an ESV for radium-226+228, a sediment screening value of 90,000 pCi/kg was used, based on the biota concentration guide (BCG) for radium-228 (US DOE, 2019).[10] The benchmarks used in this evaluation are listed in Table 3.13.

Screening Risk Results: The maximum modeled COI sediment concentrations were below their respective sediment screening benchmarks (Table 3.13). The modeled sediment concentrations attributed to potential contributions from Site groundwater for all COIs were well below 0.01% of the sediment screening benchmark. Therefore, the modeled sediment concentrations attributed to potential contributions from Site groundwater are not expected to significantly contribute to ecological exposures in the Ohio River adjacent to the Site.

Table 3.13 Risk Evaluation for Ecological Receptors Exposed to Sediment

COI	Modeled Sediment Concentration	ESV	COPC	% of Benchmark
Total Metals (mg/kg)				
Cadmium	4.8E-07	0.99[a]	No	0.00005%
Cobalt	5.5E-06	50[a]	No	0.00001%
Radionuclides (pCi/kg)				
Radium-226+228	2.4E-02	90,000[b]	No	0.00003%

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; pCi/g = Picocuries Per Gram; pCi/kg = Picocuries Per Kilogram.
(a) ESV from US EPA Region IV (2018).
(b) ESV from US DOE (2019) was converted from 90 pCi/g to 90,000 pCi/kg.

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[10] The biota concentration guide (BCG) for sediment is 90 pCi/g for Ra-228 and 100 pCi/g for Ra-226; the lower of the two values was used for Ra-226+228 and converted to pCi/kg (US DOE, 2019).

3.5.3 Ecological Receptors Exposed to Bioaccumulative Constituents of Interest

Screening Exposures: COIs with bioaccumulative properties can impact higher-trophic-level wildlife exposed to these COIs *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, and fish).

Screening Benchmark: US EPA Region IV (2018) and IEPA SWQS (IEPA, 2019) guidance were used to identify constituents with potential bioaccumulative effects.

Risk Evaluation: The ecological COIs (cadmium, cobalt, and radium-226+228) were not identified as having potential bioaccumulative effects. Therefore, these COIs are not considered to pose an ecological risk *via* bioaccumulation.

3.6 Uncertainties and Conservatisms

A number of uncertainties and their potential impact on the risk evaluation are discussed below. Wherever possible, conservative assumptions were used in an effort to minimize uncertainties and overestimate, rather than underestimate, risks.

Exposure Estimates:

- The risk evaluation included the Illinois Section 845.600 constituents detected in groundwater samples collected from wells associated with the EAP. However, it is possible that not all of the detected constituents are related specifically to the EAP.
- The human health and ecological risk characterizations were based on the maximum measured or modeled COI concentrations, rather than on averages. Thus, the variability in exposure concentrations was not considered. Assuming continuous exposure to the maximum concentration overestimates human and ecological exposures, given that receptors are mobile and concentrations change over time. For example, US EPA guidance states that risks should be estimated using average exposure concentrations as represented by the 95% upper confidence limit on the mean (US EPA, 1992).
- Only constituents detected in groundwater were used to identify COIs. The measured groundwater concentrations were used to model COI concentrations in surface water and sediment. For the constituents that were not detected in the EAP groundwater, the detection limits were below the Illinois Section 845.600 GWPS for these constituents, thus, they do not require further evaluation.
- COI concentrations in surface water were modeled using the maximum detected total metal concentrations in groundwater. Modeling surface water concentrations using total metal concentrations may overestimate surface water concentrations, because dissolved metal concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow to and mix with surface water.
- The COIs identified in this evaluation also occur naturally in the environment. Contributions to exposure from natural or other non-EAP-related sources of these constituents were not considered in the evaluation of modeled concentrations; only exposure contributions potentially attributable to Site groundwater mixing with surface water were evaluated. While not quantified, exposures from potential EAP-related groundwater contributions are likely to represent only a small fraction of the overall human and ecological exposure to COIs that also have natural or non-EAP-related sources.

- Screening benchmarks for human health were developed using exposure inputs based on US EPA's recommended values for reasonable maximum exposure (RME) assessments (US EPA, 2014c). RME is defined as "the highest exposure that is reasonably expected to occur at a site but that is still within the range of possible exposures" (US EPA, 2004a). US EPA states the "intent of the RME is to estimate a conservative exposure case (*i.e.*, well above the average case) that is still within the range of possible exposures" (US EPA, 1989). US EPA also notes that this high-end exposure "is the highest dose estimated to be experienced by some individuals, commonly stated as approximately equal to the 90th percentile exposure category for individuals" (US EPA, 2015c). Thus, most individuals will have lower exposures than those presented in this risk assessment.

Toxicity Benchmarks:

- Screening-level ecological benchmarks were compiled from IEPA and US EPA guidance and are designed to be protective of the majority of site conditions, leaving the option for site-specific refinement. In some cases, these benchmarks may not be representative of the specific conditions or receptors found at the Site, or may not accurately reflect concentration-response relationships encountered at the Site. For example, the ecological benchmark for cadmium is hardness dependent. Gradient relied on US EPA's default hardness of 100 mg/L. Hardness data are available from the Ohio River at Olmsted, Illinois (USGS Station 03612600), about 12 miles downstream of the Site. Based on the available data (103 samples, collected from 2014 to 2021), hardness ranges from 91 to 171 mg/L, with a mean of 122 mg/L (USGS, 2022a). Increasing the hardness from 100 to 122 mg/L would increase the cadmium SWQS, because benchmarks increase (*i.e.*, become less stringent) with higher levels of hardness. Regardless of the hardness, the maximum modeled cadmium concentration is orders of magnitude below the SWQS.
- In addition, for the ecological evaluation, Gradient conservatively assumed all constituents to be 100% bioavailable. Modeled COI concentrations in surface water are considered total metal concentrations. US EPA recommends using dissolved metal concentrations as a measure of ecological receptors' exposure to metals, because they represent the bioavailable fraction of metals in water (US EPA, 1993). Therefore, the modeled surface water concentrations may be an overestimation of exposure concentrations for ecological receptors.
- In general, it is important to appreciate that the human health toxicity factors used in this risk evaluation are developed to account for uncertainties, such that safe exposure levels used as benchmarks are often many times lower (even orders of magnitude lower) than the levels that cause effects that have been observed in human or animal studies. For example, toxicity factors incorporate a 10-fold safety factor to protect sensitive subpopulations. This means that a risk exceedance does not necessarily equate to actual harm.
- Boron and cobalt were identified as COPCs for the drinking water pathway. However, exceedance of a risk-based benchmark does not mean that an adverse health effect will occur, due to the conservative assumptions used in their derivation. The drinking water scenario assumes that a person drinks the maximum groundwater concentration every day for 30 years, which is unlikely to occur. In addition, the toxicity benchmarks used to calculate the RSLs, such as US EPA's chronic oral RfD, are also conservative. US EPA's RfD of 0.2 mg/kg-day for boron is based on decreased fetal body weight in rats observed at 13.3 mg/kg-day, which is a dose almost 60 times higher than the dose from drinking the maximum concentration of boron in groundwater measured at the Site (US EPA, 2004b). It is noteworthy that this effect has been observed only in animal studies, with no convincing evidence in humans. US EPA's chronic, provisional oral RfD of 3E-04 mg/kg-day for cobalt is based on decreased iodine uptake in the thyroid in human subjects. The lowest observed adverse effect level (LOAEL) determined in the study (1 mg/kg-day) is almost 1,700 times higher than the dose from drinking the maximum concentration of cobalt in groundwater

measured at the site (US EPA, 2008). The RfD includes a composite uncertainty factor of 3,000, which is highly conservative. It should be noted that the basis of the LOAEL (decreased iodine uptake by the thyroid) was described by US EPA as "reversible following relatively short-term exposure in humans" (US EPA, 2008).

4 Summary and Conclusions

A screening-level risk evaluation was performed for Site-related constituents in groundwater at the JPP, located in Massac County, Illinois, west of the Village of Joppa and northeast of the Ohio River. The CSM developed for the Site indicates that groundwater beneath the EAP flows into the Ohio River adjacent to the Site and may potentially impact surface water and sediment.

CEMs were developed for human and ecological receptors. The complete exposure pathways for humans include residential use of groundwater for drinking water or irrigation, recreators in the Ohio River who are exposed to surface water and sediment (boaters and swimmers), and anglers who consume locally caught fish. The complete exposure pathways for ecological receptors include aquatic life (including aquatic and marsh plants, amphibians, reptiles, and fish) exposed to surface water; benthic invertebrates exposed to sediment; and avian and mammalian wildlife exposed to bioaccumulative COIs in surface water, sediment, and dietary items.

Groundwater data collected from 2015 to 2022 were used to estimate exposures. For groundwater constituents retained as COIs, surface water and sediment concentrations were modeled using the maximum detected groundwater concentrations. Surface water and sediment exposure estimates were screened against benchmarks protective of human health and ecological receptors for this risk evaluation.

US EPA has established acceptable risk metrics. Risks above these US EPA-defined metrics are termed potentially "unacceptable risks." Based on the evaluation presented in this report, an unacceptable risk was identified for the potential future residential use of groundwater as a source of drinking water; however, there were no other unacceptable risks to human or ecological receptors resulting from CCR exposures associated with the EAP. Specific risk assessment results include the following:

- For the potential residential use of groundwater from the UA for drinking water, the maximum groundwater concentrations for boron and cobalt exceeded risk-based screening benchmarks. Therefore, the residential use of groundwater from the UA for drinking water poses a potential unacceptable risk to residents and requires further evaluation. It should be noted that based on the results of the windshield survey, Gradient does not believe that there are any current residents that use groundwater from the UA as a source of drinking water.
- For the potential residential use of groundwater from the UA for the irrigation of homegrown produce, the maximum COI concentrations were below their respective conservative risk-based screening benchmarks. Therefore, the use of groundwater from the UA for irrigation of homegrown produce is not expected to pose an unacceptable risk to residents.
- For recreators (boaters and swimmers) exposed to surface water, the modeled surface water concentrations for all COIs were below their respective conservative risk-based screening benchmarks. Therefore, none of the COIs evaluated in surface water are expected to pose an unacceptable risk to recreators boating or swimming in the Ohio River adjacent to the Site.
- For recreators exposed to sediment *via* incidental ingestion and dermal contact, the modeled sediment concentrations were below their respective health-protective sediment benchmarks. Therefore, none of the COIs evaluated in sediment are expected to pose an unacceptable risk to recreators exposed to sediment in the Ohio River adjacent to the Site.

- For anglers consuming locally caught fish, the modeled COI concentrations in surface water were below their respective conservative benchmarks protective of fish consumption. Therefore, none of the COIs evaluated for this pathway are expected to pose an unacceptable risk to recreators consuming fish caught in the Ohio River.
- Ecological receptors exposed to surface water include aquatic and marsh plants, amphibians, reptiles, and fish. The risk evaluation showed that none of the modeled COI concentrations in surface water exceeded their respective protective screening benchmarks. Ecological receptors exposed to sediment include benthic invertebrates. The modeled COI concentrations in sediment did not exceed their respective conservative screening benchmarks; therefore, none of the COIs evaluated in sediment are expected to pose an unacceptable risk to ecological receptors.
- Ecological receptors were also evaluated for exposure to bioaccumulative COIs. This evaluation considered higher-trophic-level wildlife with direct exposure to surface water and sediment and secondary exposure through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, fish). None of the ecological COIs were identified as having potential bioaccumulative effects. Overall, this evaluation demonstrated that none of the COIs evaluated are expected to pose an unacceptable risk to ecological receptors.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk. The risk evaluation was based on the maximum measured or modeled COI concentrations; however, US EPA guidance states that risks should be based on a representative average concentration, such as the 95% upper confidence limit on the mean. Thus, using the maximum concentration tends to overestimate exposure. Although the COIs identified in this evaluation also occur naturally in the environment, the contributions to exposure from natural background sources and nearby industry were not considered; thus, CCR-related exposures were likely overestimated. The exposure estimates also assumed 100% metal bioavailability, which likely results in overestimates of exposure and risks from the metals COIs. Lastly, exposure estimates were based on inputs to evaluate the RME; thus, most receptors will have lower exposures than those estimated in this risk assessment.

Finally, due to the planned closure and corrective measures that will be implemented at the Site, future risks are anticipated to be lower than current risks for all receptors and exposure pathways, because potential releases of CCR-related constituents will decline over time and impacted groundwater will be intercepted before it can migrate off Site. Consequently, potential exposures to CCR-related constituents in the environment will also decline.

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Appendix A

Surface Water and Sediment Modeling

Gradient modeled concentrations of constituents of interest (COIs) in the Ohio River surface water and sediment based on available groundwater data. First, we estimated the flow rate of COIs discharged to the Ohio River *via* groundwater. Then, we adapted United States Environmental Protection Agency (US EPA) indirect exposure assessment methodology (US EPA, 1998) in order to model surface water and sediment water concentrations in the Ohio River.

Model Overview

The groundwater flow to the river is represented by a one-dimensional, steady-state model. In this model, the groundwater plume migrates horizontally in the Uppermost Aquifer (UA) prior to flowing to the Ohio River. The groundwater flow entering the river is the flow going through a cross-sectional area that has a length equal to the maximum width of the East Ash Pond (EAP) and a width equal to the maximum saturated thickness of the UA. It was assumed that all the groundwater flowing through the UA would ultimately discharge to the Ohio River. The length of the groundwater discharge zone was estimated using Google Earth Pro (Google, LLC, 2022).

The groundwater flow to the Ohio River mixes with the surface water in the river. The COIs entering the river *via* groundwater can dissolve into the water column, sorb to suspended sediments, or sorb to benthic sediments. Using US EPA's indirect exposure assessment methodology (US EPA, 1998), the model evaluates the surface water and sediment COI concentrations at a location downstream of the groundwater discharge point, assuming a well-mixed water column.

Groundwater Discharge Rate

The groundwater discharge rate was evaluated using conservative assumptions. Gradient conservatively assumed that the groundwater concentrations were uniformly equal to the maximum detected concentration of each individual COI. Further, Gradient ignored adsorption by subsurface soil and assumed that all the groundwater flowing through the UA was discharged into the river.

For each groundwater unit, the groundwater flow rate into the river was derived using Darcy's Law:

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

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):

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

where:

C_{bstot} = Total COI concentration in bed sediment (mg/L or g/m^3)
C_{wtot} = Total water body COI concentration (mg/L)
f_{benth} = Fraction of COI in benthic sediments (unitless)
d_b = Depth of the upper benthic layer (m)
d_z = Depth of the water body (m). Calculated as $d_w + d_b$.

This value can be used to calculate dry weight sediment concentration as follows:

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

where:

$C_{sed\text{-}dw}$ = Dry weight sediment concentration (mg/kg)
C_{bstot} = Total sediment concentration (mg/L)
bsc = Bed sediment bulk density. Used the default value of 1 g/cm^3 from US EPA (2014).

The total sediment concentration is composed of the sum of the COI concentration dissolved in the bed sediment pore water (equal to the concentration dissolved in the water column) and the COI concentration sorbed to benthic sediments (US EPA, 1998).

The COI concentration sorbed to benthic sediments was calculated as follows (US EPA, 1998):

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

where:

C_{sb} = Concentration sorbed to bottom sediments (mg/kg)
C_{dbs} = Concentration dissolved in the sediment pore water (mg/L)
K_{dbs} = Sediments/water partition coefficient (mL/kg)

For each COI, the modeled total water column concentration, dry weight sediment concentration, and concentration sorbed to sediment are presented in Table A.5.

Table A.1 Parameters Used to Estimate Groundwater Discharge to Surface Water

Groundwater Unit	Parameter	Name	Value	Unit
UA	A	Cross-Sectional Area	14,672	m^2
UA	i	Hydraulic Gradient	0.0053	m/m
UA	K	Hydraulic Conductivity	0.0031	cm/s

Notes:
UA = Uppermost Aquifer.
Source: Hydraulic gradient and hydraulic conductivity values from Ramboll (2021).
Cross-sectional area was estimated from Ramboll (2021).

Table A.2 Partition Coefficients

Constituent	Mean Sediment-Water Partition Coefficient (K_{dbs})		Mean Suspended Sediment-Water Partition Coefficient (K_{dsw})	
	Value ($\log_{10}$) (mL/g)	Value (mL/g)	Value ($\log_{10}$) (mL/g)	Value (mL/g)
Metals				
Boron	0.8	6.31E+00	3.9	7.94E+03
Cadmium	3.3	2.00E+03	4.9	7.94E+04
Cobalt	3.1	1.26E+03	4.8	6.31E+04
Thallium	1.3	2.00E+01	4.1	1.26E+04
Radionuclides				
Radium-226+228	–	7.40E+03	–	7.40E+03

Note:
Source: US EPA (2014).

Table A.3 Surface Water Parameters

Parameter	Name	Value	Unit
TSS	Total Suspended Solids	62	mg/L
V_{fx}	Surface Water Flow Rate	9.6×10^{13}	L/year
d_b	Depth of Upper Benthic Layer (default)	0.03	m
d_w	Depth of Water Column	8.2	m
d_z	Depth of Water Body	8.23	m
bsc	Bed Sediment Bulk Density (default)	1	g/cm^3
bsp	Bed Sediment Porosity (default)	0.6	–
M_{TSS}	TSS Mass per Unit Area[a]	0.51	kg/m^2
M_S	Sediment Mass per Unit Area[b]	30	kg/m^2

Notes:
Source of default values: US EPA (2014).
(a) Determined by multiplying TSS by d_w.
(b) Determined by multiplying d_b by bsc.

Table A.4 Calculated Parameters

COI	Fraction of COI in the Water Column (f_{water})	Fraction of COI in the Benthic Sediments ($f_{benthic}$)	Fraction of COI Dissolved in the Water Column ($f_{dissolved}$)
Metals			
Boron	0.98	0.02	0.67
Cadmium	0.45	0.55	0.17
Cobalt	0.52	0.48	0.20
Thallium	0.96	0.04	0.56
Radionuclides			
Radium-226+228	0.05	0.95	0.69

Note:
COI = Constituent of Concern.

Table A.5 Surface Water and Sediment Modeling Results

COI	Groundwater Concentration (mg/L or pCi/L)	Mass Discharge Rate (mg/year or pCi/year)	Total Water Column Concentration (mg/L or pCi/L)	Concentration Sorbed to Bottom Sediments (mg/kg or pCi/kg)
Metals				
Boron	7.24	5.5E+08	5.8E-06	2.4E-05
Cadmium	0.0018	1.4E+05	1.4E-09	4.8E-07
Cobalt	0.027	2.0E+06	2.1E-08	5.5E-06
Thallium	0.0033	2.5E+05	2.6E-09	3.0E-08
Radionuclides				
Radium-226+228	5.9	4.5E+08	4.7E-06	2.4E-02

Notes:

COI = Constituent of Concern; pCi/kg = Picocuries Per Kilogram; pCi/L = Picocuries Per Liter.

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Appendix B

Screening Benchmarks

Table B.1 Soil Screening Benchmarks for Produce Ingestion

COI	Bioconcentration Factor (BCF)					Cancer						Cancer Benchmark (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	1.3E-04	2.6E-04	
		(Child)	(Child)	(Adult)	
IR	Ingestion Rate (g/kg-day)	1.5	1.5	0.9	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	23	23	73	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Exposed Vegetable Ingestion

		Non-cancer	Cancer		Basis
Intake = $\frac{IR \times EF \times ED \times CF1 \times CF2 \times TAF}{BW \times AT}$ =		1.2E-03	1.0E-04	2.4E-04	
		(Child)	(Child)	(Adult)	
IR	Ingestion Rate (g/kg-day)	1.2	1.2	0.8	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	18	18	67	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Protected Fruit Ingestion

		Non-cancer	Cancer		Basis
Intake = $\frac{IR \times EF \times ED \times CF1 \times CF2 \times TAF}{BW \times AT}$ =		2.0E-03	1.7E-04	4.2E-04	
		(Child)	(Child)	(Adult)	
IR	Ingestion Rate (g/kg-day)	2.0	2.0	1.5	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	29	29	116	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Protected Vegetable Ingestion

		Non-cancer	Cancer		Basis
Intake = $\frac{IR \times EF \times ED \times CF1 \times CF2 \times TAF}{BW \times AT}$ =		1.2E-03	1.0E-04	1.8E-04	
		(Child)	(Child)	(Adult)	
IR	Ingestion Rate (g/kg-day)	1.2	1.2	0.6	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	18	18	51	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Root Vegetable

		Non-cancer	Cancer		Basis
Intake = $\frac{IR \times EF \times ED \times CF1 \times CF2 \times TAF}{BW \times AT}$ =		5.4E-04 (Child)	4.6E-05 (Child)	1.8E-04 (Adult)	
IR	Ingestion Rate (g/kg-day)	0.5	0.5	0.6	Value US EPA used in its CCR risk assessment (US EPA, 2014a)
IR	Ingestion Rate (g/day)	8	8	51	Ingestion rate x body weight
EF	Exposure Frequency (days/year)	365	365	365	Default
ED	Exposure Duration (years)	6	6	20	US EPA (2021c) recommended value for resident
CF1	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	Conversion factor
CF2	Conversion Factor (mg/g)	1000	1000	1000	Conversion factor
BW	Body Weight (kg)	15	15	80	US EPA (2021c) recommended value for resident
AT	Averaging Time (days)	2,190	25,550	25,550	US EPA (2021c) recommended value for resident

Table B.2 Calculated Water Quality Standards Protective of Incidental Ingestion and Fish Consumption

Human Health COI	BCF[a] (L/kg-tissue)	Basis	MCL (mg/L)	RfD (mg/kg-day)	ADI[b] (mg/day)	Human Threshold Criteria Water & Fish (mg/L)	Human Threshold Criteria Water Only (mg/L)	Human Threshold Criteria 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 (L/kg-tissue) Basis	MCL (pCi/L)	ADI (pCi/day)	Food Ingestion Slope Factor[d] (risk/pCi)	Human Threshold Criteria Water & Fish (pCi/L)	Human Threshold Criteria Water Only (pCi/L)	Human Threshold Criteria 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:

$$\text{Screening Benchmark} = \frac{1}{\dfrac{1}{SL_{ing}} + \dfrac{1}{SL_{derm}}}$$

$$\text{Non-cancer } SL_{ing} = \frac{THQ * RfD}{Intake} \qquad \text{Cancer } SL_{ing} = \frac{TR}{Intake * CSF}$$

$$\text{Non-cancer } SL_{derm} = \frac{THQ * RfD}{Intake * ABS} \qquad \text{Cancer } SL_{derm} = \frac{TR}{Intake * ABS * CSF}$$

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 Child	6.8E-08 Adult	6.3E-08 Child	2.0E-08 Adult	Basis
IR	Ingestion Rate (mg/day)	67	33	67	33	One-third of US EPA residential soil ingestion rate (Professional Judgment)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and October, when air temperature is >70°F (Professional Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2021b)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2021b)
AT	Averaging Time (days)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2021b)

Sediment – Dermal Contact (Chemical)

		Non-Cancer		Cancer		
Intake Factor (IF) =	$\frac{SA \times AF \times EF \times ED \times CF}{BW \times AT}$ =	2.2E-06 Child	1.2E-06 Adult	1.9E-07 Child	3.6E-07 Adult	Basis
SA	Surface Area Exposed to Sediment (cm²/day)	1,026	3,026	1,026	3,026	Age-weighted SA for lower legs and feet (US EPA, 2011b)
AF	Sediment Skin Adherence Factor (mg/cm²)	0.2	0.2	0.2	0.2	Age-weighted AF for children exposed to sediment (US EPA, 2011b)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and October, when air temperature is >70°F (Professional Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2021b)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2021b)
AT	Averaging Time (days)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2021b)

Table B.4.1 Recreator PRGs for Soil, Input Values

Variable	Recreator Soil Default Value	Form-Input Value
A (PEF dispersion constant)	16.2302	16.8653
B (PEF dispersion constant)	18.7762	18.7848
City (climate zone)	Default	Chicago, IL (7)
C (PEF dispersion constant)	216.108	215.0624
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
$\text{CF}_{\text{rec-fowl}}$ (fowl contaminated fraction) unitless	1	1
$\text{CF}_{\text{rec-game}}$ (game contaminated fraction) unitless	1	1
ED_{rec} (exposure duration - recreator) years		26
EF_{rec} (exposure frequency - recreator) days/year		60
$f_{\text{p-fowl}}$ (fowl on-site fraction) unitless	1	1
$f_{\text{p-game}}$ (land game on-site fraction) unitless	1	1
$f_{\text{s-fowl}}$ (fraction of year fowl is on site) unitless	1	1
$f_{\text{s-game}}$ (fraction of year land game is on site) unitless	1	1
$\text{MLF}_{\text{pasture}}$ (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
$\text{ED}_{\text{rec-a}}$ (exposure duration - recreator adult) years		20
$\text{ED}_{\text{resc-c}}$ (exposure duration - recreator child) years		6
EF_{rec} (exposure frequency - recreator) days/year		60
$\text{EF}_{\text{rec-a}}$ (exposure frequency - recreator adult) days/year		60
$\text{EF}_{\text{rec-c}}$ (exposure frequency - recreator child) days/year		60
ET_{rec} (exposure time - recreator) hours/day		8
$\text{ET}_{\text{rec-a}}$ (exposure time - recreator) hours/day		8
$\text{ET}_{\text{rec-c}}$ (exposure time - recreator) hours/day		8
$\text{IFA}_{\text{rec-adj}}$ (age-adjusted inhalation rate - recreator) m^3		9,200
$\text{IFS}_{\text{rec-adj}}$ (age-adjusted soil intake rate - recreator) mg		63,720
$\text{IRA}_{\text{rec-a}}$ (inhalation rate - recreator adult) m^3/day	20	20
$\text{IRA}_{\text{rec-c}}$ (inhalation rate - recreator child) m^3/day	10	10
$\text{IRS}_{\text{rec-a}}$ (soil intake rate - recreator adult) mg/day	100	33
$\text{IRS}_{\text{rec-c}}$ (soil intake rate - recreator child) mg/day	200	67
t_{rec} (time - recreator) years		26
TR (target risk) unitless	0.000001	0.000001
U_m (mean annual wind speed) m/s	4.69	4.65
U_t (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

Notes:

IL = Illinois; PRG = Preliminary Remediation Goal.

Table B.4.2 Recreator PRGs for Soil, Ra-226

Isotope	ICRP Lung Absorption Type	Soil Ingestion Slope Factor (risk/pCi)	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/year per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Lambda (1/year)	Half-Life (years)	1,000 m^2 Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Particulate Emission Factor (m^3/kg)	Dry Soil-to-Plant Transfer Factor (pCi/g-fresh plant per pCi/g-dry soil)	Beef Transfer Factor (pCi/kg per pCi/day)	Poultry Transfer Factor (pCi/kg per pCi/day)	Ingestion PRG TR = 1.0E-06 (pCi/g)	Inhalation PRG TR = 1.0E-06 (pCi/g)	External Exposure PRG TR = 1.0E-06 (pCi/g)	Total PRG TR = 1.0E-06 (pCi/g)	Total PRG TR = 1.0E-06 (mg/kg)	Total PRG TR = 1.0E-06 (pCi/kg)
Ra-226	S	6.77E-10	2.82E-08	2.50E-08	5.14E-10	4.33E-04	1.60E+03	6.85E-01	1.00E+00	1.56E+09	1.95E-02	1.70E-03	-	2.32E+01	6.02E+03	4.10E+01	1.48E+01	1.50E-05	1.48E+04

Notes:

ICRP = International Commission on Radiological Protection; pCi = Picocurie; PRG = Preliminary Remediation Goal; Ra = Radium; S = Slow; TR = Target Risk.

Table B.4.3 Recreator PRGs for Soil, Ra-228

Isotope	ICRP Lung Absorption Type	Soil Ingestion Slope Factor (risk/pCi)	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/year per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Lambda (1/year)	Half-Life (year)	1,000 m^2 Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Particulate Emission Factor (m^3/kg)	Dry Soil-to-Plant Transfer Factor (pCi/g-fresh plant per pCi/g-dry soil)	Beef Transfer Factor (pCi/kg per pCi/day)	Poultry Transfer Factor (pCi/kg per pCi/day)	Ingestion PRG TR = 1.0E-06 (pCi/g)	Inhalation PRG TR = 1.0E-06 (pCi/g)	External Exposure PRG TR = 1.0E-06 (pCi/g)	Total PRG TR = 1.0E-06 (pCi/g)	Total PRG TR = 1.0E-06 (mg/kg)	Total PRG TR = 1.0E-06 (pCi/kg)
Ra-228	S	1.98E-09	4.37E-08	3.43E-11	1.42E-09	1.21E-01	5.75E+00	1.00E+00	1.00E+00	1.56E+09	1.95E-02	1.70E-03	-	7.93E+00	3.89E+03	2.04E+04	7.91E+00	2.90E-08	7.91E+03

Notes:

ICRP = International Commission on Radiological Protection; pCi = Picocurie; PRG = Preliminary Remediation Goal; Ra = Radium; S = Slow; TR = Target Risk.

Appendix C

Well Survey Results

RAMBOLL

ENVIRONMENT
& HEALTH

Phil Morris, PE
Senior Director, Environmental
Electric Energy, Inc.
Joppa Power Plant
2100 Portland Road
Joppa, IL 62960

Village of Joppa Well Survey and Community Water Supply Results
Joppa Power Plant, Joppa, Illinois

June 28, 2022

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this letter to document the activities and results of the well survey and Village of Joppa Community Water Supply sampling completed for the Joppa Power Plant (JPP).

Specifically, this document summarizes the results of the following tasks:

- Communication and coordination with the Village of Joppa to characterize and sample Joppa Community Water Supply (CWS) Well #2
- Investigation of potential water supply locations off-site including:
  - Evaluation of potential private well locations identified during windshield survey
  - Discussion with Village of Joppa personnel to evaluate whether potable water wells exist within village limits
  - Additional investigation, survey, and mail inquiries to identify potential private well locations
  - If private wells are confirmed downgradient within the potential extent of boron concentrations, sample private well locations. Note that no private wells were confirmed, and no sampling was completed.

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Ref. 1940102417

BACKGROUND

On April 19, 2022, Electric Energy Inc. (EEI) met with representatives of the Village of Joppa to discuss potential well installation locations and sampling of the CWS. Following discussion and completion of an access agreement, the Joppa CWS Well #2 was sampled by Ramboll on May 23, 2022. The sampling was completed while the well was operating and collected from a sample tap located at the wellhead. Three sets of field parameters (pH, temperature, and specific conductance) were measured and recorded to provide an indication of water quality and stability prior to sampling. The sample (and a duplicate) were collected following the measurement of field parameters and sent to Teklab, Inc. in Collinsville, Illinois (IEPA Certification Number [No.] 100226) for analysis of the following parameters: antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, fluoride, iron, lead, lithium, mercury, molybdenum, selenium, sulfate, thallium, and total dissolved solids.

The results are included in **Table 1**, and laboratory reports are attached (**Attachment 1**). Based on the results there are no exceedances of Illinois Class I groundwater protection standards (35 Ill. Admin. Code Part 620.410). These results will be confirmed with another sample event currently planned for September 2022.

WELL SURVEYS

Previous water well surveys have been completed in the vicinity of the JPP to identify possible receptors and evaluate the potential for impacts from Joppa East Ash Pond (EAP). Results have been included in the following reports:

- Kelron Environmental, 2013. *Memorandum: Visual Well Survey and Interviews with Village of Joppa and Fort Massac Water District Officials*. July 12, 2013.
- Natural Resource Technology, Inc. (NRT), 2013. *Phase I Hydrogeological Assessment Report, Coal Combustion Product Impoundments, Joppa Generating Station, Joppa, Illinois*. July 23, 2013.
- Ramboll US Corporation (Ramboll), 2020. *Well/Water Supply Survey and Evaluation, Coal-Fired Power Plants in Illinois*. September 24, 2020.
- Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021. *Hydrogeologic Site Characterization Report, included as Attachment H to Part 845 Operating Permit Application. East Ash Pond, Joppa Power Plant, Joppa, Illinois*. October 25, 2021.

The most recent potable water well inventory was completed utilizing federal and state databases to identify nearby pumping wells, drinking water receptors, and other uses of water in the vicinity of the EAP as provided in Section 5.1 of the Hydrogeologic Site Characterization Report (Ramboll, 2021).

In addition to the Village of Joppa CWS, three potential water wells within 300-meters of the JPP property boundary were identified downgradient and three potential wells were identified side-gradient of the EAP (**Figure 1**). The well IDs and depths of the wells is summarized as follows:

- Two potential downgradient wells (121270005500 and 121270005400) were identified to have depths of 65 feet and 137 feet bgs.
- One well (121272094200, downgradient) has Electric Energy Inc. listed as the owner and a depth of 90 feet bgs. This location is listed as Well 3, but this well is actually located on the JPP property, therefore, the location shown in the state database is not accurate.
- Three potential side-gradient wells (121270003100, 121270003000, and 121270005200) were identified to have depths ranging from 138 to 156 feet bgs.

WINDSHIELD SURVEY AND IN-PERSON INQUIRIES

A windshield survey (site visit) was completed on February 1, 2022 to confirm the locations of the wells identified in the well survey provided in Hydrogeologic Site Characterization Report (Ramboll, 2021) and identify whether any additional locations had potential wells (**Attachment 2**). Well-like features were observed at two locations (235 Main Street and 234 Pope Ave) and are depicted on **Figure 1**. Geosyntec visited the identified locations to inquire whether or not the observed features were groundwater wells. The results of their interactions are as follows:

- 234 Pope Ave – Geosyntec visited the property on May 4, 2022. The owner was present and indicated that the feature was not a well, and she only receives water from the village supply.
- 235 Main Street – An initial attempt by Geosyntec to speak with the owner on May 4, 2022 was unsuccessful. On June 2, 2022 Geosyntec again knocked on the door in an attempt to discuss the feature with the owner and/or resident. While waiting for a response at the door, a man, who lived several

houses to the west, stated that he was a nephew of the owner, and that the feature was a sewer clean out, not a well.

Based on the information gathered during the inquiries these features are not groundwater wells.

MAIL INQUIRIES

In addition to the database review, windshield survey, and in-person inquiries, EEI prepared and distributed a letter to all residents of the Village of Joppa (**Attachment 3**). The purpose of the letter was to identify wells that may not have been identified using previous methods and stated the following: ”we ask that any property owner in the Village of Joppa with a private irrigation or drinking water well contact EEI to have their well tested.” As of the date of this letter no residents downgradient of the EAP have responded.

NEXT STEPS

Based on the results of the well survey and subsequent inquiries, no downgradient potable water wells have been identified. Sampling analytical data results from Joppa CWS Well #2 indicate there are no impacts related to the EAP. Another sampling event is planned for September 2022 to confirm these results. Groundwater monitoring wells completed as part of off-site plume delineation activities within the Village of Joppa are scheduled for testing in July, September, and October 2022.

Documentation and interpretation of the data collected for the delineation activities are ongoing and will be submitted to IEPA when complete.

LICENSED PROFESSIONAL CERTIFICATIONS

I, Brian G. Hennings, a qualified professional geologist in good standing in the State of Illinois, certify that the Village of Joppa’s Community Water Supply Well #2 was sampled on May 24, 2022 and the groundwater analytical results as reported by the laboratory for all the parameters tested were below the Illinois Class I groundwater protection standards (35 Ill. Admin. Code Part 620.410).

Brian G. Hennings
Professional Geologist
196-001482
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: June 28, 2022

I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the Village of Joppa's Community Water Supply Well #2 was sampled on May 24, 2022 and the groundwater analytical results as reported by the laboratory for all the parameters tested were below the Illinois Class I groundwater protection standards (35 Ill. Admin. Code Part 620.410).

Eric J. Tlachac

Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: June 28, 2022

I, Brian G. Hennings, a qualified professional geologist in good standing in the State of Illinois, certify that to the best of my knowledge based on (i) State of Illinois database searches, (ii) windshield surveys looking for private wells, (iii) letters mailed to all known owners and/or occupants within the Village of Joppa seeking information about private wells, and (iv) in-person interviews with two homeowners that confirmed they did not have a private well on their property, there are no known private water wells, for drinking water or non-potable use, identified within the Village of Joppa or within the area served by the community water system.

Brian G. Hennings
Professional Geologist
196-001482
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: June 28, 2022

I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that to the best of my knowledge based on (i) State of Illinois database searches, (ii) windshield surveys looking for private wells, (iii) letters mailed to all known owners and/or occupants within the Village of Joppa seeking information about private wells, and (iv) in-person interviews with two homeowners that confirmed they did not have a private well on their property, there are no known private water wells, for drinking water or non-potable use, identified within the Village of Joppa or within the area served by the community water system.

Eric J. Tlachac

Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
Ramboll Americas Engineering Solutions, Inc.
Date: June 28, 2022

FIGURES (ATTACHED)

Figure 1	Well Survey Results

TABLES (ATTACHED)

Table 1	Joppa CWS Well #2 Analytical Results

ATTACHMENTS

Attachment 1	Laboratory Analytical Report for Joppa CWS Well #2 Sampling
Attachment 2	Windshield Survey Notes and Photographs
Attachment 3	Vistra's April 26, 2022 Letter to Residents of Joppa Village

cc:

TABLES

TABLE 1. Joppa CWS WELL #2 ANALYTICAL RESULTS
VILLAGE OF JOPPA WELL SURVEY AND COMMUNITY WATER SUPPLY RESULTS
JOPPA POWER PLANT
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Iron, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 620.410(a)	N/A	0.006	0.010	2.0	0.004	2.0	0.005	--	200.0	0.1	1.0	4.0	5.0	0.0075	--	0.002	--	6.5 - 9.0	0.05	400.0	0.002	1200
Joppa CWS Well #2	05/24/2022	<0.0010	0.0037	0.349	<0.0010	<0.0250	<0.0010	74.6	5	<0.0015	0.0013	0.28	1.32	0.0010	0.0111	<0.00020	0.0015	7.3	<0.0010	<10	<0.0020	270
DUP-01	05/24/2022	<0.0010	0.0037	0.349	<0.0010	<0.0250	<0.0010	75.4	6	<0.0015	0.0014	0.27	1.39	0.0008	0.011	<0.00020	0.0006	7.3	<0.0010	<10	<0.0020	266

[O: CJC 06/23/2022; C: EJT 06/24/2022]

Notes:

Detected at concentration greater than 35 I.A.C. 620.410(a) standard
-- = data not available
mg/L = milligrams per liter
SU = standard units
< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method. Estimated concentrations below the reporting limit and associated qualifiers are not provided.
35 I.A.C. 620.410(a) = Groundwater Quality Standards for Class I: Potable Resource Groundwater

FIGURES

- 🟪 COMMUNITY WATER SUPPLY
- ▫ POTENTIAL PRIVATE WELL (DOES NOT EXIST)
- 🟩 PRIVATE WELL (PRESENCE NOT CONFIRMED)
- 🟧 AREA OF WINDSHIELD SURVEY PROPERTY
- ⬚ BOUNDARY

0 275 550 Feet

WELL SURVEY RESULTS

FIGURE 1

JOPPA GENERATING STATION
ELECTRIC ENERGY INC.
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

ATTACHMENT 1

Laboratory Analytical Report for Joppa CWS Well #2 Sampling

Teklab, Inc.
Environmental Laboratory
http://www.teklabinc.com/

June 07, 2022

Eric Plante
Ramboll
300 S. Wacker Drive
Suite 130
Chicago, IL 60606
TEL: (414) 837-3687
FAX: (414) 837-3608

NELAP ACCREDITED TNI LABORATORY

Illinois	100226
Kansas	E-10374
Louisiana	05002
Louisiana	05003
Oklahoma	9978

RE: Joppa Groundwater **WorkOrder:** 22051610

Dear Eric Plante:

TEKLAB, INC received 4 samples on 5/25/2022 8:18:00 AM for the analysis presented in the following report.

Samples are analyzed on an as received basis unless otherwise requested and documented. The sample results contained in this report relate only to the requested analytes of interest as directed on the chain of custody. NELAP accredited fields of testing are indicated by the letters NELAP under the Certification column. Unless otherwise documented within this report, Teklab Inc. analyzes samples utilizing the most current methods in compliance with 40CFR. All tests are performed in the Collinsville, IL laboratory unless otherwise noted in the Case Narrative.

All quality control criteria applicable to the test methods employed for this project have been satisfactorily met and are in accordance with NELAP except where noted. The following report shall not be reproduced, except in full, without the written approval of Teklab, Inc.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Elizabeth A. Hurley

Elizabeth A. Hurley
Project Manager
(618)344-1004 ex 33
ehurley@teklabinc.com

Client: Ramboll
Work Order: 22051610
Client Project: Joppa Groundwater
Report Date: 07-Jun-22

This reporting package includes the following:

Definitions

Client: Ramboll **Work Order:** 22051610

Client Project: Joppa Groundwater **Report Date:** 07-Jun-22

Abbr	Definition
*	Analytes on report marked with an asterisk are not NELAP accredited
CCV	Continuing calibration verification is a check of a standard to determine the state of calibration of an instrument between recalibration.
CRQL	A Client Requested Quantitation Limit is a reporting limit that varies according to customer request. The CRQL may not be less than the MDL.
DF	Dilution factor is the dilution performed during analysis only and does not take into account any dilutions made during sample preparation. The reported result is final and includes all dilution factors.
DNI	Did not ignite
DUP	Laboratory duplicate is a replicate aliquot prepared under the same laboratory conditions and independently analyzed to obtain a measure of precision.
ICV	Initial calibration verification is a check of a standard to determine the state of calibration of an instrument before sample analysis is initiated.
IDPH	IL Dept. of Public Health
LCS	Laboratory control sample is a sample matrix, free from the analytes of interest,spiked with verified known amounts of analytes and analyzed exactly like a sample to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.
LCSD	Laboratory control sample duplicate is a replicate laboratory control sample that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MBLK	Method blank is a sample of a matrix similar to the batch of associated sample (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences should present at concentrations that impact the analytical results for sample analyses.
MDL	"The method detection limit is defined as the minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results."
MS	Matrix spike is an aliquot of matrix fortified (spiked) with known quantities of specific analytes that is subjected to the entire analytical procedures in order to determine the effect of the matrix on an approved test method’s recovery system. The acceptable recovery range is listed in the QC Package (provided upon request).
MSD	Matrix spike duplicate means a replicate matrix spike that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MW	Molecular weight
NC	Data is not acceptable for compliance purposes
ND	Not Detected at the Reporting Limit
NELAP	NELAP Accredited
PQL	Practical quantitation limit means the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operation conditions.
RL	The reporting limit the lowest level that the data is displayed in the final report. The reporting limit may vary according to customer request or sample dilution. The reporting limit may not be less than the MDL.
RPD	Relative percent difference is a calculated difference between two recoveries (ie. MS/MSD). The acceptable recovery limit is listed in the QC Package (provided upon request).
SPK	The spike is a known mass of target analyte added to a blank sample or sub-sample; used to determine recovery deficiency or for other quality control purposes.
Surr	Surrogates are compounds which are similar to the analytes of interest in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples.
TIC	Tentatively identified compound: Analytes tentatively identified in the sample by using a library search. Only results not in the calibration standard will be reported as tentatively identified compounds. Results for tentatively identified compounds that are not present in the calibration standard, but are assigned a specific chemical name based upon the library search, are calculated using total peak areas from reconstructed ion chromatograms and a response factor of one. The nearest Internal Standard is used for the calculation. The results of any TICs must be considered estimated, and are flagged with a "T". If the estimated result is above the calibration range it is flagged "ET"
TNTC	Too numerous to count (> 200 CFU)

Definitions

Client: Ramboll
Client Project: Joppa Groundwater

Work Order: 22051610
Report Date: 07-Jun-22

Qualifiers

\# - Unknown hydrocarbon
C - RL shown is a Client Requested Quantitation Limit
H - Holding times exceeded
J - Analyte detected below quantitation limits
ND - Not Detected at the Reporting Limit
S - Spike Recovery outside recovery limits
X - Value exceeds Maximum Contaminant Level
B - Analyte detected in associated Method Blank
E - Value above quantitation range
I - Associated internal standard was outside method criteria
M - Manual Integration used to determine area response
R - RPD outside accepted recovery limits
T - TIC(Tentatively identified compound)

Case Narrative

Client: Ramboll
Work Order: 22051610
Client Project: Joppa Groundwater
Report Date: 07-Jun-22

Cooler Receipt Temp: 5.4 °C

This report was revised on June 7, 2022 per Eric Bauer's request. The reason for the revision is to include Mercury analysis (omitted in error at sample receipt). Please replace report dated June 3, 2022 with this report. EAH 6/7/22

Locations

Collinsville

Address 5445 Horseshoe Lake Road
Collinsville, IL 62234-7425
Phone (618) 344-1004
Fax (618) 344-1005
Email jhriley@teklabinc.com

Springfield

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Accreditations

Client: Ramboll
Client Project: Joppa Groundwater

Work Order: 22051610
Report Date: 07-Jun-22

State	Dept	Cert #	NELAP	Exp Date	Lab
Illinois	IEPA	100226	NELAP	1/31/2023	Collinsville
Kansas	KDHE	E-10374	NELAP	4/30/2023	Collinsville
Louisiana	LDEQ	05002	NELAP	6/30/2023	Collinsville
Louisiana	LDEQ	05003	NELAP	6/30/2023	Collinsville
Oklahoma	ODEQ	9978	NELAP	8/31/2022	Collinsville
Arkansas	ADEQ	88-0966		3/14/2023	Collinsville
Illinois	IDPH	17584		5/31/2023	Collinsville
Kentucky	UST	0073		1/31/2023	Collinsville
Missouri	MDNR	00930		5/31/2023	Collinsville
Missouri	MDNR	930		1/31/2025	Collinsville

Client: Ramboll
Work Order: 22051610
Client Project: Joppa Groundwater
Report Date: 07-Jun-22
Lab ID: 22051610-001
Client Sample ID: CWS-Well-2
Matrix: GROUNDWATER
Collection Date: 05/24/2022 9:30

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
STANDARD METHODS 2540 C (DISSOLVED) 1997, 2011								
Total Dissolved Solids	NELAP	20		**270**	mg/L	1	05/26/2022 10:25	R312565
SW-846 9036 (TOTAL)								
Sulfate	NELAP	10		**< 10**	mg/L	1	05/26/2022 18:23	R312492
SW-846 9214 (TOTAL)								
Fluoride	NELAP	0.10		**0.28**	mg/L	1	06/02/2022 11:32	R312705
SW-846 9251 (TOTAL)								
Chloride	NELAP	1		**5**	mg/L	1	05/26/2022 18:23	R312493
SW-846 3005A, 6010B, METALS BY ICP (TOTAL)								
Lithium	NELAP	0.0050		**0.0111**	mg/L	1	06/02/2022 11:57	193089
SW-846 3005A, 6020A, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:24	193089
Arsenic	NELAP	0.0010		**0.0037**	mg/L	5	05/27/2022 13:24	193089
Barium	NELAP	0.0010		**0.349**	mg/L	5	05/27/2022 13:24	193089
Beryllium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:24	193089
Boron	NELAP	0.0250		**< 0.0250**	mg/L	5	05/27/2022 13:24	193089
Cadmium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:24	193089
Calcium	NELAP	0.125		**74.6**	mg/L	5	05/31/2022 13:49	193089
Chromium	NELAP	0.0015		**< 0.0015**	mg/L	5	05/27/2022 13:24	193089
Cobalt	NELAP	0.0010		**0.0013**	mg/L	5	05/27/2022 13:24	193089
Iron	NELAP	0.0250		**1.32**	mg/L	5	05/31/2022 13:49	193089
Lead	NELAP	0.0010	J	**0.0010**	mg/L	5	05/27/2022 13:24	193089
Molybdenum	NELAP	0.0015	J	**0.0015**	mg/L	5	05/27/2022 13:24	193089
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:24	193089
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	05/27/2022 13:24	193089
LCS recovered outside upper control limits for B and Se. Sample results are below the reporting limit. Data is reportable per the TNI Standard.								
SW-846 7470A (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	06/07/2022 10:08	193373

Client: Ramboll

Work Order: 22051610

Client Project: Joppa Groundwater

Report Date: 07-Jun-22

Lab ID: 22051610-002

Client Sample ID: DUP-01

Matrix: GROUNDWATER

Collection Date: 05/24/2022 0:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
STANDARD METHODS 2540 C (DISSOLVED) 1997, 2011								
Total Dissolved Solids	NELAP	20		**266**	mg/L	1	05/26/2022 10:26	R312565
SW-846 9036 (TOTAL)								
Sulfate	NELAP	10		**< 10**	mg/L	1	05/26/2022 18:44	R312492
SW-846 9214 (TOTAL)								
Fluoride	NELAP	0.10		**0.27**	mg/L	1	06/02/2022 11:34	R312705
SW-846 9251 (TOTAL)								
Chloride	NELAP	1		**6**	mg/L	1	05/26/2022 18:44	R312493
SW-846 3005A, 6010B, METALS BY ICP (TOTAL)								
Lithium	NELAP	0.0050		**0.0110**	mg/L	1	06/02/2022 11:59	193089
SW-846 3005A, 6020A, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:30	193089
Arsenic	NELAP	0.0010		**0.0037**	mg/L	5	05/27/2022 13:30	193089
Barium	NELAP	0.0010		**0.349**	mg/L	5	05/27/2022 13:30	193089
Beryllium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:30	193089
Boron	NELAP	0.0250		**< 0.0250**	mg/L	5	05/27/2022 13:30	193089
Cadmium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:30	193089
Calcium	NELAP	0.125	S	**75.4**	mg/L	5	05/31/2022 15:24	193089
Chromium	NELAP	0.0015		**< 0.0015**	mg/L	5	05/27/2022 13:30	193089
Cobalt	NELAP	0.0010		**0.0014**	mg/L	5	06/02/2022 12:22	193089
Iron	NELAP	0.0250		**1.39**	mg/L	5	05/31/2022 15:24	193089
Lead	NELAP	0.0010	J	**0.0008**	mg/L	5	05/27/2022 13:30	193089
Molybdenum	NELAP	0.0015	J	**0.0006**	mg/L	5	05/27/2022 13:30	193089
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	05/27/2022 13:30	193089
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	05/27/2022 13:30	193089

Matrix spike control limits for Ca are not applicable due to high sample/spike ratio.

LCS recovered outside upper control limits for B and Se. Sample results are below the reporting limit. Data is reportable per the TNI Standard.

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
SW-846 7470A (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	06/07/2022 10:11	193373

Sample Summary

Client: Ramboll

Client Project: Joppa Groundwater

Work Order: 22051610

Report Date: 07-Jun-22

Lab Sample ID	Client Sample ID	Matrix	Fractions	Collection Date
22051610-001	CWS-Well-2	Groundwater	3	05/24/2022 9:30
22051610-002	DUP-01	Groundwater	3	05/24/2022 0:00
22051610-003	Extra Set 1	Groundwater	3	05/24/2022 0:00
22051610-004	Extra Set 2	Groundwater	3	05/24/2022 0:00

Dates Report

Client: Ramboll

Client Project: Joppa Groundwater

Work Order: 22051610

Report Date: 07-Jun-22

Sample ID	Client Sample ID Test Name	Collection Date	Received Date	Prep Date/Time	Analysis Date/Time
22051610-001A	CWS-Well-2	05/24/2022 9:30	05/25/2022 8:18		
	SW-846 9036 (Total)				05/26/2022 18:23
	SW-846 9214 (Total)				06/02/2022 11:32
	SW-846 9251 (Total)				05/26/2022 18:23
22051610-001B	CWS-Well-2	05/24/2022 9:30	05/25/2022 8:18		
	Standard Methods 2540 C (Dissolved) 1997, 2011				05/26/2022 10:25
22051610-001C	CWS-Well-2	05/24/2022 9:30	05/25/2022 8:18		
	SW-846 3005A, 6010B, Metals by ICP (Total)			05/26/2022 7:36	06/02/2022 11:57
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	05/27/2022 13:24
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	05/31/2022 13:49
	SW-846 7470A (Total)			06/06/2022 13:00	06/07/2022 10:08
22051610-002A	DUP-01	05/24/2022 0:00	05/25/2022 8:18		
	SW-846 9036 (Total)				05/26/2022 18:44
	SW-846 9214 (Total)				06/02/2022 11:34
	SW-846 9251 (Total)				05/26/2022 18:44
22051610-002B	DUP-01	05/24/2022 0:00	05/25/2022 8:18		
	Standard Methods 2540 C (Dissolved) 1997, 2011				05/26/2022 10:26
22051610-002C	DUP-01	05/24/2022 0:00	05/25/2022 8:18		
	SW-846 3005A, 6010B, Metals by ICP (Total)			05/26/2022 7:36	06/02/2022 11:59
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	05/27/2022 13:30
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	05/31/2022 15:24
	SW-846 3005A, 6020A, Metals by ICPMS (Total)			05/26/2022 7:36	06/02/2022 12:22
	SW-846 7470A (Total)			06/06/2022 13:00	06/07/2022 10:11

Client: Ramboll

Client Project: Joppa Groundwater

Work Order: 22051610

Report Date: 07-Jun-22

STANDARD METHODS 2540 C (DISSOLVED) 1997, 2011

Batch **R312565** **SampType:** **MBLK** Units **mg/L**
SampID: MBLK

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Total Dissolved Solids		20		**< 20**	16.00	0	0	-100	100	05/26/2022
Total Dissolved Solids		20		**< 20**	16.00	0	0	-100	100	05/26/2022

Batch **R312565** **SampType:** **LCS** Units **mg/L**
SampID: LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Total Dissolved Solids		20		**952**	1000	0	95.2	90	110	05/26/2022
Total Dissolved Solids		20		**952**	1000	0	95.2	90	110	05/26/2022

Batch **R312565** **SampType:** **DUP** Units **mg/L** RPD Limit: **5**
SampID: 22051610-001BDUP

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Total Dissolved Solids		20		**262**				270.0	3.01	05/26/2022

SW-846 9036 (TOTAL)

Batch **R312492** **SampType:** **MBLK** Units **mg/L**
SampID: ICB/MBLK

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Sulfate		10		**< 10**	6.140	0	0	-100	100	05/26/2022

Batch **R312492** **SampType:** **LCS** Units **mg/L**
SampID: ICV/LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Sulfate		10		**21**	20.00	0	107.4	90	110	05/26/2022

Batch **R312492** **SampType:** **MS** Units **mg/L**
SampID: 22051610-001AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Sulfate		10		**20**	20.00	0	98.4	85	115	05/26/2022

Batch **R312492** **SampType:** **MSD** Units **mg/L** RPD Limit: **10**
SampID: 22051610-001AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Sulfate		10		**20**	20.00	0	100.8	19.68	2.36	05/26/2022

Quality Control Results

Client: Ramboll
Work Order: 22051610
Client Project: Joppa Groundwater
Report Date: 07-Jun-22

SW-846 9214 (TOTAL)

Batch R312705 **SampType:** MBLK Units **mg/L**
SampID: MBLK

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Fluoride		0.10		**< 0.10**	0.0370	0	0	-100	100	06/02/2022

Batch R312705 **SampType:** LCS Units **mg/L**
SampID: LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Fluoride		0.10		**1.01**	1.000	0	100.7	90	110	06/02/2022

Batch R312705 **SampType:** MS Units **mg/L**
SampID: 22051610-002AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Fluoride		0.10		**2.43**	2.000	0.2710	108.2	75	125	06/02/2022

Batch R312705 **SampType:** MSD Units **mg/L** RPD Limit: **15**
SampID: 22051610-002AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Fluoride		0.10		**2.46**	2.000	0.2710	109.2	2.434	0.90	06/02/2022

SW-846 9251 (TOTAL)

Batch R312493 **SampType:** MBLK Units **mg/L**
SampID: ICB/MBLK

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Chloride		1		**< 1**	0.5000	0	0	-100	100	05/26/2022

Batch R312493 **SampType:** LCS Units **mg/L**
SampID: ICV/LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Chloride		1		**22**	20.00	0	108.8	90	110	05/26/2022

Batch R312493 **SampType:** MS Units **mg/L**
SampID: 22051610-001AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Chloride		1		**26**	20.00	5.250	102.0	85	115	05/26/2022

SW-846 9251 (TOTAL)

Batch **R312493** **SampType:** **MSD** Units **mg/L** RPD Limit: **15**

SampID: 22051610-001AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Chloride		1		**25**	20.00	5.250	100.8	25.66	0.94	05/26/2022

SW-846 3005A, 6010B, METALS BY ICP (TOTAL)

Batch **193089** **SampType:** **MBLK** Units **mg/L**

SampID: MBLK-193089

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Lithium	*	0.0050		**< 0.0050**	0.0019	0	0	-100	100	06/01/2022
Lithium		0.0050		**< 0.0050**	0.0019	0	0	-100	100	06/02/2022

Batch **193089** **SampType:** **LCS** Units **mg/L**

SampID: LCS-193089

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Lithium		0.0050		**0.552**	0.5000	0	110.3	85	115	06/02/2022

Batch **193089** **SampType:** **MS** Units **mg/L**

SampID: 22051610-002CMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Lithium		0.0050		**0.569**	0.5000	0.01100	111.6	75	125	06/02/2022

Batch **193089** **SampType:** **MSD** Units **mg/L** RPD Limit: **20**

SampID: 22051610-002CMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Lithium		0.0050		**0.562**	0.5000	0.01100	110.1	0.5689	1.31	06/02/2022

Client: Ramboll
Client Project: Joppa Groundwater

Work Order: 22051610
Report Date: 07-Jun-22

SW-846 3005A, 6020A, METALS BY ICPMS (TOTAL)

Batch **193089** **SampType:** **MBLK** Units **mg/L**
SampID: MBLK-193089

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**< 0.0010**	0.0004	0	0	-100	100	05/27/2022
Arsenic		0.0010		**< 0.0010**	0.0004	0	0	-100	100	05/27/2022
Barium		0.0010		**< 0.0010**	0.0007	0	0	-100	100	05/27/2022
Beryllium		0.0010		**< 0.0010**	0.0002	0	0	-100	100	05/27/2022
Boron		0.0250		**< 0.0250**	0.0093	0	0	-100	100	05/27/2022
Cadmium		0.0010		**< 0.0010**	0.0001	0	0	-100	100	05/27/2022
Calcium		0.125		**< 0.125**	0.0700	0	0	-100	100	05/31/2022
Chromium		0.0015		**< 0.0015**	0.0007	0	0	-100	100	05/27/2022
Cobalt		0.0010		**< 0.0010**	0.0001	0	0	-100	100	05/27/2022
Iron		0.0250		**< 0.0250**	0.0120	0	0	-100	100	05/31/2022
Lead		0.0010		**< 0.0010**	0.0006	0	0	-100	100	05/27/2022
Molybdenum		0.0015		**< 0.0015**	0.0006	0	0	-100	100	05/27/2022
Selenium		0.0010		**< 0.0010**	0.0006	0	0	-100	100	05/27/2022
Thallium		0.0020		**< 0.0020**	0.0010	0	0	-100	100	05/27/2022

Batch **193089** **SampType:** **LCS** Units **mg/L**
SampID: LCS-193089

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**0.593**	0.5000	0	118.7	80	120	05/27/2022
Arsenic		0.0010		**0.543**	0.5000	0	108.7	80	120	06/01/2022
Barium		0.0010		**2.08**	2.000	0	103.9	80	120	06/01/2022
Beryllium		0.0010		**0.0531**	0.0500	0	106.1	80	120	06/01/2022
Boron		0.0250	S	**0.614**	0.5000	0	122.7	80	120	05/27/2022
Cadmium		0.0010		**0.0531**	0.0500	0	106.1	80	120	06/01/2022
Calcium		0.125		**2.59**	2.500	0	103.7	80	120	05/31/2022
Chromium		0.0015		**0.237**	0.2000	0	118.3	80	120	05/27/2022
Cobalt		0.0010		**0.524**	0.5000	0	104.8	80	120	06/01/2022
Iron		0.0250		**2.11**	2.000	0	105.4	80	120	05/31/2022
Lead		0.0010		**0.589**	0.5000	0	117.7	80	120	05/27/2022
Molybdenum		0.0015		**0.519**	0.5000	0	103.7	80	120	06/01/2022
Selenium		0.0010	S	**0.601**	0.5000	0	120.2	80	120	05/27/2022
Thallium		0.0020		**0.286**	0.2500	0	114.4	80	120	05/27/2022

Client: Ramboll

Client Project: Joppa Groundwater

Work Order: 22051610

Report Date: 07-Jun-22

SW-846 3005A, 6020A, METALS BY ICPMS (TOTAL)

Batch **193089** **SampType:** **MS** Units **mg/L**

SampID: 22051610-002CMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**0.576**	0.5000	0	115.1	75	125	05/27/2022
Arsenic		0.0010		**0.611**	0.5000	0.003729	121.4	75	125	05/27/2022
Barium		0.0010		**2.74**	2.000	0.3494	119.6	75	125	05/27/2022
Beryllium		0.0010		**0.0605**	0.0500	0	121.1	75	125	05/27/2022
Boron		0.0250		**0.586**	0.5000	0	117.2	75	125	05/27/2022
Cadmium		0.0010		**0.0588**	0.0500	0	117.6	75	125	05/27/2022
Calcium		0.125	S	**74.7**	2.500	75.43	-27.9	75	125	05/31/2022
Chromium		0.0015		**0.225**	0.2000	0	112.3	75	125	05/27/2022
Cobalt		0.0010		**0.619**	0.5000	0.001389	123.5	75	125	06/02/2022
Iron		0.0250		**3.48**	2.000	1.389	104.3	75	125	05/31/2022
Lead		0.0010		**0.565**	0.5000	0.0007580	112.8	75	125	05/27/2022
Molybdenum		0.0015		**0.595**	0.5000	0.0006209	118.9	75	125	05/27/2022
Selenium		0.0010		**0.575**	0.5000	0	114.9	75	125	05/27/2022
Thallium		0.0020		**0.282**	0.2500	0	112.9	75	125	05/27/2022

Batch **193089** **SampType:** **MSD** Units **mg/L** RPD Limit: **20**

SampID: 22051610-002CMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Antimony		0.0010		**0.539**	0.5000	0	107.8	0.5757	6.56	05/27/2022
Arsenic		0.0010		**0.569**	0.5000	0.003729	113.1	0.6106	7.02	05/27/2022
Barium		0.0010		**2.52**	2.000	0.3494	108.7	2.742	8.28	05/27/2022
Beryllium		0.0010		**0.0571**	0.0500	0	114.1	0.06054	5.92	05/27/2022
Boron		0.0250		**0.569**	0.5000	0	113.8	0.5860	2.93	05/27/2022
Cadmium		0.0010		**0.0556**	0.0500	0	111.1	0.05881	5.69	05/27/2022
Calcium		0.125	S	**77.1**	2.500	75.43	68.5	74.73	3.17	05/31/2022
Chromium		0.0015		**0.212**	0.2000	0	106.0	0.2246	5.78	05/27/2022
Cobalt		0.0010		**0.593**	0.5000	0.001389	118.3	0.6191	4.36	06/02/2022
Iron		0.0250		**3.50**	2.000	1.389	105.6	3.476	0.75	05/31/2022
Lead		0.0010		**0.530**	0.5000	0.0007580	105.9	0.5648	6.34	05/27/2022
Molybdenum		0.0015		**0.550**	0.5000	0.0006209	109.9	0.5953	7.86	05/27/2022
Selenium		0.0010		**0.544**	0.5000	0	108.8	0.5747	5.47	05/27/2022
Thallium		0.0020		**0.264**	0.2500	0	105.7	0.2823	6.61	05/27/2022

Client: Ramboll

Client Project: Joppa Groundwater

Work Order: 22051610

Report Date: 07-Jun-22

SW-846 7470A (TOTAL)

Batch **193373** **SampType:** **MBLK** Units **mg/L**

SampID: MBLK-193373

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**< 0.00020**	0.0001	0	0	-100	100	06/07/2022

Batch **193373** **SampType:** **LCS** Units **mg/L**

SampID: LCS-193373

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00497**	0.0050	0	99.5	85	115	06/07/2022

Batch **193373** **SampType:** **MS** Units **mg/L**

SampID: 22051610-002CMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00496**	0.0050	0	99.3	75	125	06/07/2022

Batch **193373** **SampType:** **MSD** Units **mg/L** RPD Limit: **15**

SampID: 22051610-002CMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Mercury		0.00020		**0.00487**	0.0050	0	97.3	0.004965	2.02	06/07/2022

Receiving Check List

http://www.teklabinc.com/

Client: Ramboll
Client Project: Joppa Groundwater

Work Order: 22051610
Report Date: 07-Jun-22

Carrier: FedEx

Received By: RMW

Completed by:
On:
25-May-22
Payton Yoch

Reviewed by:
On:
25-May-22
Elizabeth A. Hurley

Pages to follow: Chain of custody 1 Extra pages included 0

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐	Temp °C 5.4
Type of thermal preservation?	None ☐	Ice ☑	Blue Ice ☐	Dry Ice ☐
Chain of custody present?	Yes ☑	No ☐		
Chain of custody signed when relinquished and received?	Yes ☑	No ☐		
Chain of custody agrees with sample labels?	Yes ☐	No ☑		
Samples in proper container/bottle?	Yes ☑	No ☐		
Sample containers intact?	Yes ☑	No ☐		
Sufficient sample volume for indicated test?	Yes ☑	No ☐		
All samples received within holding time?	Yes ☑	No ☐		
Reported field parameters measured:	Field ☐	Lab ☐	NA ☑	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐		
When thermal preservation is required, samples are compliant with a temperature between 0.1°C - 6.0°C, or when samples are received on ice the same day as collected.				
Water – at least one vial per sample has zero headspace?	Yes ☐	No ☐	No VOA vials ☑	
Water - TOX containers have zero headspace?	Yes ☐	No ☐	No TOX containers ☑	
Water - pH acceptable upon receipt?	Yes ☑	No ☐	NA ☐	
NPDES/CWA TCN interferences checked/treated in the field?	Yes ☐	No ☐	NA ☑	

Any No responses must be detailed below or on the COC.

pH strip 78198 - pyoch - 5/25/2022 10:55:30 AM

Two extra sample sets were received but not identified on the container labels or chain of custody. Eric Plante was notified via work order summary. CET/EAH 5/25/22

CHAIN OF CUSTODY

pg. 1 of 1 Work order # 22051610

TEKLAB, INC. 5445 Horseshoe Lake Road - Collinsville, IL 62234 - Phone: (618) 344-1004 - Fax: (618) 344-1005

Client: Ramboll
Address: 300 S. Wacker Drive
City / State / Zip Chicago, IL 60606
Contact: Erin Plante **Phone:** (414) 837-3607
E-Mail: eric.plante@obg.com **Fax:**

Samples on: ☒ ICE ☐ BLUE ICE ☐ NO ICE 5.4 °C LTG# 3
Preserved in: ☐ LAB ☒ FIELD **FOR LAB USE ONLY**
Lab Notes ph/ 78 PBS. CET 5/25/2022
Recieved extra samples w/o sample ids. ☆

Client Comments:
ICP/MS: Sb As Ba Be B Cd Ca Cr Co Fe Pb Mo Se Tl
ICP: Li

Are these samples known to be involved in litigation? If yes, a surcharge will apply ☐ Yes ☐ No
Are these samples known to be hazardous? ☐ Yes ☒ No
Are there any required reporting limits to be met on the requested analysis?. If yes, please provide limits in the comment section. ☐ Yes ☐ No

Project Name/Number Joppa Groundwater
Sample Collector's Name SAMMY MALLOW

Results Requested
☒ Standard ☐ 1-2 Day (100% Surcharge)
☐ Other ☐ 3 Day (50% Surcharge)

Billing Instructions

Lab Use Only	Sample Identification	Oate/Time Sampled	# and Type of Containers: UNPRES	HNO3	NaOH	H2SO4	HCL	MeOH	NaHSO4	OTHER	MATRIX: Aqueous	Drinking Water	Soil	Sludge	Special Waste	Groundwater	INDICATE ANALYSIS REQUESTED: Chloride	Dissolved TDS	Fluoride	Mercury	Sulfate	Total Metals by ICP	Total Metals by ICP/MS								
22051610-001	CWS-WELL-2	5-24-22/0930	2	1												X	X	X	X	X	X	X	X							
002	DUP-01	——	2	1												X	X	X	X	X	X	X	X							
003	Extra Set 1 ☆																													
004	Extra Set 2 ☆																													

Relinquished By	Date/Time	Received By	Date/Time
SAMUEL MALLOW	5-24-22 / 1130	FED EX	5-24-22
		Roannan Willis (Fedex)	5/25/22 8:18

The individual signing this agreement on behalf of the client, acknowledges that he/she has read and understands the terms and conditions of this agreement, and that he/she has the authority to sign on behalf of the client. See www.teklabinc.com for terms and conditions.

BottleOrder: 72433

CET 5/25/2022

ATTACHMENT 2
Windshield Survey Notes and Photographs

Daily Field Report

Project and Site Information

Client: Vistra	**Project No.:** GLP8030	**Date:** December 10, 2021
Project: Joppa Well Survey	**Location:** Joppa, IL	**Phase No.**: 02

Survey Performed By: Zachary Fallert, P.E. (Geosyntec)

Weather: PM: 55°F, Partly Cloudy

Distribution List: Vistra: Stuart Cravens, Vic Modeer, Geosyntec: Allison Kreinberg, Lucas Carr, Zachary Fallert, Ramboll: Brian Hennings, Nathaniel Keller

Geosyntec Onsite Personnel

Name	Position	Arrival	Departure	Hours
Zachary Fallert (ZF)	Engineer	1230	1500	2.5

Description of Work

- ZF performed a “windshield survey” by driving most of the streets within the designated survey area (shown in blue in the attached photolog).
- ZF then parked on Blasdel Dr. and walked Blasdel Dr., Lowery Dr., and Little Rd.
    a. ZF observed two PVC stickups along this route. These stickups are approximately 6 in. diameter PVC with a threaded cap. Both appeared to be relatively new.
- ZF then parked at the Joppa Post Office and walked the southern designated survey area including Bradley St., Pope St., Copeland St., Main St., and Joppa N. Ave.
    a. ZF observed four PVC stickups similar to those noted previously. Exposed soil and straw around one indicated further that they are recent additions.
    b. ZF observed one stickup beneath a decorative windmill. From the road, it could not be discerned what the stickup was.
    c. ZF observed one stickup in a yard that had a spicket and garden hose attached.
    d. ZF spoke with one resident and informed him that this was part of a well survey. The resident informed ZF that he did not think any wells would be found as most people had cisterns prior to the public water supply coming online in the 1950s.
- ZF walked Kern St., turned south, and came to the water treatment facility. North of the facility, ZF observed a small structure that appeared to be a well house for the public water supply.
- No wells, except for the public supply well, listed by the Illinois Department of Natural Resources database were observed.
- ZF left Joppa.

Review and Approval

Report Prepared By	Signature	Date
Zachary Fallert, P.E.		February 2, 2022

Date: 2/1/2022

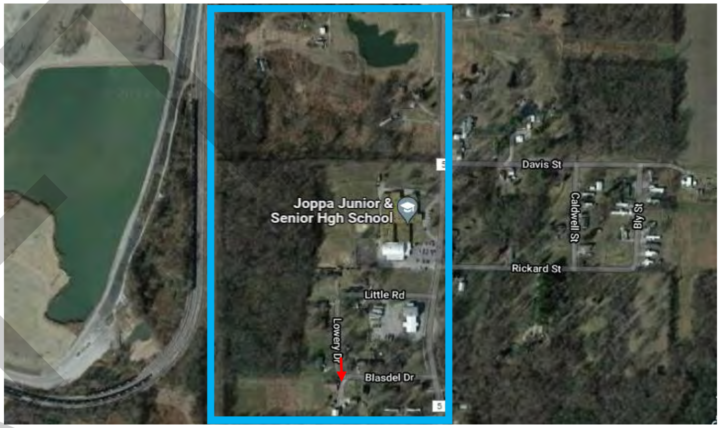
Direction: South

Approximate Location:

West end of Blasdel Dr.

Description:

PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.



Date: 2/1/2022

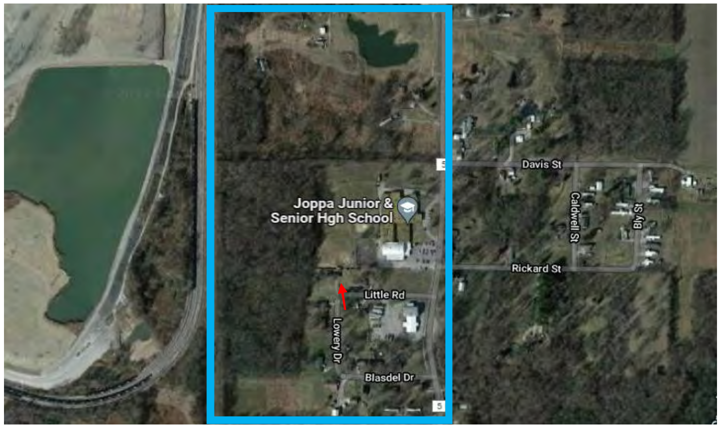
Direction: North

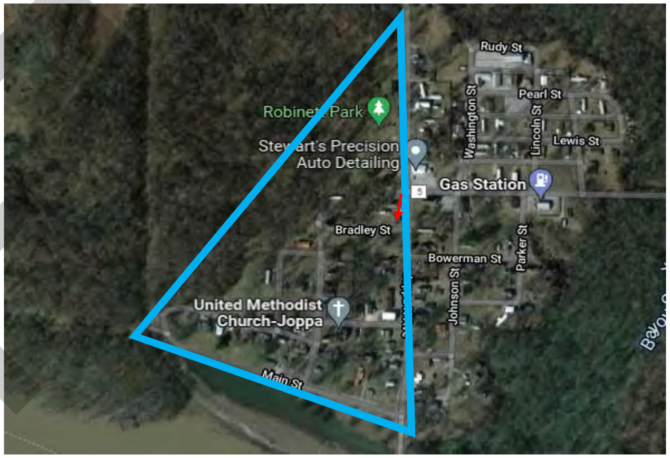
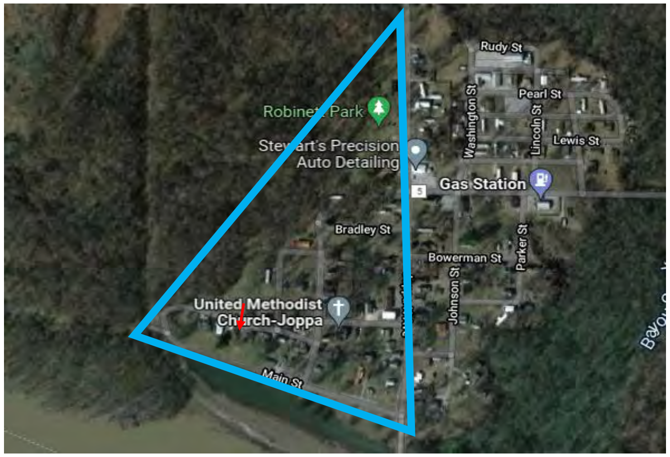
Approximate Location:

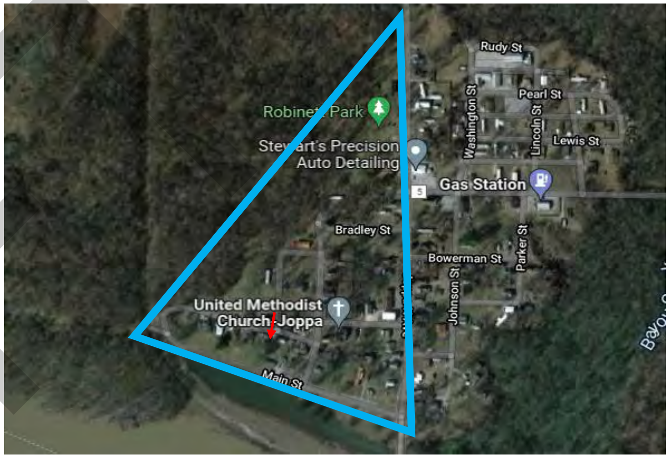
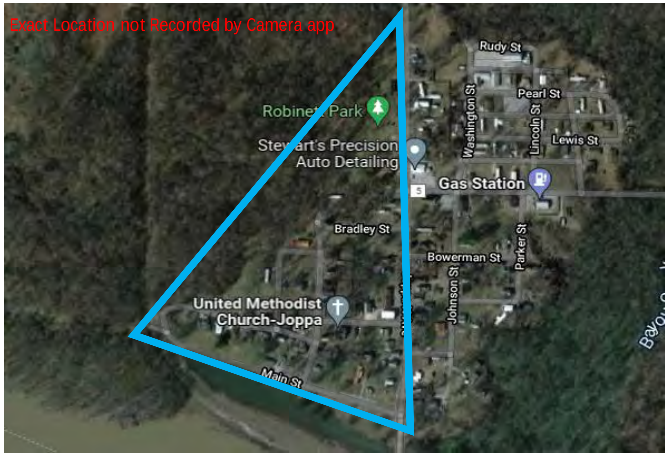
West end of Little Rd.

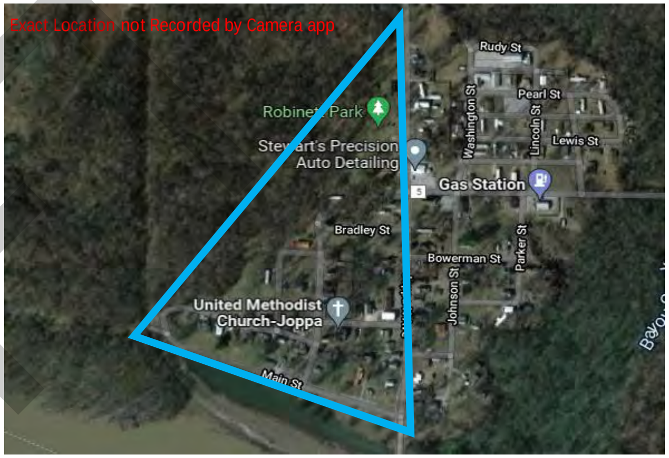
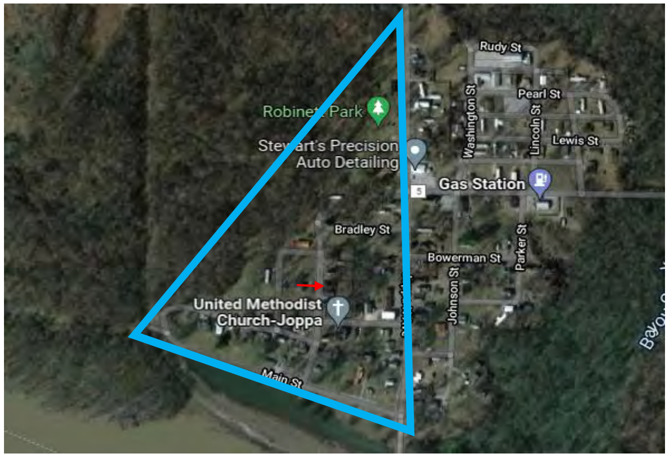
Description:

PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.

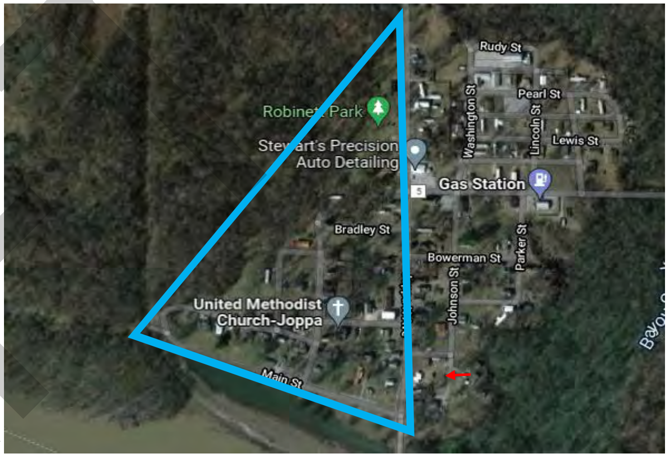


Date: 2/1/2022 **Direction:** South **Approximate Location:** Corner of Joppa N Ave. and Bradley St. **Description:** PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.		
Date: 2/1/2022 **Direction:** South **Approximate Location:** Main St. west of Copeland **Description:** Possible well location. Uknown stickup beneath decorative windmill.		

Date: 2/1/2022 **Direction:** South **Approximate Location:** Main St. west of Copeland **Description:** PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.	 	
Date: 2/1/2022 **Direction:** Unknown **Approximate Location:** Within blue boundary to right. **Description:** PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.	 	 Exact Location not Recorded by Camera app

Date: 2/1/2022 **Direction:** Unknown **Approximate Location:** Within blue boundary to right. **Description:** PVC stickup - approximately 6 in diameter. Likely valve box; appears relatively new.	 [redacted]	
Date: 2/1/2022 **Direction:** East **Approximate Location:** Pope St. between the two ends of Copeland St. **Description:** Stickup in yard. Has spicket with hose attached. Likely just water line stick up.	 [redacted]	

Date:	2/1/2022
Direction:	West
Approximate Location:	Johnson St. north of water treatment plant and south of Kern St.
Description:	Suspected public water supply well house.



ATTACHMENT 3
Vistra's April 26, 2022 Letter to Residents of Joppa Village

VISTRA

EEI
ELECTRIC ENERGY INC.

April 26, 2022

VIA U.S. MAIL

Dear Neighbor:

Last year, Vistra Corp. and Electric Energy Inc. (EEI), the entity that owns the Joppa Power Plant, announced that the Joppa Power Plant would close no later than Sept. 1, 2022. The accelerated retirement schedule was part of a settlement to resolve a complaint initiated by the Illinois Sierra Club in 2018. We're committed to an orderly and responsible plant retirement and to transforming the site into a battery energy storage center. We also remain committed to the Village of Joppa and the community and will have a presence here for decades to come.

Retirement Update

The hardest decision we make in our business is to retire a facility because we know it impacts our dedicated energy workers and creates ripples across our plant communities. Since announcing the accelerated closure date, we have been assisting our plant workers and preparing them for what's next. To that end, we recently reached a comprehensive separation agreement in partnership with the local union employee group, Operating Engineers Local 148.

We do not have a finalized retirement date yet, but the plant will retire later this summer.

Environmental Update

We are committed to being a good steward of our property and to retiring the facility in an environmentally responsible manner. As part of our diligence, groundwater monitoring stations recently installed in accordance with the Illinois coal ash rule near the plant's property boundary have detected elevated levels of boron in groundwater.

The detected levels of boron at our property's edge exceed the applicable state groundwater standard of 2.0 milligrams per liter (mg/L) and range from 3.4 mg/L to 6.94 mg/L. EEI has already briefed local, regional, and state officials, including the Illinois EPA. Our immediate priority is to notify our neighbors of this development and let you know the next steps we will take.

Boron is a naturally occurring element found in fruits, vegetables, and seawater. Many everyday items such as cosmetics, dietary supplements, and cleaning products also contain boron. While boron is naturally occurring, studies have been conducted to determine if ingestion of boron in high concentrations adversely impacts human health.

Excess boron consumption can potentially cause health impacts, but the current detected levels of boron in the upper aquifer at the property boundary are *significantly less* than the concentrations associated with health impacts in various studies.

Further, there is no evidence that groundwater in the lower aquifer, which supplies the Village's public water supply well, has been impacted. However, out of an abundance of caution, EEI is working with the Village to test the water supply to ensure that it remains unimpacted.

EEI is also working to gather additional data, including installing monitoring stations that will collect further data samples and develop a detailed understanding of the extent of boron exceedances. Again, out of an abundance of caution and to assist with data collection, *we ask that any property owner in the Village of Joppa with a private irrigation or drinking water well contact EEI to have their well tested*. We will cover the cost of the testing and will provide the test results to the well owner.

We have proposed to place additional monitoring stations at strategic locations on municipal property. This data collection and analysis will be complete by late summer, and we will share the results with the community.

We understand that you may have questions after receiving this letter. To provide you with additional resources and easy access to government-created resources on the health impacts of boron, we've created a webpage with briefings, infographics, and hyperlinks to trusted resources. Please visit **www.renewillinoispower.com/joppa** for more information.

You can also submit a request to have your private well tested or sign up for ongoing email updates on this webpage.

What We're Doing About This Development

We have already begun evaluating mitigation measures. EEI is in the process of implementing a study to evaluate the extraction of groundwater to help redirect it before it potentially moves off the plant's property. This system would collect the extracted water and then manage it appropriately. All corrective measures we take will be reviewed and permitted by Illinois EPA.

By June 1, the company will publish the draft closure documents for the East Ash Pond in accordance with state regulations governing the management and disposal of coal combustion residuals in surface impoundments known as "Part 845."

Documents associated with that process will be available at **https://www.luminant.com/ccr/illinois-ccr.**

Joppa's Future As An Energy Storage Center

State officials included the *Illinois Coal to Solar and Energy Storage Initiative* in comprehensive energy legislation passed last year. Vistra proposed the framework to facilitate the redevelopment of retired or to-be-retired coal plant sites like Joppa Power Plant.

Vistra submitted an application to the Department of Commerce and Economic Opportunity to facilitate the development of a 37-megawatt battery energy storage center at the site. We expect to hear from state officials in early summer and are continuing to work on receiving all necessary regulatory approvals needed for the project. We currently project the battery energy storage center will enter commercial service in 2025.

Please reach out to us if you have questions or concerns about our Joppa Power Plant.

Sincerely,

Brad Watson
Sr. Director, Community Affairs
EEI Community Relations Department
2100 Portland Rd.
Joppa, IL 62953
214-812-5777
joppa@renewillinoispower.com
www.renewillinoispower.com/joppa

Appendix B

Corrective Action Alternatives Analysis – Supporting Information Report

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

Date
February 17, 2025

Project No.
1940110241-004

CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT

EAST ASH POND
JOPPA POWER PLANT
IEPA ID NO. W1270100004-02

CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT IEPA ID NO. W1270100004-02

Project name	**Joppa Power Plant East Ash Pond**
Project no.	**1940110241-004**
Recipient	**Electric Energy, Inc.**
Document type	**Corrective Action Plan**
Revision	**DRAFT**
Date	**February 17, 2024**
Prepared by	**Christopher R. Glidden**
Checked by	**J. Austin Bond, PE**
Approved by	**Brian G. Hennings, PG**
Description	**Corrective Action Alternatives Analysis Supporting Information Report**

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

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

J. Austin Bond, PE
Qualified Professional Engineer

Brian G. Hennings, PG
Project Officer Hydrogeology

CONTENTS

TABLES (WITHIN TEXT)

APPENDICES

ACRONYMS AND ABBREVIATIONS

35 I.A.C.	Title 35 of the Illinois Administrative Code
40 C.F.R.	Title 40 of the Code of Federal Regulations
bgs	below ground surface
BMP	best management practices
CA	Corrective Action
CAAA	Corrective Action Alternatives Analysis
CAAA-SIR	Corrective Action Alternatives Analysis Supporting Information Report
CCR	coal combustion residuals
CIP	closure-in-place
cm/s	centimeters per second
CMA	Corrective Measures Assessment
COC	constituents of concerns
CY	cubic yards
EAP	East Ash Pond, also referred to as "the site"
EEI	Electric Energy, Inc.
Federal CCR Rule	40 C.F.R. § 257
GMR	Groundwater Modeling Report
gpm	gallons per minute
Gradient	Gradient Corporation
GMP	Groundwater Monitoring Plan
GWE	groundwater extraction
GWP	groundwater polishing
GWPS	groundwater protection standard(s)
ID	identification
IEPA	Illinois Environmental Protection Agency
JOP	Joppa Power Station
JPP	Joppa Power Plant
Kd	soil adsorption coefficient
LCU	lower confining unit
LSI	Langelier Saturation Index
mg/L	milligrams per liter
mL/g	milliliters per gram
NAVD88	North American Vertical Datum of 1988
NID	National Inventory of Dams
No.	number
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
PCA	Preliminary Corrective Action
PRB	Permeable Reactive Barrier
Ramboll	Ramboll Americas Engineering Solutions, Inc.
RS Means	RS Means Heavy Construction Cost Data
SI	surface impoundment
TDS	total dissolved solids
TSS	total suspended solids
UA	uppermost aquifer
USEPA	United States Environmental Protection Agency

1. INTRODUCTION AND BACKGROUND

1.1 Plant and Site Information

Electric Energy, Inc. (EEI) is the owner of the inactive coal-fired Joppa Power Plant (JPP), also referred to as the Joppa Power Station (JOP), in Joppa, Massac County, Illinois ("the site"). EEI intends to complete groundwater corrective action at the coal combustion residuals (CCR) surface impoundment (SI) East Ash Pond (EAP), which is identified by Illinois Environmental Protection Agency (IEPA) identification (ID) number (No.) W1270100004-02, CCR Unit ID 401, and National Inventory of Dams (NID) No. IL50714. Groundwater corrective action for the JPP EAP will be performed under the requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments [1] and the requirements of Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257, herein referred to as the Federal CCR Rule [2].

1.2 CAAA-SIR Background and Scope

35 I.A.C. § 845 requires a Corrective Action Alternatives Analysis (CAAA) to be completed as part of remedy selection, pursuant to the requirements of 35 I.A.C. § 845.670(e). The CAAA for the JPP EAP was prepared by Gradient Corporation (Gradient). Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Corrective Action Alternatives Analysis Supporting Information Report (CAAA-SIR) to provide information requested by Gradient to support the CAAA for the JPP EAP.

This CAAA-SIR is a feasibility-level assessment utilized to evaluate multiple groundwater corrective action alternatives. The remedy that is ultimately selected within the CAAA, to which this CAAA-SIR is attached, was then further developed into a permit-level remedy within the Corrective Action Plan, to which the CAAA is attached. Therefore, there may be minor differences in information presented for the selected remedy between this CAAA-SIR and the Corrective Action Plan. Information that may be different includes, but is not limited to, groundwater quality data, groundwater modeling inputs and results, implementation schedules, time to reach GWPS, the physical dimensions and scope of the remedy, and engineering design parameters. These differences are due to the further remedy refinement that is inherent with advancing the selected alternative into the permit-level remedy that is included within the Corrective Action Plan.

1.2.1 Identified Corrective Action Alternatives

Corrective action remedies selected for evaluation within this CAAA-SIR were identified as potentially feasible for the EAP in the Corrective Measures Assessment (CMA), prepared by Ramboll and attached to the CAAA prepared by Gradient. The remedies identified as potentially feasible included:

- Alternative 1: Source control with groundwater polishing (GWP)
- Alternative 2: Source control with groundwater extraction (GWE); and
- Alternative 3: Source control with deep cutoff wall.

Other remedies, including source control with Permeable Reactive Barrier (PRB), were determined to be infeasible for the site during the CMA process.

1.2.2 Scope of CAAA-SIR

Ramboll completed the following tasks and documented the tasks within this CAAA-SIR, for each of the corrective action alternative remedies listed in **Section 1.2.1**:

- Feasibility-level design drawings (**Appendix A**) were developed to show the approximate extents and typical sections/details of the Alternative 2 remedy (source control with GWE) and the Alternative 3 remedy (source control with deep cutoff wall). Drawings were not prepared for the Alternative 1 remedy as it does not involve construction at the site.
- Narratives describing the implementation of each remedy were developed, including the pre-design, design, construction, operations and maintenance (O&M), and closeout phases.
- Feasibility-level schedules providing the estimated time to implement the remedy were developed, including design, permitting, construction, and post-construction O&M.
- Feasibility-level plans for the management of extracted groundwater were developed for alternatives where groundwater extraction is a component of the potential corrective action.
- Information required to evaluate specific portions of 35 I.A.C. § 845.670(e) requirements were prepared, as requested by Gradient, including 35 I.A.C. § 845.670(e)(1)(H) and 35 I.A.C. § 845.670(e)(3).
- Estimates of implementation-based equipment mileage, vehicle delivery mileage, labor hour, and labor commuting mileage, were developed for each remedy alternative where physical construction and/or O&M activities are expected to occur.

All remedies presented within this CAAA-SIR assume that the source control presented in the Final Closure Plan (as part of the Construction Permit Application [3]) for the JPP EAP will also be implemented. Source control is the primary corrective action for the JPP EAP and will include removing free liquids from the CCR and completing a hybrid closure-in-place (CIP) by consolidating approximately 1.8 million cubic yards (CY) of CCR in the current JPP EAP footprint from 128 acres down to 74 acres (the CIP area) and installing a geomembrane final cover system.

Updated groundwater modeling (**Appendix B.1**) estimates that source control alone will result in GWPS being achieved approximately 11 years after closure completion without implementing other forms of corrective action. The potential remedies evaluated in this CAAA-SIR are intended to work in conjunction with the primary remedy, which is source control.

1.2.3 Criterion for Estimating Time to Achieve GWPS

Times to achieve GWPS for each of the remedial alternative remedies were estimated using 12 EAP monitoring wells in the vicinity of the proposed corrective action alternatives with average observed boron concentrations exceeding the GWPS of 2 milligrams per liter (mg/L).

1.3 Report Contents

The following information is included within this report:

- **Section 1** includes the introduction and background;
- **Section 2** includes information for the Alternative 1 remedy: source control with GWP;
- **Section 3** includes information for the Alternative 2 remedy: source control with GWE;

- **Section 4** includes information for the Alternative 3 remedy: source control with deep cutoff wall,
- **Section 5** includes information used to develop estimates of material quantities, labor hours, and mileage; and
- **Section 6** includes reference documents used in the development of this CAAA-SIR.

2. ALTERNATIVE 1 REMEDY: SOURCE CONTROL WITH GROUNDWATER POLISHING

The Alternative 1 remedy, source control with GWP, will include a consolidate-and-cap approach for source control, after which GWP will be implemented. GWP is a remedial alternative that relies on natural geochemical processes and can be an appropriate remedy, as recognized by the United States Environmental Protection Agency (USEPA) in a final policy directive [4] for groundwater remediation.

2.1 Supporting Groundwater Modeling and Time to Reach GWPS

The COCs exceeding the GWPS at compliance groundwater monitoring wells as of the 2024 Annual Report [5] are boron, cobalt and pH. Boron was selected for modeling the source control presented in the Final Closure Plan and was identified as a surrogate for the exceedances of cobalt and pH, as described in the Groundwater Modeling Report (GMR) [6]. For modeling purposes, it was assumed that boron would not significantly sorb or chemically react with aquifer solids (soil adsorption coefficient [Kd] was set to 0 milliliters per gram [mL/g]) which is a conservative estimate for predicting contaminant transport times in the model. Boron transport is likely to be affected by both chemical and physical attenuation mechanisms (i.e., adsorption and/or precipitation reactions as well as dilution and dispersion) [6]. Physical attenuation (dilution and dispersion) of contaminants in groundwater is simulated in the groundwater computer models. Chemical attenuation mechanisms and their effect on modeled times for exceedances to reach the GWPS are discussed in the Groundwater Polishing Evaluation Report [7] and discussed herein.

Groundwater modeling performed to support the closure plan for the EAP (**Appendix B.2**) was updated to include additional data (**Appendix B.1**). Modeling results estimated that GWPS will be met in approximately 11 years after the implementation of source control for all wells within the existing EAP monitoring well network.

2.2 Remedy Implementation

Implementation of GWP will be initiated after source control (*e.g.,* final closure of the EAP) is completed. Implementation will include performing corrective action groundwater monitoring, enacting an adaptive site management strategy, and, after GWPS have been met, performing corrective action closure and completion activities. Information associated with each of these activities is described below.

- Corrective Action Groundwater Monitoring
  - Regular corrective action groundwater monitoring will be conducted utilizing a corrective action groundwater monitoring well network designed in accordance with 35 I.A.C. § 845.680(c), which specifies that wells must be installed in the plume of contamination that lies beyond the waste boundary.
    - Samples will be collected for major ions for evaluating groundwater chemistry and COCs. Samples will be collected on a quarterly basis initially and potentially reduced to a semiannual basis once five years of monitoring have occurred, in accordance with 35 I.A.C. 845.650(b)(4).

    - Monitoring results will be submitted to IEPA for each monitoring event, in addition to an annual groundwater monitoring and corrective action report, in accordance with 35 I.A.C. 845.610(e).
    - Routine maintenance of the monitoring well network will occur during the monitoring period. This will include inspecting the wells, making repairs to the wells (as and if needed), and rehabilitating and/or replacing wells to improve performance (as and if needed).

- Adaptive Management during Monitoring
  - Groundwater monitoring results will be evaluated and documented in the monitoring reports submitted to IEPA, in accordance with 35 I.A.C. 845.610(e)
  - Remedy progress evaluation as part of adaptive site management may include additional investigation to inform updates to the CSM, groundwater, and geochemical models.
  - If remedy progress does not correspond with expectations, additional methods or techniques to achieve compliance with GWPS will be evaluated and, if feasible, implemented in accordance with 35 I.A.C. 845.680(b).
- Corrective Action Confirmation Monitoring and Completion
  - After GWPS have been met for all corrective action monitoring wells, corrective action confirmation groundwater monitoring will be implemented. This will include monitoring each well for three additional years to confirm that GWPS have been achieved, in accordance with 35 I.A.C. 845.680(c).
    - It should be noted that post-closure care groundwater monitoring required for a 30-year period by 35 I.A.C. 845.780(c) will continue to occur after corrective action groundwater monitoring is expected to be completed.
  - After completion of the corrective action confirmation monitoring period, a Corrective Action Completion Report and Certification will be prepared and submitted to IEPA, in accordance with 35 I.A.C. 845.680(e).

2.2.1 Remedy Implementation Schedule

A feasibility-level implementation schedule for the Alternative 1 source control with GWP remedy is provided in **Table A** below.

Table A. Feasibility-Level Implementation Schedule – Alternative 1: Source Control with Groundwater Polishing

Implementation Phase	Implementation Task	Timeframe* (Preliminary Estimates)
Corrective Action Implementation	Corrective Action Monitoring (Time to Meet GWPS)	132 months
	Corrective Action Confirmation Monitoring	36 months
	Corrective Action Completion	6 months
	Timeframe to Complete Corrective Action Implementation	174 months
	Total Timeline to Complete Corrective Action (after completion of source control)	174 months (15 years)

*All timeframes are assumed to start after source control (*e.g.,* final closure of the SI) is complete and a corrective action permit has been issued by IEPA, whichever is later.

2.2.2 Management of Extracted Groundwater

No groundwater extraction will occur under this remedy.

2.2.3 35 I.A.C. § 845.670(e)(1)(H) and 35 I.A.C. § 845.670(e)(3) Information

As requested by Gradient, the following information required by 35 I.A.C. § 845.670(e)(1)(H) and 35 I.A.C. § 845.670(e)(3) has been developed for the remedy. The information was developed based on preliminary-level information contained within the CMA for the JPP EAP and then refined based on additional feasibility-level design activities performed as part of the development of this CAAA-SIR.

- Potential Need for Replacement of the Remedy – 35 I.A.C. § 845.670(e)(1)(H)
  - No replacement of the remedy will be required for source control with GWP, as a physical remedy will not be constructed.
- Degree of Difficulty Associated with Constructing the Remedy – 35 I.A.C. § 845.670(e)(3)(A)
  - No construction will be required with the source control with GWP remedy; therefore, there is no difficulty in construction of the remedy.
- Expected Operational Reliability of the Remedy - 35 I.A.C. § 845.670(e)(3)(B)
  - As documented in the Groundwater Polishing Evaluation Report [7], groundwater geochemical processes anticipated to occur as downgradient groundwater approaches ambient background conditions are not expected to alter the chemical mechanisms of GWPS and are not expected to delay the modeled time to achieve GWPS compliance.
  - GWP will begin once source control has been completed without delays and continuously function during the corrective action period.

- Need to Coordinate with and Obtain Necessary Approvals and permits from Other Agencies - 35 I.A.C. § 845.670(e)(3)(C)
  - No permits from other agencies will be required outside of permits issued by IEPA for source control (Closure Plan and Construction Permit Application, submitted to IEPA in 2022 [3]).
- Availability of Necessary Equipment and Specialists - 35 I.A.C. § 845.670(e)(3)(D)
  - Equipment and specialists for field data collection and groundwater sampling are required for the GWP alternative. Laboratory equipment and specialists will also be required to assess groundwater concentrations of site constituents. Groundwater professionals (*i.e.,* geologists, hydrogeologists, statisticians, geochemists) will be required to perform statistical analysis and other assessments to confirm that GWP is functioning as-intended and prepare corrective-action related groundwater monitoring and progress reports.
  - The equipment and specialists required for site groundwater monitoring and analysis are currently performing this work as part of the routine groundwater monitoring program in accordance with 35 I.A.C. § 845.220(c)(4). Therefore, no new equipment or specialists are required for groundwater monitoring for this alternative.
- Available Capacity and Location of Needed Treatment, Storage, and Disposal Services – 35 I.A.C. § 845.670(e)(3)(E)
  - No treatment, storage, or disposal services will be required with the source control with GWP remedy, as GWP will not generate any appreciable volume of waste or wastewater.

3. ALTERNATIVE 2 REMEDY: SOURCE CONTROL WITH GROUNDWATER EXTRACTION

The Alternative 2 remedy, source control with GWE, includes groundwater extraction as part of a hydraulic containment system. Construction of the system was initiated in late 2024 as a Preliminary Corrective Action (PCA), and the system is expected to become operational in 2025. The PCA consists of a total of eight extraction wells situated along the eastern boundary of the site, east of the EAP. The wells will be utilized to contain and control easterly migration of COCs towards the Village of Joppa. The eight extraction wells will pump groundwater to a system enclosure located approximately in the middle of the extraction well transect. The groundwater will be totalized, filtered (as necessary), and transferred from the system enclosure to the Settling Lagoon for discharge to the Ohio River via JPP Outfall 010 under a National Pollutant Discharge Elimination System (NPDES) permit [8], and in accordance with site-specific permit requirements. The Alternative 2 Remedy (source control with GWE) will include transitioning of the completed PCA GWE system into a post-source control final corrective action remedy; this transition is expected to include few, if any, physical changes to the GWE system.

A drawing showing the location of the GWE remedy is provided as **Figure 1** in **Appendix A.**

3.1 Remedy Scoping and Groundwater Modeling Results

The size and scope of the remedy (*e.g.,* number and location of wells, well depths, expected flow rates) were selected using iterative, three-dimensional groundwater flow and transport modeling. This approach was supplemented by reviewing physical constraints around the EAP and designating locations where wells and associated infrastructure could be constructed with limited impacts to other site features, while avoiding sensitive areas such as wetlands and regulatory floodplains. Additionally, the well alignment is located outside of the EAP, where it will provide minimal impacts to future source control (*e.g.,* closure activities) relative to locations closer to the EAP, which may have caused significant conflicts with closure construction.

The GWE remedy design includes a total of eight extraction wells installed along a 2,700-foot alignment which runs from north to south along the existing site access road immediately east (hydrogeologically downgradient) of the EAP. The groundwater extraction wells were installed in 2024 and are spaced approximately 380 feet apart and were advanced into the uppermost aquifer (UA), which typically ranges between 40 and 90 feet below ground surface (bgs) and is the most transmissive saturated zone capable of transporting CCR-related constituents such as boron. Groundwater fate and transport modeling indicated an extraction flow rate of approximately 40 gallons per minute (gpm) per well is required to capture and prevent further migration of UA groundwater containing CCR-derived constituents eastward toward the village of Joppa. The GWE extraction pumps were sized to recover groundwater at flowrates ranging from 5 to 65 gpm in the event hydraulic conditions are variable and more recovery is required to maintain capture.

Groundwater modeling for the Alternative 2 remedy (**Appendix B.1**) estimated that GWPS will be met approximately 10 years after the implementation of source control for all wells within the existing EAP monitoring well network. This modeling included sensitivity analyses to evaluate different extraction scenarios, in order to support the selection of an appropriate scenario for the site and evaluate potential timeframes over which the system may need to operate prior to shutdown.

3.2 Remedy Implementation

Physical construction and initial implementation of the Alternative 2 remedy, for EAP pre-closure use as a PCA, was initiated in 2024 via the installation of extraction wells. Remedy construction will continue in 2025 via the installation of mechanical, electrical, and piping infrastructure, and the remedy will become active in 2025. The PCA is expected to operate nearly continuously until the EAP source control is completed. After source control is completed, the PCA will remain in-place and transition in purpose from a PCA into a post-source control GWE final corrective action remedy.

Implementation of the GWE system will consist of performing O&M of the GWE system and corrective action groundwater monitoring. Groundwater extraction will be concluded in accordance with the corrective action (CA) GMP. The system operation will cease when concentrations in monitoring wells upgradient of the GWE do not exceed the GWPS and other considerations have been evaluated as described in the CA GMP.

- Corrective Action O&M
  - Continued operation of the GWE system will require routine, scheduled inspections and associated maintenance including, but not limited to, totalizer data collection, filter system maintenance (if needed), and maintenance of extraction and transfer pumps as well as other system components.
  - Non-routine maintenance that may occur during extended operation of the GWE system may include tasks such as repair or replacement of the extraction and/or transfer pumps, repair or replacement of instrumentation, including level transducers and pump speed controllers, and flushing or jetting of water conveyance lines in the event organic or inorganic solids accumulate on the conveyance pipe interior walls.
  - Routine monitoring and compliance activities associated with the management of extracted water via the site’s NPDES permit and Outfall 010 will also be completed during this phase.
  - Corrective action O&M will be considered complete once boron concentrations are below 2 milligrams per liter (mg/L) at all monitoring wells located upgradient of the GWE system and other considerations have been evaluated as described in the CA GMP. The GWE system will be shut down at this time.
- Corrective Action Monitoring
  - Regular corrective action groundwater monitoring will be conducted utilizing a corrective action groundwater monitoring well network designed in accordance with 35 I.A.C. § 845.680(c), which specifies that wells must be installed within the plume of contamination that lies beyond the waste boundary.
    - Samples will be collected for major ions for evaluating groundwater chemistry and COCs. Samples will be collected on a quarterly basis initially and potentially reduced to a semiannual basis once five years of monitoring have occurred, in accordance with 35 I.A.C. 845.650(b)(4).
    - Monitoring results will be submitted to IEPA for each monitoring event, in addition to an annual groundwater monitoring and corrective action report, in accordance with 35 I.A.C. 845.640(e). The annual corrective action report will include an evaluation of the actual performance of the remedy relative to the remedy’s expected performance.

    - Routine maintenance of the monitoring well network will occur during the monitoring period. This will include inspecting the wells, making repairs to the wells (as and if needed), and rehabilitating and/or replacing wells to improve performance (as and if needed).
  - If the remedy does not achieve its expected performance, additional methods or techniques to achieve compliance with GWPS will be evaluated and, if feasible, implemented in accordance with 35 I.A.C. 845.680(b).
- Adaptive Management during Monitoring
  - Groundwater monitoring results will be evaluated and documented in in the monitoring reports submitted to IEPA, in accordance with 35 I.A.C. 845.610(e)
  - Remedy progress evaluation as part of adaptive site management may include additional investigation to inform updates to the CSM, groundwater, and geochemical models.
  - If remedy progress does not correspond with expectations, additional methods or techniques to achieve compliance with GWPS will be evaluated and, if feasible, implemented in accordance with 35 I.A.C. 845.680(b).
- Corrective Action Confirmation Monitoring and Completion
  - After the GWPS have been met for all corrective action monitoring wells and the GWE system has been shut down, corrective action confirmation groundwater monitoring will be implemented. This will include monitoring each well for an additional three years to confirm that GWPS have been achieved, in accordance with 35 I.A.C. 845.680(c).
    - It should be noted that post-closure care groundwater monitoring required for a 30-year period by 35 I.A.C. 845.780(c) will continue to occur after corrective action groundwater monitoring is expected to be completed.
  - After completion of the corrective action confirmation monitoring period, a Corrective Action Completion Report and Certification will be prepared and submitted to IEPA, in accordance with 35 I.A.C. § 845.680(e).

3.2.1 Remedy Implementation Schedule

A feasibility-level implementation schedule for the Alternative 2 source control with GWE is provided in **Table B** below.

Table B. Feasibility-Level Implementation Schedule – Alternative 2: Source Control with Groundwater Extraction

Implementation Phase	**Implementation Task**	**Timeframe* (Preliminary Estimates)**
Corrective Action O&M and Closeout	Corrective Action O&M (Time to Meet GWPS)	120 months
	Corrective Action Confirmation Monitoring	36 months
	Corrective Action Completion	6 months
	Timeframe to Complete Corrective Action O&M and Closeout	162 months
	Total Timeline to Complete Corrective Action (after completion of source control)	162 months (14 years)

*All timeframes are assumed to start after source control (*e.g.*, final closure of the surface impoundment) is complete and a corrective action plan permit has been issued by IEPA, whichever is longer.

3.2.2 Management of Extracted Groundwater

Extracted groundwater will be managed and treated by the GWE system and existing site treatment facilities. Groundwater collected from the extraction well network will be sent to a centralized holding tank. A vertical multistage pump will transfer the collected groundwater from the holding tank through a water treatment and filtration process to the Settling Lagoon located along the Ohio River. The Settling Lagoon will provide storage capacity and is designed for further clarification (*i.e.*, treatment) of extracted groundwater prior to discharge through Outfall 010, in accordance with the site's active NPDES permit.

The GWE system will include provisions for managing and reducing total suspended solids (TSS) as part of NPDES permit compliance via bag filtration prior to the transfer pump moving the groundwater to the Settling Lagoon, if required on an as-needed basis. High total dissolved solids (TDS) and scaling were evaluated as part of GWE design activities using the Langelier Saturation Index (LSI). LSI results suggested that there is low potential for scaling and corrosion within the system.

The Settling Lagoon will receive the extracted groundwater along the western side of the lagoon. Lagoon water will flow through a circular channel and pass through a series of five turbidity curtains to filter out remaining solids that may precipitate in the Settling Lagoon. Lagoon water will discharge out of the southeastern portion of the Settling Lagoon via NPDES Outfall 010. All groundwater will be discharged in accordance with site-specific NPDES permit requirements.

3.2.3 35 I.A.C. § 845.670(e)(1)(H) and 35 I.A.C. § 845.670(e)(3) Information

As requested by Gradient, the following information required by 35 I.A.C. § 845.670(e)(1)(H) and 35 I.A.C. § 845.670(e)(3) has been developed for the remedy. The information was developed based on preliminary-level information contained within the CMA for the JPP EAP and then refined based on additional feasibility-level design activities performed as part of the development of this CAAA-SIR.

- Potential Need for Replacement of the Remedy – 35 I.A.C. § 845.670(e)(1)(H)
  - No replacement of the remedy is expected to be required, although the remedy requires ongoing monitoring and maintenance to retain its effectiveness.
- Degree of Difficulty Associated with Constructing the Remedy – 35 I.A.C. § 845.670(e)(3)(A)
  - No construction of the remedy will be required as part of groundwater corrective action, as the construction phase remedy is expected to be completed in advance of the completion of source control. Therefore, there will be no difficulty associated with construction.
- Expected Operational Reliability of the Remedy - 35 I.A.C. § 845.670(e)(3)(B)
  - The GWE system will be initiated prior to source control implementation as a PCA to reduce the migration of CCR-impacted groundwater beyond the eastern property boundary and towards the Village of Joppa. Groundwater modeling has indicated that the GWE system is expected to effectively and reliably prevent migration of CCR impacted groundwater off-site.
  - The GWE system is a mechanical system that will require routine maintenance in order to reliably operate, as outlined in **Section 3.2**.
- Need to Coordinate with and Obtain Necessary Approvals and permits from Other Agencies - 35 I.A.C. § 845.670(e)(3)(C)
  - All necessary approvals and permits from other agencies, including a site-specific NPDES permit, are already in place as part of the PCA and are expected to remain in place during operation of the GWE as the post-closure final remedial measure.
  - Continued NPDES permit renewals may be required, depending on the timeline of corrective action implementation relative to completion of source control activities.
- Availability of Necessary Equipment and Specialists - 35 I.A.C. § 845.670(e)(3)(D)
  - Specialists will be needed to maintain the GWE system during the operational timeframe. System components that require maintenance include totalizers, bag filter housings, instrumentation, and the extraction and transfer pumps.
    - Additionally, specialists are occasionally needed for non-routine O&M which may include flushing or jetting of the conveyance lines, replacement of faulty system components, replacement of pumps or pump controllers, and replacement of faulty system instrumentation.
    - Specialists and replacement equipment are generally available within proximity (*i.e.,* 100 to 300 miles) of the site but some of the more specialized equipment, including the transfer pumps and transfer pump controller, may have extended lead times for replacement or servicing.
  - Equipment and specialists for field data collection, groundwater sampling, analysis, and periodic corrective action groundwater monitoring and reporting will be required for the source control with GWE alternative. Laboratory equipment and specialists will also be required to assess groundwater concentrations of site COCs. Groundwater professionals (*i.e.*, geologists, hydrogeologists, statisticians, geochemists) will be required to perform statistical analysis and other assessments to confirm that the remedy is functioning as intended and prepare corrective-action related groundwater monitoring and progress reports.

    - The equipment and specialists required for site groundwater monitoring and analysis are currently performing this work as part of the routine groundwater monitoring program in accordance with 35 I.A.C. § 845.220(c)(4). Therefore, no new equipment or specialists are required for groundwater monitoring for this alternative.

- Available Capacity and Location of Needed Treatment, Storage, and Disposal Services – 35 I.A.C. § 845.670(e)(3)(E)
    - The GWE system was designed to treat and/or filter suspended or dissolved solids extracted during groundwater recovery. Extracted solids quantities are relatively minor and are disposed of off-site once the solids are condensed and dried.
    - The Secondary Settling Lagoon, which is already located on-site, has sufficient capacity to receive flow from the GWE system prior to discharge at NPDES Outfall 010, based on hydraulic and hydrologic calculations that were performed to support the design of the PCA.
    - Therefore, no new treatment, storage, or disposal services are required outside of the existing services already utilized by the site to support the PCA.

4. ALTERNATIVE 3 REMEDY: SOURCE CONTROL WITH DEEP CUTOFF WALL

The Alternative 3 remedy, source control with deep cutoff wall, will include the construction of a deep barrier wall that will extend from a grade surface elevation of approximately 350 feet[1] down to an approximate elevation 250 feet, and be terminated within the UA. The total length of the cutoff wall will be approximately 4,000 feet and the cutoff wall will have a depth of approximately 100 feet bgs. The deep cutoff wall will be constructed using either a mixture of soil and bentonite or cement and bentonite and will have an expected thickness of 2 to 3 feet. The deep cutoff wall will have a hydraulic conductivity value of approximately 1×10^{-7} centimeters per second (cm/s). The purpose of the deep cutoff wall will be to provide a long-term, maintenance-free physical barrier to significantly reduce or prevent horizontal migration of impacted groundwater towards the Village of Joppa while reducing O&M efforts relative to an active system.

A feasibility-level drawing of the source control with deep cutoff wall remedy is provided as **Figure 2** in **Appendix A.**

4.1 Remedy Scoping and Groundwater Modeling Results

The location of the deep cutoff wall was selected by reviewing physical constraints around the EAP and designating locations on the EEI property where the wall could feasibly be constructed with limited impacts to other site features. The location was also selected to avoid sensitive areas such as wetlands and floodplains, while limiting adverse impacts or conflicts with the EAP final closure construction. This resulted in the wall being located along an existing site access road immediately east of the EAP, which is not within regulatory floodplains or known wetlands, provides generally straight and level alignment for the wall, and will reduce conflicts with the EAP final closure. The location also allows the wall to act as a physical barrier between the EAP and the Village of Joppa and is generally perpendicular to existing groundwater flow patterns.

The depth of the deep cutoff wall was selected using iterative, three-dimensional groundwater flow and transport modeling. This included adjusting the total depth of the wall and reviewing associated times to reach GWPS and selecting a wall depth that reduced cleanup times while also improving constructability. This resulted in a partial-depth cutoff wall being selected, as it was found to reach GWPS quicker than a wall that fully-penetrated the UA and tied into the lower confining unit (LCU). Additionally, relative to a fully-penetrating wall, the partially penetrating wall will be faster to construct and have a lower risk of construction-related delays and other implementation challenges (*i.e.,* slurry loss, sidewall instability, issues with panel alignment and overlap). The thickness and hydraulic conductivity of the wall were selected based on Ramboll's design and construction experience with cutoff walls and is supported based on preliminary discussions with cutoff wall contractors.

Groundwater modeling for the Alternative 3 remedy (**Appendix B.1**) estimated that GWPS will be met approximately 11 years after the implementation of source control for all wells within the existing EAP monitoring well network.

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[1] All elevations referenced in this report are in the North American Vertical Datum of 1988 (NAVD88), unless otherwise noted.

4.2 Remedy Implementation

Implementation of the Alternative 3 source control with deep cutoff wall remedy is expected to include multiple tasks spread out over three phases, including pre-construction activities (Phase 1), corrective action construction (Phase 2), and corrective action operations, maintenance, and closeout (Phase 3). Information for each phase is described in this section.

4.2.1 Phase 1: Pre-Construction Activities

Pre-construction activities will include further pre-design investigation, obtaining permits from other agencies, completing the final design of the remedy, and selecting a remedy implementation contractor via a bidding process. Information associated with each of these activities is described below.

- Completing pre-design investigation, final design and bid activities, including:
  - Completion of final pre-design subsurface investigations, laboratory soil testing, engineering calculations, bench scale testing of proposed wall construction materials, design drawings, specifications, and a construction quality assurance plan.
  - Bidding and selection of a deep cutoff wall construction contractor.
- Obtaining permits from other agencies including:
  - A general storm water permit for construction site activities through IEPA, including construction stormwater controls and other best management practices (BMPs) such as silt fences and other measures.
  - An amendment to the submitted EAP Closure Plan and Construction Permit Application to allow for the disposal of deep cutoff wall spoils beneath the EAP final cover system.

4.2.2 Phase 2: Corrective Action Construction

Corrective action construction will be initiated after pre-construction activities are complete. It will include mobilizing construction equipment to the site, preparing the site for construction activities, construction of the deep cutoff wall (which will include removal or partial replacement of existing subgrade soils with low-permeability wall materials), and performing post-construction and site restoration activities. Cutoff wall construction is assumed to occur concurrently with EAP closure construction; this is to allow all spoils generated during cutoff wall construction to be disposed of beneath the final cover system in the EAP closure, rather than disposing of them in another on-site location or in an off-site landfill.

Information associated with each of these activities is described below.

- The contractor will mobilize equipment and materials to the site, install stormwater BMPs around the construction area, construct a staging and laydown area, and construct a level working platform and/or temporary construction access roads along the deep cutoff wall alignment.
- Construction of the working platform will include removing, relocating, or modifying existing site infrastructure (*i.e.,* fencing or overhead electric utilities) that may conflict with the construction of the cutoff wall. This will include removing and decommissioning the current PCA system, which is located in the same general area as the deep cutoff wall will be installed in.

  - Decommissioning is expected to include removing electrical supply systems, pumps, grouting or backfilling the wells in accordance with applicable regulations, grouting subsurface piping, and removing other surface structures and piping. Some components may be salvaged and/or reproposed, while non-usable demolition debris may be disposed of in an off-site, regulated landfill.
- Other existing high-voltage electric lines along the cutoff wall alignment will be relocated as part of EAP final closure activities.
- A temporary on-site batch plant and/or material handling system will be established for the purpose of generating low permeability backfill for the cutoff wall. This will include either mixing bentonite with the subgrade soils or producing a cement-bentonite slurry to place into the wall.
- The wall will likely be constructed utilizing either crane-mounted conventional construction equipment (*i.e.,* clamshell and/or slurry cutter); however, one-pass trenching/mixing or other innovative methods could be utilized if later determined to be appropriate based on site-specific subsurface conditions and constructability considerations.
- Installation of the deep cutoff wall will occur concurrently with the removal of some of the subsurface soils (soil-bentonite walls) or all the subsurface soils (cement-bentonite wall).
- The wall will either be installed in a continuous unit, or if needed to support stability of the subgrade soils and sides of the wall during construction, in discontinuous panels (*i.e.,* primary panels) with secondary panels installed for connection after the primary panels have sufficiently cured/hardened.
- Excavated soils (*e.g.,* spoils) will be placed into off-road dump trucks and hauled to the EAP for use as contouring (*i.e.,* subgrade) fill beneath the final cover system. The material will be moisture-conditioned by spreading it in thin lifts and compacting in accordance with the subgrade fill specifications for the EAP final closure.
- Site restoration will be completed following the installation of the deep cutoff wall. This will include repairing site infrastructure that was relocated or damaged during construction and minor regrading and seeding of disturbed areas.
- Temporary BMPs will also be installed during the site restoration period, if required in accordance with site land disturbance permits. The BMPs will be removed once vegetation is established.

4.2.3 Phase 3: Corrective Action Operations, Maintenance, and Closeout

Corrective action operations, maintenance, and closure will be initiated after corrective action construction is completed. It will include performing corrective action groundwater monitoring, and, after GWPS have been met, performing corrective action closeout and completion activities. Information associated with each of these activities is described below.

- Corrective Action O&M
  - No corrective action O&M is required following installation of the deep cutoff wall, as the deep cutoff wall will be a passive, below-grade structure, without maintenance or operational needs.
- Corrective Action Monitoring

  - Regular corrective action groundwater monitoring will be conducted using a corrective action groundwater monitoring well network designed in accordance with 35 I.A.C. § 845.680(c), which specified that wells must be installed within the plume of contamination that lies beyond the waste boundary.
    - Samples will be collected for major ions for evaluating groundwater chemistry and COCs. Samples will be collected on a quarterly basis initially and potentially reduced to a semiannual basis once five years of monitoring have occurred, in accordance with 35 I.A.C. 845.650(b)(4).
    - Monitoring results will be submitted to IEPA after each monitoring event, in addition to an annual groundwater monitoring and corrective action report, in accordance with 35 I.A.C. 845.640(e). The annual corrective action report will include an evaluation of the actual performance of the remedy relative to the remedy's expected performance.
    - Routine maintenance of the monitoring well network will be conducted during the monitoring period. This will include inspecting the wells, making repairs to the wells (as and if needed), and rehabilitation and/or replacing the wells to improve performance (as and if needed).
  - If the remedy does not achieve its expected performance, additional methods or techniques to achieve compliance with GWPS will be evaluated and, if feasible, implemented in accordance with 35 I.A.C. 845.680(b).
- Adaptive Management during Monitoring
  - Groundwater monitoring results will be evaluated and documented in in the monitoring reports submitted to IEPA, in accordance with 35 I.A.C. 845.610(e)
  - Remedy progress evaluation as part of adaptive site management may include additional investigation to inform updates to the CSM, groundwater, and geochemical models.
  - If remedy progress does not correspond with expectations, additional methods or techniques to achieve compliance with GWPS will be evaluated and, if feasible, implemented in accordance with 35 I.A.C. 845.680(b).
- Corrective Action Completion
  - After GWPS have been met for all compliance wells for a period of three years, corrective action will be considered complete, per 35 I.A.C. § 845.680(c).
    - It should be noted that post-closure care groundwater monitoring required for a 30-year period by 35 I.A.C. 845.780(c) will continue to occur after corrective action groundwater monitoring is expected to be completed.
  - After completion of the corrective action confirmation monitoring period, a Corrective Action Completion Report and Certification will then be submitted to IEPA, in accordance with 35 I.A.C. § 845.680(e).

4.2.4 Remedy Implementation Schedule

A feasibility-level implementation schedule for the Alternative 3 source control with deep cutoff wall remedy is provided in **Table C** below.

Table C. Feasibility-Level Implementation Schedule – Alternative 3: Source Control with Deep Cutoff Wall

Implementation Phase	Implementation Task	Timeframe (Preliminary Estimates)
1: Pre-Construction Activities	Agency Coordination, Approvals, and Permitting	6 to 12 months
	Final Design and Bid Process	24 to 36 months
	Timeframe to Complete Corrective Pre-Construction Activities	30 to 48 months after Corrective Action Plan Approval
2: Corrective Action Construction	Corrective Action Construction	12 to 18 months
	Timeframe to Complete Corrective Action Construction	12 to 18 months after completion of pre-construction activities.
3: Corrective Action O&M and Closeout	Corrective Action Monitoring (Time to Meet GWPS)	144 months*
	Corrective Action Confirmation Monitoring	36 months*
	Corrective Action Completion	6 months*
	Timeframe to Complete Corrective Action O&M and Closeout	186 months* after completion of O&M and closeout activities.
	Total Timeline to Complete Corrective Action	228 to 252 months (19 to 21 years)
	Timeline to Complete Corrective Action (after completion of source control)	204 months* (17 years*)

*Denotes a timeframe that is assumed to start after source control (*e.g.,* final closure of the impoundment) is complete and a corrective action construction permit application has been issued by IEPA, whichever is longer.

It should be noted that Phases 1 and 2 were assumed to occur concurrently with closure construction, to allow spoils to be disposed of beneath the EAP final cover system. Therefore, the start of Phase 3 (Corrective Action O&M and closeout) was assumed to begin at the completion of source control (final closure of the EAP). In the event that Phases 1 and 2 could not be completed concurrently with source control, due to a delay in receiving permits or construction-related conflicts, the total schedule would likely increase.

4.2.5 Management of Extracted Groundwater

No groundwater extraction will occur under this remedy.

4.2.6 35 I.A.C. § 845.670(e)(1)(H) and 35 I.A.C. § 845.670(e)(3) Information

As requested by Gradient, the following information required by 35 I.A.C. § 845.670(e)(1)(H) and 35 I.A.C. § 845.670(e)(3) has been developed for the remedy. The information was developed based on preliminary-level information contained within the CMA for the JPP EAP and then refined based on additional feasibility-level design activities performed as part of the development of this CAAA-SIR.

- Potential Need for Replacement of the Remedy – 35 I.A.C. § 845.670(e)(1)(H)
  - The deep cutoff wall remedy will be unlikely to require replacement of the remedy, as the deep cutoff wall will be a robust, engineered, and maintenance-free subsurface structure.
- Degree of Difficulty Associated with Constructing the Remedy – 35 I.A.C. § 845.670(e)(3)(A)
  - The remedy will require mobilizing specialty equipment to the site (*i.e.,* large cranes, clamshells or slurry cutters, or potential one-pass trenching equipment) in addition to other supporting equipment (*i.e.,* batch plants, excavation and grading equipment).
  - While deep cutoff walls are routinely constructed to similar depths in similar geologic environments, they often encounter difficulties during construction. The difficulties could include: encountering especially pervious layers (resulting slurry loss); encountering obstructions that require specialized techniques and/or equipment to advance past; and, instability or caving in the sidewalls prior to hardening of the slurry backfill.
  - The performance of the cutoff wall will be dependent on the construction techniques of the wall, to avoid gaps, voids, or other discontinuous features or defects in the wall. Continuous quality control monitoring will be required during construction as part of construction quality control and quality assurance activities to avoid these features. The wall may also require post-construction quality assurance activities (*i.e.,* coring and testing) to verify the quality of the constructed barrier.
  - The performance of the wall will also be dependent on the actual hydraulic conductivity of the wall. This will require continual monitoring, quality control testing, and quality assurance testing of slurry mixing and placement in order to verify that the as-designed mix is utilized. Routine testing of material samples will be required.
- Expected Operational Reliability of the Remedy - 35 I.A.C. § 845.670(e)(3)(B)
  - The deep cutoff wall is expected to have high operational reliability if it is constructed in accordance with standard design and specifications for barrier walls. This is because the deep cutoff wall provides an inert, continuous, low-permeability barrier to groundwater flow.
- Need to Coordinate with and Obtain Necessary Approvals and permits from Other Agencies - 35 I.A.C. § 845.670(e)(3)(C)
  - Agency permits will need to be obtained from IEPA for construction stormwater controls and BMPs.
- Availability of Necessary Equipment and Specialists - 35 I.A.C. § 845.670(e)(3)(D)
  - Construction of the deep cutoff wall will require a specialized contractor experienced with constructing similar types of walls in similar geologic environments (*i.e.,* the Mississippi and Ohio River Valleys). The contractor will likely need specialized equipment, such as large cranes, clamshell buckets, slurry cutters, batch plants, or one-pass construction equipment.
  - Specialists in cutoff wall design and construction will also need to be utilized during the design and construction phase of the cutoff wall. The specialists will include design engineers, construction managers, and contractor staff experienced with cutoff wall construction and equipment operation.

  - These types of equipment and specialists have been utilized in the past for other similar types of deep cutoff wall design and construction projects. However, there may be shortages associated with the equipment and specialists, due to high existing backlog for specialty ground improvement contractors and design specialists who are supporting similar types of projects in the electric utility, dam/levee, and other market sectors.
  - Equipment and specialists for field data collection and groundwater sampling are required for the remedy. Laboratory equipment and specialists will also be required to assess groundwater concentrations of site COCs. Groundwater professionals (*i.e.,* geologists, hydrogeologists, statisticians, geochemists) will be required to perform statistical analysis and other assessments to confirm that the remedy is functioning as intended and prepare corrective action-related groundwater monitoring and progress reports.
    - The equipment and specialists required for site groundwater monitoring and analysis are currently performing this work in accordance with 35 I.A.C. § 845.220(c)(4). Therefore, no new equipment or specialists are required for groundwater monitoring for this alternative.
- Available Capacity and Location of Needed Treatment, Storage, and Disposal Services – 35 I.A.C. § 845.670(e)(3)(E)
  - Wastes generated during deep cutoff wall construction will be limited to spoils; these will be disposed of on-site in the EAP, during closure construction, as compacted contouring fill beneath the final cover system. Completing deep cutoff wall construction at the same time as the EAP closure will provide sufficient on-site capacity for the disposal of generated spoils.
  - No wastes will be generated during operations of the deep cutoff walls; therefore, no additional treatment, storage or disposal services will be required with the source control with deep cutoff wall remedy.

5. MATERIAL QUANTITY, LABOR, AND MILEAGE ESTIMATES

Estimates of material quantities, total labor hours, and mileage were prepared for Alternative 2 source control with GWE and Alternative 3 source control with deep cutoff wall, to support Gradient in preparing a CAAA. Estimates were prepared for the construction and O&M of each remedy. Estimates were not prepared for Alternative 1 source control with GWP as the alternative does not require remedial construction or operations and maintenance of a physical remedy. Additionally, estimates for Alternative 2 do not include construction as the system will have already been installed as a PCA prior to conversion to a long-term remedy; therefore, only O&M labor hours and mileage were estimated for Alternative 2.

Both estimates were prepared utilizing the following approach:

- Major implementation (*e.g.,* construction) components and line items were identified, in accordance with the remedy implementation narratives contained within this CAAA-SIR.
- Construction quantities were estimated based on quantity estimates for volumes, areas, and units, as obtained from the feasibility-level engineering drawings and schedules included within this CAAA-SIR.
- RS Means Heavy Construction Cost Data (RS Means) [9] was utilized to estimate the crew size, equipment description, and daily output associated with each line item.
- For line items where RS Means data was not available, the crew size, equipment description, and daily output were estimated based on Ramboll's experience, information from contractors, and/or information from material suppliers.
- For the Alternative 2 source control with GWE and Alternative 3 source control with deep cutoff wall active remedies, daily construction and O&M labor mobilization miles were estimated assuming a weekly mobilization/demobilization from Chicago (720 miles round trip) and a local commute of 40 miles round trip per day. The number of working days and hours per week were estimated from the construction schedule developed for each remedy.
- Estimates of material delivery miles were prepared based on Ramboll's experience.

The detailed material quantity, labor, and mileage estimates are provided in **Appendix C** for each alternative.

6. REFERENCES

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

[2] Code of Federal Regulations, "Title 40, Chapter I, Subchapter I, Part 257, Subpart D, Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," April 17, 2015.

[3] Geosyntec Consultants, "Construction Permit Application, Joppa Power Plant, East Ash Pond, (IEPA ED W1270100004-02), Joppa, Illinois," Geosyntec Consultants, Joppa, Illinois, July 28, 2022.

[4] United States Environmental Protection Agency, ""Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites," OSWER Directive Number 9200.4-17P, April 21, 1999.," April 21, 1999.

[5] Ramboll, "2024 35 I.A.C. S 845 Annual Groundwater Monitoring and Corrective Action Report, East Ash Pond, Joppa Power Plant, IEPA ID No. W1270100004-02," Ramboll, Joppa Illinois, January 2025.

[6] Ramboll, "Groundwater Modeling Report, Joppa Power Plant East Ash Pond," Joppa, IL, 2024.

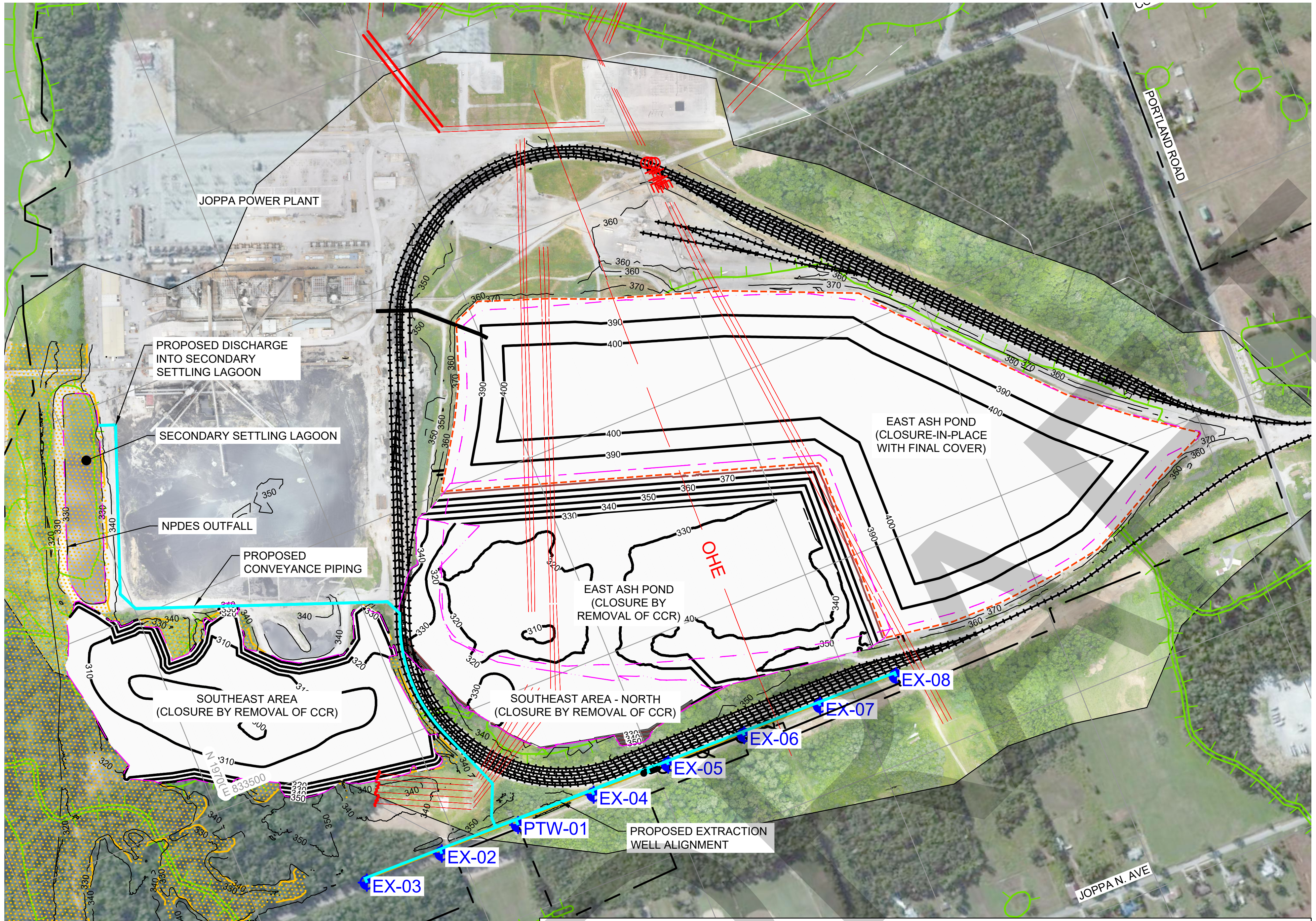
[7] Geosyntec Consultants, Inc (Geosyntec), "Groundwater Polishing Evaluation Report Joppa Power Plant - East Ash Pond Unit (EPA ID No. 401)," 2024.

[8] Illinois Environmental Protection Agency, "NPDES Permit No. IL0004171, Bureau ID: W120100004, Final Permit," Division of Water Pollution Control, Springfield, IL, September 2022.

[9] Gordian, RS Means Data version 8.7, Paducah, KY: Gordian, 2023.

APPENDIX A
FEASIBILITY-LEVEL DESIGN DRAWINGS FOR ALTERNATIVE 2 AND ALTERNATIVE 3 REMEDIES

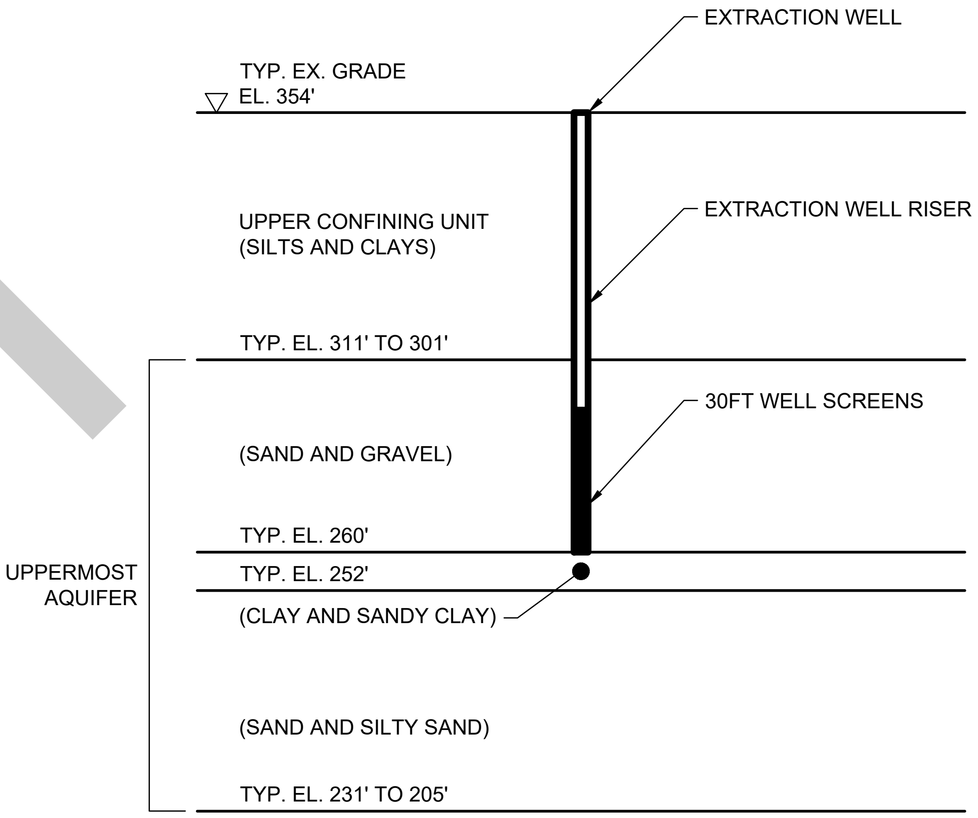
PROJECT: 1940102417 DATED: 2/1/2024 DESIGNER: LEMMONSN L:\DWG\CADDocs\ramboll gruppen as\rus-1940103584-006 vistra energy jop-eap\project files\4 delivery\40 WIP\401 civil\Drawings\03_CAAA-SIR\F-1_JOP-EAP_CAAA-SIR.dwg



NOTE:
1. EXISTING CONTOURS WERE TAKEN FROM VARIOUS SURVEYS COMPLETED BY INGENAE, LLC BETWEEN 2020 AND 2023.
2. SITE GRADING REPRESENTED PER EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS, COMPLETED BY GEOSYNTEC CONSULTANTS, JULY 2022.
3. WETLANDS REPRESENTED AS PER ILLINOIS NATIONAL WETLANDS INVENTORY.
4. 100-YEAR FLOODPLAIN REPRESENTED AS PER FEMA FIRM FOR THE SITE.

SITE PLAN

0 600 Feet



EXTRACTION WELL DETAIL

NOT TO SCALE

EXISTING

— — 360 — —	MAJOR CONTOUR
— · — · —	APPROXIMATE SITE BOUNDARY
⊥⊥⊥⊥	WETLANDS BOUNDARY (SEE NOTE 3)
▨	100-YR FLOODPLAIN (SEE NOTE 4)
—— OHE ——	OVERHEAD ELECTRICAL
++++++++	RAILROAD
— — — —	APPROXIMATE LIMITS OF CCR UNITS
- - - - - -	APPROXIMATE LIMITS OF FINAL COVER

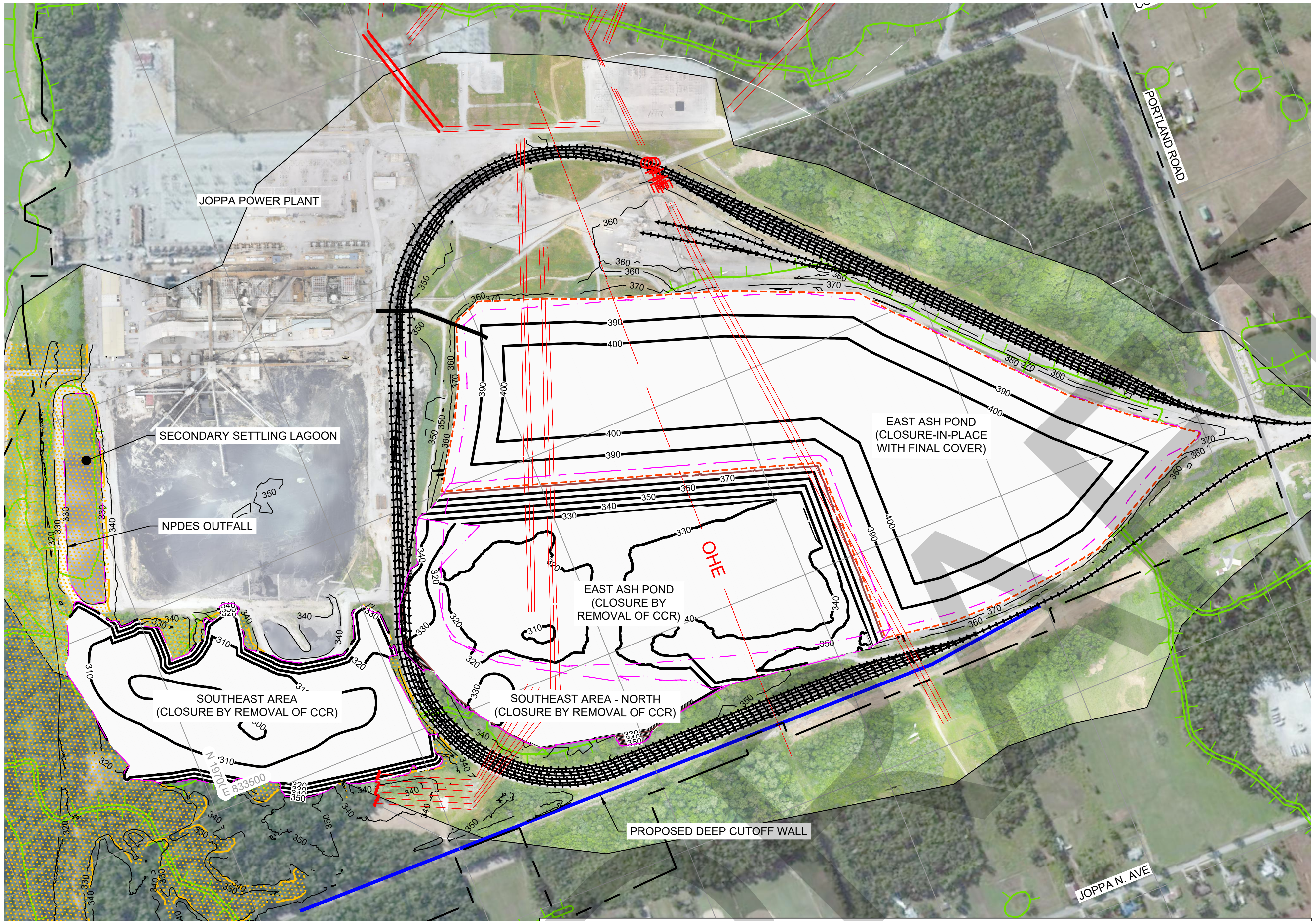
PROPOSED

—— 360 ——	MAJOR CONTOUR
——	GROUNDWATER EXTRACTION CONVEYANCE PIPING
⊕ EW-04	EXTRACTION WELL

ALTERNATIVE 2 REMEDY:
GROUNDWATER EXTRACTION
FEASABILITY-LEVEL DESIGN
Joppa East Ash Pond
Electric Energy, Inc.
Joppa Power Plant
2100 Portland Road
Joppa, Illinois 62953

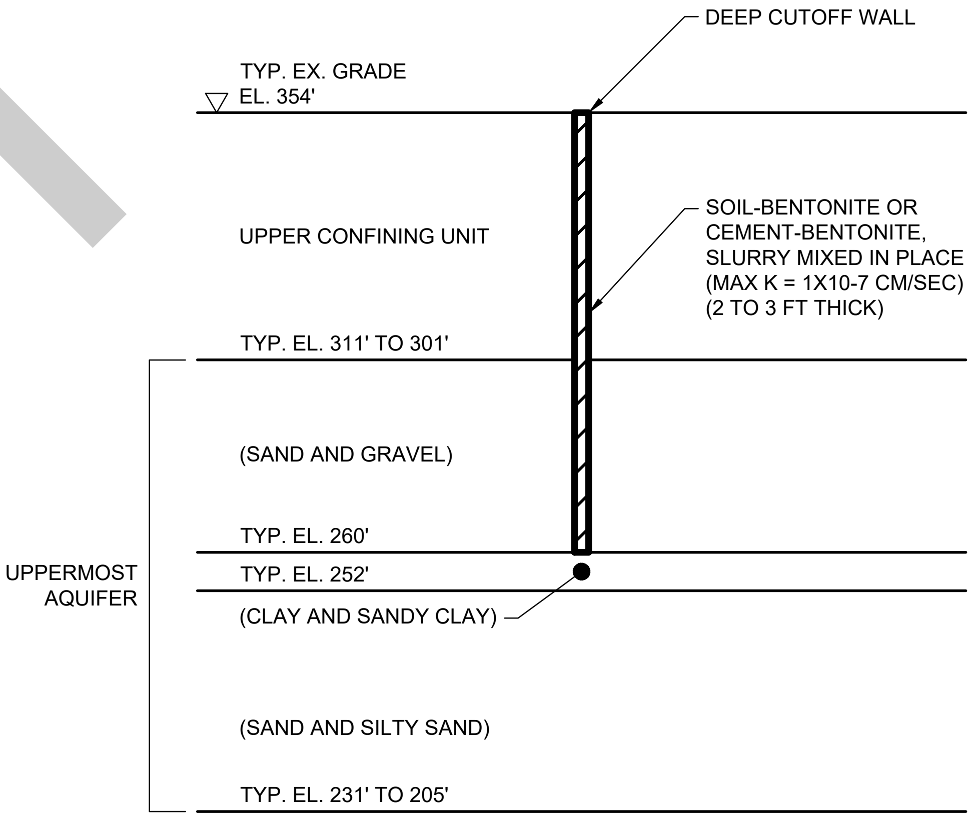
FIGURE 1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
A RAMBOLL COMPANY



NOTE:
1. EXISTING CONTOURS WERE TAKEN FROM VARIOUS SURVEYS COMPLETED BY INGENAE, LLC BETWEEN 2020 AND 2023.
2. SITE GRADING REPRESENTED PER EAST ASH POND CONSTRUCTION PERMIT APPLICATION CLOSURE DRAWINGS, COMPLETED BY GEOSYNTEC CONSULTANTS, JULY 2022.
3. WETLANDS REPRESENTED AS PER ILLINOIS NATIONAL WETLANDS INVENTORY.
4. 100-YEAR FLOODPLAIN REPRESENTED AS PER FEMA FIRM FOR THE SITE.

SITE PLAN



CUTOFF WALL DETAIL

NOT TO SCALE

EXISTING				PROPOSED	
— — 360 — —	MAJOR CONTOUR	—— OHE ——	OVERHEAD ELECTRICAL	—— 360 ——	MAJOR CONTOUR
— · — · —	APPROXIMATE SITE BOUNDARY	┼┼┼┼┼┼┼	RAILROAD	━━━━	CUTOFF WALL
┴┴┴┴┴	WETLANDS BOUNDARY (SEE NOTE 3)	— — — —	APPROXIMATE LIMITS OF CCR UNITS		
▨	100-YR FLOODPLAIN (SEE NOTE 4)	- - - - -	APPROXIMATE LIMITS OF FINAL COVER		

ALTERNATIVE 3 REMEDY:
DEEP CUTOFF WALL
FEASABILITY-LEVEL DESIGN
Joppa East Ash Pond
Electric Energy, Inc.
Joppa Power Plant
2100 Portland Road
Joppa, Illinois 62953

FIGURE 2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
A RAMBOLL COMPANY

RAMBOLL

c:\DCWACGDocs\ramboll gruppen as\rus-1940103584-006 vistra energy jop-eap\project files\4 delivery\40 WIP\401 civil\Drawings\03_CAAA-SIR\F-1_JOP-EAP_CAAA-SIR.dwg
DESIGNER: LEMMONBN
DATED: 12/5/2024
PROJECT: 1940102417

APPENDIX B.1
GROUNDWATER MODELING TECHNICAL MEMORANDUM

Intended for
Dynegy Midwest Generation, LLC

Date
February 17, 2025

Project No.
1940110241-004

GROUNDWATER MODELING TECHNICAL MEMORANDUM

EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS
IEPA ID NO. W1270100004-01

RAMBOLL Bright ideas. Sustainable change.

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT

Project Name	**Joppa Power Plant East Ash Pond**
Project No.	**1940110241-004**
Recipient	**Dynegy Midwest Generation, LLC**
Document Type	**Groundwater Corrective Action Alternatives Modeling Report**
Date	**February 17, 2025**
Prepared by	**Rajib Mozumder**
Checked by	**Katie Moran**
Approved by	**Brian G. Hennings**

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Managing Consultant

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Project Officer, Hydrogeology

CONTENTS

TABLES (IN TEXT)

TABLES (ATTACHED)

FIGURES (ATTACHED)

APPENDICES

ACRONYMS AND ABBREVIATIONS

35 I.A.C.	Title 35 of the Illinois Administrative Code
ASD	Alternative Source Demonstration
bgs	below ground surface
CAP	Corrective Action Plan
CIP	closure-in-place
CCR	coal combustion residuals
cm/s	centimeters per second
COC	constituent of concern
EAP	East Ash Pond, also referred to as Joppa East
ft/day	feet per day
ft^2/d	square feet per day
Geosyntec	Geosyntec Consultants, Inc.
GHB	general head boundaries
GMR	groundwater modeling report
gpm	gallons per minute
GWPS	groundwater protection standard
H_K	Hydraulic conductivity
ID	identification
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
JPP	Joppa Power Plant
LAU	lower aquifer unit, *i.e.,* bedrock aquifer
LCU	lower confining unit
mg/L	milligrams per liter
NAVD88	North American Vertical Datum of 1988
No.	number
R^2	correlation coefficient
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
SP	transport model stress periods
UA	uppermost aquifer
UCU	upper confining unit
WAP	West Ash Pond

EXECUTIVE SUMMARY

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Modeling Technical Memorandum on behalf of the Joppa Power Plant (JPP), operated by Electric Energy, Inc., in accordance with requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845 [1]. This document presents additional predictive groundwater modeling simulations based on the revised 2023 groundwater modeling results, in support of two potential active remedies identified in the Corrective Action Alternatives Analysis required by 35 I.A.C. § 845.670(e), for the East Ash Pond (EAP) in Joppa, Illinois, identified by Illinois Environmental Protection Agency (IEPA) identification (ID) number (No.) W1270100004-02.

The first groundwater modeling report (GMR) for the EAP was submitted in July 2022 as Attachment B.1 of the Closure Construction Permit [2]. The groundwater model was revised in 2023 to incorporate additional site data collected in the second half of 2022. In this revised report, the original flow model, historical transport model, and predictive scenarios were updated and calibrated. The model was revised to include a refined model discretization and input parameters, and an updated analysis of flow and boron transport within the uppermost aquifer (UA). Following model revisions, the two simulated potential corrective action remedial alternatives were: (i) Alternative 2 Remedy: Source Control with groundwater extraction and (ii) Alternative 3 Remedy: Source Control with Deep Cutoff Wall. In both remedial alternatives source control is the closure-in-place (CIP) scenario that had been selected as the closure alternative for the EAP in 2022 [3].

Hydrogeologic investigation completed in 2021 indicated that boron concentrations in groundwater exceeded the Groundwater Protection Standard (GWPS)[1] [4].Additional investigation and monitoring in 2022 and 2023 were completed to define the nature and extent of the impacts [5] and obtain information to design and install a preliminary corrective action (PCA) utilizing groundwater extraction in accordance with the compliance commitment agreement [6] [3] [7].The groundwater modeling efforts discussed in this report include flow and transport modeling using MODFLOW and MT3DMS to evaluate how each corrective action will achieve compliance with the applicable groundwater standards; and describe fate and transport of contaminants in support of the CAAA.

The first remedial alternative consists of operation of eight groundwater extraction wells screened across 30 feet of the UA, each pumping at a rate of 40 gallons per minute (gpm), that will operate until the GWPS has been achieved. Two groundwater extraction remedial scenarios were evaluated starting at completion of closure: a long-term continuous groundwater extraction scenario for 20 years and a short-term groundwater extraction scenario where the pumping was discontinued after 6 years. The effect of the groundwater extraction was evaluated at 12 EAP monitoring wells in the vicinity of the proposed groundwater extraction system with average observed boron concentrations exceeding the GWPS of 2 milligrams per liter (mg/L).

Boron transport modeling results for the long-term groundwater extraction scenario indicated groundwater concentrations would achieve the applicable GWPS of 2 mg/L at each of the 12 monitoring wells between approximately 1 and 12 years, following installation of the extraction wells, with a mean time of 5 ± 2 years. When compared to the base-case CIP scenario, simulation results for the long-term groundwater extraction remedy showed a reduction

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[1] The constituents of concern (COCs) exceeding the GWPSs at compliance groundwater monitoring wells include boron, cobalt, and pH.

in time to achieve the GWPS between approximately 1 to 6 years in 10 of the 12 monitoring wells while the time was either increased or remained unchanged in the remaining 2 wells.

For the short-term groundwater extraction scenario, the GWPS for boron was achieved for all 12 monitoring wells between approximately 1 and 10 years, with an approximate mean time of 4 ± 2 years. Although some wells showed a minor rebound of boron concentrations in groundwater following the shutoff of the extraction wells in the short-term groundwater extraction scenario, when compared to the base-case CIP scenario, simulation results showed a reduction in time to achieve the GWPS between approximately 1 to 6 years in all 12 monitoring wells.

The second remedial alternative consists of the construction of a low permeability deep barrier wall (or cutoff wall) to contain and divert the offsite southeasterly flow of groundwater within the UA. Two different configurations of the barrier wall were evaluated: a partial wall that would be constructed from the ground surface to an estimated depth of up to approximately 120 feet below ground surface (bgs) and a full depth wall extending up to approximately 170 feet bgs and tying into the lower confining unit (LCU). In both cases, the thickness of the wall was set to 3 feet and the hydraulic conductivity of the wall was set to 1 x 10^{-7} centimeters per second (cm/s) or 0.000283 feet per day (ft/day), assuming a cement-bentonite composition of the wall.

Boron transport modeling results for the partial barrier wall indicated that groundwater concentrations would achieve the GWPS of 2 mg/L at each of the 12 monitoring wells between approximately 2 and 11 years following closure, with a mean time of 7 ± 2 years. For the full-depth wall, the GWPS for boron was estimated to be achieved between 1 and 12 years, with a mean time of approximately 7 ± 2 years. For both the partial and full-depth barrier walls, time to achieve the boron GWPS was reduced compared to the base-case CIP scenario in four of the 12 groundwater monitoring wells while the time was either increased or remained unchanged in the remaining eight wells. The reduction of time to reach the boron GWPS in those four monitoring wells was slightly higher for the full wall scenario (approximately 0.1 to 4 years versus approximately 0.4 to 5 years for the partial wall).

In summary, the groundwater extraction remedial alternatives are more effective than the barrier wall alternatives in attaining the GWPS for boron. Both the short- and long-term groundwater extraction options are expected to be equally effective in reducing the time to achieve the boron GWPS in 10 of the 12 monitoring wells. However, the short-term groundwater extraction scenario is expected to meet the GWPS for boron between 1 and 6 years earlier at all 12 target monitoring wells compared to the base case CIP scenario.

1. INTRODUCTION

1.1 Overview

This document presents additional predictive groundwater modeling simulations for the JPP based on the revised 2023 groundwater modeling results, to support two potential active remedies identified in the Corrective Action Alternatives Analysis. The groundwater modeling activities documented in the 2022 GMR were performed to support closure of the EPA at the JPP, Joppa, Illinois. This document presents the MODFLOW and MT3DMS groundwater flow and transport models developed in 2023 to meet the Corrective Action Plan requirements. These models contain several refinements to reflect additional data collected since submittal of the 2022 GMR and enable improved simulation of future conditions.

Closure of the EAP will consist of excavation and relocation of ash material from the EAP and capping of the CCR material with a geomembrane and soil cover after consolidation of ash to the CIP area [2].A stormwater detention pond will also be constructed in the southeast corner of the EAP as part of this closure plan. The proposed CIP construction permit is pending a decision from IEPA. The CIP for the EAP was taken as the baseline for the two potential active remedies that are simulated in this report.

Site hydrogeology, and groundwater quality are summarized in **Section 1**, and described in detail in a separate Hydrogeologic Site Characterization Report [8] and Nature and Extent Report [5].The revised groundwater model development and calibration steps are documented in **Section 2** and simulation results are provided in **Appendix A**. The predictive model simulation results and their comparison relative to CIP are provided in **Section 3** and the report conclusions are summarized in **Section 4**.

1.2 Background

1.2.1 Site History

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

Three CCR units are associated with the JPP:

- Joppa East (*i.e.,* EAP): a 111-acre existing unlined CCR surface impoundment (SI) which is used to manage both fly ash and bottom ash. The EAP is not currently operating and not receiving any ash and there is no plan to resume operation in the future. A portion of the EAP footprint is an open water pond, the remainder of the area consists of ash to current ground surface.
- Joppa West (*i.e.,* West Ash Pond [WAP]): A 103.5-acre existing closed impoundment located in the western portion of the JPP property.
- Joppa Landfill: An existing permitted inactive landfill present in the northwestern portion of the JPP property.

1.2.2 Site Hydrogeology

In addition to the CCR within the EAP, four principal stratigraphic layers (from top to bottom) were encountered at the EAP and adjacent areas are:

- Upper Confining Unit (UCU): consists of fine-grained silts and clays, with an average thickness of this unit is 40 feet.
- UA: composed of the high-permeability sands and gravels of the McNairy Formation, with isolated lenses of finer-grained material. At the site, the UA is 50 to 100 feet thick. Field hydraulic conductivity tests were performed on the UA at the EAP as part of the 2021 field investigation [8]and an aquifer test was performed in late 2022 at pumping well PTW-01 [9].Horizontal hydraulic conductivities for the Upper McNairy Formation (*i.e.,* UA) ranged from 4.8×10^{-4} to 1.2×10^{-2} cm/s with a geometric mean of 3.1×10^{-3} cm/s. The 2022 aquifer test[2] yielded an estimated hydraulic conductivity for the UA between 89 and 181 ft/day.
- LCU: consists of the 12- to 14-foot-thick clay material encountered between the McNairy Formation and bedrock.
- Lower Aquifer Unit (LAU): composed of the Salem Limestone Bedrock. The LAU has an upward gradient when monitored near the southern portion of the site, and discharges into the Ohio River. A regional geologic study [10] reports a range of estimated hydraulic conductivities for the Salem Limestone of 10 to 75 feet per day (ft/day). Slug testing performed at well G09M (completed in shallow bedrock) yielded an estimated average hydraulic conductivity of 4.0×10^{-4} cm/s.

The Ohio River is the primary receiving body of water for the region. It is a large navigable waterway, approximately 3,500 feet across at the site, with stage managed by several dams.

1.2.3 Groundwater Quality

35 I.A.C. § 845 groundwater monitoring began in 2023. Exceedances to the GWPS were identified for boron, cobalt, and pH. These exceedances were discussed in the Corrective Measures Assessment [11]and Nature and Extent Report [5]. As detailed in the previous reports, an alternative source demonstration (ASD) was completed for the cobalt and pH exceedances at UA monitoring wells. The Illinois Environmental Protection Agency (IEPA) did not concur with the ASD. The non-concurrence was appealed, and the Illinois Pollution Control Board (IPCB) granted a stay on February 1, 2024. Therefore, the cobalt and pH exceedances are not included in this modeling technical report.

1.3 Conceptual Model

The overall groundwater flow direction in the UA is towards south and southeast and boron concentrations have been detected in monitoring wells downgradient of the EAP. Though potential exceedances of GWPS have been identified for several COCs, the prevalence of these exceedances (degree and spatial extent) is limited, except for boron, which has been identified in a number of wells within the UA. Concentrations of compounds in leachate potentially migrated downward from the EAP through the silts and clays of the UCU into the sands and gravels of the UA [8] [5].

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[2] The Joppa EAP PTW01 Pump Test took place on October 5-6, 2022, after the GMR was submitted on May 31, 2022. The results from the 2024 pump test of the newly installed Groundwater Extraction System were not available when this report was prepared.

Boron was simulated in the model and is considered a surrogate for other 35 I.A.C. § 845.600 constituents because (i) it is commonly present at elevated concentrations in coal ash leachate; (ii) it is mobile and typically not very reactive but conservative (i.e., low rates of sorption or degradation) in groundwater; and (iii) it is less likely than other constituents to be present at elevated concentrations in background groundwater from natural or other anthropogenic sources. The surrogate selected for groundwater flow and transport modeling is conservative (i.e., aqueous concentrations are predominantly affected by physical processes such as dilution and dispersion rather than by chemical attenuation mechanisms) and therefore represent the maximum plume extent. The use of a conservative parameter to represent plume extent and clean-up times is consistent with USEPA modeling examples intended for evaluating relative remedy effectiveness [1] as well as an independent subject matter expert review validating the modeling approach for evaluating closure alternatives [12].

Conservative parameters are most acutely affected by closure: once the source is controlled via closure, concentrations of surrogate parameters in the groundwater will respond in timeframes consistent with groundwater flow. Source control will control, minimize, or eliminate, to the maximum extent feasible, infiltration of liquids through the CCR (per 35 I.A.C. 845 § 845.750(a)(1)), mitigating the flux of not only the surrogate parameter but all other parameters potentially leaching from the unit. The time to reach the GWPS determined by modeling the surrogate parameter correlates to the effectiveness of the proposed closure as source control. Therefore, the groundwater model is appropriate for assessing the effect of closure on the flux of all CCR SI porewater constituents.

The conceptual model for transport assumes two boron sources: boron that leaches to recharge water during percolation through ash above the water table; and boron that leaches to groundwater as it flows through ash below the water table. Therefore, mass is added to groundwater via vertical recharge through coal ash, and horizontal groundwater flow through coal ash where it lies below the water table. Horizontal flow through the CCR only occurs prior to closure, after consolidation and capping all CCR will be located above the water table. Mass is transported along with groundwater toward the Ohio River which is the primary receiving body of water adjacent to the EAP. The conceptual transport model assumes that boron concentration in leachate does not vary as a function of time, although the volume of leachate decreases over time as a function liquid removal during closure and capping.

Along the flow path boron concentrations may be attenuated physically through dilution and dispersion and may be geochemically attenuated by sorption to iron oxides or clay minerals. For the model, it was assumed that boron would not significantly sorb or chemically react with aquifer solids (soil adsorption coefficient [Kd] was set to 0 milliliters per gram [mL/g]) which is a conservative estimate for predicting contaminant transport times in the model. [5] Assessment of geochemical processes on the model results is discussed in **Section 3.3**.

2. GROUNDWATER MODEL DEVELOPMENT AND CALIBRATION

This groundwater model is an update to the model developed for the EAP in 2022 [2].The updated model discretization and simulation results are provided in **Appendix A** of this report and these revisions are summarized in **Section 2.1**. Generally, the model boundaries and flow and transport parameters (*i.e.,* heads, flow directions, and spatial distributions of boron concentrations) were retained from the 2022 model; however, several adjustments were made to parameters for model calibration (flow and transport). The objectives of the model revisions were to incorporate information collected since 2021 while maintaining the previous quality of calibration. Since the model update is predicated on the need to simulate additional corrective action for boron concentrations in groundwater at the site, it was important to retain to the extent practicable the previous model components and calibrations, to ensure that predicted results would be comparable to the 2022 model predictions for the EAP closure.

Specifications and results of the MODFLOW/MT3DMS modeling are presented below. Electronic copies of the model files will be provided along with this report (**Appendix B**).

2.1 Model Background

Model updates / revisions completed in 2023 consisted of the following:

Model Discretization

- No changes were made to the grid size and spacing in the updated model domain (**Appendix A Figure A1**), which consists of an area 20,000 feet by 15,000 feet with 578 columns (x) and 408 rows (y) [2].
- Nine model layers were assigned to represent subsurface materials for the revised model instead of the original seven layers (**Table A**). The number of model layers assigned to represent the McNairy Formation was increased from 1 to 3 from the original model to enable further discretization and evaluation of flow patterns in the UA. A summary of the current model discretization is provided in **Table A**.

Table A. Revised Model Layer Description

Previous Model Layer	New Model Layer	Approximate Layer Bottom Elevation for New Model Layer (feet[3])	Layer Description
1	1	308 – surface	CCR material; fill or native materials
2	2	305 – 320	UCU – silts and clays
3	3	269 – 316	UCU – silts and clays
4	4	260	UA (McNairy formation)
n/a (4)	5	252	
n/a (4)	6	171 – 250	
5	7	157 – 236 (14 ft uniform thickness)	LCU
6	8	127 – 206 (30 ft uniform thickness)	Bedrock
7	9	Minus (-) 100	Bedrock

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[3] All elevations in this report are referenced to North American Vertical Datum of 1988 (NAVD88)

<u>Model Approach and Codes</u>

- No changes were made to code used for the new model simulations. The flow models were simulated using original MODFLOW 88/96. MT3DMS was retained as the transport model code.

<u>Boundaries and Model Parameters</u>

- No changes were made to model boundary conditions for layers 1 through 3 (**Appendix A Figures A2-A3**). Model layer 1 was set as active only in areas adjacent to the EAP and the WAP extents while no-flow boundaries were used within the shallow model layers 2 and 3 where no groundwater flow is simulated. GHB elevations were simulated at 330 feet in model layers 4, 5, and 6, and 332 feet in model layers 7, 8, and 9 (**Appendix A Figures A4-A6**).
- No modification was made to the representation of the Ohio River. The Ohio River was simulated using river boundary cells in model layer 4 (Upper McNairy) (**Appendix A Figures A4**).
- For flow calibration of the revised model, recharge was applied to the West Ash Pond (WAP) area and two additional zones were added: a recharge rate of 0.003 ft/day was applied to the north and east of the WAP, while a recharge rate of 0.001 ft/day was applied to the south and southwest of the WAP (**Appendix A Figure A7**). Background recharge was slightly increased from 0.015 to 0.017 ft/day and recharge in the open water of the EAP was slightly reduced from 0.016 to 0.005 ft/day.
- Changes were made to the spatial distribution of hydraulic conductivities assigned to the original model. The updated configurations are presented in **Appendix A Figures A8-A14**. Notably, the sandy McNairy Formation which comprises the upper portion of the UA was simulated with an increased maximum hydraulic conductivity value of 180 ft/day from the previously assigned 100 ft/day (**Appendix A Figure A11**). The upper bound estimate of 180 ft/day is based on step-drawdown test results, yielding hydraulic conductivities ranging between 88 and 181 ft/day [9].

<u>Transport Model</u>

- Since the original UA (layer 4) was split into three layers (layers 4,5, and 6), the same storativity of 0.003, specific yield of 0.2, and porosity of 0.25 of layer 4 were extended to layers 5 and 6.
- In the updated model, the maximum recharge input in zone 2 (ash) was increased from 12 mg/L to 20 mg/L. This is based upon the maximum boron concentration of 16 mg/L measured at monitoring well XPW02 completed within the EAP. Recharge input in the rest of the zones (*i.e.,* zones 1, 3, 5, and 6) were kept the same as in the 2022 model.

2.2 Model Approach

Three modeling codes were used to model groundwater flow and contaminant transport: (i) percolation through the cap system was modeled using the Hydrologic Evaluation of Landfill Performance (HELP) model. HELP [13]was used to estimate percolation through the EAP areas for the CIP removal areas and CIP consolidation and cover system areas [2][4]; (ii) groundwater flow was modeled in three dimensions using MODFLOW version 88/96; and (iii) contaminant transport was modeled in three dimensions using MT3DMS.

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[4] No additional or revised HELP model runs were completed as part of the 2023 modeling.

A three-dimensional groundwater flow and transport model was developed to represent the conceptual flow system described above and then calibrated to match the groundwater monitoring results since 2015. A detailed sensitivity analysis of input values was performed and documented in the 2022 model [2] but is not included in this report. A number of simulations were created to represent different periods of time (see **Table B below**):

- A steady-state flow model was developed and calibrated to represent current conditions for groundwater flow at the EAP. This flow model provided the base model for modifications for other phases of modeling (Steady-State Flow Model)
- A transient flow model was developed by modifying the current conditions model to simulate groundwater flow conditions throughout operation of the EAP to the present time. A total of three stress periods (SP) were simulated, to represent 49 years of ash pond operation, from 1973 to 2022 (**Table B below**). For the 2023 model updates, no changes were made to the stress periods.
- A solute transport model was developed to simulate boron concentrations in groundwater throughout EAP operation to enable comparison of the simulated concentrations to the measured concentrations (transport calibration) and provide a stable distribution of current boron concentrations as a baseline for predictive modeling.
- Modifications to the site flow and transport models were made to simulate the CIP alternative for the EAP. Additionally, two Corrective Action Plan (CAP) remedial alternatives (groundwater extraction and barrier wall) were simulated to evaluate effects of additional remedial actions on boron concentrations at the Joppa EAP. Simulated groundwater flow and boron concentrations from the historical transport calibration and current conditions models were used to provide baseline conditions for these predictive simulations.

Table B. Model Simulation Stress Periods

Model Stage	Time Period	Model Description
Flow Model	Steady-State Flow Calibration	Flow Model Calibration to represent current conditions for groundwater flow at the EAP
Transient Flow Model and Historical Transport Model	Stress Period 1 (1973-1985)	SP1 – Initial operation of EAP; northern portion only
	Stress Period 2 (1985-2016)	SP2 – Operation of northern and southern portions
	Stress Period 3 (2016-2022)	SP3 – Installation of the DMM barrier
Predictive Corrective Action Alternative Simulations (Flow and Transport)	CIP Scenario • Period 1: Extended Current Condition (2022 – 2025) • Period 2: Dewatering and Construction (2025 – 2027) • Period 3: Post-Closure (2027 - 2077)	Predictive scenario simulations
	CIP with groundwater extraction (2022 - 2042)	
	CIP with barrier wall (2022 – 2042)	

Notes: DMM = Deep Mixing Method

2.3 Model Codes

MODFLOW uses a finite difference approximation to solve a three-dimensional head distribution in a transient, multi-layer, heterogeneous, anisotropic, variable-gradient, variable-thickness, confined or unconfined flow system—given user-supplied inputs of hydraulic conductivity, aquifer/layer thickness, recharge, wells, and boundary conditions. The program also calculates water balance at wells, rivers and drains.

MODFLOW was developed by the United States Geological Survey [14] and has been updated several times since. Major assumptions of the code are: (i) groundwater flow is governed by Darcy's law; (ii) the formation behaves as a continuous porous medium; (iii) flow is not affected by chemical, temperature, or density gradients; and (iv) hydraulic properties are constant within a grid cell. Other assumptions concerning the finite difference equation can be found in [14].). MODFLOW version 88/96 was used for this model revision using Groundwater Vistas 8 software for model pre- and post-processing tasks [15]. MODPATH Version 3 was used in conjunction with the MODFLOW flow prediction simulations. MODPATH is a particle tracking post-processing program designed to work with MODFLOW [16]. The results of the MODFLOW prediction simulations were used in MODPATH to compute hypothetical flow paths of water particles traveling from the EAP to the groundwater extraction wells.

MT3DMS [17] is an update of MT3D. It calculates concentration distribution for a single dissolved solute as a function of time and space. Concentration is distributed over a three-dimensional, non-uniform, transient flow field. Solute mass may be input at discrete points (wells, drains, river nodes, constant head cells), or distributed evenly or unevenly over the land surface (recharge).

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

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

2.4 Model Setup

2.4.1 Grid and Boundary Conditions

The model domain consists of an area 20,000 feet by 15,000 feet (approximately 7,000 acres). The grid was rotated -23.5 degrees to align the southern edge of the model grid with the bank of the Ohio River near the EAP. The model domain is divided into 578 columns (x) and 408 rows (y), with variable grid spacing of 20 feet in areas of interest increasing to 150 feet at the edges of the model domain. **Appendix A Figure A1** presents the model grid.

The flow model includes five types of boundary conditions: no-flow, recharge (specified flux), and river (head-dependent flux), general head (head-dependent flux), and pumping wells (specified flux). **Appendix A Figures A2 through A6** (layer 1, layers 2 and 3, layers 4-6, layers 8 and 9, respectively) present boundary conditions for the flow model. In the 2022 model, model layer 1 was active only within the EAP, and the cells surrounding the EAP in model layer 1 were inactive [2].In the updated 2023 model, cells in model layer 1 remained active for both the EAP and WAP, while cells outside these two ash ponds were set to inactive (**Appendix A Figure A2**).

Flow and transport model domain boundaries were the same for all scenarios. General head boundaries (GHB) were used to simulate inflow into the upgradient (northern) edge of the model domain in model layers 4 through 9 (**Appendix A Figures A4 through A6**). GHB elevations were simulated at 330 feet in model layers 4, 5, and 6, and 332 feet in model layers 7, 8, and 9.

Groundwater is pumped for water supply from four bedrock wells located within the model domain. This consists of three supply wells for the plant (JPP1, JPP2, JPP3), and one public water supply well for the town of Joppa (Joppa CWS2). These pumping wells were simulated in the groundwater flow model, within model layer 9 (bedrock) and shown on **Appendix A Figure A6**.

2.4.2 Flow Model Input Parameters

Layer Bottom

The number of model layers assigned to represent the McNairy Formation was increased from 1 (2022 model layer 4) to 3 (2023 model layers 4, 5, and 6). The new layer bottom elevations for layers 4 and 5 were set at 260 and 252 feet, respectively (**Table A**). The bottom elevations for the updated model layers 6, 7, 8, and 9 remain the same as previous model layers 4, 5, 6, and 7 bottom elevations, respectively. The bottom elevations of top three model layers were retained as used in the 2022 model [2].

Hydraulic Conductivity

Hydraulic conductivity values had been adjusted for most model layers during calibration of the flow model. **Appendix A Table A1** presents the hydraulic conductivities assigned for the current conditions flow model with revisions noted for each layer, as described below. The hydraulic conductivities specified were selected from site data presented in the HCR and other site reports and were carefully adjusted during calibration using iterative sensitivity testing.

- **Model Layer 1**
  - Five conductivity zones (Model Zones 1, 8, 12, 17, and 20) were simulated for the EAP, which includes two separate conductivity zones for the WAP (WAP north and WAP south) that were not included in the 2022 model simulation (Appendix A Table A1, Figure A8).
  - Zone 1 represents the ash material; hydraulic conductivities for this material were selected from the range of available slug test data for the ash (HCR) and adjusted during calibration.
  - Zone 12 represents the open water area of the EAP and has an artificially high conductivity to produce uniform head across this area.
  - Zone 8 represents the DMM by a narrow zone in the southeast corner of the EAP with very low hydraulic conductivity (1×10^{-4} ft/day).
  - The two zones in the WAP were calibrated with a horizontal conductivity value of 4 ft/day for WAP north and 3 ft/day for WAP south.
- **Model Layer 2**
  - Model layer 2 represents the silts and clays of the UCU (Zone 2), with calibrated conductivity of 0.5 ft/day (**Appendix A Table A1, Figure A9**), consistent with slug test data for the UCU wells. Since the UCU is a surficial confining unit, flow is predominantly vertical within the unit.
  - As presented in [18],the McNairy Formation outcrops at ground surface some distance north of the river. This transition was approximated with Zone 18 in model layers 2 and 3, with a horizontal conductivity of 20 ft/day (**Appendix A Table A1, Figure A9**).

  - A zone of lower conductivity (Zone 13) was assigned south of the EAP and east to the WAP, based upon calibration; and a zone of slightly higher conductivity (Zone 11) was assigned in the southern half of the WAP and extended in the southeasterly direction from the EAP towards the Ohio River during calibration (**Appendix A Table A, Figure A9**).
- **Model Layer 3**
  - The spatial distribution of the boundaries between distinct hydraulic conductivities in model layer 3 were mostly equivalent to those in model layer 2 with two exceptions (**Appendix A Table A1, Figure A10**). First, the low conductivity Model Zone 13 was extended in west (south of WAP) and in east (south of EAP). Second, the zone of elevated permeability (Model Zone 11) was removed from model layer 3. The silts and clays of the UCU were calibrated with a horizontal conductivity of 0.1 ft/day (Zone 3). Both Zones 3 and 13 have the same horizontal hydraulic conductivity, but different vertical hydraulic conductivity values (0.02 and 0.007 ft/day for Zone 3 and 13, respectively).
- **Model Layer 4**
  - The sandy McNairy Formation which comprises the upper portion of the UA was simulated with hydraulic conductivities of 10 ft/day (Model Zone 14) to 180 ft/day (Zone 25) (**Appendix A Table A1, Figure A11**).
  - A background hydraulic conductivity specified for most of the model domain was 40 ft/day (Zone 4) (**Appendix A Table A1, Figure A11**). The upper bound estimate of 180 ft/day is based on step-drawdown test results, yielding hydraulic conductivities ranging between 88 and 181 ft/day [9].
  - The high hydraulic conductivity zone extends in the southeast towards the Ohio River and spatially bounded to the north by the low conductivity Zone 14 and to the south by both the background Zone 4 and low conductivity Zone 14 (**Appendix A Table A1, Figure A11**).
  - The spatial distribution of the high conductivity Zone 25 and low conductivity Zone 14 manipulated during calibration to reproduce the observed groundwater flow directions and hydraulic heads observed in this unit (**Appendix A Table A1, Figure A11**).
- **Model Layers 5 and 6**
  - The bottom portion of the McNairy consists of Model layers 5 and 6. The horizontal hydraulic conductivity values in both layers include the background hydraulic conductivity of 40 ft/day (Zone 4) for most of the model domain and the low conductivity Zone 14 of 10 ft/day in the south of the ash ponds (**Appendix A Table A1, Figure A12**).
- **Model Layer 7**
  - Site-specific hydraulic conductivities were not available for the LCU silt/clay (Model layer 7). Layer 7 was simulated with three zones. Model Zones 27 and 28 were assigned the same background horizontal hydraulic conductivity of 0.1 ft/day (**Appendix A Table A1, Figure A13**) but different vertical conductivity values of 0.001 ft/day and 0.0001 ft/day, respectively. The third model Zone 16 was placed in layer 7 under the southern portion of the river to provide flexibility for calibration of vertical flow (**Appendix A Table A1, Figure A13**).

- **Model Layers 8 and 9**
  - Model layers 8 and 9 were simulated with two zones of equivalent extent within each layer, with one zone representing uniform background hydraulic conductivities for each material, and one zone was placed under the southern portion of the river to provide flexibility for calibration of vertical flow (**Appendix A Table A1, Figure A14**). Background horizontal hydraulic conductivities were specified for model layers 8 and 9 as 40 ft/day (Zone 6) and 70 ft/day (Zone 7), respectively. The hydraulic conductivities for the bedrock layers 8 and 9 were initially identified from regional data cited in the HCR and adjusted during calibration.

Recharge

Recharge rates for the model domain were adopted from the previous 2022 model and were adjusted during calibration. A comparison of the recharge rates between the 2022 and 2023 models are summarized below in **Table C** and the spatial distribution of the current recharge assignment is shown in **Appendix A Figure A7**.

Table C. Model Recharge (Current Conditions Flow Model)

Zone	2022 Recharge (ft/day)	2023 Recharge (ft/day)	Zone Description
1	0.0015	0.0017	Background recharge
2	0.0027		Ash
3	0.016	0.005	open water ash pond
5	0.0015		EAP external ash
6	0.007		EAP external ash, high recharge (limited ground cover)
7	NA	0.001	WAP north
8	NA	0.003	WAP south end

Storage Parameters and Porosity

Simulation of transient flow conditions requires assignment of storage parameters to active model cells, specifically values of storativity, specific yield, and porosity. Uniform storage parameters were specified for each model layer as designated in **Table D** below.

Table D. Transient Model Storage Parameters

Model Layer	Storativity	Specific Yield	Porosity	Material/ Stratigraphic Layer
1	0.003	0.1	0.2	CCR
2	0.003	0.1	0.3	UCU
3	0.003	0.1	0.3	UCU
4	0.003	0.2	0.25	UA
5	0.003	0.2	0.25	
6	0.003	0.2	0.25	
7	0.003	0.1	0.3	LCU
8	0.001	0.05	0.05	Bedrock
9	0.001	0.05	0.1	Bedrock

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

River parameters

The Ohio River was simulated using river boundary cells in model layer 4 (Upper McNairy) (**Appendix A Figures A4**). A river stage of 300 feet was simulated in the steady-state flow model, with a base of 260 feet and conductance of 1.2 x 10^5 square feet per day [ft^2/d].

2.4.3 Historical Transport Model Input Parameters

Sensitivity analysis of transport model inputs was conducted as part of the model development and is documented in the 2022 GMR [2] but is not included in this report. The only significant change in transport parameter was an increase in boron input concentration. No adjustments were made to the duration of any of the transport model stress periods.

Source Boron Concentration

- Stress Period 1 incorporated boron recharge in the northern portion of the EAP active at that time only, at a concentration of 20 mg/L (increased from 12 mg/L for the 2022 model); Stress Period 2 and Stress Period 3 incorporated boron recharge consistent with the full area of the EAP. No initial concentrations were incorporated into the historical transport model prior to construction of the EAP. **Appendix A Figures A25 and A26** present the simulated recharge concentration distribution of boron for Stress Period 1 and Stress Period 2/Stress Period 3.
- The maximum recharge input of 20 mg/L of boron was selected based upon the maximum boron concentration of 16 mg/L measured at monitoring well XPW02 completed within the EAP. Consistent with the 2022 model, a concentration of 7 mg/L was assigned during calibration to represent dilution of influent within the open water ash pond (**Appendix A Figures A25 and A26**). Boron concentrations of 10 and 12 mg/L were assigned for the ash external to the EAP.

Dispersivity

A background dispersivity of 1/0.1 feet (longitudinal/transverse) was applied to all model layers (**Appendix A Figure A27**). An increased dispersivity of 30/10 feet (longitudinal/transverse) was applied only within the observed boron plume location in model layers 2, 3, and 4 (**Appendix A Figure A27**) during transport calibration.

2.5 Flow and Transport Model Assumptions and Limitations

Simplifying assumptions were made while developing these models:

- Simulation of the groundwater flow system as steady state is representative of current conditions.
- The approximate base of ash surface in the EAP was developed from information presented in the HCR [8].
- Source concentrations are assumed to remain constant over time.
- Boron is not adsorbed and does not decay, and mixing and dispersion and mixing are the only attenuation mechanisms.
- Recharge instantaneously migrates to groundwater (*e.g.,* rapid vertical infiltration through the unsaturated zone).

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

2.6 Model Calibration

2.6.1 Flow Model Targets and Calibration Statistics

Groundwater measurements and elevations have been collected during previous hydrogeologic investigations and characterization to meet requirements of regulatory programs. Water elevations used for calibration were compiled from the HCR [8]and supplemented with additional data collected during installation and monitoring of wells installed in September 2021 [2]and 2022 [19]to delineate the extent of potential impacts.

Flow Model Targets

- A total of 73 flow model targets were selected in the updated 2023 model (compared with 36 in 2022) from available groundwater level data within the model domain, which includes the Joppa Landfill (3 targets), the EAP (42 targets), and the WAP (28).
- Targets were present in model layers 1 through 4, 6, 8, and 9 with the majority (35) in the UA (model layer 4). Water levels used for targets include the new wells installed along the eastern property boundary in late 2021 and 2022. Calibration targets with simulated groundwater elevations, model residuals, and calibration statistics are presented in **Appendix A Table A2**.

Model Calibration Results and Statistics

- The flow balance for the steady-state model was assessed during calibration to ensure that inflow/outflow rates for the model and various boundaries (river and GHBs versus recharge) were reasonable. The flow balance error for the steady-state model was 0.35 percent.
- A model residual is defined as the calculated difference between the observed and simulated hydraulic head at a specific location (observed – simulated). The mean residual for the 2023 calibration is 0.14 in comparison to 0.30 for 2022 model (**Appendix A Table A2**). The residual standard deviation for the 2023 calibration is 4.1 (compared to 2.1 for 2022 model), which is less than 10 percent of the observation range (**Appendix A Table A2**).
- Simulated groundwater elevations and target residuals are presented in **Appendix A Figures A15 through A23**, for model layers 1 through 9. The near-linear relationship between observed and simulated values in **Appendix A Figure A24** along the 1:1 line indicates that the model adequately represents the calibration dataset. The evenly distributed pattern of residuals plotted against the range of observed groundwater elevations also indicates the model results are not biased toward any groundwater elevation or layer within the model domain (**Appendix A Figure A24**).

2.6.2 Transport Model Calibration and Targets

- Boron concentrations at site monitoring wells were available from 2014 to 2023, with between 1 and 31 sample results available for each monitoring well. The average boron concentrations from recent (2014 to 2023) sample results were used to provide targets representing current conditions for the transport model (**Appendix A Table A3**).

- A total of 42 boron concentration targets were selected for the EAP, one in the UCU model layer 2, three in the bedrock (one in model layer 9 and two in model layer 8), one in LCU model layer 7, and the remainder within the UA: three in model layer 6, two in model layer 5, and thirty-two in model layer 4 (**Appendix A Table A3**).

Model Calibration Results and Statistics

- Simulated (predicted) boron concentrations and transport model target residuals are presented in **Appendix A Table A3** and **Appendix A Figures A28 through A30.**
- The overall distribution (extent) of simulated boron concentrations in the UA and magnitude are appropriate for observed concentrations. The observed boron concentrations at 25 of the 42 monitoring wells were below the GWPS of 2 mg/L for boron (**Appendix A Table A4)**. Of the remaining 17 target monitoring wells with observed boron concentrations exceeding 2 mg/L, in three wells (G17S, G20S, G20D) the 2022 simulated boron concentrations were predicted below 2 mg/L and in two wells (G12S and G12D) the 2022 simulated boron concentrations were only marginally above 2 mg/L (*i.e.,* 2.06 mg/L). Therefore, these 5 wells from the 17 target monitoring wells were excluded from the predictive analysis as the model results would not provide an estimate of when concentrations would be expected to decrease below the GWPS as they were already at or below the GWPS in the model (**Appendix A Table A4**). Twelve monitoring wells were carried forward for predictive modeling discussed in **Section 3**.
- Concentrations at G12S/D, G13S/D, G17S, and G20S/D, along the eastern property boundary, are underpredicted by 1.5 to 4.5 mg/L (**Appendix A Table A4**); underprediction in this portion of the plume is due to slight underrepresentation of south-easterly flow directions which are observed in this area despite efforts to calibrate the model to address this specific area.
- Simulation of the lower observed concentrations to the west and south of the EAP is consistent with observed concentrations, except for concentrations at G09, G15S, G53D, and Well 3, which are overpredicted by 2.3 mg/L, 4.7 mg/L, 3.5 mg/L, and 2.4 mg/L, respectively (**Appendix A Table A4**).

3. PREDICTIVE MODELING

Prediction models were evaluated from projected remedy completion of 2022 to 20 years in the future (2242). The objective of predictive modeling of the below corrective action scenarios is to simulate boron concentrations in groundwater for different corrective actions to evaluate if implementation of these actions will reduce the amount of time to meet GWPS of 2 mg/L for boron at the 12 target monitoring wells and within groundwater at the site. Simulated concentrations of boron were evaluated spatially using maps of maximum boron concentration within each layer at various points in time, and through time-series plots of boron concentrations for the 12 monitoring wells.

3.1 Model Prediction Scenarios

3.1.1 Closure in Place (CIP)

CIP was simulated using the calibrated historical flow and transport model for the EAP as a base, to be consistent with the specifications and timelines expressed in the CCR Surface Impoundment Final Closure Plan [20].The model was developed to simulate three explicit periods of closure: current conditions (Period 1), dewatering and construction (Period 2), and– post-closure (Period 3) [2].

Boron was selected for modeling the closure scenarios. Boron concentrations at 12 EAP monitoring wells were used as targets to evaluate adequacy of model simulated boron concentrations (**Table 3-1, Appendix A Table A4**). Of the detected constituents, boron has been detected in groundwater at the highest concentrations relative to its GWPS and it will likely take the longest time to meet the GWPS. It is not necessary to model all constituents that show GWPS exceedances[5] or have been detected at lower concentrations relative to their GWPSs, because those constituents will likely achieve their GWPSs faster than boron.

3.1.2 Alternative 1 - Groundwater Polishing

This scenario is consistent with the closure conditions (capping of the EAP and CIP) that was initially simulated in the 2022 model report and revised in 2023. The completed closure and capping of the EAP provide source control for this scenario. Groundwater polishing of boron is further discussed in the *Groundwater Polishing Evaluation Report* prepared by Geosyntec [21].

3.1.3 Alternative 2 –CIP with Groundwater Extraction

Groundwater extraction by pumping will be utilized to control easterly migration of groundwater that exceeds the applicable GWPS toward the Village of Joppa. This simulation includes eight extraction wells screened across 30 feet of the UA, each pumping at a rate of 40 gpm. This design was a result of using MODPATH particle-tracking tools to optimize the potential design specifications of the Groundwater Extraction Scenario (well spacing and pumping rate) and to capture groundwater from the EAP. The model was used to predict the time (post-closure) to reach GWPS for boron under a continuous pumping scenario (*i.e.,* long-term groundwater extraction) and a scenario where the pumping is discontinued after groundwater reaches the boron GWPS in a subset of groundwater target wells within the property boundary (*i.e.,* short-term groundwater extraction).

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[5] The most recent exceedances of GWPS had been identified for pH, cobalt, and boron in the UA wells, with boron exceedances (in terms of degree and spatial extent) being the most prevalent.

Model Approach

The CIP predictive model presented in the Closure Construction Permit GMR was modified to include extraction wells that are placed along a railroad bed (~2,650-feet alignment) to capture groundwater from the EAP (**Figure 3-1**). Several sensitivity analyses were performed iteratively to identify the optimum configuration, including the number of extraction wells, their spatial location along the railroad bed, and screen length and pumping rate of those extraction wells as part of the Groundwater Extraction Scenario design process. The optimized well configuration (*i.e.,* base case groundwater extraction scenario) consists of eight extraction wells, spaced about 380 feet apart, screened in the McNairy Formation between 270 and 240 feet (*i.e.,* 30-foot screen length), with each extraction well pumping at a rate of 40 gpm. The 30-foot screen length intersects approximately 10 feet across each of the three McNairy model layers: layer 4 (270 to 260 feet), layer 5 (260 to 252 feet), and layer 6 (252 to 240 feet).

Two extended groundwater extraction scenarios were evaluated. In the first scenario, groundwater extraction was simulated with continuous pumping for 20 years (*i.e.,* long-term groundwater extraction). For a second scenario, the groundwater extraction was discontinued after 6 years of pumping (*i.e.,* short-term groundwater extraction). Model simulation results of the short-term groundwater extraction identified the magnitude and spatial extent of potential boron concentration rebound in the UA following the cessation of pumping after 6 years of operation. The 6-year timeframe for the short-term groundwater extraction scenario was selected following sensitivity evaluation of potential operational lengths and pumping configurations.

3.1.4 Alternative 3 – CIP with Cutoff Wall

The CIP with barrier wall scenario consists of construction of a low permeability deep barrier wall (or cutoff wall) to contain and divert the offsite southeasterly flow of groundwater within the UA. The deep cutoff wall would be approximately 4,000 feet in length and 2 to 3 feet in thickness and would be constructed using either a mixture of soil and bentonite or cement and bentonite. The model was used to predict the time (post-closure) to reach the GWPS for boron for two configurations of a cutoff wall, full depth, and partial depth.

Model Approach

The CIP predictive model was modified to include the deep cutoff wall using the hydraulic flow barrier (HFB) package of MODFLOW. The thickness of the wall was set to 3 feet and the hydraulic conductivity of the wall was set to 1×10^{-7} cm/s or 0.000283 ft/day assuming a cement-bentonite composition of the wall. The partial-depth barrier wall was assigned from ground surface through the bottom of model layer 4 (model layers 2, 3, and 4). The partial cutoff wall is underlain by a relatively low-permeability sand and clay (layer 5) with horizontal hydraulic conductivities of 40 and 10 ft/day. The fully penetrated barrier wall was assigned from ground surface through the bottom of the McNairy (model layers 2, 3, 4, 5, and 6). The full-depth cutoff wall is underlain by the lower confining unit (layer 7) with very low hydraulic conductivities of 0.1 and 1 ft/day. **Table 3-3** shows the elevation of the model layers at the location of the cutoff wall and corresponding cutoff wall depths used in the model.

3.2 Prediction Scenario Results Discussion

3.2.1 Closure in Place (CIP) with Groundwater Polishing

Figure 3-2(A) and **Figure 3-3(B)** present concentrations of boron following closure at the 12 target monitoring wells which have average concentrations observed between 2021 and 2023 exceeding the GWPS of 2 mg/L (**Table 3-1**). Predicted concentrations of boron fell below the GWPS at these locations within approximately 5 to 11 years of completion of the CIP remedy, with a mean time of 7.5 ± 1 years (**Figure 3-2(A)**). Boron concentrations in eight of the twelve monitoring wells (*i.e.,* G06, G07, G08, G09, G10, G13S, G13D, and G14S) were predicted to fall below 2 mg/L within 7.5 years; and, in the remaining four monitoring wells (*i.e.,* G15D, G16S, G16D, G21S) boron concentrations were predicted to decrease below 2 mg/L between 9 and 11 years (**Figure 3-2(A)**). These results slightly differ from the 2022 groundwater model which estimated that the GWPS would be met after approximately 14 years. Of the 10 target monitoring wells that were common between the previous CIP scenario and the current model update, the time to reach the GWPS in the previous model was 2 to 4.5 years shorter for five wells (G06, G07, G08, G16S, and G16D) compared to the updated model. For the remaining five wells (G09, G10, G13S, G13D, and G15D), the time to reach the GWPS in the previous model was 0.2 to 7.2 years longer than the estimates provided by the updated model.

3.2.2 Closure in Place (CIP) with Groundwater Extraction

3.2.2.1 Flow Model

MODPATH was used to compute and trace the southeasterly flow of groundwater originating from the EAP (*i.e.,* source area). MODPATH particles were released along the western margin of the entire length of the EAP and simulated forward under steady-state flow conditions. MODPATH particle-tracking results indicated capture of groundwater from the EAP for the selected Groundwater Extraction Scenario configuration (**Figure 3-1**). Overall, pumping-induced drawdown of groundwater lowered hydraulic heads by approximately one foot near the extraction wells though the overall southeasterly groundwater flow direction remains unaffected in response to pumping (**Figures 3-3(B) and 3-3(C)**).

3.2.2.2 Transport Models

Boron transport modeling results for the long-term groundwater extraction scenario indicated GWPS of 2 mg/L would be achieved for all 12 monitoring wells between 1 and 12 years, following installation of the extraction wells, with a mean time of 5 ± 2 years (**Figure 3-2(C)**, **Table 3-1**). For the short-term groundwater extraction scenario (6 years of pumping), the GWPS for boron was achieved between 1 and 10 years, with a mean time of 4± 2 years (**Figure 3-2(B)**, **Table 3-1**). In both cases, the GWPS of 2 mg/L for boron was achieved at the same time in 10 of the 12 monitoring wells (*i.e.,* G06 through G10, G13S and 13D, G14S, G15D, and G21S). Differences in time to achieve GWPS were noted for the two monitoring wells G16S and G16D (discussed below).

Comparison of long-term groundwater extraction scenario to base-case CIP scenario

For long-term groundwater extraction scenario, time to achieve the GWPS of 2 mg/L was reduced compared to the CIP base case in 10 of the 12 groundwater monitoring wells, by 1 to 6 years (**Figures 3-2(A) and 3-2(C)**, **Table 3-1**). The average time required to meet the boron GWPS for those 10 wells was 3 ± 1 years. The time to achieve GWPS was estimated to be similar or slightly longer for G16S (12 years for long-term groundwater extraction vs. 11 years for CIP only) and G16D (10 years for long-term groundwater extraction vs. 9 years for CIP only). These two wells are located west and side-gradient of the line of extraction wells. The increased time to achieve the GWPS simulated at G16S/G16D is associated with the transport of residual boron in groundwater through past wells G16S/D for a longer period of time in response to pumping. In summary, results of simulation of long-term groundwater extraction operation indicated reduced time to achieve GWPS in 10 of 12 wells, with slightly increased timeframes in the remaining two wells (but not exceeding 12 years following closure).

Sensitivity testing was performed to assess if the addition of an extraction well might reduce the time to meet the GWPS of 2 mg/L at G16S/D after closure (**Table 3-2**). A ninth extraction well was added to the south of EX-03 and within 400 feet of G16S/D, with consistent design to the other 8 extraction wells. The results of the 9-well simulation indicated similar timeframes to achieve the GWPS of 2 mg/L at G16S (12 years after closure) and G16D (10 years after closure) when compared with 8-well groundwater extraction scenario (12 and 10 years after closure, respectively) (**Table 3-2**). Further evaluation of increased pumping rate at the ninth well (70 gpm) yielded a small reduction in the time to achieve the GWPS observed at G16S (12 years after closure) and G16D (9 years after closure) (**Table 3-2**), indicating that the addition of a ninth extraction well provided little to no benefit over the eight well design.

Comparison of short-term groundwater extraction scenario to base-case CIP scenario

For the short-term groundwater extraction with eight wells, time to achieve the GWPS of 2 mg/L was reduced relative to CIP at each of the 12 monitoring wells, including G16S and G16D, by 1 to 6 years (**Figures 3-2(A)**, **1(B)**, **2(B)**, and **2(C)**, **Table 3-1**). Small increases in boron concentrations (*i.e.,* rebound effect) were observed in seven monitoring wells after the pumps were shut off, however concentrations did not exceed the GWPS of 2 mg/L boron (**Figure 3-2(B)**). Three of those seven monitoring wells (G06, G07, and G15D) indicated an immediate rebound in boron concentrations while the other four wells (G21S, G13S, G13D, and G14S) showed a lag before any noticeable increase in boron was observed. Boron concentrations in all those seven monitoring wells reached new equilibrium concentrations (*i.e.,* stabilized) below the GWPS within 6 years after the shut-off of the extraction wells and thereafter showed a steady decline over time (**Figure 3-2(B)**). Monitoring wells G08, G09, and G10 did not show a boron rebound effect (*i.e.,* boron concentrations declined steadily in those wells) in response to the shutdown of the groundwater extraction wells.

In summary, boron transport modeling results indicated a notable reduction in time to achieve the GWPS of 2 mg/L by post-closure groundwater extraction. Reduction in boron concentrations at monitoring wells was similar for continuous operation of the Groundwater Extraction Scenario for 20 years versus shutdown of the Groundwater Extraction Scenario after 6 years of pumping. In both cases, no off-property boron GWPS exceedances were observed. Although some wells showed a minor rebound of boron following the shutoff of extraction wells in the short-term groundwater extraction scenario, the GWPS was met at all wells within a short timeframe after closure.

3.2.3 Evaluation of Closure in Place (CIP) with a Barrier Wall

3.2.3.1 Flow Model

Simulation of the full-depth and partial-depth cutoff walls affected groundwater heads and flow conditions near the barrier. Since the cutoff wall acts as a barrier to lateral groundwater flow, it resulted in cross-wall head “steps” of up to 3 feet being simulated between the upgradient and downgradient areas of the wall (**Figure 3-3(D)**). Overall, the placement of the wall did not alter the south and southeasterly flow direction of groundwater.

3.2.3.2 Transport models

Boron transport modeling results for the partial barrier wall indicated that the GWPS of 2 mg/L was reached at each of the 12 monitoring wells between 2 and 11 years following closure, with a mean time of 7 ± 2 years (**Figure 3-2(D)**, **Table 3-1**). For the full-depth wall, the GWPS for boron was achieved between 1.1 and 12.1 years, with a mean time of 7 ± 2 years (**Figure 3-2(E)**, **Table 3-1**). The variations in the time to reach GWPS between these two wall configurations were inconsistent as neither scenario resulted in faster time to reach the GWPS at every well. Achievement of the GWPS with the partial wall took place earlier at wells G06, G07, G13S/D, and G14S whereas the GWPS was achieved with the full wall earlier at G08, G09, G10, G15D, and G16S/D.

Comparison of cutoff wall scenarios to base-case CIP scenario
For both the partial and full-depth barrier walls, time to achieve the GWPS of 2 mg/L was reduced compared to the CIP in 4 of the 12 groundwater monitoring wells G06, G13S/13D, and G14S (**Figures 3-2(D)** and **3-2(E)**; **Table 3-1**). The time was either increased or remained unchanged in the remaining eight wells. For the partial barrier wall, the time to reach GWPS was reduced in those 4 monitoring wells by 0.1 to 4 years whereas for the full-length wall, GWPS was reduced by 0.4 to 5 years (**Table 3-1**).

The time to achieve GWPS for boron relied on the spatial location of the wells with respect to the location of the cutoff wall. All four wells that achieved the boron GWPS at an earlier time are located on the opposite side of the barrier wall (*i.e.,* to the east or southeast of the barrier wall) (**Figure 3-3(D)**). The eight wells which did not have reduced time to reach GWPS are either located in the area between the EAP and the wall (G07 through G10) where groundwater was contained or redirected by the wall, or at the southern tip of the wall (G16S/D and G15S) where the wall provides no barrier against the southerly flow of the boron plume (**Figure 3-3(D)**).

3.3 Assessment of Geochemical Processes

This groundwater flow and transport model estimates the time for boron to reach the GWPS under different potential corrective actions based on physical components of groundwater polishing. As described in the Groundwater Modeling Report submitted with the construction permit, it was assumed that boron would not significantly sorb or chemically react with aquifer solids (distribution coefficient [Kd] was set to 0 milliliters per gram [mL/g]), which is a conservative estimate for estimating contaminant transport times.

A Groundwater Polishing Evaluation Report (GPR) was prepared as an attachment to the Corrective Actions Alternative Analysis (CAAA) prepared by Geosyntec for the JPP EAP [21]. The geochemical modeling effort presented in the GPR supports the assessment of groundwater polishing as a component of the proposed corrective action by evaluating the potential for chemical attenuation of constituents of concern COCs before and after source control as a means of contextualizing the times estimated in the flow and transport model. The GPR also provides an initial foundation for understanding groundwater chemistry to inform adaptive site management as a key component of the Corrective Action Groundwater Monitoring Program.

In their report, Geosyntec evaluated the potential for natural groundwater polishing processes, which involve both physical and chemical mechanisms, to attenuate boron and prevent previously attenuated boron from being remobilized into groundwater as the concentration of boron returns to background levels [21].The groundwater polishing evaluation suggests that chemical attenuation of boron is feasible under current conditions through sorption to iron and aluminum oxide solids [21].

Modeling results presented in the *Groundwater Polishing Evaluation Report* [21] show that boron attenuation via sorption to mineral surfaces is expected to remain stable under post-source control conditions, as the dissolution of iron and aluminum oxide minerals in the presence of background groundwater composition is predicted to be minimal, if any. Aqueous boron concentrations are anticipated to decrease below the boron GWPS of 2 mg/L at all monitoring wells following post-closure. Further, modeling results suggest that boron remobilization is unlikely to impact the estimated timeline for reaching the GWPS [21],as shown for the CIP scenario in **Section 3.2.1**. In other words, the impact of groundwater polishing through physical/chemical attenuation mechanisms has only a minimal effect on the time it takes for boron concentrations to reach the GWPS of 2 mg/L, as demonstrated above for CIP (**Figure 3-2(A)**).

4. CONCLUSIONS

This report presents additional predictive groundwater modeling simulations for the JPP based on the revised 2023 groundwater modeling results, to support evaluation of two potential active remedies identified in the Corrective Action Alternatives Analysis. This report includes a summary of the revisions made to the 2022 groundwater model to incorporate updates to the original flow and transport model, and simulation of additional predictive scenarios using MODFLOW, MODPATH and MT3DMS.

The groundwater modeling efforts in this report consist of flow and transport modeling to assess the time to achieve GWPS for boron for two different corrective action alternatives: (1) source control with a groundwater extraction system and (2) source control with a deep barrier wall. The effects of these two corrective measures were evaluated with the CIP scenario that was selected as the closure alternative for the EAP in 2022. Two separate scenarios of the groundwater extraction (short-term versus long-term pumping) and two barrier wall configurations (partial versus full-depth wall) were evaluated.

Overall, the groundwater extraction corrective action alternatives were more effective than the barrier wall alternatives. The time to achieve GWPS for boron in all 12 target monitoring wells were from 1 to 10 years (mean of 4 ± 2 years) for short-term groundwater extraction scenario, from 1 to 12 years (mean of 5 ± 2 years) for long-term groundwater extraction scenario, from 2 to 11 years (mean of 7 ± 2 years) for partial barrier wall, and from 1 to 12 years (mean of 7 ± 2 years) for full-depth barrier wall scenarios.

Both the short- and long-term groundwater extraction options are equally effective in reducing the time to achieve the boron GWPS in 10 of the 12 monitoring wells. In the case of the short-term groundwater extraction scenario, the GWPS for boron was met at all 12 target monitoring wells 1 to 6 years earlier when compared to the base-case CIP scenario. For the long-term groundwater extraction scenario, the GWPS was achieved between 1 and 6 years earlier at 10 of the 12 target monitoring wells.

5. REFERENCES

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TABLE 3-1. PREDICTED BORON CONCENTRATIONS AT THE EAP MONITORING WELLS.

GROUNDWATER MODELING TECHNICAL MEMORANDUM
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	2022 Simulated Boron Concentration (mg/L)	Target Value (Average Boron Concentration [mg/L])	Year 0 Predicted Boron Concentration (mg/L)	CIP Years to Meet GWPS	Groundwater Extraction[1] Years to Meet GWPS	Partial Barrier Wall[2] Years to Meet GWPS	Full Barrier Wall[2] Years to Meet GWPS
G01D	0.00	0.02	0.00				
G02D	0.00	0.06	0.00				
G03	0.05	0.33	0.06				
G04	1.17	0.02	1.01				
G05	1.56	0.15	1.33				
G06	4.14	3.34	4.13	6.2	**1.7**	**6.0**	**5.7**
G07	5.00	4.62	4.81	7.3	**3.7**	7.7	7.3
G08	6.16	4.42	5.17	6.4	**5.4**	6.8	8.6
G09	5.44	3.19	5.21	7.0	**5.3**	7.4	8.9
G10	4.23	4.38	4.03	5.0	**4.1**	5.3	6.8
G11	0.71	0.33	0.66				
G112D	0.00	0.03	0.00				
G12S	2.06	5.92	1.90				
G12D	2.06	6.53	1.90				
G13S	3.08	5.29	3.08	5.3	**0.7**	**2.0**	**1.1**
G13D	3.08	5.00	3.08	5.3	**0.7**	**2.0**	**1.1**
G14S	3.60	3.65	3.53	7.3	**1.5**	**3.1**	**2.6**
G14D	0.17	0.04	0.17				
G15S	5.78	1.06	5.75				
G15D	5.14	6.09	4.98	8.7	**5.4**	9.3	11.1
G16S	8.08	6.97	7.41	11.1	**10.3** (12.1*)	11.1	12.1
G16D	6.07	6.20	5.90	9.3	**8.8** (9.9*)	9.8	10.1
G17S	0.10	2.62	0.09				
G18S	0.00	1.64	0.00				
G19S	0.00	0.56	0.00				
G19D	0.00	0.60	0.00				
G20S	1.63	4.09	1.48				
G20D	1.24	2.69	1.19				
G21S	4.83	4.33	4.83	8.8	**3.5**	9.2	8.8
G22S	0.50	1.25	0.45				
G22D	0.05	0.62	0.05				
G23S	0.00	0.72	0.00				
G24S	0.00	0.69	0.00				
G51D	0.63	0.46	0.51				
G53D	3.85	0.35	3.61				
G54D	0.73	0.05	0.83				
Well_3	2.99	0.59	3.23				
G13M	0.00	0.03	0.00				
G20M	0.00	0.04	0.00				
G21M	0.00	0.02	0.00				
G09M	0.00	0.04	0.00				
G113	0.00	0.03	0.00				

Notes:

CIP = closure in place
GWPS = groundwater protection standard
ID = identifier
mg/L = milligrams per liter

[1] Except for Wells G16S and G16D, the groundwater pumping results are the same for the continuous pumping scenario and for the scenario where the pumps are shut off after 6 years of continuous pumping; for those two wells, the times to meet GWPS for the continuous pumping scenario are identified with an asterisk (*).

[2] The partially penetrating barrier wall was placed only in layer 4 of the McNairy Fm. while the fully penetrating barrier wall was placed across multiple layers (4, 5, and 6) of the McNairy Fm.

A subset of 12 monitoring wells selected for CAP simulations are highlighted with gray shading. These 12 all exhibited boron levels above the GWPS of 2 mg/L.

Bold font used when the corrective remedy time to meet GWPS is lower than that for CIP only (i.e., no remedy applied)

TABLE 3-2. Sensitivity Analyses for the Groundwater Extraction Scenario.

GROUNDWATER MODELING TECHNICAL MEMORANDUM
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	CIP Years to Meet GWPS	CIP GWE Scenario (Base case^1) Years to Meet GWPS	CIP GWE Scenario (9-extraction wells^2) Years to Meet GWPS	CIP GWE Scenario (variable pumping rate^3) Years to Meet GWPS
G06	6.2	**1.7**	**1.7**	**1.6**
G07	7.3	**3.7**	**3.6**	**3.6**
G08	6.4	**5.4**	**5.3**	**5.2**
G09	7.0	**5.3**	**5.2**	**5.1**
G10	5.0	**4.1**	**4.0**	**4.0**
G13S	5.3	**0.7**	**0.7**	**0.6**
G13D	5.3	**0.7**	**0.7**	**0.6**
G14S	7.3	**1.5**	**1.2**	**1.0**
G15D	8.7	**5.4**	**3.3**	**2.8**
G16S	11.1	12.1	12.0	11.9
G16D	9.3	9.9	9.5	**9.2**
G21S	8.8	**3.5**	**2.8**	**2.4**

Notes:
CIP = closure in place
GWE = Groundwater Extraction
GWPS = groundwater protection standard
mg/L = milligrams per liter

[1] base groundwater pumping scenario with eight wells, all pumping at 40 gpm.

[2] GWE scenario with nine extraction wells, all pumping at 40 gpm.

[3] GWE scenario with nine extraction wells; the ninth extraction well pumping at 70 gpm and the rest at 40 gpm.

Bold font used when the corrective remedy time to meet GWPS is lower than that for CIP only (i.e., no remedy)

TABLE 3-3. Estimated Cut-off Wall Depths

GROUNDWATER MODELING TECHNICAL MEMORANDUM
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Elevation Layer	Minimum Elevation[1] (feet NAVD88)	Maximum Elevation[1] (feet NAVD88)	Maximum Estimated Depth (feet)[2]	Maximum Estimated Depth of Cutoff Wall (feet)[3]
Ground Surface[4]	343.0	358.0		Partial Wall: (53 + 13 + 51) = **117** Full Wall: (53 + 13 + 51 + 8 + 47) = **172**
Model Layer 2	305.0	314.0	53.0	
Model Layer 3	301.0	311.0	13.0	
Model Layer 4	260.0	260.0	51.0	
Model Layer 5	252.0	252.0	8.0	
Model Layer 6	205.0	231.0	47.0	

Notes:

NAVD88 = North American Vertical Datum of 1988

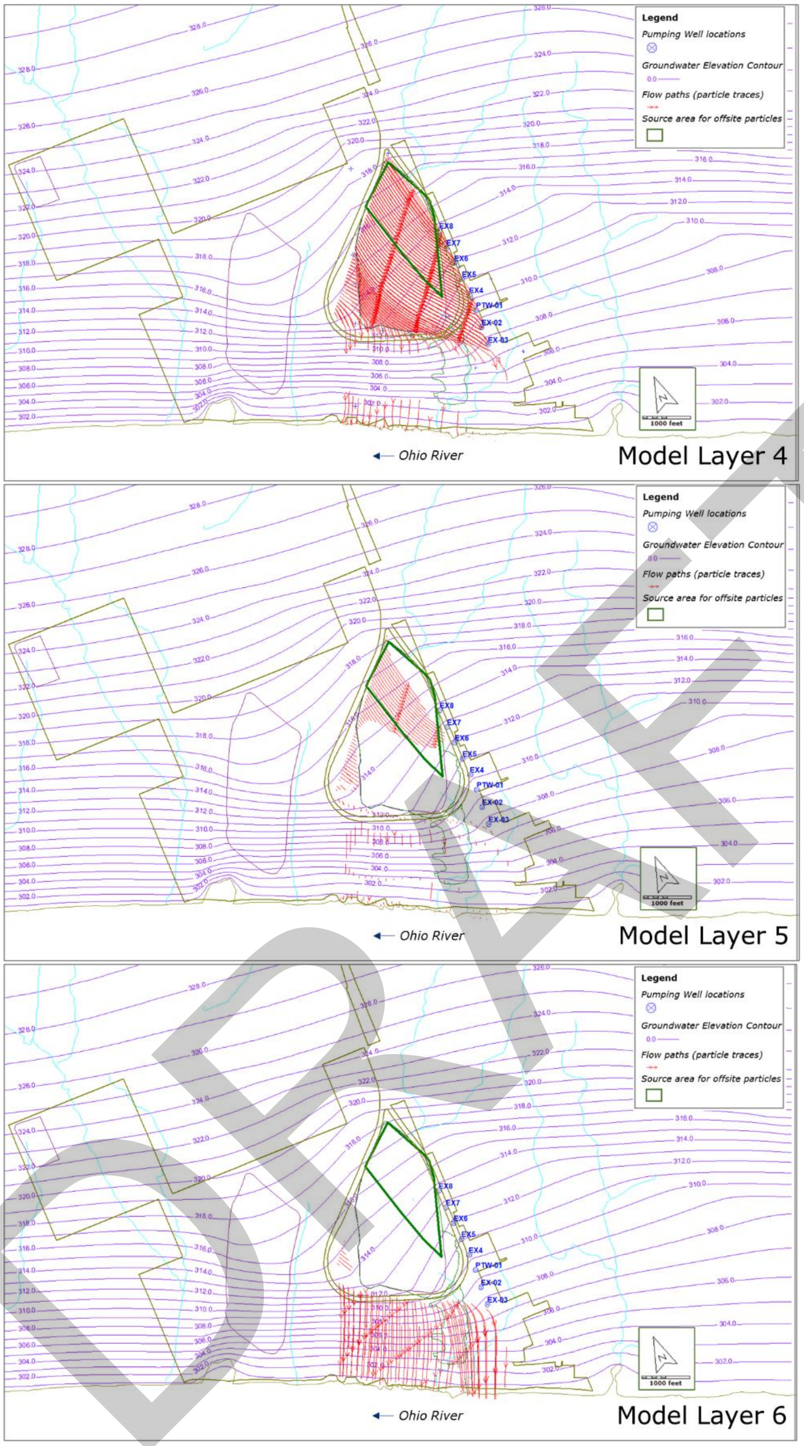
[1] Bottom elevations for each model layer.

[2] Estimated by subtracting the minimum elevation of the layer from the maximum elevation of the top layer.

[3] Partial Wall cuts through model layers 2, 3, and 4; Full Wall cuts through model layers 2, 3, 4, 5, and 6.

[4] Range of elevations (feet NAVD88) based on ground elevations of wells G05 (358.5), G06 (352.6), G07 (350.3), and G15 (343) that are located along the proposed transect for the barrier wall.

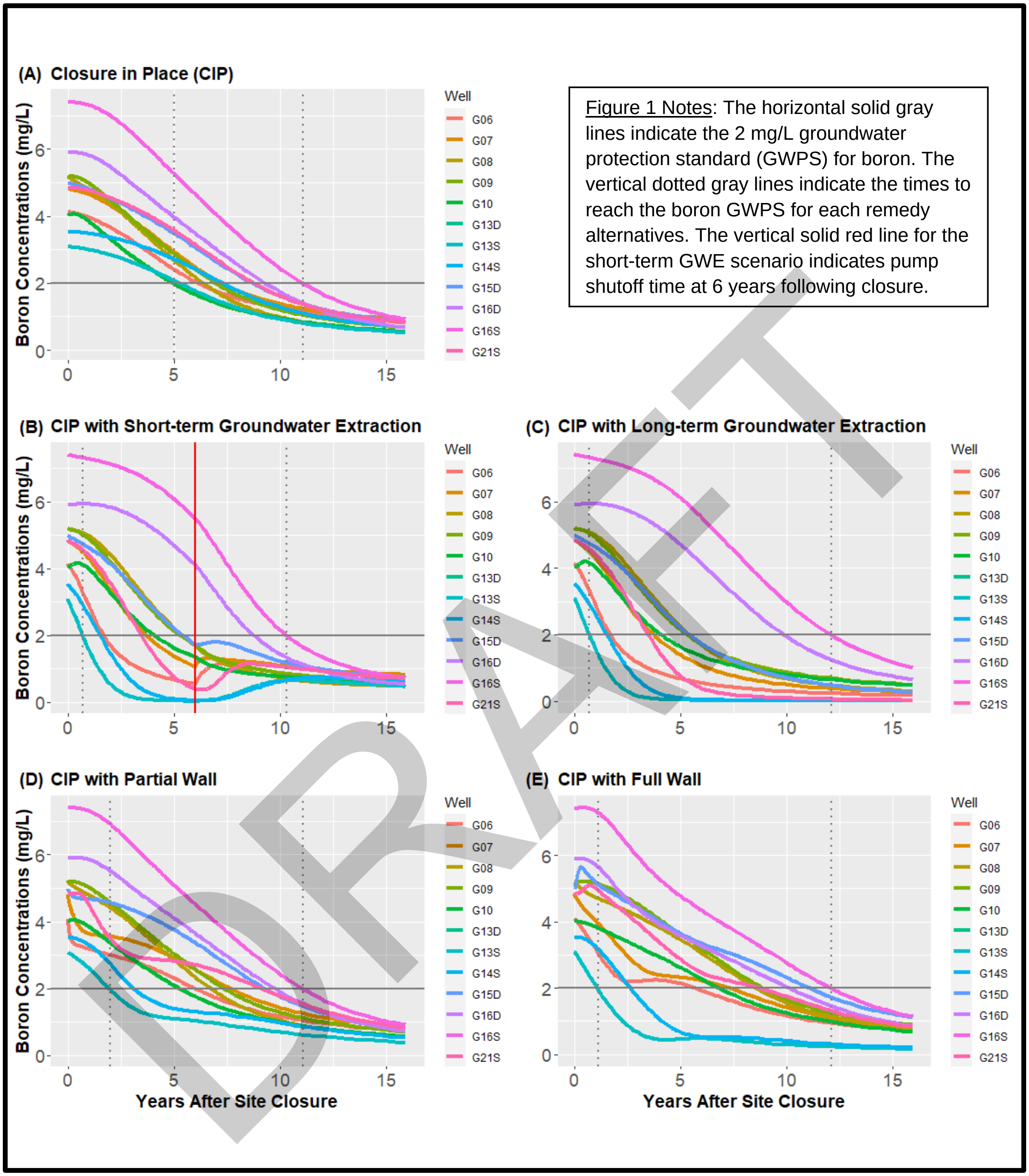
FIGURE 3-1



MODPATH Particle Tracking Results for the Groundwater Extraction Scenario, Model Layers 4 through 6

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL


(A) Closure in Place (CIP)

(B) CIP with Short-term Groundwater Extraction

(C) CIP with Long-term Groundwater Extraction

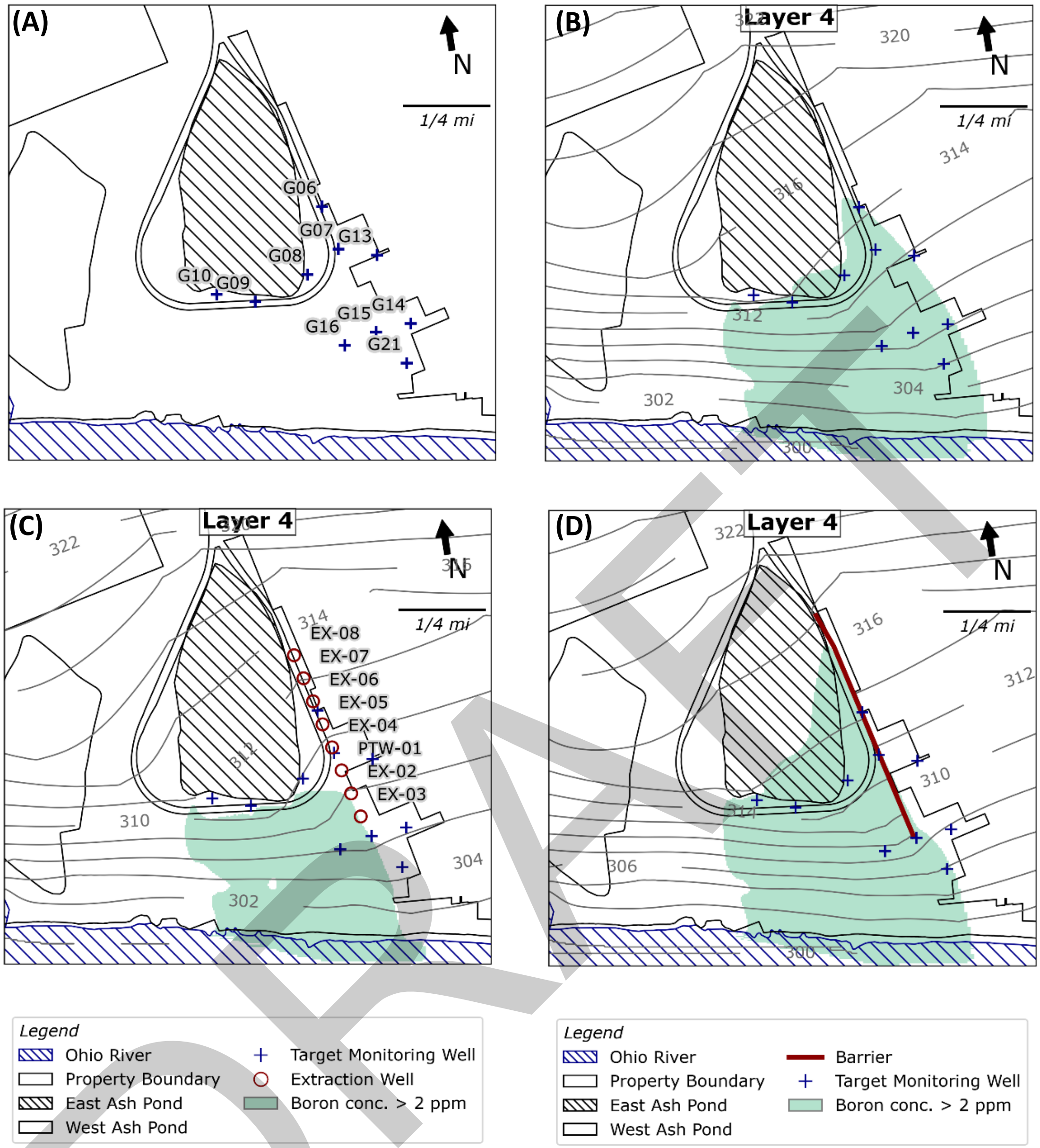
(D) CIP with Partial Wall

(E) CIP with Full Wall

Figure 1 Notes: The horizontal solid gray lines indicate the 2 mg/L groundwater protection standard (GWPS) for boron. The vertical dotted gray lines indicate the times to reach the boron GWPS for each remedy alternatives. The vertical solid red line for the short-term GWE scenario indicates pump shutoff time at 6 years following closure.

TIME-SERIES OF PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS.

FIGURE 3-3



SPATIAL DISTRIBUTION OF BORON CONCENTRATIONS IN MODEL LAYER 4 (6 YEARS AFTER CLOSURE)

(A) Spatial location and IDs of the 12 target EAP monitoring wells, (B) predicted boron for CIP scenario; (C) predicted boron for short-term groundwater extraction remedy, and (D) predicted boron for remedy with a full depth wall.

APPENDIX A. REVISED 2023 JOPPA EAP GROUNDWATER MODEL SIMULATIONS

APPENDIX A TABLES A1 THROUGH A4

APPENDIX A TABLE A1. CURRENT CONDITIONS FLOW MODEL HYDRAULIC CONDUCTIVITY ASSIGNMENTS

TABLE A1. CURRENT CONDITIONS FLOW MODEL HYDRAULIC CONDUCTIVITY ASSIGNMENTS

Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Hydraulic Conductivity

Zone	Kx or Ky (ft/d) [1]	Kz (ft/d) [1]	Model Layer	Zone Description	Revision Notes
1	0.9	0.009	1	Ash	Increased both horizontal and vertical hydraulic conductivities; prior 2022 model Kx = Ky = 0.3 ft/d and Kz = 0.0013 ft/d.
12	200	0.02	1	Standing water in EAP (open water)	Retained horizontal hydraulic conductivity but increased vertical hydraulic conductivity from 0.01 ft/d (2022 model) to 0.02 ft/d (revised 2023 model).
17	4	4	1	WAP north	No hydraulic conductivity was assigned to WAP in the prior 2022 model as it was not included in flow modeling.
20	3	3	1	WAP south	No hydraulic conductivity was assigned to WAP in the prior 2022 model as it was not included in flow modeling.
2	0.5	0.015	2	UCU - silt and clay	Increased horizontal hydraulic conductivity but decreased vertical HK; prior 2022 model Kx = Ky = 0.2 ft/d and Kz = 0.0045 ft/d.
11	1.5	0.001	2	higher-permeability zone within UCU	Reduced both horizontal and vertical hydraulic conductivities; prior 2022 model Kx = Ky = 2 ft/d and Kz = 0.06 ft/d
8	0.0001	0.0001	1,2	DMM	Retained the same hydraulic conductivities of 2022 model for DMM.
3	0.1	0.02	3	UCU - silt and clay	Decreased both horizontal and vertical hydraulic conductivities; previous 2022 model Kx = Ky = 0.2 ft/d and Kz = 0.05 ft/d.
13	0.1	0.007	2,3	interpreted less permeable zone within UCU	Retained horizontal hydraulic conductivity but decreased vertical hydraulic conductivity from 0.008 ft/d (2022 model) to 0.007 ft/d (revised 2023 model).
18	20	2	2,3	McNairy formation upgradient surface outcrop	Retained the same hydraulic conductivities of 2022 model.
19	8	1	2,3	"drain" area above Ohio River in shallow layers	Retained the same hydraulic conductivities of 2022 model.
4	40	4	4,5,6	McNairy formation - sand	The same hydraulic conductivities of layer 4 was extended to new model layers 5 and 6 in certain areas.

TABLE A1. CURRENT CONDITIONS FLOW MODEL HYDRAULIC CONDUCTIVITY ASSIGNMENTS

Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Hydraulic Conductivity

Zone	Kx or Ky (ft/d) [1]	Kz (ft/d) [1]	Model Layer	Zone Description	Revision Notes
14	10	1	4,5,6	interpreted less permeable zone within UA	The same hydraulic conductivities of layer 4 was extended to new model layers 5 and 6 in certain areas.
25	180	10	4	Interpreted gravel zone within McNairy formation	Increased both horizontal and vertical hydraulic conductivities; prior 2022 model Kx = Ky = 100 ft/d and Kz = 5 ft/d.
27	0.1	0.001	7	LCU - silt/clay or saprolite	Retained horizontal hydraulic conductivity but decreased vertical hydraulic conductivity from 0.002 ft/d (2022 model) to 0.001 ft/d (revised 2023 model) in north, west, and northwest.
28	0.1	0.0001	7	LCU - silt/clay or saprolite	Decreased both horizontal and vertical hydraulic conductivities in southeast; previous 2022 model Kx = Ky = 1 ft/d and Kz = 0.1 ft/d.
6	40	0.5	8	Shallow bedrock	Retained the same hydraulic conductivities of 2022 model for shallow bedrock.
7	70	3.5	9	Limestone bedrock	Retained the same hydraulic conductivities of 2022 model for limestone bedrock.
16	1	0.1	7,8,9	vertical communication area under Ohio River	Retained the same hydraulic conductivities.

Notes

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

APPENDIX A TABLE A2. CURRENT CONDITIONS FLOW MODEL CALIBRATION TARGETS AND STATISTICS

TABLE A2. CURRENT CONDITIONS FLOW MODEL CALIBRATION TARGETS AND STATISTICS

Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	Unit	X	Y	Layer	Observed GWE (feet NAVD88)	Simulated GWE (feet NAVD88)	Residual (observed-simulated, feet)
XPW01	Joppa East	833203	200780	1	368.5	373.6	-5.1
XTPW08	Joppa West	829770	199201	2	337.4	330.5	6.9
XTPW02	Joppa West	829911	200017	1	331.6	338.5	-7.0
XTPW07	Joppa West	829450	199475	2	339.6	331.0	8.6
XTPW06	Joppa West	829163	199639	2	330.3	330.7	-0.4
XTPW01	Joppa West	830167	200570	1	343.7	340.0	3.7
XPW03	Joppa East	832213	199021	1	372.3	375.0	-2.7
XTPW03	Joppa West	830878	201088	1	343.5	343.3	0.1
XPW02	Joppa East	832343	200371	1	371.2	371.1	0.1
TPZ114	Joppa West	828684	199377	2	335.2	329.5	5.6
TPZ117	Joppa West	829989	197896	2	307.6	306.4	1.2
G113	Joppa West	830366	199600	2	338.1	329.1	8.9
TPZ118	Joppa West	831103	201775	2	331.0	335.5	-4.6
TPZ116	Joppa West	830005	198506	2	313.2	316.2	-3.1
TPZ124	Joppa West	831300	201129	2	327.3	332.6	-5.3
G13	Joppa East	834563	198270	2	323.7	324.4	-0.7
TPZ120	Joppa West	830597	200074	2	334.9	329.4	5.5
TPZ119	Joppa West	831137	200507	2	324.8	330.1	-5.3
G20	Joppa East	834986	197096	2	332.5	315.9	16.6
G102	Landfill	826535	205073	2	328.9	325.1	3.8
G105	Landfill	826290	204659	2	323.5	324.0	-0.5
G109	Landfill	826650	204021	2	321.8	324.3	-2.5
G151	Joppa East	832154	200439	2	321.4	333.8	-12.4
TPZ115	Joppa West	828623	199070	3	306.8	309.4	-2.6
G112C	Joppa West	829088	198552	3	317.2	307.8	9.4
TPZ122	Joppa West	829019	200039	2	337.4	328.8	8.5
G06S	Joppa East	834117	199303	3	315.1	315.3	-0.2
G54S	Joppa East	831609	199074	3	312.7	316.7	-4.0
G101JE	Joppa West	831717	202049	3	318.9	321.2	-2.3
G153	Joppa East	833979	200068	3	314.7	316.8	-2.1

TABLE A2. CURRENT CONDITIONS FLOW MODEL CALIBRATION TARGETS AND STATISTICS

Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	Unit	X	Y	Layer	Observed GWE (feet NAVD88)	Simulated GWE (feet NAVD88)	Residual (observed-simulated, feet)
TPZ115DD	Joppa West	828636	199057	4	303.5	306.0	-2.5
TPZ118DD	Joppa West	831094	201781	4	320.9	320.6	0.3
OW-01	Joppa East	834076	198223	4	312.5	312.6	-0.1
G08	Joppa East	833493	198423	4	313.7	313.9	-0.2
OW-02	Joppa East	834027	197958	4	311.6	311.9	-0.3
G19D	Joppa East	835757	197685	4	309.8	310.2	-0.4
G112D	Joppa West	829115	198539	4	304.0	303.8	0.1
TPZ124D	Joppa West	831302	201120	4	319.1	319.4	-0.4
G12D	Joppa East	834639	198793	4	311.8	313.6	-1.8
G06	Joppa East	834115	199293	4	316.8	315.1	1.7
G18S	Joppa East	835369	199520	4	314.2	314.8	-0.6
TPZ120D	Joppa West	830589	200061	4	318.0	317.5	0.5
G10	Joppa East	832089	198700	4	313.5	315.2	-1.7
G21S	Joppa East	834352	196564	4	305.6	306.3	-0.7
G09	Joppa East	832589	198357	4	312.4	314.5	-2.1
TPZ117D	Joppa West	829987	197892	4	301.2	302.3	-1.2
G24S	Joppa East	836033	197026	4	306.0	308.2	-2.1
TPZ119DD	Joppa West	831138	200516	4	318.4	318.4	-0.1
G23S	Joppa East	836051	198940	4	313.2	313.3	0.0
G14S	Joppa East	834653	197097	4	304.8	308.6	-3.8
G17S	Joppa East	835111	198803	4	313.6	313.4	0.2
G03	Joppa East	833699	202118	4	320.2	320.3	-0.1
G07	Joppa East	834089	198591	4	315.2	313.6	1.6
G13S	Joppa East	834598	198270	4	310.4	312.3	-1.9
G04	Joppa East	834001	201154	4	319.0	318.6	0.4
G11	Joppa East	831953	199843	4	319.7	317.0	2.7
G01D	Joppa West	831716	202039	4	321.0	321.1	-0.1
G05	Joppa East	834089	200844	4	319.0	318.0	1.0
TPZ123	Joppa West	830028	201784	4	320.7	320.1	0.5
G02D	Joppa East	832843	202137	4	320.6	320.6	0.0

TABLE A2. CURRENT CONDITIONS FLOW MODEL CALIBRATION TARGETS AND STATISTICS

Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	Unit	X	Y	Layer	Observed GWE (feet NAVD88)	Simulated GWE (feet NAVD88)	Residual (observed-simulated, feet)
G51D	Joppa East	832152	200430	4	320.1	317.9	2.2
G53D	Joppa East	833980	200075	4	318.7	316.6	2.1
G54D	Joppa East	831610	199067	4	314.7	315.7	-1.0
Well_2	Joppa West	830912	197457	4	301.7	302.0	-0.3
Well_3	Joppa East	832373	196800	4	301.5	302.7	-1.2
G22D	Joppa East	835260	196326	6	305.1	305.5	-0.4
G16D	Joppa East	833584	197196	6	306.2	308.7	-2.5
G15D	Joppa East	834112	197189	6	304.9	309.2	-4.3
G20D	Joppa East	834992	197096	6	306.3	308.4	-2.2
G20M	Joppa East	834995	197096	8	318.5	320.8	-2.3
G21M	Joppa East	834359	196575	8	318.9	320.2	-1.3
G09M	Joppa East	832585	198359	8	317.3	319.3	-2.0
G13M	Joppa East	834565	198271	9	316.5	321.2	-4.8

NOTES:
GWE = groundwater elevation
NAVD88 = North American Vertical Datum of 1988

Calibration Statistics	
Residual Mean	-0.14
Absolute Residual Mean	2.68
Residual Std. Deviation	4.09
Sum of Squares	1221.6
RMS Error	4.1
Min. Residual	-12.4
Max. Residual	16.6
Number of Observations	73.0
Range in Observations	71.1
10% of Range	7.11

APPENDIX A TABLE A3. HISTORICAL TRANSPORT MODEL CALIBRATION TARGETS AND STATISTICS

TABLE A3. HISTORICAL TRANSPORT MODEL CALIBRATION TARGETS AND STATISTICS

Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	X	Y	Screen Depth (feet bgs)	Model Layer	Boron Concentration (mg/L)		Residual (Observed - Simulated)
					Observed	Simulated	
G01D	831716	202039	(54-64)	4	0.02	0.00	0.0
G02D	832843	202137	(62-72)	4	0.06	0.00	0.1
G03	833699	202118	(55-65)	4	0.33	0.05	0.3
G04	834001	201154	(50-60)	4	0.02	1.17	-1.1
G05	834089	200844	(50-60)	4	0.15	1.56	-1.4
G06	834115	199293	(75-85)	4	3.34	4.14	-0.8
G07	834089	198591	(50-60)	4	4.62	5.00	-0.4
G08	833493	198423	(75-85)	4	4.42	6.16	-1.7
G09	832589	198357	(60-70)	4	3.19	5.44	-2.2
G10	832089	198700	(60-70)	4	4.38	4.23	0.2
G11	831953	199843	(56-66)	4	0.33	0.71	-0.4
G112D	829115	198539	(60-65)	4	0.03	0.00	0.0
G12S	834634	198795	(60-70)	4	5.92	2.06	3.9
G12D	834634	198795	(80-90)	4	6.53	2.06	4.5
G13S	834598	198270	(50-60)	4	5.29	3.08	2.2
G13D	834598	198270	(80-90)	4	5.00	3.08	1.9
G14S	834653	197097	(53-63)	4	3.65	3.60	0.1
G14D	834653	197098	(120-130)	6	0.04	0.17	-0.1
G15S	834112	197199	(50-60)	4	1.06	5.78	-4.7
G15D	834112	197189	(83-93)	5	6.09	5.14	1.0
G16S	833584	197196	(50-60)	4	6.97	8.08	-1.1
G16D	833584	197196	(98-108)	6	6.20	6.07	0.1
G17S	835111	198803	(65-75)	4	2.62	0.10	2.5
G18S	835369	199521	(75-85)	4	1.64	0.00	1.6
G19S	835759	197689	(62-72)	4	0.56	0.00	0.6
G19D	835757	197685	(87-97)	4	0.60	0.00	0.6
G20S	834989	197096	(60-70)	4	4.09	1.63	2.5
G20D	834992	197096	(85-95)	5	2.69	1.24	1.5
G21S	834352	196564	(60-70)	4	4.33	4.83	-0.5
G22S	835260	196322	(65-75)	4	1.25	0.50	0.7
G22D	835260	196326	(107-117)	6	0.62	0.05	0.6
G23S	836051	198940	(70-80)	4	0.72	0.00	0.7
G24S	836033	197026	(66-76)	4	0.69	0.00	0.7
G51D	832152	200430	(50-59)	4	0.46	0.63	-0.2
G53D	833980	200075	(47-57)	4	0.35	3.85	-3.5
G54D	831610	199067	(70-80)	4	0.05	0.73	-0.7
Well_3	832373	196800	(40-50)	4	0.59	2.99	-2.4
G13M	834565	198271	(215-225)	9	0.03	0.00	0.0
G20M	834995	197096	(175-185)	8	0.04	0.00	0.0
G21M	834359	196575	(156-166)	8	0.02	0.00	0.0
G09M	832585	198359	(145-155)	7	0.04	0.00	0.0

TABLE A3. HISTORICAL TRANSPORT MODEL CALIBRATION TARGETS AND STATISTICS

Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	X	Y	Screen Depth (feet bgs)	Model Layer	Boron Concentration (mg/L)		Residual (Observed - Simulated)
					Observed	Simulated	
G113	830366	199600	(30-40)	2	0.03	0.00	0.0

Notes
Target time is 49 years elapsed time from beginning of simulation, corresponding to early 2022.
Boron concentrations were averaged from available data for 2014-2023
bgs = below ground surface
mg/L = milligrams per Liter
X = latitude
Y = longitude

APPENDIX A TABLE A4. PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP

TABLE A4. PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP

Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	2022 Simulated Boron Concentration (mg/L)	Target Value (Average Boron Concentration [mg/L])	Year 0 Predicted Boron Concentration (mg/L)	CIP Years to Meet GWPS
G01D	0.00	0.02	0.00	
G02D	0.00	0.06	0.00	
G03	0.05	0.33	0.06	
G04	1.17	0.02	1.01	
G05	1.56	0.15	1.33	
G06	4.14	3.34	4.13	6.2
G07	5.00	4.62	4.81	7.3
G08	6.16	4.42	5.17	6.4
G09	5.44	3.19	5.21	7.0
G10	4.23	4.38	4.03	5.0
G11	0.71	0.33	0.66	
G112D	0.00	0.03	0.00	
G12S	2.06	5.92	1.90	
G12D	2.06	6.53	1.90	
G13S	3.08	5.29	3.08	5.3
G13D	3.08	5.00	3.08	5.3
G14S	3.60	3.65	3.53	7.3
G14D	0.17	0.04	0.17	
G15S	5.78	1.06	5.75	
G15D	5.14	6.09	4.98	8.7
G16S	8.08	6.97	7.41	**11.1**
G16D	6.07	6.20	5.90	9.3
G17S	0.10	2.62	0.09	
G18S	0.00	1.64	0.00	
G19S	0.00	0.56	0.00	
G19D	0.00	0.60	0.00	
G20S	1.63	4.09	1.48	
G20D	1.24	2.69	1.19	
G21S	4.83	4.33	4.83	8.8
G22S	0.50	1.25	0.45	
G22D	0.05	0.62	0.05	
G23S	0.00	0.72	0.00	
G24S	0.00	0.69	0.00	
G51D	0.63	0.46	0.51	
G53D	3.85	0.35	3.61	
G54D	0.73	0.05	0.83	
Well_3	2.99	0.59	3.23	

TABLE A4. PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP

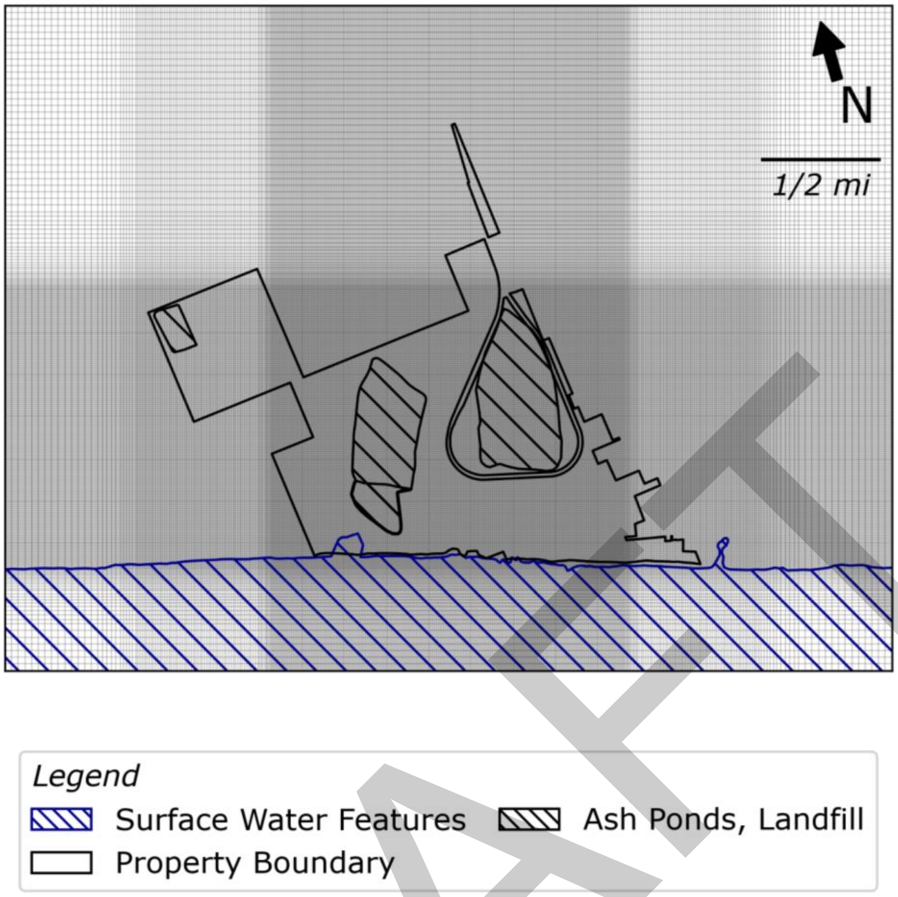
Groundwater Modeling Technical Memorandum
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	2022 Simulated Boron Concentration (mg/L)	Target Value (Average Boron Concentration [mg/L])	Year 0 Predicted Boron Concentration (mg/L)	CIP Years to Meet GWPS
G13M	0.00	0.03	0.00	
G20M	0.00	0.04	0.00	
G21M	0.00	0.02	0.00	
G09M	0.00	0.04	0.00	
G113	0.00	0.03	0.00	

Notes:
CBR = closure by removal
CIP = closure in place
GWPS = groundwater protection standard
mg/L = milligrams per liter
Blue shaded cells contain <2 mg/L average Target boron concentrations
Gray shaded cells include the 12 monitoring wells that were carried forward for predictive modeling

APPENDIX A FIGURES A1 THROUGH A30

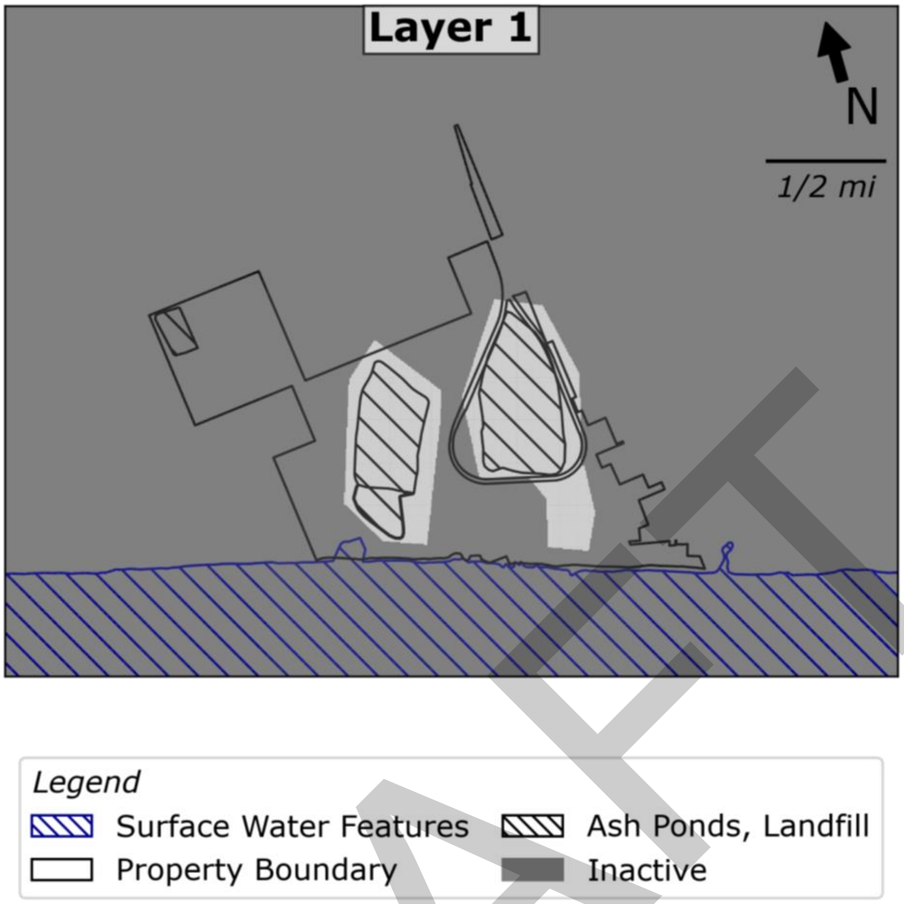
APPENDIX FIGURE A1



MODEL GRID

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

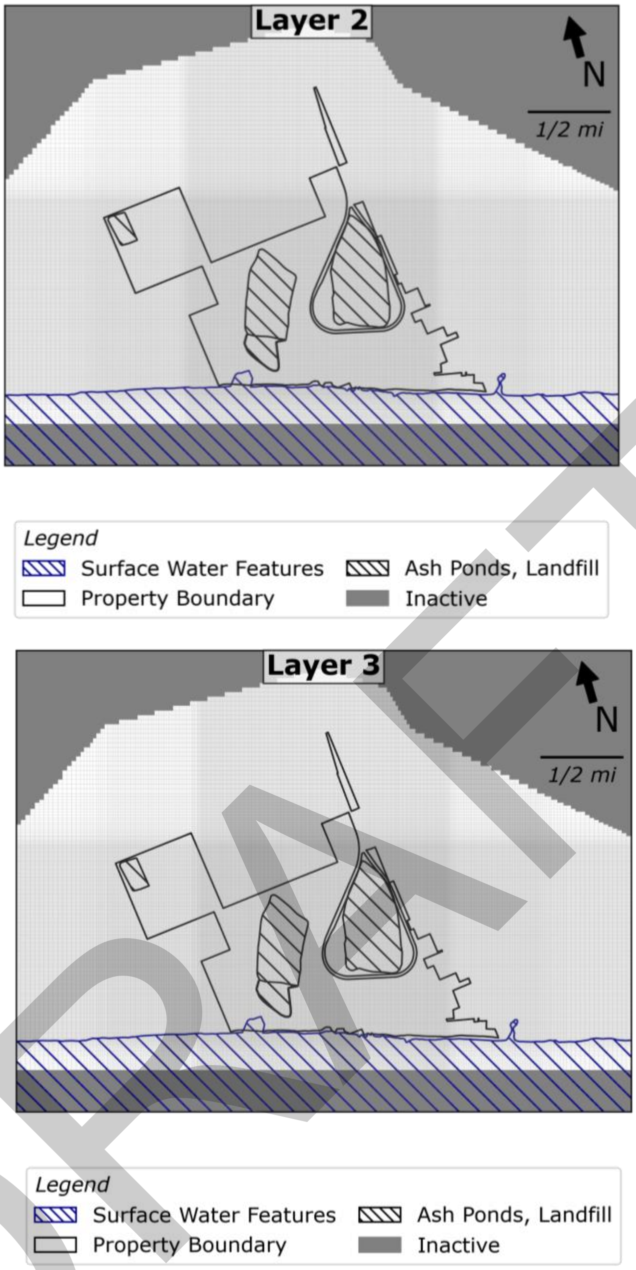
APPENDIX FIGURE A2



BOUNDARY CONDITIONS, MODEL LAYER 1

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

APPENDIX FIGURE A3

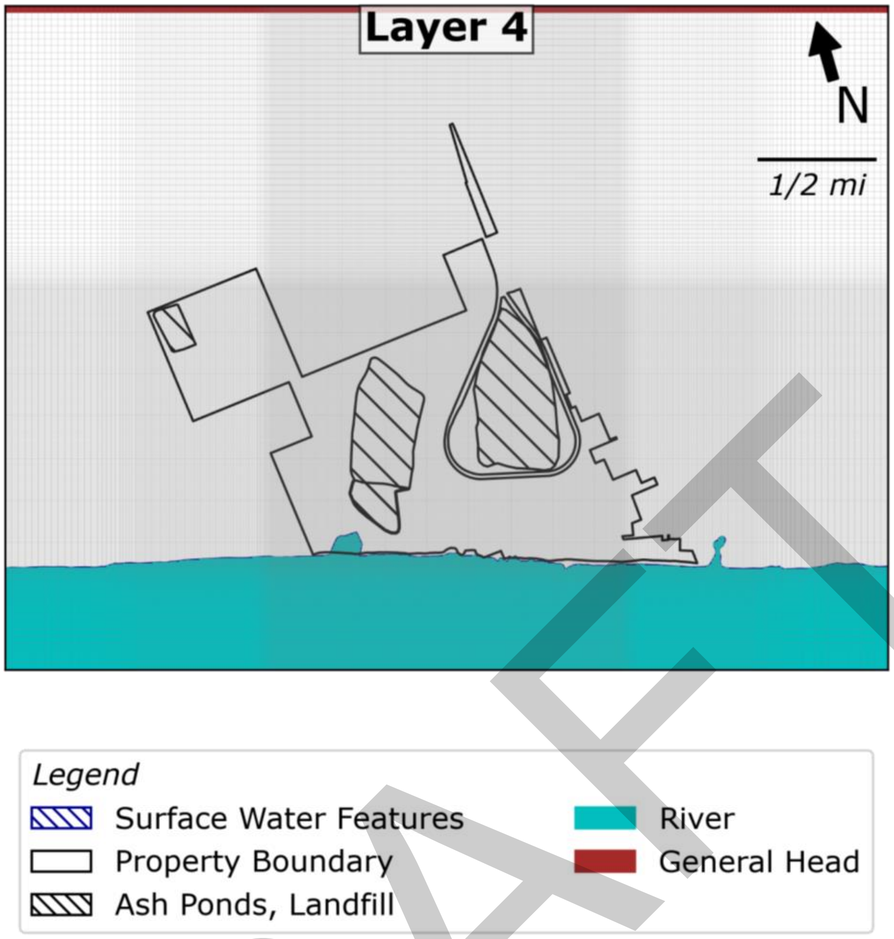


BOUNDARY CONDITIONS, MODEL LAYERS 2 AND 3

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

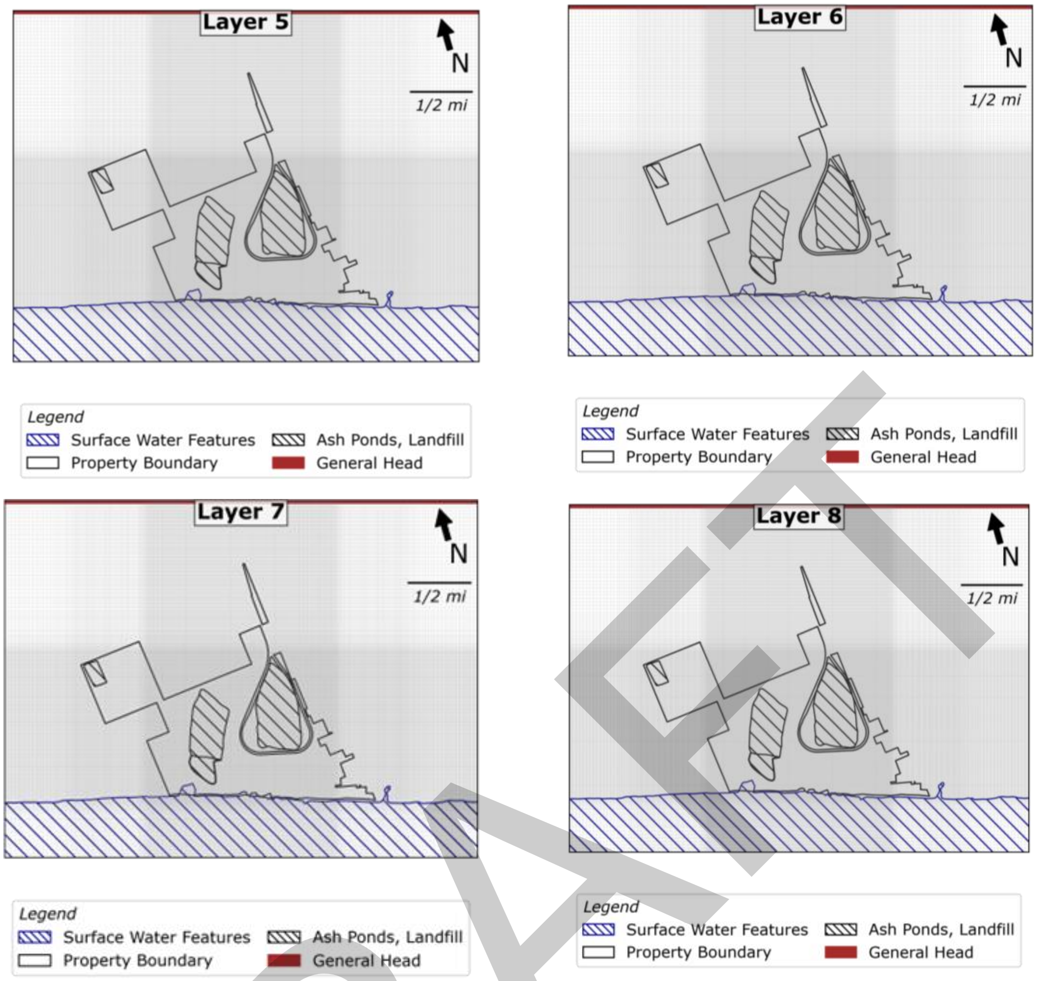
APPENDIX FIGURE A4



BOUNDARY CONDITIONS, MODEL LAYER 4

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

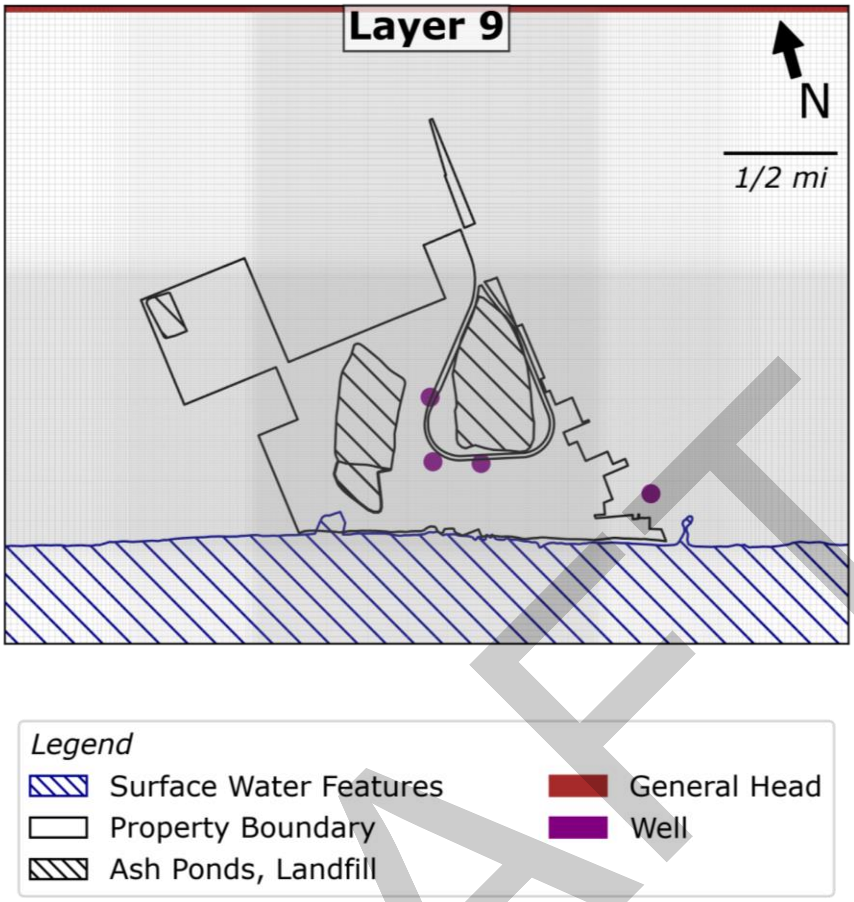
APPENDIX FIGURE A5



BOUNDARY CONDITIONS, MODEL LAYERS 5 THROUGH 8

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

APPENDIX FIGURE A6

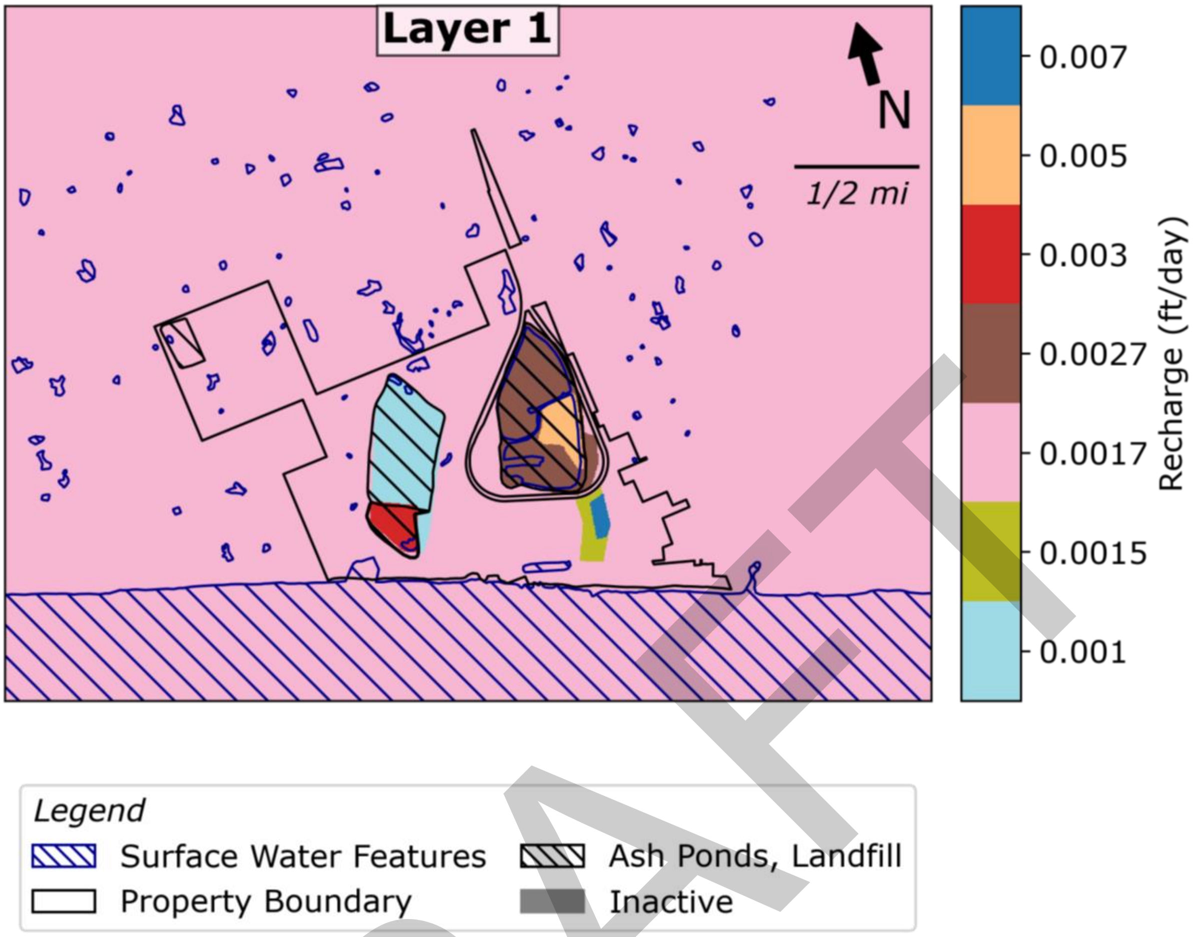


BOUNDARY CONDITIONS, MODEL LAYER 9

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

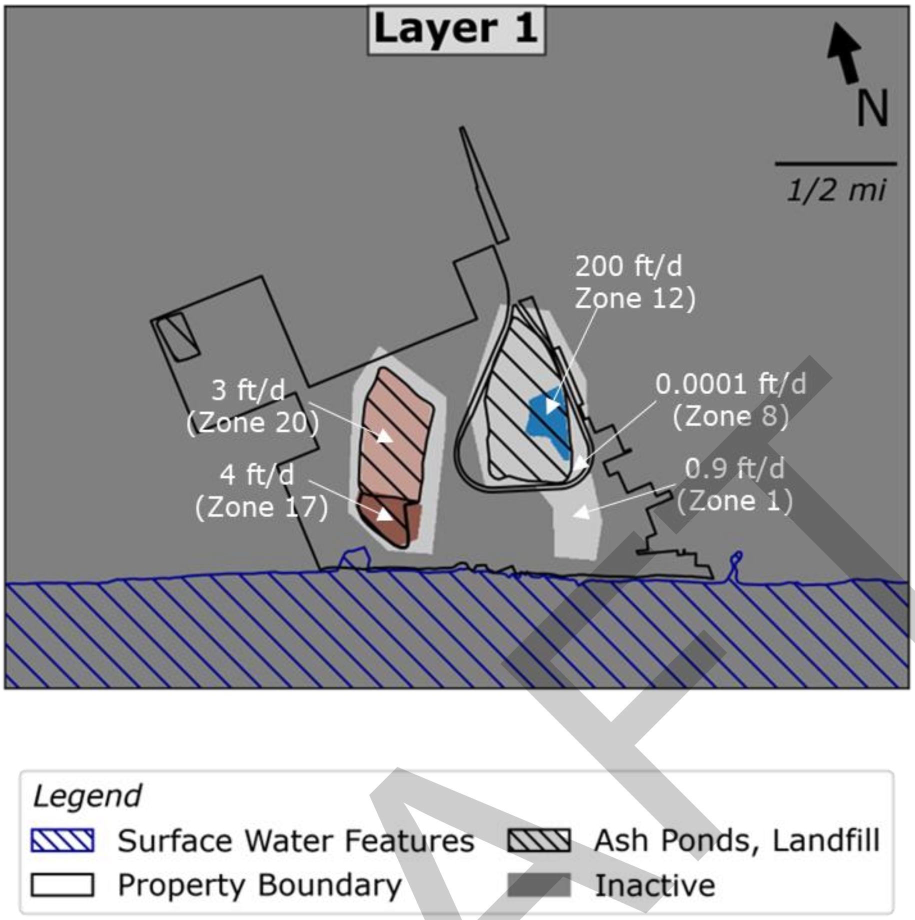
APPENDIX FIGURE A7



MODEL RECHARGE, STEADY-STATE FLOW MODEL

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

APPENDIX FIGURE A8



ASSIGNED HORIZONTAL HYDRAULIC CONDUCTIVITIES, MODEL LAYER 1

GROUNDWATER MODELING TECHNICAL MEMORANDUM
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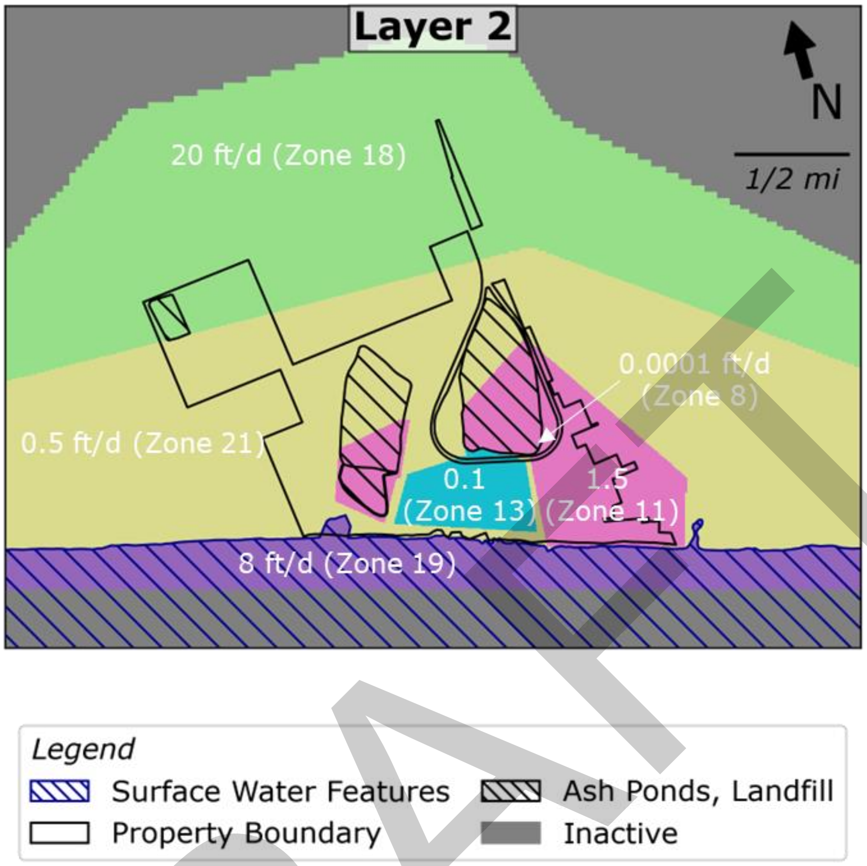
JOPPA POWER PLANT
JOPPA, ILLINOIS

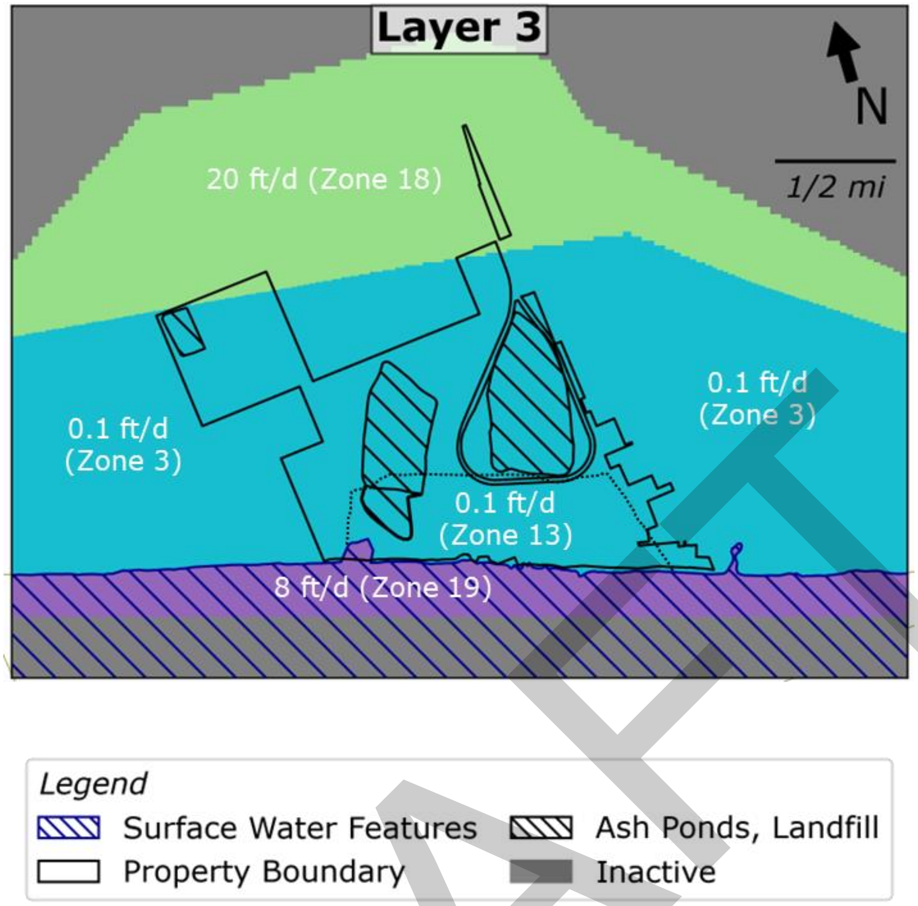
APPENDIX FIGURE A9



ASSIGNED HORIZONTAL HYDRAULIC CONDUCTIVITIES, MODEL LAYER 2

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

APPENDIX FIGURE A10



ASSIGNED HORIZONTAL HYDRAULIC CONDUCTIVITIES, MODEL LAYER 3

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

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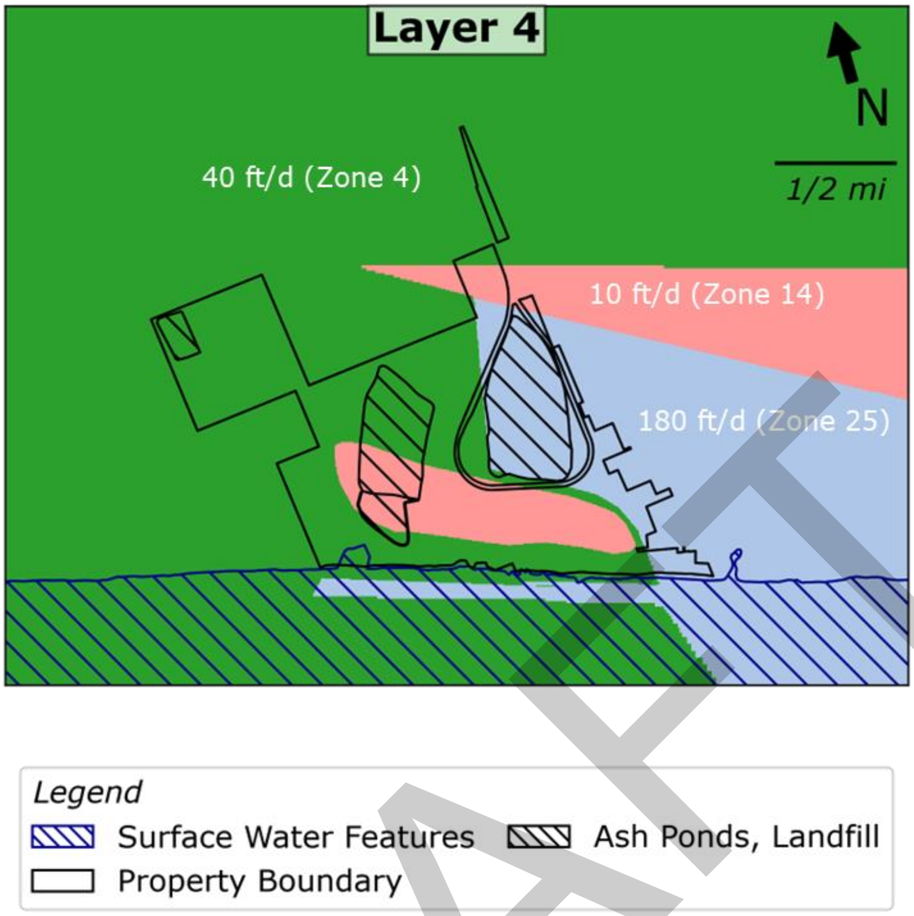
APPENDIX FIGURE A11



ASSIGNED HORIZONTAL HYDRAULIC CONDUCTIVITIES, MODEL LAYER 4

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
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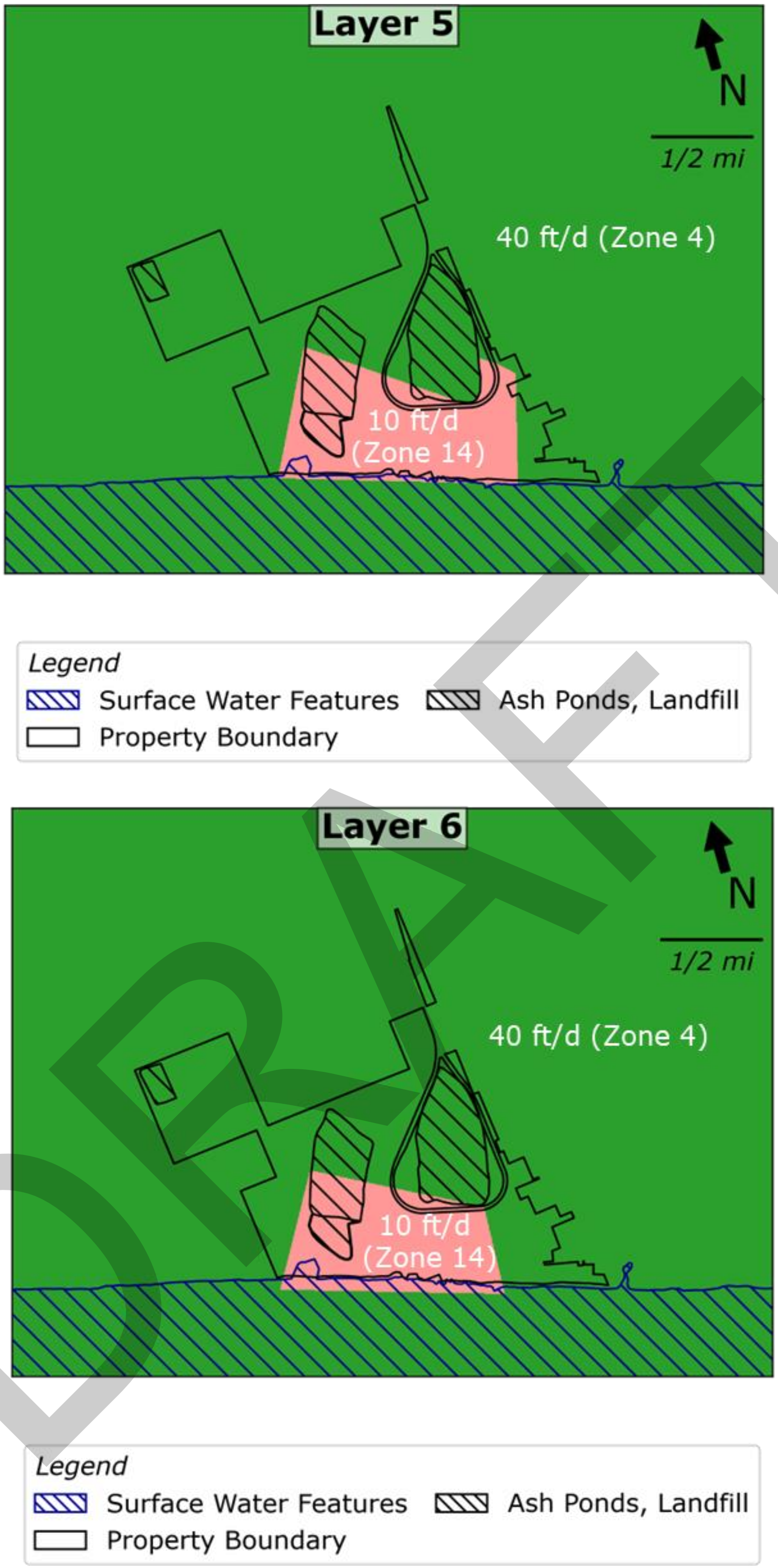

ASSIGNED HORIZONTAL HYDRAULIC CONDUCTIVITIES, MODEL LAYERS 5 AND 6

GROUNDWATER MODELING TECHNICAL MEMORANDUM
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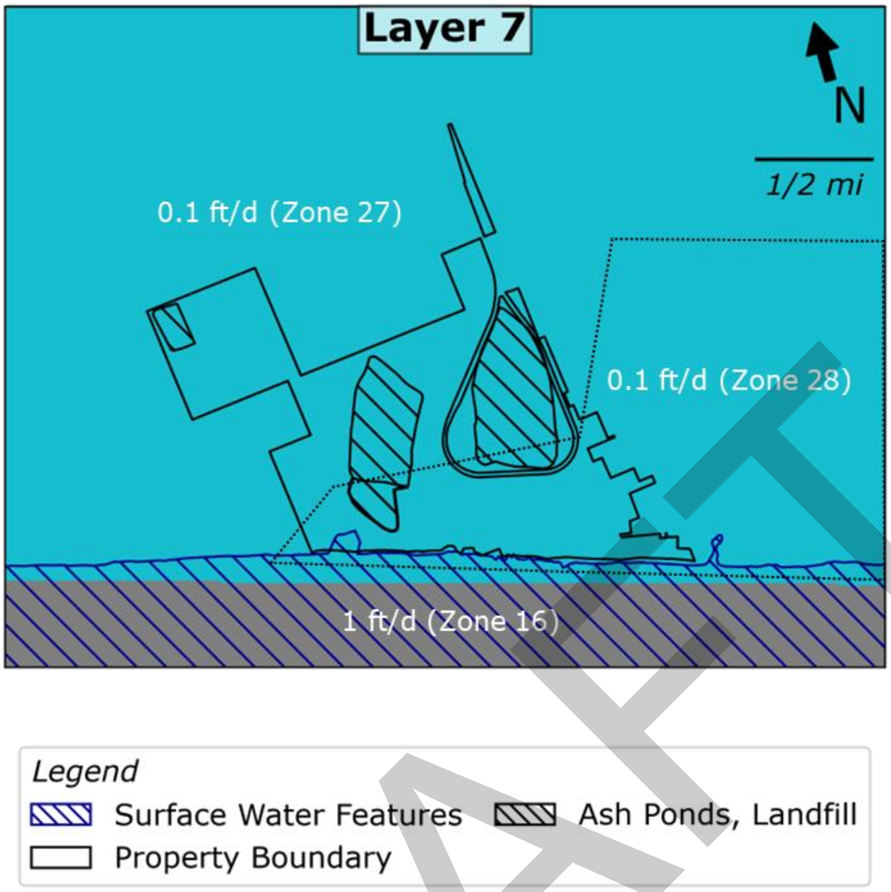
APPENDIX FIGURE A13



ASSIGNED HORIZONTAL HYDRAULIC CONDUCTIVITIES, MODEL LAYER 7

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
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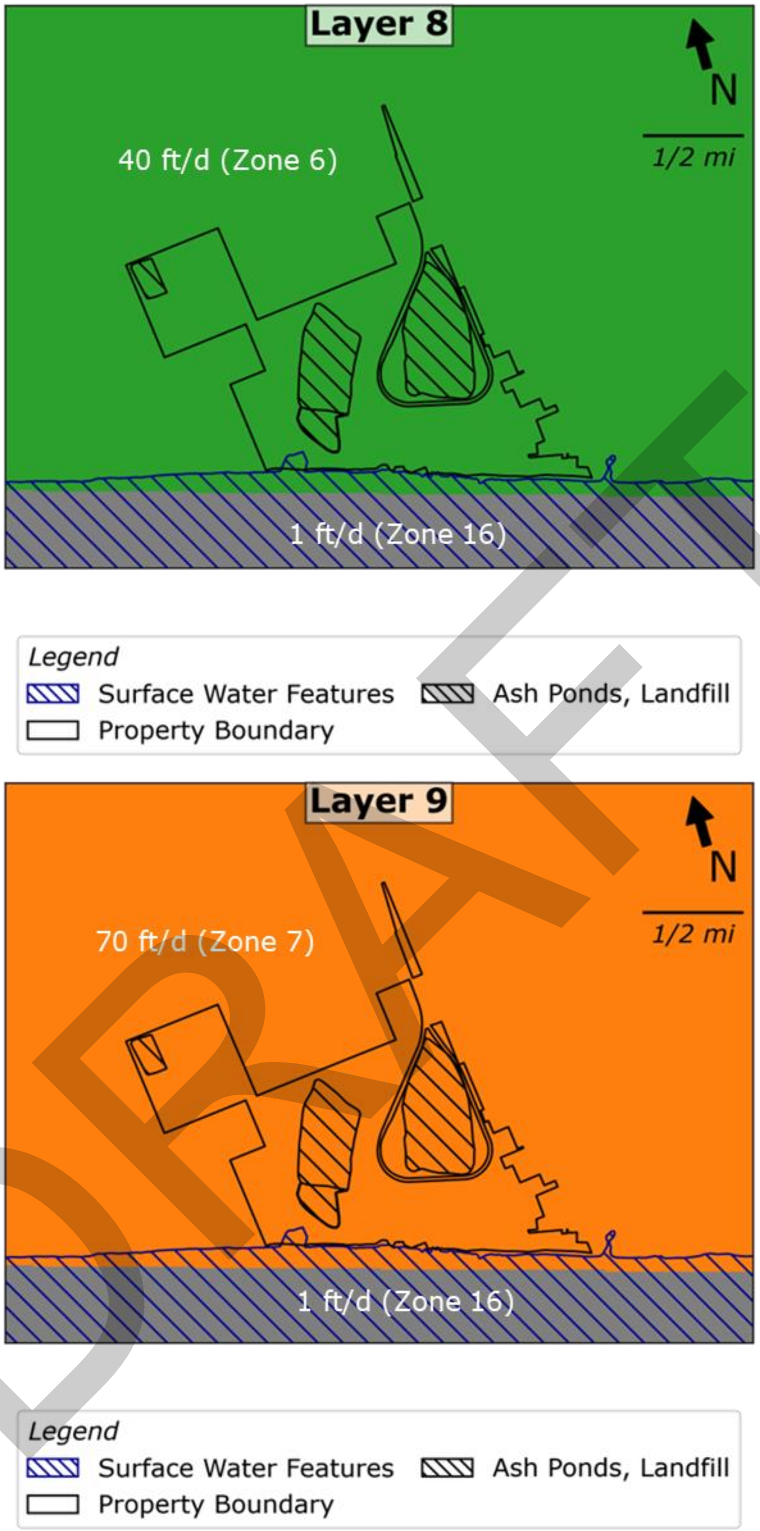
JOPPA, ILLINOIS

APPENDIX FIGURE A14



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GROUNDWATER MODELING TECHNICAL MEMORANDUM
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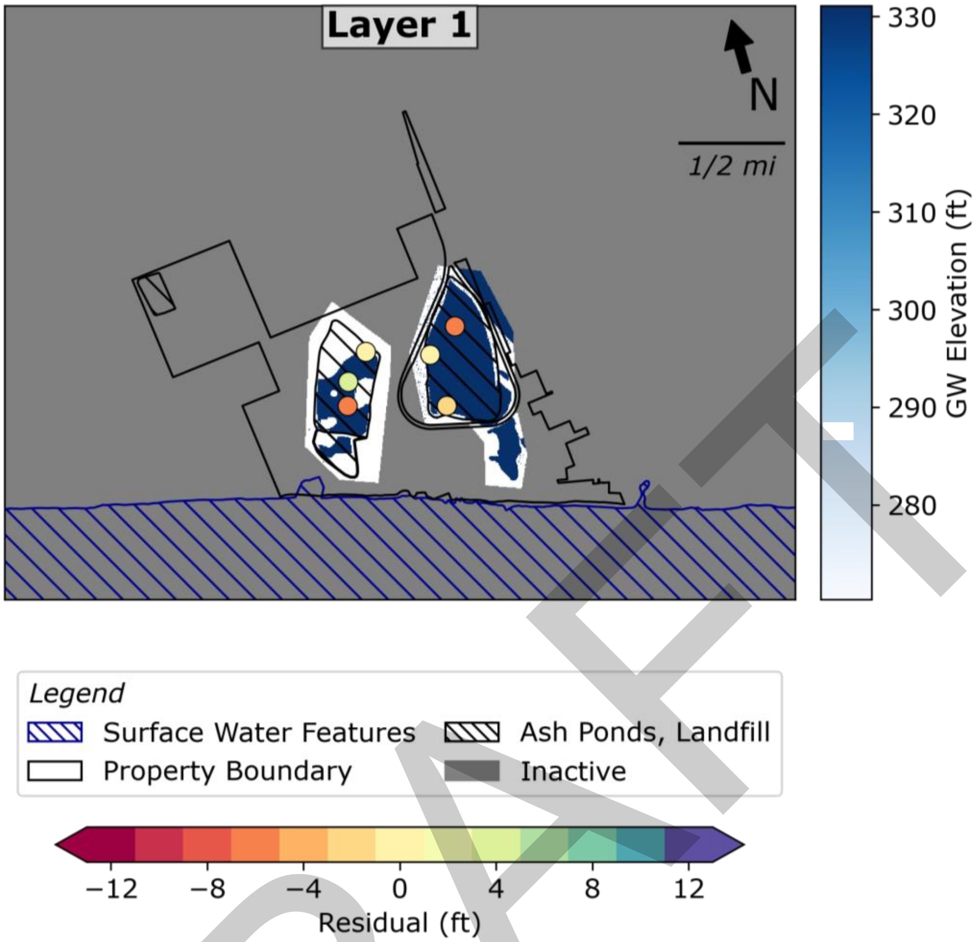
JOPPA POWER PLANT
JOPPA, ILLINOIS



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

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
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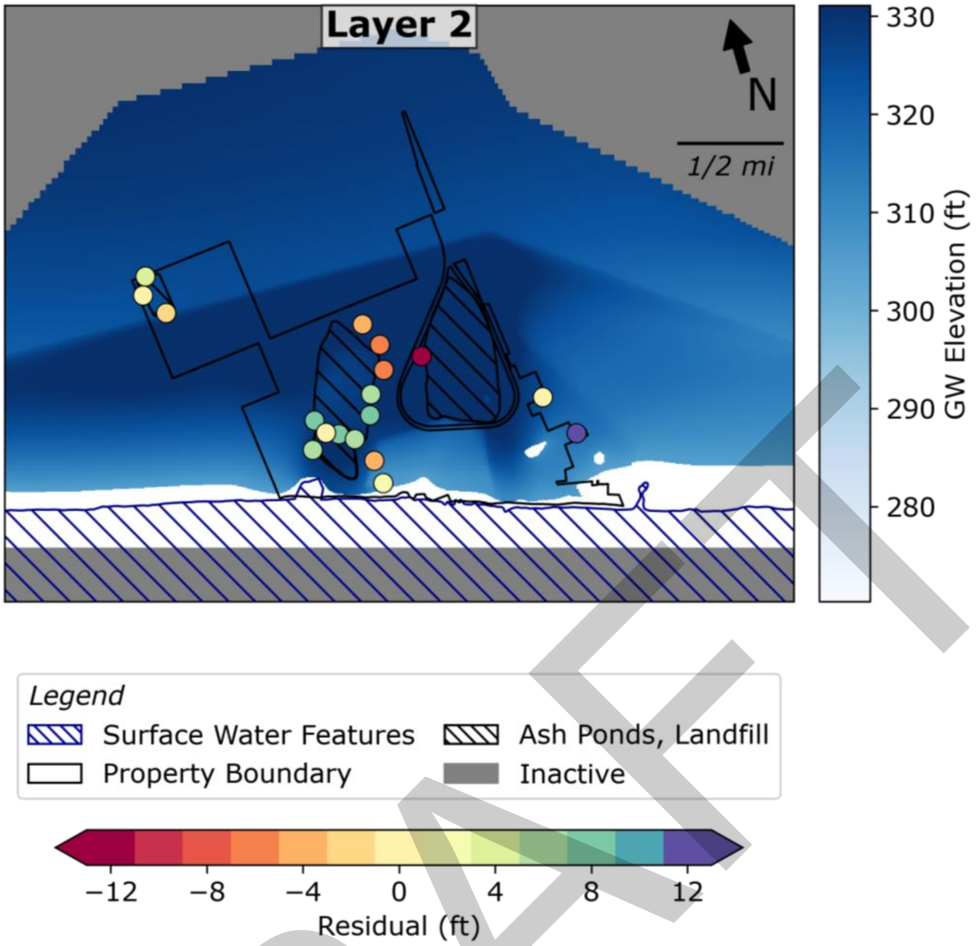
JOPPA, ILLINOIS



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

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
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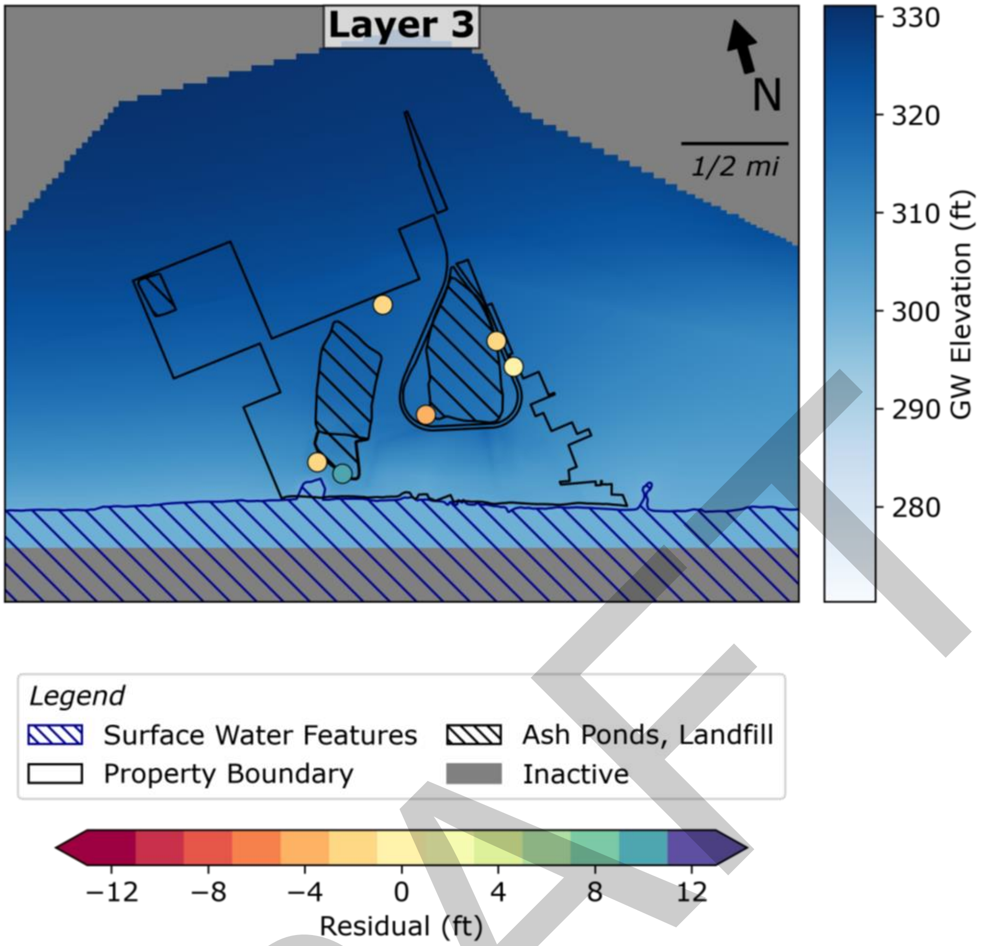
JOPPA, ILLINOIS

APPENDIX FIGURE A17



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

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
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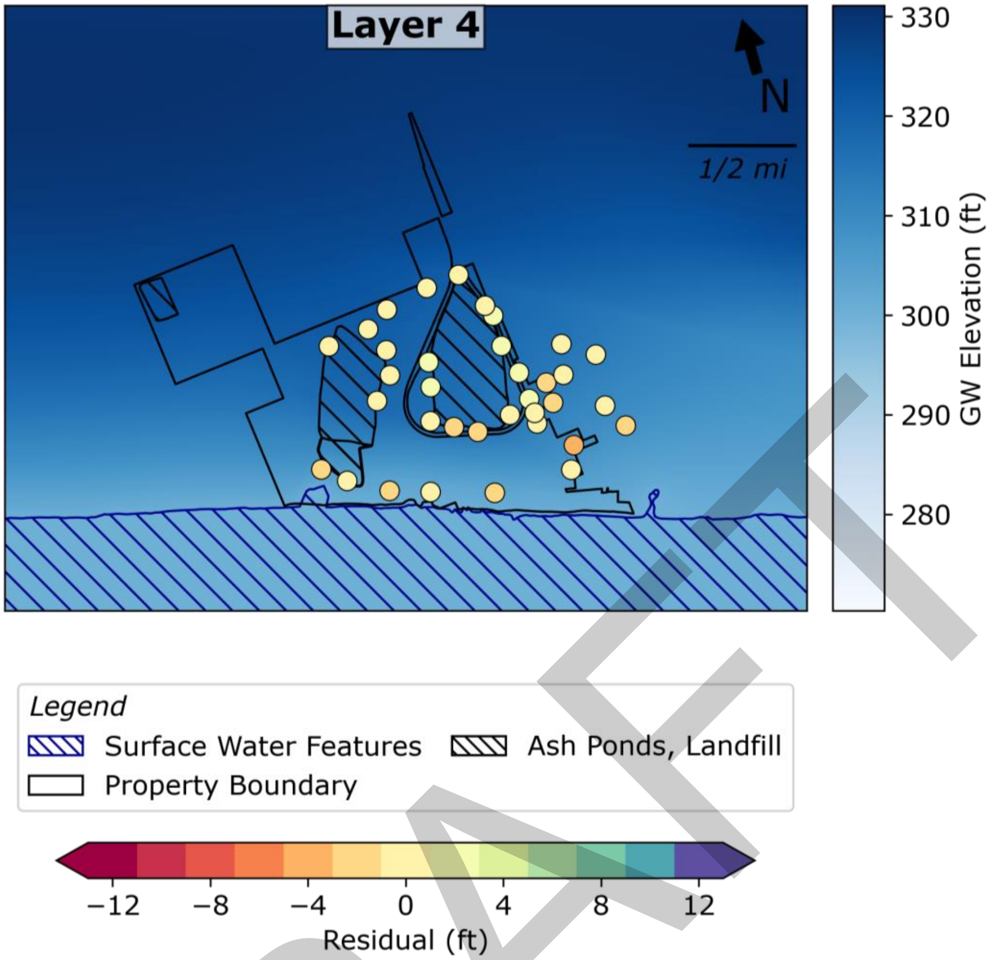
APPENDIX FIGURE A18



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

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
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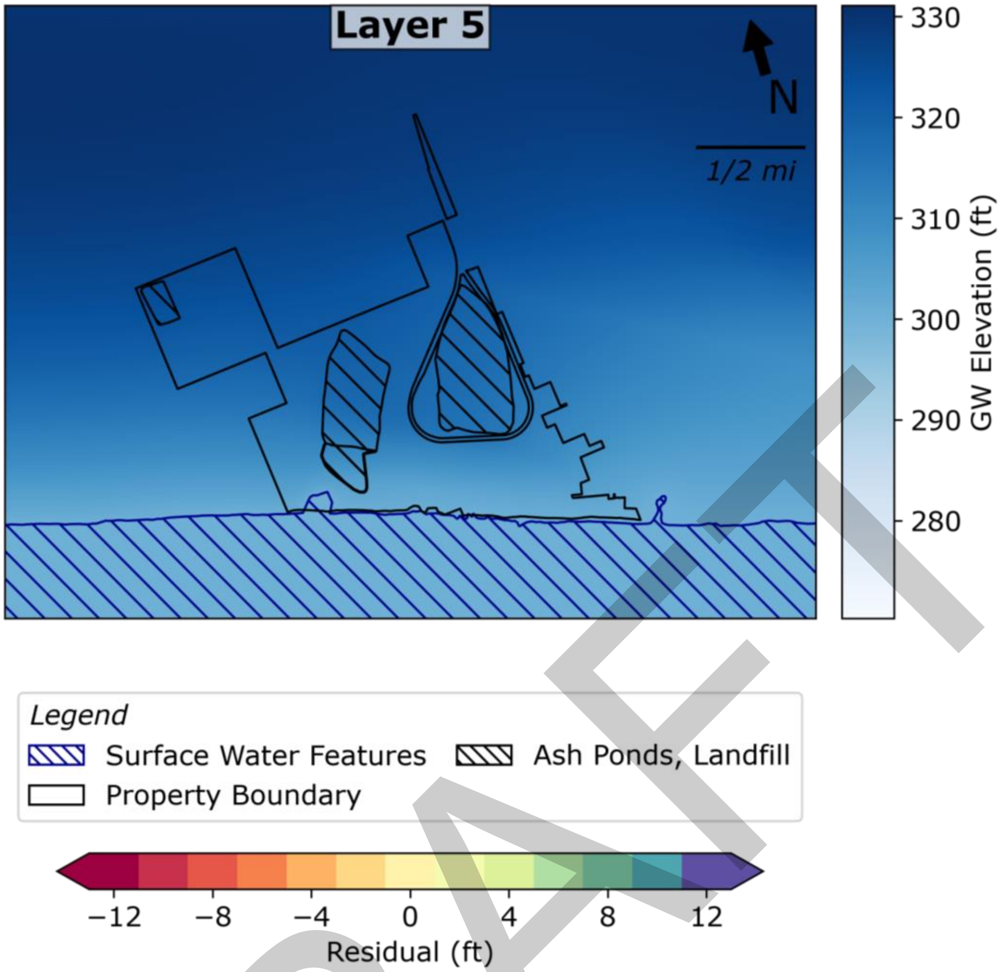

SIMULATED GROUNDWATER ELEVATIONS, FLOW MODEL,
MODEL LAYER 5

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
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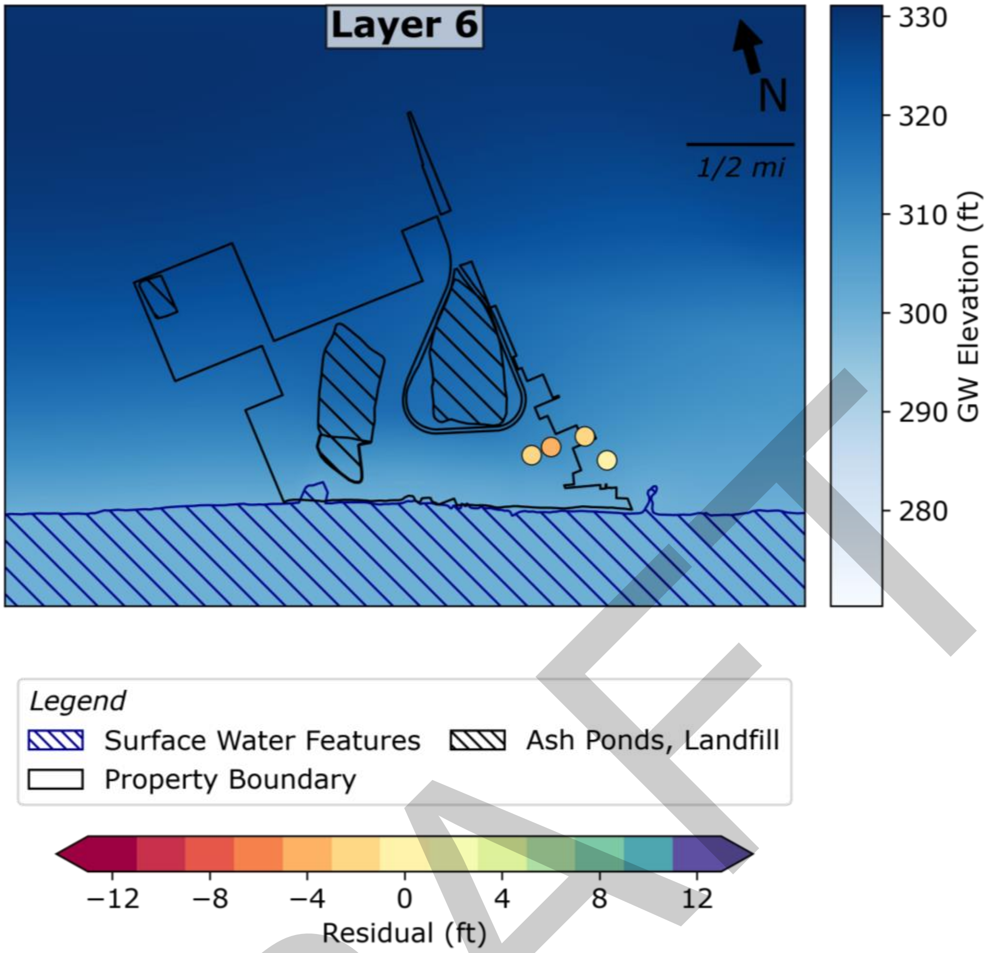
JOPPA, ILLINOIS



SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 6

GROUNDWATER MODELING TECHNICAL MEMORANDUM
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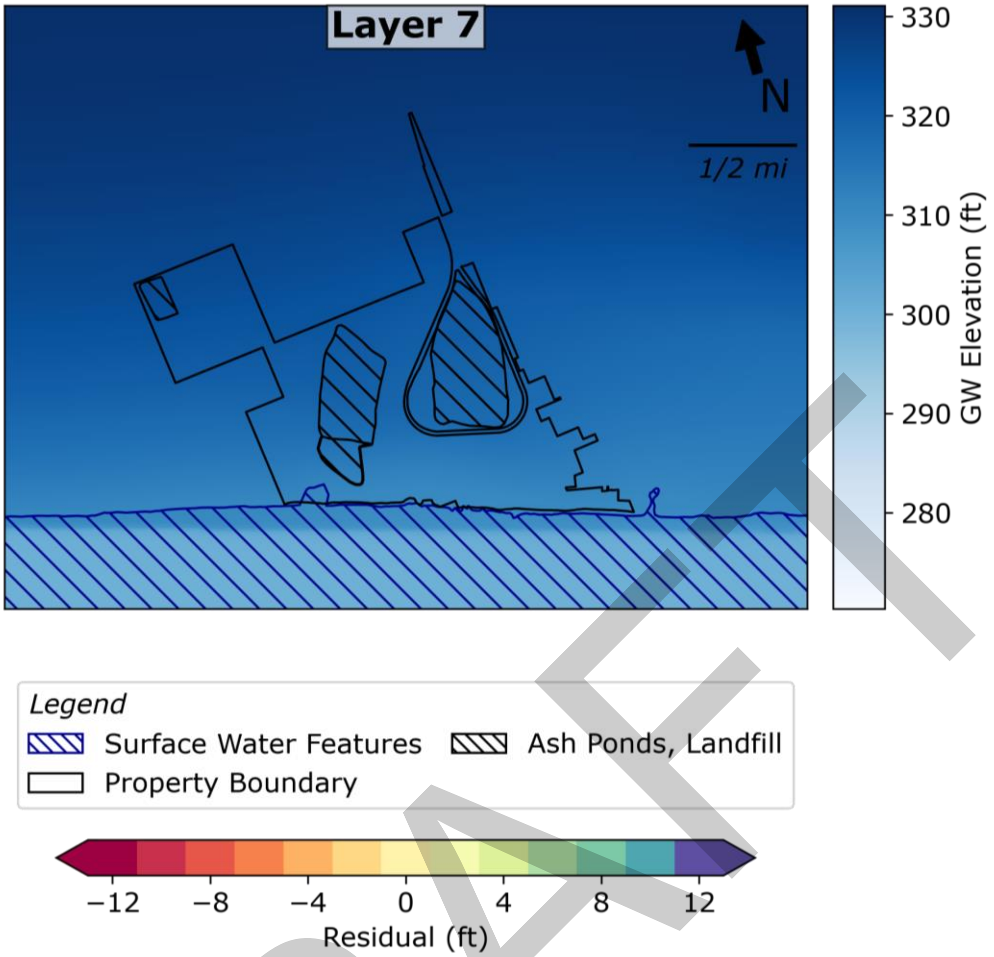
APPENDIX FIGURE A21



SIMULATED GROUNDWATER ELEVATIONS, FLOW MODEL,
MODEL LAYER 7

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
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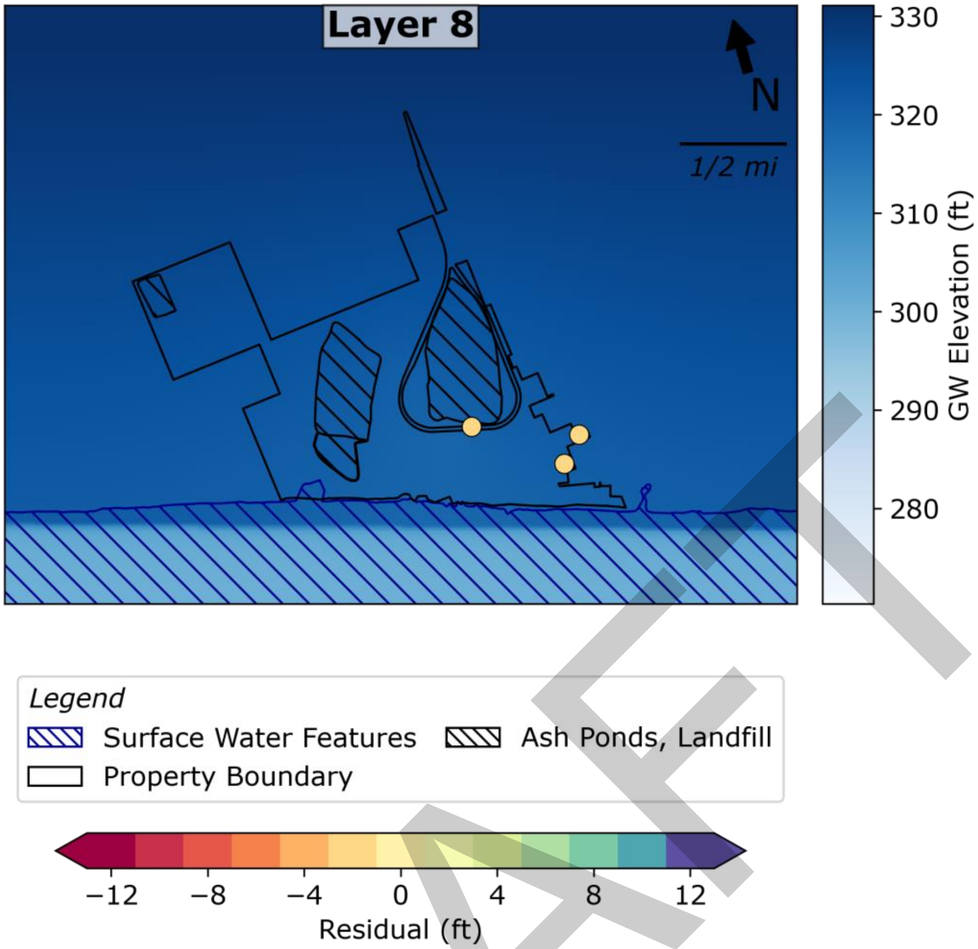
APPENDIX FIGURE A22



SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 8

G GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
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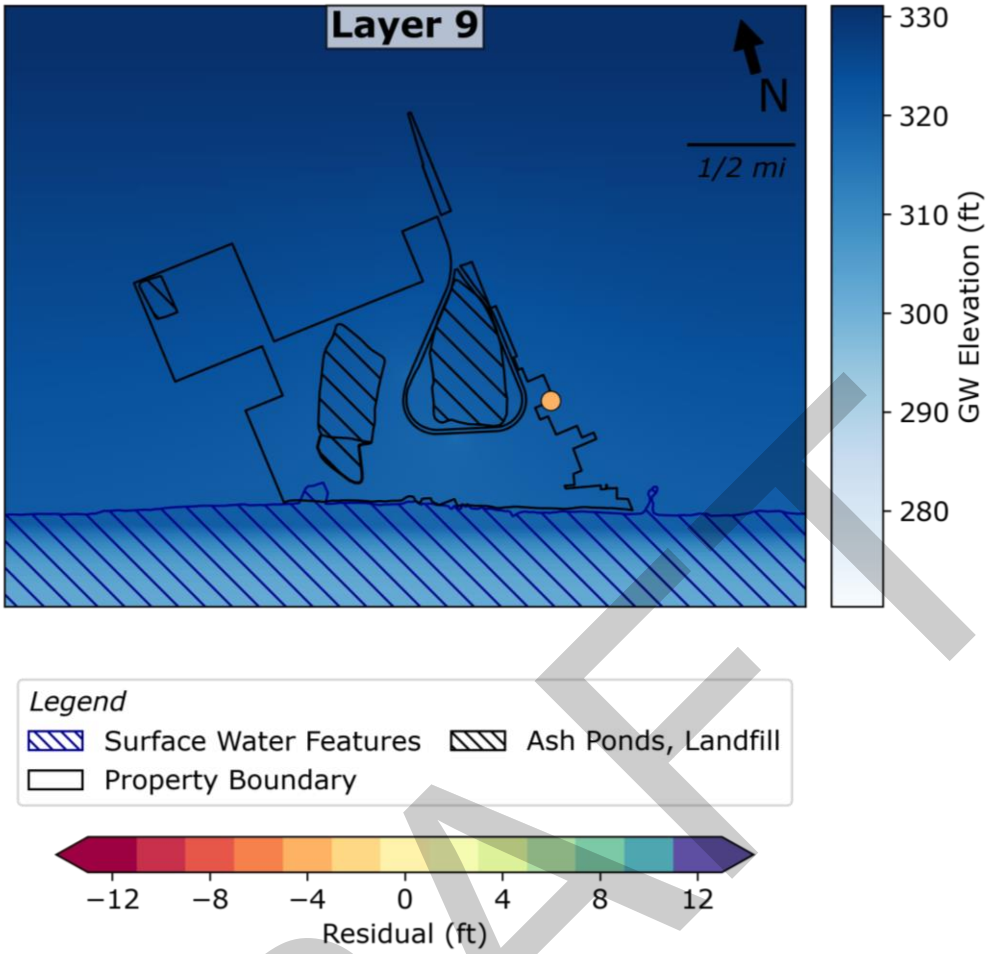
RAMBØLL



SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 9

GROUNDWATER MODELING TECHNICAL MEMORANDUM
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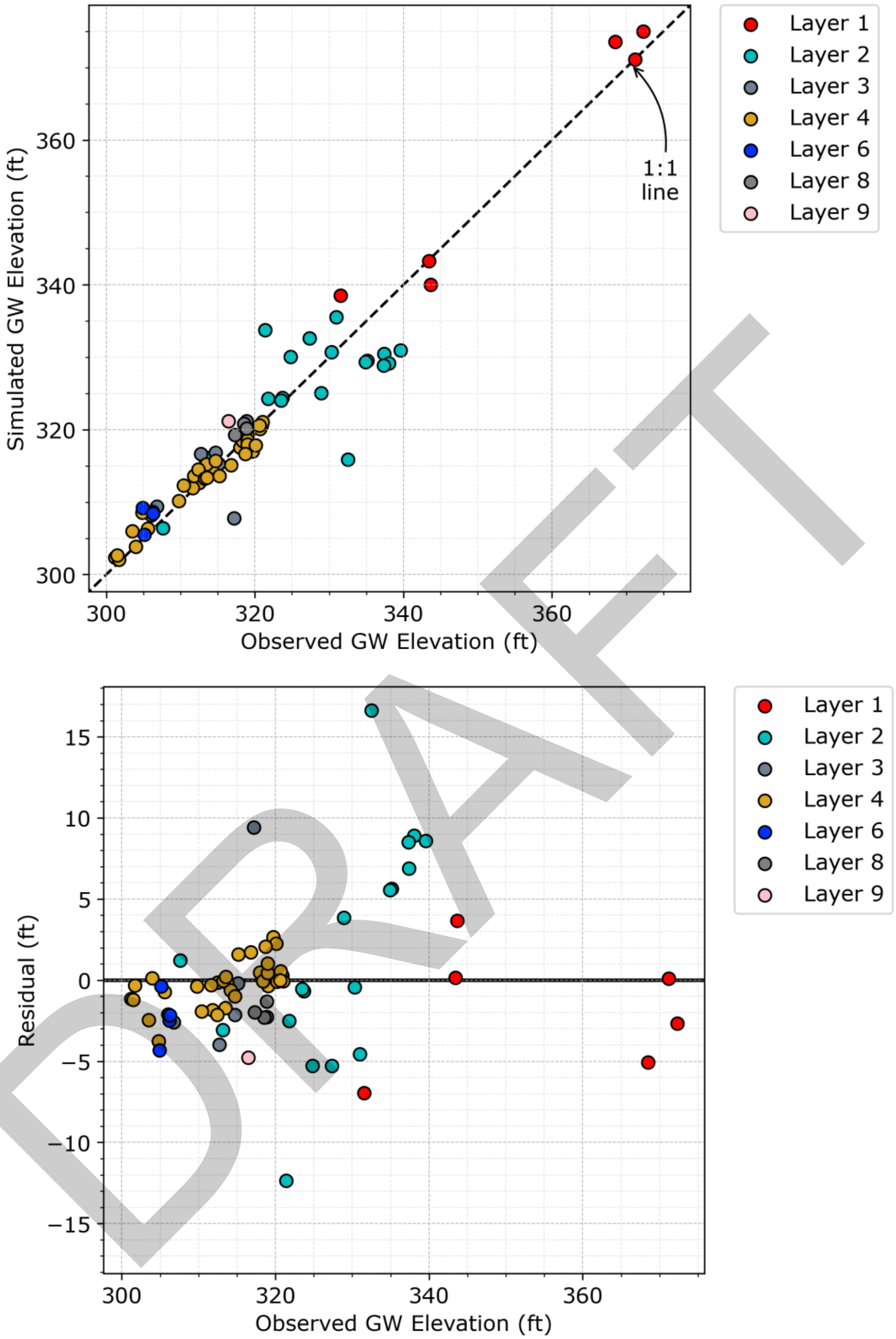
APPENDIX FIGURE A24



FLOW MODEL CALIBRATION PLOTS, OBSERVED VS SIMULATED GWE AND RESIDUALS

GROUNDWATER MODELING TECHNICAL MEMORANDUM
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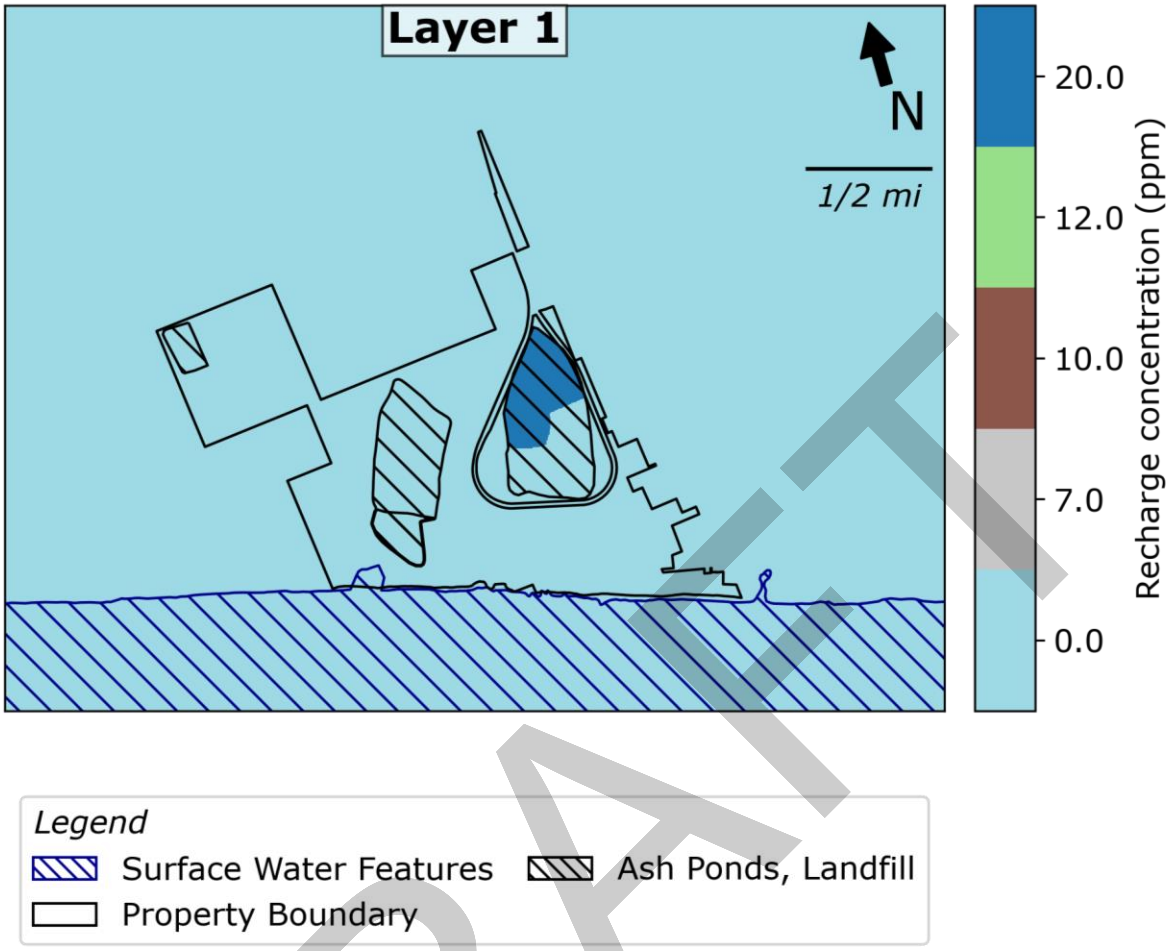

BORON RECHARGE, HISTORIC TRANSPORT MODEL, SP1

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
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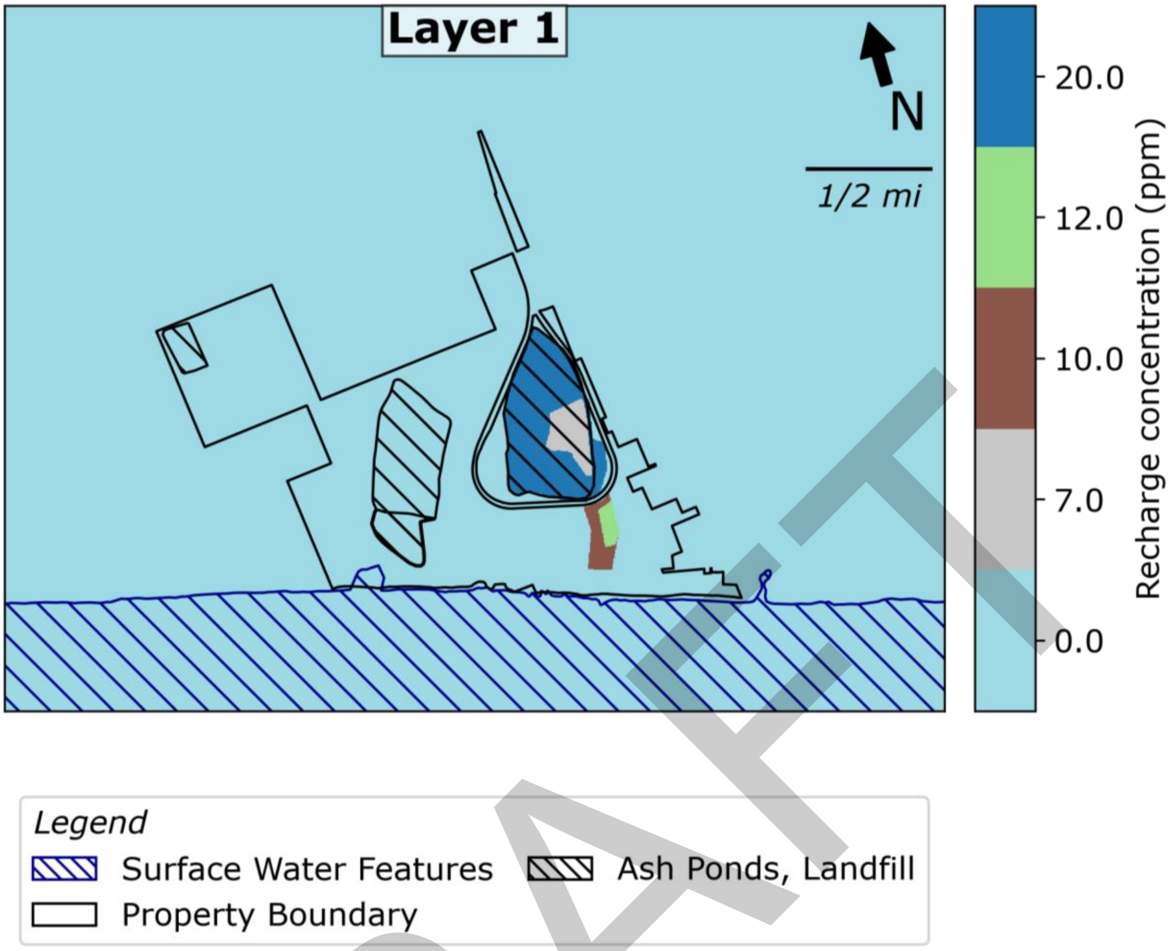
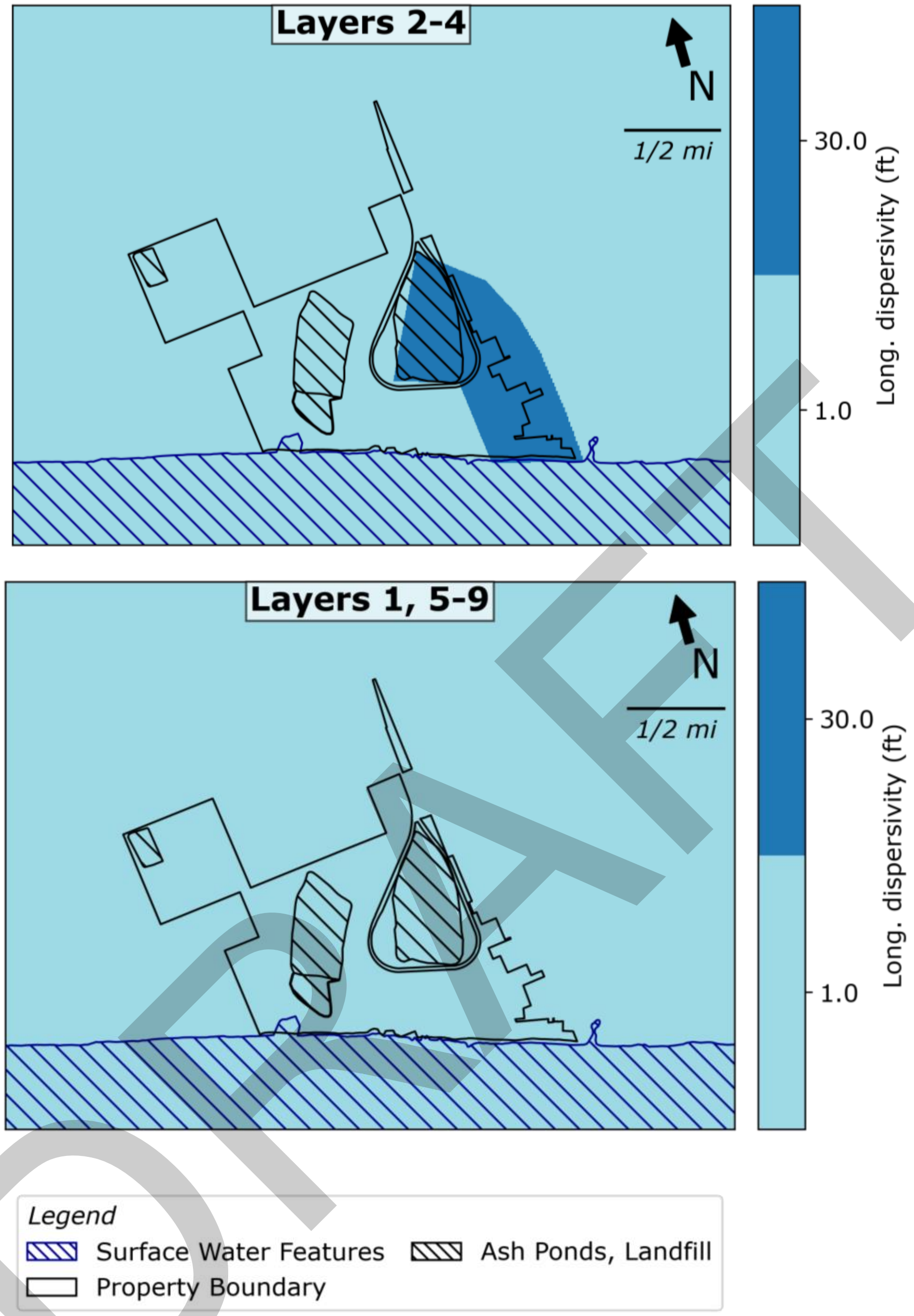
APPENDIX FIGURE A26



BORON RECHARGE, HISTORIC TRANSPORT MODEL, SP2 AND SP3

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

APPENDIX FIGURE A27

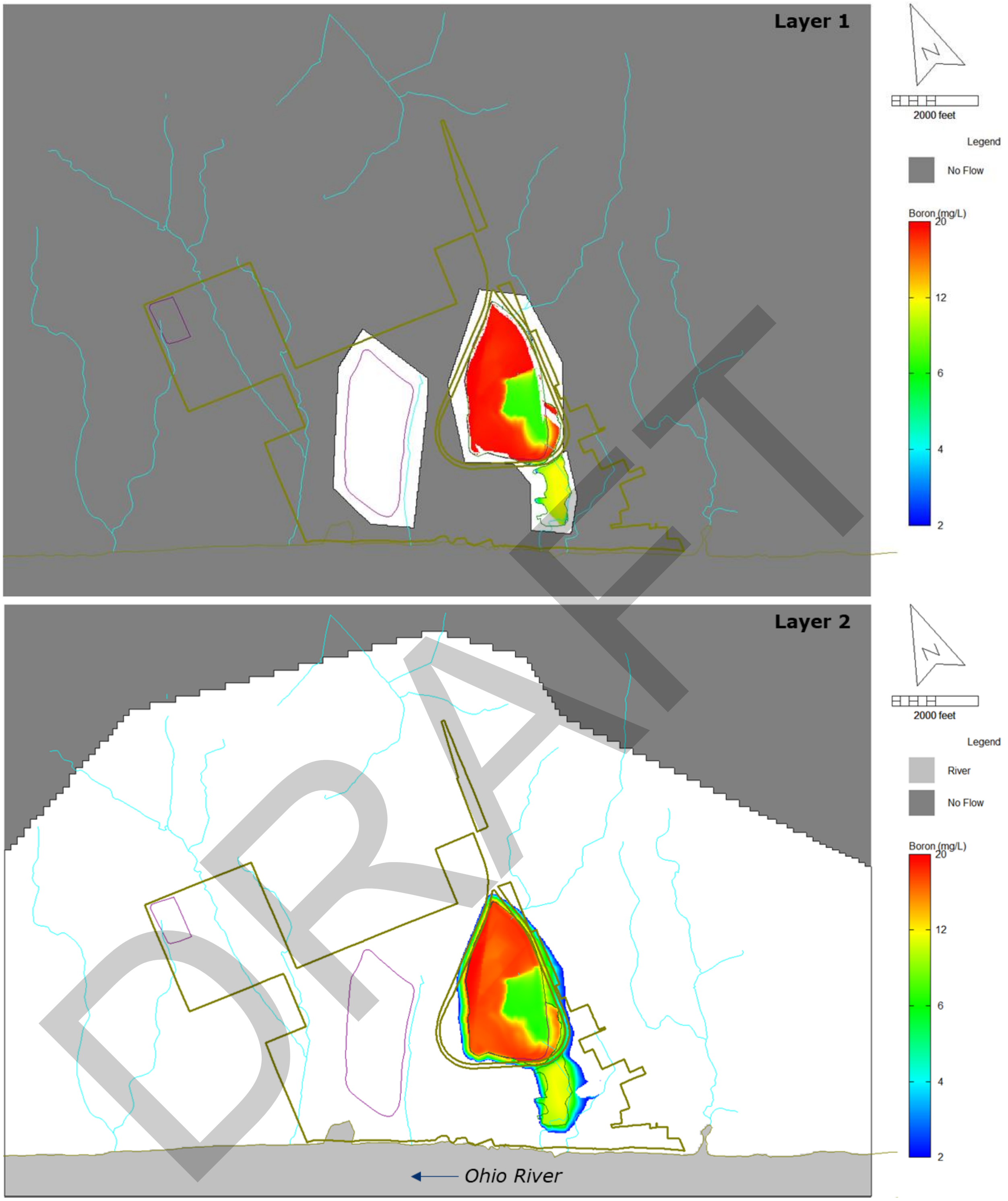


SIMULATED LONGITUDINAL DISPERSIVITY

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

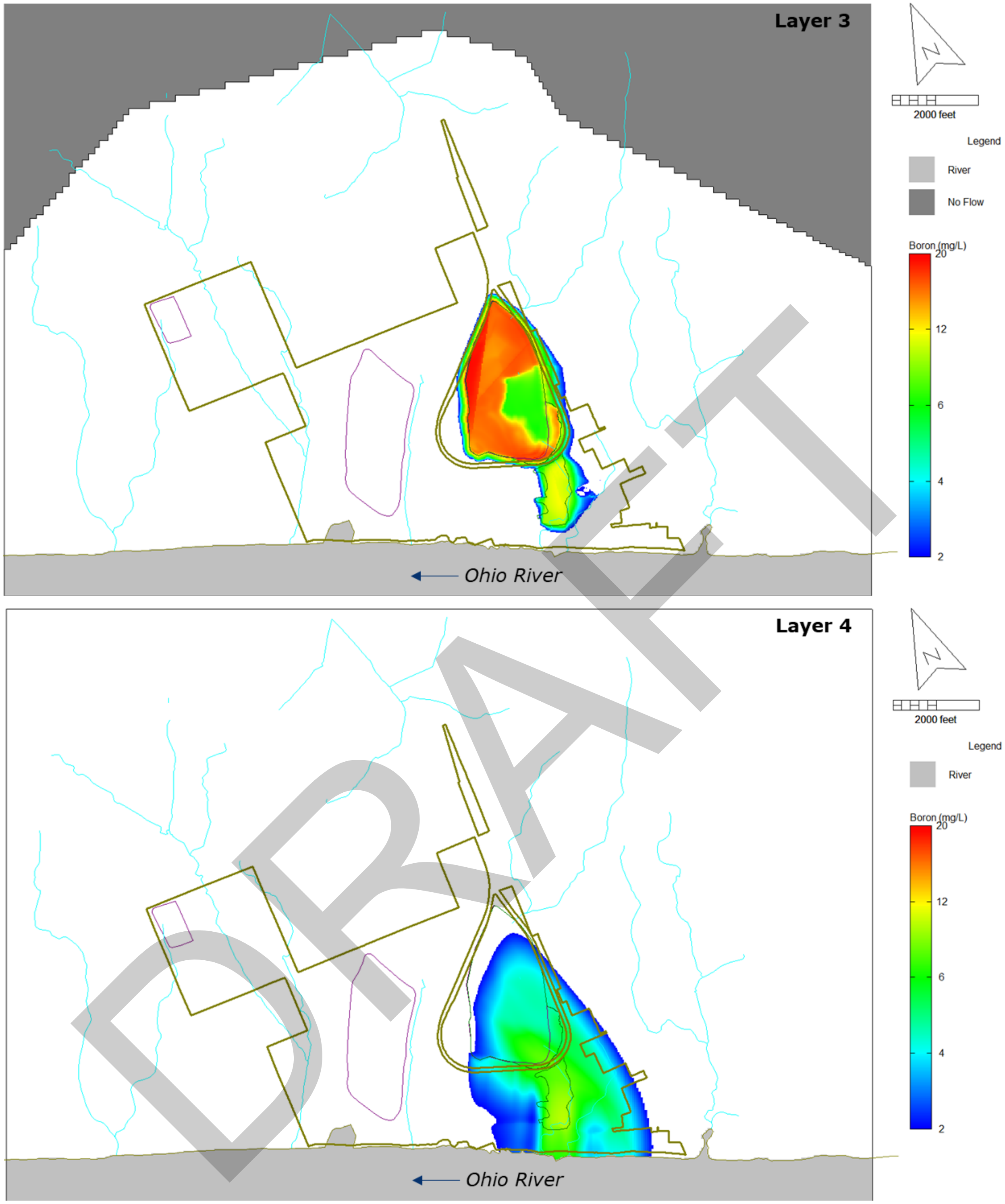
APPENDIX FIGURE A28



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYERS 1 AND 2

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

APPENDIX FIGURE A29



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYERS 3 AND 4

GROUNDWATER MODELING TECHNICAL MEMORANDUM
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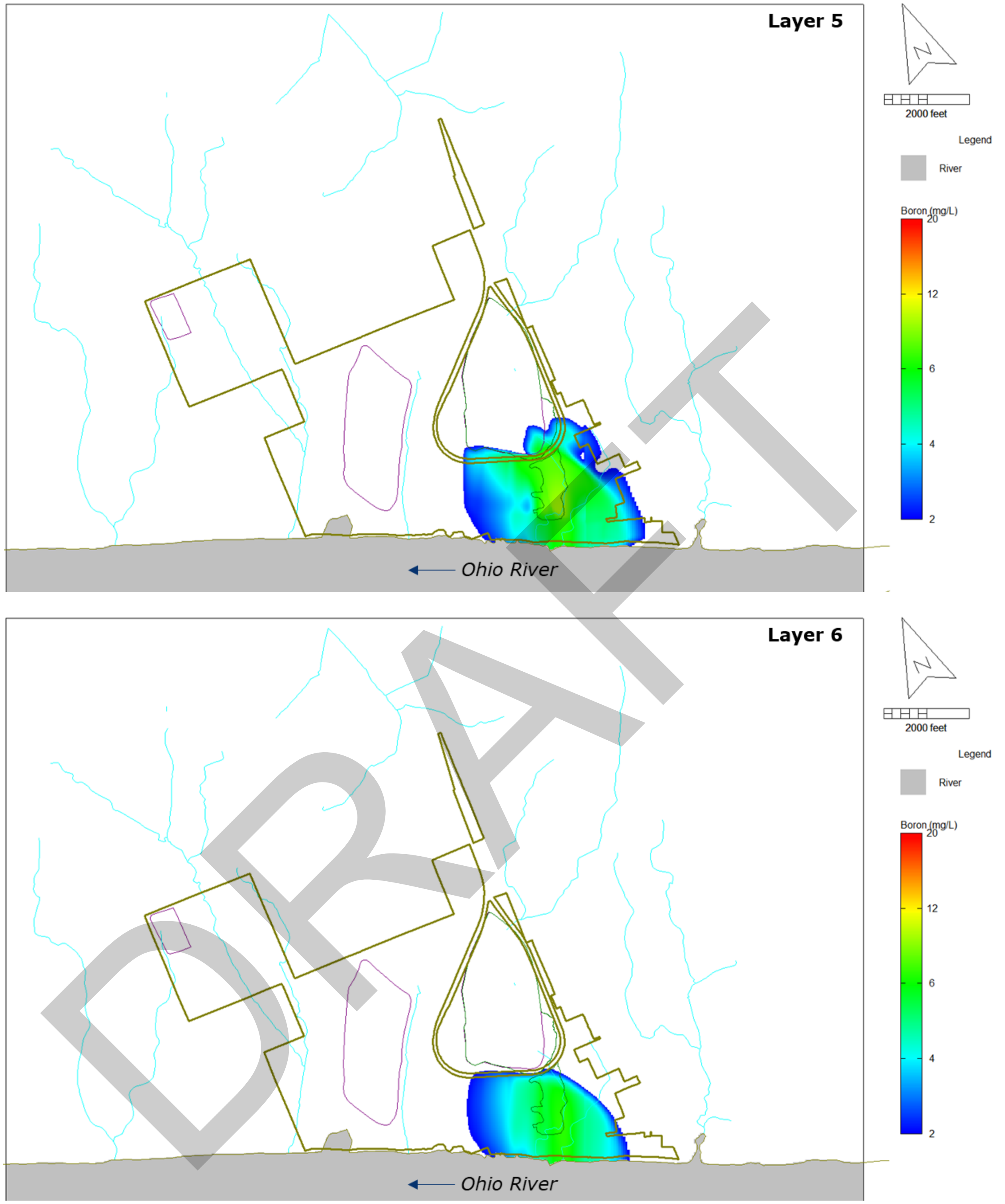
JOPPA, ILLINOIS

APPENDIX FIGURE A30



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYERS 5 AND 6

GROUNDWATER MODELING TECHNICAL MEMORANDUM
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

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APPENDIX B.2
GROUNDWATER MODELING REPORT (2022)

Intended for
Electric Energy, Inc.

Date
July 28, 2022

Project No.
1940101010-012

GROUNDWATER MODELING REPORT

EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

GROUNDWATER MODELING REPORT
JOPPA POWER PLANT EAST ASH POND

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

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Senior Managing Hydrogeologist

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TABLES (IN TEXT)

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FIGURES (IN TEXT)

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APPENDICES

ACRONYMS AND ABBREVIATIONS

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

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

EXECUTIVE SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1. INTRODUCTION

1.1 Overview

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

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

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

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

1.2 Site Location and Background

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

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

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

1.3 Site History and Unit Description

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

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

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

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

1.4 Status of Site Investigations

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

2. SITE GEOLOGY AND HYDROGEOLOGY

2.1 Site Topography

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

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

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

2.2 Site Geology

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

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

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

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

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

2.3 Site Hydrogeology

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

- **CCR:** CCR consisting of fly ash and bottom ash. Water elevations measured in early March 2021 within the EAP indicate the phreatic surface is approximately 370 to 374 feet NAVD88. The saturated thickness within the CCR varies based upon the base elevation of the ash material and varies from 0 to 45 feet.
- **UCU:** This unit is comprised of the Equality Formation, the Silt Unit, and Metropolis Formation deposits, which are similar in composition and consist primarily of fine-grained silts and clays. The average thickness of this unit is 40 feet with a range of 8 to 58 feet at the site. The UCU underlies the CCR fill and is thinnest beneath the southeast corner of the EAP. This unit is not an aquifer; it is characterized as a confining unit based upon composition, and flow directions with this unit are predominantly vertical.
- **UA:** This unit is composed of the high-permeability sands and gravels of the McNairy Formation, with isolated lenses of finer-grained material. At the site, the UA is 50 to 100 feet thick.
- **LCU:** The LCU consists of the 12- to 14-foot thick clay material encountered between the McNairy Formation and bedrock. This unit is expected to be low permeability with predominantly vertical flow directions between the two high-permeability aquifers above and below.
- **LAU:** This unit, composed of the Salem Limestone Bedrock, is the lowermost HSU identified. The limestone is high permeability and is used as a regional water supply. The LAU has an

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

2.3.1 Hydraulic Parameters and Characteristics

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

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

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

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

2.3.2 Pumping Wells

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

2.3.3 Ohio River

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

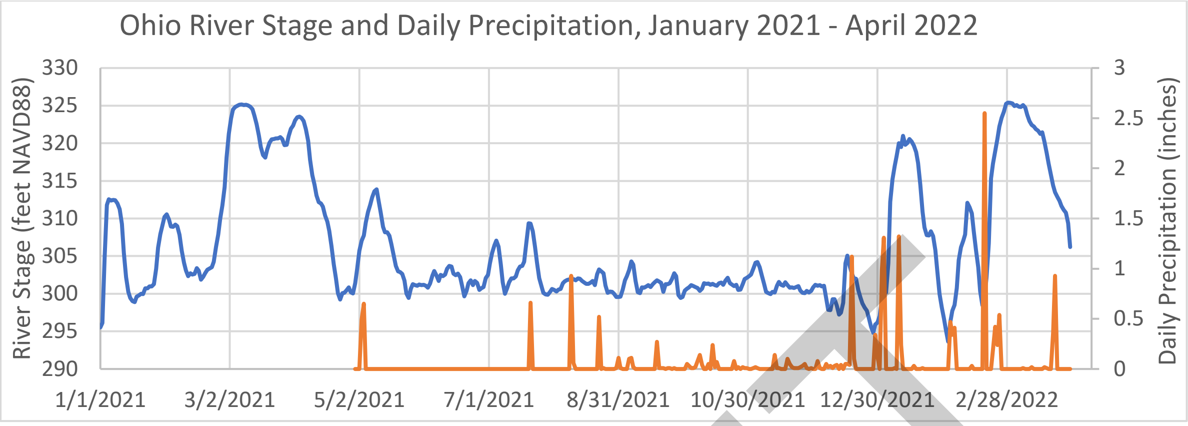

Figure A. Daily Gauge Height (feet) and Daily Precipitation (inches) January 1, 2021 to March 30, 2022 for Joppa Power Plant Gaging Station at the Ohio River at Joppa, Illinois.

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

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

2.3.4 Conceptual Site Model for Flow

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

Discussion of Groundwater Elevations and River Stage

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

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

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

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

3. GROUNDWATER QUALITY

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

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

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

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

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

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

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

4. MODEL APPROACH

4.1 Overview

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

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

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

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

4.2 Description of Site-Specific Groundwater Models

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

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

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

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

4.3 Conceptual Site Model for Transport

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

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

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

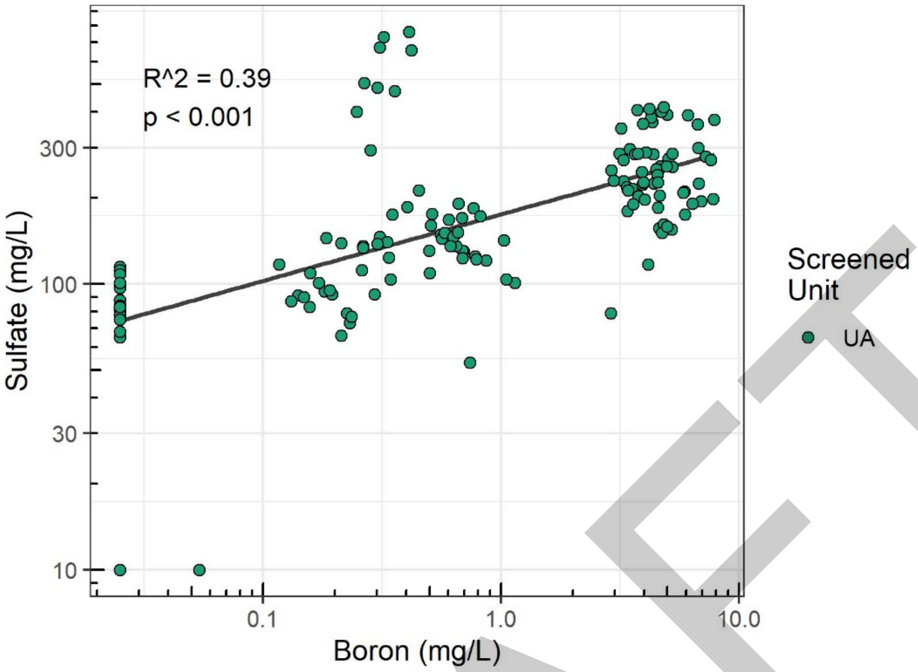

Figure B. Correlation of Observed Sulfate and Boron Concentrations in Downgradient UA Wells.

4.4 Model Code Descriptions

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

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

MT3DMS (Zheng and Wang, 1998) is an update of MT3D. It calculates concentration distribution for a single dissolved solute as a function of time and space. Concentration is distributed over a three-dimensional, non-uniform, transient flow field. Solute mass may be input at discrete points (wells, drains, river nodes, constant head cells), or distributed evenly or unevenly over the land surface (recharge).

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

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

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

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

5. MODEL SETUP AND CALIBRATION

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

5.1 Current Conditions Flow Model

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

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

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

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

5.1.1 Model Domain and Discretization

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

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

Table A. Flow Model Layer Description

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

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

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

5.1.2 Boundary Conditions and Hydraulic Parameters

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

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

5.1.2.1 No-Flow Boundaries

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

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

5.1.2.2 River

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

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

5.1.2.3 General Head Boundaries

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

5.1.2.4 Pumping wells

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

Table B. Pumping Well Summary

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

Notes:
gpm = gallons per minute

5.1.2.5 Recharge

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

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

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

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

Table C. Model Recharge (Current Conditions Flow Model)

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

5.1.2.6 Hydraulic Conductivity

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

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

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

5.1.3 Flow Model Calibration

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

5.1.3.1 Flow Model Targets and Model Calibration Statistics

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

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

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

A total of 36 flow model targets were selected from available groundwater level data within the model domain, which includes the Joppa Landfill (3 targets) and the EAP (33 targets). Targets were present in model layers 1 through 4 and 6, with the majority (24) in the UA (model layer 4). Water levels used for targets include the new wells installed along the eastern property boundary in late 2021. Target water levels from these wells were selected from initial well development water levels collected in late 2021 because the synoptic measurements at these locations were collected in early 2022 during a period of high river stage, thus elevated above the levels required for calibration to baseflow (*i.e.,* minimum) conditions.

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

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

5.1.3.2 Model Calibration Results and Statistics

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

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

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

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

5.2 Historical Transport Model

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

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

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

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

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

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

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

5.2.1.1 Storage Parameters and Porosity

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

Table E. Transient Model Storage Parameters

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

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

5.2.2 Transport Model Construction

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

5.2.2.1 Sources of Boron

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

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

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

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

5.2.2.2 Transport Parameters

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

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

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

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

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

5.2.3 Transport Model Calibration and Targets

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

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

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

5.2.3.1 Transport Model Calibration Results and Statistics

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

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

5.3 River Flood Evaluation

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

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

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

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

5.3.1 Flood Model Construction

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

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

5.3.2 Flood Model Results

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

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

5.4 Flow and Transport Model Assumptions and Limitations

Simplifying assumptions were made while developing these models:

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

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

6. SIMULATION OF CLOSURE SCENARIO

6.1 Overview and Prediction Model Development

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

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

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

6.2 HELP Model Setup

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

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

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

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

6.3 Simulation of Closure Scenarios

6.3.1 Closure Scenario 1 (CIP)

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

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

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

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

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

6.3.1.1 Model Setup

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

Period 1 – Current Conditions (Extended)

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

Period 2 – Dewatering and Construction

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

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

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

Period 3 – Post-Closure

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

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

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

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

6.3.1.2 Model Results

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

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

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

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

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

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

6.3.2 Closure Scenario 2 (CBR)

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

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

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

6.3.2.1 Model Setup

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

Period 1 – Current Conditions (Extended)

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

Period 2 – Dewatering and Construction

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

Period 3 – Post-Closure

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

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

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

6.3.2.2 Model Results

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

Boron concentrations begin to decrease in Period 2, with the removal of boron recharge to the model, and accelerates in Period 3 following completion of closure activities. **Figure 6-2** presents concentrations of boron following closure at the 12 of 30 EAP monitoring wells which have average concentrations exceeding the GWPS of 2 mg/L. with current average concentrations over time following closure. As shown, predicted concentrations of boron fall below the GWPS at these locations within 14.2 years of completion of the CBR remedy. Concentrations of most of the monitoring wells are predicted to fall below 2 mg/L with 5 to 10 years, with the exception of concentrations at G09, which was overpredicted in the calibration model (5.5 mg/L versus the target value of 3.1 mg/L in 2022). Groundwater elevations in each of the model layers reach a new equilibrium (*i.e.,* new steady-state groundwater elevations) within one year of closure.

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

7. CONCLUSIONS

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

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

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

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

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

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

8. REFERENCES

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TABLES

TABLE 5-1. CURRENT CONDITIONS FLOW MODEL HYDRAULIC CONDUCTIVITY ASSIGNMENTS

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

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

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

Notes

[1] Isotropic horizontal conductivity was assumed (*i.e.,* Kx=Ky)

ft/d = feet/foot per day
DMM = deep mixing method
EAP = East Ash Pond
Kx = horizontal hydraulic conductivity
Ky = horizontal hydraulic conductivity
Kz = vertical hydraulic conductivity
LCU = lower confining unit
UA = uppermost aquifer
UCU = upper confining unit

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

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

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

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

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

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

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

NOTES:
GWE = groundwater elevation

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

TABLE 5-3. HISTORICAL TRANSPORT MODEL CALIBRATION TARGETS AND STATISTICS

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

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

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

Notes

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

TABLE 5-4. OBSERVED AND SIMULATED FLOOD EVENT GROUNDWATER ELEVATIONS

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

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

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

Notes

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

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

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

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

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

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

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

Notes:

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

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

References:

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

TABLE 6-2. PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP AND CBR

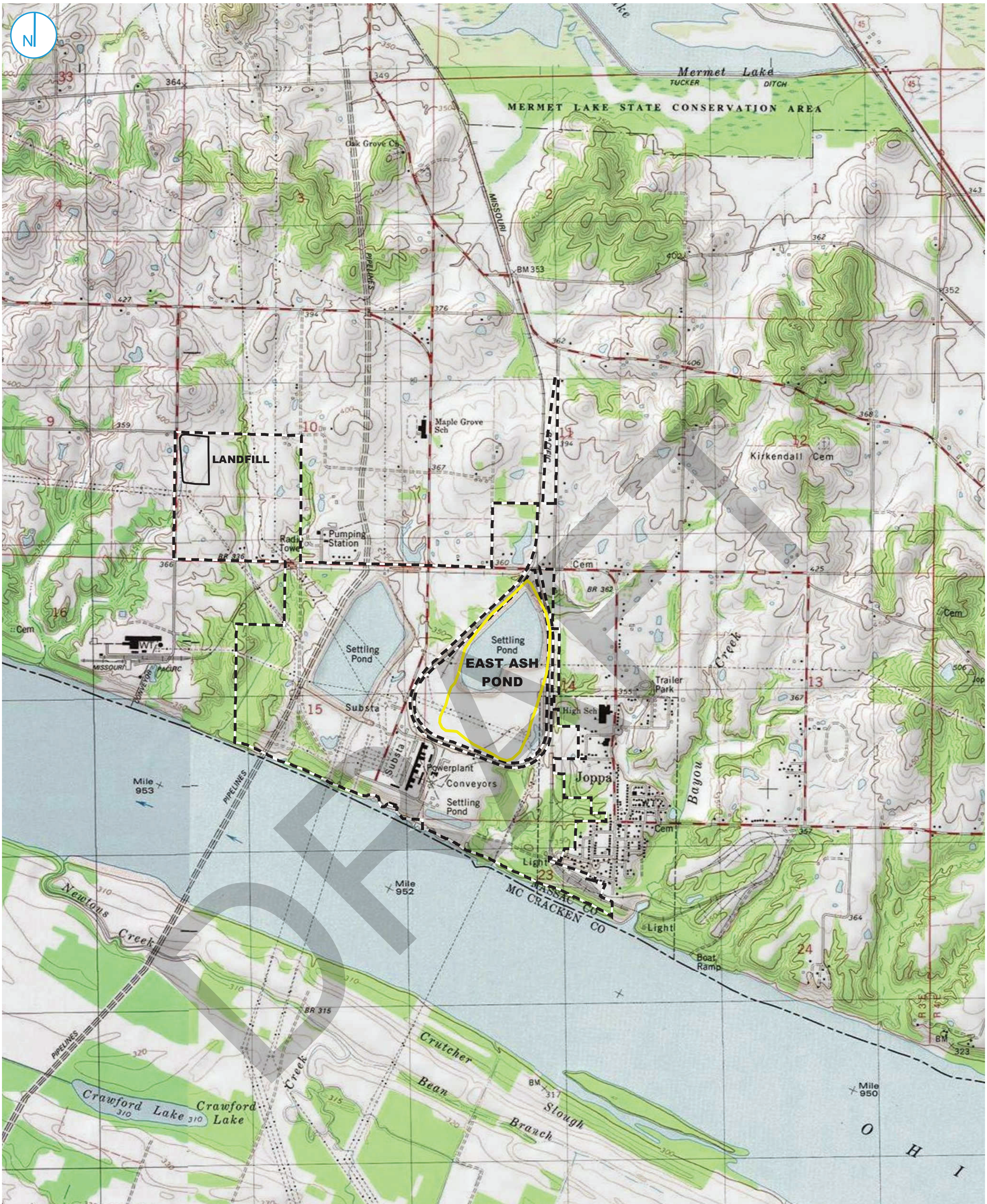
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

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

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

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

FIGURES



🟨 PART 845 REGULATED UNIT (SUBJECT UNIT)
☐ OTHER UNIT
⬚ PROPERTY BOUNDARY

0 1,000 2,000
Feet

SITE LOCATION MAP

FIGURE 1-1

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

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Joppa\Figure 1-2_Site Map.mxd

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

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

- ☐ PART 845 REGULATED UNIT (SUBJECT UNIT)
- ☐ OTHER UNIT
- — CENTRAL DIKE
- ⬚ PROPERTY BOUNDARY

0 500 1,000 Feet

SITE MAP

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

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

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

Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Joppa\Figure 2-1_Site Topographic Map.mxd

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

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

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

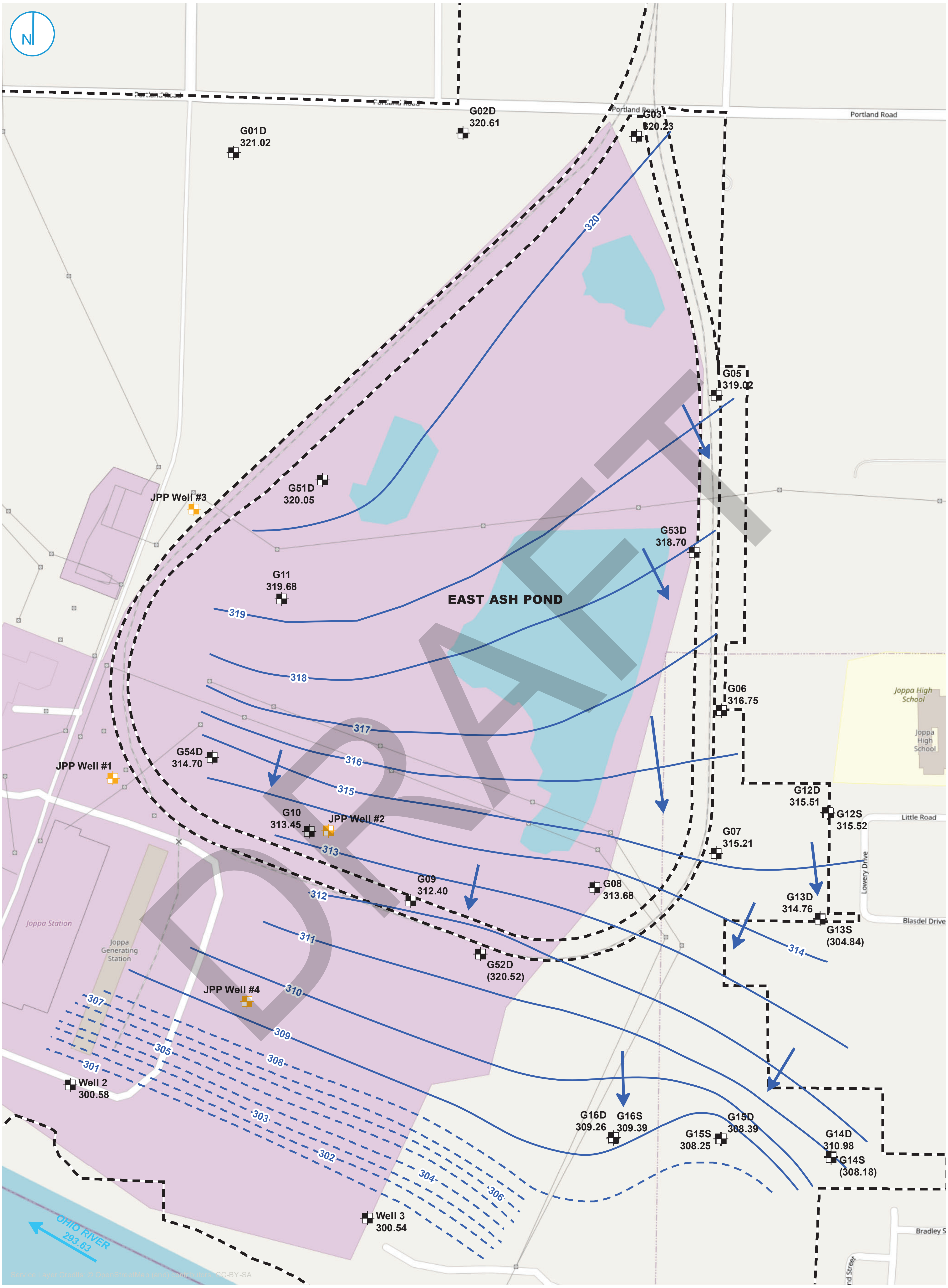
0 250 500 Feet

SITE TOPOGRAPHIC MAP

FIGURE 2-1

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

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



- MONITORING WELL
- JOPPA POWER PLANT NON-POTABLE WELLS
- PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

NOTE:
ELEVATIONS IN PARENTHESIS NOT USED FOR CONTOURING

0 225 450 Feet

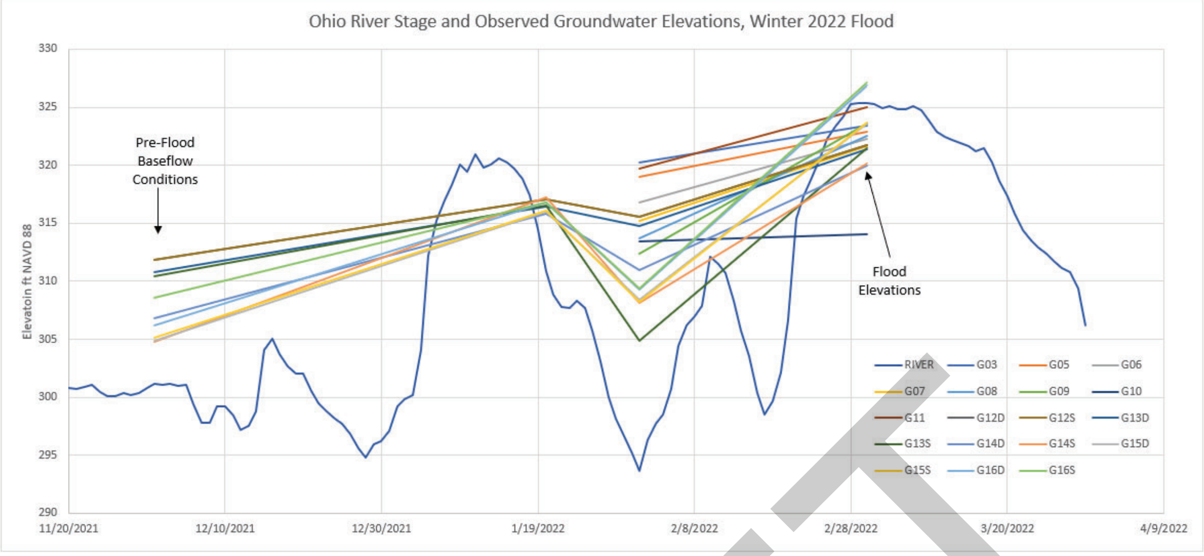
POTENTIOMETRIC SURFACE MAP
FEBRUARY 1, 2022

FIGURE 2-2

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

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



Notes

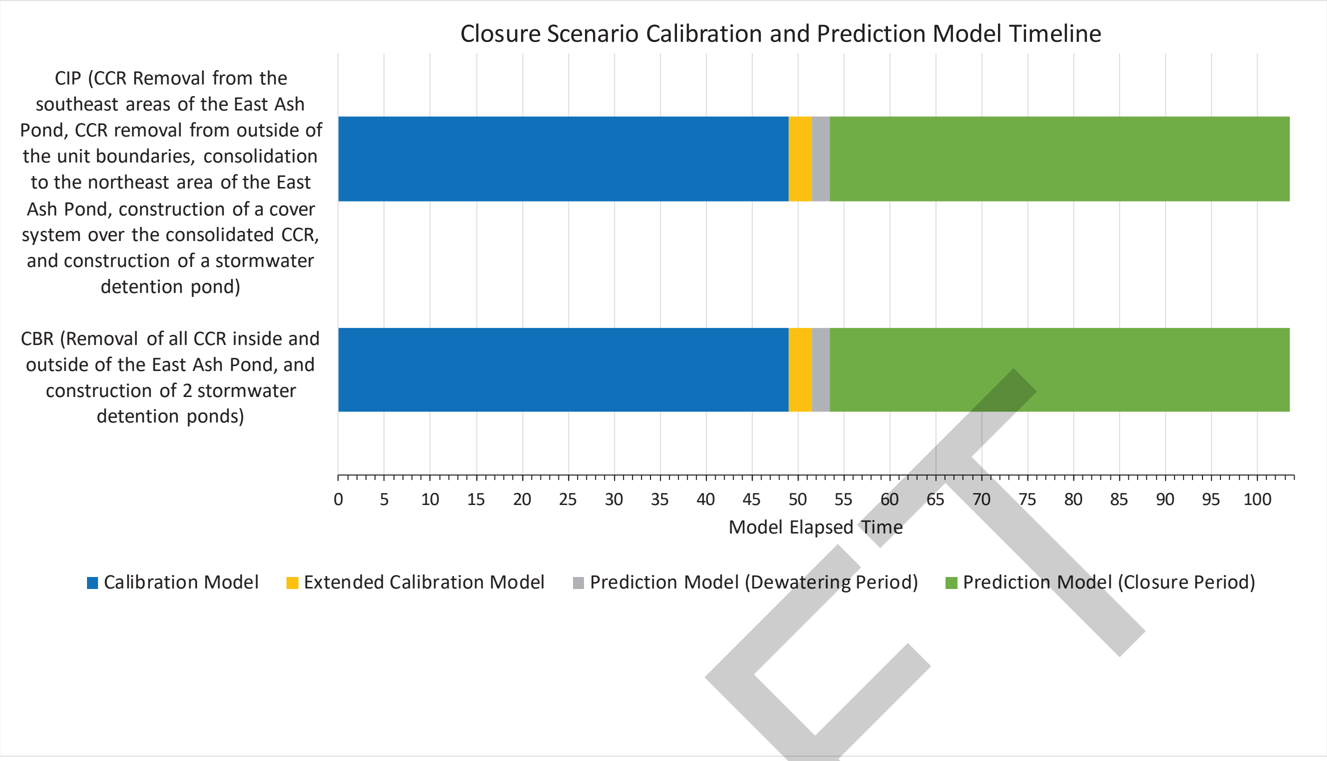
Dates shown for monitoring well elevations are approximate, and were aggregated for analysis purposes, as described below.

Baseline groundwater elevations were aggregated from available data within the baseflow period (*i.e.,* June to mid-December, 2021).

Dates for Flood Period 1 were collected over 2 days (January 19 and 20, 2022).

OHIO RIVER STAGE AND OBSERVED GROUNDWATER ELEVATIONS

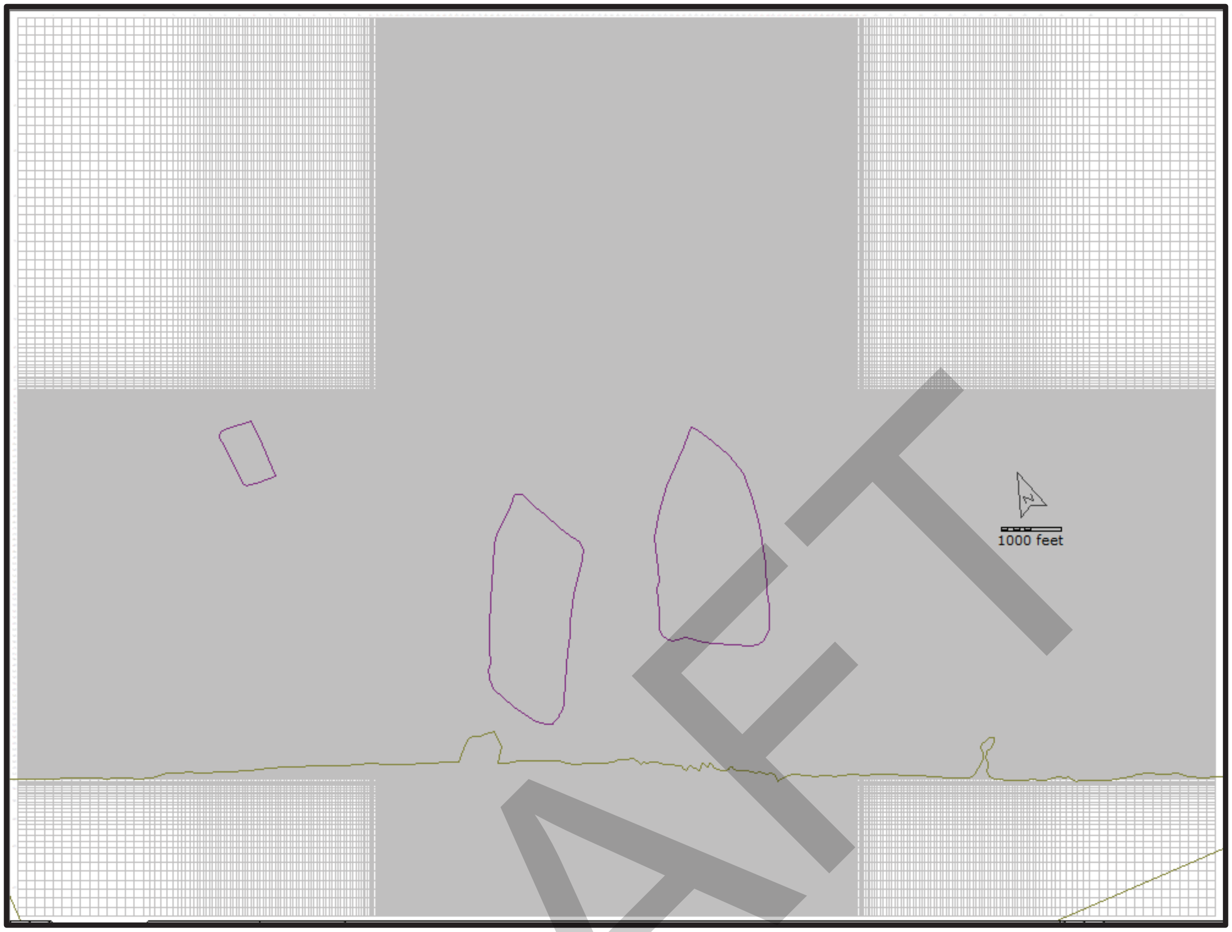
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



CLOSURE SCENARIO CALIBRATION AND PREDICTION MODEL TIMELINE

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

FIGURE 5-1

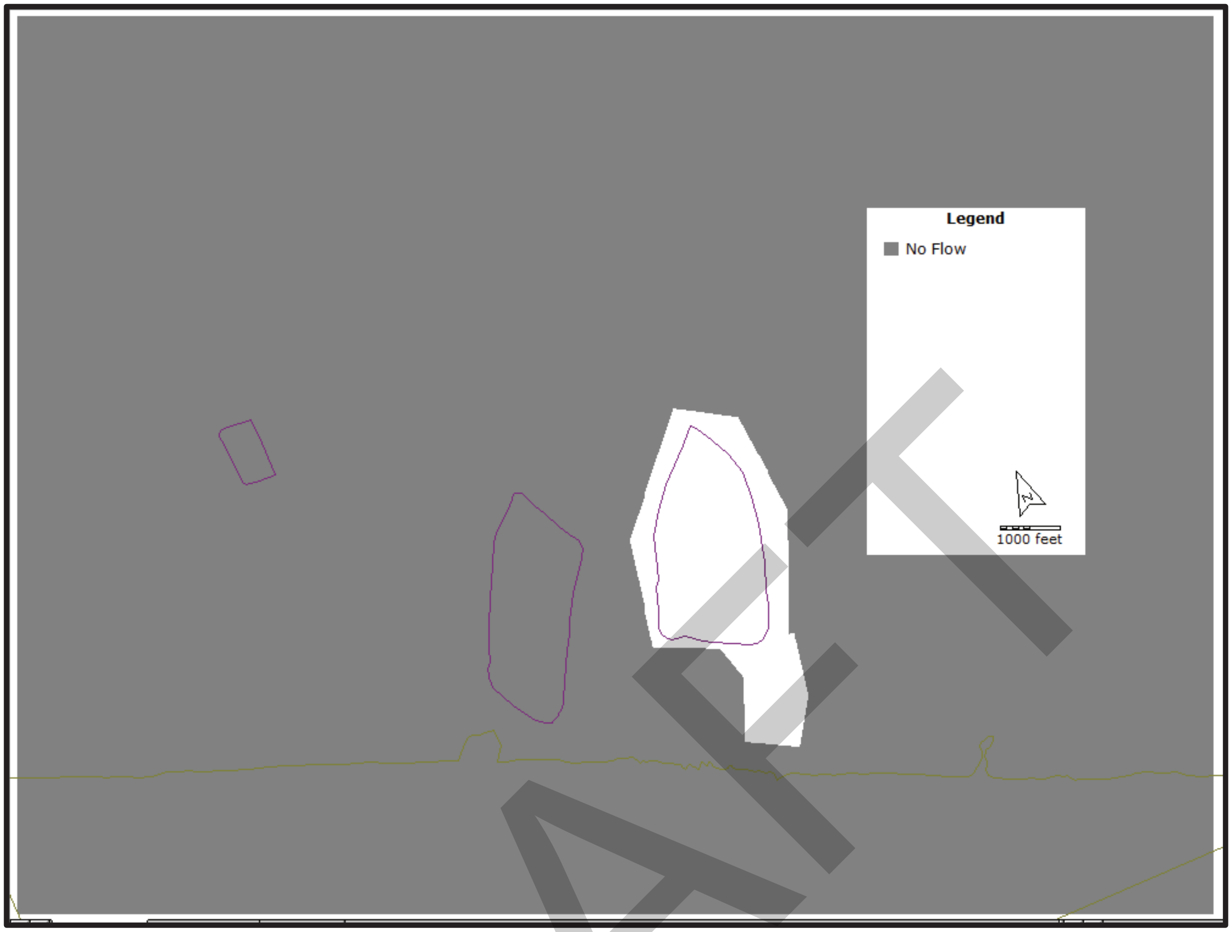


MODEL GRID

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

RAMBOLL

FIGURE 5-2

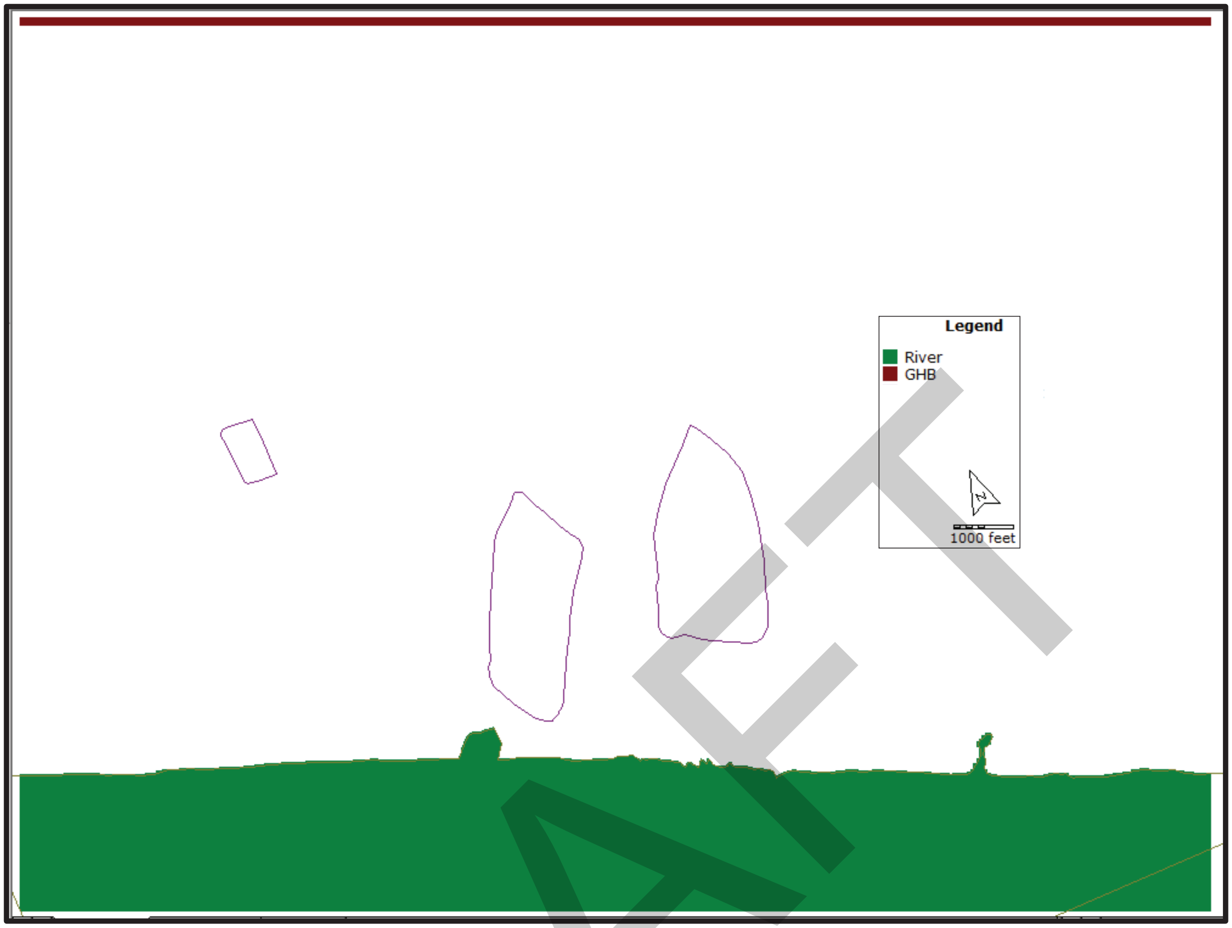


BOUNDARY CONDITIONS, MODEL LAYER 1

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

BOUNDARY CONDITIONS, MODEL LAYERS 2 AND 3

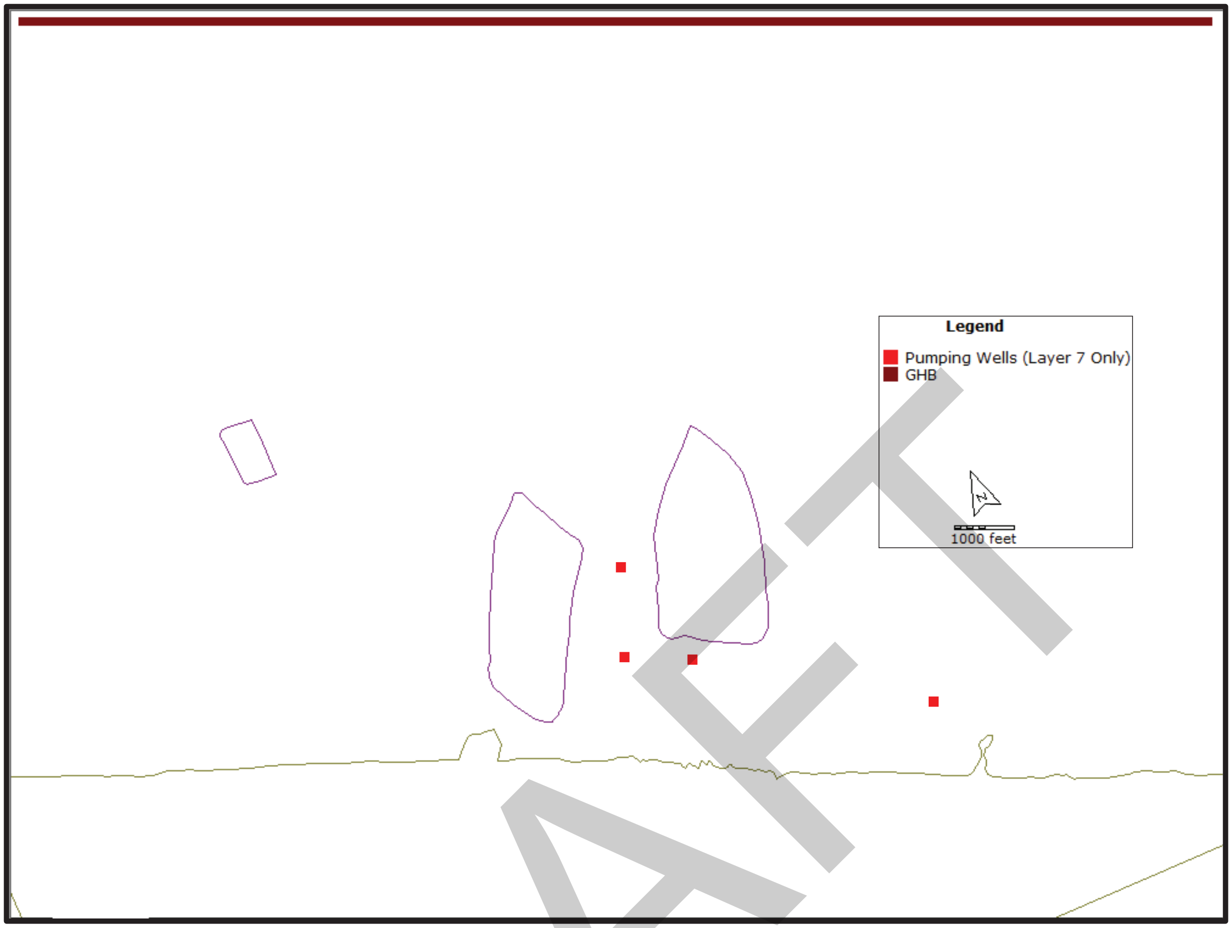
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



BOUNDARY CONDITIONS, MODEL LAYER 4

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

RAMBOLL



BOUNDARY CONDITIONS, MODEL LAYERS 6 AND 7

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

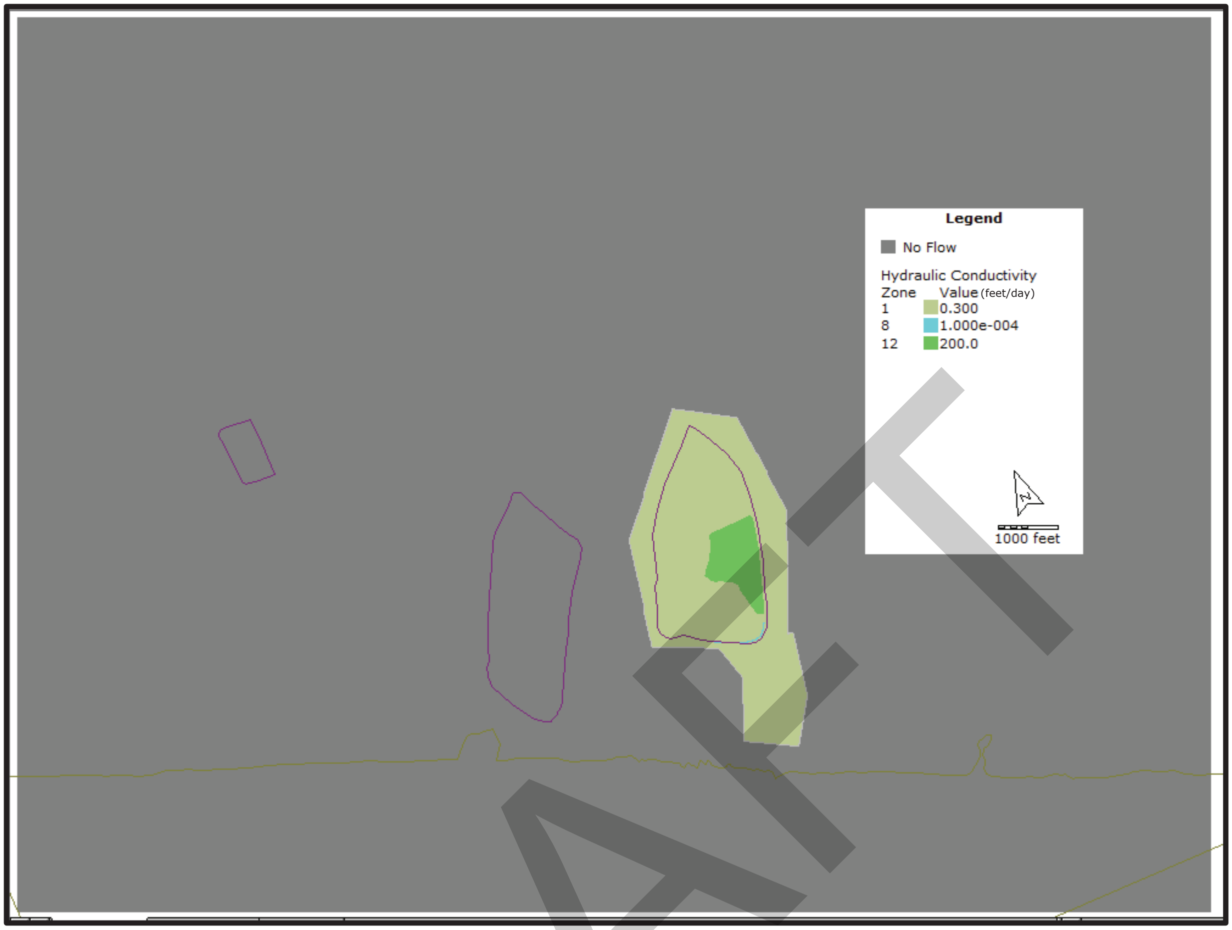
RAMBOLL

FIGURE 5-6

MODEL RECHARGE, STEADY-STATE FLOW MODEL

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

RAMBOLL

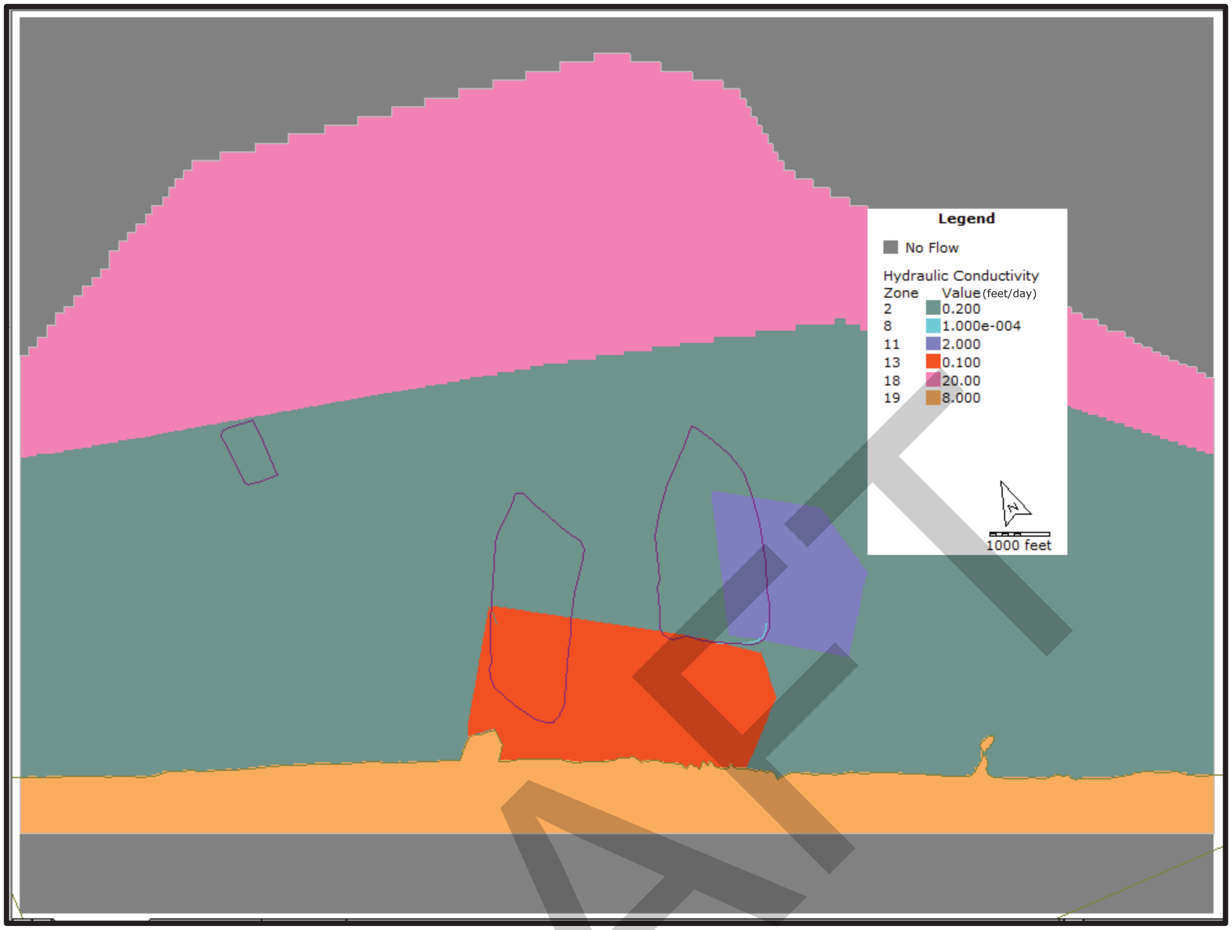


ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 1

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

RAMBOLL

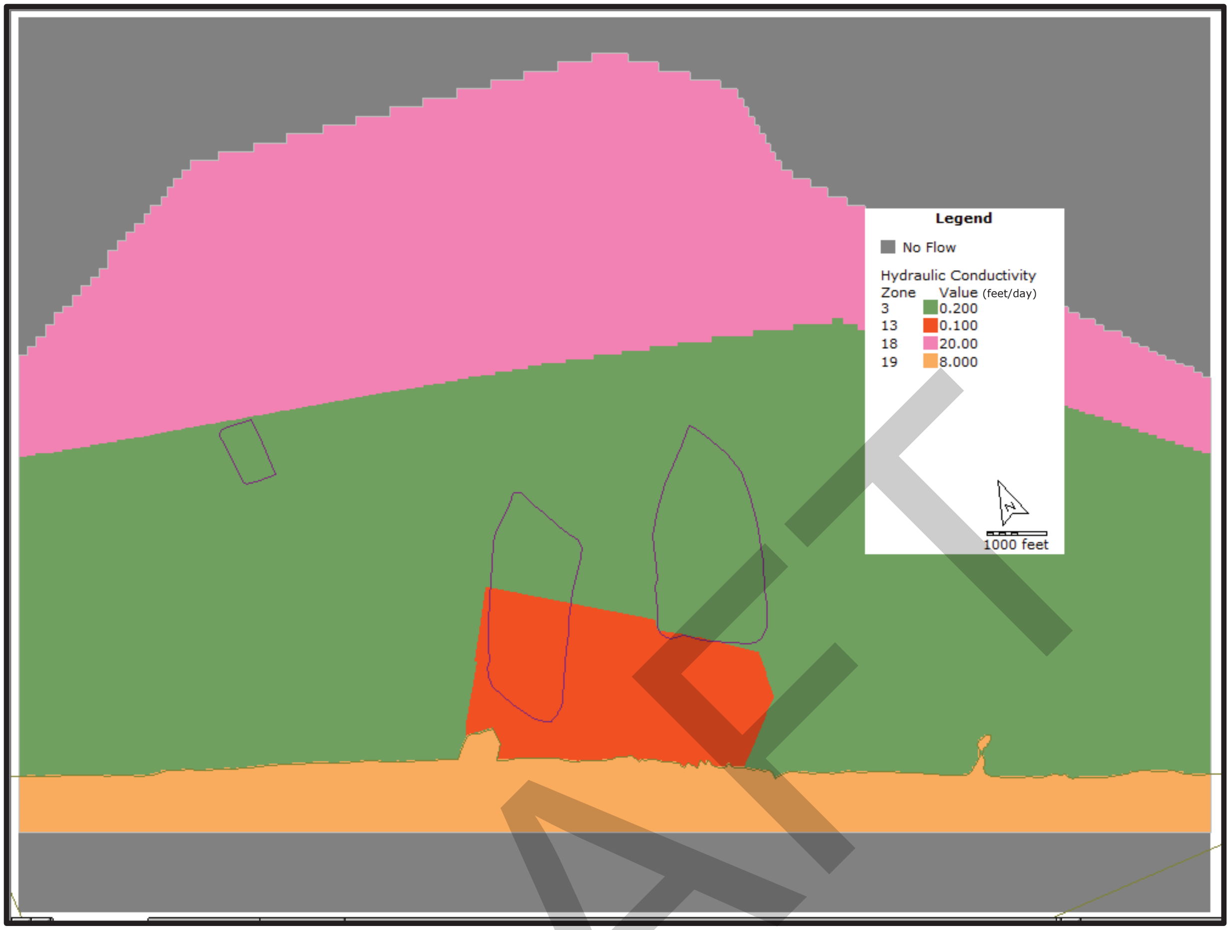
FIGURE 5-8



ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 2

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

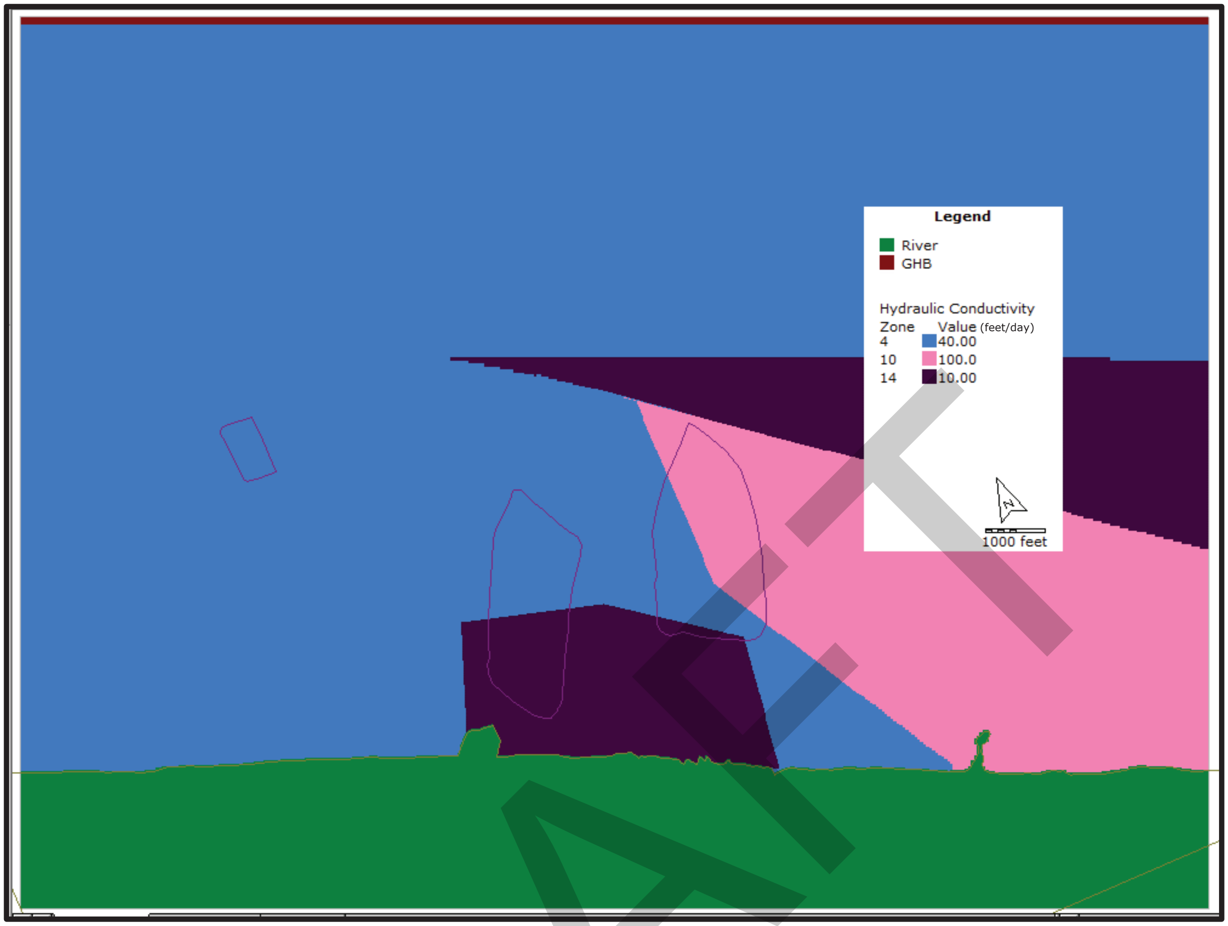
RAMBOLL



ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 3

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

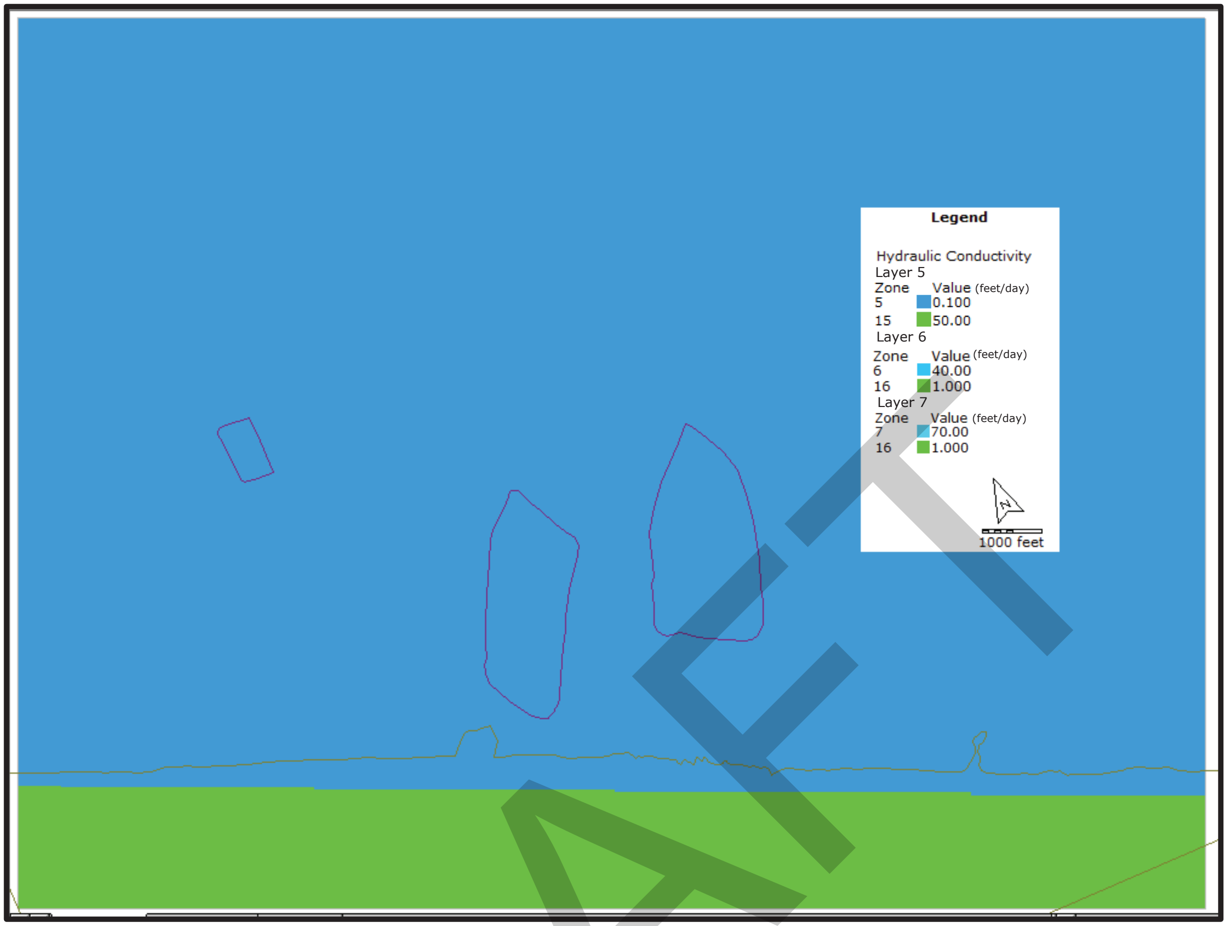
FIGURE 5-10



ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 4

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

FIGURE 5-11



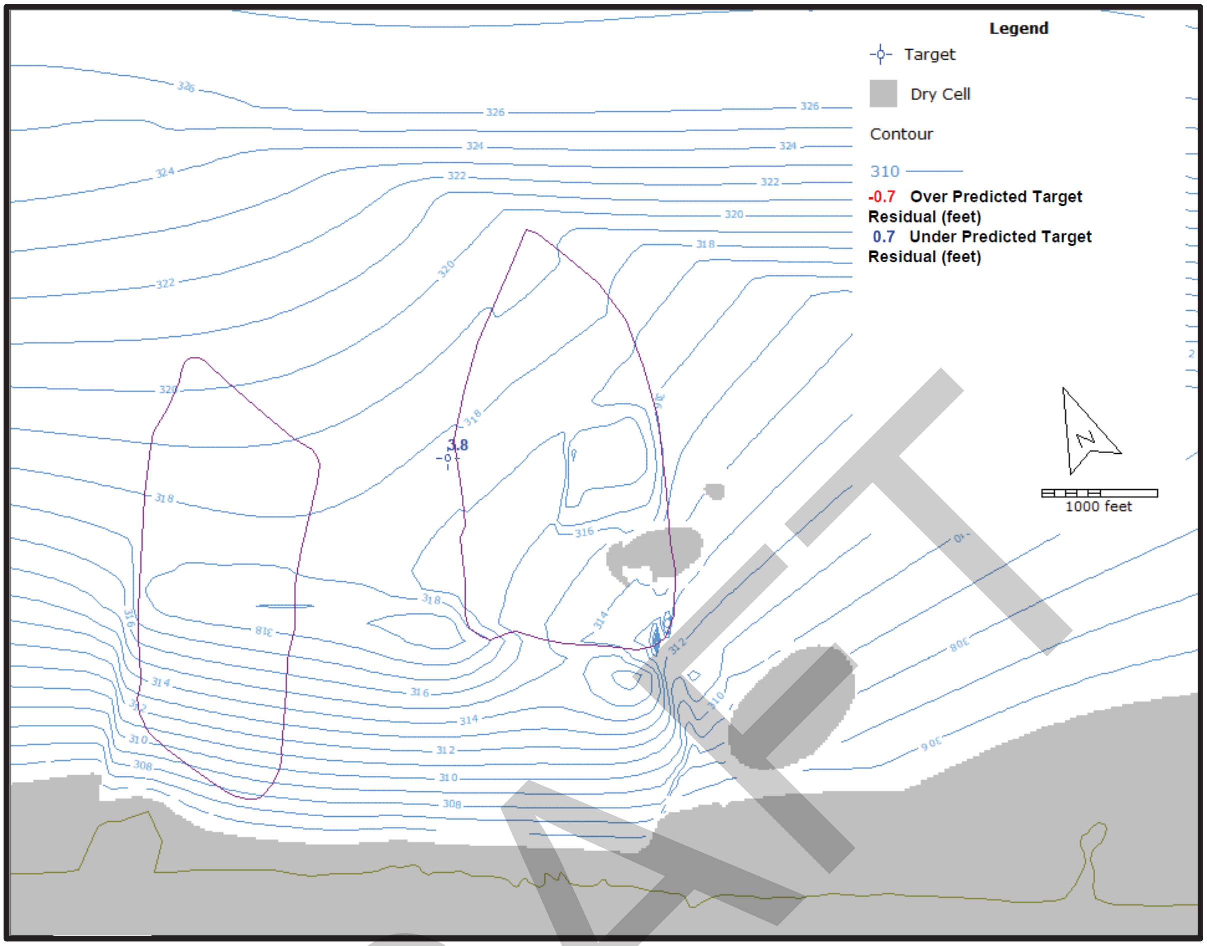
ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYERS 5, 6, 7

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

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

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

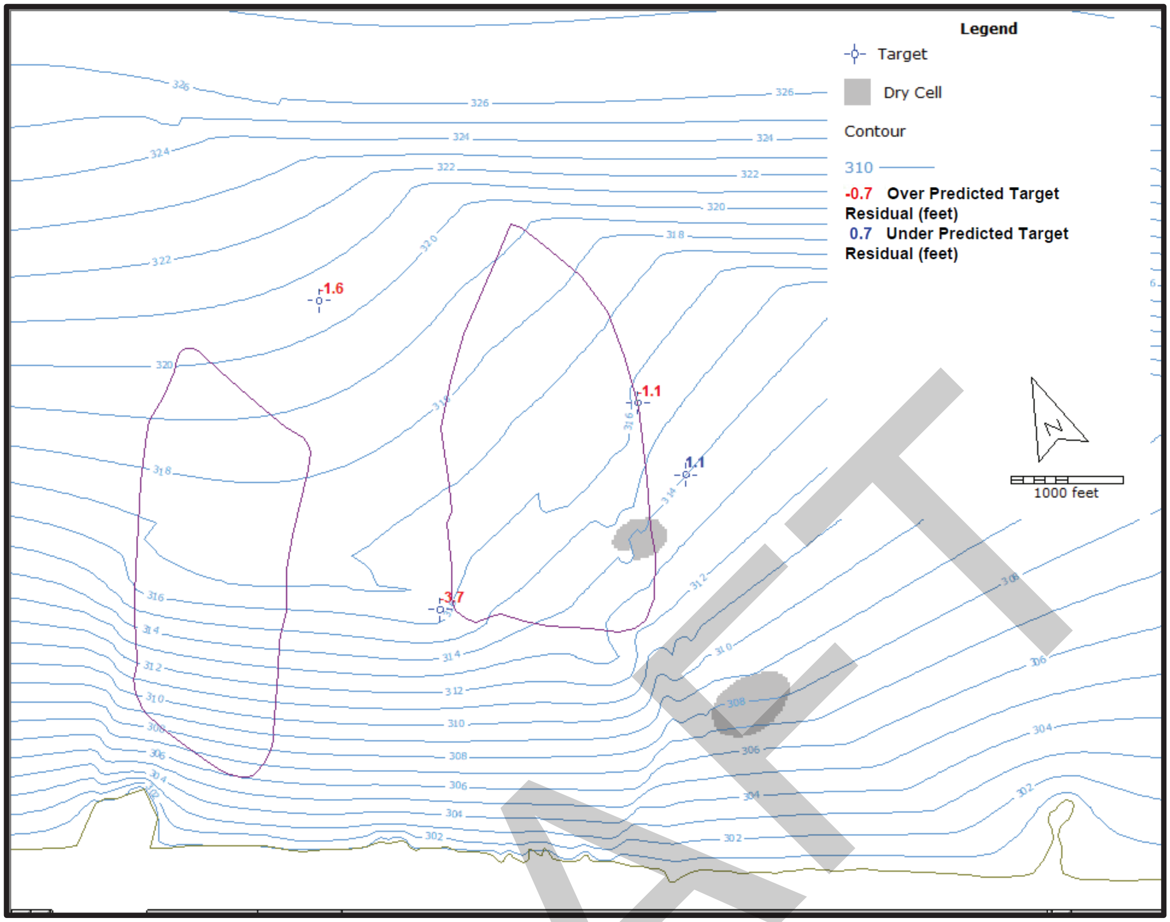
FIGURE 5-13



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

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

RAMBOLL

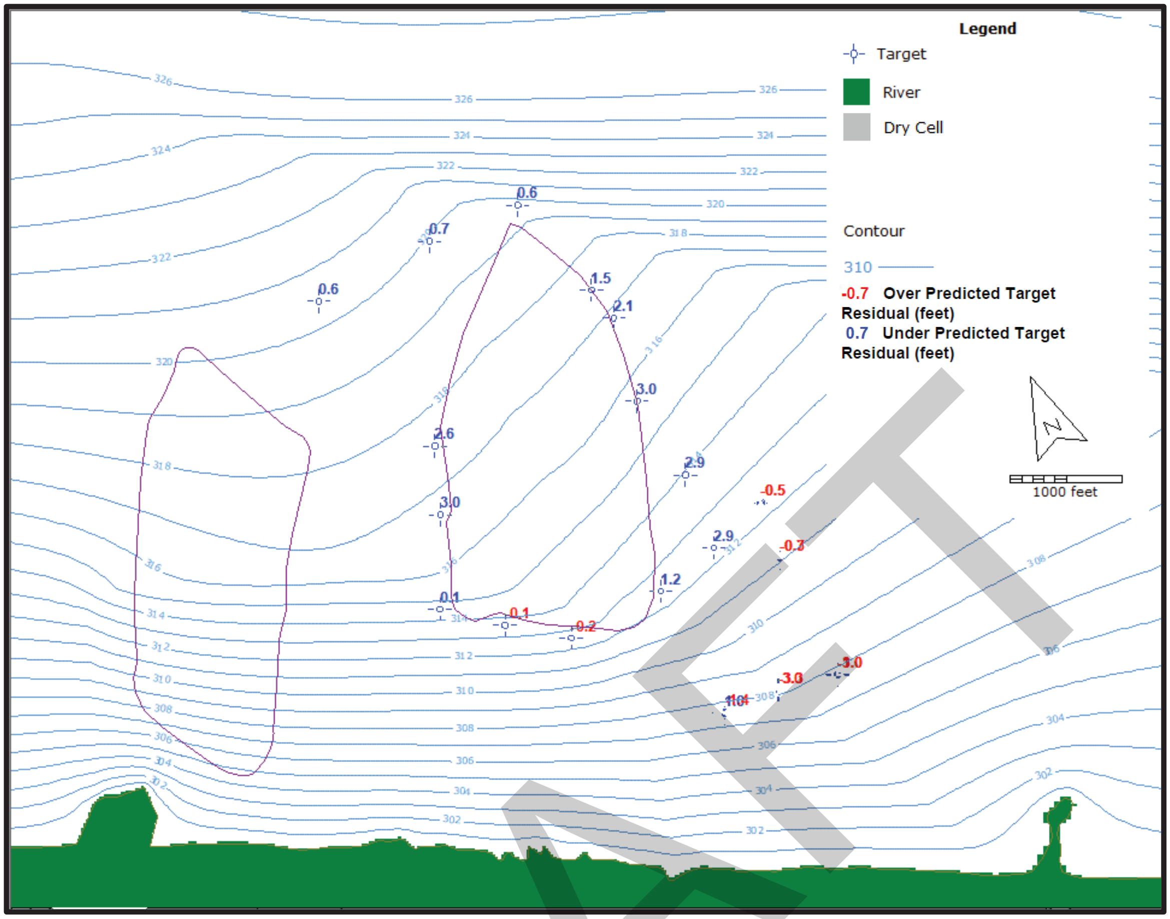


SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 3

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

RAMBOLL

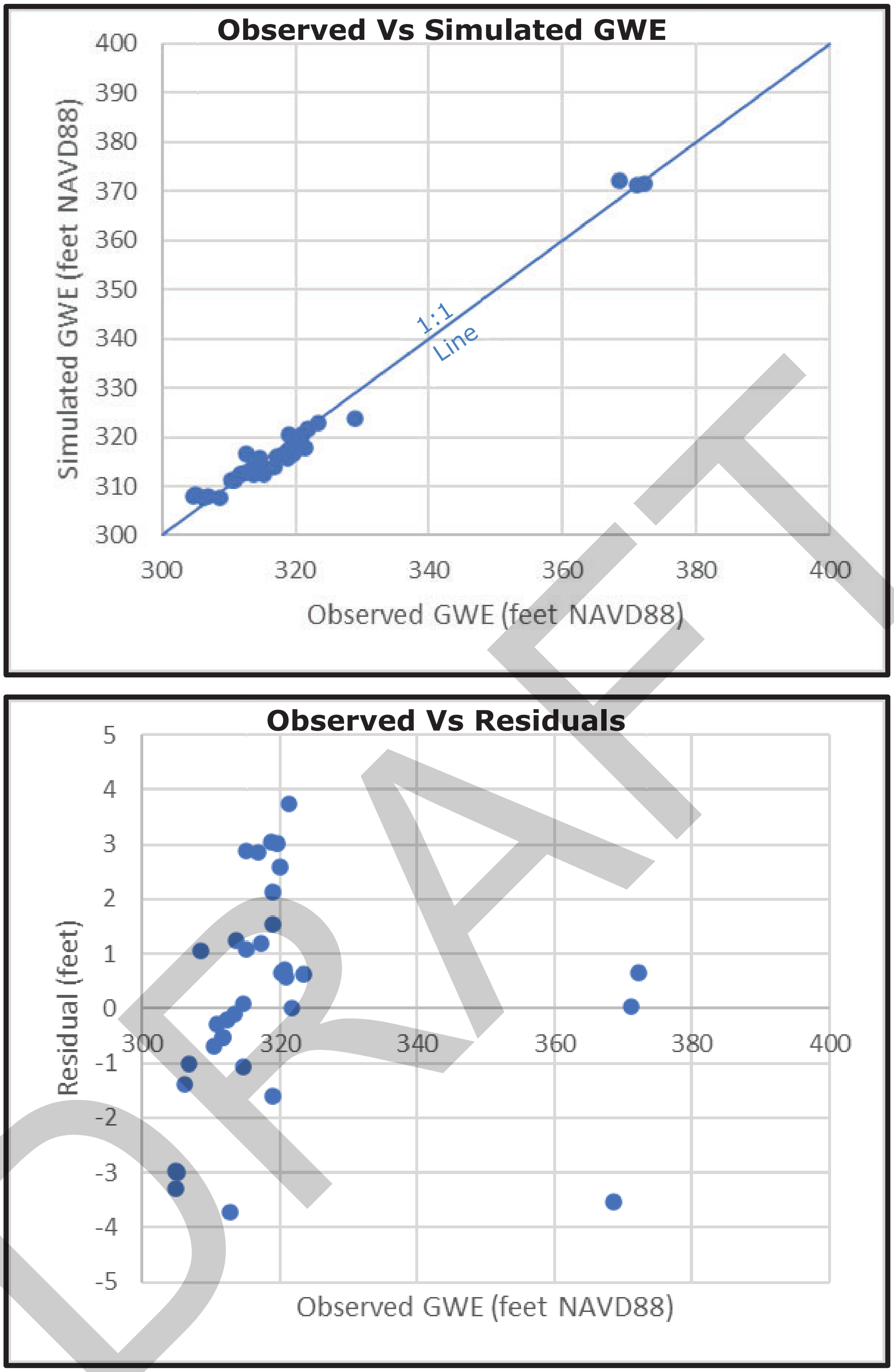
FIGURE 5-15



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

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

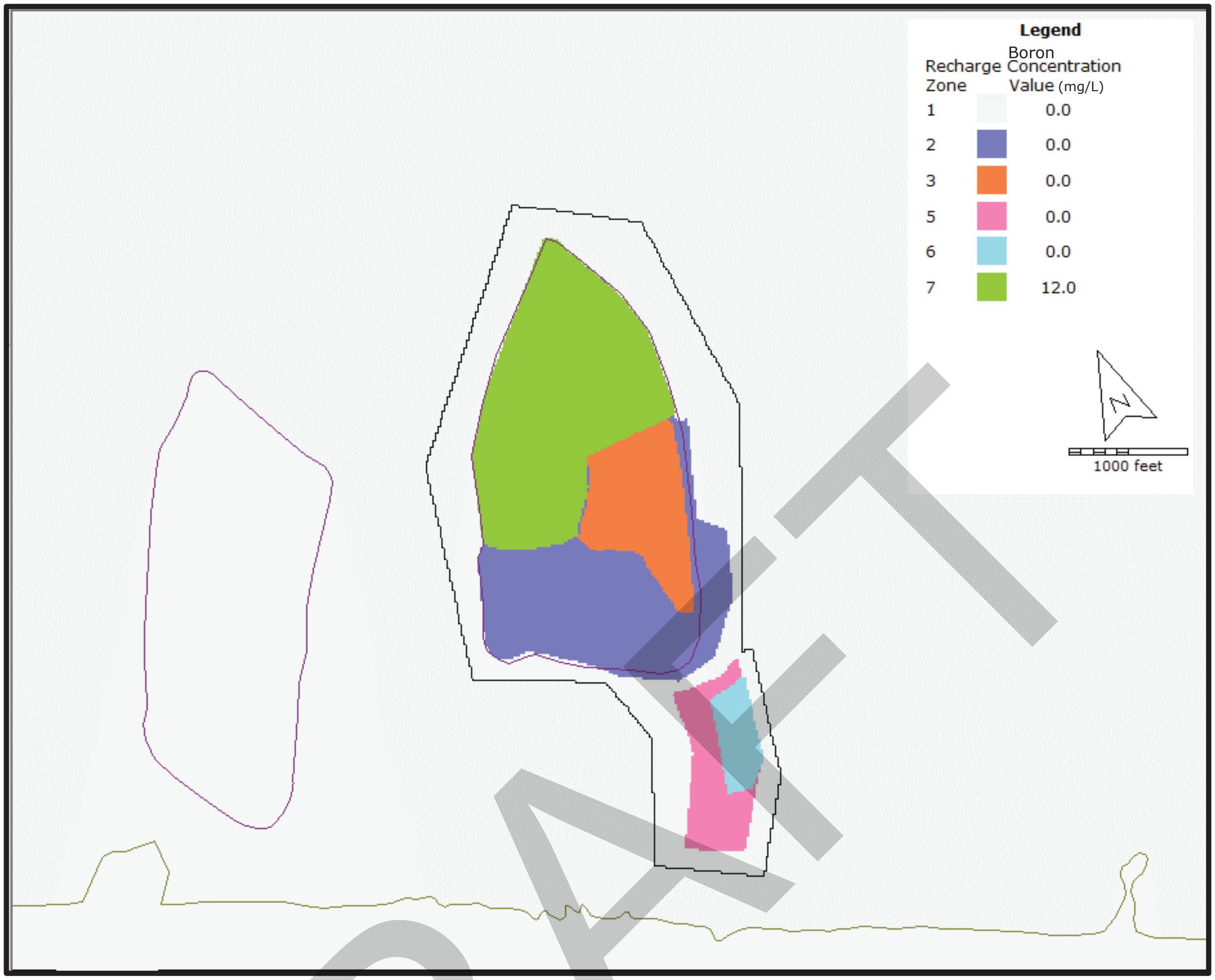
FIGURE 5-16



FLOW MODEL CALIBRATION PLOTS, OBSERVED VS SIMULATED GWE AND RESIDUALS

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

FIGURE 5-17

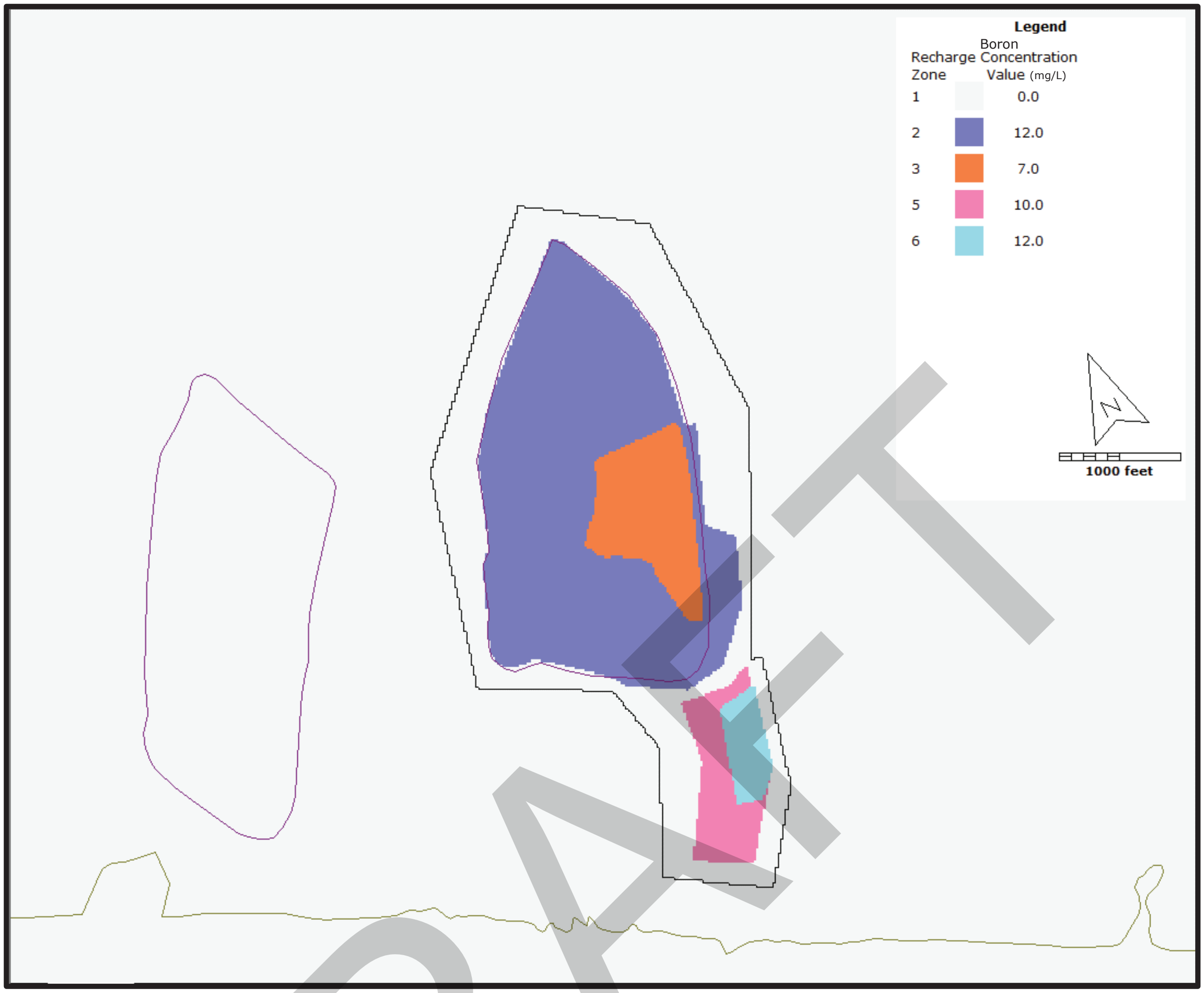


BORON RECHARGE, HISTORIC TRANSPORT MODEL, SP1

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

RAMBØLL

FIGURE 5-18



BORON RECHARGE, HISTORIC TRANSPORT MODEL, SP2 AND SP3

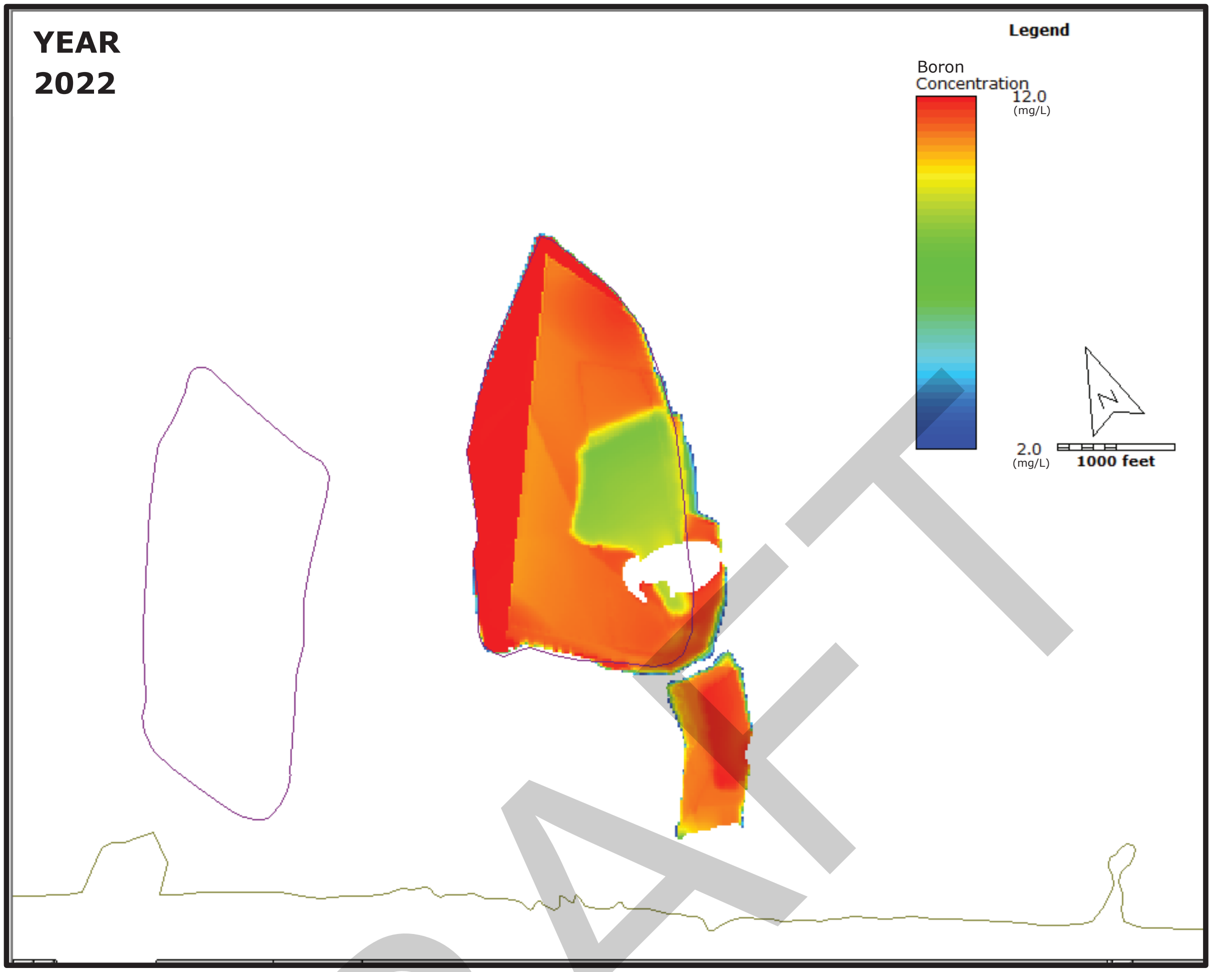
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

SIMULATED DISPERSIVITY, TRANSPORT MODEL LAYERS 2 THROUGH 4

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

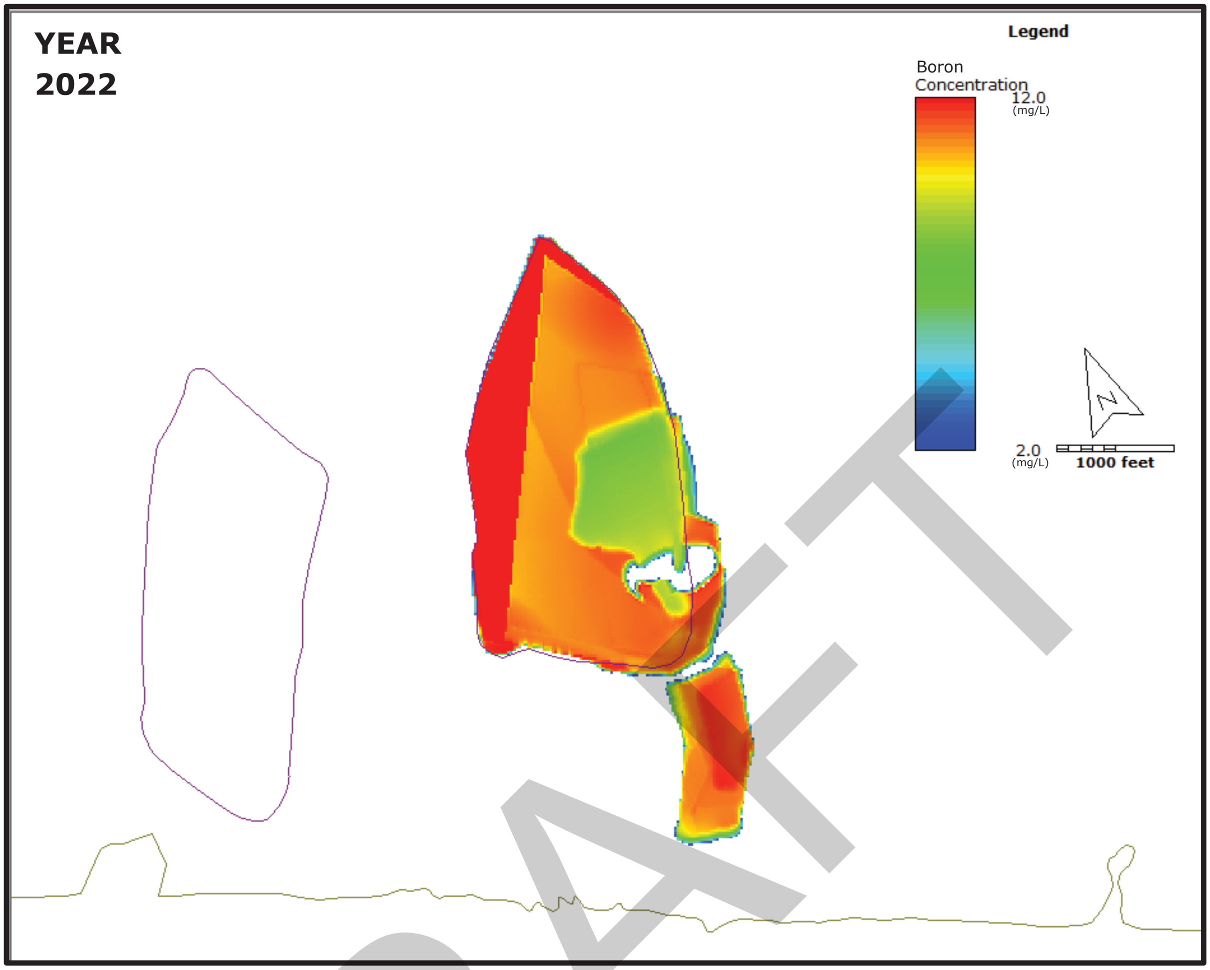
RAMBOLL



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 2

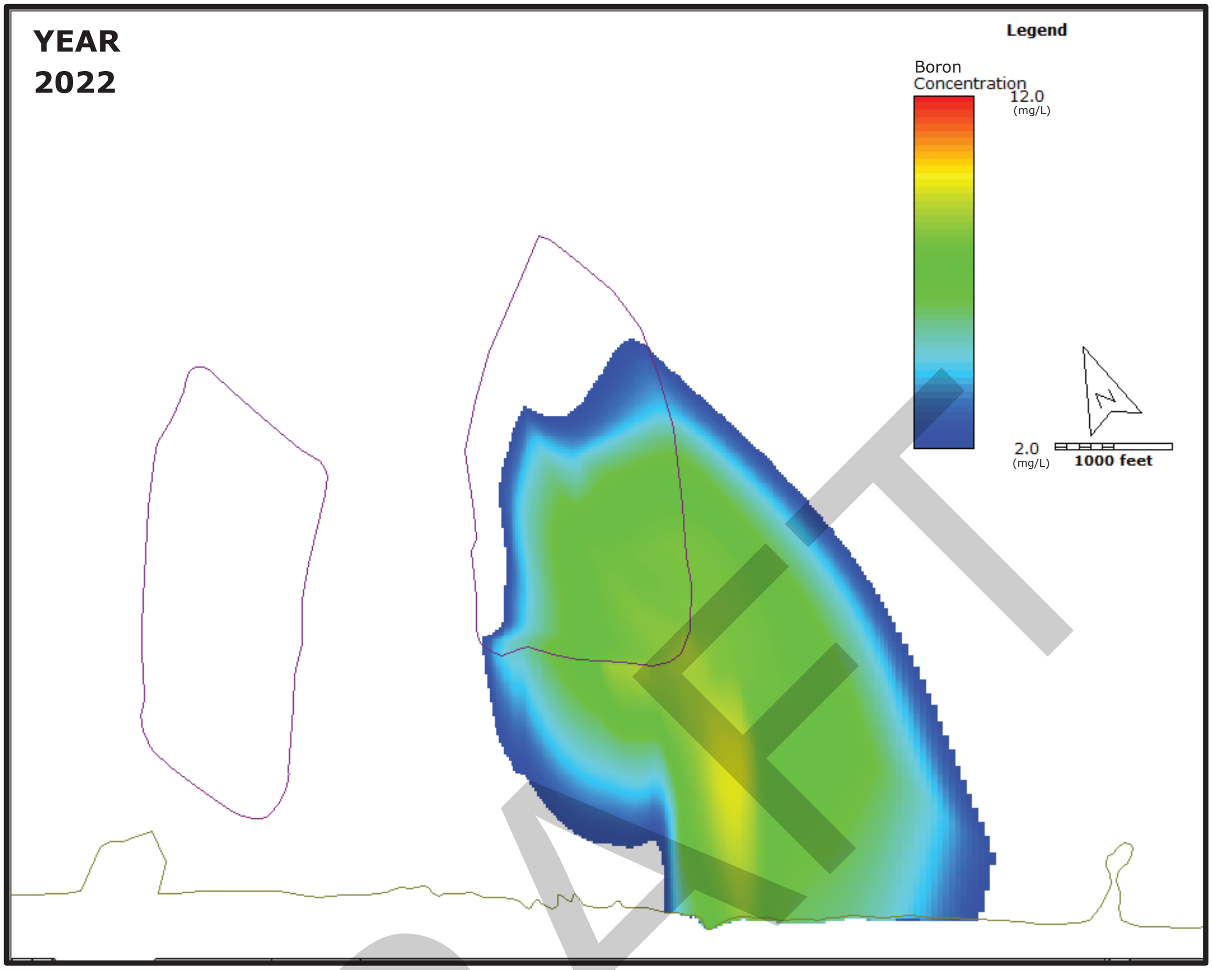
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 3

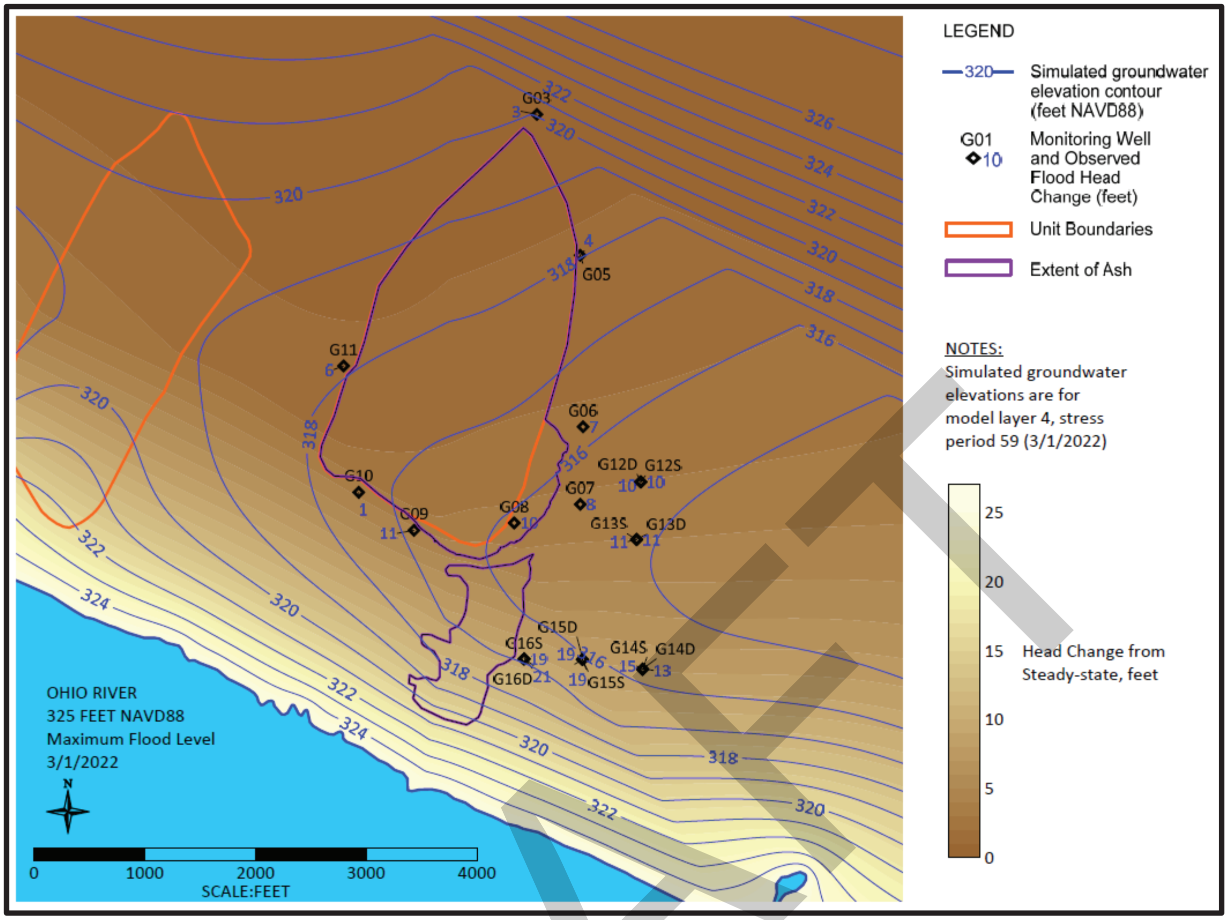
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 4

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

FIGURE 5-23



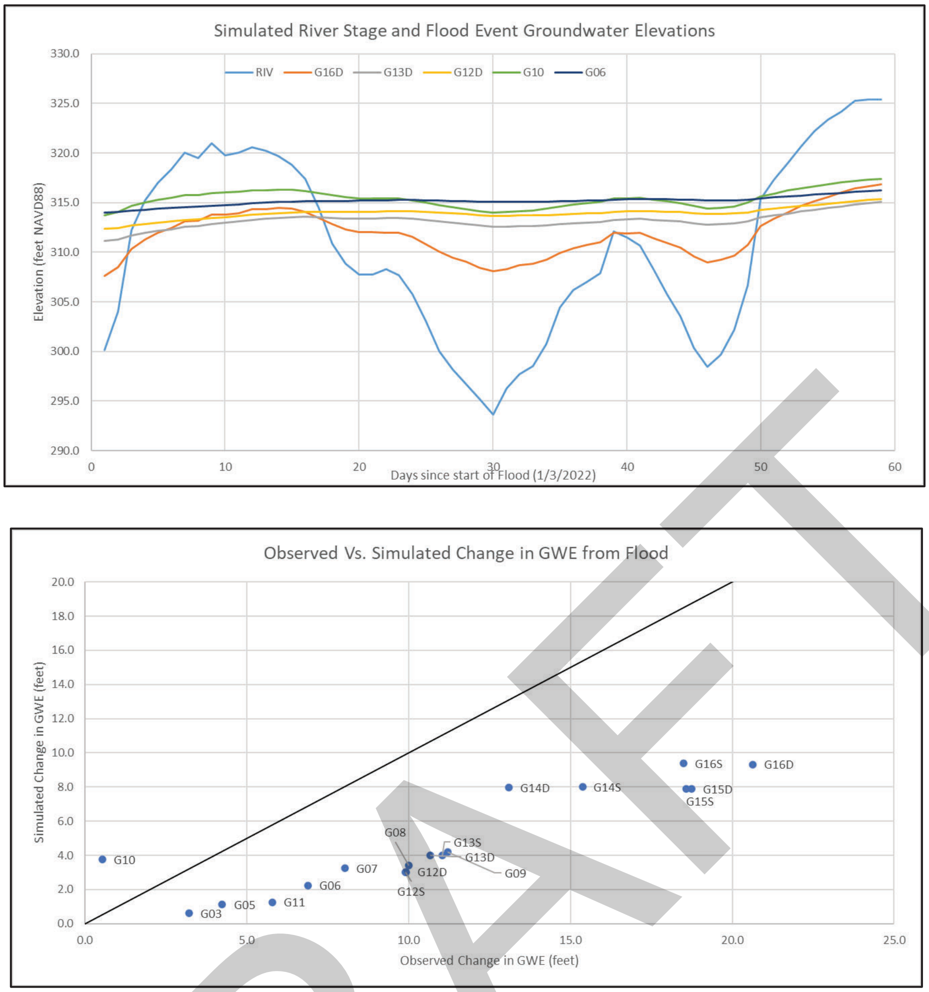
NOTES:
Simulated groundwater elevations are for model layer 4, stress period 59 (3/1/2022)

OHIO RIVER
325 FEET NAVD88
Maximum Flood Level
3/1/2022

SIMULATED FLOOD EVENT GROUNDWATER ELEVATIONS IN MODEL LAYER 4

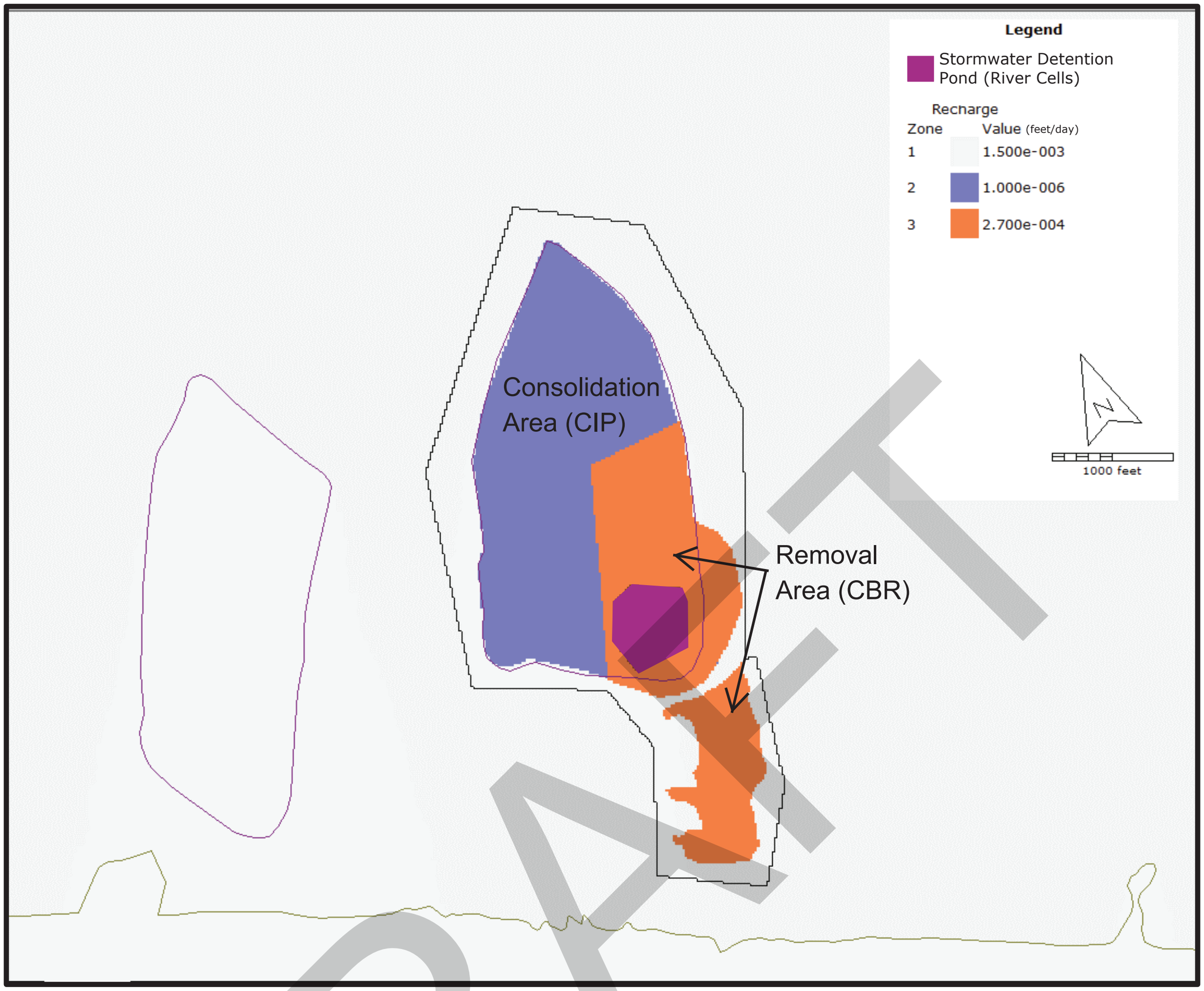
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 5-24



SIMULATED RIVER STAGE AND FLOOD EVENT GROUNDWATER ELEVATIONS

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

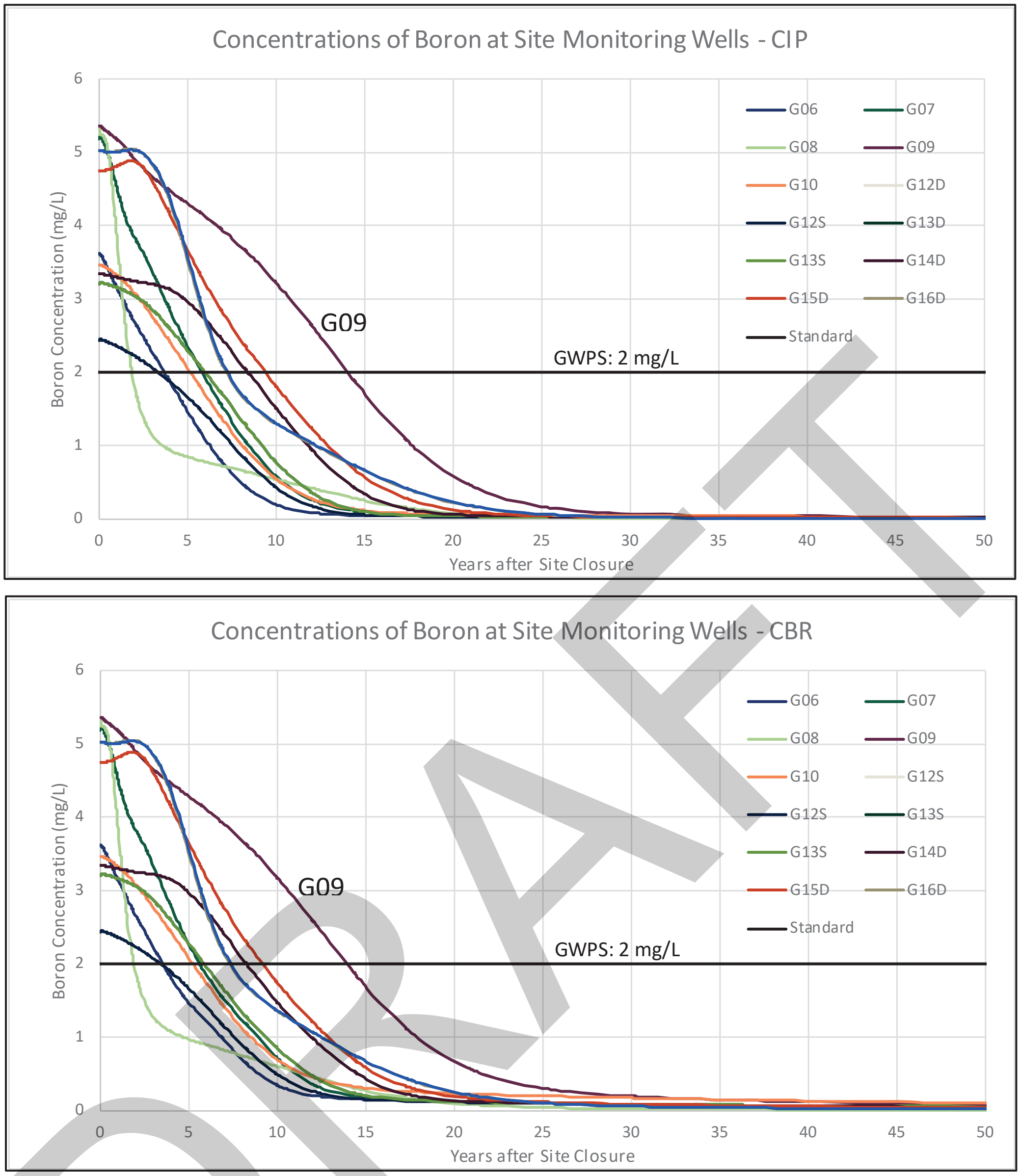


CIP RECHARGE DISTRIBUTION AND BOUNDARY CONDITIONS, MODEL LAYER 1

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

RAMBOLL

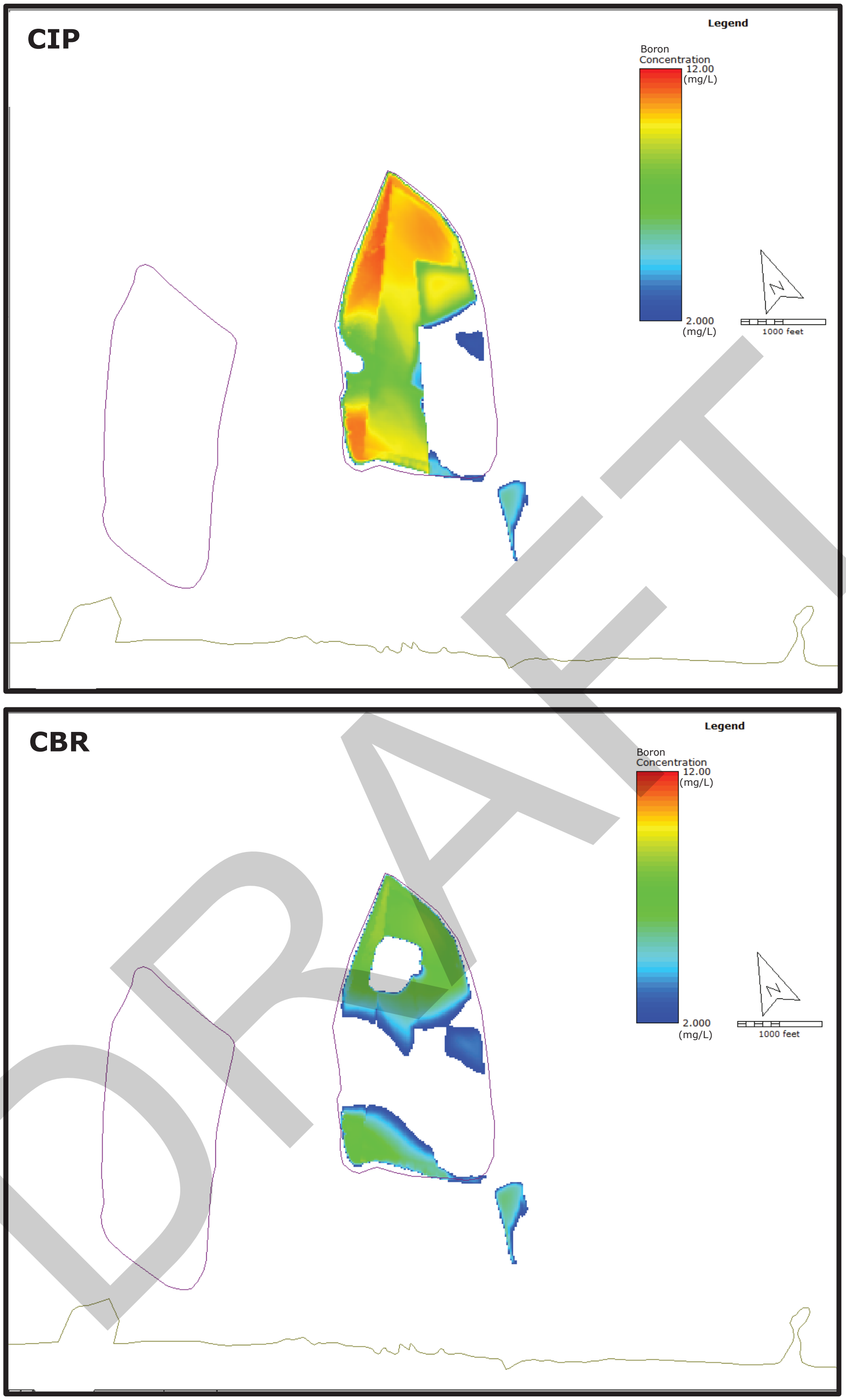
FIGURE 6-2



PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP AND CBR

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

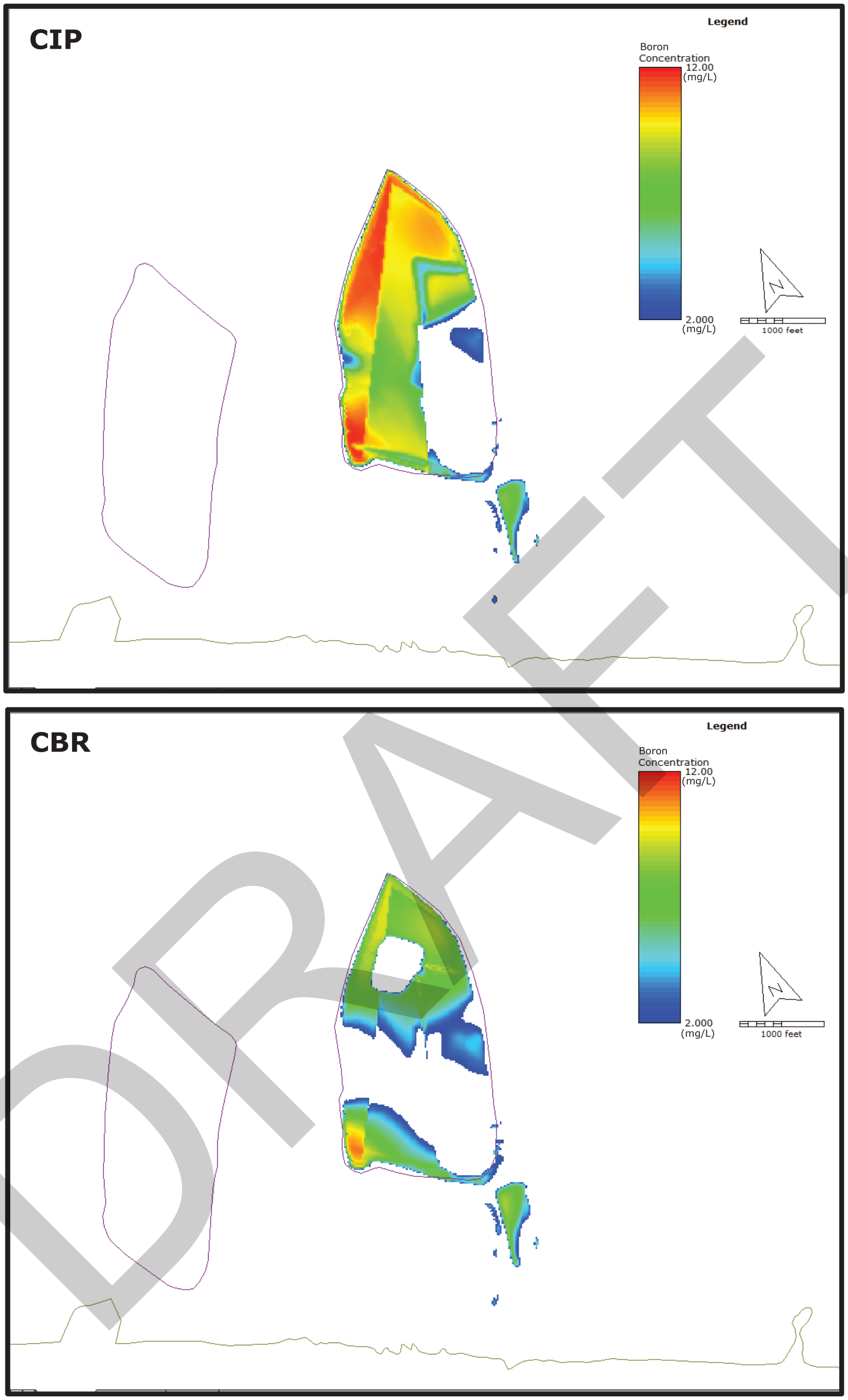
FIGURE 6-3



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

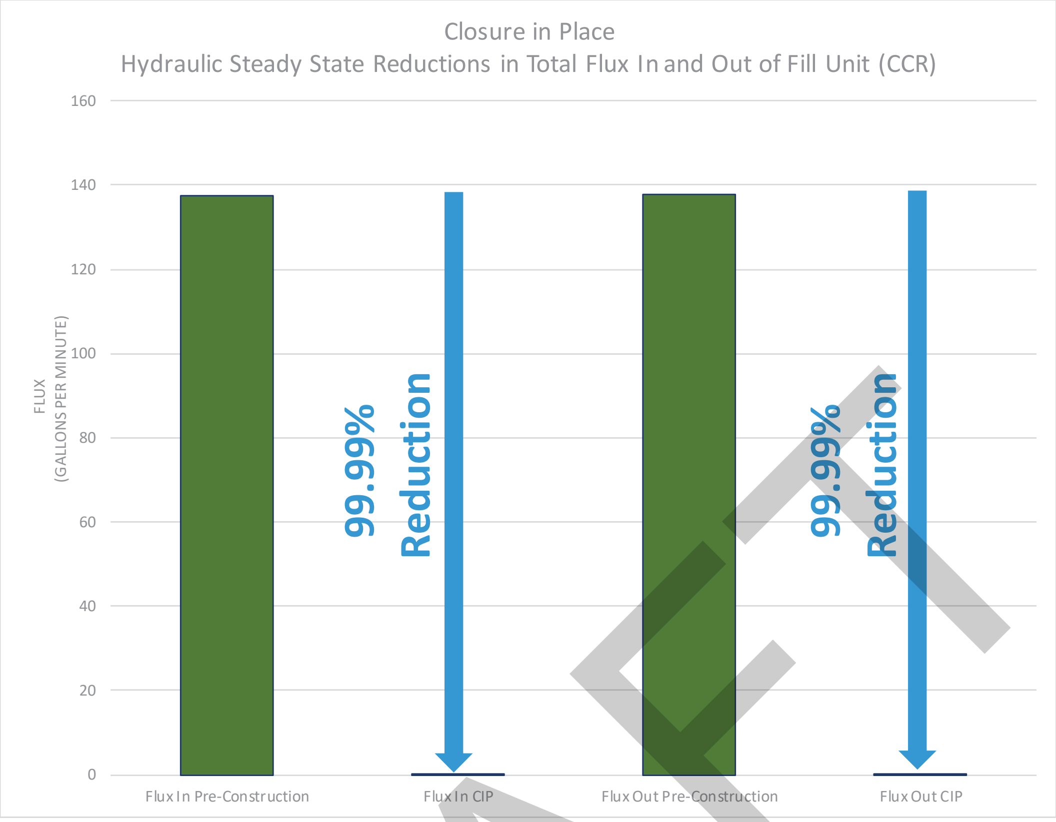
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 6-4



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

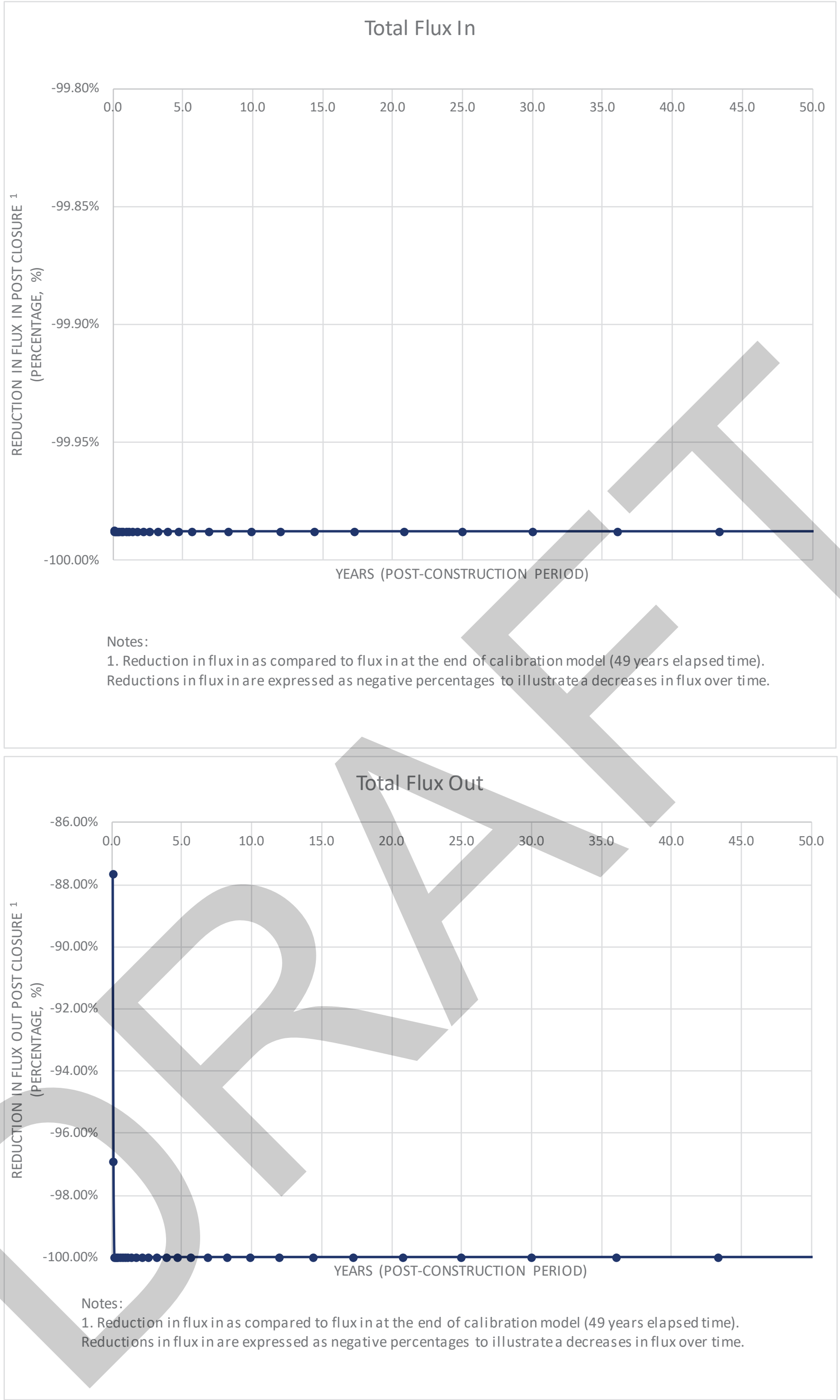
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



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

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

FIGURE 6-6

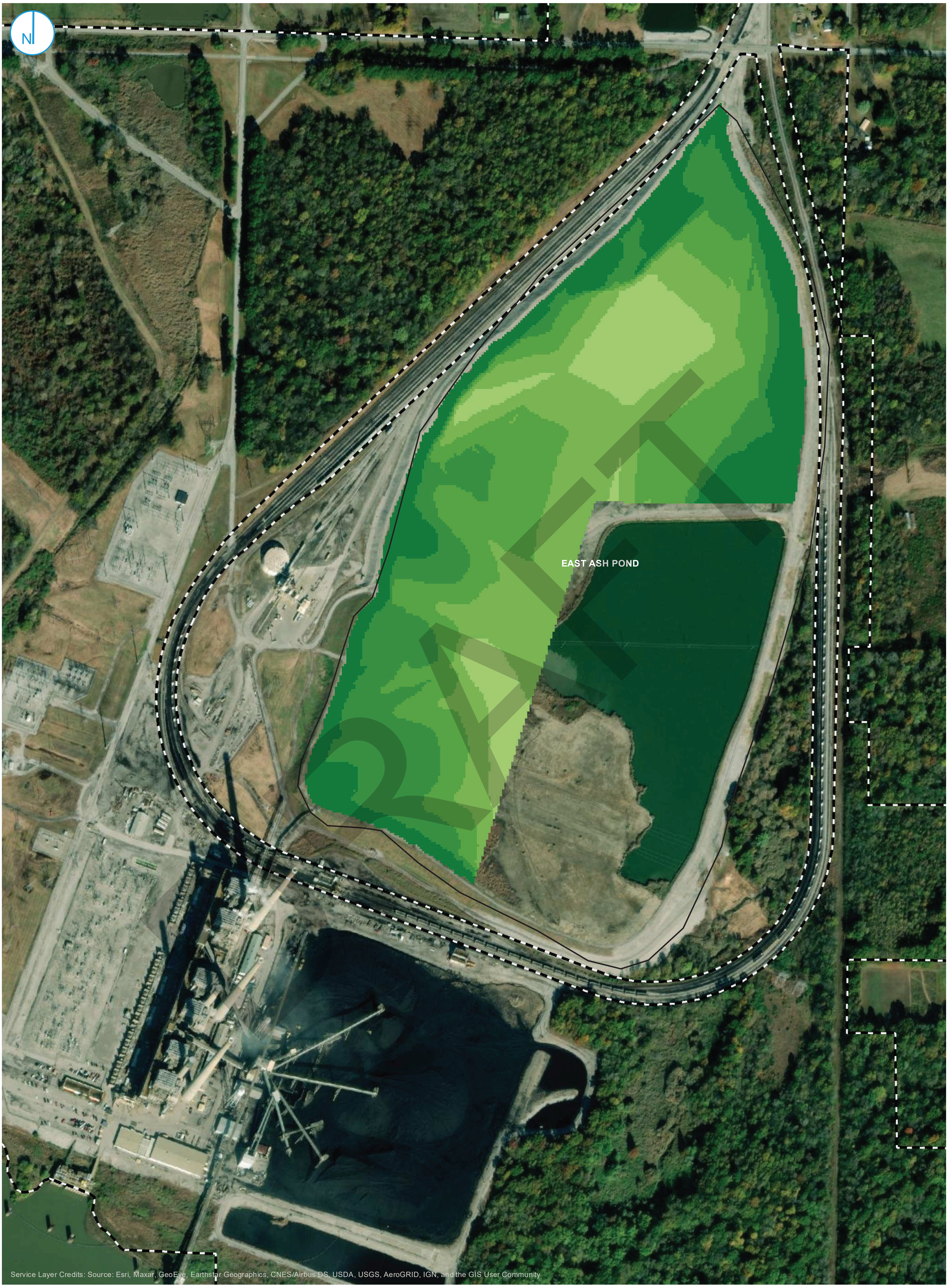


Notes:
1. Reduction in flux in as compared to flux in at the end of calibration model (49 years elapsed time). Reductions in flux in are expressed as negative percentages to illustrate a decreases in flux over time.

Notes:
1. Reduction in flux in as compared to flux in at the end of calibration model (49 years elapsed time). Reductions in flux in are expressed as negative percentages to illustrate a decreases in flux over time.

CIP – MODEL PREDICTED FLUX REDUCTION OVER TIME

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



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☐ SITE FEATURE

⬚ PROPERTY BOUNDARY

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

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

0 200 400
Feet

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

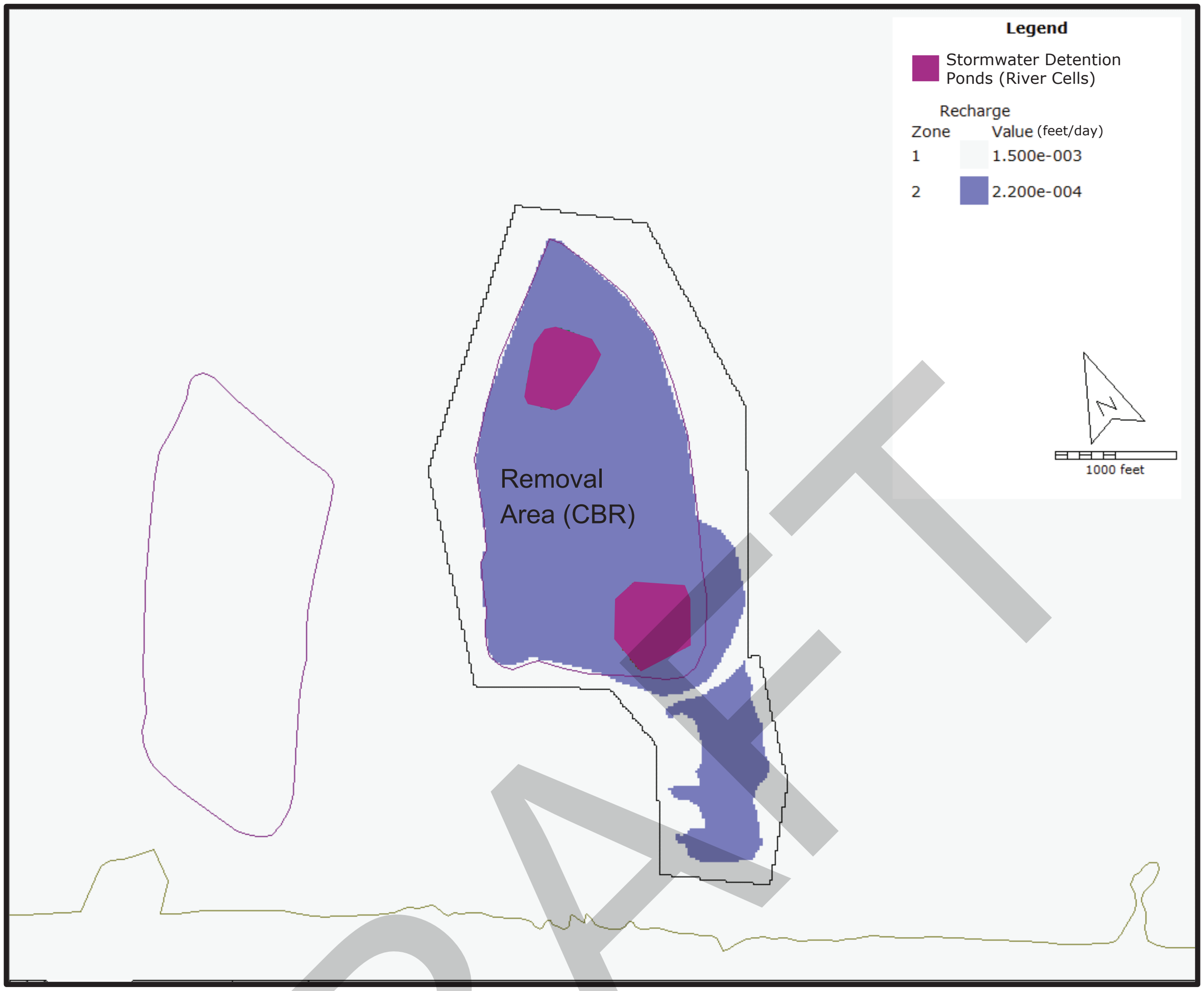
POTENTIAL ASH SATURATION SIMULATED CLOSURE IN PLACE GROUNDWATER SURFACE

FIGURE 6-7

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL



CBR RECHARGE DISTRIBUTION AND BOUNDARY CONDITIONS, MODEL LAYER 1

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

APPENDICES

APPENDIX A
EVALUATION OF POTENTIAL GWPS EXCEEDANCES

Intended for
Electric Energy, Inc.

Date
May 23, 2022

Project No.
1940102417

EVALUATION OF POTENTIAL GWPS EXCEEDANCES

JOPPA POWER PLANT
EAST ASH POND
CCR UNIT 401

RAMBOLL Bright ideas. Sustainable change.

CONTENTS

FIGURES (IN TEXT)

FIGURES (ATTACHED)

TABLES (IN TEXT)

ACRONYMS AND ABBREVIATIONS

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

1. INTRODUCTION

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

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

2. SITE INFORMATION

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

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

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

3. POTENTIAL GWPS EXCEEDANCES

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

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

The potential exceedances are summarized in Table A below.

Table A. Potential pH exceedances of the GWPS.

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

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

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

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

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

These are described and supported in greater detail below.

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

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

4.2 The EAP Porewater is Not a Source of Low pH

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

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

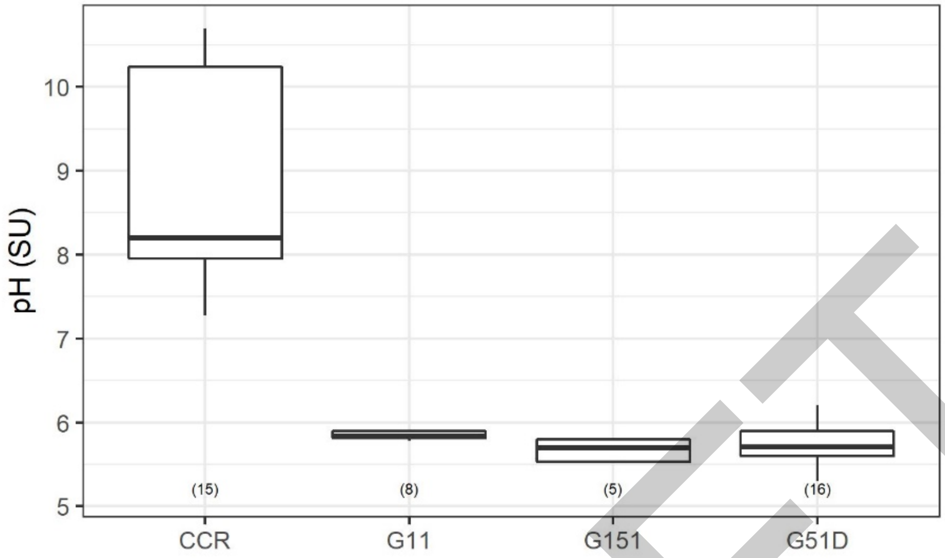


Figure A. pH Ranges Measured in CCR Porewater and Monitoring Wells from 2015 to 2021. The number in parentheses below each box plot represents the sample count.

4.3 Background pH Is Trending Downward

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

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

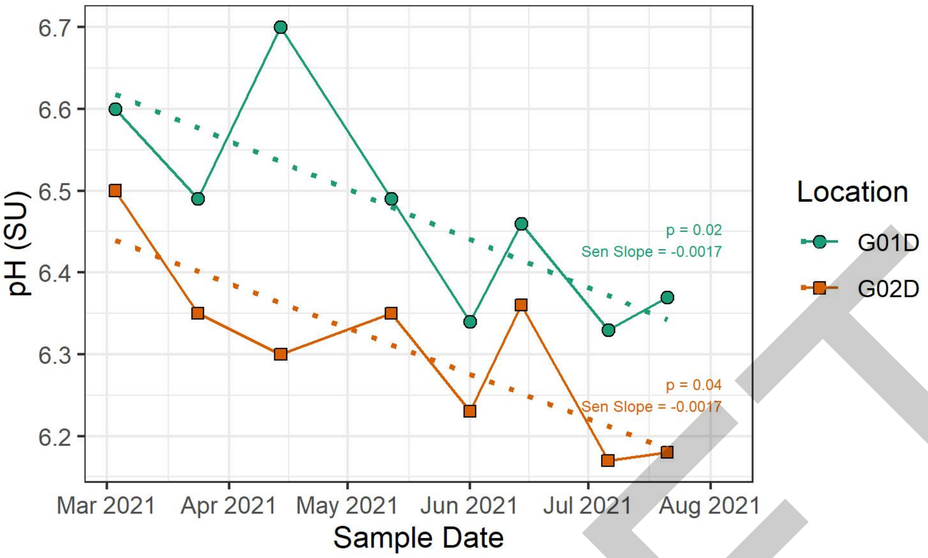


Figure B. 2021 Sampling Data and Mann-Kendall Trend Test Results for pH in Background Wells.

5. CONCLUSIONS

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

6. REFERENCES

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

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

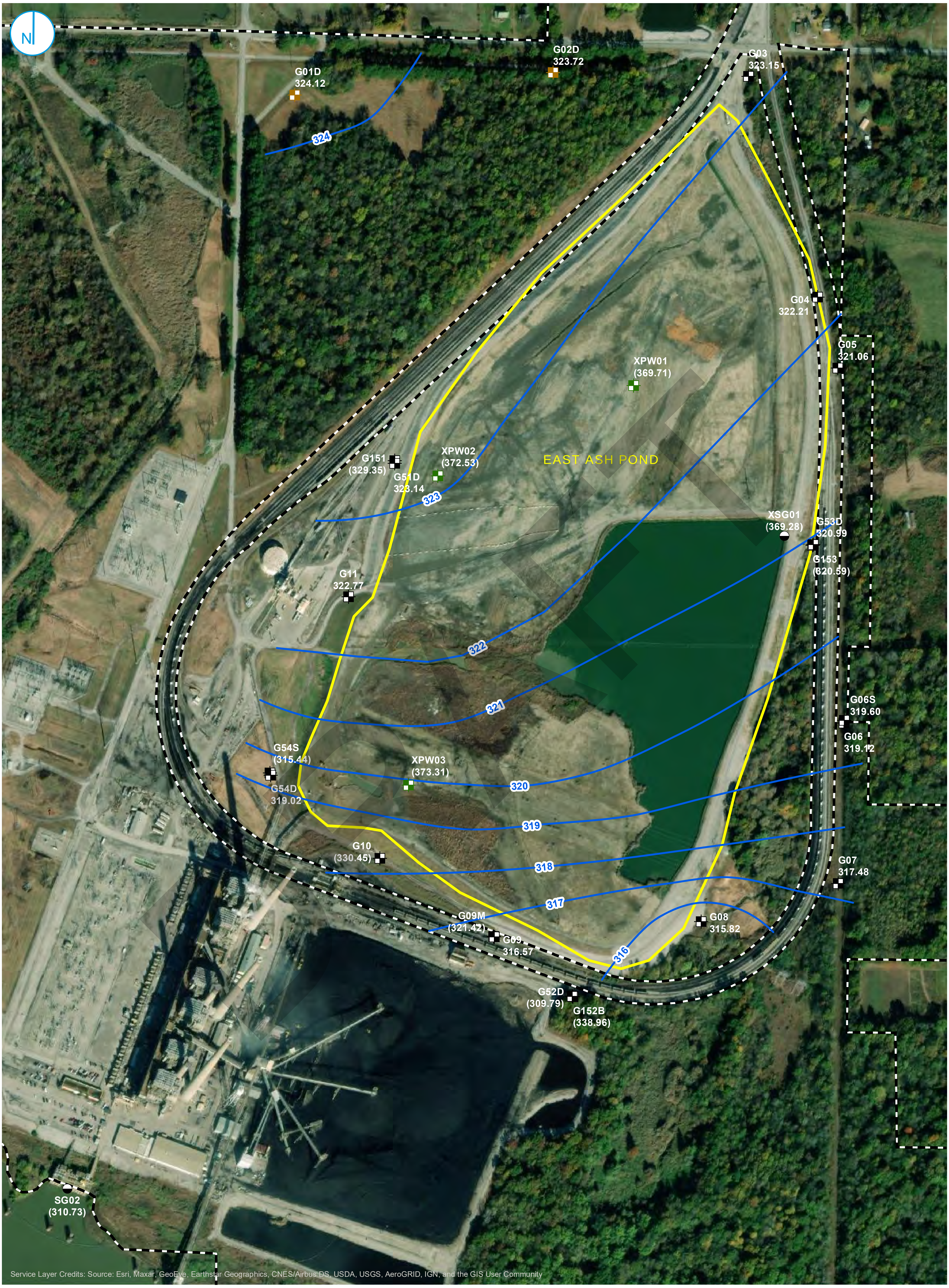
Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021c. *Statistical Analysis Plan, Joppa East Ash Pond, Joppa Power Plant*. October 25, 2021.

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

FIGURES

PROJECT: 169000XXXX | DATED: 9/28/2021 | DESIGNER: STOLZSD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\Figure 3-5_GWE_Contours_20210511_12.mxd



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

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

0 200 400
Feet

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

UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP
MAY 11 AND 12, 2021

FIGURE 2-1

EVALUATION OF POTENTIAL GWPS EXCEEDANCES

JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

APPENDIX B
HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT

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

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

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Appendices

1. Introduction

1.1 Background

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

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

1.2 Site Location

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

2. Hydrogeologic Investigation and Additional Evaluations

2.1 Hydrogeologic Investigation

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

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

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

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

2.2 Base of CCR

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

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

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

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

2.3 Top of Uppermost Aquifer

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

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

2.4 Water Table Evaluation

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

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

3. Conclusions

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

The separation distance between the base of CCR and the top of the UA is illustrated on **Figure 3-1**. Separation distance ranges from 0.5 ft to 89 feet with an average of approximately 31 feet. The separation distances are smallest in the southeast corner of the EAP within the former drainage feature where the top of the UA is shallowest.

4. References

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

Geosyntec Consultants, Inc. (Geosyntec), 2022. *CCR Surface Impoundment Final Closure Plan, Joppa Power Plant, East Ash Pond, Joppa, Illinois*. April 26, 2022.

Nelson, W. John, 1997. *ISGS Core Study*. January 1997.

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

TABLES

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS

JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

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

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS

JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

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

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

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS

JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

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

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

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

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

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

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

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

TABLE 2-3. UPPER CONFINING UNIT GROUNDWATER ELEVATIONS

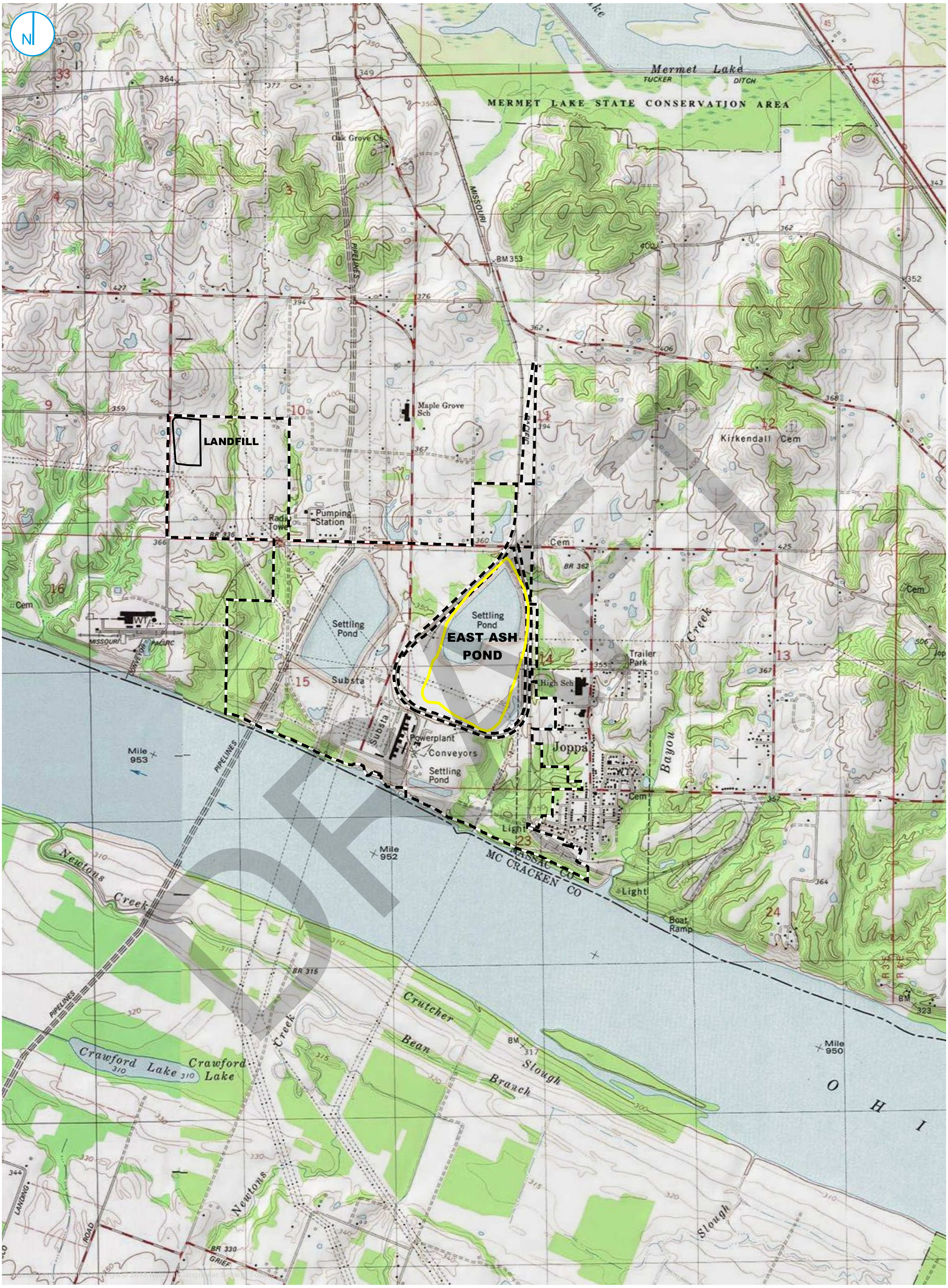
HYDROGEOLOGIC UPDATE FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

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

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

Notes:
[1] GWE is in feet referenced to North American Vertical Datum of 1988 (NAVD88)
GWE = groundwater elevation

FIGURES



🟨 PART 845 REGULATED UNIT (SUBJECT UNIT)
☐ OTHER UNIT
⬚ PROPERTY BOUNDARY

0 1,000 2,000 Feet

SITE LOCATION MAP

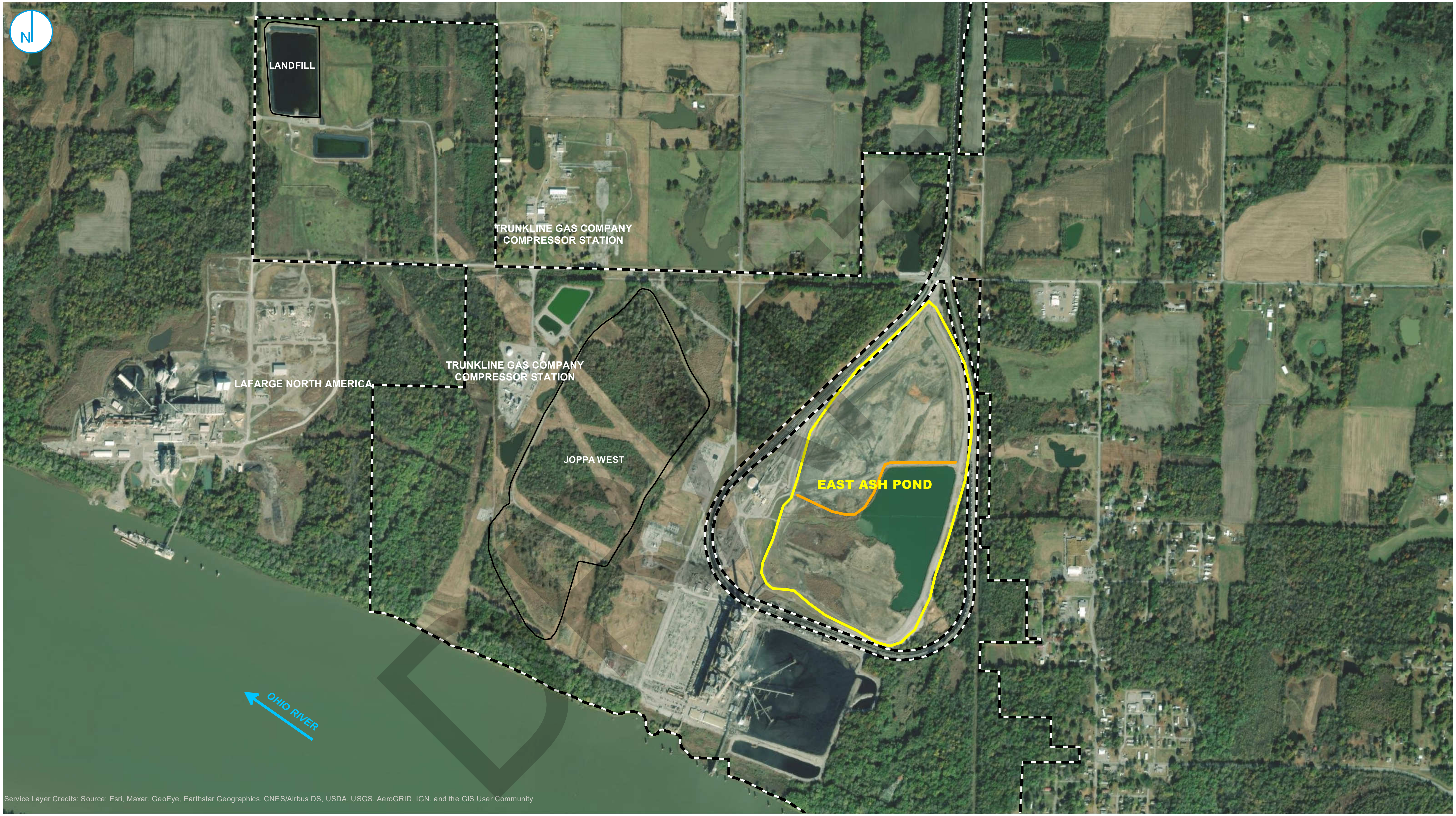
FIGURE 1-1

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

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\Plume_Delineation\Joppa\JOP_INV_2022\Part845_Construction_Permit\Figure 1-2_Site Map.mxd



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

PROJECT: 169000XXXX | DATED: 5/25/2022 | DESIGNER: galarnmc

🟨 PART 845 REGULATED UNIT (SUBJECT UNIT)
☐ OTHER UNIT
— CENTRAL DIKE
▭ PROPERTY BOUNDARY

0 500 1,000 Feet

SITE MAP

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

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

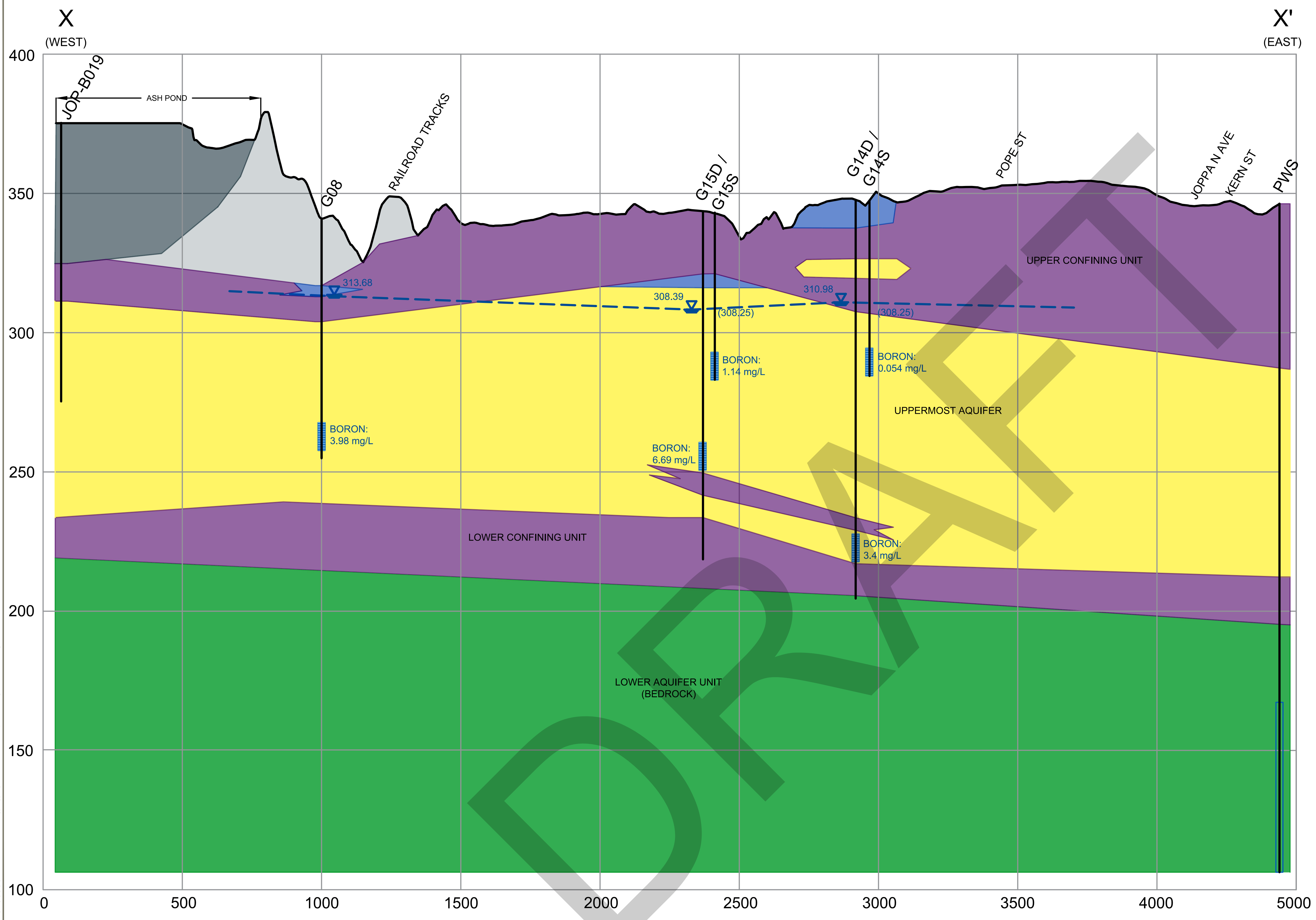
RAMBOLL

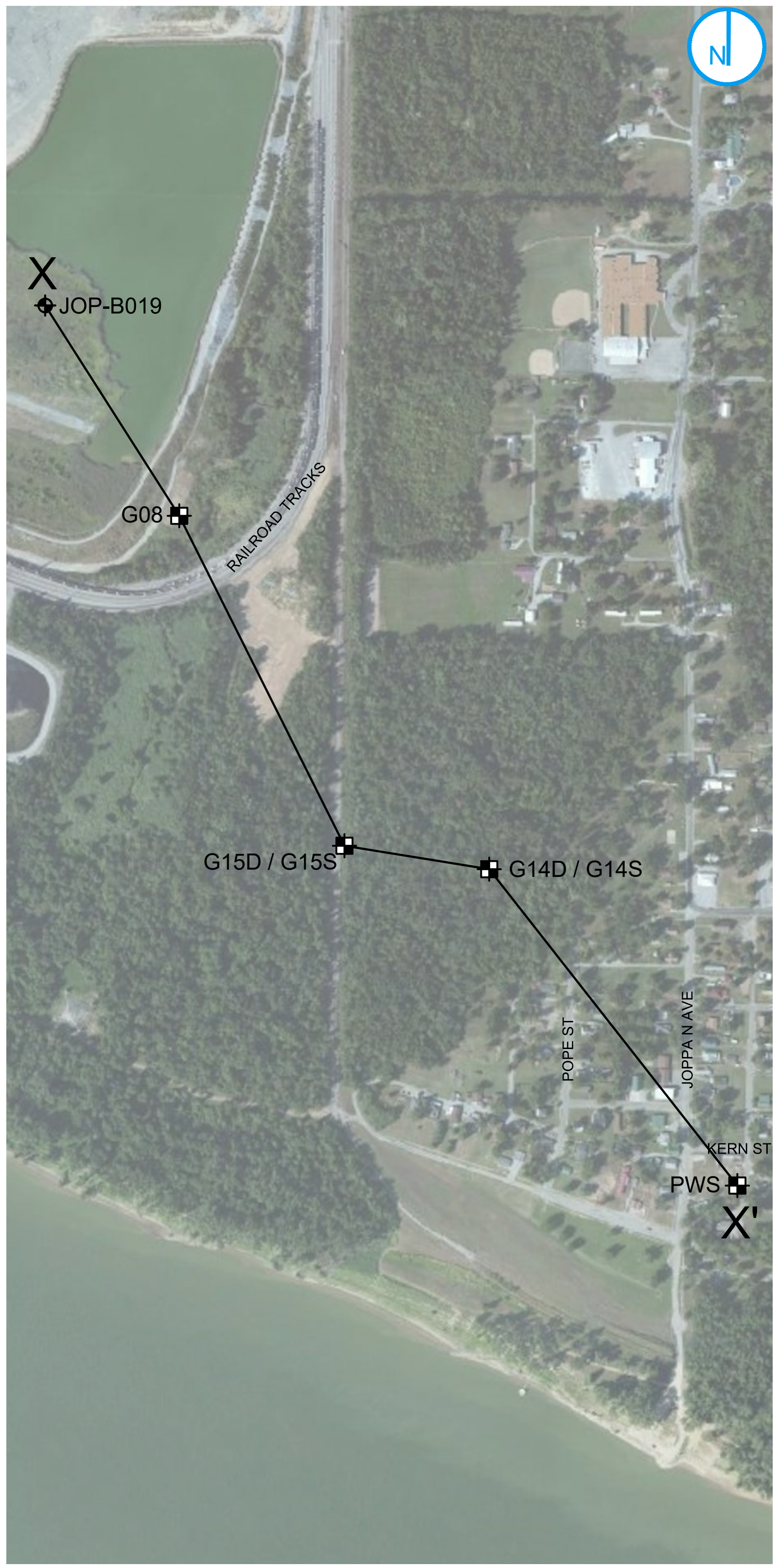
C:\Users\cawrseag\OneDrive - Ramboll\Desktop\Figure 2-1 Cross Section X-X'.dwg

DESIGNER: CAWRSEAG

DATED: 5/26/2022

PROJECT: 1940100806



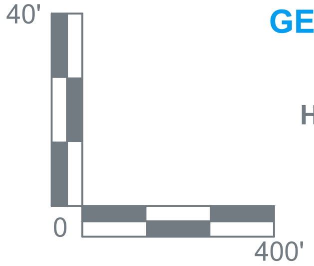


LEGEND

- ⬛ COAL COMBUSTION RESIDUALS (CCR)
- ⬜ FILL
- 🟦 SILT
- 🟪 CLAY
- 🟨 SAND
- 🟩 BEDROCK
- ▤ WELL SCREEN INTERVAL
- - - UPPERMOST AQUIFER POTENTIOMETRIC SURFACE
- ▽ UPPERMOST AQUIFER GROUNDWATER ELEVATION

NOTES

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



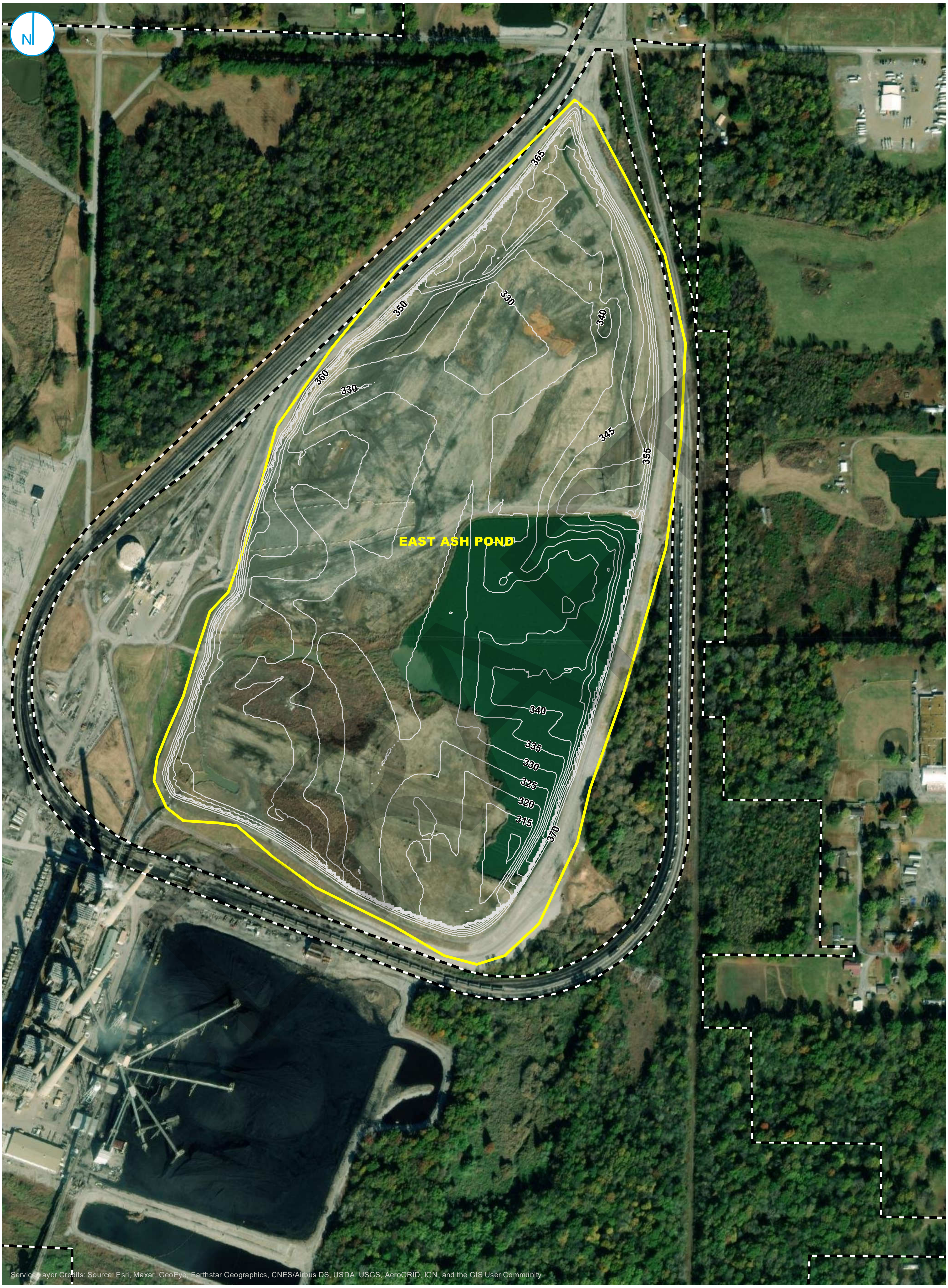
GEOLOGIC CROSS SECTIONS
X-X'

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

FIGURE 2-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



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

― BOTTOM OF ASH CONTOUR (5-FT INTERVAL)

🟨 PART 257 REGULATED UNIT (SUBJECT UNIT)

⬚ PROPERTY BOUNDARY

0 200 400 Feet

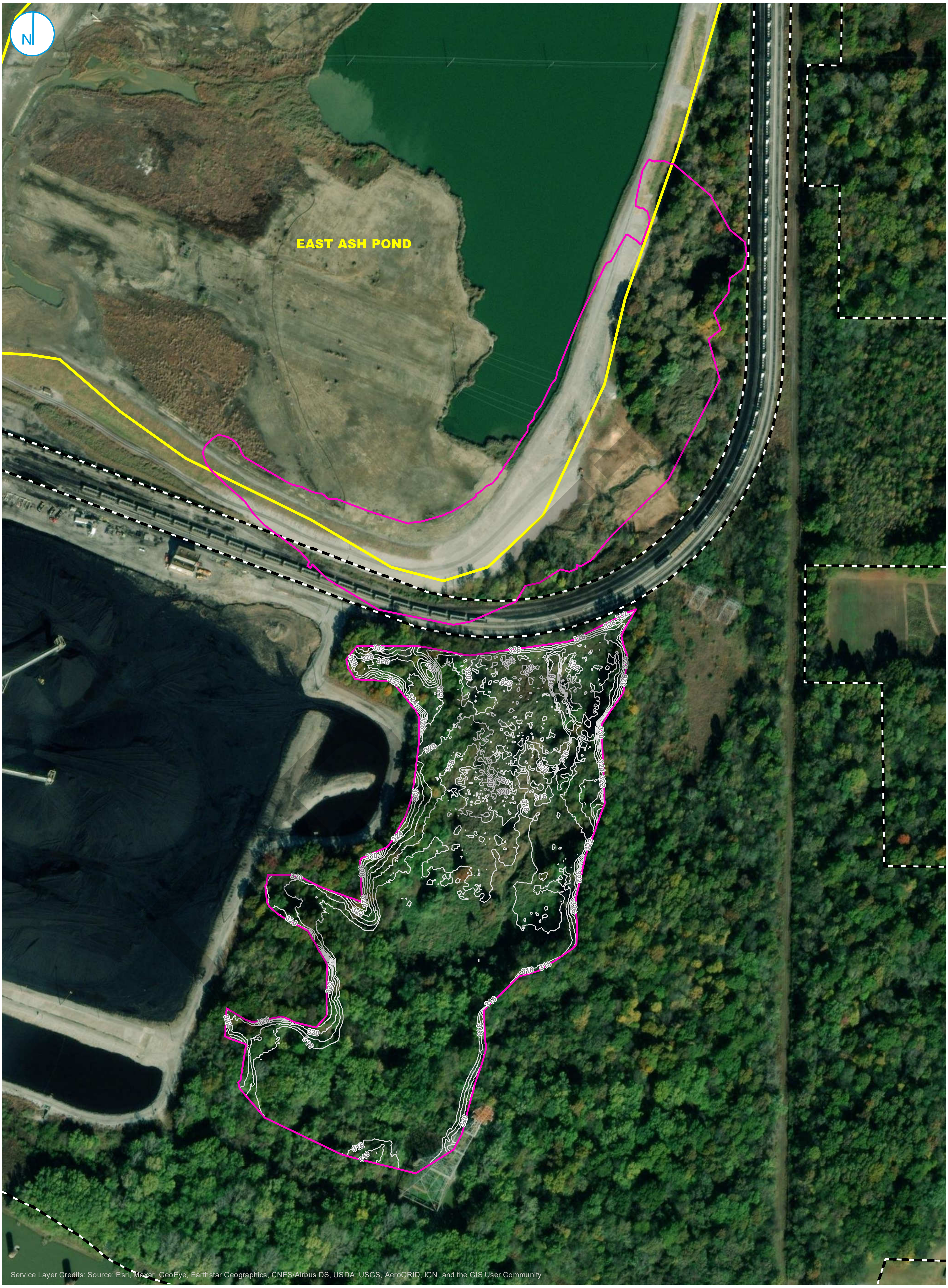
BASE OF CCR (INSIDE EAP)

FIGURE 2-2

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

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



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

ASH EXTERIOR BOUNDARY

BOTTOM OF ASH CONTOUR (2-FT INTERVAL)

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

0 125 250 Feet

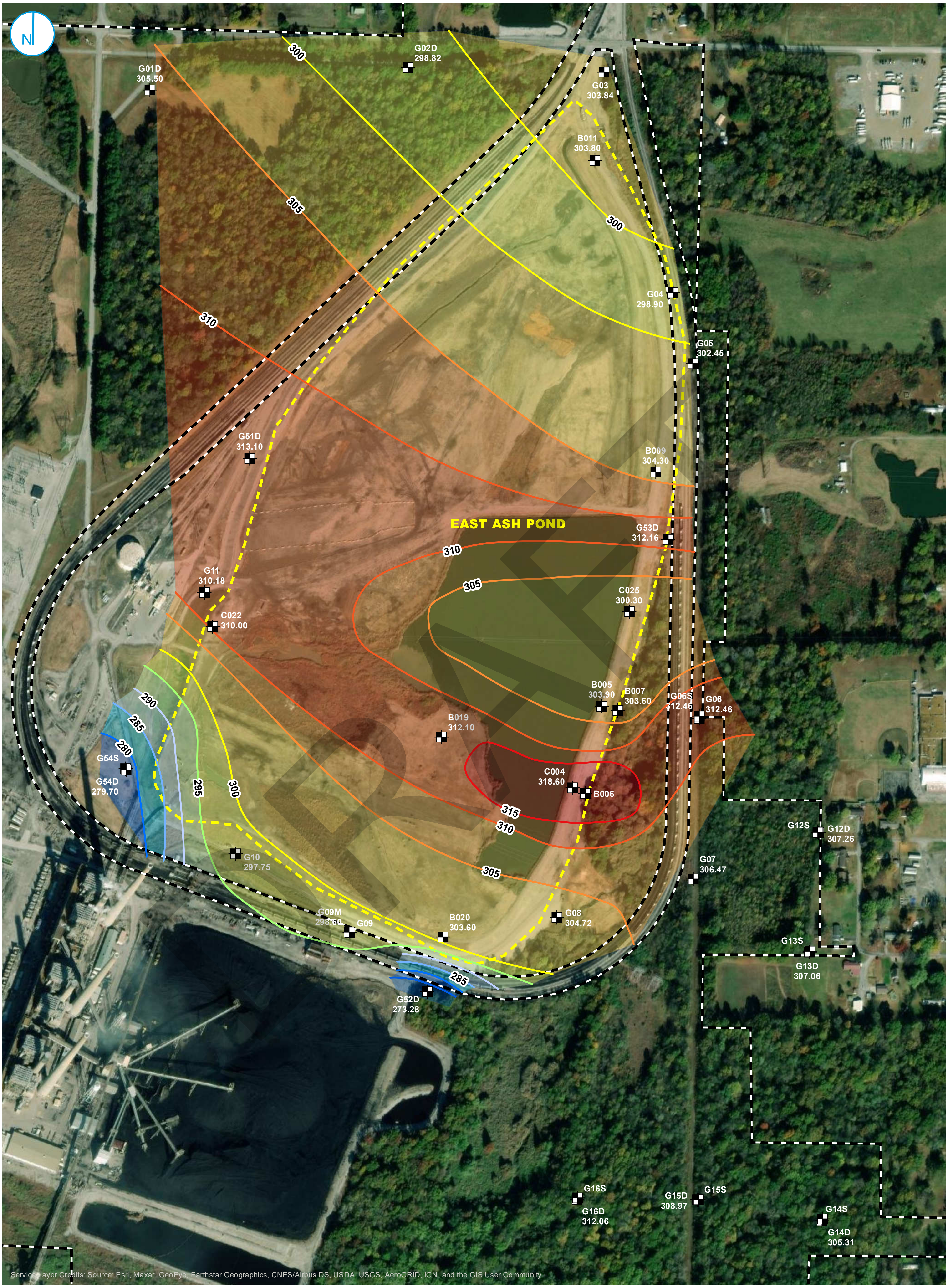
BASE OF CCR (OUTSIDE EAP)

FIGURE 2-3

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

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



⊞	WELL LOCATION
▭	PART 257 REGULATED UNIT (SUBJECT UNIT)
▭	PROPERTY BOUNDARY

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

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

0 200 400
Feet

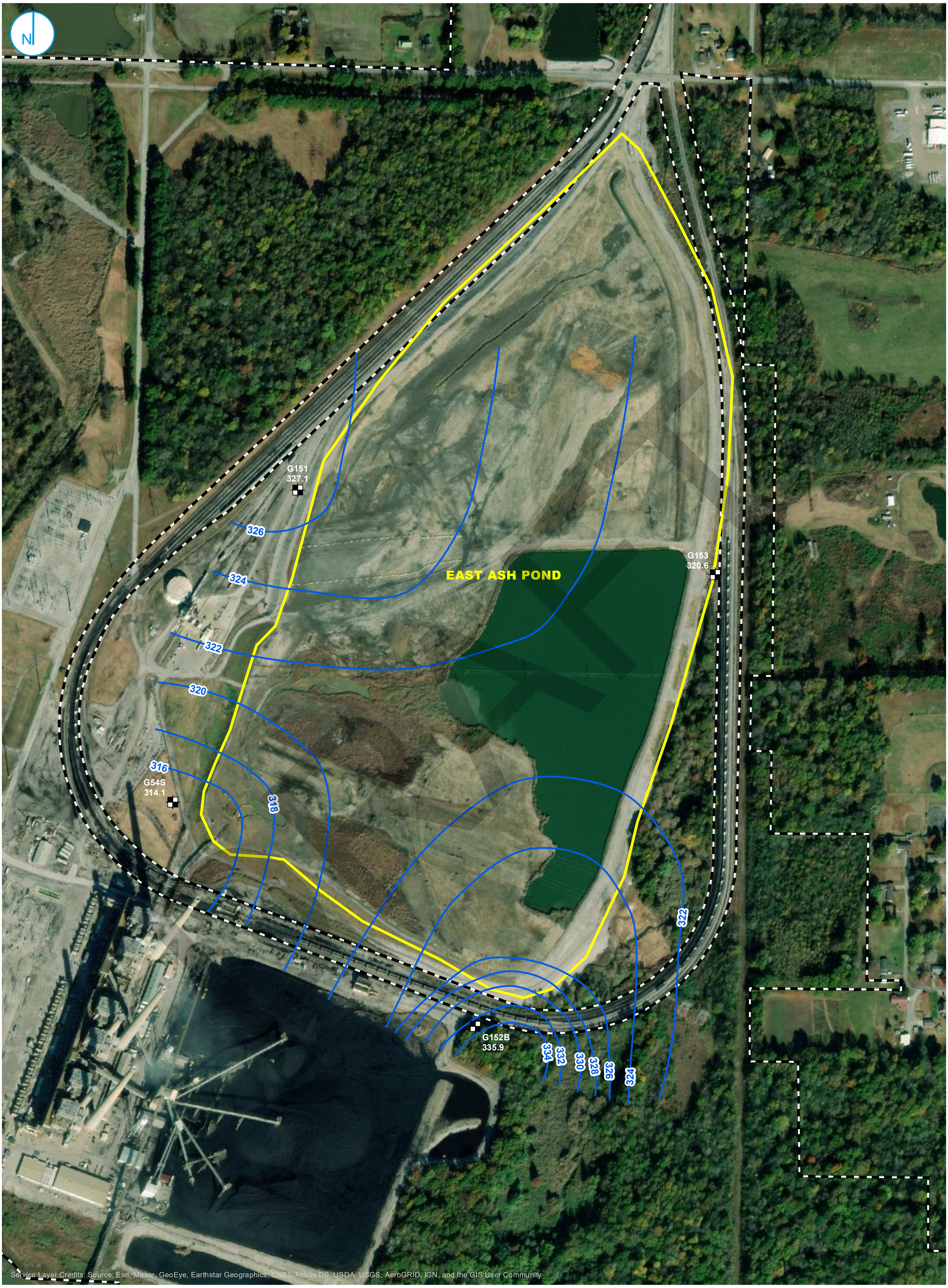
TOP OF UPPERMOST AQUIFER

FIGURE 2-4

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

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



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

- ▣ WELL LOCATION
- AVERAGE UCU WATER TABLE ELEVATION CONTOUR 2021
- ▭ PART 257 REGULATED UNIT (SUBJECT UNIT)
- ⬚ PROPERTY BOUNDARY

0 200 400 Feet

UPPER CONFINING UNIT AVERAGE WATER TABLE ELEVATIONS 2021

FIGURE 2-5

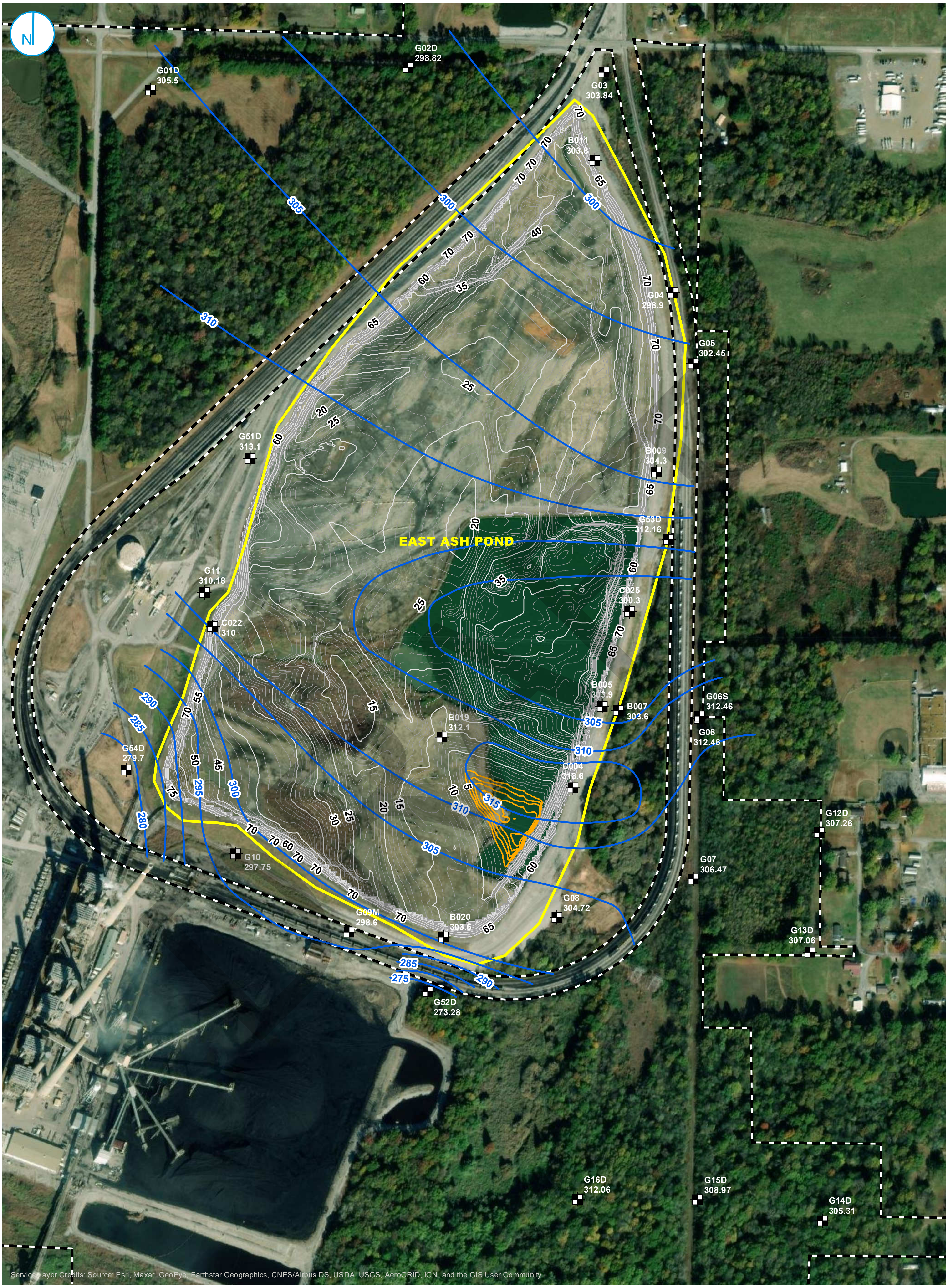
HYDROGEOLOGIC UPDATES
FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

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

Y:\Mapping\Projects\22\2285\MXD\Plume_Delineation\Joppa\JOP_INV_2022\Part845_Construction_Permit\Figure 3-1_TOA_wCCR.mxd



- ▪ WELL LOCATION
- INTERPRETED TOP OF UPPERMOST AQUIFER (95TH PERCENTILE GROUNDWATER ELEVATION CONTOURS, 2022)
- PART 257 REGULATED UNIT (SUBJECT UNIT)
- PROPERTY BOUNDARY
- SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER LESS THAN 5FT
- SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER (5FT CONTOUR INTERVAL)
- SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER (1FT CONTOUR INTERVAL)

0 200 400 Feet

BASE OF CCR - TOP OF UPPERMOST AQUIFER SEPARATION

FIGURE 3-1

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

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

APPENDIX A
SOIL BORING LOGS AND WELL CONSTRUCTION FORMS

Geosyntec consultants
engineers | scientists | innovators

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

WELL LOG

Well No. G12D
Page: 1 of 5

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

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
0								(0') SILT (ML); light brown, fine grained, loose, moist.		0
5										5
10								(10') As above: gray with light brown mottling.		10
15								(14.5') As above: light gray with orange mottling, trace clay, cohesive.		15
								(16.5') Clayey SILT (ML); light gray and orange, cohesive, dry.		
20										20

NOTES:

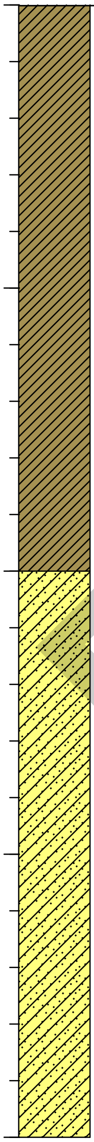
Geosyntec consultants
engineers | scientists | innovators

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

WELL LOG

Well No. G12D
Page: 2 of 5

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



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

NOTES:

Geosyntec consultants
engineers | scientists | innovators

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

WELL LOG

Well No. G12D
Page: 3 of 5

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

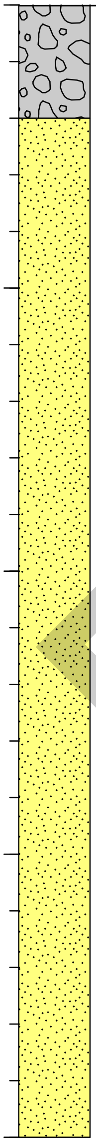
DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') Silty SAND (SM); reddish orange, fine grained, cohesive, moist.		40
								(42.5') As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

NOTES:

Geosyntec consultants engineers | scientists | innovators	**Client:** Vistra **Project:** GLP8030, Joppa Power Station **Address:** 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** G12D **Page:** 4 of 5

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

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



NOTES:

Geosyntec consultants

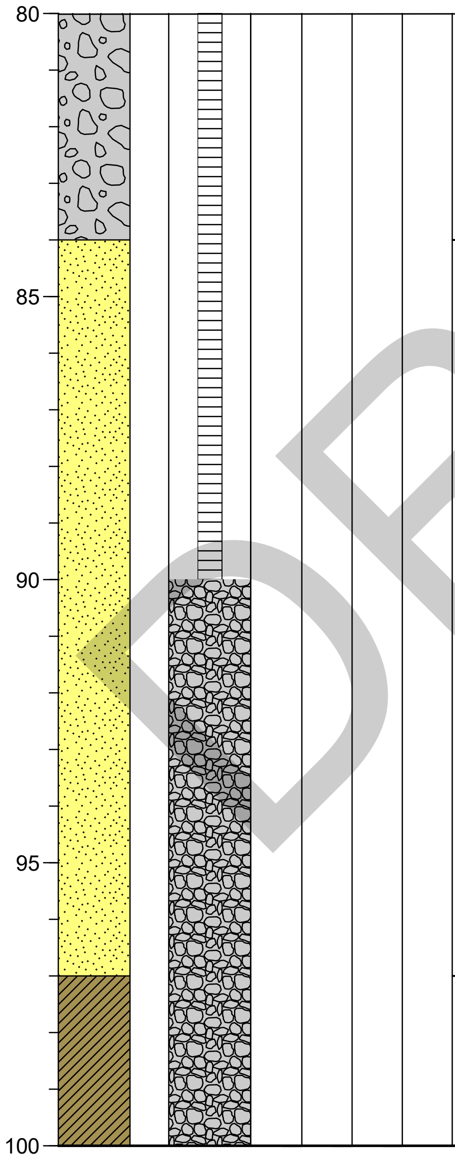
engineers | scientists | innovators

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

WELL LOG

Well No. **G12D**
Page: **5 of 5**

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



SOIL/ROCK VISUAL DESCRIPTION

(80') GRAVEL (GP); brown, well-graded, loose, saturated.

(84') SAND (SP); orange, fine grained, cohesive, saturated.

(97') CLAY (CL); light gray, some silt, medium soft, medium plasticity, moist.

(100') Boring terminated. Monitoring well G12D installed at 80-90 ft bgs.

MEASURE

Lab Sample

DEPTH (ft)

80

85

90

95

100

NOTES:

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

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

NOTES:

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

WELL LOG
Well No. G12S
Page: 2 of 4

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

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

NOTES:

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

WELL LOG
Well No. G12S

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

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	COLLECT Recovery (ft)	COLLECT Blow Counts	COLLECT N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
40								(40') Blind drill.		40
45										45
50								(50') SAND (SP); light gray, trace gravel, fine grained, moist.		50
								(52') Gravelly SAND (SP); reddish brown, coarse grained, saturated, 10 inch sand lense at 53 ft bgs.		
55										55
60										60

NOTES:

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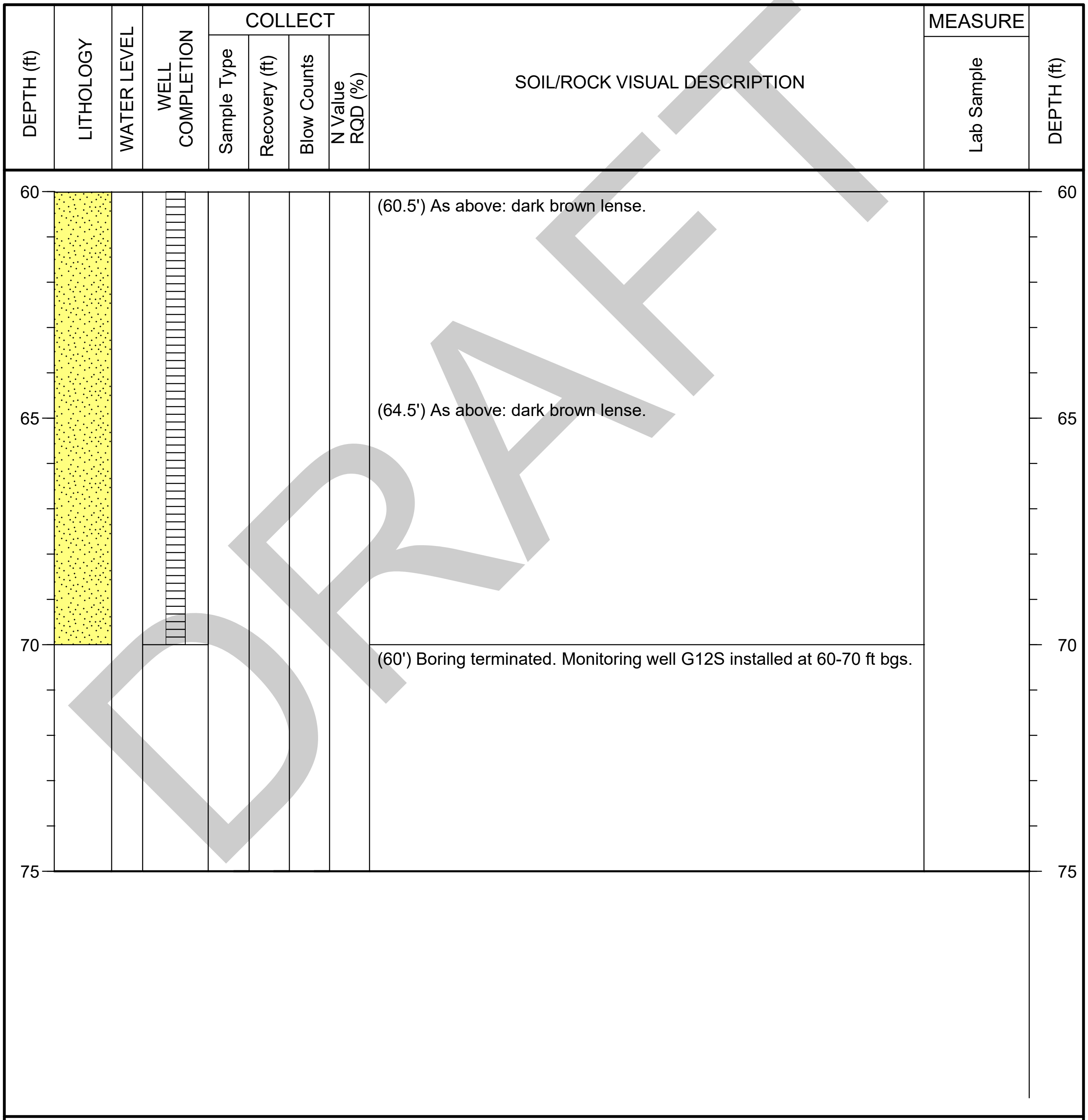
Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**70**	Well Depth (ft):	**70**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Drilling Sonic**	DTW After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



(60.5') As above: dark brown lense.

(64.5') As above: dark brown lense.

(60') Boring terminated. Monitoring well G12S installed at 60-70 ft bgs.

NOTES:

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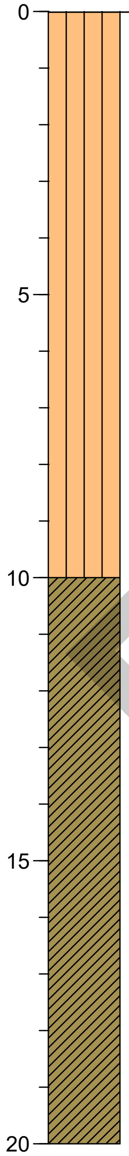
Drilling Start Date: **09/24/2021**	Boring Depth (ft): **110**	Well Depth (ft): **90**
Drilling End Date: **09/24/2021**	Boring Diameter (in): **6**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After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

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)		Lab Sample	



(0') SILT (ML); light gray with light brown mottling, orange.

(3.5') Clayey SILT (ML); light gray with light brown mottling, medium stiff, medium plasticity, moist.

(10') Sandy CLAY (CL); orange with light gray mottling, medium soft, medium plasticity, moist.

0
5
10
15
20

NOTES:

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

WELL LOG

Well No. G13D
Page: 2 of 6

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

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

NOTES:

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

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

NOTES:

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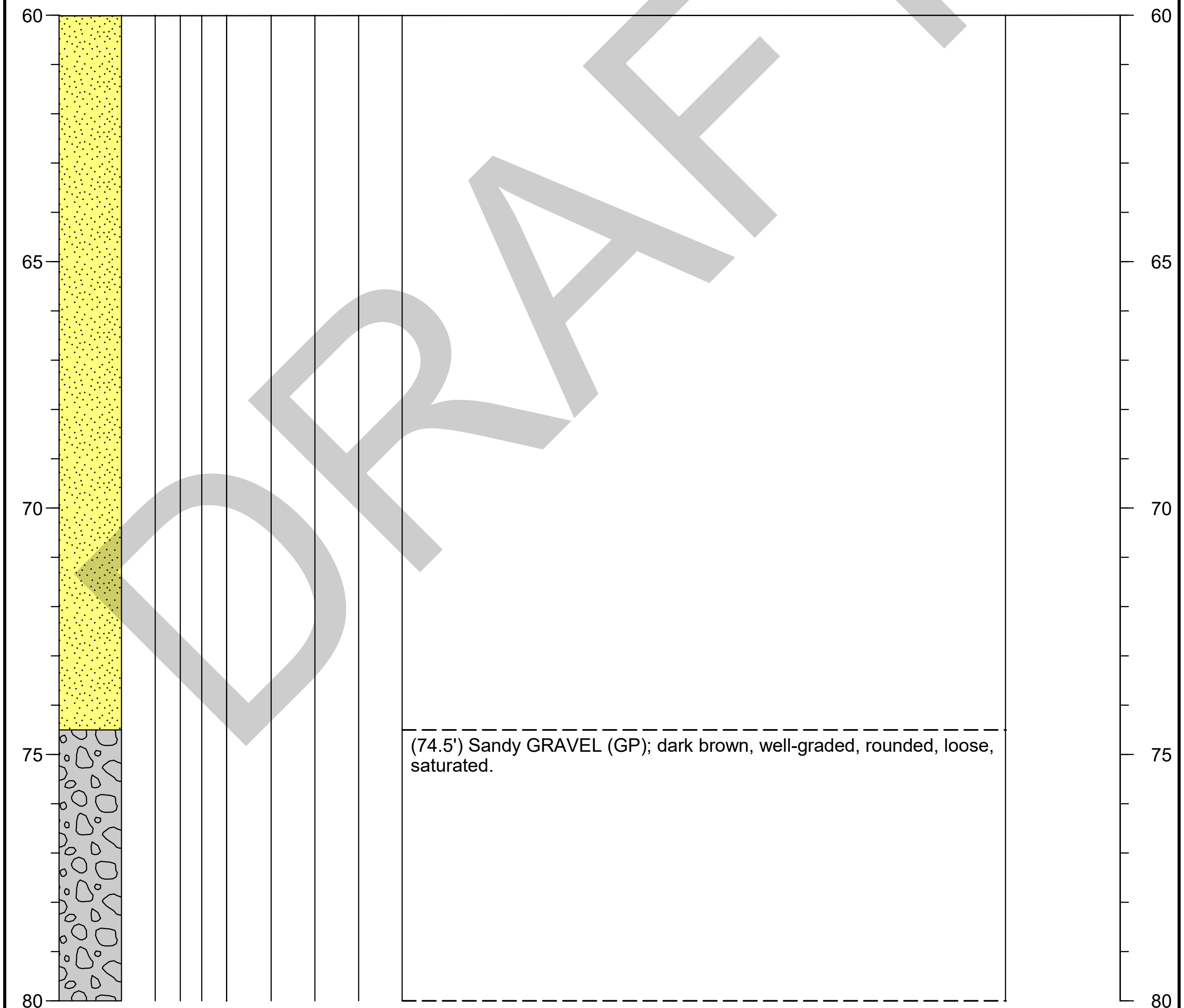
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G13D
Page: 4 of 6

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

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	COLLECT Recovery (ft)	COLLECT Blow Counts	COLLECT N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
74.5								(74.5') Sandy GRAVEL (GP); dark brown, well-graded, rounded, loose, saturated.		



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

WELL LOG

Well No. G13D
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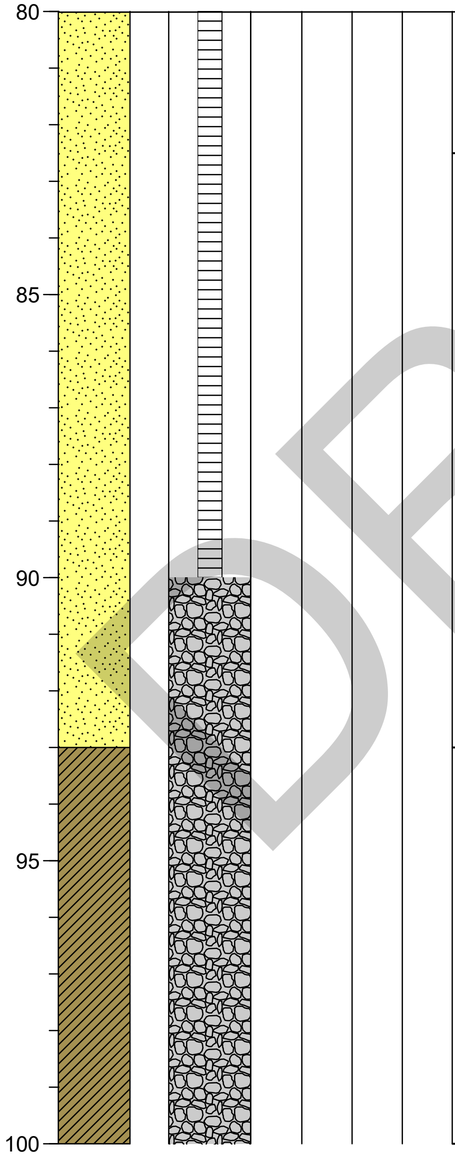
Drilling Start Date:	**09/24/2021**	Boring Depth (ft): **110**		Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in): **6**		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft): **354.11**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **351.31**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80								(80') Gravelly SAND (SP); orange, coarse grained, well-graded, loose, saturated.		80
								(82.5') SAND (SP); orange, fine grained, semi cohesive, saturated.		
85										85
90										90
								(93') CLAY (CL); light gray, trace silt, medium stiff, moist.		
95										95
100										100

NOTES:

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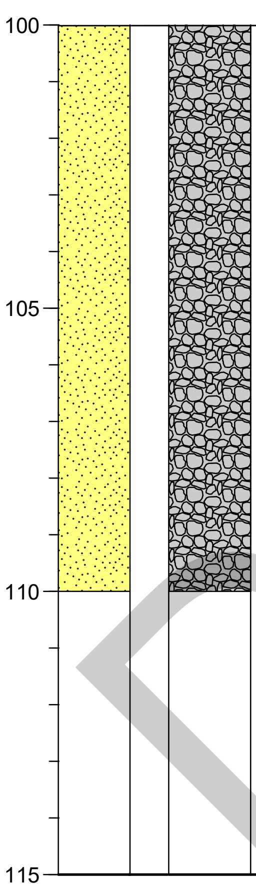
Client:	**Vistra**
Project:	**GLP8030, Joppa Power Station**
Address:	**2100 Portland Rd, Joppa, IL**

WELL LOG

Well No. **G13D**

Page: **6 of 6**

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



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

NOTES:

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

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

NOTES:

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Client: Vistra **Project:** GLP8030, Joppa Power Station **Address:** 2100 Portland Rd, Joppa, IL		**WELL LOG** **Well No.** G13S **Page:** 2 of 3

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

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

NOTES:

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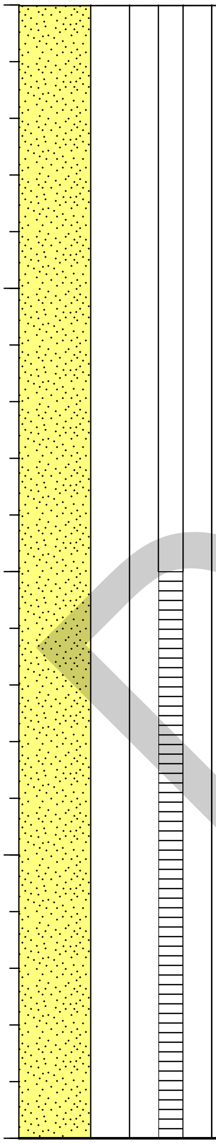
Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After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



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

NOTES:

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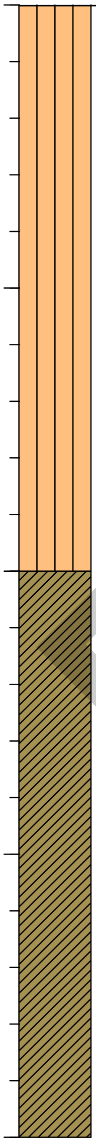
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G14D
Page: 1 of 8

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

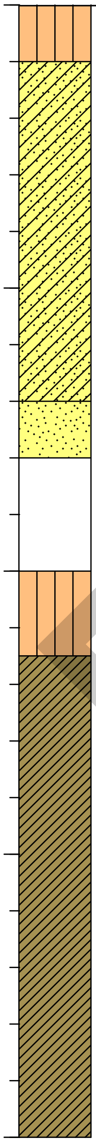
				COLLECT					MEASURE	
DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
0								(0') Clayey SILT (ML); orange with light gray mottling, fine grained, medium stiff, moist.		0
5										5
10								(10') Silty CLAY (CL); orange with light gray mottling, low plasticity, moist.		10
15										15
								(17') CLAY with some silt (CL); orange with light gray mottling, medium plasticity, moist.		
20										20



NOTES:

Geosyntec consultants engineers | scientists | innovators	**Client:** Vistra **Project:** GLP8030, Joppa Power Station **Address:** 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** G14D **Page:** 2 of 8

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



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

NOTES:

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

WELL LOG

Well No. G14D
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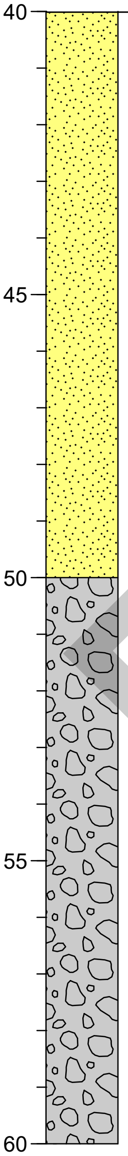
Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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

NOTES:

Geosyntec consultants engineers | scientists | innovators	**Client:** Vistra **Project:** GLP8030, Joppa Power Station **Address:** 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** G14D **Page:** 4 of 8

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

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

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Client:	**Vistra**
Project:	**GLP8030, Joppa Power Station**
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WELL LOG

Well No. **G14D**

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

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

NOTES:

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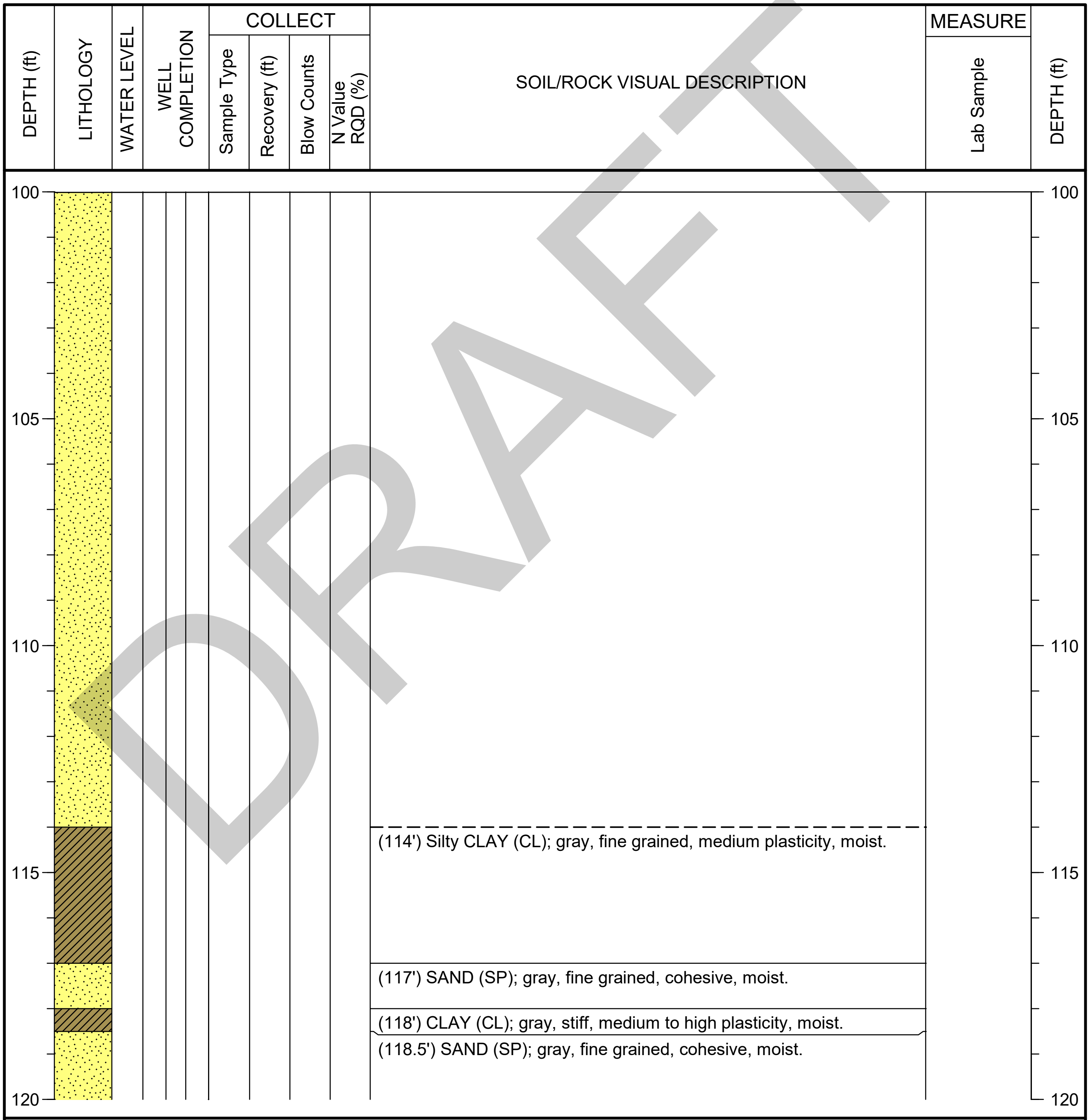
Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW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



(114') Silty CLAY (CL); gray, fine grained, medium plasticity, moist.

(117') SAND (SP); gray, fine grained, cohesive, moist.

(118') CLAY (CL); gray, stiff, medium to high plasticity, moist.

(118.5') SAND (SP); gray, fine grained, cohesive, moist.

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

WELL LOG

Well No. G14D
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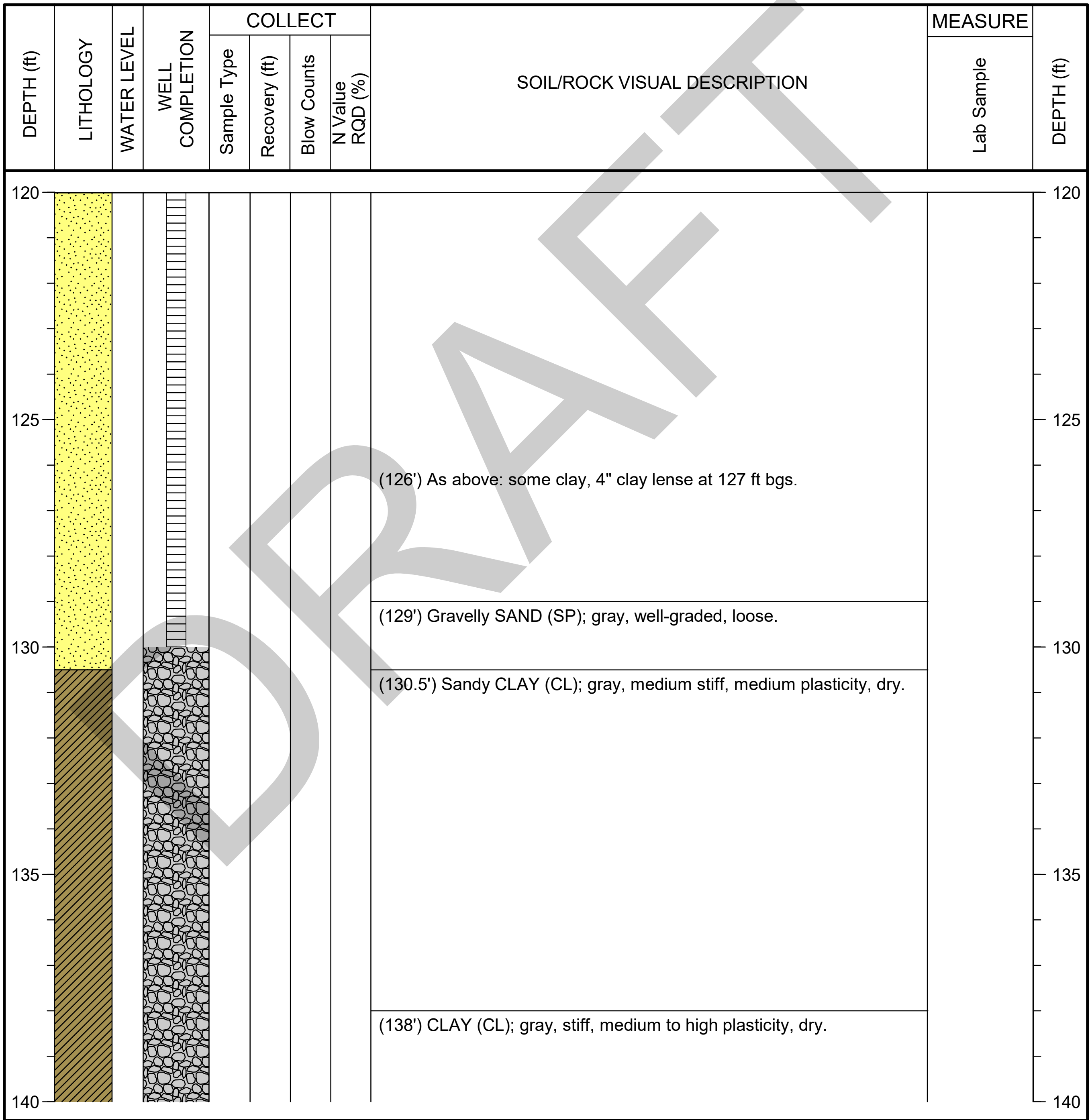
Drilling Start Date: **09/16/2021**
Drilling End Date: **09/16/2021**
Drilling Company: **Cascade Drilling**
Drilling Method: **Sonic**
Drilling Equipment: **Truck-mounted**
Driller: **Dave Gordon**
Logged By: **Amanda Toye**

Boring Depth (ft): **143**
Boring Diameter (in): **4**
DTW During Drilling (ft):
DTW After Drilling (ft):
Top of Casing Elev. (ft): **348.09**
Ground Elev. (ft): **345.31**
Northing, Easting (NAD83):

Well Depth (ft): **130**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Sch 40 PVC Slotted**
Seal Material(s): **NA**
Filter Pack: **NA**



(126') As above: some clay, 4" clay lense at 127 ft bgs.

(129') Gravelly SAND (SP); gray, well-graded, loose.

(130.5') Sandy CLAY (CL); gray, medium stiff, medium plasticity, dry.

(138') CLAY (CL); gray, stiff, medium to high plasticity, dry.

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Client:	**Vistra**
Project:	**GLP8030, Joppa Power Station**
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WELL LOG

Well No. **G14D**
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Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

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

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

WELL LOG

Well No. **G14S**
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Drilling Start Date:	**9/16/2021**	Boring Depth (ft):	**63**	Well Depth (ft):	**63**
Drilling End Date:	**9/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.26**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.46**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

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

NOTES:

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

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

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

WELL LOG

Well No. G14S
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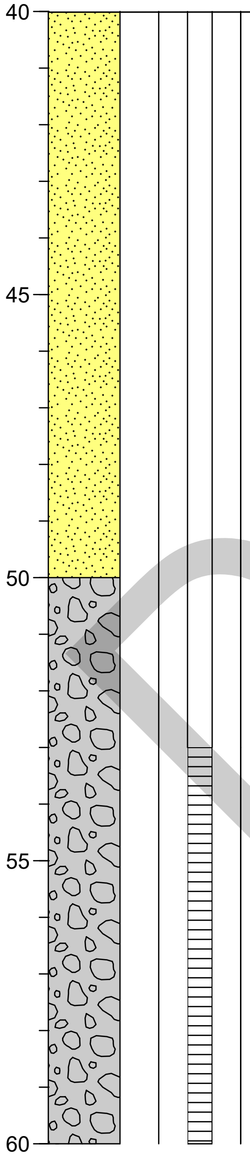
Drilling Start Date:	**9/16/2021**	Boring Depth (ft):	**63**	Well Depth (ft):	**63**
Drilling End Date:	**9/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.26**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.46**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

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



NOTES:

Geosyntec consultants engineers | scientists | innovators	**Client:** **Vistra** **Project:** **GLP8030, Joppa Power Station** **Address:** **2100 Portland Rd, Joppa, IL**	**WELL LOG** **Well No.** **G14S** **Page:** **4 of 4**

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

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

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Client: Vistra
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WELL LOG

Well No. G15D
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Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)		Lab Sample	
0	▨							(0') Silty CLAY (CL); brownish orange, low plasticity, dry.		0
5	▨							(5') CLAY with some silt (CL); light gray with orange mottling, low plasticity, moist.		5
10	▨							(10') As above: trace coal throughout.		10
15	▨									15
20										20

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Client: Vistra
Project: GLP8030, Joppa Power Station
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WELL LOG

Well No. G15D
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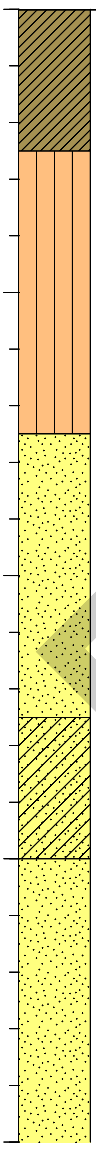
Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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

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

WELL LOG
Well No. **G15D**
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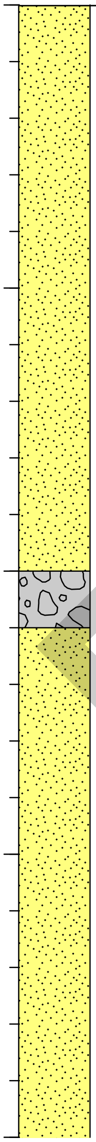
Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

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



NOTES:

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

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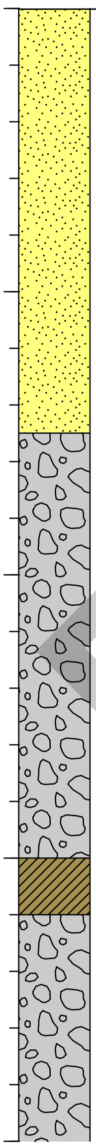
Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After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



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

NOTES:

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Client: Vistra

Project: GLP8030, Joppa Power Station

Address: 2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G15D

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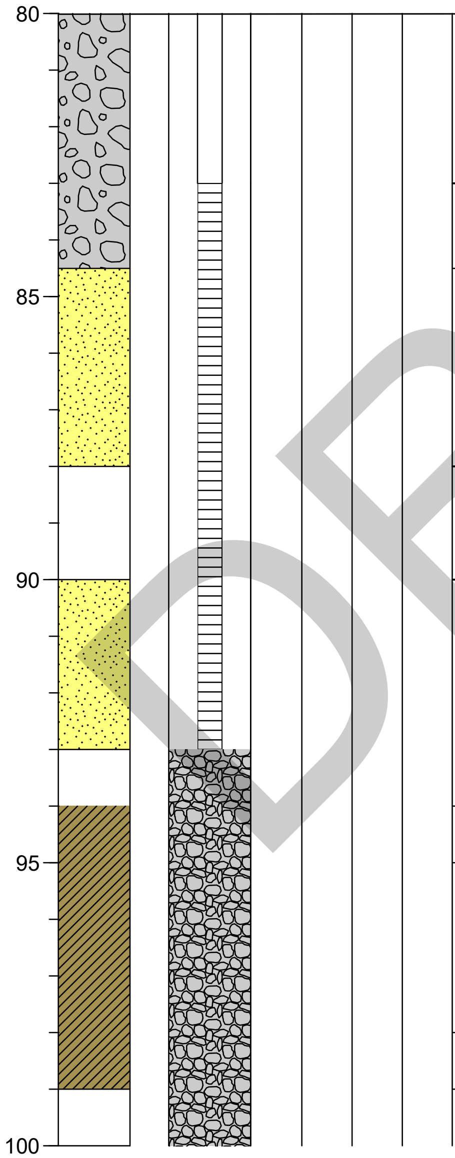
Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After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

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)



(83') GRAVEL (GP); orange, poorly graded, loose, saturated.

(84.5') Gravelly SAND (SP); orange, loose, fine grained, well-graded, medium loose, saturated.

(88') No Recovery.

(90') SAND (SP); light brown to dark orange, fine grained, cohesive, moist.

(94') Sandy CLAY (CL); burnt orange, medium plasticity, stiff, moist.

(95') Sandy gravelly CLAY (CL); light gray, fine grained, well-graded gravel, low plasticity, moist.

(98') CLAY with sand (CL); light gray clay, burnt orange sand, stiff, low to medium plasticity, moist.

(99') No Recovery.

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

WELL LOG

Well No. G15D
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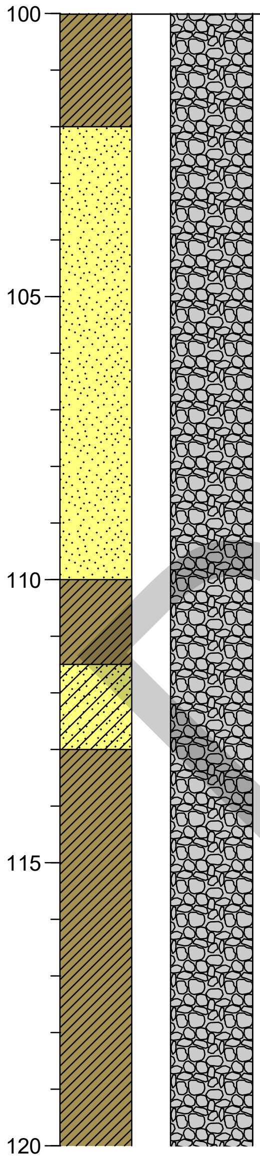
Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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

NOTES:

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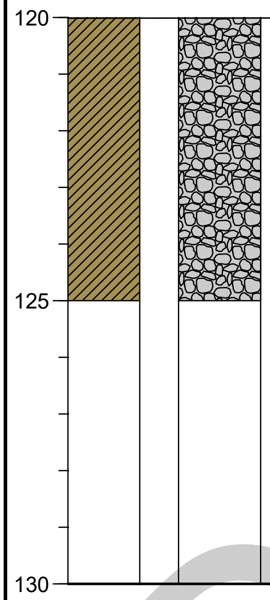
Client:	**Vistra**
Project:	**GLP8030, Joppa Power Station**
Address:	**2100 Portland Rd, Joppa, IL**

WELL LOG
Well No. **G15D**
Page: **7 of 7**

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



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

NOTES:

Geosyntec consultants engineers | scientists | innovators	**Client:** **Vistra** **Project:** **GLP8030, Joppa Power Station** **Address:** **2100 Portland Rd, Joppa, IL**	**WELL LOG** **Well No.** **G15S** **Page:** **1 of 3**

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

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

NOTES:

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

WELL LOG

Well No. G15S
Page: 2 of 3

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

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

NOTES:

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

WELL LOG

Well No. G15S
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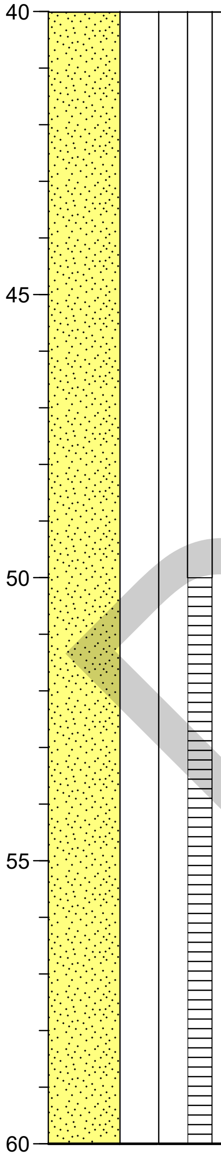
Drilling Start Date: **9/15/2021**
Drilling End Date: **9/15/2021**
Drilling Company: **Cascade Drilling**
Drilling Method: **Sonic**
Drilling Equipment: **Truck-mounted**
Driller: **Dave Gordon**
Logged By: **Amanda Toye**

Boring Depth (ft): **60**
Boring Diameter (in): **4**
DTW During Drilling (ft):
DTW After Drilling (ft):
Top of Casing Elev. (ft): **346.81**
Ground Elev. (ft): **343.76**
Northing, Easting (NAD83):

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): **NA**
Filter Pack: **NA**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') As above: tan to burnt orange.		40
45										45
50								(50') Gravelly SAND (SP); burnt orange, medium to large grained, saturated to moist, loose, trace fine sand.		50
								(54') SAND (SP); burnt orange, fine to medium grained, moist, loose.		
55								(55') Gravelly SAND (SP); burnt orange, medium to large grained, saturated to moist, loose, trace fine sand.		55
60								(60') Boring terminated. Monitoring well G-15S installed at 50-60 ft bgs.		60

NOTES:

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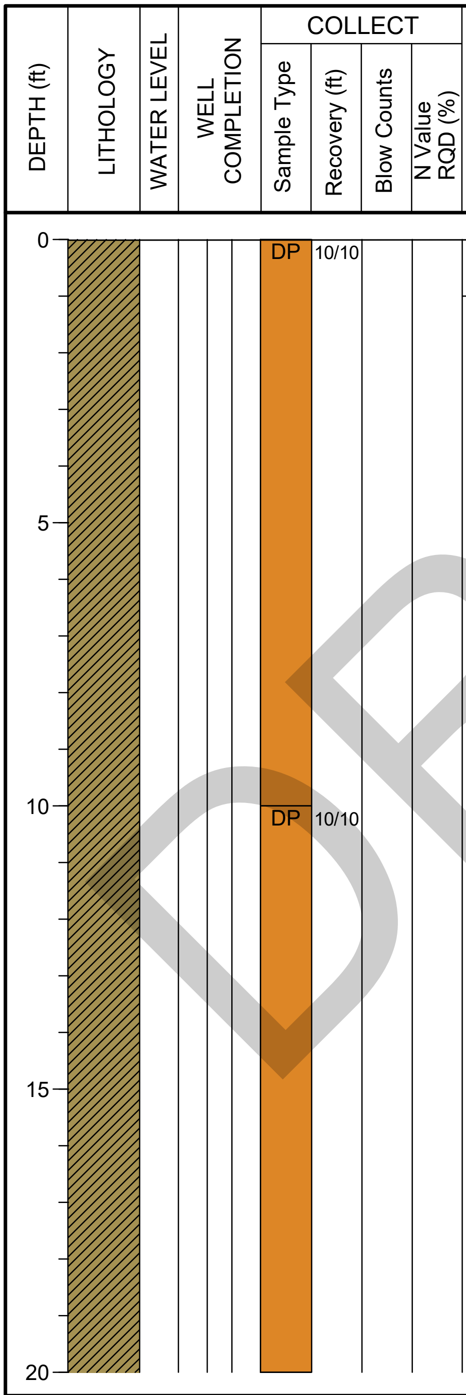
Client:	**Vistra**
Project:	**GLP8030, Joppa Power Station**
Address:	**2100 Portland Rd, Joppa, IL**

WELL LOG

Well No. **G16D**
Page: **1 of 7**

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



SOIL/ROCK VISUAL DESCRIPTION

MEASURE: Lab Sample

DEPTH (ft): 0, 5, 10, 15, 20

(0') Silty CLAY (CL); dry, tan (2.5Y 7/6), some organics. [Topsoil]

(1') Silty CLAY (CL); moist, tan (2.5Y 7/6) to brown (2.5Y 3/3).

(12') As above: tan (2.5Y 7/6) with orange/brown (10YR 6/8) and gray (10YR 7/1) mottling.

(18') As above: increased moisture content.

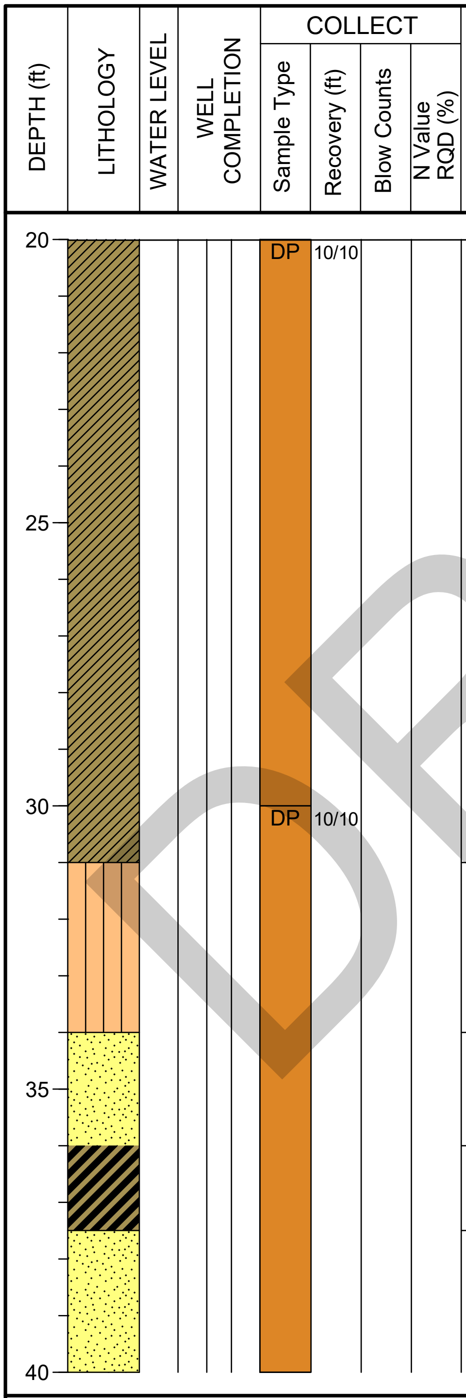
NOTES:

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

WELL LOG

Well No. G16D
Page: 2 of 7

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



SOIL/ROCK VISUAL DESCRIPTION

(20') As above.

(31') Clayey SILT with fine sand (ML); moist, tan (2.5Y 7/6) with orange/brown (10YR 6/8) and gray (10YR 7/1) mottling.

(34') SAND (SP); fine grained, some silt, moist, gray (10YR 7/1).

(36-37.5') Fat CLAY (CH); moist, gray (10YR 7/1) with tan (2.5Y 7/6) mottling.

(37.5') SAND (SP); fine grained, some silt, moist, gray (10YR 7/1).

MEASURE

Lab Sample

DEPTH (ft)

20

25

30

35

40

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

WELL LOG
Well No. G16D
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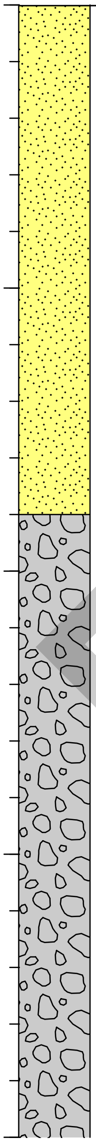
Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	COLLECT Recovery (ft)	COLLECT Blow Counts	COLLECT N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
40				DP	9/10			(40') As above.		40
								(42') As above: becomes coarser with depth.		
45										45
								(49') Sandy GRAVEL to gravelly SAND with silt (SP-GP); wet, brown (10YR 6/8).		
50				DP	9/10					50
55										55
60										60

NOTES:

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

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

NOTES:

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

WELL LOG
Well No. G16D
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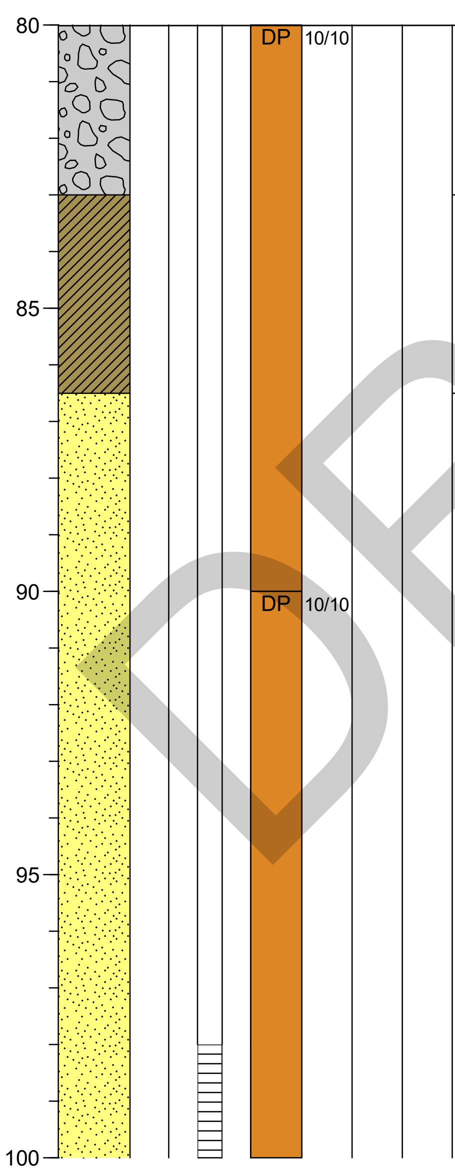
Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)		Lab Sample	
80				DP	10/10			(80') Sandy GRAVEL (GP); light brown with orange mottling, wet, hard, trace silt.		80
								(83') Silty CLAY (CL); mottled red-purple-tan-brown, moist, stiff to slightly hard, trace clay.		
85										85
								(86.5') SAND (SP); fine grained, tan with medium orange mottling, moist, loose.		
90				DP	10/10			(90') As above: orange, fine to lower medium grains.		90
95										95
100										100

NOTES:

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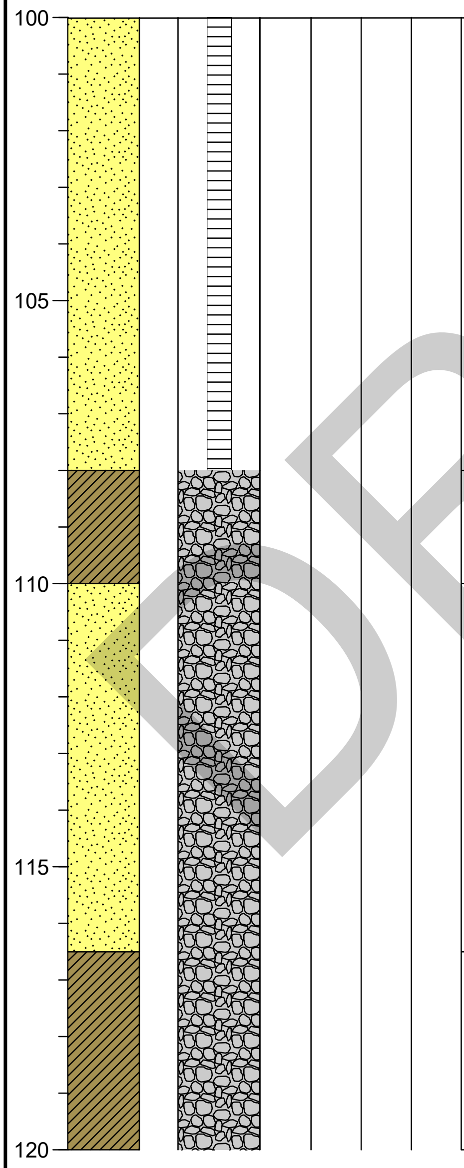
Client:	**Vistra**	**WELL LOG**	
Project:	**GLP8030, Joppa Power Station**	**Well No.**	**G16D**
Address:	**2100 Portland Rd, Joppa, IL**	**Page:**	**6 of 7**

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

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)



(100') As above: SAND, orange to tan with red staining at 106', fine to lower medium grains, moist, loose.

(107') 1 ft Silty SAND, tan, moist, loose, fine grained.

(108') Silty CLAY (CL); reddish brown to purple brown, moist, hard to very stiff, low plasticity.

(110') SAND (SP); tan to orange, fine grained, moist, loose, trace large sand grains and small gravel.

(116.5') Sandy silty CLAY (CL); burnt orange with mottled gray and purple, moist, stiff to slightly hard, moderate to high plasticity.

100
105
110
115
120

NOTES:

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

WELL LOG

Well No. G16D
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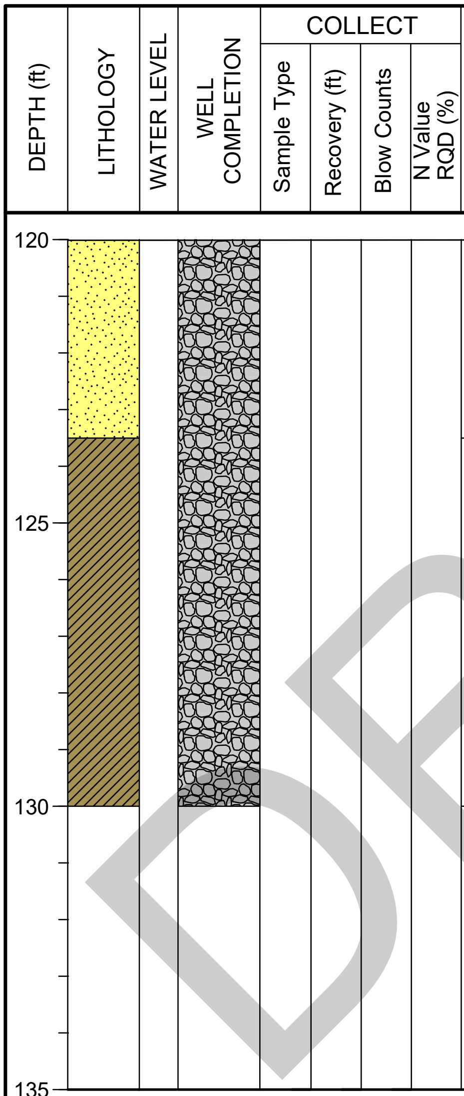
Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**



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

NOTES:

Geosyntec consultants engineers | scientists | innovators	**Client:** Vistra **Project:** GLP8030, Joppa Power Station **Address:** 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** G16S **Page:** 1 of 3

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

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

NOTES:

Geosyntec consultants engineers | scientists | innovators	**Client:** Vistra **Project:** GLP8030, Joppa Power Station **Address:** 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** G16S **Page:** 2 of 3

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

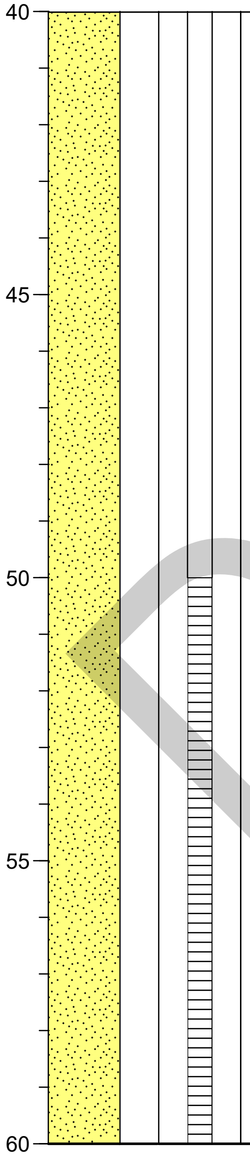
DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

NOTES:

Geosyntec consultants engineers | scientists | innovators	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** **G16S** **Page:** **3 of 3**

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

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



NOTES:

Geosyntec consultants engineers | scientists | innovators	Client: Vistra Project: GLP8030, Joppa Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** **Well 3** **Page:** **1 of 3**

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

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

NOTES:

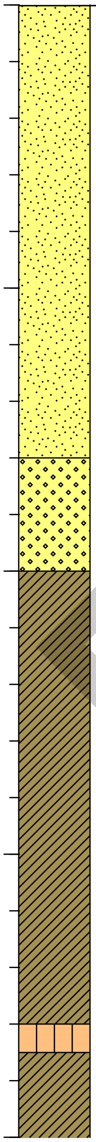
Geosyntec consultants
engineers | scientists | innovators

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

WELL LOG

Well No. **Well 3**
Page: **2 of 3**

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



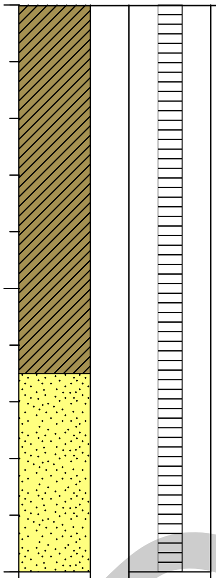
DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	 Recovery (in)	 Blow Counts	 N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
20								(20') SAND (SP); brown and light gray with orange throughout, fine grained, cohesive, moist.		20
25								(25') As above: saturated.		25
								(28') Gravelly SAND (SW); light gray with orange mottling, fine grained, well graded gravel, loose, saturated.		
30								(30') CLAY with sand (CL); light gray with orange mottling, 3" sand lens at 30'9" bgs, medium plasticity, cohesive, moist.		30
35								(35') As above: sand and clay pockets present.		35
								(38') SILT (ML); light gray with orange mottling, trace clay, cohesive, saturated.		
								(38.5') Gravelly CLAY (CL); brown, fine to coarse grained, well graded, loose, saturated.		
40										40

NOTES:

Geosyntec consultants engineers | scientists | innovators	**Client:** **Vistra** **Project:** **GLP8030, Joppa** **Address:** **2100 Portland Rd, Joppa, IL**	**WELL LOG** **Well No.** **Well 3** **Page:** **3 of 3**

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

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') As above: very dark brown, poorly graded small gravel. (40.75') As above.		40
45										45
								(46.5') SAND (SP); brown with some light gray throughout, little gravel, fine grained, semi cohesive, saturated.		
50								(50') End of Boring.		50
55										55



NOTES:

MONITORING WELL
CONSTRUCTION DETAIL

Geosyntec consultants

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

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

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

Materials Used

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

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☑ No

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

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

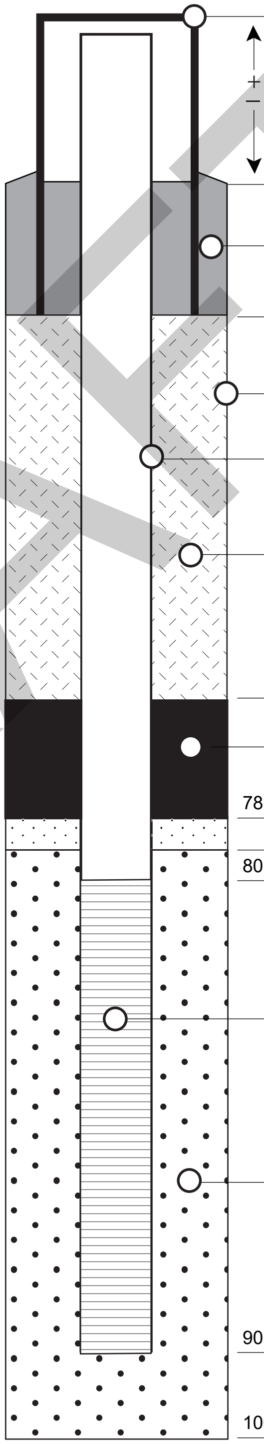
Protective Casing: Length feet
Diameter inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation: Length 90 feet
Diameter 2 inches
Material PVC

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

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

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



☑ above ground protective casing
☐ flush mount protective casing
☐ other

3 feet

ground surface elevation
☐ surveyed ☐ estimated

☐ surface seal backfill
☑ surface seal grout

feet*

drilled hole 4 inches diameter

well casing 2 inches diameter

☐ backfill
☑ grout
☐ density of grout

feet*

☐ bentonite slurry
☑ bentonite pellets

78 feet*
feet*
80 feet*

well screen 2 inches diameter
0.01 slot

☐ gravel pack
☑ sand pack
☐ formation collapse

90 feet*

100 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

Geosyntec consultants

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

MONITORING WELL CONSTRUCTION DETAIL

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

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

Materials Used

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

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☑ No

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

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

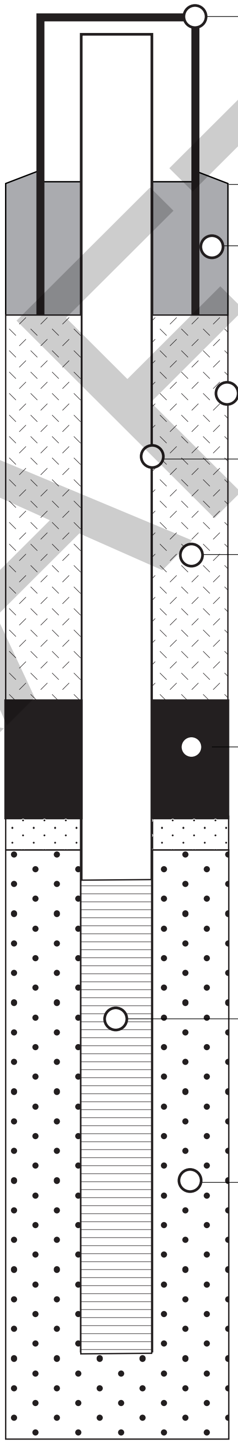
Protective Casing:
Length feet
Diameter inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation:
Length 70 feet
Diameter 2 inches
Material PVC

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

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

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



☐ above ground protective casing
☐ flush mount protective casing
☐ other

2.8 feet

ground surface elevation
☐ surveyed ☐ estimated

☐ surface seal backfill
☑ surface seal grout

feet*

drilled hole 4 inches diameter

well casing 2 inches diameter

☐ backfill
☑ grout
☐ density of grout

feet*

☐ bentonite slurry
☑ bentonite pellets

58 feet*
feet*
60 feet*

well screen 2 inches diameter
0.01 slot

☐ gravel pack
☑ sand pack
☐ formation collapse

70 feet*

70 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

Geosyntec
consultants

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

MONITORING WELL CONSTRUCTION DETAIL

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

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

Materials Used

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

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

Silt Trap Used ☐ Yes ☐ No

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

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

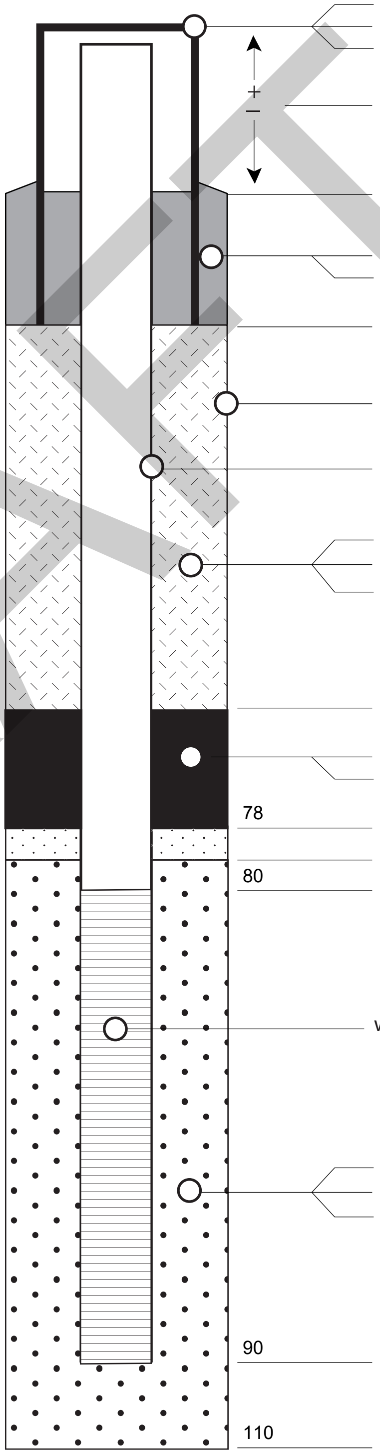
Protective Casing:
Length feet
Diameter inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation:
Length 90 feet
Diameter 2 inches
Material PVC

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

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

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



☑ above ground protective casing
☐ flush mount protective casing
☐ other

2.8 feet

ground surface elevation
☐ surveyed ☐ estimated

☐ surface seal backfill
☑ surface seal grout

feet*

drilled hole 4 inches diameter

well casing 2 inches diameter

☐ backfill
☑ grout
☐ density of grout

feet*

☐ bentonite slurry
☑ bentonite pellets

78 feet*
feet*
80 feet*

well screen 2 inches diameter
0.01 slot

☐ gravel pack
☑ sand pack
☐ formation collapse

90 feet*

110 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants

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

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

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

Materials Used

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

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

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

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

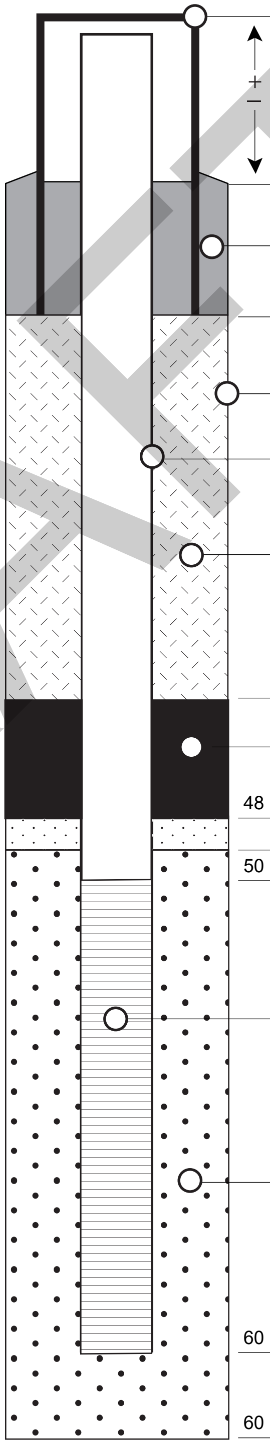
Protective Casing: Length feet
Diameter inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation: Length 60 feet
Diameter 2 inches
Material PVC

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

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

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



☑ above ground protective casing
☐ flush mount protective casing
☐ other

2.6 feet

ground surface elevation
☐ surveyed ☐ estimated

☐ surface seal backfill
☑ surface seal grout

feet*

drilled hole 4 inches diameter

well casing 2 inches diameter

☐ backfill
☑ grout
☐ density of grout

feet*

☐ bentonite slurry
☑ bentonite pellets

48 feet*

feet*

50 feet*

well screen 2 inches diameter
0.01 slot

☐ gravel pack
☑ sand pack
☐ formation collapse

60 feet*

60 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

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

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

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

Materials Used

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

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

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

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

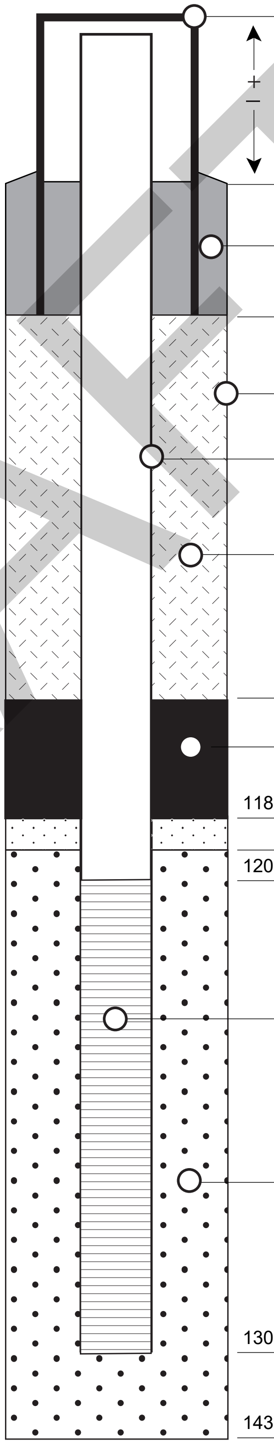
Protective Casing:
Length ___ feet
Diameter ___ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation:
Length 130 feet
Diameter 2 inches
Material PVC

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

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

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



☐ above ground protective casing
☐ flush mount protective casing
☐ other
+/− 2.8 feet
ground surface elevation ___
☐ surveyed ☐ estimated
☐ surface seal backfill
☑ surface seal grout
___ feet*
drilled hole 4 inches diameter
well casing 2 inches diameter
☐ backfill
☑ grout
☐ density of grout ___
___ feet*
☐ bentonite slurry
☑ bentonite pellets
118 feet*
___ feet*
120 feet*
well screen 2 inches diameter
0.01 slot
☐ gravel pack
☑ sand pack
☐ formation collapse
130 feet*
143 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

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

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

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

Materials Used

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

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

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

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

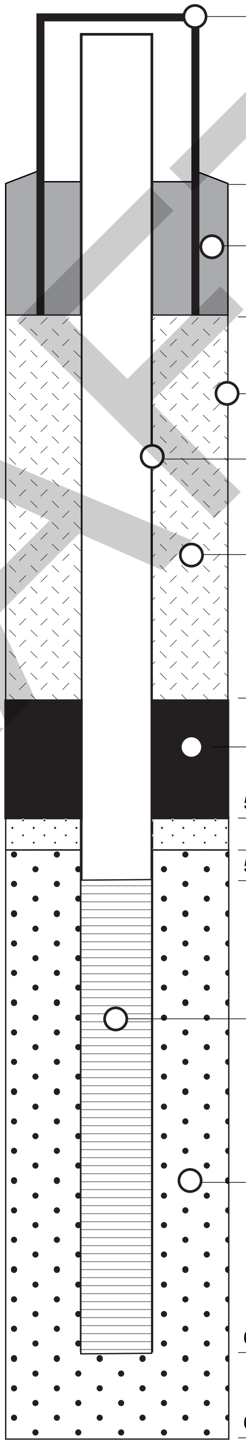
Protective Casing: Length feet
Diameter inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation: Length 63 feet
Diameter 2 inches
Material PVC

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

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

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



☑ above ground protective casing
☐ flush mount protective casing
☐ other
+/− 2.8 feet
ground surface elevation
☐ surveyed ☐ estimated
☐ surface seal backfill
☑ surface seal grout
feet*
drilled hole 4 inches diameter
well casing 2 inches diameter
☐ backfill
☑ grout
☐ density of grout
feet*
☐ bentonite slurry
☑ bentonite pellets
51 feet*
feet*
53 feet*
well screen 2 inches diameter
0.01 slot
☐ gravel pack
☑ sand pack
☐ formation collapse
63 feet*
63 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

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

MONITORING WELL CONSTRUCTION DETAIL

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

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

Materials Used

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

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

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

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

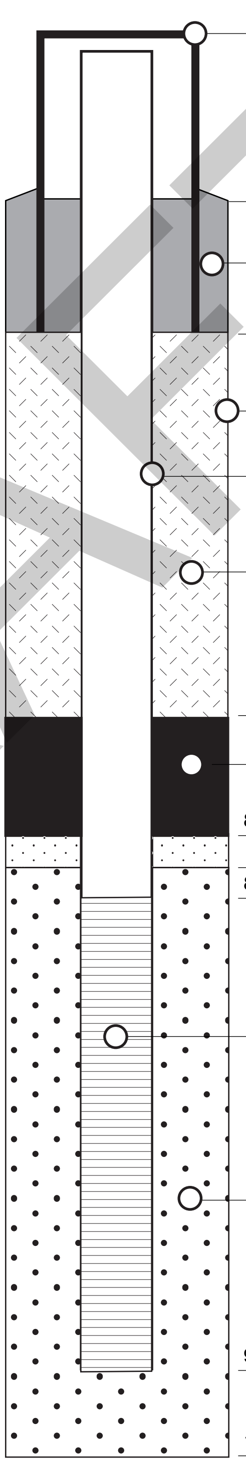
Protective Casing: Length 93 feet
Diameter inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation: Length 108 feet
Diameter 2 inches
Material PVC

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

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

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



☑ above ground protective casing
☐ flush mount protective casing
☐ other
3 feet
ground surface elevation
☐ surveyed ☐ estimated
☐ surface seal backfill
☑ surface seal grout
feet*
drilled hole 4 inches diameter
well casing 2 inches diameter
☐ backfill
☑ grout
☐ density of grout
feet*
☐ bentonite slurry
☑ bentonite pellets
81 feet*
feet*
83 feet*
well screen 2 inches diameter
0.01 slot
☐ gravel pack
☑ sand pack
☐ formation collapse
93 feet*
125 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

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

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

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

Materials Used

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

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

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

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

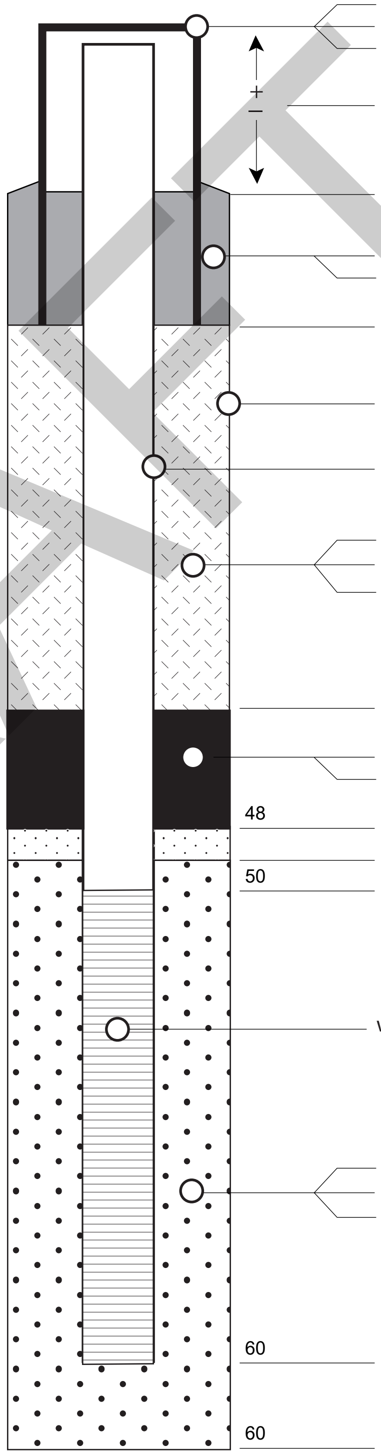
Protective Casing:
Length feet
Diameter inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation:
Length 60 feet
Diameter 2 inches
Material PVC

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

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

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



☑ above ground protective casing
☐ flush mount protective casing
☐ other

2.7 feet

ground surface elevation
☐ surveyed ☐ estimated

☐ surface seal backfill
☑ surface seal grout

feet*

drilled hole 4 inches diameter

well casing 2 inches diameter

☐ backfill
☑ grout
☐ density of grout

feet*

☐ bentonite slurry
☑ bentonite pellets

48 feet*
feet*
50 feet*

well screen 2 inches diameter
0.01 slot

☐ gravel pack
☑ sand pack
☐ formation collapse

60 feet*

60 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

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

Well ID G16D
Project Name Vistra - Joppa Power Station
Project Number GLP8030
Site Location Joppa, IL
Field Personnel Amanda Toye & Michael Jury
Recorded By Amanda Toye

Permit Number
Installation Date(s) 9/14/21
Drilling Method Sonic
Borehole Diameter 4"
Drilling Contractor Cascade
Driller Dave Gordon
Drilling Fluid Water
Fluid Loss During Drilling 600 Gallons

Materials Used

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

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

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

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

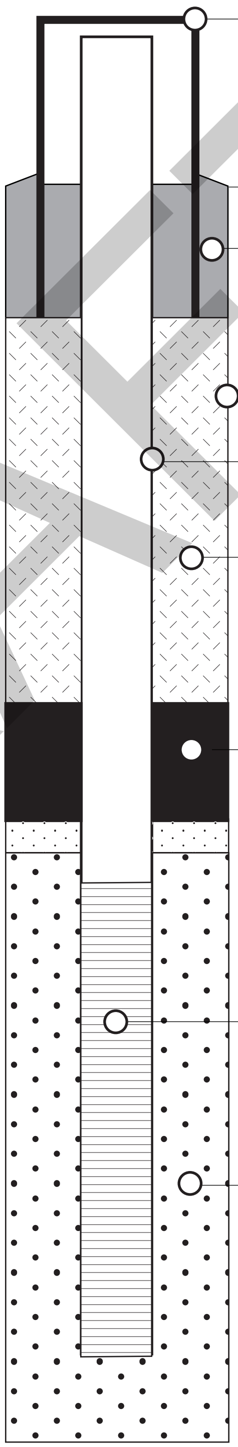
Protective Casing: Length 108 feet
Diameter 2 inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation: Length 108 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: __ bags of __ lb per bag Size __
Fine Sand: 4 bags of 50 lb per bag Size __

Seal:
Bentonite Pellets: 6 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: __ bags of __ lb per bag Type __

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



☑ above ground protective casing
☐ flush mount protective casing
☐ other
+/− 2.9 feet
ground surface elevation
☐ surveyed ☐ estimated
☐ surface seal backfill
☑ surface seal grout
feet*
drilled hole 4 inches diameter
well casing 2 inches diameter
☐ backfill
☑ grout
☐ density of grout
feet*
☐ bentonite slurry
☑ bentonite pellets
96 feet*
feet*
98 feet*
well screen 2 inches diameter
0.01 slot
☐ gravel pack
☑ sand pack
☐ formation collapse
108 feet*
130 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

Geosyntec consultants

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

MONITORING WELL CONSTRUCTION DETAIL

Well ID G16S
Project Name Vistra - Joppa Power Station
Project Number GLP8030
Site Location Joppa, IL
Field Personnel Amanda Toye & Michael Jury
Recorded By Amanda Toye

Permit Number
Installation Date(s) 9/14/21
Drilling Method Sonic
Borehole Diameter 4"
Drilling Contractor Cascade
Driller Dave Gordon
Drilling Fluid Water
Fluid Loss During Drilling ______ Gallons

Materials Used

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

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

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

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

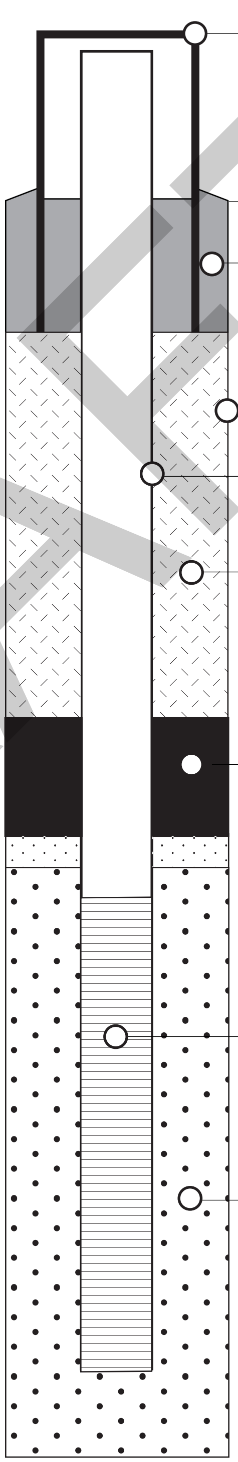
Protective Casing:
Length ______ feet
Diameter ______ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation:
Length 60 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag Size ___
Fine Sand: 4 bags of 50 lb per bag Size ___

Seal:
Bentonite Pellets: 6 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ___

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



☑ above ground protective casing
☐ flush mount protective casing
☐ other ______

2.7 feet

ground surface elevation ______
☐ surveyed ☐ estimated

☐ surface seal backfill
☑ surface seal grout

______ feet*

drilled hole 4 inches diameter

well casing 2 inches diameter

☐ backfill
☑ grout
☐ density of grout ______

______ feet*

☐ bentonite slurry
☑ bentonite pellets

48 feet*
______ feet*
50 feet*

well screen 2 inches diameter
0.01 slot

☐ gravel pack
☑ sand pack
☐ formation collapse

60 feet*

60 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

Geosyntec consultants

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

MONITORING WELL CONSTRUCTION DETAIL

Well ID: Well 3
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: AT, GA
Project Number:
Recorded By: AT

Permit Number:
Installation Date(s): 9/22/2021
Drilling Method: Sonic
Borehole Diameter: 6
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

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

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0,010 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

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

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

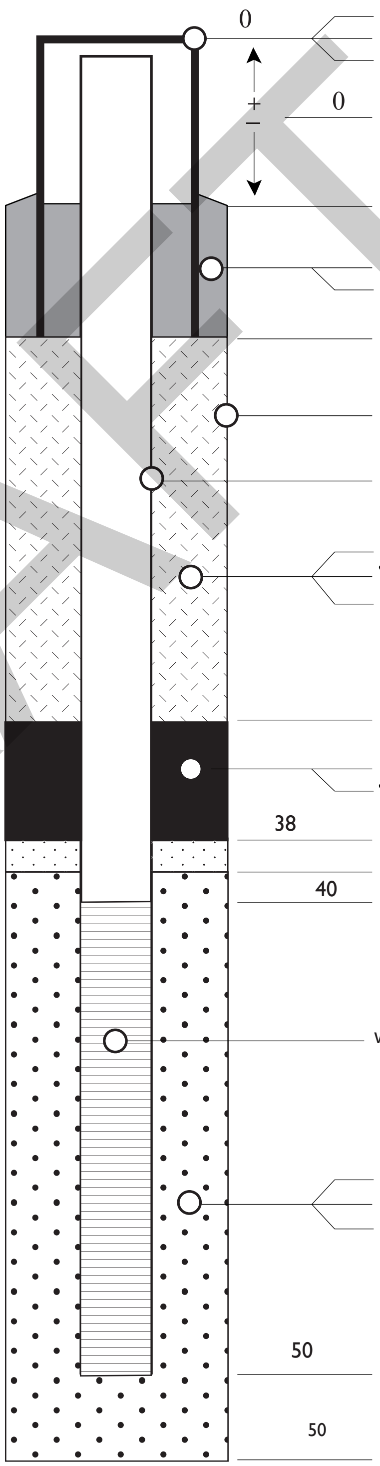
Protective Casing:
Length feet
Diameter inches
Construction ☐ Cast Aluminum
☐ Cast Steel
☑ Other

Casing Installation:
Length 68 feet
Diameter 2 inches
Material PVC

Sandpack: Filter sil
Coarse Sand: ___ bags of ___ lb per bag Size
Fine Sand: 7 bags of 50 lb per bag Size

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

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



0
☐ above ground protective casing
☑ flush mount protective casing
☐ other
\+ − 0 inches
ground surface elevation
☐ surveyed ☐ estimated
☐ surface seal backfill
☐ surface seal grout
feet*
drilled hole 6 inches diameter
well casing 2 inches diameter
☐ backfill
☑ grout
☐ density of grout
feet*
☐ bentonite slurry
☑ bentonite pellets
38 feet*
feet*
40 feet*
well screen 2 inches diameter
0.01 slot
☐ gravel pack
☑ sand pack
☐ formation collapse
50 feet*
50 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

APPENDIX C
MODFLOW, MT3DMS, HELP MODEL, AND FLUX EVALUATION DATA EXPORT FILES (ELECTRONIC ONLY)

APPENDIX D
EVALUATION OF PARTITION COEFFICIENT RESULTS

Geosyntec consultants

1 McBride and Son Center Drive, Suite 202
Chesterfield, MO 63005
www.geosyntec.com

Memorandum

Date: July 5, 2022

To: David Mitchell, Stu Cravens, Vic Modeer
Electric Energy Inc.

Copies to: Brian Hennings - Ramboll

From: Allison Kreinberg, Ryan Fimmen – Geosyntec Consultants, Inc.

Subject: Evaluation of Partition Coefficient Results – Joppa East Ash Pond
CCR Unit 401, Joppa Power Plant, Joppa, Illinois

INTRODUCTION

Electric Energy, Inc. currently operates the Joppa Power Plant (JPP) and its associated ash ponds located in Joppa, Illinois. The East Ash Pond (EAP) (Vistra identification [ID] No. 401; Illinois Environmental Protection Agency [IEPA] ID No. W1270100004-02; National Inventory of Dams [NID] No. IL50714) is an active 111-acre unlined surface impoundment used to manage CCR and non-CCR waste streams at the JPP. Geosyntec Consultants (Geosyntec) is assisting Electric Energy, Inc. with Part 845 compliance at the Site.

Electric Energy, Inc. is currently preparing a Construction Permit application for the EAP as required under Section 845.220. As part of the Construction Permit application, groundwater modeling is being completed for known potential exceedances of groundwater protection standards (GWPS) identified in the Operating Permit (Burns & McDonnell, 2021). In the Operating Permit (October 2021), Burns & McDonnell identified potential GWPS exceedances for several constituents potentially associated with the EAP, including boron, pH (field), and sulfate. An evaluation of potential exceedances of applicable GWPS found that the pH potential exceedances are not related to the EAP (Ramboll, 2022). Batch adsorption testing was conducted for boron to generate site-specific partition coefficients. This technical memorandum summarizes the results of the batch adsorption testing and calculation of partition coefficients.

BATCH ATTENUATION TESTING

In 2021, Geosyntec conducted a field investigation at the EAP which included completion of three (3) soil/rock borings ranging in depth from 50 to 80 feet below ground surface. As part of that investigation, soil and groundwater samples were submitted to SiREM Laboratories (Guelph, ON) for batch solid/liquid partitioning testing.

One groundwater sample (G07) and one soil sample (SB-03) were used for batch attenuation testing at five (5) soil:solution ratios (**Table 1**), each ran in duplicate. For each treatment, 0.1 L of groundwater was brought into contact with varying amounts of soil (0.004 to 0.2 kg) and equilibrated over a seven-day period. Each microcosm was amended (i.e., spiked) with boric acid (H_3BO_3) to achieve the desired initial concentration (5 mg/L) of boron (**Table 2**).

An initial sample of the stock solution for each experimental design was collected on Day 0, and a control sample (i.e., only amended G07 groundwater with no aquifer solids) was collected on Day 7 after tumbling in polypropylene bottleware to evaluate any loss due to interactions with the bottleware or changes in ambient conditions. Duplicates were constructed for each microcosm, including the control samples. After seven days of contact time, an aliquot of the free liquid was collected and filtered through a 0.45-micron (µm) filter prior to analysis for dissolved concentrations of boron. The oxidation/reduction potential (redox) and pH were measured for each batch test at the beginning and end of the contact period and in the control samples.

Data obtained from the test (**Table 3**) were used to construct isotherms for boron; 5-point isotherms were constructed by averaging duplicate results for each soil:solution ratio. Mathematical fitting was used to calculate the attenuation distribution coefficients (K_d), assuming linear adsorption. The linear adsorption equation was used:

$$q_e = K_d \times C_e \qquad \text{Eq. 1}$$

where q_e is the mass of constituent adsorbed to the solid phase at equilibrium, C_e is the remaining aqueous constituent concentration at equilibrium, and K_d is the linear sorption coefficient (reported in liters per kilogram [L/kg]). The data showed a deviation from a linear trend, and so were also fitted using non-linear isotherms. The non-linear Langmuir isotherm was used:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \qquad \text{Eq. 2}$$

where q_m is the inverse of the slope and K_L is the Langmuir distribution coefficient. The adsorption data were linearized according to:

$$\frac{C_e}{q_e} = \frac{1}{(K_L \times q_m)} + \frac{C_e}{q_m} \qquad \text{Eq. 3}$$

A common non-linear Freundlich equation was also used:

$$q_e = K_F(C_e)^{1/n} \qquad \text{Eq. 4}$$

where q_e is the mass of constituent adsorbed to the solid phase at equilibrium, C_e is the remaining aqueous constituent concentration at equilibrium, K_F is the Freundlich distribution coefficient, and $1/n$ is a non-linearity constant. The adsorption data were plotted as log-transformed values to perform the non-linear isotherm fitting using the linearized Freundlich equation:

$$log(q_e) = \log(K_F) + (1/n)\log(C_e) \qquad \text{Eq. 5}$$

The calculated linear, Langmuir, and Freundlich distribution coefficients (K_d, K_L, and K_F, respectively) and 1/*n* values are shown in **Table 4**.

SUMMARY OF RESULTS

The partition coefficient values for G07 are presented in **Table 4**. A figure which shows the linear, Langmuir, and Freundlich isotherms for boron is provided in **Appendix A**.

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

REFERENCES

Burns & McDonnell. 2021. Initial Operating Permit Joppa East Ash Pond. October

EPRI, 2005. *Chemical Constituents In Coal Combustion Product Leachate: Boron. Final Report 1005258.*

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2022. *Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond, CCR Unit 401, May 2022.*

Strenge, D. and Peterson, S. 1989. Chemical Data Bases for the Multimedia Environmental Pollutant Assessment System (MEPAS) (No. PNL-7145). Pacific Northwest National Laboratory, Richland, WA (USA).

TABLES

Table 1 - Batch Attenuation Testing Data Summary
Joppa EAP

Groundwater Sample ID	Soil Sample ID	Soil: Water Ratio
G07	SB-03 (57.5-62.5, 63.5-70.0 ft bgs)	2:1.3
		1:1.2
		1:5.6
		1:11.0
		1:27.3

Notes:

ft bgs = feet below ground surface

Table 2 - Microcosm Amendment and Target Concentration
Joppa EAP

Groundwater Sample ID	Soil Sample ID	Compound	Amendment	Target Concentration (mg/L)
G07	SB-03 (57.5-62, 63.5-70.0 ft bgs)	Boron	7.89 mL of a 2 g/L H_3BO_3	5

Notes:
ft bgs - feet below ground surface
mg/L - milligrams per liter
mL - milliliters
H_3BO_3 - boric acid

Table 3 - Batch Attenuation Testing Results, G07
Joppa EAP

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	pH	ORP
						mg/L	SU	mV
G07	--	Water Control Only	23-Dec-21	0	G07-1a	5.8	7.23	81
					G07-2a	5.4	7.3	73
					Average Concentration (mg/L)	**5.6**	**7.3**	**77**
			30-Dec-21	7	G07-1	4.1	7.14	193
					G07-2	4.3	7.09	168
					Average Concentration (mg/L)	**4.2**	**7.1**	**181**
	SB-03	2:1.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 2:1-1	2.5	6.85	148
					SB-03: G07 2:1-2	3.1	6.75	132
					Average Concentration (mg/L)	**2.8**	**6.8**	**140**
		1:1.2 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:1-1	3.1	6.84	146
					SB-03: G07 1:1-2	3.1	6.95	142
					Average Concentration (mg/L)	**3.1**	**6.9**	**144**
		1:5.6 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:5-1	3.8	6.96	134
					SB-03: G07 1:5-2	4.3	6.91	135
					Average Concentration (mg/L)	**4.1**	**6.9**	**135**
		1:11 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:10-1	4.4	6.98	136
					SB-03: G07 1:10-2	4.4	6.89	131
					Average Concentration (mg/L)	**4.4**	**6.9**	**134**
		1:27.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:20-1	4.5	7.08	146
					SB-03: G07 1:20-2	4.4	6.92	150
					Average Concentration (mg/L)	**4.5**	**7.0**	**148**

Notes:

mg/L - milligrams per liter
mV - millivolts
SU - Standard Units
ORP - oxidation/reduction potential

Table 4 - Partition Coefficient Results, G07
Joppa EAP

Materials	**Analyte**	**Isotherm**	**Variable**	**Value**
G07/SB-03	**Boron**	**Linear**	**R^2**	0.998
			K_D (L/kg)	2.40
		Langmuir	**R^2**	0.982
			q_m (mg/g)	0.06
			K_L (L/kg)	5.66E+04
		Freundlich	**R^2**	0.999
			1/n	0.83
			K_F (L/kg)	86.4

Notes:

K_D - linear partition coefficient

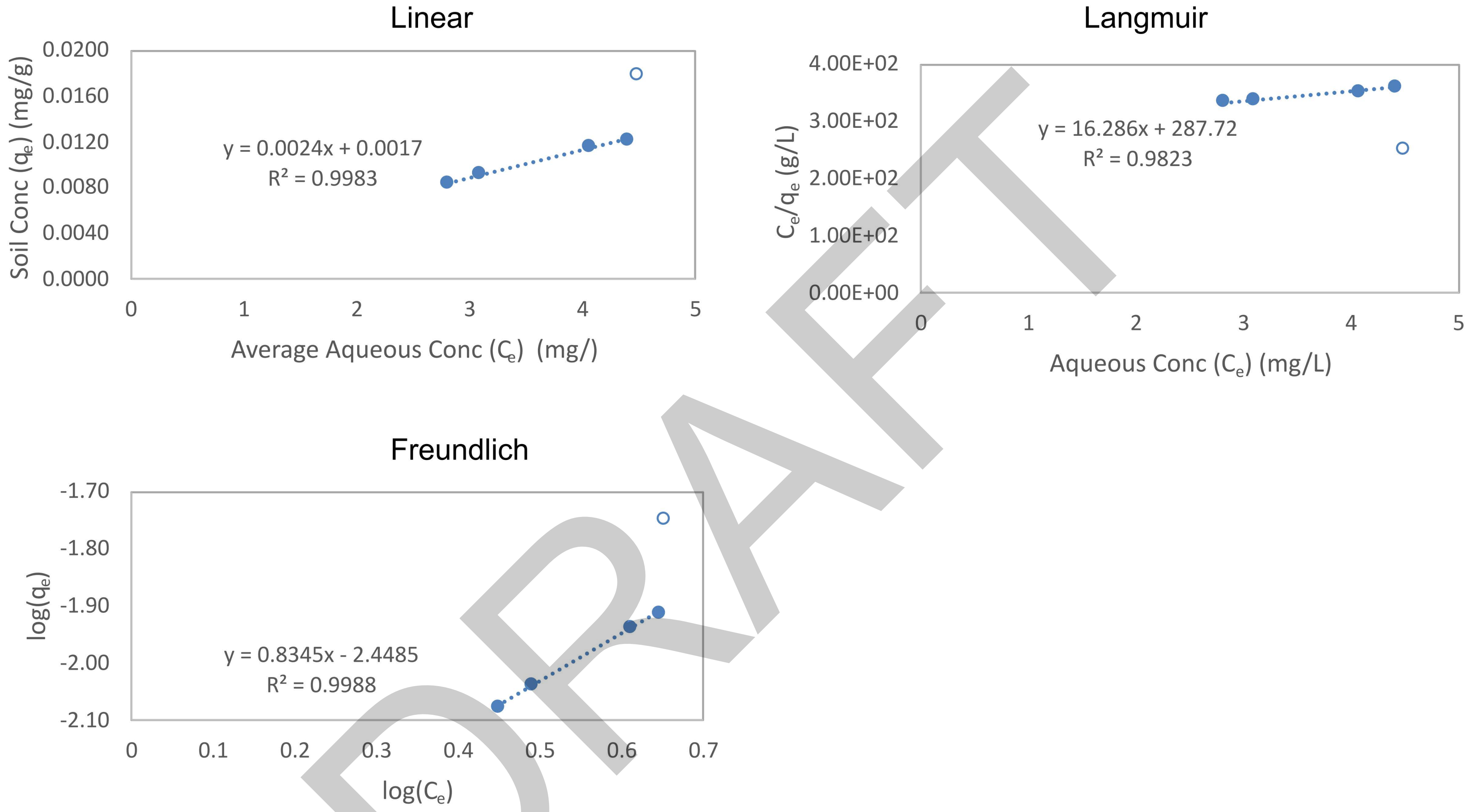
K_L - Langmuir partition coefficient

K_F - Freundlich partition coefficient

q_m - inverse of the slope of the linearized Langmuir isotherm

n - non-linearity constant of the Freundlich isotherm

APPENDIX A
BATCH TESTING ISOTHERM PLOTS



Notes:

q_e - mass of constituent adsorbed to the solid phase
C_e - remaining aqueous constituent concentration
mg/L - milligrams per liter
mg/g - milligrams per gram
g/L - grams per liter

The results from the 1:27.3 soil:solution ratio, shown as hollow symbols, were not used to calculate the partition coefficients.

G07 Boron Partitioning Coefficients
Joppa Power Plant EAP
Joppa, Illinois

Geosyntec
consultants

Columbus, OH
May 2022

Figure
1

APPENDIX E
HELP MODEL OUTPUT FILES

```
-----------------------------------------------------------------------------------------------------------------------
            HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
                    HELP MODEL VERSION 4.0 BETA (2018)
     DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
-----------------------------------------------------------------------------------------------------------------------
      Title:       Joppa EAP CIP Default Earth              Simulated On:       6/24/2022 16:51
-----------------------------------------------------------------------------------------------------------------------

                                   Layer 1
                Type 1 - Vertical Percolation Layer (Cover Soil)
                            SCL - Sandy Clay Loam
                         Material Texture Number 10
      Thickness                                      =              6  inches
      Porosity                                       =          0.398  vol/vol
      Field Capacity                                 =          0.244  vol/vol
      Wilting Point                                  =          0.136  vol/vol
      Initial Soil Water Content                     =          0.398  vol/vol
      Effective Sat. Hyd. Conductivity               =       1.20E-04  cm/sec

                                   Layer 2
                     Type 1 - Vertical Percolation Layer
                            C - Clay (Low Density)
                         Material Texture Number 15
      Thickness                                      =             30  inches
      Porosity                                       =          0.475  vol/vol
      Field Capacity                                 =          0.378  vol/vol
      Wilting Point                                  =          0.265  vol/vol
      Initial Soil Water Content                     =          0.475  vol/vol
      Effective Sat. Hyd. Conductivity               =       1.70E-05  cm/sec

                                   Layer 3
                         Type 3 - Barrier Soil Liner
                              Liner Soil (High)
                         Material Texture Number 16
      Thickness                                      =             36  inches
      Porosity                                       =          0.427  vol/vol
      Field Capacity                                 =          0.418  vol/vol
      Wilting Point                                  =          0.367  vol/vol
      Initial Soil Water Content                     =          0.427  vol/vol
      Effective Sat. Hyd. Conductivity               =       1.00E-07  cm/sec
```

Layer 4

Type 1 - Vertical Percolation Layer (Waste)
CCR Material
Material Texture Number 83

Thickness	=	312	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1933	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-06	cm/sec

Layer 5

Type 1 - Vertical Percolation Layer
Clay
Material Texture Number 43

Thickness	=	252	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.371	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	85.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	74	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.088	inches
Upper Limit of Evaporative Storage	=	8.088	inches
Lower Limit of Evaporative Storage	=	3.996	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	185.811	inches
Total Initial Water	=	185.811	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude = 37.21 Degrees
Maximum Leaf Area Index = 4.5
Start of Growing Season (Julian Date) = 95 days
End of Growing Season (Julian Date) = 297 days
Average Wind Speed = 7 mph
Average 1st Quarter Relative Humidity = 71 %
Average 2nd Quarter Relative Humidity = 70 %
Average 3rd Quarter Relative Humidity = 76 %
Average 4th Quarter Relative Humidity = 75 %

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Default Earth
Simulated on: 6/24/2022 16:52

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	12.078	[5.327]	3,244,351.3	25.07
Evapotranspiration	34.049	[3.576]	9,146,287.4	70.68
Subprofile1				
Percolation/leakage through Layer 3	2.050194	[0.070975]	550,723.0	4.26
Average Head on Top of Layer 3	23.4090	[2.0491]	---	---
Subprofile2				
Percolation/leakage through Layer 5	0.000793	[0.002101]	213.0	0.00
Water storage				
Change in water storage	2.0443	[1.766]	549,145.3	4.24

* Note: Average inches are converted to volume based on the user-specified area.

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Joppa EAP CIP Cons **Simulated On:** 6/24/2022 16:36

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SCL - Sandy Clay Loam
Material Texture Number 10

Thickness = 6 inches
Porosity = 0.398 vol/vol
Field Capacity = 0.244 vol/vol
Wilting Point = 0.136 vol/vol
Initial Soil Water Content = 0.398 vol/vol
Effective Sat. Hyd. Conductivity = 1.20E-04 cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
C - Clay (Low Density)
Material Texture Number 15

Thickness = 18 inches
Porosity = 0.475 vol/vol
Field Capacity = 0.378 vol/vol
Wilting Point = 0.265 vol/vol
Initial Soil Water Content = 0.475 vol/vol
Effective Sat. Hyd. Conductivity = 1.70E-05 cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
10 oz Nonwoven Geotextile
Material Texture Number 123

Thickness = 0.11 inches
Porosity = 0.85 vol/vol
Field Capacity = 0.01 vol/vol
Wilting Point = 0.005 vol/vol
Initial Soil Water Content = 0.85 vol/vol
Effective Sat. Hyd. Conductivity = 3.00E-01 cm/sec
Slope = 4.67 %
Drainage Length = 600 ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness = 0.04 inches
Effective Sat. Hyd. Conductivity = 4.00E-13 cm/sec
FML Pinhole Density = 1 Holes/Acre
FML Installation Defects = 1 Holes/Acre
FML Placement Quality = 3 Good

Layer 5

Type 1 - Vertical Percolation Layer (Waste)
CCR Material
Material Texture Number 83

Thickness = 312 inches
Porosity = 0.541 vol/vol
Field Capacity = 0.187 vol/vol
Wilting Point = 0.047 vol/vol
Initial Soil Water Content = 0.1871 vol/vol
Effective Sat. Hyd. Conductivity = 1.00E-06 cm/sec

Layer 6

Type 1 - Vertical Percolation Layer
Clay
Material Texture Number 43

Thickness = 252 inches
Porosity = 0.479 vol/vol
Field Capacity = 0.371 vol/vol
Wilting Point = 0.251 vol/vol
Initial Soil Water Content = 0.371 vol/vol
Effective Sat. Hyd. Conductivity = 1.70E-07 cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number = 85.5
Fraction of Area Allowing Runoff = 100 %
Area projected on a horizontal plane = 74 acres
Evaporative Zone Depth = 18 inches
Initial Water in Evaporative Zone = 8.088 inches
Upper Limit of Evaporative Storage = 8.088 inches
Lower Limit of Evaporative Storage = 3.996 inches
Initial Snow Water = 0 inches
Initial Water in Layer Materials = 162.884 inches
Total Initial Water = 162.884 inches
Total Subsurface Inflow = 0 inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude = 37.21 Degrees
Maximum Leaf Area Index = 4.5
Start of Growing Season (Julian Date) = 95 days
End of Growing Season (Julian Date) = 297 days
Average Wind Speed = 7 mph
Average 1st Quarter Relative Humidity = 71 %
Average 2nd Quarter Relative Humidity = 70 %
Average 3rd Quarter Relative Humidity = 76 %
Average 4th Quarter Relative Humidity = 75 %

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Cons
Simulated on: 6/24/2022 16:37

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	10.613	[5.037]	2,850,768.6	22.03
Evapotranspiration	33.583	[3.577]	9,021,032.4	69.71
Subprofile1				
Lateral drainage collected from Layer 3	3.9684	[0.5199]	1,066,001.8	8.24
Percolation/leakage through Layer 4	0.016120	[0.003456]	4,330.0	0.03
Average Head on Top of Layer 4	9.5123	[2.0558]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.004411	[0.000998]	1,185.0	0.01
Water storage				
Change in water storage	0.0038	[1.6278]	1,009.3	0.01

* Note: Average inches are converted to volume based on the user-specified area.

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Joppa EAP CIP Default Cover **Simulated On:** 6/24/2022 16:46

Layer 1
Type 1 - Vertical Percolation Layer (Cover Soil)
SCL - Sandy Clay Loam
Material Texture Number 10

Thickness = 6 inches
Porosity = 0.398 vol/vol
Field Capacity = 0.244 vol/vol
Wilting Point = 0.136 vol/vol
Initial Soil Water Content = 0.398 vol/vol
Effective Sat. Hyd. Conductivity = 1.20E-04 cm/sec

Layer 2
Type 1 - Vertical Percolation Layer
C - Clay (Low Density)
Material Texture Number 15

Thickness = 30 inches
Porosity = 0.475 vol/vol
Field Capacity = 0.378 vol/vol
Wilting Point = 0.265 vol/vol
Initial Soil Water Content = 0.475 vol/vol
Effective Sat. Hyd. Conductivity = 1.70E-05 cm/sec

Layer 3
Type 2 - Lateral Drainage Layer
10 oz Nonwoven Geotextile
Material Texture Number 123

Thickness = 0.11 inches
Porosity = 0.85 vol/vol
Field Capacity = 0.01 vol/vol
Wilting Point = 0.005 vol/vol
Initial Soil Water Content = 0.85 vol/vol
Effective Sat. Hyd. Conductivity = 3.00E-01 cm/sec
Slope = 4.67 %
Drainage Length = 600 ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness = 0.04 inches
Effective Sat. Hyd. Conductivity = 4.00E-13 cm/sec
FML Pinhole Density = 1 Holes/Acre
FML Installation Defects = 1 Holes/Acre
FML Placement Quality = 3 Good

Layer 5

Type 1 - Vertical Percolation Layer (Waste)
CCR Material
Material Texture Number 83

Thickness = 312 inches
Porosity = 0.541 vol/vol
Field Capacity = 0.187 vol/vol
Wilting Point = 0.047 vol/vol
Initial Soil Water Content = 0.1871 vol/vol
Effective Sat. Hyd. Conductivity = 1.00E-06 cm/sec

Layer 6

Type 1 - Vertical Percolation Layer
Clay
Material Texture Number 43

Thickness = 252 inches
Porosity = 0.479 vol/vol
Field Capacity = 0.371 vol/vol
Wilting Point = 0.251 vol/vol
Initial Soil Water Content = 0.371 vol/vol
Effective Sat. Hyd. Conductivity = 1.70E-07 cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number = 85.5
Fraction of Area Allowing Runoff = 100 %
Area projected on a horizontal plane = 74 acres
Evaporative Zone Depth = 18 inches
Initial Water in Evaporative Zone = 8.088 inches
Upper Limit of Evaporative Storage = 8.088 inches
Lower Limit of Evaporative Storage = 3.996 inches
Initial Snow Water = 0 inches
Initial Water in Layer Materials = 168.594 inches
Total Initial Water = 168.594 inches
Total Subsurface Inflow = 0 inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude = 37.21 Degrees
Maximum Leaf Area Index = 4.5
Start of Growing Season (Julian Date) = 95 days
End of Growing Season (Julian Date) = 297 days
Average Wind Speed = 7 mph
Average 1st Quarter Relative Humidity = 71 %
Average 2nd Quarter Relative Humidity = 70 %
Average 3rd Quarter Relative Humidity = 76 %
Average 4th Quarter Relative Humidity = 75 %

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: Joppa EAP CIP Default Cover
Simulated on: 6/24/2022 16:47

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	12,939,997.0	100.00
Runoff	9.606	[5.013]	2,580,252.8	19.94
Evapotranspiration	33.574	[3.579]	9,018,602.4	69.70
Subprofile1				
Lateral drainage collected from Layer 3	4.9822	[0.4157]	1,338,319.0	10.34
Percolation/leakage through Layer 4	0.030562	[0.005081]	8,209.6	0.06
Average Head on Top of Layer 4	17.9539	[2.9669]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.003474	[0.001644]	933.3	0.01
Water storage				
Change in water storage	0.0070	[2.1225]	1,889.5	0.01

* Note: Average inches are converted to volume based on the user-specified area.

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: JOP EAP CIP Rem **Simulated On:** 4/26/2022 16:50

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
Clay
Material Texture Number 43

Thickness	=	120	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.3927	vol/vol
Effective Sat. Hyd. Conductivity	=	1.70E-07	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	89.7	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	36	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	8.221	inches
Upper Limit of Evaporative Storage	=	8.622	inches
Lower Limit of Evaporative Storage	=	4.518	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	47.126	inches
Total Initial Water	=	47.126	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	37.21	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	95	days
End of Growing Season (Julian Date)	=	297	days
Average Wind Speed	=	7	mph
Average 1st Quarter Relative Humidity	=	71	%
Average 2nd Quarter Relative Humidity	=	70	%
Average 3rd Quarter Relative Humidity	=	76	%
Average 4th Quarter Relative Humidity	=	75	%

Note: Evapotranspiration data was obtained for Joppa, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.326786	3.822219	4.179644	4.79944	5.408958	4.723047
4.166973	2.932918	2.815835	3.667123	3.907273	4.421913

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
38	41.9	52.8	61.2	72.2	81.8
84.6	82.9	76.6	65.6	53.2	42

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.21/-88.85

Average Annual Totals Summary

Title: JOP EAP CIP Rem
Simulated on: 4/26/2022 16:51

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	48.17	[6.22]	6,295,133.7	100.00
Runoff	17.495	[5.179]	2,286,282.6	36.32
Evapotranspiration	29.229	[3.315]	3,819,647.2	60.68
Subprofile1				
Percolation/leakage through Layer 1	1.162109	[0.592091]	151,864.4	2.41
Water storage				
Change in water storage	0.2857	[1.449]	37,339.4	0.59

* Note: Average inches are converted to volume based on the user-specified area.

APPENDIX F
FLUX EVALUATION DATA

APPENDIX F. FLUX EVALUATION DATA

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

Calibration Model					
Model	**Years (Model Elapsed Time)**	**HSU**	**Total Flux In[1] (ft^3/d)**	**Total Flux In (gpm)**	
Calibration Model	49	Fill Unit (CCR)	29802	155	
Model	**Years (Model Elapsed Time)**	**HSU**	**Total Flux Out[1] (ft^3/d)**	**Total Flux Out (gpm)**	
Calibration Model	49	Fill Unit (CCR)	-29845	-155	
CIP (CCR Removal from the southeast areas of the East Ash Pond, CCR removal from outside of the unit boundaries, consolidation to the northwest area of the East Ash Pond, construction of a cover system over the consolidated CCR, and construction of a stormwater detention pond)					
Prediction Model	**Years (Post-Construction Period)**	**HSU**	**Total Flux In[1] (ft^3/d)**	**Total Flux In (gpm)**	**Reduction in Flux In Post Closure[2] (Percentage, %)**
CIP	25	Fill Unit (CCR)	3.66	0.02	99.99%
Prediction Model	**Years (Post-Construction Period)**	**HSU**	**Total Flux Out[1] (ft^3/d)**	**Total Flux Out (gpm)**	**Reduction in Flux Out Post Closure[2] (Percentage, %)**
CIP	25	Fill Unit (CCR)	3.66	-0.02	99.99%

[O: KEM 6/29/22; C: BGH 6/30/22]

Notes:

1. Reduction in flux as compared to flux at the end of calibration model (model elapsed time of 49 years).
2. Total flux in and out source data provided in flux calculation data files included in Appendix C.

CCR = coal combustion residuals
CIP = closure in place
HSU = Hydrostratigraphic Unit
% = percentage
ft^3/d = cubic feet per day
gpm = gallons per minute

APPENDIX C
MATERIAL QUANTITY, LABOR, AND MILEAGE ESTIMATES FOR ALTERNATIVE 2 AND ALTERNATIVE 3 REMEDIES

ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 2 - SOURCE CONTROL WITH GROUNDWATER EXTRACTION (CONTINUATION OF PCA)[1]

ITEM NO.	Corrective Action Operation and Maintenance	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
Operation and Maintenance								
1	Routine GWE System O&M	-	-	-	-	2,640	-	Assumes continued operation of the GWE following EAP CIP for a period of 6 years.
	Operation and Maintenance	Event	144	OM	-	1,440	-	Assumes two site visits per month to perform standard OMM of the GWE system for a period of 6 years following EAP CIP
	Bag Filter Replacement	Event	144	-	-	-	-	Assumes replacement of up to 24 bag filters per OMM visit which is anticipated to occur at two visits per month
	Equipment Servicing	Event	24	ES	-	480	-	Assumes one site visit per quarter for troubleshooting and/or replacement of system related pumps or mechanical components for a period of 6 years following EAP CIP
	Sludge processing / cake disposal	MO	72	WT	-	720	-	Assumes one site visit per month to process any solids or sludge collected in the frac tank.
2	Non-routine GWE System O&M	-	-	-	-	1,140	-	Assumes non-routine tasks including flushing of groundwater conveyance lines, re-development of groundwater extraction wells and tree trimming within electrical distribution right of way
	Groundwater Conveyance Line Flushing - Vacuum Truck	LF	36,000	VT	-	360	-	330130116140: Pipe, internal cleaning and inspection, cleaning, power rodder with header & cutts, 4"-12" diameter. Assumes one 3-day cleaning event of 6,000 linear feet of 6" HDPE pipe per year for a total of 6 years.
	Extraction Well Development and Maintenance	LS	6	WD	-	600	-	Assumes extraction wells will be developed on a yearly basis to maximize connectivity with upper aquifer using a two man crew over a 5 day period
	Electrical Alignment Tree Trimming	AC	4.5	A1C	0.25	180	-	311313100020: Selective clearing, brush, with brush saw, includes cutting and site cleanup, excludes offsite removal. Assumes approximately 1.5 acres if tree line will be trimmed back to maintain electrical infrastructure right of way
3	GWE System Abandonment			-	-	641	-	Abandonment of GWE system will occur following the 30-year post-closure care and maintenance period is complete.
	Removal of GWE Electrical Distribution Equipment	EA	15	R3	1.7	221	-	337116337200: Electrical utility pole, wood, class 3, Douglas Fir, penta-treated, 45', excludes excavation, backfill and cast in place concrete. Assumes removal of approximately 2,600 linear feet of overhead powerlines, transformer bank and up to 15 utility poles related to GWE electrical distribution
	Extraction Well Abandonment - Grouting	EA	8	GRT	-	160	-	Assumes one (1) drill rig is needed to abandon one (1) extraction well per day based on Ramboll previous project experience
	Conveyance Piping Abandonment - Grouting	Days	13	GRT	-	260	-	Assumes 3 days labor to grout approximately 6,000 linear feet of 2" extraction well HDPE conveyance line based on Ramboll previous project experience. Assumes 10 days labor to grout approximately 4,500 linear feet of 6" transfer pump HDPE conveyance line based on Ramboll previous project experience
	Roll Off Dumpsters for Infrastructure Disposal	EA	4	-	-	-	-	Assumes a total of four (4) roll offs are needed to dispose of GWE related infrastructure following shutdown and decommissioning based on Ramboll previous project experience
4	Engineering Oversight	LS	1	Eng	-	1,781	-	Assumes engineering oversight will be required during non-routine GWE system O&M and GWE system abandonment only.
	CORRECTIVE ACTION OPERATION AND MAINTENANCE SUBTOTAL					**6,201**	**-**	

	Total Labor Hours	Total Equipment Hours
ENGINEERING AND CONSTRUCTION SUBTOTAL	**-**	**-**
CORRECTIVE ACTION OPERATION AND MAINTENANCE SUBTOTAL	**6,200**	**-**
ALTERNATIVE 2 SUBTOTAL	**6,200**	**-**

NOTES:

1. Alternative 2: Source control with groundwater extraction (Continuation of the preliminary corrective remedial measure) is estimated to take approximately 10 years to achieve groundwater protection standards (GWPS-35 I.A.C Section 845.600) at all perimeter wells associated with the Eastern Ash Pond (EAP) following EAP closure in place (CIP).
2. RS Means refers to the 2023 online edition of RS Means Commercial New Construction. All unit rates refer to standard union labor in Paducah, KY.
3. See crew tab (Alt 2 - GWE) for assumptions regarding crew size, total labor hours and required construction equipment, as needed, for each task.
4. See mileage tab (Alt 2 - Mileage & Labor) for assumptions regarding total mileage for tasks outlined in this alternative.

ACRONYMS:
AC = acre
CIP = closure in place
CY = cubic yard
EA = each
EAP = Eastern Ash Pond
GWE = groundwater extraction
GWPS = groundwater protection standards
LF = linear foot
LS = lump sum
MO = month
O&M = operation and maintenance
PCA = preliminary corrective action

CREW CODES
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 2 - SOURCE CONTROL WITH GROUNDWATER EXTRACTION (CONTINUATION OF PCA)

Item No.	Crew Code	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Onsite Labor Hours	Onsite Heavy Equipment Hours
Operation and Maintenance							
2	A1C	Laborer x1	10	1 Chain Saw, Gas, 18"	8	180	-
3	R3	1 Electrician Foreman 1 Electrician 0.5 Operator (crane)	25	0.5 S.P. Crane, 4x4, 5 Ton	8	221	-
1	ES	Laborer x1 Operator x1	20	Mounted Winch or Hoisting System	8	480	-
3	GRT	Laborer x 1 Operator x1	20	Service Truck x1	10	420	-
1	OM	Laborer x1	10	None	0	1,440	-
2	VT	Laborer x1 Operator x1	20	Vacuum Truck with Flushing Capabilities	8	360	-
2	WD	Laborer x1 Operator x1	20	Well Development Rig, Mounted Winch or Hoisting System	8	600	-
1	WT	Laborer x1	10	None	0	720	-
4	Eng	Engineer x1	10	None	0	1,781	-
				O&M Subtotals		6,201	-
					Totals	**6,200**	-

Note: Blue shaded crew codes were created by Ramboll based on experience (not pulled from RS Means).

MILEAGE AND LABOR ESTIMATES
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 2 - SOURCE CONTROL WITH GROUNDWATER EXTRACTION (CONTINUATION OF PCA)

Construction Mileage and Labor Estimates

Item	Quantity	Assumptions
Labor Total Hours	0	No Construction for Alt 2
Duration of Onsite Construction Days	0	-
Average Daily Crew Size	0	-
Daily Labor Mobilization Miles	0	-
Vehicles Miles Onsite	0	-
Equipment Mobilization Miles - Unloaded	0	-
Equipment Mobilization Miles - Loaded	0	-
Onsite Haul Truck Miles - Unloaded	0	-
Onsite Haul Truck Miles - Loaded	0	-
Offsite Haul Truck Miles - Unloaded	0	-
Offsite Haul Truck Miles - Loaded	0	-
Material Delivery Miles - Unloaded	0	-
Material Delivery Miles - Loaded	0	-

O&M Mileage and Labor Estimates

Item	Quantity	Assumptions
Labor Total Hours	4,421	Per projected O&M total in cost estimate (does not include contingency)
Duration of Onsite O&M in Days	327.5	Total Days
Average Daily Crew Size	1.4	Assumes multiple crew sizes and an 8 to 10 hour work day
Daily Labor Mobilization Miles	77,802	Includes mob/demob from Chicago (720 miles round trip) and local daily commute mileage (40 miles per day)
Vehicles Miles Onsite	6,631	Includes light and medium commercial vehicles 1 mile per day round trip from gate to parking 5 miles per day for onsite miles 9 miles per day local trips (Vil. of Joppa) No contingency Included
Equipment Mobilization Miles - Unloaded	0	Normal work vehicles only for this alternative & phase No heavy equipment to mobilize
Equipment Mobilization Miles - Loaded	0	Normal work vehicles only for this alternative & phase No heavy equipment to mobilize
Onsite Haul Truck Miles - Unloaded	0	No spoil hauling will occur under this alternative
Onsite Haul Truck Miles - Loaded	0	No spoil hauling will occur under this alternative
Offsite Haul Truck Miles - Unloaded	280	Assumes unloaded haul for four (4) rolloff dumpsters
Offsite Haul Truck Miles - Loaded	280	Assumes empty haul miles for four (4) rolloff dumpsters
Material Delivery Miles - Unloaded	0	No materials will be delivered during OMM
Material Delivery Miles - Loaded	0	No materials will be delivered during OMM

ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 3 - SOURCE CONTROL WITH DEEP CUTOFF WALL[1]

ITEM NO.	ENGINEERING, PRE-CONSTRUCTION, AND CONSTRUCTION SUPPORT TASKS	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
1	Engineering Support and CQA During Construction	LS	1	Eng	12	3,504	1,168	Assumed percentage based on Ramboll previous project experience. Total cost is calculated as a percentage of the sum of item numbers 2-10.
	ENGINEERING, PRE-CONSTRUCTION, AND CONSTRUCTION SUPPORT TASKS ESTIMATED SUBTOTAL					**3,500**	**1,170**	
ITEM NO.	**SITE PREPARATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
2	Tree clearing in Cutoff Wall Alignment and Laydown Areas	-	-	-	-	583	194	Assumes some tree clearance and fine site preparation work is needed ahead of construction activities.
	Tree Clearing Down to Grade	Acre	8.5	B7	0.7	583	194	311110100200: Clearing and grubbing, medium trees to 12" diameter, cut and chip. Assumes 25-feet of tree clearance along the 4,000-foot deep cutoff wall alignment.
3	Staging/Laydown Area Preparation	-	-	-	-	1,295	390	Assumes the general work area associated with the deep cutoff wall will need to be graded and built-up in order to make way for construction equipment needed for the install.
	Subgrade Stabilization Nonwoven Geotextile	SY	19,400	2 Clab	2500	124	-	313219161550: Geosynthetic soil stabilization, geotextile fabric, non-woven, 120 lb tensile strength includes scarifying and compaction; assume we need for roads, staging area, and material handling system.
	Construct Staging/Laydown Areas	SY	15,000	B14	615	1,171	390	015523500100: Temporary, roads, gravel fill, 8" gravel depth, excluding surfacing. Assumes 3-acre staging/laydown area.
4	Construction Soil Erosion & Sediment Controls	-	-	-	-	596	199	Assumes soil erosion and sediment controls will be implemented only during the deep cutoff wall construction.
	Silt Fence	LF	16,000	B62	650	591	197	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Assumes silt fence is installed down both sides of the deep cutoff wall alignment (8,000 ft total per event) and the silt fence is replaced once during deep cutoff wall construction. (16,000 ft total)
	Straw Wattles	LF	200	A2	1000	5	2	312514160705: Sediment Log, Filter Sock, 9". Assume straw wattles are needed along perimeter of deep cutoff wall and staging/laydown area at an occurrence of 1 every 50 feet.
5	GWE System Abandonment	-	-	-	-	612	394	Assumes extraction well conveyance piping, electrical infrastructure, and well vaults will have to be removed as their location conflicts with footprint of the Deep Cutoff Alignment. The 6" HDPE conveyance line associated with the transfer pump would be grouted between the train tracks and the southern settling lagoon but will be removed between the IRM system location and the train tracks.
	Removal of GWE Electrical Distribution Equipment	EA	15	R3	1.7	176	176	337116337200: Electrical utility pole, wood, class 3, Douglas Fir, penta-treated, 45', excludes excavation, backfill and cast in place concrete. Assumes removal of approximately 2,600 linear feet of overhead powerlines, transformer bank and up to 15 utility poles related to IRM electrical distribution.
	Removal of GWE System, Conveyance Piping, and Extraction Well Infrastructure	CY	1,200	B11M	200	96	48	3122316130060: Excavating, trench or continuous footing, common earth, 1/2 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering. Assumes extraction well subsurface conveyance piping and electrical infrastructure related to the IRM is removed following shutdown of the IRM system.
	Extraction Well Abandonment - Grout	EA	8	GRT	-	160	80	Assumes one (1) drill rig is needed to abandon one (1) extraction well per day based on Ramboll previous project experience
	Conveyance Piping Abandonment - Grouting	Days	9	GRT	-	180	90	Assumes 9 days labor to grout approximately 4,000 linear feet of 6" transfer pump HDPE conveyance line based on Ramboll previous project experience
	Roll Off Dumpsters for Infrastructure Disposal	EA	4	-	-	-	-	Assumes a total of four (4) roll offs are needed to dispose of IRM related infrastructure following shutdown and decommissioning. Based on Ramboll previous project experience.
6	Deep Cutoff Wall Alignment Preparation Work Pad	-	-	-	-	2,157	671	Includes one (1) office trailers, three (3) storage trailers, and four (4) portable toilets.
	Fence Removal	LF	4,000	B6	890	108	36	024113620600: Selective Demolition, chain link fences & gates, fence, 5' high. Scaled up to 6'.
	Fence Concrete Support Removal	EA	500	B6	80	150	50	024113621000: Selective demolition, chain link fences & gates, posts, steel in concrete. Assume foundation every 8 feet.
	Install Nonwoven Geotextile	SY	22,300	2 Clab	2500	143	-	313219161550: Geosynthetic soil stabilization, geotextile fabric, non-woven, 120 lb tensile strength includes scarifying and compaction; assume we need for roads, staging area, and working pad.
	Install Crushed Gravel Road (18" Thick) - Right of Way	SY	22,500	B14	615	1,756	585	015523500100: Temporary, roads, gravel fill, 8" gravel depth, excluding surfacing. Spanning 4,000-feet long and 50-feet wide.
	SITE PREPARATION ESTIMATED SUBTOTAL					**5,242**	**1,849**	

ITEM NO.	DEEP CUTOFF WALL CONSTRUCTION	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
7	Installation of Deep Cutoff Wall	SF	400,000	B12H	2000	3,200	1,600	Demolish/Excavate DMM in southeast corner of EAP. Spoils to be placed in EAP. Spoils to be placed in East Ash Pond onsite as contouring fill beneath the final cover system. Assumes 4,000-foot wall alignment, 3-foot wall width, and 100-foot wall depth 312316420550: Excavating, bulk bank measure, 1 C.Y. capacity = 35 C.Y./hour, clamshell, excluding truck loading. Crane costs are included in the Installation of Deep Cutoff Wall line item. This line item was included to quantify labor and equipment hours.
8	Spoils Management	CY - Loose	52,000	-	-	2,102	1,565	Quantity based on surface to surface calculation performed in AutoCAD.
	Loading	CY - as excavated	52,000	B14B	5000	125	83	312316435320: Excavating, large volume projects; excavation with truck loading; excavator, 6 C.Y. bucket, 100% fill factor (assume 10% fluff factor from ground to excavated).
	Hauling and Placement at EAP	CY - as excavated	52,000	B34G	850	489	489	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. Unit rate and daily output extrapolated down to 10 min wait.
	Spreading/Drying Moisture Conditioning	CY - as excavated	52,000	B10B	1000	624	416	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience. Quantity assumes 50% of volume requires moisture conditioning.
	Spreading Lifts	CY - as excavated	52,000	B10B	1000	624	416	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Material	CY - in place	52,000	B10F	2600	240	160	312323235060: Compaction; Riding, vibrating roller, 12" lifts, 2 passes. RS Means Crew is B10Y; altered to B10F based on experience. RS Means unit rate halved for 24" lifts.
	DEEP CUTOFF WALL CONSTRUCTION					**5,302**	**3,165**	

ITEM NO.	SITE RESTORATION	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
9	Infrastructure Restoration	-	-	-	-	392	179	Assumes restoration of chain link fence along property boundary and restoration of grade surface following deep cutoff wall installation
	Fence Restoration	LF	4,000	B80C	300	320	107	323113202100: Fence, chain link industrial, no barbed wire, galvanized steel, 2" line post, 10' OC, 1-5/8" top rail, 5' -0" high, includes excavation and concrete. Fence replacement along entire cutoff wall alignment
	Lime	MSF	350	B66	700	4	4	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader. Unit multiplied by 1.1 to account for soils possibly being void of nutrients.
	Fertilizer	MSF	350	B66	700	4	4	329113234150: Soil preparation, structural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader. Unit multiplied by 1.1 to account for soils possibly being void of nutrients.
	Grassland Mix	MSF	350	B66	52	54	54	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quantity all disturbed areas minus wetland area, pollinator area, and 15-acre pond in consolidated area.
	Mulch	MSF	350	B65	530	11	11	329113160350: Mulching, Hay, 1" deep, power mulcher, large.
	SITE RESTORATION ESTIMATED SUBTOTAL					**392**	**179**	

	Total Labor Hours	**Total Equipment Hours**
ENGINEERING AND CONSTRUCTION SUBTOTAL	**14,400**	**6,400**
CORRECTIVE ACTION OPERATION AND MAINTENANCE SUBTOTAL	**-**	**-**
ALTERNATIVE 3 SUBTOTAL	**14,400**	**6,400**

NOTES:

1. Alternative 3: Source Control with deep cut off wall is estimated to take approximately 11 years to achieve groundwater protection standards (GWPS-35 I.A.C Section 845.600) at all perimeter wells associated with the Eastern Ash Pond (EAP) following EAP closure in place (CIP).
2. RS Means refers to the 2023 online edition of RS Means Commercial New Construction. All unit rates refer to standard union labor in Paducah, KY.
3. Corrective Action Groundwater Monitoring (CAGM) Mileage and Labor Estimates
4. See mileage tab (Alt 3 - Mileage & Labor) for assumptions regarding total mileage for tasks outlined in this alternative.

ACRONYMS:

AC = acre
CIP = closure in place
CY = cubic yard
Loose: Material swelled when removed from compacted state
DMM = deep mixing method
EAP = Eastern Ash Pond
EA = each
GWE = groundwater extraction
GWPS = groundwater protection standards
LF = linear foot
LS = lump sum
MSF = square feet divided by 1000
MO = month
O&M = operation and maintenance

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CREW CODES
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 3 - SOURCE CONTROL WITH DEEP CUTOFF WALL

Item No.	Crew Code	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Crew Size	Onsite Labor Hours	Onsite Heavy Equipment Hours
Construction								
3,6	2 Clab	Laborer x2	16	None	0	2	267	-
4	A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	3	5	2
6	B6	Laborer x 2 Operator (light) x 1	24	Backhoe Loader, 48 H.P.	8	3	258	86
2	B7	Laborer x4 Labor Foreman x1 Operator (med) x 1	48	Brush Chipper, 12", 130 H.P Crawler Loader, 3 C.Y. Chain Saws, Gas, 36" Long x 2	16	6	583	194
8	B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	1.5	1,248	832
8	B10F	Operator (med) x1 Laborer x0.5	12	Tandem Roller, 10, Ton	8	1.5	240	160
5	B11M	Laborer x1 Operator x1	16	1 Backhoe Loader, 80 H.P.	8	2	96	48
7	B12H	Laborer x1 Operator x1	16	1 Crawler Crane, 25 Ton 1 Clamshell Bucket, 1 C.Y.	8	2	3,200	1,600
3,6	B14	Labor Foreman x 1 Operator (light) x1 Laborer x 4	48	Hyd. Excavator, 4.5 C.Y.. Backhoe Loader, 48 H.P.	16	6	2,927	976
8	B14B	Operator x1 Laborer x0.5	12	Hyd. Excavator, 6 C.Y.	8	1.5	125	83
8	B34G	Truck Driver x1	8	Dump Truck, Off Hwy., 50 ton	8	1	489	489
4	B62	Laborer x2 Operator x 1	24	Loader, Skid Steer, 30 H.P.	8	3	591	197
9	B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	2	11	11
9	B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	1	62	62
9	B80C	2 Laborers 1 Operator (light)	24	1 Crane, Flatbed Mounted, 3 Ton	8	3	320	107
5	R3	1 Electrician Foreman 1 Electrician 0.5 Operator (crane)	20	0.5 S.P. Crane, 4x4, 5 Ton	8	2.5	176	176
5	GRT	Laborer x 1 Operator x1	20	Service Truck x1	10	2	340	170
1	Eng	Engineering Staff x1.2	10	Side by Side x1	4	1.2	3,504	1,168
				Construction Subtotals			14,400	6,400
						Totals	**14,400**	**6,400**

Note: Blue shaded crew codes were created by Ramboll based on experience (not pulled from RS Means).

CONSTRUCTION MILEAGE AND LABOR ESTIMATES
ELECTRIC ENERGY INC. - JOPPA POWER PLANT
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 3 - SOURCE CONTROL WITH DEEP CUTOFF WALL

Construction Mileage and Labor Estimates

Item	Quantity	Assumptions
Labor Total Hours	14,441	Per projected Construction total in cost estimate (does not include contingency)
Duration of Onsite Construction Days	292	Total Days
Average Daily Crew Size	9.7	Assumes multiple crew sizes and a 10 hour work day
Daily Labor Mobilization Miles	197,587	Includes light and medium commercial vehicles Average of 70 miles round trip per day
Vehicles Miles Onsite	42,340	Includes light and medium commercial vehicles 1 mile per day round trip from gate to parking 5 miles per day for onsite miles 9 miles per day local trips (Vil. of Joppa) No contingency Included
Equipment Mobilization Miles - Unloaded	42,048	Average of 720 miles round trip for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	42,048	Average of 720 miles round trip for equipment hauling Average 1 load of equipment per working week
Onsite Haul Truck Miles - Unloaded	3,059	34 CY Off Road Dump Truck 2 mile round trip per load
Onsite Haul Truck Miles - Loaded	3,059	34 CY Off Road Dump Truck 2 mile round trip per load
Offsite Haul Truck Miles - Unloaded	23,438	Assumes 16 CY loads of gravel are delivered to the site from a regional supplier located within 50 miles of the site
Offsite Haul Truck Miles - Loaded	23,438	Assumes truck is returning to the regional supplier located within 50 miles of the site
Material Delivery Miles - Unloaded	58,400	Misc. construction materials (cement, bails, etc) Assumes 200 mile round trip on a daily basis
Material Delivery Miles - Loaded	58,400	Misc. construction materials (cement, bails, etc) Assumes 200 mile round trip on a daily basis

O&M Mileage and Labor Estimates

Item	Quantity	Assumptions
Labor Total Hours	0	No O&M for Alt 3
Duration of Onsite O&M Days	0	-
Average Daily Crew Size	0	-
Daily Labor Mobilization Miles	0	-
Vehicles Miles Onsite	0	-
Equipment Mobilization Miles - Unloaded	0	-
Equipment Mobilization Miles - Loaded	0	
Onsite Haul Truck Miles - Unloaded	0	-
Onsite Haul Truck Miles - Loaded	0	-
Offsite Haul Truck Miles - Unloaded	0	-
Offsite Haul Truck Miles - Loaded	0	-
Material Delivery Miles - Unloaded	0	-
Material Delivery Miles - Loaded	0	-

Appendix C

Corrective Measures Assessment

Intended for
Electric Energy, Inc.

Date
April 18, 2024

Project No.
1940103584-006

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT

JOPPA POWER PLANT, EAST ASH POND, IEPA ID NO. W1270100004-02

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35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT JOPPA POWER PLANT, EAST ASH POND, IEPA ID NO. W1270100004-02

Project name	**Joppa Power Plant East Ash Pond**
Project no.	**1940103584-006**
Recipient	**Electric Energy, Inc.**
Document type	**35 I.A.C. § 845 Corrective Measures Assessment**
Revision	**FINAL**
Date	**April 18, 2024**
Prepared by	**Frances Ackerman, RG, PE**
Checked by	**Lucas P. Carr, PE**
Approved by	**Brian G. Hennings, PG**

Frances Ackerman, RG, PE
Senior Managing Engineer

Brian Hennings, PG
Project Officer, Hydrogeology

CONTENTS

TABLES

FIGURES

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

%	percent
35 I.A.C.	Title 35 of the Illinois Administrative Code
ASD	Alternative Source Demonstration
CAAA	Corrective Action Alternatives Analysis
CAP	Corrective Action Plan
CBR	closure-by-removal
CCR	coal combustion residuals
CIP	closure-in-place
CMA	Corrective Measures Assessment
cm/s	centimeters per second
CSM	conceptual site model
E001	Event 1
EAP	East Ash Pond
EEI	Electric Energy, Inc.
EPRI	Electric Power Research Institute
GMP	groundwater monitoring plan
gpm	gallons per minute
GWPS	groundwater protection standard(s)
HCR	Hydrogeologic Site Characterization Report
ID	identification
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
ITRC	National Research Council, Interstate Technology & Regulatory Council
IX	ion exchange
JPP	Joppa Power Plant
LAU	Lower Aquifer Unit
LCU	Lower Confining Unit
NID	National Inventory of Dams
No.	number
NPDES	National Pollutant Discharge Elimination System
NRT/OBG	Natural Resource Technology, an OBG Company
PCRM	Preliminary Corrective Remedial Measure
PRB	Permeable Reactive Barrier
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
SSI	Supplemental Site Investigation
UA	uppermost aquifer
UCU	upper confining unit
USEPA	United States Environmental Protection Agency
ZVI	zero-valent iron

1. INTRODUCTION

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has developed this assessment of groundwater corrective measures on behalf of Electric Energy, Inc. (EEI), to assist in the compliance with the requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments. This assessment applies specifically to the coal combustion residuals (CCR) surface impoundment (SI) referred to as the East Ash Pond (EAP) at the Joppa Power Plant (JPP), also referred to as CCR Unit identification [ID] Number (No.) 401, Illinois Environmental Protection Agency (IEPA) ID No. W1270100004-02, and National Inventory of Dams (NID) No. IL50714. This report addresses content requirements specific to 35 I.A.C. § 845.660 (Assessment of Corrective Measures) for exceedances of boron at the EAP.

1.1 Source Control and Residual Plume Management

EEI intends to initiate significant source control and residual plume management efforts as part of the EAP closure, as documented in the Final Closure Plan and Construction Permit Application that were submitted to IEPA in July of 2022 (Geosyntec Consultants, 2022). The proposed closure exceeds the minimum Closure Performance Standards listed in 35 I.A.C. § 845.750. The closure will include removing free liquids in accordance with the performance standard in 35 I.A.C. § 845 and maintaining that condition during the closure construction period. The closure will eliminate, to the maximum extent feasible, the hydraulic head that can force leachate into subsurface soils and is the mechanism that can drive risk (United States Environmental Protection Agency [USEPA], 2015a, p. 21342):

> *EPA's risk assessment shows that the highest risks are associated with CCR surface impoundments due to the hydraulic head imposed by impounded water. Dewatered CCR surface impoundments will no longer be subjected to hydraulic head so the risk of releases, including the risk that the unit will leach into the groundwater, would be no greater than those from CCR landfills.*

The EAP will be closed using a consolidate-and-cap approach consisting of excavating approximately 1.8 million cubic yards of CCR (including CCR from an approximately 54-acre closure-by-removal [CBR] area within the perimeter dikes of the EAP and all CCR from a 32-acre area outside of the perimeter dikes of the EAP) and using it for beneficial use in a consolidated closure-in-place (CIP) footprint. The consolidated CCR will be covered with an alternate geomembrane final cover system having performance that exceeds the 35 I.A.C. §845.750(c)(2) minimum final cover requirements. The proposed source control is predicted to reduce water flux into and out of the EAP by 99.99 percent (%) and allow the groundwater protection standards (GWPS) to be achieved within approximately 20 years after the completion of closure (Ramboll, 2022). These source control activities will serve as the primary groundwater corrective measure at the EAP. The potentially feasible corrective measures presented herein are intended to be supplementary to the primary groundwater corrective measure (*i.e.,* source control) and are intended to serve as management measures to address any residual plume(s) that remain after completion of source control.

Attachment A includes summary figures from the Construction Permit Application that show the proposed final source control and primary corrective action.

1.2 Adaptive Site Management

Adaptive site management strategies will be employed as an integral part of ongoing corrective action at the EAP. The adaptive site management approach will allow timely incorporation of new site information over the closure and post-closure life cycle of the EAP to ensure the achievement of the GWPS. The adaptive site management approach is proposed to expedite progress toward meeting the GWPS while acknowledging uncertainties, such as the persistence of current groundwater flow directions and flux quantities and potential related changes in geochemical conditions. A structured decision-making process and explicitly planned iterations between the implemented corrective measures and monitoring results will ensure that active remediation is occurring. System performance and the condition of the residual plume will be monitored as the corrective measure(s) selected through the 35 I.A.C. § 845.710 Corrective Action Plan (CAP) process are implemented to supplement the source control measures described above. If the groundwater concentrations do not decrease consistent with modeling predictions, the adaptive site management approach will facilitate timely modifications or enhancements to the corrective measure(s), as needed, in accordance with 35 I.A.C. § 845.680(b). This approach will be employed to provide continuous improvement to the EAP groundwater remediation in response to new site information and/or the performance of the selected corrective measure(s).

The planned adaptive site management strategies are generally consistent with National Research Council, Interstate Technology & Regulatory Council (ITRC) and USEPA methodologies developed to address sites with long remediation times and high levels of uncertainty regarding the remedial actions necessary to achieve final and protective remediation goals (USEPA, 2022). The elements of the proposed adaptive site management strategy at the EAP will be responsive to the changing conditions associated with pond closure and performance of the selected corrective measure(s) and will include the following:

1. Implementing the groundwater corrective measure(s) selected as part of the CAP for the current conditions at the EAP. The selected corrective measures may include a combination of the technologies presented in this Corrective Measures Assessment (CMA).
2. Establishing both the absolute remedial objective and functional (interim) goals to monitor progress toward the remedial objective. Achieving the GWPS for 35 I.A.C. § 845.600 constituents at the downgradient waste boundary is the remedial objective for the EAP. Specific functional goals will be developed as part of the CAP process. The functional goals will be measurable thresholds for future action and may include short-term or technology-specific objectives and triggers. Functional goals may vary for different locations, CCR constituents or other site-specific considerations (ITRC, 2017) and will serve as benchmarks for comparison to ongoing groundwater monitoring at the EAP.
3. Ongoing groundwater monitoring at the EAP will continue throughout the implementation of source control and residual plume management activities. Post-closure monitoring will continue for a period of at least 30 years, in accordance with 35 I.A.C. § 845.780(c). A comprehensive groundwater monitoring plan (GMP) will be developed as part of the CAP process in accordance with 35 I.A.C. § 845.670 and 35 I.A.C. § 845.220(c)(4). The GMP will include the functional goals and proposed action levels.

4. Groundwater monitoring information will be used to guide decisions regarding whether progress toward the remedial goal is advancing as expected and/or whether additional actions may be needed to achieve the remedial objective, in conjunction with IEPA, as required by 35 I.A.C. § 845.680(b).

2. SITE INFORMATION

The JPP is located west of the Village of Joppa in Massac County, Illinois, northeast of the Ohio River (**Figure 2-1**). The EAP is located in the west half of Section 14 directly north of the JPP and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa. The EAP (**Figure 2-2**) is a 128-acre inactive unlined CCR SI used to manage CCR and non-CCR waste streams during operation of the JPP.

2.1 Conceptual Site Model

Significant site investigation has been completed at the JPP to characterize the geology, hydrogeology, and groundwater quality. Based on extensive investigation and monitoring, the EAP has been well characterized and detailed in the Hydrogeologic Site Characterization Report (HCR; Ramboll, 2021a), which was prepared to comply with the requirements specified in 35 I.A.C. § 845.620 and expands upon the Hydrogeologic Monitoring Plan (Natural Resource Technology, an OBG Company [NRT/OBG], 2017). The conceptual site model (CSM) is presented below.

In addition to the CCR present at the EAP, the following four distinct hydrostratigraphic units have been identified beneath the EAP, based on stratigraphic relationships and common hydrogeologic characteristics:

- **Upper Confining Unit (UCU)**: Includes approximately 50 feet of low permeability silt and clay of the Equality Formation, silts of the Peoria/Roxana/Loveland, and clay and silt of the Metropolis Formation. This unit limits the vertical migration of CCR impacts into the UA.
- **Uppermost Aquifer (UA)**: Includes high permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation. The UA is laterally continuous across the JPP and is approximately 85 feet thick near the EAP.
- **Lower Confining Unit (LCU)**: Includes clay and silt of the Lower McNairy Formation above the regional bedrock surface. Based on material description, continuous lateral extent, and observed vertical gradients, this unit has been identified as the LCU.
- **Lower Aquifer Unit (LAU)**: The lowermost unit identified at the EAP, which underlies all unlithified deposits, is considered a potential migration pathway. This unit is comprised of the Salem Limestone, which is the uppermost lithified unit identified at the EAP and is used as a potable and non-potable water supply in the vicinity of the JPP.

Groundwater flow in the EAP migrates downward through the UCU into the relatively high permeability sands and gravels of the UA. In the UA, groundwater generally migrates south and east towards the Ohio River. Vertical gradients measured between the LAU and the UA indicate upward migration of groundwater from the LAU to the UA and into the Ohio River. Groundwater elevations and contours for the May 1, 2023 groundwater monitoring event (Event 1 [E001]) are presented in **Figure 2-3**.

2.2 Groundwater Quality

Groundwater monitoring in accordance with the proposed GMP and sampling methodologies provided in the operating permit application for the EAP began in the second quarter of 2023. The 35 I.A.C. § 845 groundwater monitoring system is displayed on **Figure 2-4** and consists of two background monitoring wells screened in the UA, 12 compliance wells screened in the UA, and two temporary water level only surface water staff gages. The groundwater samples collected from the 14 wells are used to monitor and evaluate groundwater quality and demonstrate compliance with the groundwater quality standards listed in 35 I.A.C. § 845.600(a). The proposed monitoring wells yield groundwater samples that represent the quality of downgradient groundwater at the CCR boundary (as required in 35 I.A.C. § 845.630(a)(2)).

The E001 groundwater monitoring event was completed on May 3, 2023. In accordance with 35 I.A.C. § 845.610(b)(3)(C), statistically derived values were compared with the GWPSs summarized in 35 I.A.C. § 845.600 to determine exceedances of the GWPS. The statistical determination identified the following GWPS exceedances at compliance groundwater monitoring wells (Ramboll, 2023a):

- Boron at wells G06, G07, G08, G09, G10
- Cobalt at well G05
- pH at wells G11 and G51D

Pursuant to 35 I.A.C. § 845.650(e), an Alternative Source Demonstration (ASD) presented evidence demonstrating that sources other than the EAP were the cause of the cobalt and pH GWPS exceedances listed above (Ramboll, 2023b). IEPA did not concur with the ASD due to the following alleged data gaps (IEPA, 2023):

- Source characterization of the CCR at the EAP must include total solids sampling in accordance with SW846.
- Characterization of alternative source to include sample and analysis in accordance with 35 I.A.C. § 845.640 must be provided with the ASD.

EEI submitted written comments and additional information in response to IEPA's request for information and filed a petition asking the Illinois Pollution Control Board (IPCB) to review IEPA's ASD denial. The petition included a motion for a partial stay of the 35 I.A.C. § 845 requirements as they apply to the exceedances of the cobalt and pH GWPS at the EAP. IEPA had no objection to the requested stay, which was granted by IPCB to EEI on February 1, 2024. Therefore, the CMA will address GWPS exceedances in accordance with 35 I.A.C. § 845.660, exclusive of the cobalt and pH exceedances. The 35 I.A.C. § 845.650 groundwater monitoring requirements will continue to ensure that there will be timely detection of any additional changes in groundwater quality during the stay. The inclusion of the cobalt and pH GWPS exceedances in the CAP process will remain under review pending IPCB's final action on EEI's appeal of the IEPA ASD denial or until IPCB orders otherwise.

2.3 Groundwater Plume Delineation

Due to the identification of concentrations of boron above the anticipated GWPS (Ramboll, 2021b), additional investigations were conducted in 2022 in accordance with 35 I.A.C. § 845.650 to further assess the nature, degree, and extent of boron groundwater impacts downgradient of the EAP. The Supplemental Site Investigation (SSI) fully delineated the boron impacts to groundwater downgradient of the JPP EAP, both vertically and laterally. Boron has migrated downward through the UCU, reaching the UA and migrated laterally to the south and southeast; however, downward migration of boron from the UA to the LAU has not been observed (Geosyntec Consultants, 2023).

2.4 2024 Groundwater Extraction

Groundwater extraction is planned for the EAP in 2024 as a preliminary corrective remedial measure (PCRM) to provide hydraulic containment along the eastern boundary of the stie. Groundwater will be extracted from the UA using a system of extraction wells installed to the east of, and hydrogeologically downgradient from, the EAP. Each extraction well is planned to be designed to intercept impacted groundwater from the UA at flow rates that are currently expected to be around 30 to 40 gallons per minute (gpm) per well with a maximum design extraction rate of 70 gpm per well. Extracted groundwater will be conveyed from the extraction wells to an equalization tank, then transferred by a single pump to the Settling Lagoon located at the southern end of the JPP before being discharged to the Ohio River via the facility's existing National Pollutant Discharge Elimination System (NPDES) Outfall 010.

3. CORRECTIVE MEASURES ASSESSMENT METHODOLOGY

This section describes the CMA methodology initiated in response to the identification of exceedances of the GWPSs for 35 I.A.C. § 845.600 constituents at the downgradient waste boundary of the EAP during the E001 groundwater monitoring event (Ramboll, 2023a). The CMA was initiated on November 20, 2023, within 90 days after the detection of exceedance(s) of GWPS. Under 35 I.A.C. § 845, owners and operators of existing CCR SIs must initiate the assessment of corrective measures in accordance with 35 I.A.C. § 845.660 if one or more constituents are detected, and confirmed by an immediate resample, to be in exceedance of a GWPS in 35 I.A.C. § 845.600, and the owner or operator has not demonstrated that: a source other than the CCR SI caused the exceedance, or that the exceedance of the GWPS resulted from error in sampling, analysis, statistical evaluation, natural variation in groundwater quality or a change in the potentiometric surface and groundwater flow direction (*i.e.,* an ASD).

The CMA is the first step in developing a long-term CAP to address the GWPS exceedances at CCR SIs. The process provides a systematic, rational method for evaluating potential corrective measures by first identifying potentially viable technologies and assessing them using qualitative information to eliminate from consideration infeasible or otherwise unacceptable remedial technologies (*i.e.,* the 35 I.A.C. § 845.660). The remaining technologies will be evaluated individually, or assembled into combined alternatives, and further evaluated under the CAP process per 35 I.A.C. § 845.670.

This CMA identified applicable corrective measure technologies and evaluated them for viability, given the site-specific conditions and considerations at the EAP, by addressing the following 35 I.A.C. § 845.660 evaluation criteria:

- Performance, reliability, ease of implementation and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;
- Time required to begin and complete the CAP; and
- Institutional requirements, such as State or local permit requirements or other environmental or public health requirements, that may substantially affect implementation of the CAP.

The evaluation included qualitative and/or semi-quantitative screening of the potential corrective measures (technologies) relative to their general performance, reliability, and ease of implementation characteristics and their potential impacts, timeframes, and institutional requirements to assess the viability of each technology to address the GWPS exceedances at the EAP. This approach provided a reasoned set of corrective measures that could be used, either individually or in combination, to supplement the primary source control measures described in **Section 1.1**. This set of corrective measures will be further evaluated in the Corrective Action Alternatives Assessment (CAAA).

4. DESCRIPTION OF POTENTIAL CORRECTIVE MEASURE TECHNOLOGIES

The potential groundwater corrective measures summarized below are applicable to the EAP and were included in the CMA development and analysis. Site-specific considerations provided in **Section 2** were used to evaluate potential groundwater corrective measures. Each of the corrective measures evaluated may be capable of satisfying the requirements and objectives, listed in **Section 3**, to varying degrees of effectiveness. The corrective measure review process was intended to yield a set of applicable corrective measures that could be used to supplement the primary corrective action, which will be the source control activities described in **Section 1.1** (hybrid consolidate-and-cap approach with a geomembrane final cover system). The source control is expected to reduce downgradient concentrations in the UA to less than the GWPS via naturally occurring physical and chemical processes over an approximately 20 year timeframe. Ongoing monitoring will be an integral part of all corrective measures to verify and document the remedial process. The corrective measures ultimately advanced to the CAAA and selected in the CAP will be used to enhance the effectiveness of the source control and may be used independently or combined into specific remedial alternatives to leverage the advantages of multiple corrective measures to attain GWPSs.

Source control measures will be initiated for the EAP, as described in **Section 1.1**; all of the evaluated corrective measure technologies are proposed to be supplemental and complementary to source control activities. The following potential corrective measures, commonly used to mitigate groundwater impacts, were considered as a part of the CMA process:

- Source Control with Groundwater Polishing;
- Source Control with Groundwater Extraction (groundwater pumping wells or collection trenches);
- Source Control with a Cutoff Wall; and
- Source Control with In-Situ Treatment (Permeable Reactive Barrier [PRB] or In-Situ Chemical Treatment).

4.1 Source Control with Groundwater Polishing

Both federal and state regulators have long recognized that natural geochemical processes can be an acceptable component of a remedial action when it can achieve remedial action objectives in a reasonable timeframe. In 1999, USEPA published a final policy directive (USEPA, 1999) for groundwater remediation and described the process as follows:

- *"The 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. The 'natural attenuation processes that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants."*

The USEPA has stated that source control is the most effective means of ensuring the timely attainment of remediation objectives (USEPA, 1999). Natural geochemical processes may be appropriate as a "finishing step" after effective source control implementation (*i.e.*, groundwater polishing), to reduce the residual mass remaining in the groundwater after closure, if there are no risks to receptors and/or the contaminant plume is not expanding. Thus, groundwater polishing would be used in conjunction with the significant planned source control effort at the site, which will consist of a hybrid consolidate-and-cap approach with a final cover system described in **Section 1.1**.

In 2015, USEPA addressed remediation of inorganic compounds in groundwater and noted that the use of natural geochemical processes to address inorganic contaminants: (1) is not intended to constitute a treatment process for inorganic contaminants; (2) when appropriately implemented, can help to restore an aquifer to beneficial uses by immobilizing contaminants onto aquifer solids and providing the primary means for attenuation of contaminants in groundwater; and (3) is not intended to be a "do nothing" response (USEPA, 2015b). Rather, documenting the applicability of natural geochemical processes for groundwater remediation should be thoroughly and adequately supported with site-specific characterization data and analysis (USEPA 1999; USEPA, 2007; USEPA, 2015b):

Both physical and chemical processes can contribute to the reduction of the small amount of residual mass remaining after closure of the EAP, and the toxicity, mobility, volume, or concentration of contaminants in groundwater. Physical processes applicable to CCR constituents in groundwater include dilution, dispersion, and flushing. Chemical processes applicable to CCR constituents in groundwater include precipitation and coprecipitation (*e.g.,* incorporation into sulfide minerals), sorption (*e.g.,* to iron, manganese, aluminum; to other metal oxides or oxyhydroxides; or to sulfide minerals or organic matter), and ion exchange.

All inorganic compounds are subject to physical processes, and under typical environmental conditions the physical mechanisms most often exert the dominant control on the CCR constituents of interest. Chemical mechanisms are also likely to be active, though not dominant, such as adsorption, ion exchange, and organic complexations. In combination with source control, these natural controls can provide an effective means to polish residual loading and achieve the GWPS in a reasonable timeframe. Additional data collection and analysis may be required to support the USEPA's evaluation framework (USEPA, 2015b) and obtain regulatory approval.

4.2 Source Control with Groundwater Extraction

Groundwater extraction is one of the most widely used groundwater corrective technologies and has a long history of performance. This corrective measure includes installation of one or more groundwater pumping wells or an extraction trench to control and extract impacted groundwater. Groundwater extraction captures and contains impacted groundwater and can limit plume expansion and/or off-site migration. Construction of a groundwater extraction system typically includes, but is not limited to, the following primary components:

- Designing and constructing a groundwater extraction system consisting of one or more extraction wells or trenches and operating at a rate to allow capture of CCR impacted groundwater within the UA.

- Management of extracted groundwater, which may include modification to the existing NPDES permit.
- Ongoing inspection and maintenance of the groundwater extraction system.

Remediation of inorganics by groundwater extraction can be effective, but systems do not always perform as expected. A combination of factors, including geologic heterogeneities, difficulty in flushing low-permeability zones, and rates of contaminant desorption from aquifer solids can limit effectiveness. Groundwater extraction systems require ongoing operation and maintenance to address issues such as iron bacteria and well fouling and to ensure optimal performance. The extracted groundwater must be managed, either by ex-situ treatment or disposal.

Groundwater extraction may reduce the timeframe to achieve GWPS and limit the off-site migration of constituents that exceed the GWPS. Extraction could be accomplished using a groundwater pumping well system or an extraction trench.

4.3 Source Control with Groundwater Cutoff Wall

Since the late 1970s and early 1980s, vertical cutoff walls have been used to control and/or isolate impacted groundwater. Low-permeability cutoff walls can be used to prevent horizontal off-site migration of potentially impacted groundwater. Cutoff walls act as barriers to lateral transport of impacted groundwater and can isolate soils that have been impacted by CCR to prevent mixing with unimpacted groundwater. Cutoff walls are often used in conjunction with an interior pumping system to establish an inward gradient within the cutoff wall. The gradient imparted by the pumping system maintains an inward flow through the wall, keeping it from acting as a groundwater dam and controlling potential end-around or breakout flow of contaminated groundwater. Constructing the cutoff wall such that it intersects a low-permeability material at its base, referred to as “keying”, greatly increases its effectiveness.

A commonly used cutoff wall construction technology is the slurry trench method, which consists of excavating a trench and backfilling it with a soil-bentonite mixture, often created with the excavated soils, or, for deeper walls, a cement-bentonite mixture that is produced at an onsite batch plant. The trench is temporarily supported with bentonite slurry pumped into the trench during excavation (D’Appolonia and Ryan, 1979). Cutoff wall excavation uses conventional hydraulic excavators, hydraulic excavators equipped with specialized booms to extend their reach (*i.e.,* long-stick excavators), clamshells, or more specialized equipment such as hydromills or secant-pile drill rigs, depending upon trench depth, material excavated, and type of material that the wall is keyed into.

Cutoff walls are a widely accepted technology for containing impacted groundwater. Combining groundwater polishing with a limited cutoff wall and groundwater extraction in specific areas may provide advantages over independent use of these potential corrective technologies. Cutoff walls can be used in combination with groundwater extraction or as part of a PRB system (as the “funnel” in a funnel-and-gate system; **Section 4.4**).

4.4 Source Control with In-Situ Chemical Treatment

The use of in-situ treatment, either by injection or PRBs is a widely used technology for treating impacted groundwater. However, in-situ treatment techniques for boron are not well established; therefore, performance is unknown.

Chemical treatment could consist of injection of reactive materials into the subsurface to treat contaminants at specific, targeted locations. Alternatively, treatment could be accomplished via PRB, where subsurface barriers (*i.e.,* cutoff walls) are placed at locations designed to direct the contaminant plume along a flow path through the reactive media. In either system, the contaminants are transformed or otherwise rendered into environmentally acceptable forms to attain remediation concentration goals downgradient of the barrier (Electric Power Research Institute [EPRI], 2006).

As groundwater passes through the PRB under natural gradients, dissolved constituents in the groundwater react with the reactive media and are transformed or immobilized. A variety of media have been used or proposed for use in PRBs. Zero-valent iron (ZVI) has been shown to effectively immobilize some CCR constituents, including arsenic, chromium, cobalt, molybdenum, selenium, and sulfate. Use of a combination media consisting of ZVI and a boron-selective ion exchange resin to treat boron has been documented in a pilot-scale test (EPRI, 2006).

System configurations include continuous PRBs, in which the reactive media extends across the entire path of the contaminant plume; and funnel-and-gate systems, where low-permeability barriers are installed to control groundwater flow through a permeable gate containing the reactive media. Continuous PRBs intersect the entire contaminant plume and do not materially impact the groundwater flow system. Design may or may not include keying the PRB into a low-permeability unit at depth. Funnel-and-gate systems utilize a system of barriers to groundwater flow (funnels) to direct the contaminant plume through the reactive gate. The barriers, typically some form of cutoff wall, are keyed into a low-permeability unit at depth to prevent short circuiting of the plume. Funnel-and-gate design must consider the residence time to allow chemical reactions to occur. Directing the contaminant plume through the reactive gate can significantly increase the flow velocity, thus reducing residence time.

Design of in-situ treatment systems requires rigorous site investigation to characterize the site hydrogeology and to delineate the contaminant plume. A thorough understanding of the geochemical and redox characteristics of the plume is critical to assess the feasibility of the process and select appropriate reactive media. Laboratory studies, including batch studies and column studies using samples of site groundwater, are needed to determine the effectiveness of the selected reactive media at the site (EPRI, 2006). The main considerations in selecting reactive media are as follows (Gavaskar et al., 1998; cited by EPRI, 2006):

- Reactivity–- The media should be of adequate reactivity to immobilize a contaminant within the residence time of the design.
- Hydraulic performance–- The media should provide adequate flow through the PRB, meaning a greater particle size than the surrounding aquifer materials. Alternatively, gravel beds have been placed in front of barriers to direct flow through the barrier.
- Stability–- The media should remain reactive for an amount of time that makes its use economically advantageous over other technologies.
- Environmentally compatible by-products–- Any by-products of media reaction should be environmentally acceptable. For example, iron released by ZVI corrosion should not occur at levels exceeding regulatory acceptance levels.

Availability and price: The media should be easy to obtain in large quantities at a price that does not negate the economic feasibility of using a PRB.

5. ASSESSMENT OF CORRECTIVE MEASURE TECHNOLOGIES

This CMA was initiated to address exceedances of the 35 I.A.C. § 845.600 GWPS for boron at the downgradient waste boundary of the EAP identified during the E001 groundwater monitoring event (**Section 2.2**).

5.1 Requirements

The potential groundwater corrective technologies described in the previous section were evaluated relative to the requirements presented in **Section 1.2** and reiterated below:

- Performance, reliability, ease of implementation and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;
- Time required to begin and complete the CAP; and
- Institutional requirements, such as State or local permit requirement or other environmental or public health requirements that may substantially affect implementation of the CAP.

Table 5-1 presents the qualitative CMA evaluation for each corrective technology relative to these requirements, as well as their ability to address boron GWPS exceedances. The following sections provide a summary of these evaluations and a summary discussion of the potential groundwater corrective measure technologies that may be viable, either independently or in combination, to address GWPS exceedances. This section also provides a summary of corrective measure technologies that have been retained and advanced for evaluation as part of the CAAA process for selecting the final remedy for the EAP per 35 I.A.C. § 845.670.

5.2 Groundwater Corrective Technology Assessment

Source control, consisting of CCR consolidation and CIP with a final cover system, will be the primary groundwater corrective measure for the EAP. In addition, the PCRM will be constructed in 2024 to control off-site migration of boron. Closure will be in accordance with the closure plan and each of the potential groundwater corrective measure technologies would supplement the positive impact of the closure activities. The following sections evaluate groundwater corrective measure technologies that, when combined with site closure, may be viable to address boron GWPS exceedances. Technologies that are not viable for addressing exceedances of GWPS at the EAP will be eliminated from further evaluation and viable technologies will be advanced for further evaluation as part of the CAAA process per 35 I.A.C. § 845.600.

5.2.1 Source Control with Groundwater Polishing

Source control corrective measures (**Section 1.1**) will reduce the mass loading to the groundwater system and the groundwater polishing process could decrease the timeframe for attainment of GWPS in the UA. Groundwater flow and fate and transport modeling incorporating only physical processes indicate that source control would meet GWPS in approximately 14 to 24 years. Physical processes are expected to perform well in the UA, as discussed below.

Groundwater polishing by natural geochemical processes is a widely accepted component of groundwater remediation and is routinely approved by the IEPA when paired with source control. The performance of groundwater polishing as a groundwater corrective measure varies based on site-specific conditions and additional data collection may be needed to support the design and achieve regulatory approval. The sandy nature of the UA suggests good performance by physical processes in addressing the boron in the UA.

Naturally occurring geochemical processes are ongoing at the EAP and will continue to affect groundwater constituent concentrations during and after the EAP closure. Ongoing monitoring of groundwater conditions is needed to better understand the mechanisms and efficacy of the groundwater polishing process and to confirm the effectiveness over time. Thus, additional groundwater sample collection and analyses would be required to characterize potential mechanisms, as discussed above, and to provide long term monitoring of the remedial progress. Enhancements to the groundwater monitoring system may be required to ensure that groundwater polishing is occurring as predicted, consistent with the adaptive site management approach. The reliability of groundwater polishing as a groundwater corrective measure is high because operation and maintenance requirements are limited. However, the reliability can also vary based on site-specific hydrogeologic and geochemical conditions.

Following characterization and approval of the CAP, monitoring of the groundwater polishing processes and comparison to functional goals established to monitor progress toward the remedial objective could begin prior to, or concurrently with, site closure activities. Installing additional monitoring wells could begin as quickly as within a few months of CAP approval. The time required could be reduced if existing groundwater monitoring well systems could be utilized for monitoring.

No potential safety impacts or exposure to human health or environmental receptors are expected to result from the groundwater polishing processes. Timeframes to achieve GWPS are dependent on site-specific conditions, which require detailed technical analysis which are ongoing and will be evaluated in connection with the CAAA. Selecting groundwater polishing as a corrective measure for the EAP will require approval of the closure and CAP permits by the IEPA.

Monitoring the groundwater polishing to track progress toward achievement of the GWPS, in conjunction with source control at the EAP, would require long-term maintenance and monitoring of the groundwater monitoring system to confirm source control and verify the effectiveness in reducing groundwater concentrations to levels below the GWPS. System design could begin immediately after approval of the CAP permit. Additional investigations to characterize site conditions and installation of the final monitoring system could be performed concurrently with the source control (unit closure) activities.

Groundwater polishing processes will continue before and after source control implementation and may be a viable corrective measure for the boron exceedances at the EAP. Therefore, these processes are being advanced to the CAAA for further evaluation.

5.2.1 Source Control with Groundwater Extraction

Source control will reduce the mass loading to the groundwater system and implementing a groundwater extraction system may reduce the time required to attain the GWPS in the UA and reduce migration off-site. Groundwater extraction is a widely accepted corrective measure with a long track record of performance and reliability, especially when contaminants are migrating off-site. It is routinely approved by the IEPA. The PCRM to be constructed in 2024 to control off-site migration of boron could be used, or enhanced with additional extraction wells as needed, to maintain off-site migration and ultimately achieve the GWPS. The performance of a groundwater extraction system would be expected to be effective in the high permeability UA.

Implementation of a groundwater extraction system, or enhancement of the planned groundwater extraction system, if needed, is feasible and will provide control of boron migration in the UA. Extracted groundwater generated will be managed and discharged to the permitted outfall at the Settling Lagoon. Enhancements, if needed, to the 2024 extraction system (*i.e.,* additional wells to the south and increased total flow rate) may require modification to the existing NPDES permit. Specialized groundwater treatment equipment may be required, and ongoing operations and maintenance activities would be necessary.

There could be some impacts associated with constructing and operating a groundwater extraction system, including some limited exposure to extracted groundwater. A new groundwater extraction system, or enhancements to the planned extraction system could be implemented within approximately 1 to 2 years after approval of the CAP permit, including characterization, design, permitting, and construction. An extraction system would reduce the time to attain GWPS in the UA relative to the post-closure timeframe predicted by the groundwater modeling (approximately 14 to 24 years).

Implementing a groundwater extraction system at the EAP as part of the CAP would require IEPA approval of the CAP permit and discharge of extracted groundwater may require a modification to the NPDES permit.

Groundwater extraction could be viable corrective measure for the boron exceedances at the EAP. Therefore, groundwater extraction is being advanced to the CAAA for further evaluation.

5.2.2 Source Control with Groundwater Cutoff Wall

Source control will reduce the mass loading to the groundwater system and implementing additional groundwater corrective measures may reduce the time required to attain the GWPS in the UA. Groundwater cutoff walls are a widely accepted corrective measure used to control and/or isolate impacted groundwater and are routinely approved by the IEPA. Cutoff walls have a long history of reliable performance as hydraulic barriers, provided they are properly designed and constructed. However, if not coupled with a groundwater extraction system, a cutoff wall will provide directional groundwater control only and may result in redistribution of contaminants and potentially GWPS exceedances at new locations.

Cutoff walls are designed to act as hydraulic barriers; as a result, cutoff walls inherently alter the existing groundwater flow system. Changes to the existing groundwater flow system may need to be controlled to maximize the effectiveness of the remedy by, for example, combining a cutoff wall with groundwater extraction to control build-up of hydraulic head upgradient and around the cutoff walls. The effectiveness of a cutoff wall as a hydraulic barrier also relies on the contrast between the hydraulic conductivity of the aquifer and the cutoff wall. The most effective barriers have hydraulic conductivity values that are several orders of magnitude lower than the aquifer they are in contact with. A cutoff wall designed with hydraulic conductivity of 1×10^{-7} centimeters per second (cm/s) would be several orders of magnitude lower than the UA, thus would be expected to be an effective containment method in the UA.

Constructing a cutoff wall in the UA may be challenging due to the physical site constraints (presence of multiple high-voltage electrical transmission lines) and specialized construction contractor(s) may be required, due to the depth to the bottom of the UA, which could delay implementation.

Additional data collection and analyses would be required to design a cutoff wall. Construction could be completed within 3 to 4 years, including characterization, design, permitting and construction. Construction could possibly be accelerated by combining with site closure activities. To attain GWPS, cutoff walls require a separate groundwater corrective measure to operate in concert with the cutoff wall(s). Cutoff walls are commonly coupled with groundwater polishing and/or groundwater extraction as groundwater corrective measures. The time to attain GWPS is dependent on the selected groundwater corrective measure or measures that are coupled with the cutoff walls.

Constructing a cutoff wall at the EAP would require IEPA approval of the CAP permit and, depending on the location, an Illinois Department of Natural Resources (IDNR) land disturbance permit. An IDNR land disturbance permit and potential permitting requirements related to wetlands and threatened and endangered species may also be required for construction.

A cutoff wall alone would not be a viable corrective measure for the boron exceedances at the EAP. However, a cutoff wall may serve to increase the efficiency of a groundwater extraction system. Therefore, the cutoff wall is being advanced to the CAAA for further evaluation.

5.2.3 Source Control with In-Situ Chemical Treatment

Source control will reduce the mass loading to the groundwater system and implementing additional groundwater corrective measures, including the groundwater extraction system to be constructed in 2024, may reduce the time required to attain the GWPS in the UA. Use of in-situ treatment, either through targeted injection of reactive media or in PRB systems, to transform contaminants into environmentally acceptable forms to attain the GWPS was considered.

In-situ treatment using ion exchange (IX) to address boron exceedances in groundwater is not an established or widely accepted groundwater corrective measure; therefore, its performance and reliability are unknown. Regulatory acceptance of this innovative approach to achieving the GWPS is uncertain.

In-situ treatment presents design and construction challenges, including targeted reactive media delivery via injection to the lenses of finer grained material within the coarse-grained UA. Specialized contractors may be required due to the depth to the bottom of the UA and periodic change-outs of IX resin media may be required.

Additional data collection and analyses would be required to design an in-situ treatment system and bench scale and/or pilot scale testing may be required to demonstrate performance and reliability. Time of implementation is approximately 4 to 6 years after approval of the CAP permit, including characterization, design, permitting, and construction. Timeframes to achieve GWPS are dependent on demonstrations of performance and reliability along with regulatory acceptance. It is not known whether in-situ treatment would reduce the time to attain GWPS in the UA relative to the post-closure timeframe predicted by the groundwater modeling.

Due to the uncertain performance, reliability, and potential for not attaining regulatory acceptance, in-situ chemical treatment is not a viable corrective measure for the boron exceedances at the EAP and is not being advanced to the CAAA for further evaluation.

5.3 Technologies Advanced to CAAA

Based on the evaluations presented above, the following potential corrective technologies are being advanced to the CAAA, individually or in combination, for more detailed evaluations:

- Source control with groundwater polishing;
- Source control and with groundwater extraction; and
- Source control with a groundwater cutoff wall.

6. REFERENCES

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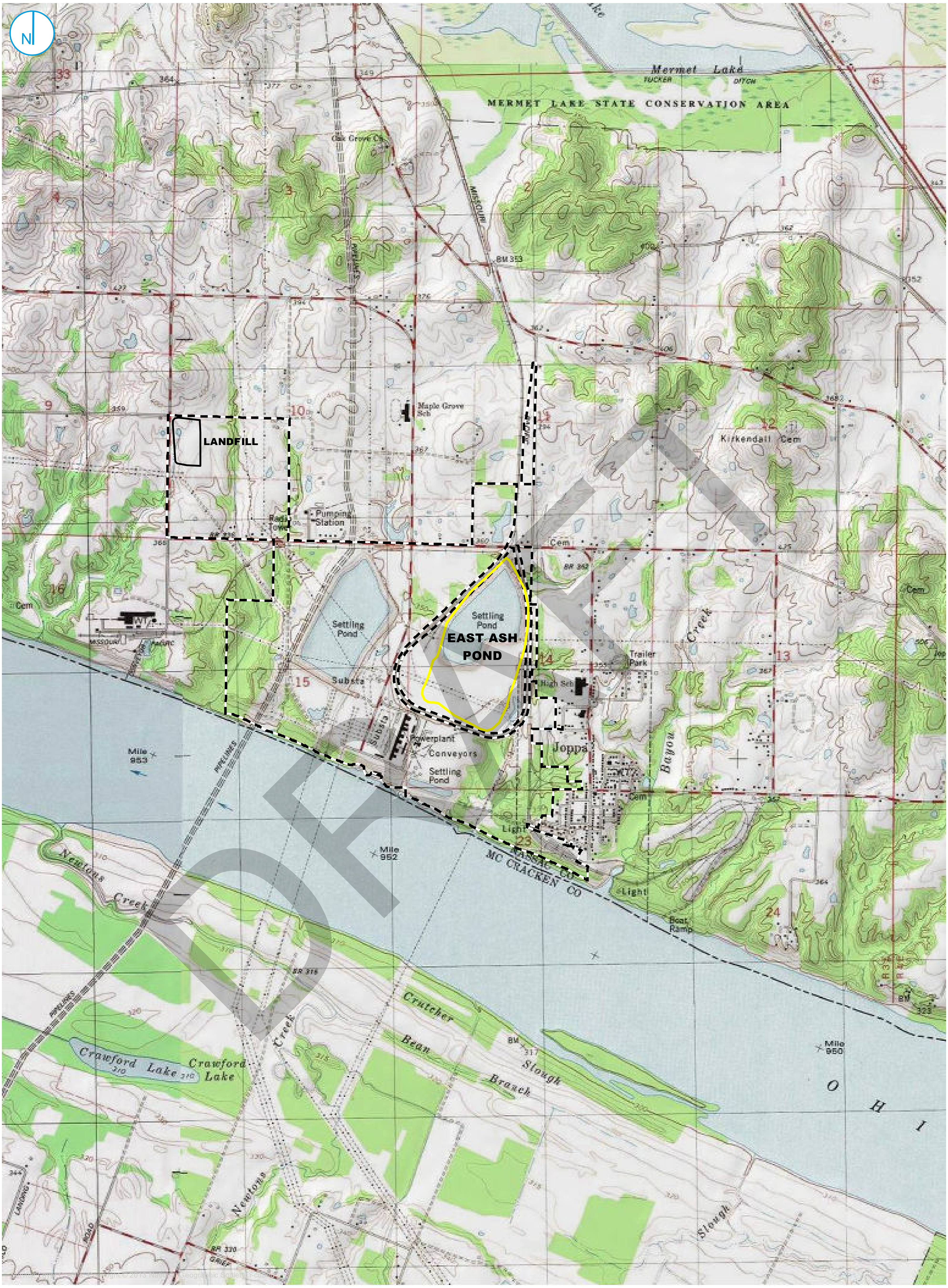
TABLES

TABLE 5-1
35 I.A.C. PART 845 CORRECTIVE MEASURES ASSESSMENT MATRIX
EAST ASH POND
JOPPA POWER PLANT
JOPPA , ILLINOIS
April 18, 2024

Remedy	**Evaluation Factors**						
	Performance	**Reliability**	**Ease of Implementation**	**Potential Impacts of Remedy (safety impacts, cross-media impacts, control of exposure to any residual contamination)**	**Time Required to Begin and Implement Remedy[1]**	**Time to Attain Groundwater Protection Standards**	**Institutional Requirements (state / local permit requirements, environmental / public health requirements that affect implementation of remedy)**
Source Control with Groundwater Polishing	Performs best paired with source control, which is to be completed within 5 years of IEPA construction permit approval. Site conditions are favorable for physical processes, while chemical processes are limited under normal aquifer conditions.	Ongoing analysis will evaluate whether the attenuation mechanism has low reversibility, the aquifer has sufficient capacity, and the hydrogeology is favorable for physical processes.	Groundwater polishing evaluation is underway and is expected to be completed in 2024. Long-term monitoring would be required. Implementing would not require extensive specialized equipment or contractors.	None identified.	90 days after CAP permit approval.	Less than the 24 years predicted by the groundwater model.	IEPA approval of the CAP permit is required. The Village of Joppa does not have any specific requirements, but a county may require a land use permit to prevent downgradient well installation until GWPS are met.
Source Control with Groundwater Extraction	A widely accepted and routinely approved technology, groundwater extraction would provide hydraulic control of the contaminant plume and prevent off-site migration. Could be used to supplement the planned preliminary corrective remedial measure (PCRM), consisting of a groundwater extraction system to control off-site migration. Additional pumping wells may be needed to address onsite migration.	Reliable if properly designed, constructed and maintained. Groundwater treatment prior to discharge can be considered if indicated by performance monitoring.	Specialized contractors would not be necessary for construction of the groundwater extraction system. The extraction system would require ongoing routine operation and maintenance activities and extracted groundwater would require management, possibly including treatment. Groundwater treatment, if needed, may require specialized equipment/contractors and higher maintenance costs.	Groundwater extracted as part of the PCRM will be discharged to the permitted outfall at the West Lagoon. Groundwater extraction alters the groundwater flow system and there is the some limited potential for contact exposure to extracted groundwater.	The PCRM groundwater extraction to begin in 2024. If necessary, a groundwater extraction system to address onsite migration could be designed, permitted and constructed in 1 to 2 years after CAP approval.	Less than the 24 years predicted by the groundwater model.	IEPA approval of the CAP is required. Groundwater extracted as part of the PCRM will be discharged under a NPDES permit, which is currently pending approval. A larger groundwater extraction system may require an NPDES permit modification.
Source Control with Groundwater Cutoff Wall	Widely accepted and routinely approved technology with good performance if properly designed and constructed. Depth to the bottom of the UA may result in design and construction challenges and high cost. If not combined with extraction wells, a cutoff wall will provide directional control only, thus redirecting flow to other areas where GWPS may be exceeded.	Reliable for groundwater flow directional control if properly designed and constructed.	Widely used, established technology. Depth to the bottom of the UA and UCU would likely require specialized construction equipment and delay implementation (compared to groundwater extraction only). The presence of multiple energized high-voltage electrical transmission lines traversing the East Ash Pond and may cause construction related challenges.	Alters groundwater flow system but does not provide any treatment. Can result in unintended consequences resulting form redirecting contaminants to areas where they are not currently present.	Design, permitting and construction would take 3 to 4 years after CAP approval.	Provides groundwater directional control only. Combination with another groundwater corrective measure, such as groundwater extraction or a permeable reactive barrier, would reduce time to achieve and maintain GWPS.	IEPA approval of the CAP permit is required. An IDNR land disturbance permit and potential permitting requirements related to wetlands, threatened and endangered species may also be required for construction.
Source Control with In-Situ Chemical Treatment	Groundwater treatment using a permeable reactive barrier and ion exchange (IX) is not well established for boron, therefore performance is unknown.	Unknown reliability for boron.	Depth to the bottom of the UA and UCU would likely require specialized construction equipment. High permeability gravel layer found in the middle section of the UA might allow construction of a relatively shallow barrier system targeting a specific area within the UA. Could require periodic change-outs of IX resin media.	None identified.	May require bench scale and/or pilot scale testing as part of design. Design, permitting and construction would take 4 to 6 years after CAP approval.	There is uncertainty regarding whether a permeable reactive barrier would reduce boron concentrations to achieve the GWPS. Dependent on conditions specific to the reactive media used and the site. Treatment technology not well understood.	IEPA approval of the CAP permit is required. IEPA approval of this innovative and relatively unproved solution may be challenging. An IDNR land disturbance permit and potential permitting requirements related to wetlands, threatened and endangered species may also be required for construction.

FIGURES



▭ REGULATED UNIT (SUBJECT UNIT)
▭ OTHER UNIT
⬚ PROPERTY BOUNDARY

0 1,000 2,000
Feet

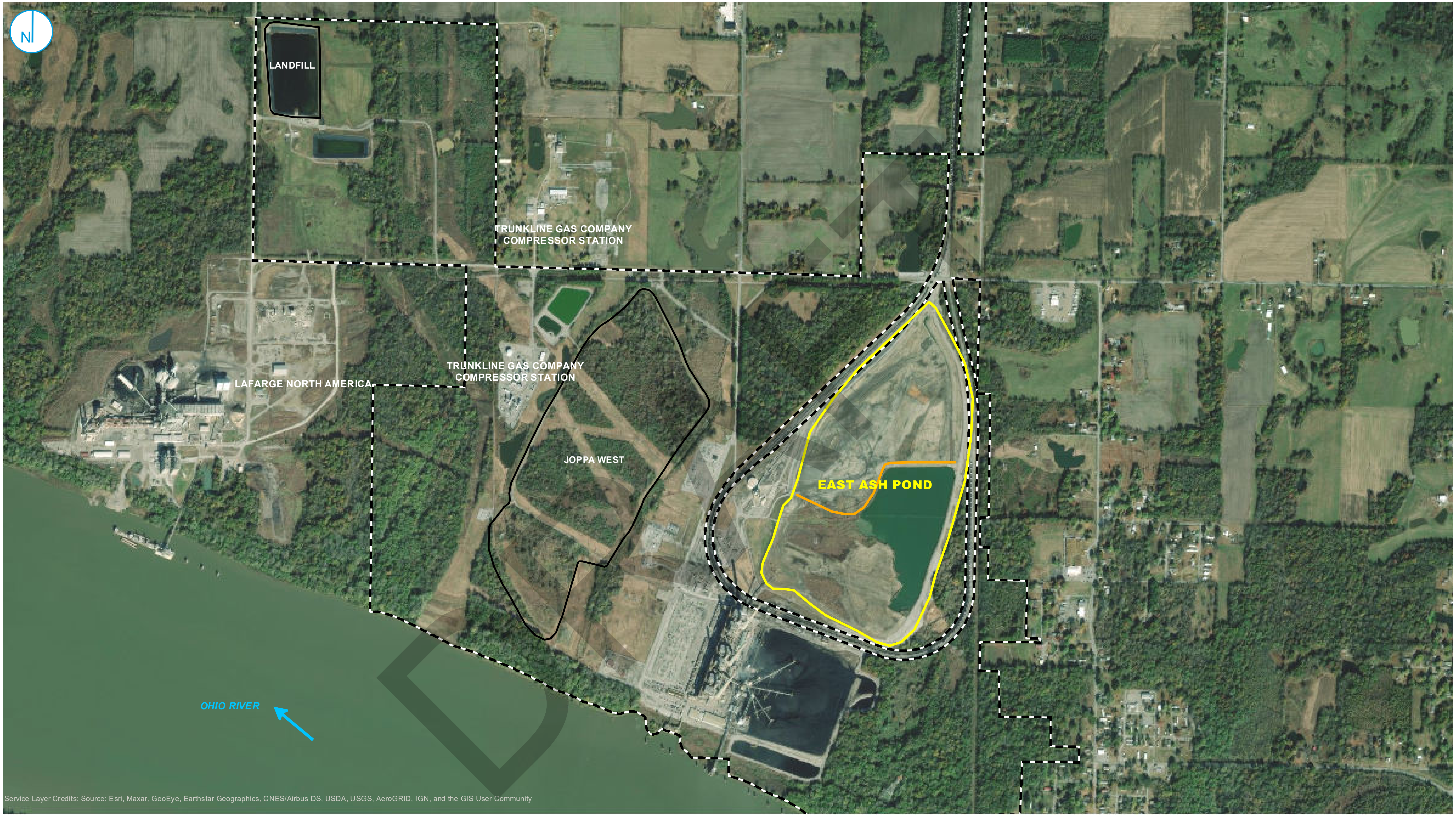
SITE LOCATION MAP

FIGURE 2-1

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\GMP\Figure 1-2_Site Map.mxd



PROJECT: 169000XXXX | DATED: 10/15/2021 | DESIGNER: HOTCALD

🟨	REGULATED UNIT (SUBJECT UNIT)
☐	OTHER UNIT
—	CENTRAL DIKE
⬚	PROPERTY BOUNDARY

0 375 750
Feet

SITE MAP

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

▨	COMPLIANCE MONITORING WELL
▨	BACKGROUND MONITORING WELL
▨	PORE WATER WELL
▨	MONITORING WELL
◒	STAFF GAGE, CCR UNIT
—	GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- -	INFERRED GROUNDWATER ELEVATION CONTOUR
→	GROUNDWATER FLOW DIRECTION
☐	REGULATED UNIT (SUBJECT UNIT)
☐	PROPERTY BOUNDARY

0 275 550 Feet

NOTES
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)
*GAGING DATA FROM USGS 03612600 OHIO RIVER AT OLMSTED, IL LOCATED APPROXIMATELY 12 MILES DOWNSTREAM OF JOPPA POWER PLANT.

MONITORING WELL LOCATION MAP
MAY 1, 2023

FIGURE 2-3

35 I.A.C. Ä845 CORRECTIVE MEASURES ASSESSMENT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 10/18/2021 | DESIGNER: STOLZSD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\GMP\Figure 2-1_Proposed Monitoring Well Network.mxd

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

▣ COMPLIANCE WELL
▣ BACKGROUND WELL
◓ STAFF GAUGE
▭ REGULATED UNIT (SUBJECT UNIT)
⬚ PROPERTY BOUNDARY

0 200 400 Feet

MONITORING WELL LOCATION MAP

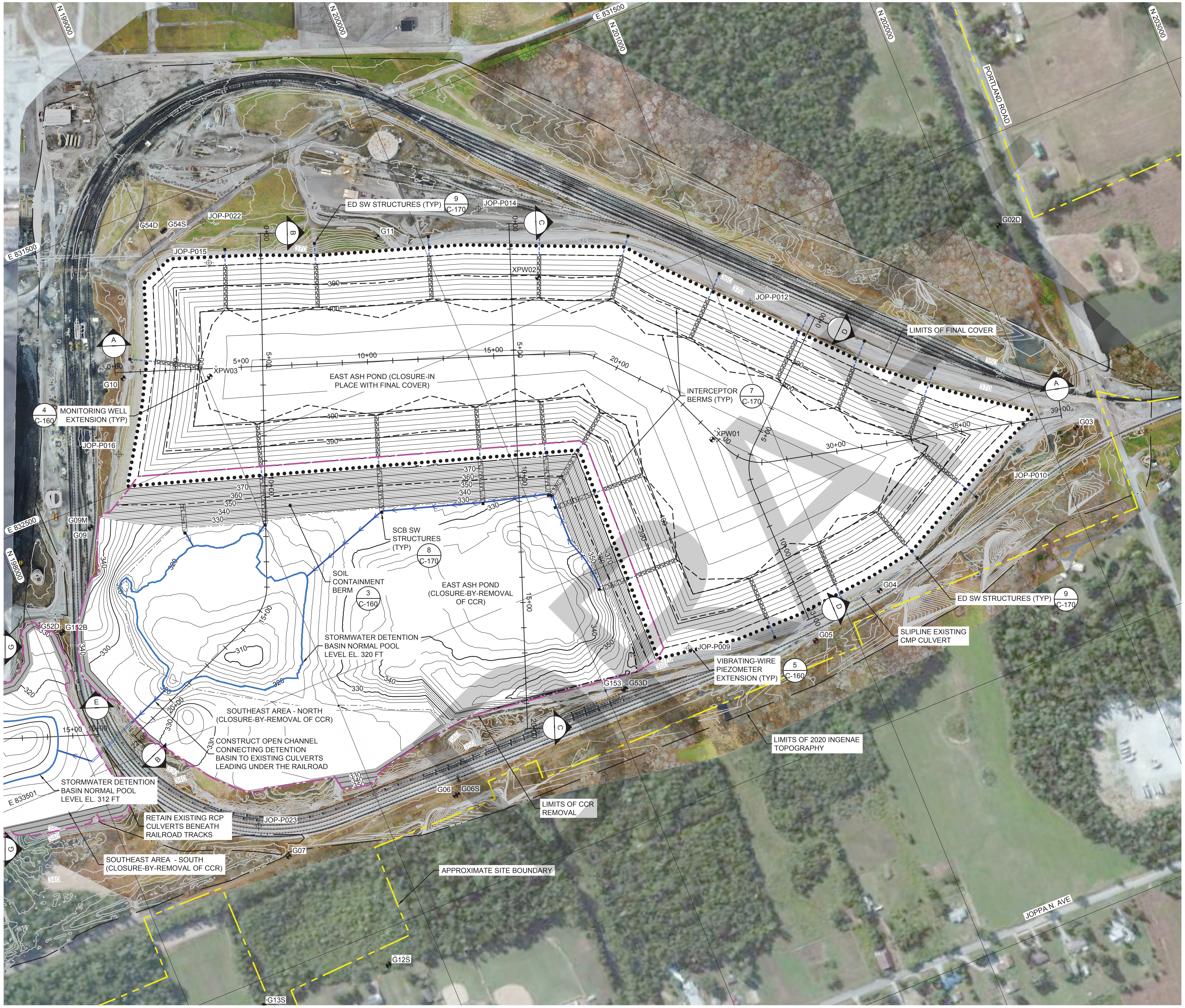
FIGURE 2-4

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

ATTACHMENTS

ATTACHMENT A
SELECTED CONSTRUCTION PERMIT APPLICATION PLANS



N

LEGEND

— 350 —	EXISTING GROUND SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
— 400 —	PROPOSED SURFACE ELEVATION (MAJOR) (2-FT INTERVAL)
— · — · —	LIMITS OF CCR REMOVAL
— — —	APPROXIMATE SITE BOUNDARY
— · · —	TOPOGRAPHIC SURVEY LIMITS
┼┼┼┼┼┼	RAILROAD
●●●●●●	LIMITS OF FINAL COVER
— — — —	INTERCEPTOR BERM
▨	ROCK CHUTE
======	EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
——> ——	STORMWATER CHANNEL
■	RIPRAP APRON
⊕	EXISTING MONITORING WELL
⊕	EXISTING PIEZOMETERS
— — — —	EXISTING BURIED CULVERT (LOCATION APPROXIMATE)

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING THE COORDINATE SYSTEM, SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS, AND THE LIMITS OF CCR OUTSIDE OF THE EAP.
2. EXISTING AND RELOCATED UTILITY ALIGNMENTS ARE NOTE SHOWN ON THIS SHEET. SEE SHEET G-110 AND G-130 FOR UTILITY INFORMATION.
3. THE EXISTING PERIMETER DIKES ARE TO BE REMOVED WITHIN THE EAST ASH POND (CLOSURE-BY-REMOVAL OF CCR) AREA.
4. GRADES SHOWN WITHIN THE CLOSURE-BY-REMOVAL AREAS CORRESPOND TO 1 FT BELOW THE PRESUMED BOTTOM-OF-CCR GRADES, AS TAKEN FROM THE "CCR INVESTIGATION AND DELINEATION REPORT, JOPPA POWER PLANT, EAST ASH POND", DATED JULY 2022, BY GEOSYNTEC CONSULTANTS. ACTUAL GRADES MAY VARY BASED ON OBSERVATIONS PERFORMED DURING CCR EXCAVATION.
5. STORMWATER CHANNEL ALIGNMENTS AND DETENTION BASINS OUTSIDE OF THE FINAL COVER SYSTEM ARE APPROXIMATE AND WILL BE REFINED AT A LATER PHASE OF DESIGN.

0 200 400
SCALE IN FEET

DRAFT - NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec
consultants

600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE:
FINAL GRADING PLAN - EAST ASH POND INSERT

PROJECT:
EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

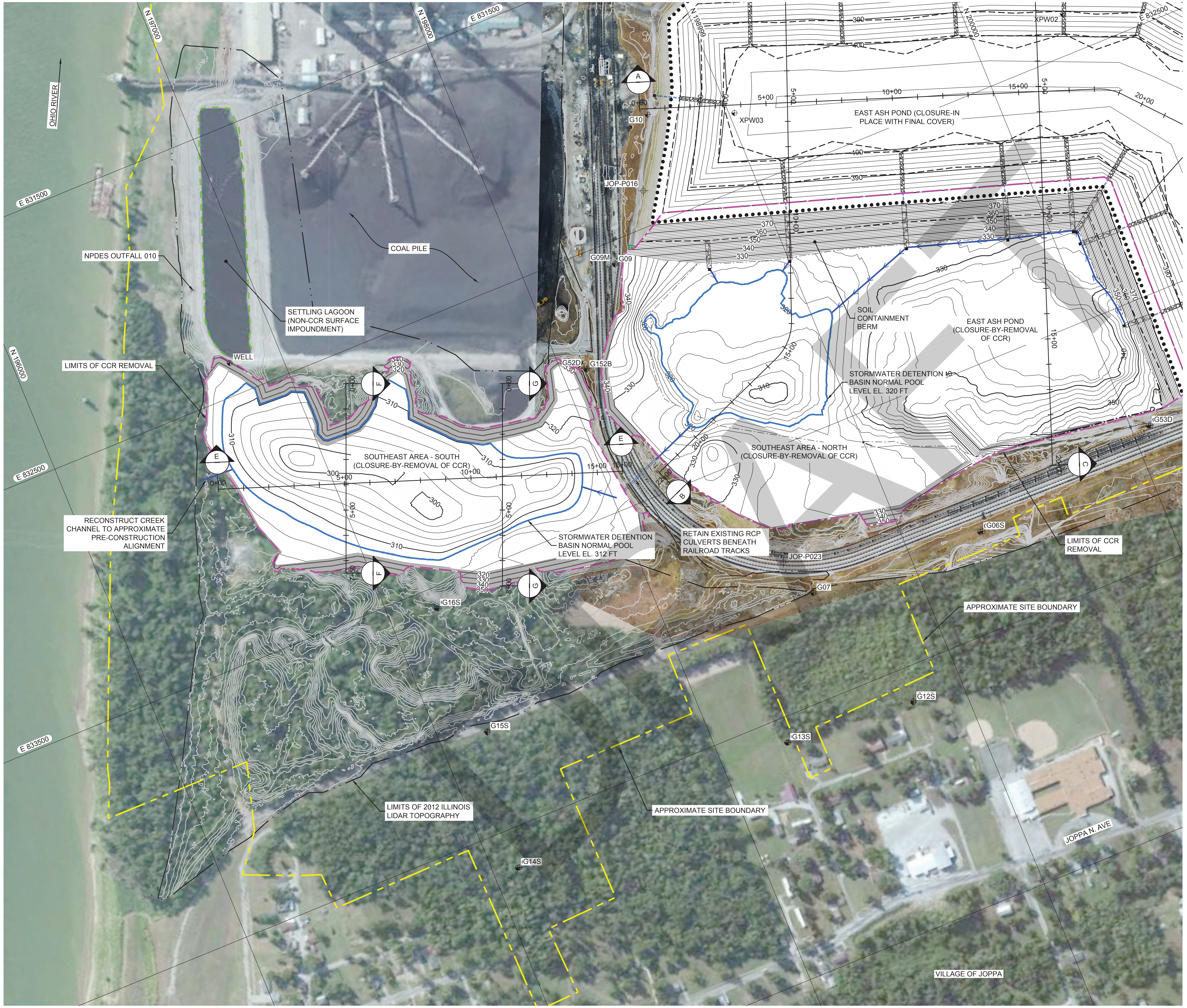
SITE:
JOPPA POWER PLANT
JOPPA, ILLINOIS

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

SIGNATURE

DATE

DESIGN BY:	LPC	DATE:	JULY 2022
DRAWN BY:	DW/SRN	PROJECT NO.:	GLP8025
CHECKED BY:	TWW	FILE:	GLP8025 C-120
REVIEWED BY:	JPS	DRAWING NO.:	C-120
APPROVED BY:	LPC		



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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
— — —	INTERCEPTOR BERM
▨	ROCK CHUTE
- - - -	CULVERT
→	STORMWATER CHANNEL
▪	PROPOSED RIPRAP APRON
●	EXISTING MONITORING WELL
⊕	EXISTING PIEZOMETERS
— — —	EXISTING BURIED CULVERT (LOCATIONS APPROXIMATE

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING THE COORDINATE SYSTEM, SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
2. EXISTING AND RELOCATED UTILITY ALIGNMENTS ARE NOT SHOWN ON THIS SHEET. SEE SHEET G-110 AND G-130 FOR UTILITY INFORMATION.
3. GRADES SHOWN WITHIN THE CLOSURE-BY-REMOVAL AREAS CORRESPOND TO 1 FT BELOW THE PRESUMED BOTTOM-OF-CCR GRADES. ACTUAL GRADES MAY VARY BASED ON OBSERVATIONS PERFORMED DURING CCR EXCAVATION.
4. STORMWATER CHANNEL ALIGNMENTS OUTSIDE OF THE FINAL COVER SYSTEM ARE APPROXIMATE AND WILL BE REFINED AT A LATER PHASE OF DESIGN.

0 200 400
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants
600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE:
FINAL GRADING PLAN - SOUTHEAST AREA INSERT

PROJECT:
EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

SITE:
JOPPA POWER PLANT
JOPPA, ILLINOIS

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DATE

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

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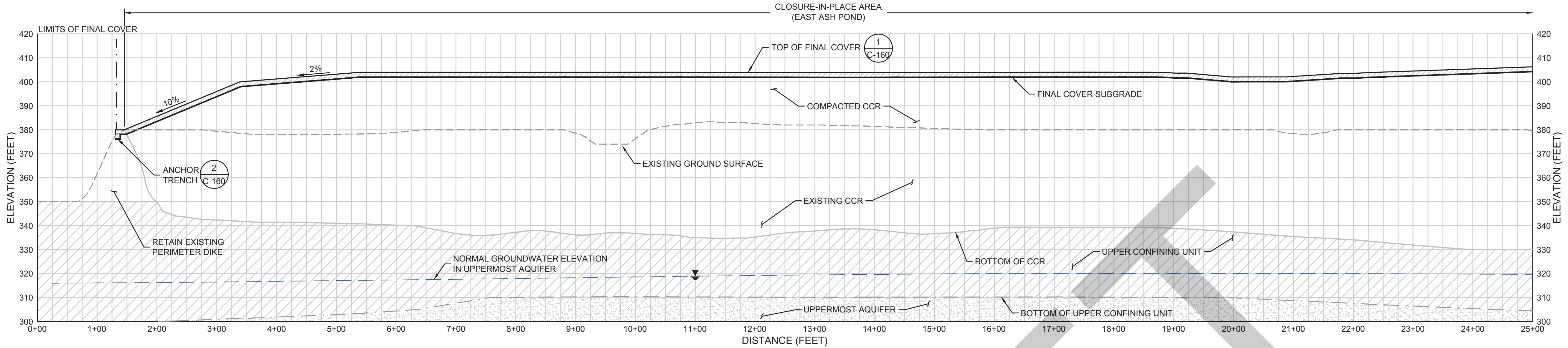
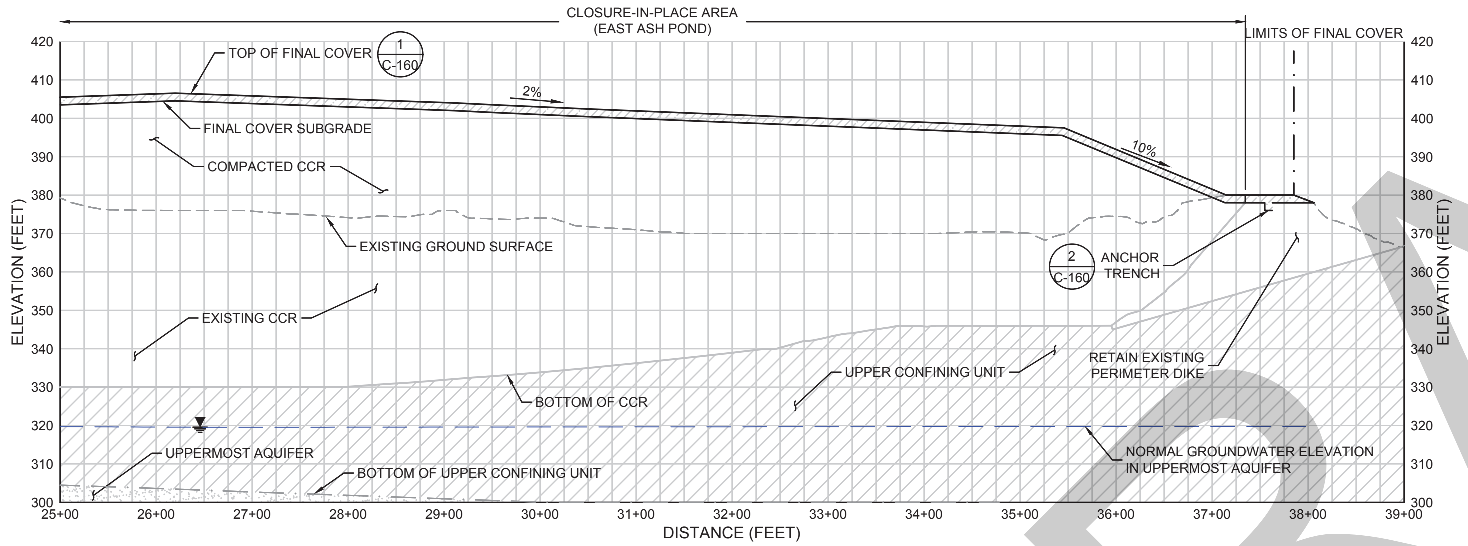


A SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'

NOTES:

1. SEE SHEET G-110 FOR NOTES REGARDING COORDINATE SYSTEMS AND SOURCES FOR EXISTING GROUND SURFACE ELEVATIONS.
2. THE BOTTOM AND LIMITS OF CCR INSIDE AND OUTSIDE OF THE EAP WAS TAKEN FROM THE "CCR INVESTIGATION AND DELINEATION REPORT, JOPPA POWER PLANT, EAST ASH POND", DATED JULY 2022, BY GEOSYNTEC CONSULTANTS.
3. THE INTERFACE BETWEEN THE UPPER CONFINING UNIT AND UPPERMOST AQUIFER AND THE NORMAL GROUNDWATER LEVEL WITHIN THE UPPERMOST AQUIFER WAS TAKEN FROM THE HYDROGEOLOGIC SITE CHARACTERIZATION REPORT, EAST ASH POND, JOPPA POWER PLANT, JOPPA ILLINOIS", RAMBOLL, OCTOBER 25, 2021. THE INTERFACE IS NOT SHOWN OUTSIDE OF THE HORIZONTAL LIMITS PROVIDED BY RAMBOLL.
4. THE NORMAL GROUNDWATER ELEVATION IN THE UPPERMOST AQUIFER WAS CALCULATED BY RAMBOLL USING DATA COLLECTED FROM 2015-2022. THIS NORMAL ELEVATION IS NOT EXPECTED TO CHANGE UNDER POST-CLOSURE CONDITIONS. THE GROUNDWATER ELEVATION IS NOT SHOWN OUTSIDE OF THE HORIZONTAL LIMITS PROVIDED BY RAMBOLL.
5. THE EXTENTS OF THE DEEP MIXING METHOD STABILITY IMPROVEMENT ZONE (DMM ZONE) WERE TAKEN FROM THE AECOM REPORT TITLED HISTORY OF CONSTRUCTION, USEPA FINAL CCR RULE, 40 CFR § 257.73(C), JOPPA POWER STATION, JOPPA, ILLINOIS". THE EXTENTS SHOULD BE CONSIDERED APPROXIMATE AND MAY VARY.
6. GRADES SHOWN WITHIN THE CLOSURE-BY-REMOVAL AREAS CORRESPOND TO 1 FT BELOW THE PRESUMED BOTTOM-OF-CCR GRADES. ACTUAL GRADES MAY VARY BASED ON OBSERVATIONS PERFORMED DURING CCR EXCAVATION.

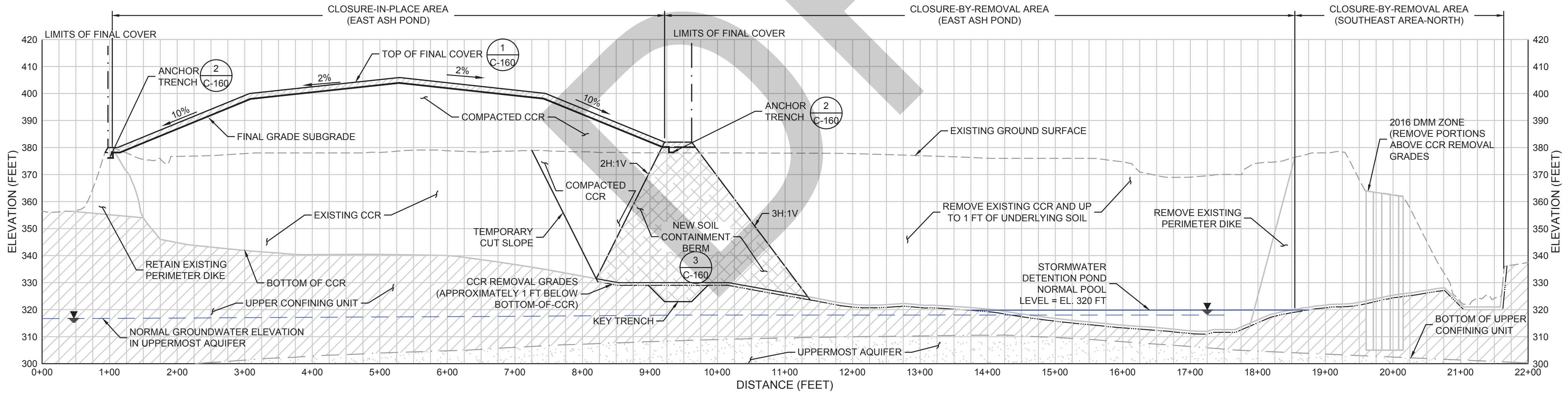


A SECTION
HORIZONTAL: 1" =100'
VERTICAL: 1" =25'

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
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VERTICAL: 1" =25'

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REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants

600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
TELEPHONE: 573-242-4530

ELECTRIC ENERGY INCORPORATED
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

TITLE:
SECTIONS - 1 OF 2

PROJECT:
EAST ASH POND CONSTRUCTION PERMIT APPLICATION
CLOSURE DRAWINGS

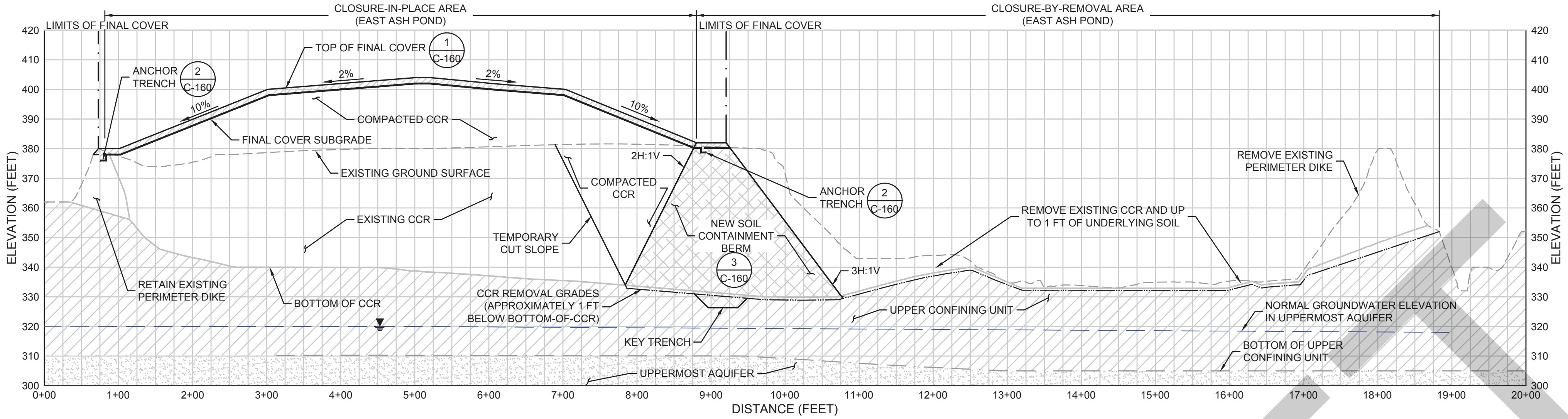
SITE:
JOPPA POWER PLANT
JOPPA, ILLINOIS

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

SIGNATURE

DATE

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



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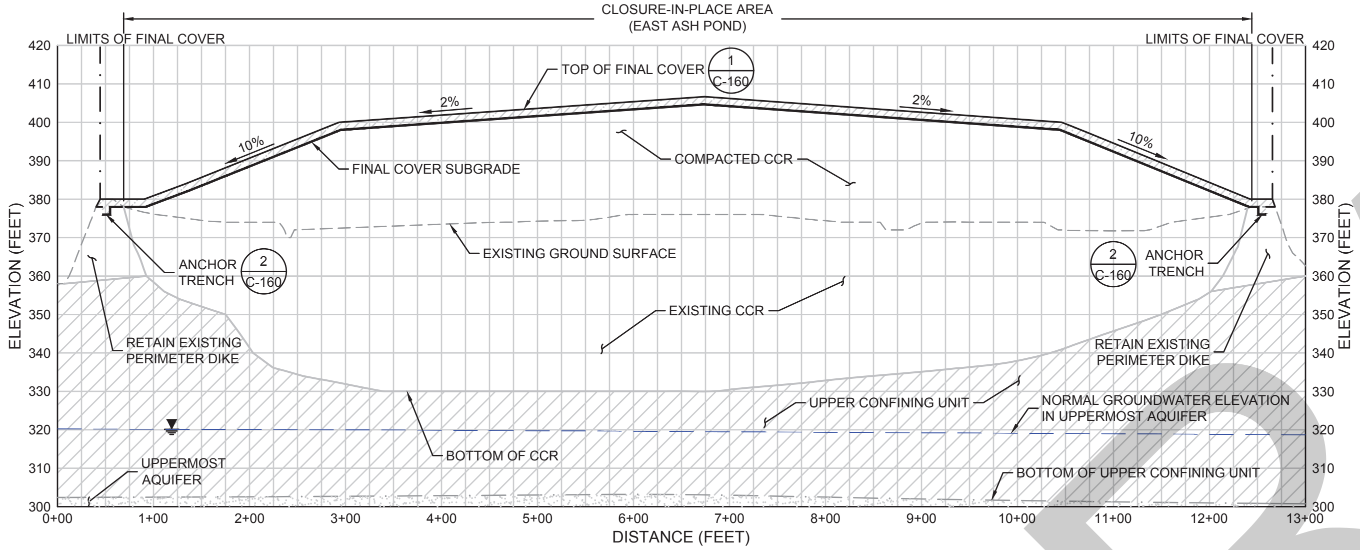
VERTICAL: 1" =25'



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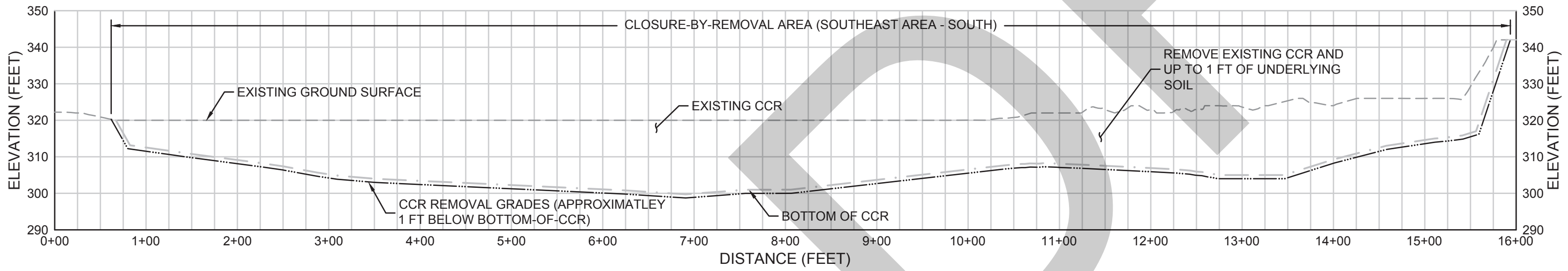
VERTICAL: 1" =25'



E SECTION
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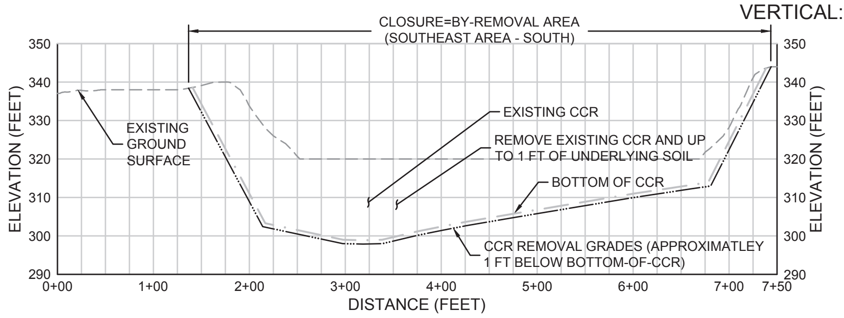
VERTICAL: 1" =25'



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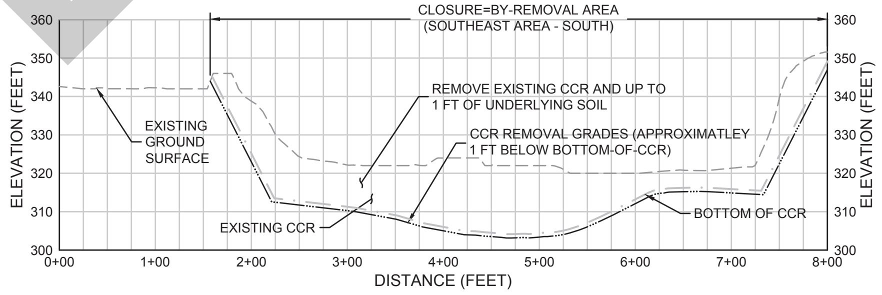
VERTICAL: 1" =25'



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.
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5. 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
— — —	NORMAL GROUNDWATER ELEVATION IN UPPERMOST AQUIFER
— · —	BOTTOM OF UPPER CONFINING UNIT
▨	PROTECTIVE COVER SOIL
▩	NEW SOIL CONTAINMENT BERM
▨	UPPER CONFINING UNIT
░	PERMOST AQUIFER

0 100 200
SCALE IN FEET

DRAFT - NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	DRN	APP
0	7/26/2022	CONSTRUCTION PERMIT APPLICATION SUBMITTAL	DW/SRN	LPC

Geosyntec consultants

600 ROSELANE COURT,
FARMINGTON, MO 63640 USA
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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:	JULY 2022
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Appendix D

Nature and Extent Report

Intended for
Electric Energy, Inc.
1500 Eastport Plaza Drive
Collinsville, IL 62234

Date
April 18, 2024

Project No.
1940103584-006

NATURE AND EXTENT REPORT

JOPPA POWER PLANT, EAST ASH POND, IEPA ID NO. W1270100004-02

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NATURE AND EXTENT REPORT
JOPPA POWER PLANT, EAST ASH POND, IEPA ID NO. W1270100004-02

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FIGURES (ATTACHED)

APPENDICES

ACRONYMS AND ABBREVIATIONS

35 I.A.C.	Title 35 of the Illinois Administrative Code
ASD	Alternative Source Demonstration
CCR	coal combustion residuals
cm/s	centimeters per second
CSM	conceptual site model
CWS	Community Water Supply
E001	Event 1
EAP	East Ash Pond
EEI	Electric Energy, Inc.
GCSM	geochemical conceptual site model
GWPS	groundwater protection standard
HCR	Hydrogeologic Site Characterization Report
HSU	hydrostratigraphic unit
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
JPP	Joppa Power Plant
LAU	lower aquifer unit
LCL	lower confidence limit
LCU	lower confining unit
mg/L	milligrams per liter
NAVD88	North American Vertical Datum 1988
SI	surface impoundment
UA	uppermost aquifer
UCU	upper confining unit
WAP	West Ash Pond

EXECUTIVE SUMMARY

Groundwater samples collected at the Joppa Power Plant (JPP) East Ash Pond (EAP) during May 2023 for the Quarter 2, 2023 compliance sampling event (Event 1 [E001]) were evaluated for exceedances of the groundwater protection standards (GWPS) described in Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845.600. Exceedances were identified in the following wells in the Uppermost Aquifer (UA):

- Boron at wells G06, G07, G08, G09, G10
- Cobalt at well G05
- pH at wells G11 and G51D

An alternative source demonstration (ASD) was completed for the cobalt exceedance at UA monitoring well G05 and pH exceedances at UA monitoring wells G11 and G51D. The Illinois Environmental Protection Agency (IEPA) did not concur with the ASD. The non-concurrence was appealed, and the Illinois Pollution Control Board (IPCB) granted a stay on February 1, 2024.

As required by 35 I.A.C. § 845.650(d)(1) this report characterizes the nature and extent of boron and relevant site conditions to determine how they may affect the corrective measures ultimately selected for the EAP and documents the additional measures taken in accordance with 35 I.A.C. § 845.650(d).

Boron was encountered above the GWPS within the UA at monitoring wells G06, G07, G08, G09, and G10. Additional shallow and deep (S/D) nested wells, installed to delineate the extent of elevated boron concentrations, identified additional locations with boron above the GWPS (G12S/D, G13S/D, G14S, G15D, G16S/D, G17D, G20S/D, and G21S/D). In the UA, the extent of boron above the GWPS is defined laterally by the additional wells installed in 2022 and the Ohio River, and vertically by the presence of low permeability clay and silt that form the lower confining unit, or deeper wells that do not have GWPS exceedances. The boron concentrations within the UA are attenuated physically through dilution and dispersion; and may be geochemically attenuated by sorption to iron oxides and clays. Boron concentrations in the Ohio River were evaluated and they do not present unacceptable risk [1].

1. INTRODUCTION

35 I.A.C. § 845.650(d)(1) requires the owner or operator of a coal combustion residuals (CCR) surface impoundment (SI) to characterize the nature and extent of a release and relevant site conditions that may affect the remedy ultimately selected for a CCR SI if any constituent regulated under 35 I.A.C. § 845 is found to exceed the GWPS. This report documents the nature and extent of constituents detected above the GWPS that are attributable to the JPP EAP.

The groundwater data and analysis in this report includes results from historical sampling (initiated in 2015) through the E001 sampling event, which was completed on May 3, 2023. Results of the E001 sampling event were submitted and placed in the facility's operating record by August 22, 2023 as required by 35 I.A.C. § 845.800(d)(15), within 60 days of receiving final laboratory analytical data [2]. The statistical determination presented in the report identified the following exceedances of the GWPS at compliance groundwater wells in the UA:

- Boron at wells G06, G07, G08, G09, G10
- Cobalt at well G05
- pH at wells G11 and G51D

An ASD, as allowed by 35 I.A.C. § 845.650(e), was completed for the cobalt exceedance at UA monitoring well G05 and pH exceedances at UA monitoring wells G11 and G51D. IEPA did not concur with the ASD in a letter dated November 16, 2023 due to the following data gaps:

1. Source characterization of the CCR at the EAP must include total solids sampling in accordance with SW846.
2. Characterization to include sample and analysis in accordance with 35 I.A.C. § 845.640 of an alternative source must be provided with the ASD.

On December 22, 2023, Electric Energy, Inc. (EEI) submitted a petition for review [3] of the non-concurrence with the cobalt and pH ASD and motion for stay to the IPCB. The IPCB granted a stay on February 1, 2024. Therefore, the nature and extent of cobalt and pH is not discussed in this document. This Nature and Extent Report discusses in detail the extent of the boron exceedances as well as a geochemical conceptual site model (GCSM) describing the nature of these exceedances.

2. BACKGROUND

2.1 Site Location and Description

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

2.2 Description of CCR SI

The JPP operated the EAP for management of CCR waste streams between 1973 and 2022. Another inactive SI, referred to as the West Ash Pond (WAP), is present in the western portion of the JPP property, and a permit exempt landfill is present in the northwestern portion of the JPP property. The landfill and the WAP are not the subject of this report.

The EAP is an unlined CCR SI which was used to manage both fly ash and bottom ash. The EAP perimeter embankment height varies from approximately 15 to 45 feet above the outboard toe of slope and the crest is at an approximate elevation of 380 feet[1] [4].

2.3 Geology and Hydrogeology

The information used to describe the hydrogeology is based on the local geology obtained from published sources, hydrogeologic investigation data, and boring data collected during site investigations conducted from 1997 to 2022 [5, 6, 7].

2.3.1 Hydrostratigraphic Units

In addition to CCR, four hydrostratigraphic units (HSUs) have been identified at the EAP based on stratigraphic relationships, geologic composition, and common hydrogeologic properties. The units, listed from surface downward, are summarized as follows:

- **CCR:** CCR consisting of fly ash and bottom ash. Water elevations measured in early March 2021 within the EAP indicate the phreatic surface is approximately 370 to 374 feet. A maximum thickness of saturated fill and CCR of approximately 42 feet was observed at location XPW01 in April 2021. The thickness of saturated fill and CCR in the EAP is generally consistent, ranging from 35 to 45 feet from March through August 2021, based on an estimated base of ash from 425 to 435 feet (**Figure 2-3**) and the measured phreatic surface.

  During delineation activities in 2021, CCR material mixed with sand, silt, and/or clay was identified at the surface southeast of the unit in a drainage feature (**Appendix A**). The CCR material ranged from approximately 1 to 20 feet thick and occurred at elevations as low as approximately 296 feet.

- **Upper Confining Unit (UCU):** This unit consists of approximately 25 to 50 feet of low permeability clay, silt, and silty clay from the Equality and Metropolis Formations and was observed in almost all borings at the site. In the southeast portion of the site near the

---

[1] All elevations in this report are referenced to North American Vertical Datum of 1988 (NAVD88) unless otherwise noted.

drainage feature (**Appendix A**) the UCU material was present but intermixed with CCR material from historical activities. The UCU is also thin (~25 feet) near G15S, and boring logs indicate potential fill, likely placed for the railroad line, extending to approximately 20 feet below ground surface in G15S and 39 feet in G14S. This area was historically utilized as a water reservoir for steam engines and the elevations of fill versus the top of the UA indicate surface water has the potential to preferentially infiltrate in these areas.

- **Uppermost Aquifer (UA):** This unit is composed of sandy gravel deposits of the Mounds Gravel and sand/silty sand deposits of the McNairy Formation, which are in hydrologic communication. The UA is laterally continuous across the JPP and its lithologies range in thickness from 21 to 51 feet for the Mounds Gravel, and 17 to 50 feet for the McNairy Formation [7].
- **Lower Confining Unit (LCU):** This unit overlies the shallow bedrock in the study area and has been interpreted as part of the Lower McNairy Formation, Post Creek Formation, or weathered limestone residuum. This interval has been encountered in all borings advanced to bedrock and is generally described as having high clay and/or silt content with partial cementation. The observed interval ranges in thickness from 14 feet at G09M to 28 feet at G20M [7].
- **Lower Aquifer Unit (LAU):** This unit is composed of the Salem Limestone (bedrock) and is used for potable and non-potable water supply in the vicinity of the site. Monitoring wells installed in the LAU include G09M, G13M, G20M, and G21M. Packer testing completed during installation of G13M and G20M indicated permeability in the limestone was variable [7]. The Community Water Supply (CWS) well for the Village of Joppa obtains water from this unit. The CWS was sampled twice during 2022, and no concentrations above the GWPS were reported [7, 8].

2.3.2 Uppermost Aquifer

The UA is comprised of the sand and gravel of the Mounds Gravel and McNairy Formation. The unit was encountered at its shallowest elevation (>315 feet) at B006 near well G06 located on the east/ southeast edge of the EAP. **Figure 2-4** shows the top elevation of the UA. Where present, the Mounds Gravel is generally loose, wet, well graded/poorly sorted, subrounded, and consists of clasts up to 2-inches, with larger clasts noted periodically. The thickness of the Mounds Gravel varied from 21 to 51 feet within the advanced borings. The Mounds Gravel is generally thought to have been deposited by braided rivers within paleotopographic lows eroded into the McNairy Formation [9]. It is considered the upper portion of the UA at the site and is in hydrologic communication with the McNairy Formation.

The McNairy Formation was observed to be from 17 to 50 feet thick at borings that encountered its entire interval. The sand of the McNairy is characterized by the presence of mica flakes and is commonly loose, wet, tan to brown, medium grain sand. In combination with the Mounds Gravel, it makes up the UA at the site. Within the UA, lenses of silt and clay several feet thick were encountered in borings completed downgradient (*i.e.,* G12D, G13D, G14D, G15D, G16D). The lenses of clay and silt within the Upper McNairy are encountered at isolated locations and not interpreted to be laterally continuous but may locally limit the downward migration of impacted groundwater (*e.g.,* G14D).

This HSU at the site ranges from approximately 50 to 85 feet thick and extends down to the clay and silt of the Lower McNairy or Post Creek Formation which overlies the Mississippian Aged Salem Limestone.

2.3.3 Potential Migration Pathways

Based on a review of the lithology underlying the EAP, potential impacts to groundwater migrate downwards through the unlithified UCU into the UA (Mounds Gravel and Upper McNairy Formation). Further downward migration is limited by the Lower McNairy Formation, which is the LCU. Below the LCU is the LAU which is comprised of the Salem Limestone. The LAU has been identified as a potential migration pathway.

2.3.4 Regional Bedrock Geology

The regional bedrock consists of a sequence of Mississippian System sedimentary rocks hundreds of feet thick and consolidated prior to the Cretaceous Period. The bedrock dips gently northward toward the center of the Illinois Basin. The uppermost bedrock near the JPP generally consists of limestone. The total thickness of the Mississippian System in southern Illinois is greater than 3,200 feet [10].

The uppermost bedrock unit encountered in the vicinity of the JPP is the Salem Limestone (**Appendix B**). The Salem Limestone is described as fine-grained, fossiliferous limestone, and is approximately 200 to 500 feet thick in the area. The Salem Limestone overlies the Ullin Limestone which is described as a light-colored fine- to coarse-grained limestone. The overall thickness of the Ullin Limestone near the JPP is approximately 200 feet. The Fort Payne Formation, which is overlain by the Ullin Limestone, is described as a very fine-grained, siliceous, cherty limestone, and is approximately 200 to 600 feet thick in the study area [10, 11, 12].

2.3.5 Water Table Elevation and Groundwater Flow Direction

The EAP is located upgradient of the Ohio River and the groundwater elevation measured in wells surrounding the EAP in 2023 ranged from 309.46 feet in G09 (located along the southern portion of the EAP) to 343.91 feet in G51D (located along the western portion of the EAP). Groundwater elevation contours generally illustrate flow from northwest to southeast (**Figure 2-5**), although in periods of high river stage groundwater flow is more easterly (**Figure 2-6**).

The elevations of water within the EAP (as observed in XPW01, XPW02, XPW03, and XSG01) are greater than the surrounding areas. The phreatic surface within the EAP in 2023 averaged 368.57 feet, ranging from 359.78 feet in XSG01 (eastern edge of EAP) to 373.04 feet in XPW02 (western edge of the EAP) (**Figure 2-5**).

The groundwater elevation in wells within the UCU (G101, G151, G153, and G54S) in 2023 averaged 328.88 feet, with a range from 315.84 feet in G153 (eastern edge of the EAP) to 347.77 feet in G54S (southwestern edge of EAP). Well G54S, located southwest of the EAP, consistently recorded the highest groundwater elevation, with an average groundwater elevation of 345.56 feet. The elevated groundwater here is assumed to be a result of well G54S screen being situated in low conductivity materials. Groundwater elevations at well G151 (along the western edge of the EAP) were also consistently higher than the remaining UCU wells, with an average groundwater elevation of 325.01 feet.

The groundwater elevation in wells within the UA (G01D, G02D, G03, G05, G06, G07, G08, G09, G10, G11, G51D, G52D, G53D and G54D) in 2023 averaged 316.90 feet, with a range from 309.46 feet in G09 (southern edge of EAP) to 324.55 feet in G01D (background well, northwest of EAP). Elevations measured in G52D do not appear to be consistent with other UA locations near the southeast corner of the EAP. The boring log from this location indicates more heterogenous geology, and as a result the well may have less hydraulic connection with the UA.

The groundwater elevation within the LAU wells (G09M, G13M, G20M, and G21M) in 2023 averaged 319.00 feet, with a range from 307.65 to 323.89 feet (**Table 2-1)**.

Groundwater elevations are primarily controlled by river stage of the Ohio River near the JPP. Seasonal variation of groundwater levels has been observed, and the river has been observed at elevations higher than groundwater. Flow reversals associated with flooding of the Ohio River have not been observed to extend northward beneath the EAP (**Figure 2-5** and **Figure 2-6**).

Groundwater elevations vary seasonally and may fluctuate by about 10 feet. Slight seasonal variation in groundwater flow directions ranging from southeast to southwest are also observed; however, the major component of groundwater flow direction is consistently south toward the Ohio River [13].

2.3.5.1 Vertical Hydraulic Gradients

Vertical hydraulic gradients calculated using available groundwater elevation data from early March to July 2021 at nested well locations within the UCU, the UA, and LAU were previously summarized in the Hydrogeologic Site Characterization Report (HCR) [6]. Recent data collected through 2023 including the additional wells installed in 2022 [7] were evaluated and the results of the vertical gradient calculations for these HSUs are summarized below (**Appendix C**):

- UCU to UA:
  - Gradients calculated between G151 (UCU)/G51D (UA) and G152B (UCU)/G52D (UA), were consistently downward.
  - Variable gradients were measured at UCU/UA well pairs G101/G01D, G153/G53D, and G54S/G54D. On average, gradients were downward at G101/G01D and G54S/G54D, while they were flat at G153/G53D.
- UA (within):
  - Gradients calculated at nested UA wells G06S and G06 were slightly downward.
  - Gradients calculated at nested UA wells G12, G13, G14, G15, G16, G17, G18, G23, and G24 were variable to flat.
  - Gradients at nested UA wells G19 and G22 were consistently downward in 2023.
  - Gradients at nested UA wells G21S/G21D, which is located nearest the river, were consistently upward.
- UA to LAU:
  - Gradients calculated between G09 (UA)/G09M (LAU) and G21D (UA)/G21M (LAU) were consistently upward. Consistent upward gradients indicate that the Ohio River is a regional discharge point for the bedrock aquifer system and the LCU is continuous in the vicinity of the JPP.

Overall gradients are consistently upward between the LAU and the UA, and within the UA downward gradients are generally observed closer to the EAP with a transition to upward gradients near the Ohio River.

2.3.5.2 Impact of Surface Water Bodies on Groundwater Flow

The river basin typically experiences annual floods during the months of March, April, May, and occasionally June, while smaller floods occur less frequently in autumn. There have been no monitoring events in 2023 with observations that indicate groundwater flow reverses direction (*i.e.,* groundwater flows from the Ohio River north into the UA) beneath the EAP.

2.3.6 Hydraulic Conductivities

2.3.6.1 Field Hydraulic Conductivities

Field hydraulic conductivity tests performed on the UA and LAU materials at the EAP were completed as part of the 2021 field investigation [6] and supplemented with additional values from field investigations in 2022 [7]. The results are summarized in **Table 2-2**, and discussed below:

- **CCR**: Results of field hydraulic tests in wells screened within the CCR (XPW02 and XPW03) ranged 4.5×10^{-3} to 1.7×10^{-1} centimeters per second (cm/s), with a geometric mean of 1.3×10^{-2} cm/s.
- **UCU**: No field hydraulic conductivity tests were performed within the UCU.
- **UA**: Field hydraulic conductivity tests indicated that the horizontal hydraulic conductivity for the Mounds Gravel and McNairy Formation sands and gravels at the site are variable, but very permeable with measured hydraulic conductivity ranging from 4.8×10^{-4} to 1.4×10^{-1} cm/s and a geometric mean of 9.6×10^{-3} cm/s (**Table 2-2**). This is higher than measurements of the UA calculated in 2017 [5], which resulted in a geometric mean conductivity of 3.4×10^{-4} cm/s. The high hydraulic conductivity values occur in the poorly graded gravels.
- **LCU**: No hydraulic conductivities are available for the LCU as no wells are screened within this unit.
- **LAU**: Hydraulic conductivity within the LAU was measured at wells G09M, G13M, and G20M and ranged from 6.8×10^{-5} to 9.06×10^{-4} cm/s, with a geometric mean of 3.4×10^{-4} cm/s [6, 7].

2.3.6.2 Laboratory Hydraulic Conductivities

Falling head permeability tests (ASTM D5084 Method F) were performed in the laboratory on samples collected during the 2021 and 2022 investigations [6, 7]. The results are summarized in **Table 2-3** and discussed below.

- **CCR**: Three samples were analyzed from CCR Fill unit borings at XPW01 and XPW03. Laboratory falling head permeability test results in the CCR Fill unit indicated a geometric mean vertical hydraulic conductivity of 1.0×10^{-6} cm/s.
- **UCU**: Four UCU samples were analyzed from borings G03, G09M, and G11. Laboratory falling head permeability results in the UCU indicated a geometric mean vertical hydraulic conductivity of 1.7×10^{-7} cm/s.

- **UA**: No UA samples were analyzed.
- **LCU**: Four LCU samples were analyzed from borings G13M and G21M (**Appendix D**). Laboratory falling head permeability results in the LCU indicated a geometric mean vertical hydraulic conductivity of 3.8 x 10^{-8} cm/s.
- **LAU**: No LAU samples were analyzed.

2.4 Groundwater Monitoring

The monitoring system for the EAP is shown on **Figure 2-7** and consists of two background monitoring wells (G01D and G02D), 12 compliance monitoring wells (G03, G05, G06, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D), and two temporary water level only surface water staff gages (XSG01 and SG02[2]) to monitor potential impacts from the EAP [14]. The following monitoring wells are screened within the UA (G01D, G02D, G03, G05, G06, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D) along the perimeter of the EAP. Porewater samples are collected from locations XPW01 and XPW02 on the northern side of the EAP and from XPW03 on the southern side of the EAP (**Figure 2-7**).

2.5 Hydrogeologic Conceptual Site Model

The HCR [6] and information provided above forms the foundation of the EAP hydrogeological setting. In general, groundwater is recharged from surficial precipitation and from upgradient areas, flowing from northwest to southeast within the UA and LAU (bedrock) towards the regional discharge area of the Ohio River. Groundwater flow is predominantly vertical in the confining units (*i.e.,* UCU and LCU). Groundwater flow in the UA is south towards the river, with an easterly flow component along the east portion of the pond towards the eastern property boundary. Vertical gradients between the bedrock and the UA and within the UA are upward near the Ohio River.

Review of groundwater elevations from site monitoring wells screened within the UA indicates some variability in groundwater elevations over time. The degree of variability in the groundwater elevation record at each well is not consistent and varies by location. Evaluation of recent data collected between 2021 and 2023 suggested that the source for variation of groundwater elevations in the UA may be changes in river stage.

Generally, evaluation of synoptic (*i.e.*, site-wide) groundwater elevations within the UA indicates that the direction of groundwater flow near the EAP is towards the river from upgradient areas, with some easterly component of flow direction noted near the eastern boundary of the EAP and the site. This is evident in **Figure 2-5**, which presents groundwater elevations measured in the UA on May 1, 2023.

The geologic conceptual model for the site used for the groundwater modeling [15] consists of the following layers:

- Ash Material (CCR) – fly ash and bottom ash with a saturated thickness that varies upon the base elevation (ranges from approximately 310 to 350 feet) of the ash material from 0 to 45 feet. This includes both CCR within the EAP boundary and portions of the JPP property where CCR/ soil mixtures have been identified during investigation activities.

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[2] Staff gage SG02 was decommissioned. A new staff gage (SG03) was installed in January 2023.

- Silt and clay (UCU) – laterally continuous fine-grained clays, silts, and silty clays of the Equality Formation, Silt Unit, and Metropolis Formation, underlying the CCR fill at the EAP.
- Sand and gravel (UA) – permeable sands and gravels of the Mounds Gravel and McNairy Formation.
- Silt/Clay, weathered limestone residuum (LCU) – clay and silt of the Lower McNairy Formation or Post Creek Formation that form a continuous lower confining unit.
- Limestone Bedrock (LAU) – lowermost unit identified at the site and underlies all unlithified deposits. This unit is comprised of the Salem Limestone.

Porewater from the EAP can migrate downward through the UCU and mix with groundwater from upgradient of the EAP. Groundwater migrates towards the Ohio River primarily within the high permeability portions of the UA, which generally correspond to intervals where the Mounds Gravel is present. Monitoring wells screened near the top of the UA and/or in fine-grained portions of the UA have lower boron concentrations (*i.e.,* G06, G15S, G17S, etc.). Downward vertical migration of groundwater is limited locally by silt/clay lenses within the UA (*e.g.,* G14D), and regionally by the silt and clay of the LCU which has been observed in all borings advanced near the EAP.

3. OCCURRENCE AND DISTRIBUTION OF GROUNDWATER EXCEEDANCES (EXTENT)

Results from groundwater samples collected from the EAP during E001 were received on June 23, 2003. In accordance with 35 I.A.C. § 845.610(b)(3)(C), comparison of statistically derived values with the GWPSs described in 35 I.A.C. § 845.600 to determine exceedances of the GWPS was completed [2]. Exceedances for which an ASD was not completed include the following parameters and wells in the UA:

- Boron at G06, G07, G08, G09, and G10

Exceedances for which an ASD was completed include the following parameters and wells in the UA:

- Cobalt at G05
- pH at G11 and G51D

As described in **Section 1**, an ASD was completed for the cobalt and pH exceedances. The IEPA did not concur with the ASD in a letter dated November 16, 2023. On December 22, 2023, EEI submitted a petition for review [3] of the non-concurrence with the ASD and motion for stay to the IPCB. The IPCB granted a stay on February 1, 2024. Therefore, the nature and extent of cobalt and pH is not discussed in this document.

3.1 Additional Investigation to Define Nature and Extent

Following initial sampling in 2021, potential exceedances of the GWPS were identified for the parameters and locations identified above [16]. Additional investigation was completed between 2021 and 2023 to further delineate the extent of boron in groundwater and investigate hydrogeologic conditions downgradient (south and east) of the EAP.

Three borings were advanced and solids samples were collected from the uppermost aquifer in three locations (G03, G07, and G08) during October 2021 to supplement previous samples collected in January 2021. The three solid samples were submitted for the following analyses:

- 7-step sequential extraction via EPA 6010B (arsenic, boron, cobalt, lithium, and molybdenum);
- Total Metals via EPA 6010B (§ 845.600 parameters plus silver, aluminum, bismuth, copper, iron, potassium, magnesium, manganese, sodium, nickel, phosphorus, sulfur, tin, strontium, titanium, uranium, vanadium, yttrium, and zinc);
- Bulk Mineralogy by Reitveld x-ray diffraction analysis;
- Total Organic Carbon Analysis; and,
- Loss on ignition.

A total of 31 monitoring wells were installed southeast of the EAP in two phases to further delineate the extent of boron concentrations above the GWPS. Ten wells were installed in the UA in September 2021 (G12S, G12D, G13S, G13D, G14S, G14D, G15S, G15D, G16S, and G16D). Based on three rounds of groundwater sampling conducted during the first quarter of 2022, additional data collection was needed [8]. A total of 21 additional monitoring wells were installed between March and September 2022, including three wells in the LAU (G13M, G20M, and G21M), 16 wells in the UA (G17S, G17D, G18S, G18D, G19S, G19D, G20S, G20D, G21S, G21D, G22S, G22D, G23S, G23D, G24S, and G24D), and two wells in the UCU (G13 and G20). Monitoring well construction details are summarized in **Table 3-1**. Data from this investigation were reported in the Geosyntec's Supplemental Site Investigation Report [7] and incorporated into this document.

3.2 Extent in the Uppermost Aquifer

Groundwater samples are evaluated quarterly and exceedances are identified following comparison of lower confidence limits (LCLs) to the GWPSs described in 35 I.A.C. § 845.600. The LCLs vary as the dataset is updated to include additional quarterly events (**Table 3-2**). The discussion below includes ranges of concentrations measured in wells with exceedances, because there is no single value for LCLs.

3.2.1 Boron

Boron exceedances in the UA are present south of the EAP at monitoring wells G09 and G10, and east of the EAP at monitoring wells G06, G07, and G08. Boron concentrations above the GWPS were also reported in monitoring wells installed for delineation (G12S/D, G13S/D, G14S, G15D, G16S/D, G17S/D, G20S/D, and G21S/D; **Table 3-3**). Concentrations of boron in monitoring wells south of the EAP (G09 and G10) range from 2.35 to 4.57 milligrams per liter (mg/L) and are defined laterally in the UA to the west by monitoring well G54D, to the east by G52D, and to the south by Well 2 and Well 3 where concentrations range from non-detect in G52D to 1.8 mg/L in Well 2 (**Figure 3-1**).

Boron concentrations in UA monitoring wells east of the EAP (G06, G07, G08, G12S/D, G13S/D G14S, G15D, G16S/D, G17S/D, G20S/D, and G21S/D) range from 2.16 mg/L in G20S to 10.6 mg/L in G16S, which is located immediately downgradient of the mixed CCR/soil material outside of the unit southeast of the site (**Appendix B**). Laterally, these exceedances are defined by the monitoring well nests installed to the east in 2022 including G18, G19, G22, G23, and G24. Concentrations of boron in groundwater collected from these monitoring wells ranged from non-detect in G24D to 2.26 mg/L in G18S.

Downward migration of boron in the UA is inhibited by the underlying LCU which has a thickness of greater than 10 feet. Vertical permeability tests completed on samples of the LCU beneath the UA indicate a geometric mean vertical hydraulic conductivity of 3.8×10^{-8} cm/s with a range from 1.9×10^{-8} to 8.3×10^{-8} cm/s. This is very low relative to the horizontal hydraulic conductivity measured within the UA (geomean 3×10^{-3} cm/s). The significant contrast in permeability (greater than two orders of magnitude) and upward gradients observed between the LAU and UA indicate groundwater will preferentially migrate horizontally in the UA and the elevated boron concentrations will not extend into the underlying LCU and LAU as evidenced by the results of groundwater samples collected from LAU wells (G09M, 13M, G20M, and G21M; [6, 7]) that have all been below the GWPS of 2 mg/L with the highest measured boron concentrations all below 0.05 mg/L.

4. GEOCHEMICAL CONCEPTUAL SITE MODEL (NATURE)

A GCSM was developed to describe the conditions of the groundwater in the vicinity of the JPP EAP and is summarized here (full analysis presented in **Appendix E**). The GCSM describes the geochemical processes that contribute to the mobilization, distribution, and attenuation of chemicals in the environment. This report describes the GCSM for parameters that have exceeded the GWPS in EAP groundwater and which will be addressed in the Corrective Action Plan. Boron is the only constituent with exceedances observed at the EAP. Boron exceedances are present in one HSU at the site: the UA, comprised of high permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation .

The primary source of boron to groundwater of the UA within the monitoring network is the EAP coal combustion residual porewater present within the unit and at the surface outside of the unit east and southeast of the site, based on boron concentrations within the source and relationships to hydrogeological patterns at the site. Boron was not identified within UA solids at concentrations that would suggest that aquifer solids could provide an additional potential natural geogenic source of boron to groundwater.

Boron in the groundwater system may be attenuated via adsorption and surface complexation reactions within portions of the UA, with conditions within groundwater from the UA typically predicted to favor amorphous iron oxide stability at most locations, and the presence of iron oxides in some site solids supporting the occurrence of this mechanism. Limited variability in pH or redox conditions is observed between upgradient background and downgradient locations. The presence of clay minerals (*e.g.,* kaolinite) in the UA solids material indicates that adsorption to clays may be another potential attenuation mechanism for boron at locations near the EAP.

5. COMBINED GEOCHEMICAL AND HYDROGEOLOGIC CONCEPTUAL SITE MODELS

5.1 Boron Conceptual Site Model

The conceptual site model (CSM) describing current conditions at the EAP combining the hydrogeologic and geochemical CSMs for boron is as follows. Surface water including historical sluice water and recharge within the EAP comes into contact with CCR, enters the pore spaces within the CCR material, and becomes porewater within the unlined CCR unit. Porewater containing elevated concentrations of boron can migrate into the UA, predominantly in the south/southeast portion of the EAP where there is less separation between the base of ash and the top of the UA.

Groundwater within the UA flows primarily to the south/southeast with occasional periods when flow is more easterly, and ultimately migrating toward the Ohio River. The lateral extent of boron concentrations above the GWPS has been defined following the installation of additional monitoring well nests G18, G19, G22, G23, and G24. The boron extent downgradient is defined by the additional groundwater monitoring wells as well as the Ohio River, which is downgradient of the EAP. Along the flow path boron concentrations are attenuated physically through dilution and dispersion and may be geochemically attenuated by sorption to iron oxides or clay minerals. Overall boron concentrations near the EAP decline from approximately 6 to 8 mg/L in G12S and G12D, to approximately 3 to 5 mg/L in G21S and G21D. Boron concentrations in the Ohio River were evaluated and they do not present unacceptable risk [1]. The presence or absence of exceedances within an individual well can be attributed to flow directions and attenuation along the length of the flow path from the EAP downgradient.

The vertical migration of boron within the UA is limited in areas by low conductivity clay and silt lenses (*i.e.,* G14D), and ultimately by the continuous clay and silt of the Lower McNairy Formation, Post Creek Formation, or weathered limestone residuum which is the lower confining unit across the JPP. Upward vertical gradients measured between the LAU and UA and the lack of elevated boron concentrations in LAU wells support that there is no downward migration of boron concentrations below the UA.

6. CONCLUSIONS AND FUTURE ACTIVITIES

In accordance with 35 I.A.C. § 845.650(d)(1), the nature and extent of GWPS exceedances of boron have been described in sufficient detail to support a complete and accurate assessment of the corrective measures necessary to effectively clean up all releases from the EAP.

The lateral extents of exceedances are illustrated in **Figure 3-1**. As discussed in **Section 3.2.1**, the horizontal delineation of boron has been defined by monitoring wells installed and sampled in 2022 and 2023. Results from sampling of the Village of Joppa CWS during 2022 indicate the CWS is not impacted.

A groundwater extraction system that will eliminate the migration of groundwater from the EAP until groundwater at monitoring locations downgradient reaches the GWPS is currently being designed and implementation of that system will occur following completion of construction activities and pilot testing. Following initiation of the extraction system, a Groundwater Monitoring Plan will be prepared and submitted with the Corrective Action Plan application to the IEPA to identify locations and parameters to monitor system effectiveness and assess groundwater conditions during operation of the system.

7. REFERENCES

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TABLES

Table 2-1. Summary of Groundwater Elevation Data
Nature and Extent Report
Joppa Power Plant
East Ash Pond
Joppa, Illinois

DATE LOCATION	1/18/2023	1/23/2023 & 1/24/2023	2/14/2023	3/7/2023	3/10/2023	4/1/2023	5/1/2023	5/22/2023	6/10/2023	7/10/2023 & 7/11/2023	8/25/2023	9/25/2023	10/23/2023	11/07/2023 & 11/08/2023	12/12/2023
G01D	319.83	320.08	321.20	322.96	--	324.55	323.66	--	320.98	319.85	320.64	319.81	319.31	319.74	318.77
G02D	--	319.21	--	322.08	--	--	322.71	--	--	319.72	--	319.19	318.55	318.91	318.04
G03	--	--	--	321.46	--	322.65	322.06	--	320.35	319.06	319.45	318.47	317.89	318.23	317.31
G04	--	--	--	--	--	--	--	--	--	--	--	--	--	317.12	--
G05	--	--	--	320.16	--	321.97	320.36	--	--	317.83	--	316.90	316.29	316.49	315.69
G06	--	--	--	318.64	--	--	317.29	--	--	314.35	--	314.14	313.31	313.52	312.81
G06S	--	--	--	--	--	--	--	--	--	--	--	--	--	313.60	--
G07	--	--	--	317.29	--	318.35	315.44	--	313.54	312.55	312.66	312.01	311.53	311.70	311.07
G08	--	--	--	317.72	--	318.62	313.92	--	--	311.32	--	310.85	310.39	310.58	310.05
G09	311.31	--	311.88	318.86	--	319.04	312.64	--	311.29	310.60	310.79	310.22	309.78	309.98	309.46
G09M	319.05	--	320.13	323.89	--	--	320.73	--	--	318.83	--	318.55	318.17	318.35	--
G10	312.79	--	315.34	319.71	--	320.32	314.25	--	312.95	312.09	312.55	311.69	311.19	311.45	310.87
G11	318.60	--	319.75	322.29	--	323.46	321.45	--	318.38	317.75	318.34	317.86	317.25	317.55	316.75
G12D	--	313.04	--	317.58	--	--	315.15	--	313.74	312.84	312.82	312.17	311.84	311.94	--
G12S	--	313.05	--	318.04	--	--	315.37	--	313.79	312.84	312.81	312.24	311.83	311.94	--
G13	--	--	--	--	--	--	341.78	--	--	--	--	--	--	323.58	--
G13M	--	308.65	--	--	--	--	320.33	--	--	318.21	--	317.63	317.46	317.58	--
G13S	--	--	--	317.42	--	318.30	314.87	--	313.38	312.50	311.75	311.94	311.35	310.85	--
G14D	--	312.23	--	--	319.25	321.47	315.27	--	--	310.66	--	310.05	309.83	309.92	--
G14S	--	308.46	--	--	317.92	324.74	315.48	--	--	305.97	--	305.60	305.25	305.36	--
G15D	--	308.40	--	317.44	--	316.24	307.04	--	306.37	305.73	305.96	305.57	305.10	305.23	--
G15S	--	308.55	--	317.56	--	316.82	307.74	--	306.58	306.08	306.39	305.56	305.34	305.47	--
G16D	--	309.82	--	318.50	--	--	308.41	--	307.64	307.09	307.15	306.77	306.39	306.50	--
G16S	--	309.75	--	318.41	--	--	303.49	--	307.60	307.12	--	306.74	306.43	306.56	--
G17D	--	312.22	--	--	--	--	--	314.84	--	312.98	--	312.45	311.94	312.17	--
G17S	--	312.37	--	--	--	--	--	314.76	--	312.95	--	312.36	311.84	312.05	--
G18D	--	314.71	--	--	--	--	--	316.97	--	316.23	--	314.53	314.14	314.37	--
G18S	--	314.58	--	--	--	--	317.96	--	318.21	308.01	--	314.63	314.01	314.36	--
G19D	--	309.16	--	--	--	--	311.46	--	--	309.29	--	308.79	308.33	308.53	--
G19S	--	309.40	--	--	--	--	311.56	--	--	309.33	--	308.85	308.35	308.61	--
G20	--	--	--	--	--	--	339.64	--	--	--	--	--	--	331.28	--
G20D	--	307.01	--	--	--	--	307.32	--	--	305.98	--	305.65	305.29	305.43	--
G20M	--	322.05	--	--	--	--	307.65	--	--	321.87	--	321.42	321.38	321.10	--
G20S	--	306.89	--	--	--	--	307.33	--	--	305.98	--	305.69	305.30	305.41	--
G21D	--	309.37	--	--	--	--	306.93	--	--	321.05	--	305.45	305.04	305.19	--
G21M	--	322.71	--	--	--	--	--	323.85	--	308.14	--	322.34	322.09	321.96	--
G21S	--	308.55	--	--	--	--	306.10	--	--	305.48	--	305.18	304.78	304.89	--
G22D	--	304.88	--	--	--	--	306.27	--	--	304.99	--	304.63	304.36	304.44	--
G22S	--	304.92	--	--	--	--	306.31	--	--	305.06	--	304.73	302.36	304.51	--
G23D	--	314.18	--	--	--	--	--	316.06	--	314.16	--	--	313.12	313.39	--
G23S	--	--	--	--	--	--	316.95	--	--	314.24	--	313.61	313.08	313.38	--
G24D	--	308.64	--	--	--	--	--	308.40	--	306.97	--	306.57	306.12	306.36	--
G24S	--	308.89	--	--	--	--	308.76	--	--	306.81	--	306.56	307.08	306.33	--
G51D	343.91	--	319.96	322.22	--	--	322.03	--	320.00	318.94	316.87	318.45	317.81	318.21	317.32
G52D	--	--	--	320.41	--	318.79	321.25	--	321.51	321.59	319.31	319.60	317.30	314.31	318.01
G53D	--	--	--	320.12	--	--	319.72	--	317.85	316.79	316.97	316.25	315.65	316.09	315.24
G54D	314.09	--	314.73	321.04	--	321.46	315.77	--	314.37	313.51	--	313.18	312.65	312.98	312.29
G54S	342.17	--	344.18	345.47	--	346.09	347.69	--	347.77	346.19	346.11	345.86	345.02	344.62	--
SG03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Well 2	--	--	--	--	--	--	302.05	--	--	302.02	--	301.86	301.51	301.63	--
Well 3	--	--	--	303.88	--	--	303.41	--	301.73	301.78	--	301.65	301.23	301.43	--
XPW01	--	--	--	--	--	370.28	369.57	--	366.98	365.74	368.80	366.66	365.51	366.66	--
XPW02	--	--	--	--	--	373.04	372.30	--	369.48	368.32	371.58	369.54	367.92	369.47	--
XPW03	--	--	--	--	--	372.01	371.32	--	368.92	367.50	369.24	367.52	368.39	366.99	--

[O: NRK 04/10/2024]

Notes:
-- = Not Measured
All groundwater elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88).

Table 2-2. Field Hydraulic Conductivities

Nature and Extent Report

Joppa Power Plant

East Ash Pond

Joppa, Illinois

Well ID	Gradient Position	Bottom of Screen Elevation (ft NAVD88)	Screen Length[1] (ft)	Field Identified Screened Material	Slug Type	Analysis Method	Falling Head (Slug In) K (cm/s)			Rising Head (Slug Out) K (cm/s)			Average Hydraulic Conductivity (cm/s)	Minimum Hydraulic Conductivity (cm/s)	Maximum Hydraulic Conductivity (cm/s)	Hydraulic Conductivity Geometric Mean (cm/s)
							1	2	3	1	2	3				
Uppermost Aquifer																
G06	D	267.60	10.0	Gravely Silty Clay	Solid	Bouwer-Rice	1.20E-03	1.02E-03	---	1.03E-03	8.14E-04	---	1.02E-03	4.84E-04	1.41E-01	9.61E-03
G07	D	290.34	10.0	Sand	Solid	Bouwer-Rice	6.96E-03	1.18E-02	8.98E-03	8.22E-03	1.05E-02	1.02E-02	9.45E-03			
G08	D	256.72	10.0	Sand	Solid	Bouwer-Rice	5.51E-03	5.82E-03	---	2.92E-03	3.69E-03	---	4.49E-03			
G09	D	279.19	10.0	Sandy Gravel	Solid	Bouwer-Rice	2.62E-03	---	---	1.55E-03	---	---	2.08E-03			
G10	D	280.45	10.0	Sand and Sandy Gravel	Solid	Bouwer-Rice	1.36E-03	8.69E-04	---	4.84E-04	5.25E-04	---	8.08E-04			
G11	U	297.68	10.0	Sand	Solid	Bouwer-Rice	7.15E-03	6.36E-03	---	6.72E-03	7.23E-03	---	6.86E-03			
G12S	D	287.56	10.0	Sand	Pneumatic	Butler/ Bower-Rice	---	---	---	1.24E-01	8.75E-02	6.05E-02	9.07E-02			
G12D	D	267.26	10.0	Sandy Gravel	Pneumatic	Butler	---	---	---	1.37E-01	---	---	1.37E-01			
G13S	D	291.72	10.0	Sand	Solid	Butler	---	---	---	1.41E-01	---	---	1.41E-01			
G13D	D	261.31	10.0	Sand	Pneumatic	Butler	---	---	---	1.09E-01	---	---	1.09E-01			
G14S	D	282.50	10.0	Sandy Gravel	Pneumatic	Butler-Zhan	---	---	---	6.16E-02	---	---	6.16E-02			
G14D	D	215.30	10.0	Sand	Solid	Kansas Geological Survey	---	---	---	5.88E-04	---	---	5.88E-04			
G15S	D	283.80	10.0	Sand	Pneumatic	Kansas Geological Survey	---	---	---	1.43E-02	---	---	1.43E-02			
G15D	D	251.00	10.0	Sand	Solid	Butler	---	---	---	4.60E-02	4.70E-02	---	4.65E-02			
G16S	D	289.60	10.0	Sand	Solid	Kansas Geological Survey	---	---	---	2.41E-02	---	---	2.41E-02			
G16D	D	241.56	10.0	Sand	Solid	Kansas Geological Survey	---	---	---	9.98E-02	---	---	9.98E-02			
G17S	D	284.58	10.0	Gravel	Pneumatic	Kansas Geological Survey	---	---	---	6.02E-03	---	---	6.02E-03			
G17D	D	262.54	10.0	Sand	Pneumatic	Butler-Zhan	---	---	---	2.43E-02	---	---	2.43E-02			
G19S	D	284.17	10.0	Gravel	Pneumatic	Kansas Geological Survey	---	---	---	1.93E-02	---	---	1.93E-02			
G19D	D	259.10	10.0	Sandy Gravel	Pneumatic	Butler-Zhan	---	---	---	3.00E-02	---	---	3.00E-02			
G20S	D	277.50	10.0	Gravel	Pneumatic	Butler-Zhan	---	---	---	1.15E-01	---	---	1.15E-01			
G20D	D	252.67	10.0	Sand	Pneumatic	Kansas Geological Survey	---	---	---	1.66E-02	---	---	1.66E-02			
G21S	D	278.90	10.0	Gravel	Pneumatic	Butler-Zhan	---	---	---	4.54E-02	---	---	4.54E-02			
G21D	D	248.87	10.0	Sand	Solid	Kansas Geological Survey	---	---	---	1.46E-03	---	---	1.46E-03			
G22S	D	276.79	10.0	Gravel	Pneumatic	Butler-Zhan	---	---	---	1.00E-01	---	---	1.00E-01			
G22D	D	234.83	10.0	Sand	Pneumatic	Kansas Geological Survey	---	---	---	6.24E-03	---	---	6.24E-03			
Lower Aquifer Unit																
G09M	D	193.60	10.0	Bedrock	Solid	Bouwer-Rice	2.73E-04	5.82E-04	---	3.78E-04	4.16E-04	---	4.12E-04	6.84E-05	9.06E-04	3.40E-04
G13M	D	126.55	10.0	Bedrock	Solid	Kansas Geological Survey	---	---	---	9.06E-04	---	---	9.06E-04			
G20M	D	162.92	10.0	Bedrock	Solid	Cooper-Bredehoeft-Papadopulos	---	---	---	6.84E-05	---	---	6.84E-05			
CCR																
XPW02	NA	343.53	5.0	Ash	Solid	Bouwer-Rice	9.82E-03	9.25E-03	---	4.46E-03	5.39E-03	---	7.23E-03	4.46E-03	1.65E-01	1.29E-02
XPW03	NA	341.95	5.0	Ash	Solid	Springer-Gelhar	---	---	---	1.65E-01	---	---	1.65E-01			

Notes:

[1] All wells are constructed from 2 inch PVC with 0.01 inch slotted screens.

--- = Test not analyzed/performed

CCR = coal combustion residuals

cm/s = centimeters per second

D = downgradient

ft = foot/feet

NA = Not Applicable

NAVD88 = North American Vertical Datum of 1988

U = upgradient

[O: XXX MM/DD/YY; U: CJC 08/24/21; C: LDC 08/30/21; KP 04/09/2024]

Table 2-3. Geotechnical Results
Nature and Extent Report
Joppa Power Plant
East Ash Pond
Joppa, Illinois

Sample ID	Field Location ID	Top of Sample (ft bgs)	Bottom of Sample (ft bgs)	Moisture Content (%)	Dry Density (pcf)	Specific Gravity	Calculated Porosity [1] (%)	Vertical Hydraulic Conductivity (cm/s)	LL	PL	PI	Laboratory USCS	Gravel (%)	Sand (%)	Fines (%)
Equality Formation															
SB-G03-(32-34)-20210202	G03	32	34	15.5	112.7	2.659	32.1	4.7E-07	27	16	11	SC	0.6	53.8	45.6
SB-G09M-(16-18)-20210127	G09M	16	18	20.6	105.4	2.666	36.7	8.3E-08	39	16	23	CL	0	5.0	95.0
SB-G11-(24-26)-20210119	G11	24	26	18.5	109.1	2.688	35.0	5.6E-08	36	15	21	CL	0	11.5	88.5
Metropolis Formation															
SB-G09M-(46-48)-20210127	G09M	46	48	19.8	105.7	2.715	37.6	3.5E-07	35	15	20	CL	0	17.2	82.8
McNairy Formation															
SB-G03-(60-62)-20210202	G03	60	62	20.0	- -	2.671	- -	- -	- -	- -	- -	SP	1.5	94.4	4.1
SB-G09M-(82-84)-20210127	G09M	82	84	7.6	100.0	2.686	40.4	- -	- -	- -	- -	SP	22.7	75.4	1.9
SB-G09M-(112-114)-20210127	G09M	112	114	25.5	87.0	2.675	47.9	- -	- -	- -	- -	- -	0.7	84.1	15.2
SB-G11-(56-58)-20210119	G11	56	58	14.4	110.0	2.661	33.8	- -	NP	NP	NP	SM	0.2	87.7	12.1
Post Creek Formation															
G13M 117-119	G13M	117	119	17.5	110.0	2.680	34.3	8.30E-08	22	13	9	CL	0	25.9	74.1
G21M 126-128	G21M	126	128	16.1	112.5	2.632	31.5	4.90E-08	51	23	28	CH	0	14.9	85.1
G21M 132-133	G21M	132	133	20.2	102.0	2.537	35.6	2.60E-08	50	24	26	CH	0	6.3	93.7
G21M 136-138	G21M	136	138	23.3	100.2	2.638	39.2	1.90E-08	29	16	13	CL	0	0.7	99.3
CCR															
SB-XPW01-(6-8)-20210120	XPW01	6	8	34.7	85.6	2.711	49.4	2.1E-05	NP	NP	NP	SM	26.3	45.4	28.3
SB-XPW01-(46-48)-20210120	XPW01	46	48	31.7	87.7	2.675	47.5	2.8E-07	25	20	5	CL-ML	0	18.7	81.3
SB-XPW02-(24-26)-20210120	XPW02	24	26	47.6	74.0	2.567	53.8	- -	NP	NP	NP	SM	9.3	74.1	16.6
SB-XPW03-(22-24)-20210121	XPW03	22	24	45.4	- -	2.410	- -	- -	- -	- -	- -	- -	0	4.2	95.8
SB-XPW03-(36-38)-20210121	XPW03	36	38	46.5	65.7	1.999	47.4	1.8E-07	46	31	15	ML	0	9.4	90.6

[O: NMP 08/19/21; U: CJC 08/24/21; C: LDC 08/27/21; U:NRK 4/8/24; C: KRP 4/9/24]

Notes:

[1] Porosity calculated as relationship of bulk density (p_b) to particle density (p_d) ($n = 100[1- (p_b/p_d)]$)

- - = Not Applicable/Not Analyzed
% = Percent
bgs = below ground surface
CCR = coal combustion residuals
cm/s = centimeters per second
ft = foot/feet
LL = Liquid limit
NP = Non-Plastic
pcf = pounds per cubic foot
PI = Plasticity Index
PL = Plastic Limit

USCS = Unified Soil Classification System
CL = Lean Clay
CL-ML = Silty Lean Clay
SC = Clayey Sand
SM = Silty Sand
SP = Poorly-Graded Sand

Table 3-1. Monitoring Well Construction Details

Nature and Extent Report
Joppa Power Plant
East Ash Pond
Joppa, Illinois

Location	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft bgs)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
G01D	UA	2015-08-14	364.2	364.4	Top of Disk	361.5	54.19	63.85	307.3	297.6	64.4	297.1	9.7	2	37.22042921	-88.85717876
G02D	UA	2015-08-13	363.6	363.8	Top of Disk	360.8	62.21	71.84	298.6	289.0	72.4	288.5	9.6	2	37.2207148	-88.85331072
G03	UA	2021-02-02	357.9	358.0	Top of PVC	354.8	55	65	302.9	292.9	65	289.8	10	2	37.220682	-88.850376
G05	UA	2021-02-01	361.2	361.4	Top of PVC	358.4	50	60	311.2	301.2	60	298.5	10	2	37.21719	-88.849014
G06	UA	2021-01-29	355.2	355.4	Top of PVC	352.6	75	85	280.2	270.2	85	267.6	10	2	37.212929	-88.848893
G07	UA	2021-01-29	353.5	353.7	Top of PVC	350.3	50	60	303.5	293.5	60	290.3	10	2	37.211001	-88.848969
G08	UA	2021-01-28	343.5	343.7	Top of PVC	341.7	75	85	268.5	258.5	85	256.7	10	2	37.210531	-88.851015
G09	UA	2021-01-31	351.7	351.9	Top of PVC	348.7	59.5	69.5	292.2	282.2	69.5	279.2	10	2	37.210336	-88.854116
G09M	LAU	2021-01-28	351.5	351.5	Top of PVC	348.6	145	155	206.5	196.5	155	193.6	10	2	37.210341	-88.85413
G10	UA	2021-02-01	353.5	353.7	Top of PVC	350.8	60.3	70.3	293.2	283.2	70.3	280.5	10	2	37.211272	-88.855841
G11	UA	2021-01-19	366.6	366.7	Top of PVC	363.4	55.7	65.7	310.9	300.9	65.7	297.7	10	2	37.214408	-88.85633
G12S	UA	2021-09-23	360.3	360.5	Top of PVC	357.6	60	70	297.6	287.6	70	287.6	10	2	37.211564	-88.847086
G12D	UA	2021-09-23	360.2	360.4	Top of PVC	357.3	80	90	277.3	267.3	90	257.3	10	2	37.21157	-88.847103
G13S	UA	2021-09-23	354.8	354.9	Top of PVC	352.0	50	60	301.7	291.7	60	291.7	10	2	37.210142	-88.847213
G13M	LAU	2022-05-18	354.0	354.0	Top of PVC	351.6	215	225	136.6	126.5	225	122.5	10	2	37.210129	-88.847331
G13D	UA	2021-09-23	354.6	354.7	Top of PVC	351.7	80	90	271.3	261.3	90	241.3	10	2	37.210129	-88.847217
G14S	UA	2021-09-16	345.6	345.6	Top of PVC	345.5	53	63	292.5	282.5	63	282.5	10	2	37.206927	-88.847006
G14D	UA	2021-09-16	345.5	345.5	Top of PVC	345.3	120	130	225.5	215.3	130	202.3	10	2	37.206909	-88.847007
G15S	UA	2021-09-15	346.8	347.0	Top of PVC	343.8	50	60	293.8	283.8	60	283.8	10	2	37.20715	-88.848881
G15D	UA	2021-09-15	346.7	346.9	Top of PVC	344.0	83	93	261.0	251.0	93	219.0	10	2	37.207152	-88.848865
G16S	UA	2021-09-14	352.3	352.3	Top of PVC	349.6	50	60	299.6	289.6	60	289.6	10	2	37.207163	-88.850678
G16D	UA	2021-09-14	352.4	352.6	Top of PVC	349.6	98	108	251.6	241.6	108	219.6	10	2	37.207147	-88.850687
G17S	UA	2022-06-01	359.2	359.2	Top of PVC	359.6	65	75	294.6	284.6	75	282.6	10	2	37.2116	-88.845465
G17D	UA	2022-05-21	359.3	359.3	Top of PVC	359.5	87	97	272.5	262.5	97	262.5	10	2	37.211598	-88.845475
G19S	UA	2022-06-01	355.6	355.6	Top of PVC	355.9	61.75	71.75	294.2	284.2	71.75	283.9	10	2	37.208548	-88.84322
G19D	UA	2022-06-01	355.4	355.4	Top of PVC	355.8	86.75	96.75	269.1	259.1	96.75	258.8	10	2	37.208538	-88.843225
G20S	UA	2022-05-20	350.2	350.2	Top of PVC	347.5	60	70	287.5	277.5	70	275.5	10	2	37.206909	-88.845853
G20M	LAU	2022-05-19	351.1	351.1	Top of PVC	347.9	175	185	172.9	162.9	185	118.9	10	2	37.206909	-88.845833
G20D	UA	2022-05-20	350.7	350.7	Top of PVC	347.7	85	95	262.7	252.7	95	250.7	10	2	37.206909	-88.845842
G21S	UA	2022-03-31	352.0	352.0	Top of Casing	348.9	60	70	288.9	278.9	70	278.9	10	2	37.20544	-88.84803
G21M	LAU	2022-04-11	353.1	353.1	Top of Casing	349.0	156	166	193.0	183.0	166	183.0	10	2	37.205468	-88.848005
G21D	UA	2022-03-31	351.7	351.7	Top of Casing	348.9	90	100	258.9	248.9	100	248.9	10	2	37.205439	-88.84799
G22S	UA	2022-05-24	351.6	351.6	Top of PVC	351.8	65	75	286.8	276.8	75	274.8	10	2	37.204787	-88.844908
G22D	UA	2022-05-22	351.5	351.5	Top of PVC	351.8	107	117	244.8	234.8	117	234.8	10	2	37.204799	-88.844907
G51D	UA	2015-08-18	363.9	364.0	Top of PVC	361.1	49.61	59.27	311.5	301.8	59.9	301.2	9.7	2	37.216016	-88.855653
G52D	UA	2015-08-19	348.4	348.6	Top of PVC	345.9	69.85	79.55	276.0	266.3	80.01	265.9	9.7	2	37.20962587	-88.85294308
G53D	UA	2015-08-21	355.5	355.6	Top of PVC	352.2	47.29	56.89	304.9	295.3	57.33	294.2	9.6	2	37.21506911	-88.84936671
G54D	UA	2015-08-11	357.0	357.2	Top of PVC	353.7	69.96	79.66	283.8	274.1	80.14	273.6	9.7	2	37.21226413	-88.85748523
XPW01	CCR	2021-01-20	383.4	383.5	Top of PVC	380.8	48.7	53.7	334.7	329.7	53.7	327.1	5	2	37.216965	-88.852074
XPW02	CCR	2021-01-21	376.0	376.2	Top of PVC	373.2	24.7	29.7	351.3	346.3	29.7	343.6	5	2	37.215865	-88.855001
XPW03	CCR	2021-01-21	381.5	381.7	Top of PVC	378.6	31.7	36.7	349.8	344.8	36.7	342.0	5	2	37.212153	-88.85542

Notes:

All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
bgs = below ground surface
ft = foot or feet
HSU = Hydrostratigraphic Unit
UA = Uppermost Aquifer
CCR = Coal Combustion Residuals
LAU = Lower Aquifer Unit
PVC = polyvinyl chloride

Table 3-2. Exceedance Parameter Statistical Results
Nature and Extent Report
Joppa Power Plant
East Ash Pond
Joppa, Illinois

Location	Parameter	Unit	Groundwater Protection Standard	2023 Q2 LCL	2023 Q3 LCL	2023 Q4 LCL
G06	Boron, total	mg/L	2	3.05	3.08	3.11
G07	Boron, total	mg/L	2	4.26	4.29	4.34
G08	Boron, total	mg/L	2	4.08	4.10	4.18
G09	Boron, total	mg/L	2	3.15	3.64	3.19
G10	Boron, total	mg/L	2	3.65	3.61	2.17
G05	Cobalt, total	mg/L	0.006	0.00700	0.00601	0.000824
G11	pH (field)	SU	6.0/9.0	5.8/5.9	5.8/6.0	5.8/5.9
G51D	pH (field)	SU	6.0/9.0	5.2/5.5	5.2/5.4	5.1/5.4

Notes:
LCL = Lower Confidence Level
mg/L = Milligrams per Liter
SU = Standard Units

Table 3-3. Summary of Groundwater Data

Nature and Extent Report
Joppa Power Plant
East Ash Pond
Joppa, Illinois

HSU	Location	Well Type	Parameter	Unit	Sample Count	Non-Detect Results	Percent Non-Detect Results	First Sample	Last Sample	Minimum	Median	Mean	Maximum
CCR	XPW01	Porewater	Boron, total	mg/L	10	0	0	2021/03/05	2023/10/25	8.79	10	10	12.8
CCR	XPW01	Porewater	Cobalt, total	mg/L	10	7	70	2021/03/05	2023/10/25	0.000100	0.0010	0.00075	<0.0001
CCR	XPW01	Porewater	pH (field)	SU	10	0	0	2021/03/05	2023/10/25	7.3	8.4	8.2	8.5
CCR	XPW02	Porewater	Boron, total	mg/L	10	0	0	2021/03/04	2023/10/25	10.8	12	13	16.0
CCR	XPW02	Porewater	Cobalt, total	mg/L	10	8	80	2021/03/04	2023/10/25	<0.0001	0.0010	0.00076	<0.0001
CCR	XPW02	Porewater	pH (field)	SU	10	0	0	2021/03/04	2023/10/25	7.6	7.8	7.8	8.0
CCR	XPW03	Porewater	Boron, total	mg/L	10	0	0	2021/03/04	2023/10/25	8.06	11	10	12.2
CCR	XPW03	Porewater	Cobalt, total	mg/L	10	10	100	2021/03/04	2023/10/25	<0.0001	<0.0001	0.00064	<0.0001
CCR	XPW03	Porewater	pH (field)	SU	10	0	0	2021/03/04	2023/10/25	10.0	11	11	10.8
LAU	G13M	Delin	Boron, total	mg/L	4	0	0	2022/07/29	2023/01/26	0.0180	0.037	0.034	0.0456
LAU	G13M	Delin	Cobalt, total	mg/L	4	4	100	2022/07/29	2023/01/26	<0.0001	<0.0001	0.00010	<0.0001
LAU	G13M	Delin	pH (field)	SU	4	0	0	2022/07/29	2023/01/26	7.4	7.6	7.9	9.2
LAU	G20M	Delin	Boron, total	mg/L	4	0	0	2022/07/29	2023/01/26	0.0220	0.039	0.037	0.0487
LAU	G20M	Delin	Cobalt, total	mg/L	4	3	75	2022/07/29	2023/01/26	<0.0001	<0.0001	0.00012	0.000200
LAU	G20M	Delin	pH (field)	SU	4	0	0	2022/07/29	2023/01/26	7.5	8.0	7.9	8.3
LAU	G21M	Delin	Boron, total	mg/L	4	2	50	2022/07/29	2023/01/25	<0.0092	0.016	0.016	0.0240
LAU	G21M	Delin	Cobalt, total	mg/L	4	3	75	2022/07/29	2023/01/25	<0.0001	0.000200	0.00012	0.000200
LAU	G21M	Delin	pH (field)	SU	4	0	0	2022/07/29	2023/01/25	10.0	12	11	12.3
LAU	G09M	Delin	Boron, total	mg/L	8	0	0	2021/03/04	2022/11/01	0.0191	0.029	0.033	0.0544
LAU	G09M	Delin	Cobalt, total	mg/L	8	0	0	2021/03/04	2022/11/01	0.00160	0.0054	0.0055	0.0105
LAU	G09M	Delin	pH (field)	SU	8	0	0	2021/03/04	2022/11/01	6.8	7.0	7.2	8.3
UA	G01D	B	Boron, total	mg/L	32	22	69	2015/12/03	2023/10/23	0.0140	0.025	0.025	0.0416
UA	G01D	B	Cobalt, total	mg/L	31	10	32	2015/12/03	2023/10/23	0.000700	0.0015	0.0034	0.0136
UA	G01D	B	pH (field)	SU	32	0	0	2015/12/03	2023/10/23	6.2	6.6	6.6	7.2
UA	G02D	B	Boron, total	mg/L	32	0	0	2015/12/03	2023/10/23	0.0266	0.042	0.040	0.0552
UA	G02D	B	Cobalt, total	mg/L	31	28	90	2015/12/03	2023/10/23	<0.0001	0.0010	0.00091	0.00240
UA	G02D	B	pH (field)	SU	32	0	0	2015/12/03	2023/10/23	6.2	6.5	6.5	7.3
UA	G03	C	Boron, total	mg/L	13	0	0	2021/03/05	2023/10/23	0.213	0.27	0.32	0.603
UA	G03	C	Cobalt, total	mg/L	13	4	31	2021/03/05	2023/10/23	<0.0001	0.0025	0.0034	0.0146
UA	G03	C	pH (field)	SU	13	0	0	2021/03/05	2023/10/23	6.2	6.3	6.3	6.5
UA	G05	C	Boron, total	mg/L	13	0	0	2021/03/04	2023/10/24	0.0436	0.14	0.12	0.195
UA	G05	C	Cobalt, total	mg/L	13	0	0	2021/03/04	2023/10/24	0.00200	0.0078	0.0074	0.0103
UA	G05	C	pH (field)	SU	13	0	0	2021/03/04	2023/10/24	6.3	6.4	6.4	6.6
UA	G06	C	Boron, total	mg/L	13	0	0	2021/03/04	2023/10/24	2.90	3.3	3.3	3.93
UA	G06	C	Cobalt, total	mg/L	13	6	46	2021/03/04	2023/10/24	0.000600	0.0010	0.0016	0.00400
UA	G06	C	pH (field)	SU	12	0	0	2021/03/04	2023/10/24	6.3	6.6	6.5	6.7

Table 3-3. Summary of Groundwater Data
Nature and Extent Report
Joppa Power Plant
East Ash Pond
Joppa, Illinois

HSU	Location	Well Type	Parameter	Unit	Sample Count	Non-Detect Results	Percent Non-Detect Results	First Sample	Last Sample	Minimum	Median	Mean	Maximum
UA	G07	C	Boron, total	mg/L	13	0	0	2021/03/04	2023/10/24	3.91	4.5	4.7	5.80
UA	G07	C	Cobalt, total	mg/L	13	1	8	2021/03/04	2023/10/24	<0.0001	0.0023	0.0029	0.00780
UA	G07	C	pH (field)	SU	13	0	0	2021/03/04	2023/10/24	6.0	6.4	6.4	7.1
UA	G08	C	Boron, total	mg/L	13	0	0	2021/03/04	2023/10/24	3.77	4.6	4.7	6.30
UA	G08	C	Cobalt, total	mg/L	13	0	0	2021/03/04	2023/10/24	0.00220	0.0041	0.0051	0.0113
UA	G08	C	pH (field)	SU	13	0	0	2021/03/04	2023/10/24	6.8	6.9	7.0	7.6
UA	G09	C	Boron, total	mg/L	13	0	0	2021/03/04	2023/10/25	0.282	3.5	3.4	4.57
UA	G09	C	Cobalt, total	mg/L	13	0	0	2021/03/04	2023/10/25	0.00110	0.0086	0.0082	0.0159
UA	G09	C	pH (field)	SU	13	0	0	2021/03/04	2023/10/25	6.0	6.2	6.3	7.6
UA	G10	C	Boron, total	mg/L	13	0	0	2021/03/04	2023/10/24	2.35	4.2	4.0	4.98
UA	G10	C	Cobalt, total	mg/L	13	0	0	2021/03/04	2023/10/24	0.00210	0.0050	0.0062	0.0122
UA	G10	C	pH (field)	SU	13	0	0	2021/03/04	2023/10/24	6.3	6.6	6.6	6.8
UA	G11	C	Boron, total	mg/L	13	0	0	2021/03/04	2023/10/24	0.247	0.31	0.33	0.420
UA	G11	C	Cobalt, total	mg/L	13	4	31	2021/03/04	2023/10/24	0.000600	0.0020	0.0037	0.0185
UA	G11	C	pH (field)	SU	13	0	0	2021/03/04	2023/10/24	5.8	5.9	5.9	6.3
UA	G51D	C	Boron, total	mg/L	24	0	0	2015/12/03	2023/10/25	0.0297	0.53	0.49	0.963
UA	G51D	C	Cobalt, total	mg/L	23	1	4	2015/12/03	2023/10/25	0.000600	0.0026	0.0060	0.0249
UA	G51D	C	pH (field)	SU	24	0	0	2015/12/03	2023/10/25	5.3	5.6	5.7	6.9
UA	G52D	C	Boron, total	mg/L	23	19	83	2015/12/03	2023/10/24	0.0110	0.025	0.053	0.682
UA	G52D	C	Cobalt, total	mg/L	22	0	0	2015/12/03	2023/10/24	0.00110	0.0038	0.0041	0.00930
UA	G52D	C	pH (field)	SU	23	0	0	2015/12/03	2023/10/24	5.9	6.3	6.3	6.7
UA	G53D	C	Boron, total	mg/L	24	0	0	2015/12/03	2023/10/25	0.138	0.36	0.35	0.431
UA	G53D	C	Cobalt, total	mg/L	23	4	17	2015/12/03	2023/10/25	<0.0002	0.0020	0.0026	0.00870
UA	G53D	C	pH (field)	SU	24	0	0	2015/12/03	2023/10/25	6.2	6.6	6.7	7.9
UA	G54D	C	Boron, total	mg/L	24	0	0	2015/12/03	2023/10/25	0.178	0.56	0.55	1.03
UA	G54D	C	Cobalt, total	mg/L	23	0	0	2015/12/03	2023/10/25	0.00450	0.013	0.013	0.0268
UA	G54D	C	pH (field)	SU	24	0	0	2015/12/03	2023/10/25	6.4	6.7	6.7	7.1
UA	G12S	Delin	Boron, total	mg/L	11	0	0	2022/01/20	2023/10/24	5.24	6.2	6.3	8.16
UA	G12S	Delin	Cobalt, total	mg/L	11	6	55	2022/01/20	2023/10/24	<0.0001	0.00030	0.00055	<0.0001
UA	G12S	Delin	pH (field)	SU	11	0	0	2022/01/20	2023/10/24	6.1	6.5	6.5	7.1
UA	G12D	Delin	Boron, total	mg/L	11	0	0	2022/01/20	2023/10/24	5.31	6.6	6.6	8.01
UA	G12D	Delin	Cobalt, total	mg/L	11	4	36	2022/01/20	2023/10/24	0.000100	0.00040	0.00057	0.00140
UA	G12D	Delin	pH (field)	SU	11	0	0	2022/01/20	2023/10/24	6.5	6.6	6.7	7.3
UA	G13S	Delin	Boron, total	mg/L	11	0	0	2022/01/20	2023/10/24	4.34	5.2	5.4	7.31
UA	G13S	Delin	Cobalt, total	mg/L	11	11	100	2022/01/20	2023/10/24	<0.0001	<0.0001	0.00039	<0.0001
UA	G13S	Delin	pH (field)	SU	11	0	0	2022/01/20	2023/10/24	6.0	6.5	6.6	7.3

Table 3-3. Summary of Groundwater Data
Nature and Extent Report
Joppa Power Plant
East Ash Pond
Joppa, Illinois

HSU	Location	Well Type	Parameter	Unit	Sample Count	Non-Detect Results	Percent Non-Detect Results	First Sample	Last Sample	Minimum	Median	Mean	Maximum
UA	G13D	Delin	Boron, total	mg/L	11	0	0	2022/01/20	2023/10/24	3.64	4.8	5.1	6.81
UA	G13D	Delin	Cobalt, total	mg/L	11	9	82	2022/01/20	2023/10/24	<0.0001	<0.0001	0.00045	0.00120
UA	G13D	Delin	pH (field)	SU	11	0	0	2022/01/20	2023/10/24	5.9	6.6	6.6	7.3
UA	G14S	Delin	Boron, total	mg/L	8	0	0	2022/01/19	2023/03/10	3.09	3.7	3.6	4.34
UA	G14S	Delin	Cobalt, total	mg/L	8	6	75	2022/01/19	2023/03/10	<0.0001	0.00025	0.00048	<0.0001
UA	G14S	Delin	pH (field)	SU	8	0	0	2022/01/19	2023/03/10	6.4	6.6	6.7	7.6
UA	G14D	Delin	Boron, total	mg/L	8	2	25	2022/01/19	2023/03/10	0.0180	0.025	0.043	0.101
UA	G14D	Delin	Cobalt, total	mg/L	8	4	50	2022/01/19	2023/03/10	0.000100	0.00045	0.00056	<0.0001
UA	G14D	Delin	pH (field)	SU	8	0	0	2022/01/19	2023/03/10	6.9	7.1	7.2	7.9
UA	G15S	Delin	Boron, total	mg/L	8	0	0	2022/01/19	2023/03/09	0.740	1.1	1.1	1.33
UA	G15S	Delin	Cobalt, total	mg/L	8	0	0	2022/01/19	2023/03/09	0.000400	0.0024	0.0027	0.00690
UA	G15S	Delin	pH (field)	SU	8	0	0	2022/01/19	2023/03/09	5.9	6.2	6.4	7.1
UA	G15D	Delin	Boron, total	mg/L	8	0	0	2022/01/19	2023/03/09	4.17	6.2	6.1	7.88
UA	G15D	Delin	Cobalt, total	mg/L	8	0	0	2022/01/19	2023/03/09	0.00400	0.0095	0.012	0.0238
UA	G15D	Delin	pH (field)	SU	8	0	0	2022/01/19	2023/03/09	6.7	6.8	7.1	8.2
UA	G16S	Delin	Boron, total	mg/L	11	0	0	2022/01/19	2023/10/24	5.85	7.2	7.3	10.6
UA	G16S	Delin	Cobalt, total	mg/L	11	0	0	2022/01/19	2023/10/24	0.00360	0.0046	0.0047	0.00710
UA	G16S	Delin	pH (field)	SU	11	0	0	2022/01/19	2023/10/24	6.5	6.7	6.9	8.0
UA	G16D	Delin	Boron, total	mg/L	8	0	0	2022/01/19	2023/03/09	2.89	6.8	6.2	7.79
UA	G16D	Delin	Cobalt, total	mg/L	8	3	38	2022/01/19	2023/03/09	0.000300	0.00050	0.00062	<0.0001
UA	G16D	Delin	pH (field)	SU	8	0	0	2022/01/19	2023/03/09	6.8	7.0	7.1	8.0
UA	G17S	Delin	Boron, total	mg/L	4	0	0	2022/07/24	2023/01/24	2.43	2.6	2.6	2.76
UA	G17S	Delin	Cobalt, total	mg/L	4	0	0	2022/07/24	2023/01/24	0.000300	0.00035	0.00065	0.00160
UA	G17S	Delin	pH (field)	SU	4	0	0	2022/07/24	2023/01/24	6.6	6.7	6.9	7.5
UA	G17D	Delin	Boron, total	mg/L	4	0	0	2022/07/24	2023/01/24	3.81	4.1	4.0	4.15
UA	G17D	Delin	Cobalt, total	mg/L	4	0	0	2022/07/24	2023/01/24	0.000400	0.00055	0.00092	0.00220
UA	G17D	Delin	pH (field)	SU	4	0	0	2022/07/24	2023/01/24	6.5	6.9	7.0	7.7
UA	G19S	Delin	Boron, total	mg/L	7	0	0	2022/07/27	2023/10/23	0.449	0.66	0.62	0.743
UA	G19S	Delin	Cobalt, total	mg/L	7	1	14	2022/07/27	2023/10/23	<0.0001	0.00050	0.00061	0.00160
UA	G19S	Delin	pH (field)	SU	7	0	0	2022/07/27	2023/10/23	6.2	6.4	6.8	7.8
UA	G19D	Delin	Boron, total	mg/L	7	0	0	2022/07/27	2023/10/23	0.496	0.64	0.66	0.809
UA	G19D	Delin	Cobalt, total	mg/L	7	4	57	2022/07/27	2023/10/23	0.000100	0.000100	0.00030	0.00120
UA	G19D	Delin	pH (field)	SU	7	0	0	2022/07/27	2023/10/23	6.2	6.7	6.7	7.5
UA	G20S	Delin	Boron, total	mg/L	7	0	0	2022/07/24	2023/10/24	3.24	3.8	4.0	4.84
UA	G20S	Delin	Cobalt, total	mg/L	7	6	86	2022/07/24	2023/10/24	<0.0001	0.000200	0.00011	0.000200
UA	G20S	Delin	pH (field)	SU	7	0	0	2022/07/24	2023/10/24	6.3	6.7	6.8	7.9

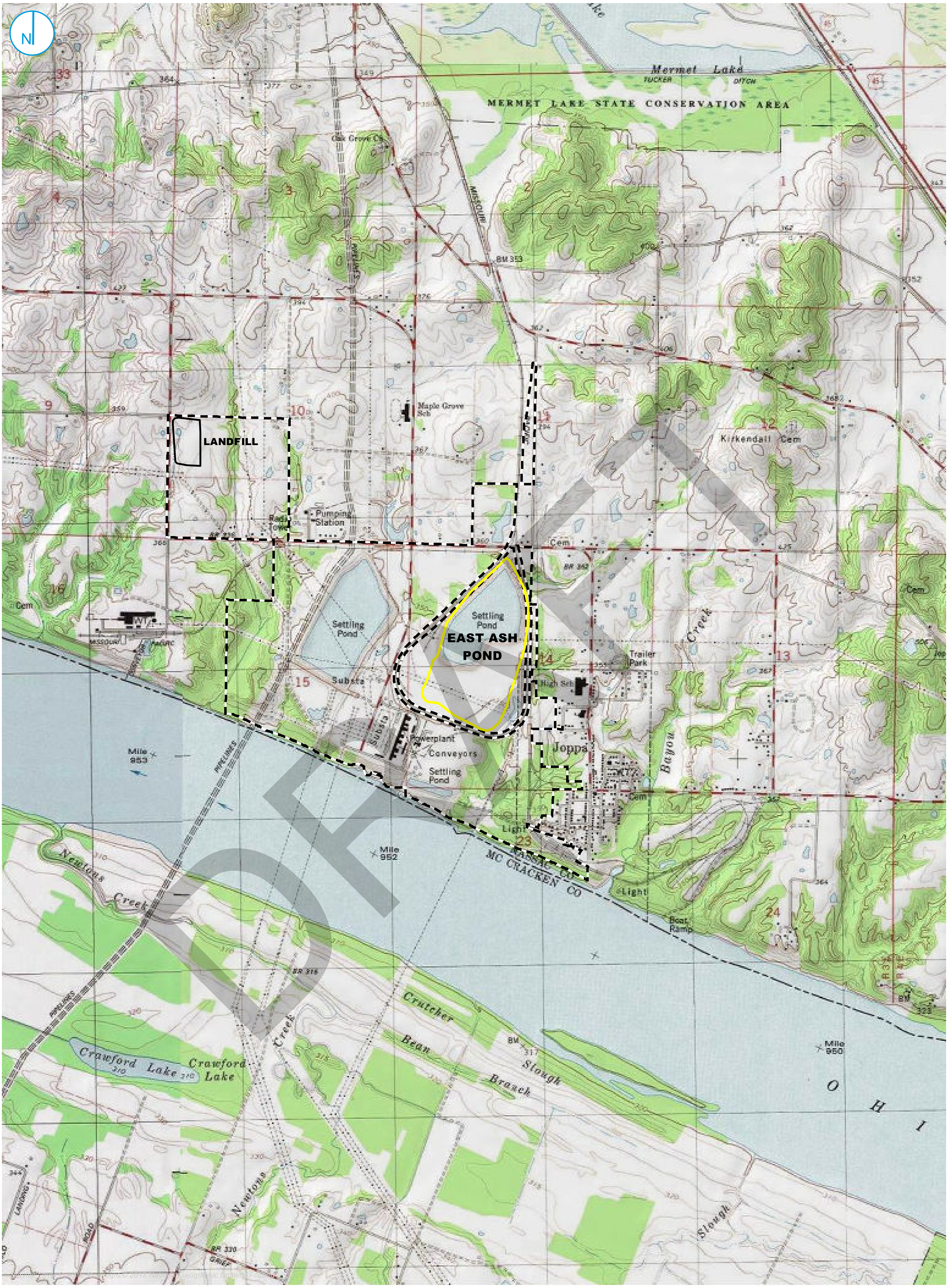
Table 3-3. Summary of Groundwater Data

Nature and Extent Report
Joppa Power Plant
East Ash Pond
Joppa, Illinois

HSU	Location	Well Type	Parameter	Unit	Sample Count	Non-Detect Results	Percent Non-Detect Results	First Sample	Last Sample	Minimum	Median	Mean	Maximum
UA	G20D	Delin	Boron, total	mg/L	7	0	0	2022/07/24	2023/10/24	2.16	2.5	2.6	2.93
UA	G20D	Delin	Cobalt, total	mg/L	7	3	43	2022/07/24	2023/10/24	<0.0001	0.00040	0.00046	<0.0001
UA	G20D	Delin	pH (field)	SU	7	0	0	2022/07/24	2023/10/24	6.7	7.0	7.2	8.1
UA	G21S	Delin	Boron, total	mg/L	7	0	0	2022/07/28	2023/10/23	3.39	4.3	4.2	5.00
UA	G21S	Delin	Cobalt, total	mg/L	7	1	14	2022/07/28	2023/10/23	<0.0001	0.00040	0.00046	0.000900
UA	G21S	Delin	pH (field)	SU	7	0	0	2022/07/28	2023/10/23	6.6	6.8	6.8	7.3
UA	G21D	Delin	Boron, total	mg/L	7	0	0	2022/07/28	2023/10/23	2.63	3.0	3.1	3.91
UA	G21D	Delin	Cobalt, total	mg/L	7	1	14	2022/07/28	2023/10/23	<0.0001	0.0021	0.0020	0.00280
UA	G21D	Delin	pH (field)	SU	7	0	0	2022/07/28	2023/10/23	6.8	7.1	7.2	7.7
UA	G22S	Delin	Boron, total	mg/L	8	0	0	2022/07/25	2023/10/23	1.10	1.3	1.3	1.39
UA	G22S	Delin	Cobalt, total	mg/L	8	7	88	2022/07/25	2023/10/23	0.000100	0.000100	0.00010	0.000100
UA	G22S	Delin	pH (field)	SU	8	0	0	2022/07/25	2023/10/23	5.7	6.7	6.8	7.6
UA	G22D	Delin	Boron, total	mg/L	7	0	0	2022/07/27	2023/10/23	0.562	0.68	0.70	0.896
UA	G22D	Delin	Cobalt, total	mg/L	7	1	14	2022/07/27	2023/10/23	<0.0001	0.00030	0.00033	0.000700
UA	G22D	Delin	pH (field)	SU	7	0	0	2022/07/27	2023/10/23	6.5	6.8	6.9	7.8

Notes:
B = Background
C = Compliance
CCR = Coal Combustion Residuals
Delin = Delineation
HSU = Hydrostratigraphic Unit
LAU = Lower Aquifer Unit
mg/L = Milligrams per Liter
UA = Uppermost Aquifer

FIGURES



🟨 REGULATED UNIT (SUBJECT UNIT)

☐ OTHER UNIT

⬚ PROPERTY BOUNDARY

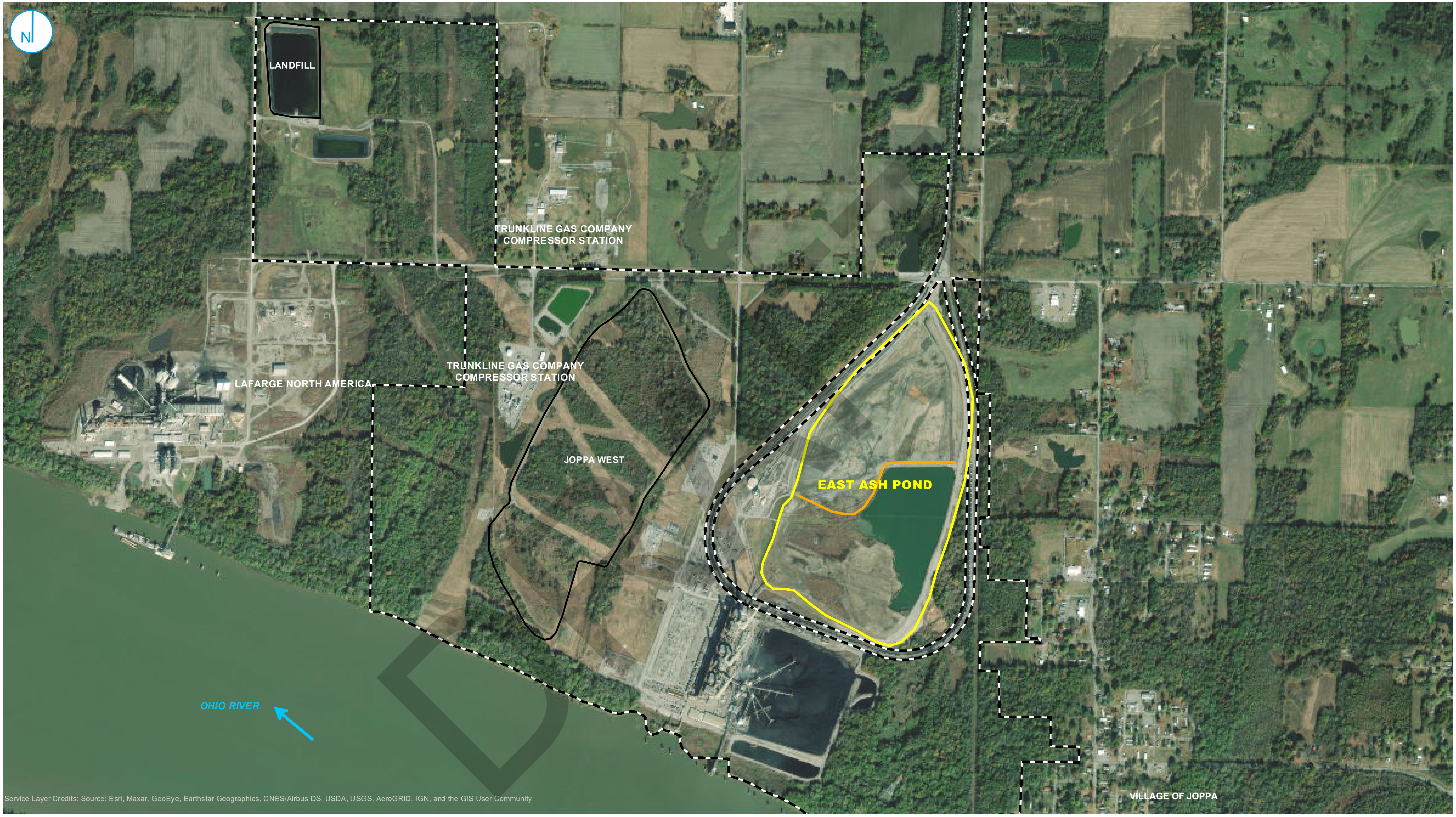
0 1,000 2,000 Feet

SITE LOCATION MAP

FIGURE 2-1

NATURE AND EXTENT REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\GMP\Figure 1-2_Site Map.mxd

PROJECT: 169000XXXX | DATED: 10/15/2021 | DESIGNER: HOTCALD

▭ REGULATED UNIT (SUBJECT UNIT)
▭ OTHER UNIT
— CENTRAL DIKE
⬚ PROPERTY BOUNDARY

SITE MAP

FIGURE 2-2

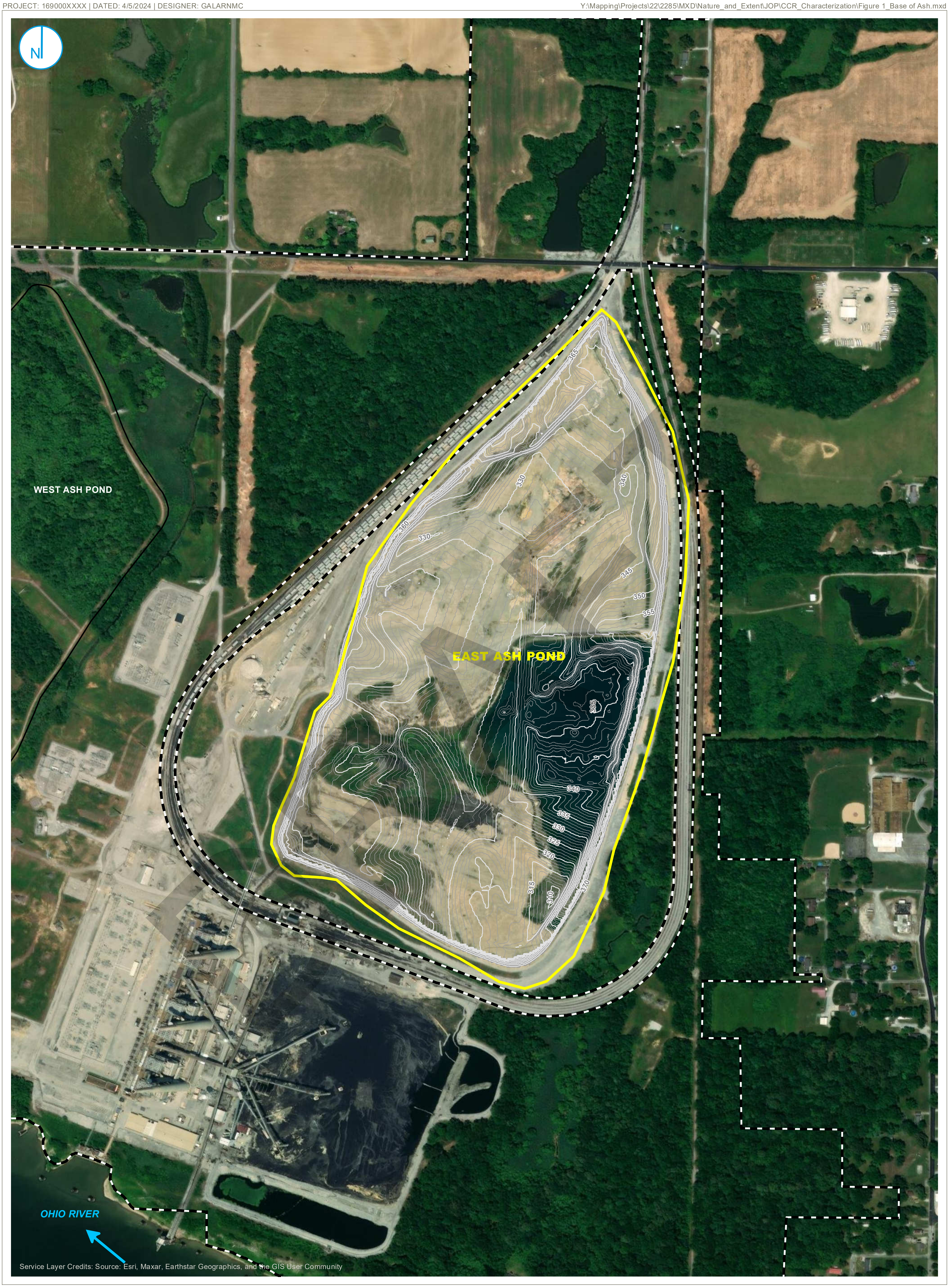
NATURE AND EXTENT REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 4/5/2024 | DESIGNER: GALARNMC

Y:\Mapping\Projects\22\2285\MXD\Nature_and_Extent\JOP\CCR_Characterization\Figure 1_Base of Ash.mxd



Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

5FT TOPOGRAPHIC CONTOUR
1FT TOPOGRAPHIC CONTOUR
REGULATED UNIT (SUBJECT UNIT)
SITE FEATURE
PROPERTY BOUNDARY

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

0 250 500
Feet

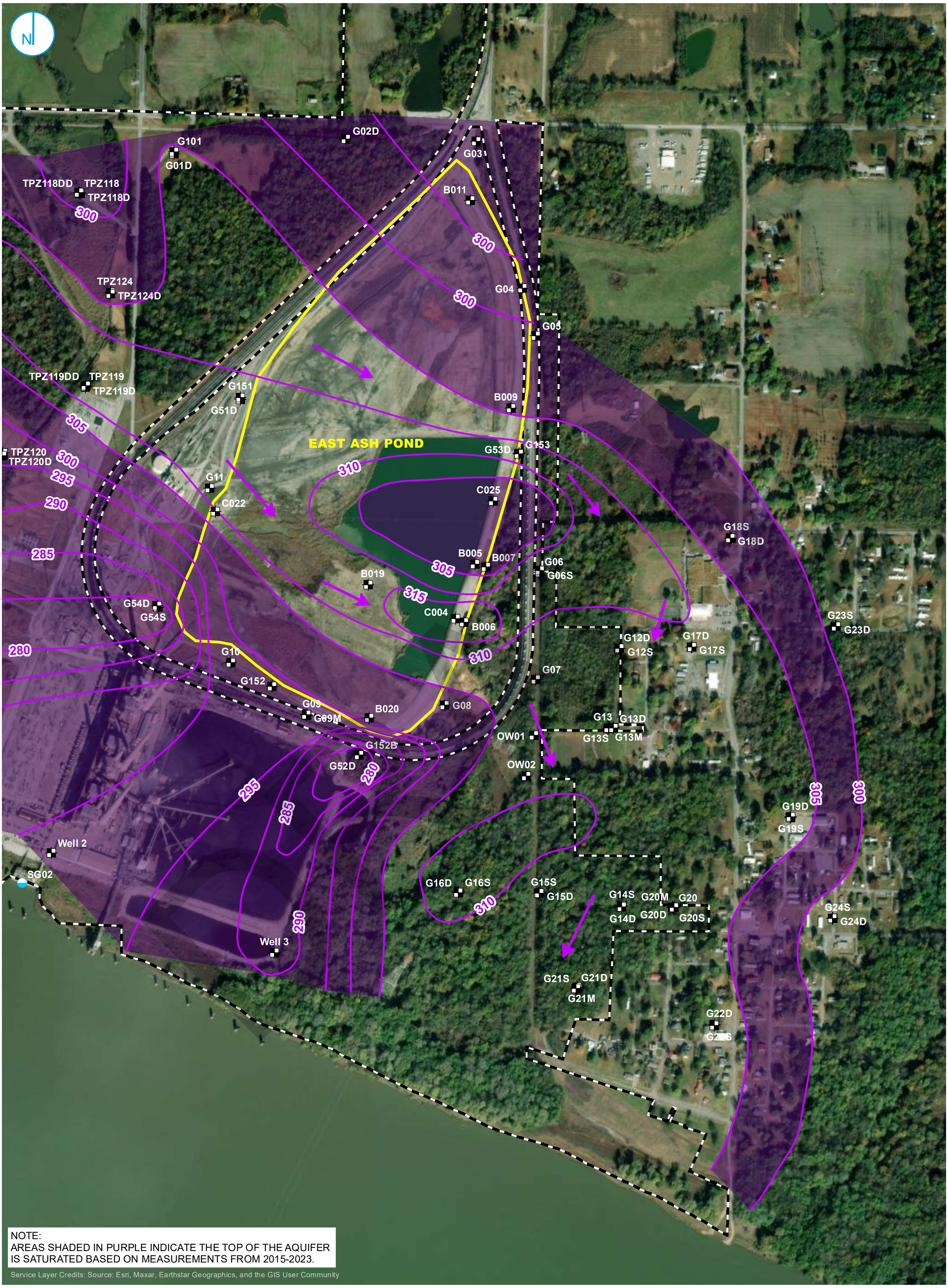
BASE OF CCR

FIGURE 2-3

NATURE AND EXTENT REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



NOTE:
AREAS SHADED IN PURPLE INDICATE THE TOP OF THE AQUIFER IS SATURATED BASED ON MEASUREMENTS FROM 2015-2023.

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- ▣ MONITORING WELL
- ◒ STAFF GAGE, RIVER
- — TOP OF MCNAIRY FORMATION ELEVATION (5-FT CONTOUR INTERVAL)
- → FLOW DIRECTION
- ⬬ AREA WHERE TOP OF AQUIFER IS SATURATED BASED ON MEASUREMENTS FROM 2015-2023
- ▭ REGULATED UNIT (SUBJECT UNIT)
- ⬚ PROPERTY BOUNDARY

0 300 600
Feet

TOP OF UPPERMOST AQUIFER

FIGURE 2-4

NATURE AND EXTENT REPORT
EAST ASH POND
JOPPA POWER PLANT JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

- 🟦 COMPLIANCE MONITORING WELL
- 🟫 BACKGROUND MONITORING WELL
- 🟩 PORE WATER WELL
- ⬛ MONITORING WELL
- ◒ STAFF GAGE, CCR UNIT
- GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- → GROUNDWATER FLOW DIRECTION
- 🟨 REGULATED UNIT (SUBJECT UNIT)
- ▨ PROPERTY BOUNDARY

0 275 550
Feet

NOTES
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)
*GAGING DATA FROM USGS 03612600 OHIO RIVER AT OLMSTED, IL LOCATED APPROXIMATELY 12 MILES DOWNSTREAM OF JOPPA POWER PLANT.

UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP MAY 1, 2023 (E001)

FIGURE 2-5

NATURE AND EXTENT REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- COMPLIANCE MONITORING WELL
- BACKGROUND MONITORING WELL
- PORE WATER WELL
- MONITORING WELL
- STAFF GAGE, CCR UNIT
- GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- REGULATED UNIT (SUBJECT UNIT)
- PROPERTY BOUNDARY

0 275 550
Feet

NOTES
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)
*GAGING DATA FROM USGS 03612600 OHIO RIVER AT OLMSTED, IL LOCATED APPROXIMATELY 12 MILES DOWNSTREAM OF JOPPA POWER PLANT.

UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP
MARCH 7 AND 10, 2023

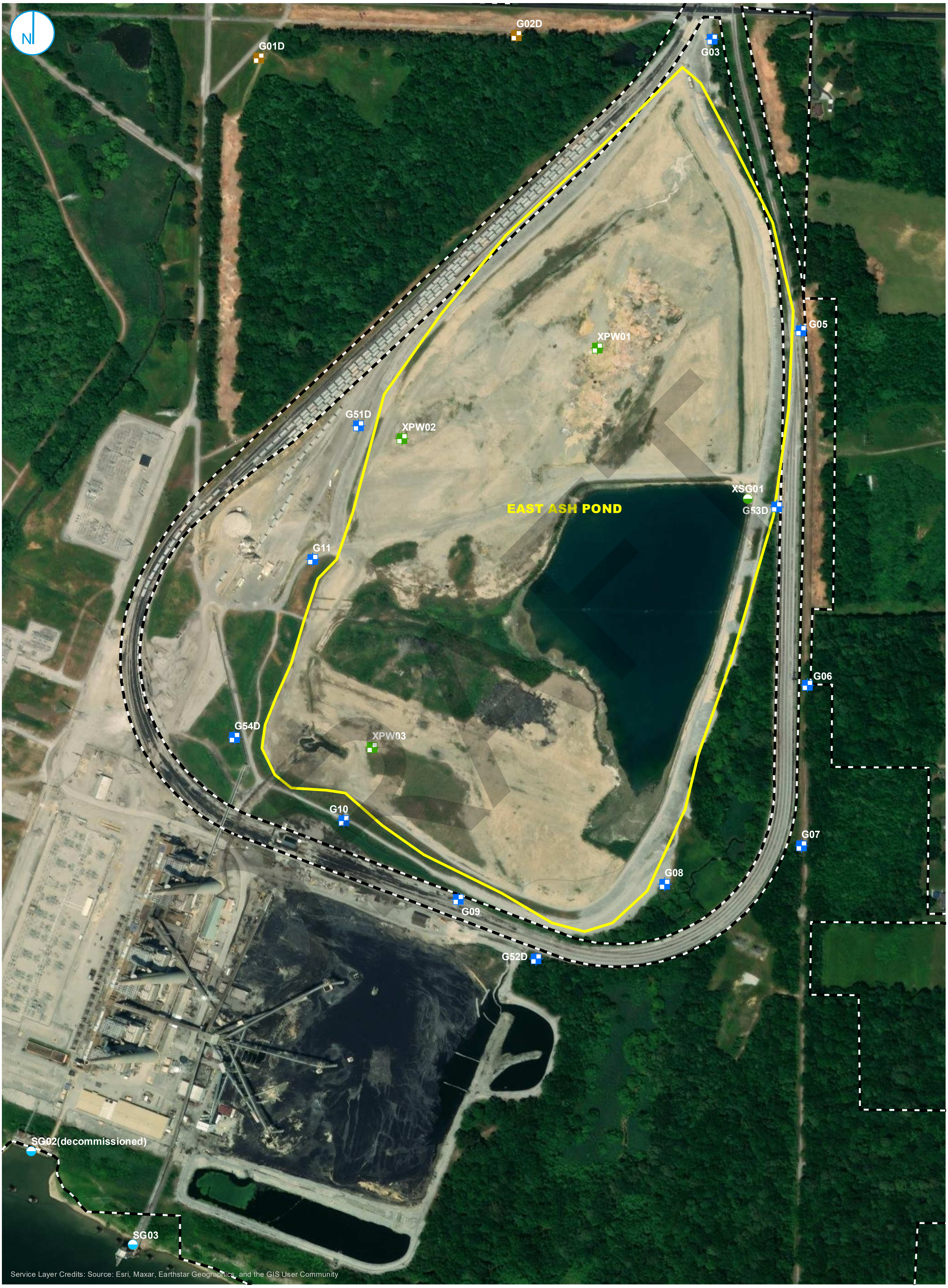
FIGURE 2-6

NATURE AND EXTENT REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

PROJECT: 169000XXXX | DATED: 4/10/2024 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\845_Quarterly_Reports\24Q1\JOP\Figure 1. Monitoring Well Network.mxd



Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- 🟦 COMPLIANCE MONITORING WELL
- 🟫 BACKGROUND MONITORING WELL
- 🟩 PORE WATER WELL
- ◒ STAFF GAGE, CCR UNIT
- ◒ STAFF GAGE, RIVER
- ▭ REGULATED UNIT (SUBJECT UNIT)
- ▭ PROPERTY BOUNDARY

0 200 400
Feet

MONITORING WELL LOCATION MAP

FIGURE 2-7

NATURE AND EXTENT REPORT
EAST ASH POND
JOPPA POWER PLANT JOPPA,
ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

PROJECT: 169000XXXX | DATED: 4/10/2024 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\Nature_and_Extent\JOP\Nature_and_Extent_Report\Figure 3-1. JOP 401 GWPS UA.mxd

● TOTAL BORON EXCEEDANCE

● COMPLIANCE WELL WITHOUT EXCEEDANCE

▭ REGULATED UNIT (SUBJECT UNIT)

▭ PROPERTY BOUNDARY

0 275 550 Feet

GWPS EXCEEDANCE MAP
UPPERMOST AQUIFER

FIGURE 3-1

NATURE AND EXTENT REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

APPENDICES

APPENDIX A
CCR Delineation Report

Prepared for

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

CCR INVESTIGATION AND DELINEATION REPORT

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

Prepared by

Geosyntec consultants
engineers | scientists | innovators

600 Roselane Court
Farmington, MO 63640

Project Number GLP8025

Revision 0

July 25, 2022

TABLE OF CONTENTS

FIGURES

TABLES

ATTACHMENTS

1. INTRODUCTION AND BACKGROUND

Electric Energy, Inc. (EEI) is the owner of the coal-fired Joppa Power Plant (JPP), also referred to as Joppa Power Station, in Joppa, Illinois. The JPP is currently active, although EEI intends to cease the generation of electricity by September of 2022. EEI intends to complete closure of the East Ash Pond (EAP) at the JPP (IEPA ID No. W1270100004-02, EEI CCR Unit ID 401, and National Inventory of Dams Number IL50714). Closure of the EAP will be performed under the relevant Illinois Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845) [1] and the United States Environmental Protection Agency (USEPA) CCR Rule [2].

The evaluation of closure alternatives and closure design requires the delineation of the lateral and vertical extents of coal combustion residuals (CCRs) contained both within and outside of the limits of the EAP. The delineation is required to support groundwater modeling, the development of permit-level closure design drawings, supporting closure alternatives assessments that consider the total volume of CCR that must be either closed in-place or closed-by-removal, and performing geotechnical assessments. Additionally, the delineation of the interface between fine-grained clay and coarse-grained sand foundation soils beneath the EAP was required for performing geotechnical assessments.

This report summarizes the existing data sources, a subsurface investigation program completed by Geosyntec in 2022, and the procedures used to develop three-dimensional models of the bottom of CCR, top of CCR, and bottom of foundation clay (e.g., top of coarse-grained sand foundation soils) units within and outside of the limits of the EAP.

1.1. Report Contents

The following information is contained within this report:

- **Section 1** includes the introduction and background.
- **Section 2** includes a summary of existing data sources utilized by Geosyntec and areas where CCR is known to be present within and outside the limits of the EAP.
- **Section 3** includes a summary of subsurface investigations completed by Geosyntec in 2022 to support CCR delineation.
- **Section 4** includes an overview of the development of three-dimensional subsurface models for use in design and estimates of CCR volumes.
- **Section 5** includes a summary of this CCR delineation and recommendations for further phases of work.

2. EXISTING DATA SOURCES AND HISTORICAL CCR PLACEMENT

2.1. Existing Data Sources

Multiple existing data sources, including topographic data and subsurface explorations, were utilized as part of the CCR delineation. These data sources included:

- Topographic Ground Surface Data
    - Light detection and ranging (LIDAR) topographical and bathymetric survey data of the EAP and immediate surrounding areas collected in December 2020 by IngenAE, LLC (IngenAE) [3], representing existing topographical conditions.
    - LIDAR topographical data of the area outside of the EAP collected in 2012 by the State of Illinois [4], representing existing topographical conditions beyond the limits of the IngenAE survey.
    - United States Geological Survey (USGS) topographic maps dated 1932 [5], representing topographical conditions prior to construction of the EAP.
    - Design drawings for the EAP perimeter dike, dated 1973 and 1982, showing topographical conditions prior to construction of the EAP in some areas and conditions prior to construction of dike raises in other areas ([6], [7], [8]).
    - The topographic ground surface data is provided in **Attachment A**.
- Subsurface Explorations
    - Geotechnical borings and cone penetration tests (CPTs) performed in and around the EAP in 2015 and 2016 by AECOM [9].
    - Geotechnical borings and monitoring well installations performed in and around the EAP by Geosyntec in 2021 [10].
    - The existing subsurface explorations are summarized in **Table 1**, shown in plan on **Figure 1**, and provided in **Attachment A**.

2.2. CCR Outside of the EAP Dike Limits

CCR is known to be located both within and outside the limits of the existing EAP perimeter dikes. The CCR located outside of the EAP perimeter dikes is herein referred to as the “Southeast Area”, and is subdivided into the following sub-areas:

- The Southeast Area – North is approximately 21 acres in size and is located between the southeastern corner of the EAP perimeter dikes and the railroad loop embankment.

- The Southeast Area – South is approximately 11 areas in size and is located south of the Southeast Area – North, between the railroad loop embankment and the Ohio River.

The limits of the Southeast Area – North and Southeast Area – South are shown in plan on **Figure 1**.

3. 2022 GEOSYNTEC SUBSURFACE INVESTIGATION

While subsurface investigation data was available within the footprint of the existing EAP, limited subsurface investigation data was available for the Southeast Area – North and no subsurface investigation data was available for the Southeast Area – South. To support the delineation of the horizontal and vertical extents of CCR within these areas, Geosyntec completed a subsurface investigation program using hand augers and direct push technology (DPT) borings in March and April of 2022, as described in this section.

Hand auger and DPT information is summarized in **Table 2**; the locations of the investigations are shown on **Figure 1**; photographs collected during the investigation program, including photographs of soil samples, are provided in **Attachment B**. The subsurface investigation logs are provided in **Attachment C**.

3.1. Hand Augers

A total of 13 hand augers were completed by Geosyntec in March and April 2022 (HA-01 through HA-13). The hand augers were advanced using a 3-inch diameter auger to depths ranging from 2.5 to 7.5 ft below grade. The hand augers were generally advanced to below the bottom of observed CCR materials, or until either refusal or borehole collapse occurred. Material obtained from each hand auger was observed and photographed by Geosyntec to develop a log of subsurface conditions at each hand auger location. Hand auger locations backfilled with soil cuttings and their locations were surveyed by IngenAE.

3.2. DPT Borings

A total of 11 DPT borings were completed by Geosyntec in April 2022 (GEO-01 and GEO-06 through GEO-15[1]). The DPT borings were advanced using either a track-mounted or skid-steer mounted direct-push drilling rig subcontracted to Roberts Environmental Drilling, Inc., with a borehole diameter of 2.25 inches and a soil sample diameter of 1.5 inches. The DPTs were advanced to depth ranging from 17.0 to 23.9 ft below grade, until refusal occurred on dense or stiff subsurface materials that the DPT was unable to penetrate. Soil obtained from each DPT was observed and photographed by Geosyntec to develop a log of subsurface conditions at each boring location. DPT locations were backfilled with bentonite chips and their locations were surveyed by IngenAE.

---

[1] DPT borings GEO-02 through GEO-05 were initially proposed and staked in the field but were unable to be accessed due to steep slopes and equipment access considerations. Therefore, DPTs were not advanced at these locations.

3.3. Summary of Subsurface Conditions

CCR and/or coal fines were encountered in hand augers HA-02, HA-03, and HA-04, but were not encountered in HA-01. CCR and/or coal fines were encountered in GEO-01 and GEO-09 through GEO-15), but not in GEO-06 through GEO-08.

Where the CCR and coal fines were encountered (which are herein jointly referred to as “CCR”), they were typically mixed and/or interbedded with soil and alluvial sediments into a single stratum. The CCR was generally observed to overly fine-grained native foundation soils, although CCR was encountered directly overlying alluvial sand in GEO-14. Photographs showing the interbedded and layered nature of the CCR and soil sediments are provided in **Attachment B**.

4. DEVELOPMENT OF THREE-DIMENSIONAL SUBSURFACE MODELS

Three-dimensional models of the bottom of CCR, top of CCR, and bottom of foundation clay were developed and volumes of CCR were estimated utilizing AutoCAD Civil 3D computer aided design (CAD) [11] and geographic information system (GIS) software. The three-dimensional models were generated utilizing available topographical and subsurface data obtained from others and collected by Geosyntec in 2021 and 2022. Where GIS was utilized, three-dimensional models were developed and interpolated from available data using a combination of the kriging method within Earth Volumetric Studio (EVS) [12] and the topo to raster method within ArcMap GIS software [13].

Three laterally-separate bottom of CCR surfaces were developed, including the Bottom of CCR within the EAP, the Bottom of CCR in the Southeast Area – North, Bottom of CCR in the Southeast Area – South. Additionally, a Top of CCR surface was developed in the Southeast Area – North, to delineate where the perimeter dike raise [6] was constructed over existing CCR. A Bottom of Clay surface was developed with lateral extents that were similar to all three of the Bottom of CCR surfaces.

4.1. Individual Surfaces

Four separate three-dimensional model surfaces, each representing the bottom of CCR that was indicated from the source data, were developed utilizing available topographic, bathymetric, and subsurface investigation data. Each of the surfaces included three separate sub-surfaces, with adjacent but not overlapping lateral extents, including the Bottom of CCR within the EAP, Bottom of CCR in the Southeast Area – North, and Bottom of CCR in the Southeast Area – South. Two Bottom of Clay surfaces were developed, including one surface for the EAP and the Southeast Area – North, and one surface for the Southeast Area – South. Procedures used to develop each of the four surfaces are described below.

- Existing Conditions Surface
    - The 2020 IngenAE LIDAR and bathymetric survey [3] was used to represent existing topographical conditions, including the ground surface beneath impounded water within the EAP.
    - The 2012 State of Illinois LIDAR survey [4] was used to represent existing topographical conditions in the Southeast Area – South, beyond the limits of the IngenAE survey.
        - It should be noted that this LIDAR survey was collected in an area of dense vegetation and may have been collected during a high-water event on the Ohio River, therefore the actual existing ground surface elevations may vary from this survey.

- Pre-Construction Surface
  - The 1932 USGS topographical map [5] was digitized and used to represent approximate conditions prior to construction of the EAP, and ground surface elevations and the presumed top-of-clay prior to the deposition of CCR into the EAP and the Southeast Area.
- Intermediate EAP Operations Surface
  - Design drawings for the construction of the EAP embankment and dike raises from 1973 [7] and 1982 [8] were digitized and were used to represent conditions during operation of the EAP.
    - These drawings showed pre-construction ground surfaces in some areas, but not all, of the EAP, and ground surface during intermediate operation of the EAP in other areas. Therefore, they represent the presumed top-of-clay prior to the deposition of CCR into these areas.
- Subsurface Investigation Surface
  - Composite surfaces were developed using observed bottom-of-CCR data, and, for the southeast Area – North, top-of-CCR data from subsurface investigations, including the sources listed below.
    - A total of 53 geotechnical borings and CPTs performed in and around the EAP in 2015 and 2016 by AECOM [9].
    - A total of three geotechnical borings and monitoring well installations performed in and around the EAP in 2021 by Geosyntec [10].
    - The 24 hand augers and DPTs advanced by Geosyntec in 2022, as described in **Section 3**.
- Each of the four surfaces were compared, and, where the surface intersected, the lowest elevation surface was conservatively assumed to represent the bottom of CCR.
- Where the CCR was adjacent to the earthen EAP dikes, the interior slopes of the interface between the dikes and CCR was assumed to be 1.5H:1V (horizontal to vertical) based on design drawings [7].
- Within the Southeast Area, the lateral limits of the CCR were developed based on the observed boring data (e.g., where CCR was no longer located in borings), and based on an

examination of the existing conditions topography (e.g., CCR was not assumed to be present beyond the horizontal limits of the valley floor outside of the creek channel).

  - Additionally, CCR was not assumed to be present beneath the rail loop, as CCR was not observed beneath the rail loop in limited subsurface investigations completed along the edges of the rail loop fill by AECOM in 2015 [9].

The resulting composite bottom-of-CCR and top-of-CCR surfaces were then constructed and are provided in **Figures 2**, **3**, and **4**.

4.2. Bottom of Clay

A composite Bottom-of-Clay surface was developed using bottom-of-clay observed from subsurface investigation data, using the same data sources as utilized for the bottom-of-CCR described in **Section 4.1**.

The bottom-of-clay was defined by Geosyntec by reviewing each boring or CPT log and identifying where the clay transitioned to a material which was sandier in nature and expected to behave in a drained manner during geotechnical loading conditions. It should be noted that Geosyntec's bottom-of-clay surface is similar, but not the same, as the top of the uppermost aquifer evaluated by others. This is because Geosyntec's surface is based on a geotechnical assessment of the foundation soils, considering shear strength, rather than a hydrogeological assessment, which would be based on permeability.

The resulting surface is provided in **Figure 5**. Similar to the CCR surfaces, Geosyntec did not extend the surface beneath the rail loop, due to relatively limited subsurface investigation data indicating the bottom of clay in that area.

4.3. Volume Estimates

The surfaces described in **Section 4.1** were used to estimate the volume of CCR present within the EAP, in the Southeast Area – North, and in the Southeast Area – South. Each volume estimate was performed using CAD. Estimated volumes are summarized is described below.

- The volume of CCR within the EAP was estimated to be 5.8 million cubic yards, by comparing the existing conditions topographic and bathymetric survey [3] and the bottom of CCR surface.

- The volume of CCR in the Southeast Area – North was estimated to be 80,000 cubic yards, by comparing the existing conditions topographic survey [3], the bottom of CCR surface, and the top of CCR surface.

- The volume of CCR in the Southeast Area – South was estimated to be 450,000 cubic yards, by comparing the existing conditions topographic survey [4] and the bottom of CCR surface.

5. SUMMARY AND RECOMMENDATIONS

Geosyntec developed three-dimensional models to delineate the vertical and horizontal extents of CCR within the EAP, the Southeast Area – North, and the Southeast Area – South using available:

- Existing subsurface investigation data;
- Subsurface investigation data collected by Geosyntec in 2022; and
- Available recent and historical topographical and bathymetric survey data.

These three-dimensional model surfaces were used to estimate volumes of CCR present within the EAP (5.8 million cubic yards), in the Southeast Area – North (80,000 cubic yards), and in the Southeast Area – South (450,000 cubic yards).

These three-dimensional models should be considered approximate and were based on the best available data. However, subsurface investigation data is not currently available to verify the surfaces within significant areas of the EAP, and the scope of the subsurface investigation for the Southeast Area – North and Southeast Area – South was limited due to site access concerns. Additionally, the existing ground surface elevations within the Southeast Area – South may vary from the 2012 State of Illinois LIDAR survey of the area. Therefore, the actual bottom of CCR, top of CCR, bottom of clay, and volumes of CCR may vary from these surfaces and estimates. If a refined estimate of the bottom of CCR and/or bottom of clay is required, additional subsurface investigation data should be collected and the surfaces presented in this report should be updated, as and if appropriate.

6. REFERENCES

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

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

[3] IngenAE, LLC, Electric Engergy, Inc., Joppa Power Station, December 2020 Topography, 2021.

[4] Illinois Geospatial Data Clearinghouse, "Massac, 2012," 2012. [Online]. Available: Massac, 2012 | clearinghouse.isgs.illinois.edu.. [Accessed 2022].

[5] United States Geologic Survey (USGS), L.A. Center Kentucky-Illinois Quandrangle, 1932.

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

[7] Wapora, Inc., Electric Energy, Inc. East Ash Pond Plan, Sections and Details, 1973.

[8] Electric Energy, Inc., Joppa, IL, East Ash Pond, 4229-8211, 1982.

[9] AECOM, CCR Certification Report: Initial Structural Stability Assessment, Initial Factor of Safetey Assessment, and Initial Inflow Design Flood Control System Plan for East CCR Pond at Joppa Power Station, 2016.

[10] Geosyntec Consultants, Illinois Administrative Code Part 845 Data Gap Analysis - Site: Joppa East Pond-CCR Unit 401, 2021.

[11] Autodesk, *AutoCAD Civil3D,* San Rafael, CA, 2022.

[12] C Tech Development Corporation, *Earth Volumetric Studio, Version 2021.4.3,* Las Vegas, 2021.

[13] ESRI, *ArcMap, Version 10.8.1,* Redlands, California, 2020.

FIGURES

Legend

● Geosyntec Boring Locations
● AECOM Boring Locations
— Limits of EAP
— Limits of Southeast Area - North
— Litmits of Southeast Area - South
—+— Rail Loop

NOTES:
1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.
2.THE EXTENTS OF CCR PRESENTED IN THESE DRAWINGS SHOULD BE CONSIDERED APPROXIMATE, DUE TO LIMITED INVESTIGATION DATA TO CONFIRM THE EXTENTS OF CCR.

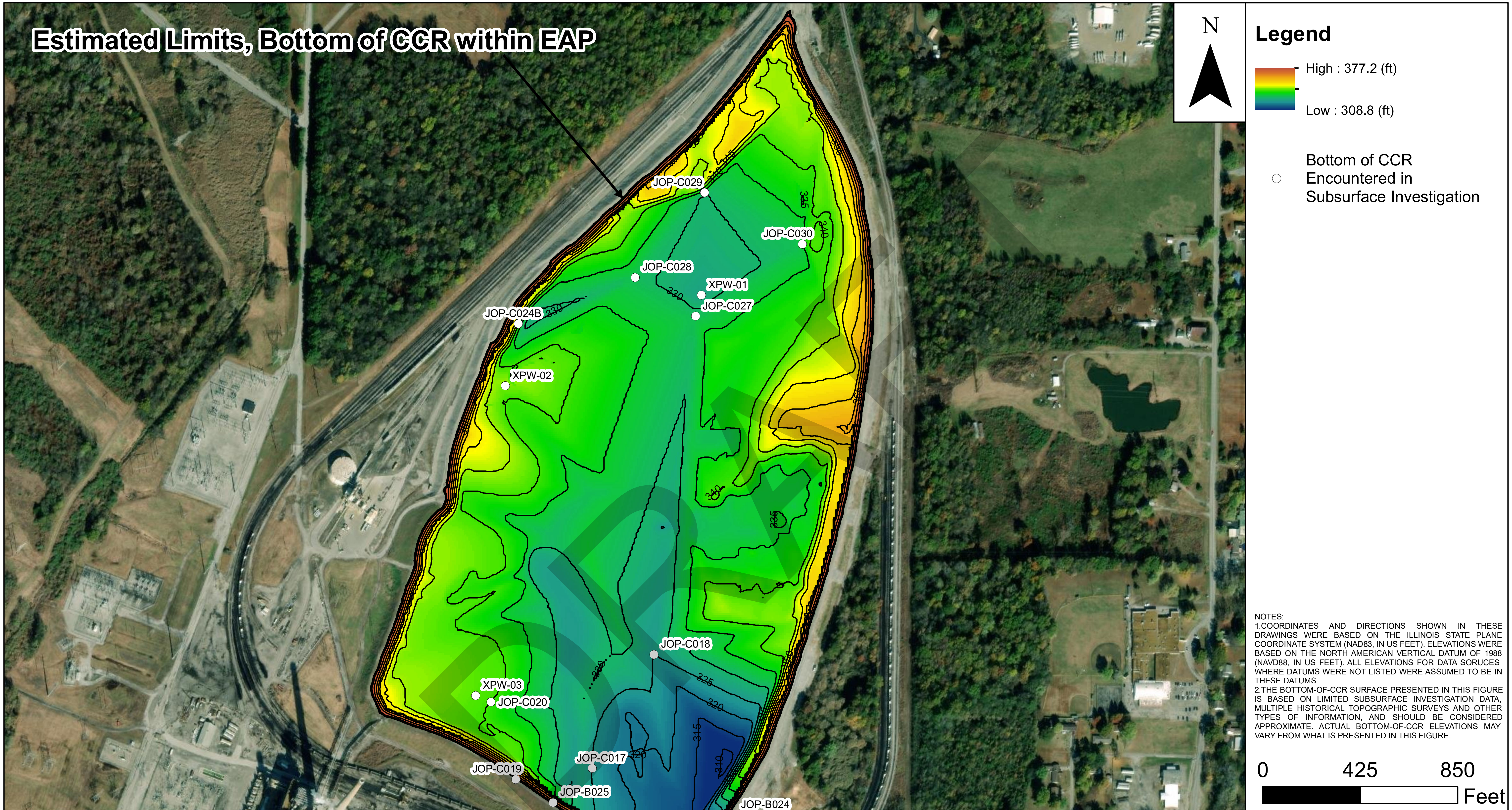
0 810 1,620
Feet

Site Plan
East Ash Pond
Joppa Power Plant
Joppa, Illinois

Geosyntec
consultants

GLP8025
6/1/2022

Figure
1



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

NOTES:

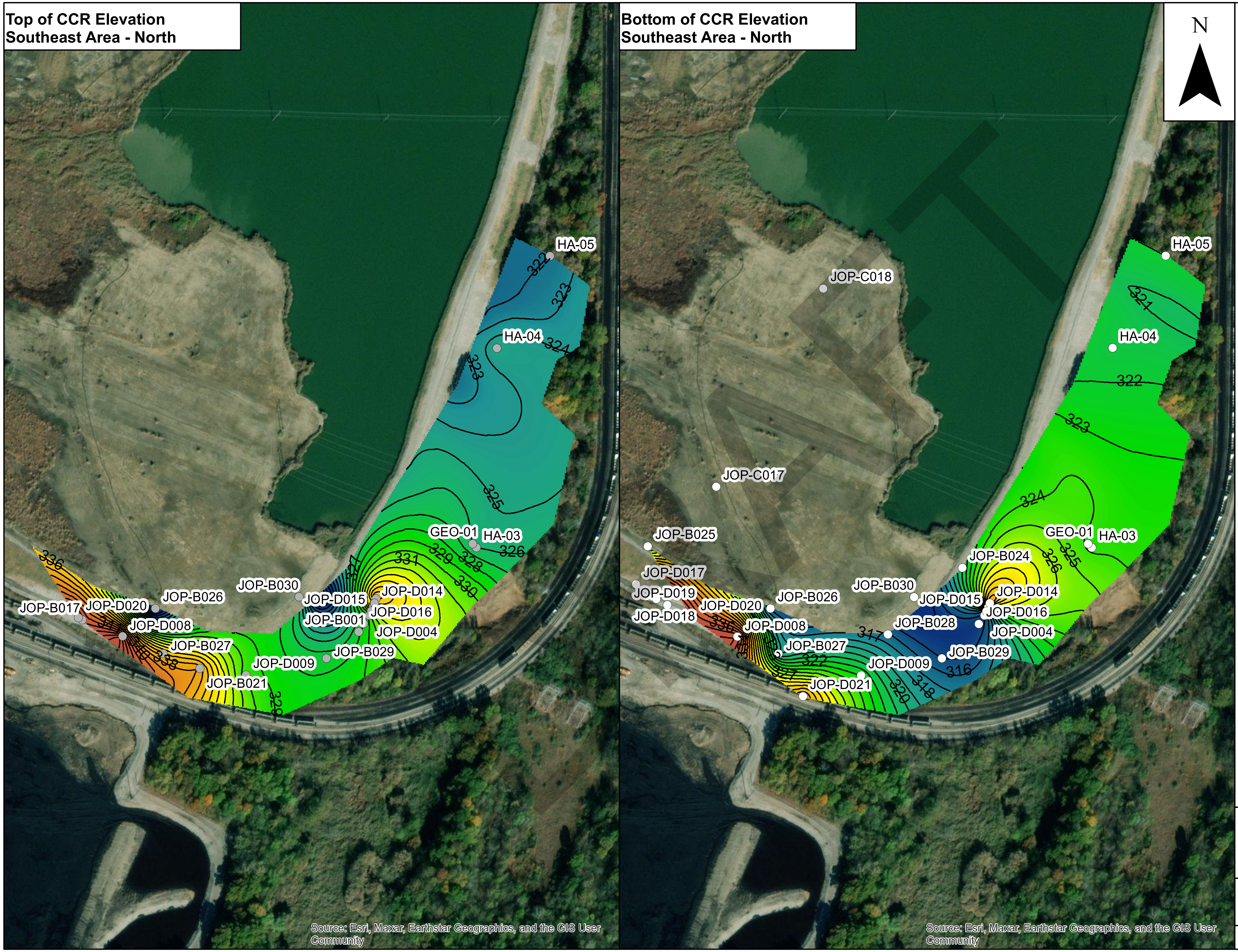
1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.

2.THE BOTTOM-OF-CCR SURFACE PRESENTED IN THIS FIGURE IS BASED ON LIMITED SUBSURFACE INVESTIGATION DATA, MULTIPLE HISTORICAL TOPOGRAPHIC SURVEYS AND OTHER TYPES OF INFORMATION, AND SHOULD BE CONSIDERED APPROXIMATE. ACTUAL BOTTOM-OF-CCR ELEVATIONS MAY VARY FROM WHAT IS PRESENTED IN THIS FIGURE.

Bottom of CCR Elevations within EAP,
Joppa Power Plant
Joppa, Illinois

Geosyntec consultants

GLP8025	6/1/2022	Figure 2



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Legend

● Top of CCR Encountered in Subsurface Investigation

○ Bottom of CCR Encountered in Subsurface Investigation

Top of CCR

Value

High : 345.6 (ft)

Low : 314.6 (ft)

Bottom of CCR

High : 338.3 (ft)

Low : 313.0 (ft)

NOTES:

1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.

2.THE BOTTOM-OF-CCR AND TOP-OF-CCR SURFACES PRESENTED IN THIS FIGURE ARE BASED ON LIMITED SUBSURFACE INVESTIGATION DATA, MULTIPLE HISTORICAL TOPOGRAPHIC SURVEYS, AND OTHER TYPES OF INFORMATION, AND SHOULD BOTH BE CONSIDERED APPROXIMATE. ACTUAL BOTTOM-OF-CCR AND TOP-OF-CCR ELEVATIONS MAY VARY FROM WHAT IS PRESENTED IN THIS FIGURE.

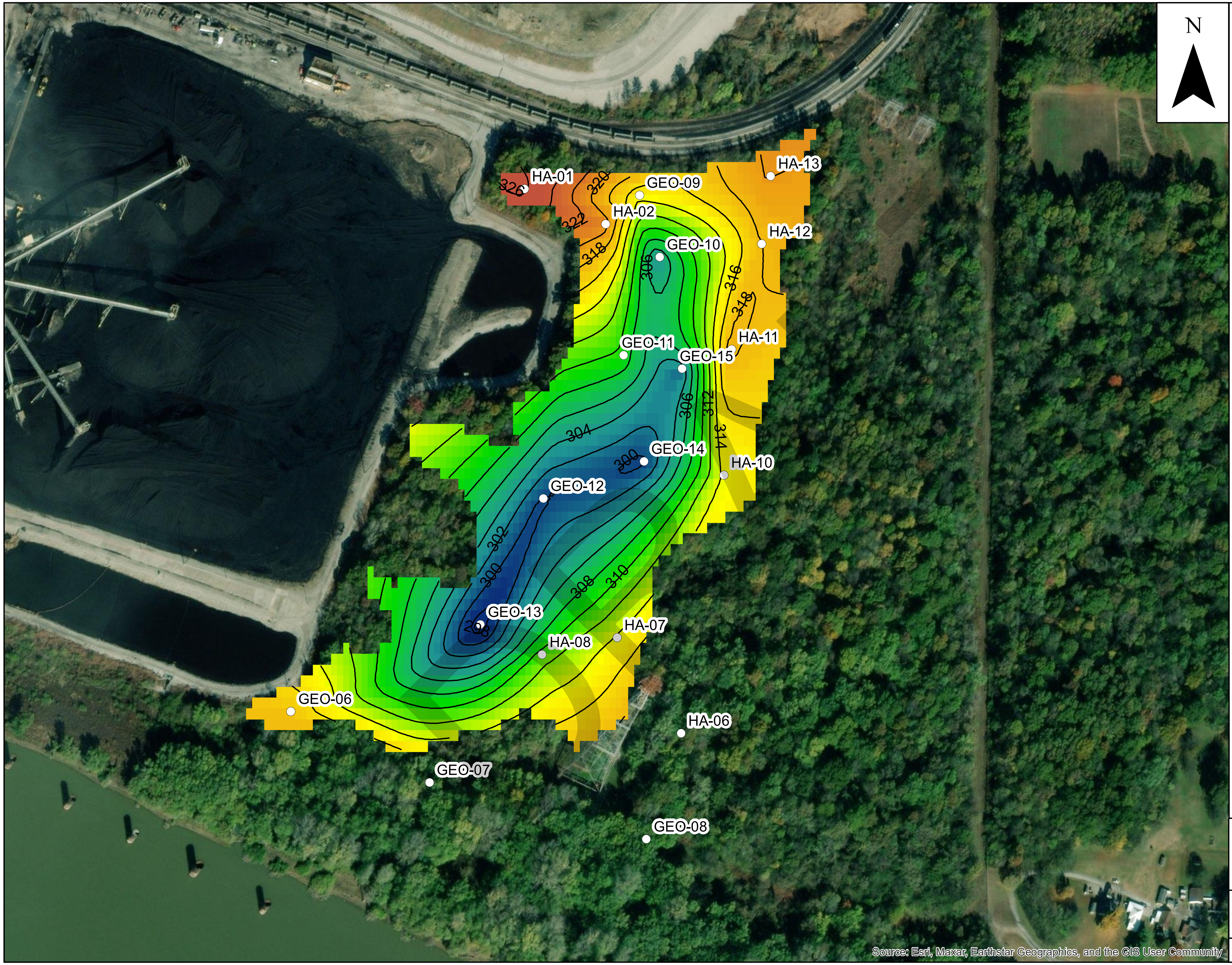
0 225 450 Feet

Top and Bottom of CCR Elevations within Southeast Area - North East Ash Pond, Joppa Power Plant, Joppa, Illinois

Geosyntec consultants

Figure 3

GLP8025 6/1/2022



Legend

○ Bottom of CCR Encountered in Subsurface Investigation

Bottom of CCR

High : 326.4 (ft)

Low : 296.7 (ft)

NOTES:

1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.

2.THE BOTTOM-OF-CCR AND TOP-OF-CCR SURFACES PRESENTED IN THIS FIGURE ARE BASED ON LIMITED SUBSURFACE INVESTIGATION DATA, MULTIPLE HISTORICAL TOPOGRAPHIC SURVEYS AND OTHER TYPES OF INFORMATION, AND SHOULD BE CONSIDERED APPROXIMATE. ACTUAL BOTTOM-OF-CCR AND TOP-OF-CCR ELEVATIONS MAY VARY FROM WHAT ARE PRESENTED IN THIS FIGURE.

0 225 450 Feet

Bottom of CCR Elevations
within Southeast Area - South
East Ash Pond, Joppa Power Plant
Joppa, Illinois

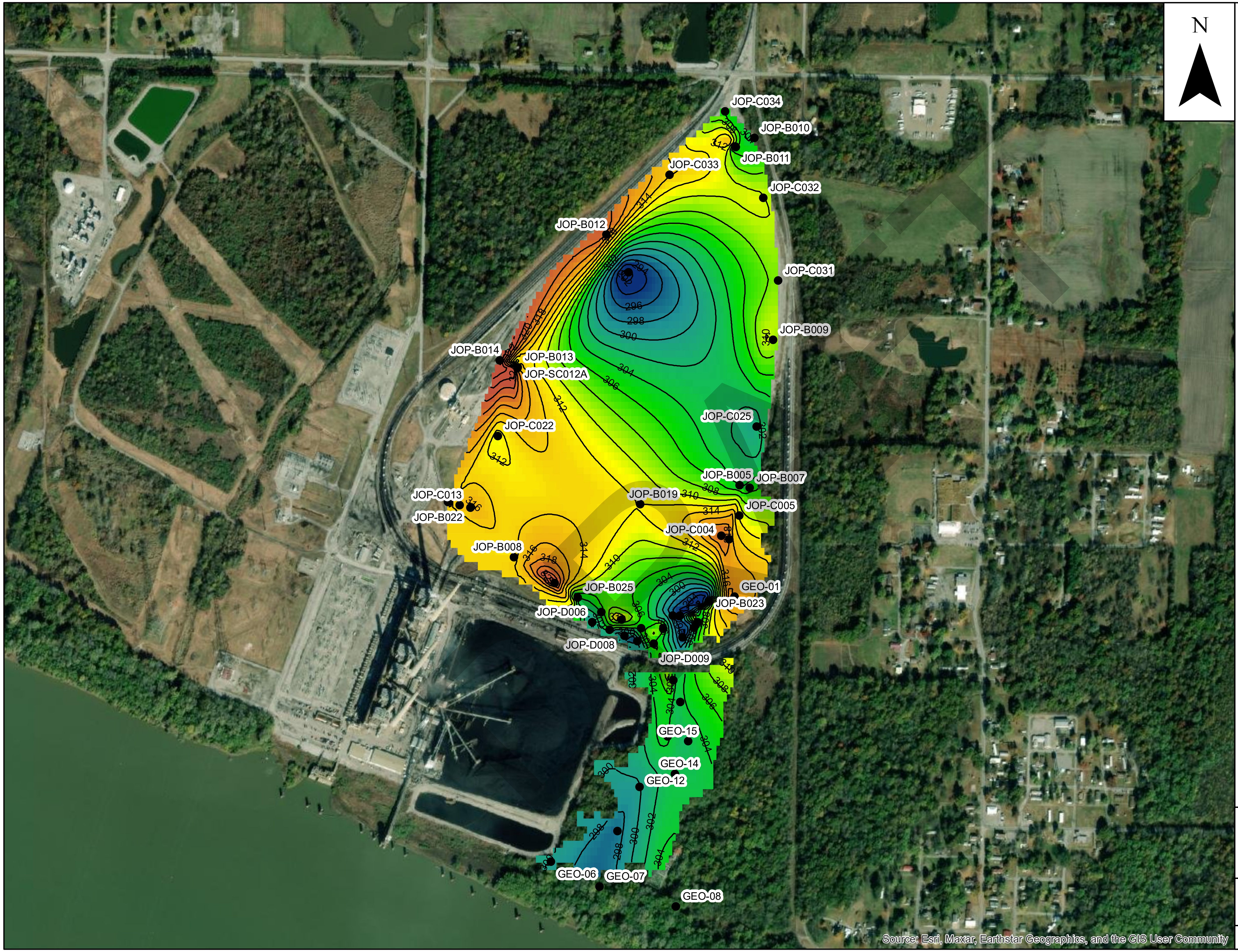
Geosyntec
consultants

GLP8025

6/1/2022

Figure

4



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Legend

High : 328.7 (ft)

Low : 290.8 (ft)

● Bottom of Clay Encountered in Subsurface Investigation

NOTES:

1.COORDINATES AND DIRECTIONS SHOWN IN THESE DRAWINGS WERE BASED ON THE ILLINOIS STATE PLANE COORDINATE SYSTEM (NAD83, IN US FEET). ELEVATIONS WERE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET). ALL ELEVATIONS FOR DATA SORUCES WHERE DATUMS WERE NOT LISTED WERE ASSUMED TO BE IN THESE DATUMS.

2.THE BOTTOM-OF-CLAY SURFACE PRESENTED IN THIS FIGURE IS BASED ON LIMITED SUBSURFACE INVESTIGATION DATA AND SHOULD BE CONSIDERED APPROXIMATE. ACTUAL BOTTOM-OF-CLAY ELEVATIONS MAY VARY FROM WHAT IS PRESENTED IN THIS FIGURE.

0 680 1,360 Feet

Bottom of Clay Elevations
East Ash Pond
Joppa Power Plant
Joppa, Illinois

Geosyntec consultants

GLP8025	6/1/2022	Figure 5

TABLES

July 2022

Table 1: Existing Investigation Data

Exploration ID	Northing (ft NAD83)	Easting (ft NAD83)	Ground Surface Elevation (ft NAVD88)	Estimated Layer Elevations (ft NAVD88)		
				Bottom of CCR	Top of CCR in SE Dike	Bottom of Clay
2015 AECOM Investigation						
JOP-B001	198,339.4	833,368.3	333.6	315.6	327.6	290.1
JOP-B002	198,526.7	833,473.7	341.5	NE	NA	285.6
JOP-B004	198,426.3	833,270.9	379.0	310.0	314.5	290.5
JOP-B005	199,345.5	833,690.4	379.9	NE	NA	303.9
JOP-B006	198,964.5	833,617.0	357.1	NE	NA	320.1
JOP-B007	199,326.6	833,760.8	347.6	NE	NA	303.6
JOP-B008	198,838.5	832,101.2	380.4	NE	NA	312.4
JOP-B009	200,368.5	833,926.1	378.8	NE	NA	310.3
JOP-B010	201,791.2	833,794.1	350.0	NE	NA	303.5
JOP-B011	201,732.5	833,659.5	380.0	NE	NA	316.5
JOP-B012	201,111.0	832,753.5	379.6	NE	NA	321.6
JOP-B013	200,176.2	832,128.5	379.3	NE	NA	307.3
JOP-B014	200,225.8	832,001.4	361.8	NE	NA	329.8
JOP-B015	199,187.8	831,795.1	380.3	NE	NA	316.8
JOP-B017	198,369.4	832,674.8	347.2	339.2	342.2	NE
JOP-B018	198,450.7	832,716.5	378.6	NE	NA	303.1
JOP-B019	199,211.3	832,989.8	376.1	325.1	NA	312.1
JOP-B020	198,337.4	832,996.0	378.1	NE	NA	305.1
JOP-B021	198,247.4	832,969.4	344.0	330.5	338.0	296.0
JOP-B022	199,227.6	831,636.1	353.4	NE	NA	314.1
JOP-B023	198,526.7	833,473.7	341.5	300.5	NA	292.5
JOP-C004	198,989.8	833,562.6	380.6	NE	NA	320.8
JOP-C005	199,130.6	833,688.6	344.0	NE	NA	316.5
JOP-C013	199,204.9	831,720.2	354.0	NE	NA	314.0
JOP-C017	198,703.0	832,722.1	377.6	334.1	NA	NE
JOP-C018	199,199.8	832,990.7	376.2	325.2	NA	0.0
JOP-C019	198,655.5	832,387.7	380.0	380.0	NA	326.3
JOP-C020	198,992.1	832,279.5	378.8	345.3	NA	NE
JOP-C021	198,847.0	832,092.2	380.0	380.0	NA	0.0
JOP-C022	199,692.4	831,988.8	379.5	379.5	NA	310.7
JOP-C024	200,642.3	832,399.8	373.8	327.8	NA	NE
JOP-C024A	200,642.3	832,399.8	373.8	373.8	NA	NE
JOP-C024B	200,642.3	832,399.8	373.8	373.8	NA	NE
JOP-C025	199,758.8	833,810.6	380.3	380.3	NA	300.3
JOP-C027	200,675.5	833,173.1	380.5	331.5	NA	0.0
JOP-C028	200,844.1	832,909.1	373.4	331.4	NA	290.4
JOP-C029	201,214.5	833,211.5	373.0	330.0	NA	NE
JOP-C030	200,989.8	833,638.7	371.7	332.2	NA	NE
JOP-C031	200,786.5	833,960.8	378.7	NE	NA	308.2
JOP-C032	201,370.3	833,857.1	381.2	NE	NA	310.7
JOP-C033	201,531.9	833,197.9	379.4	NE	NA	314.9
JOP-C034	201,978.0	833,588.0	380.3	NE	NA	305.8
JOP-B027	198,284.6	832,878.2	343.5	330.5	337.0	297.5
JOP-B028	198,333.0	833,152.3	378.0	NE	NA	310.0
JOP-B030	198,426.6	833,218.3	381.0	312.0	NA	298.0
JOP-D006	198,380.9	832,653.7	346.4	NE	NA	298.9
JOP-D008	198,327.8	832,775.7	345.9	337.9	345.4	303.9
JOP-D009	198,230.3	833,085.6	341.6	322.8	NA	307.1
JOP-D012	198,422.2	833,411.4	337.5	336.5	337.0	NE
JOP-D013	198,400.8	833,404.0	335.9	332.9	335.4	NE
JOP-D014	198,411.3	833,407.5	336.0	332.7	333.7	NE
JOP-D015	198,391.0	833,399.3	335.3	315.8	332.3	NE
JOP-D016	198,359.4	833,380.5	333.4	NE	327.4	311.4
2021 Geosyntec Investigation						
XPW-01	200,767.2	833,197.3	380.7	326.7	NA	NE
XPW-02	200,371.3	832,342.6	373.2	345.4	NA	NE
XPW-03	199,020.7	832,213.2	378.6	341.6	NA	NE

NA = Not applicable
NE = Not encountered

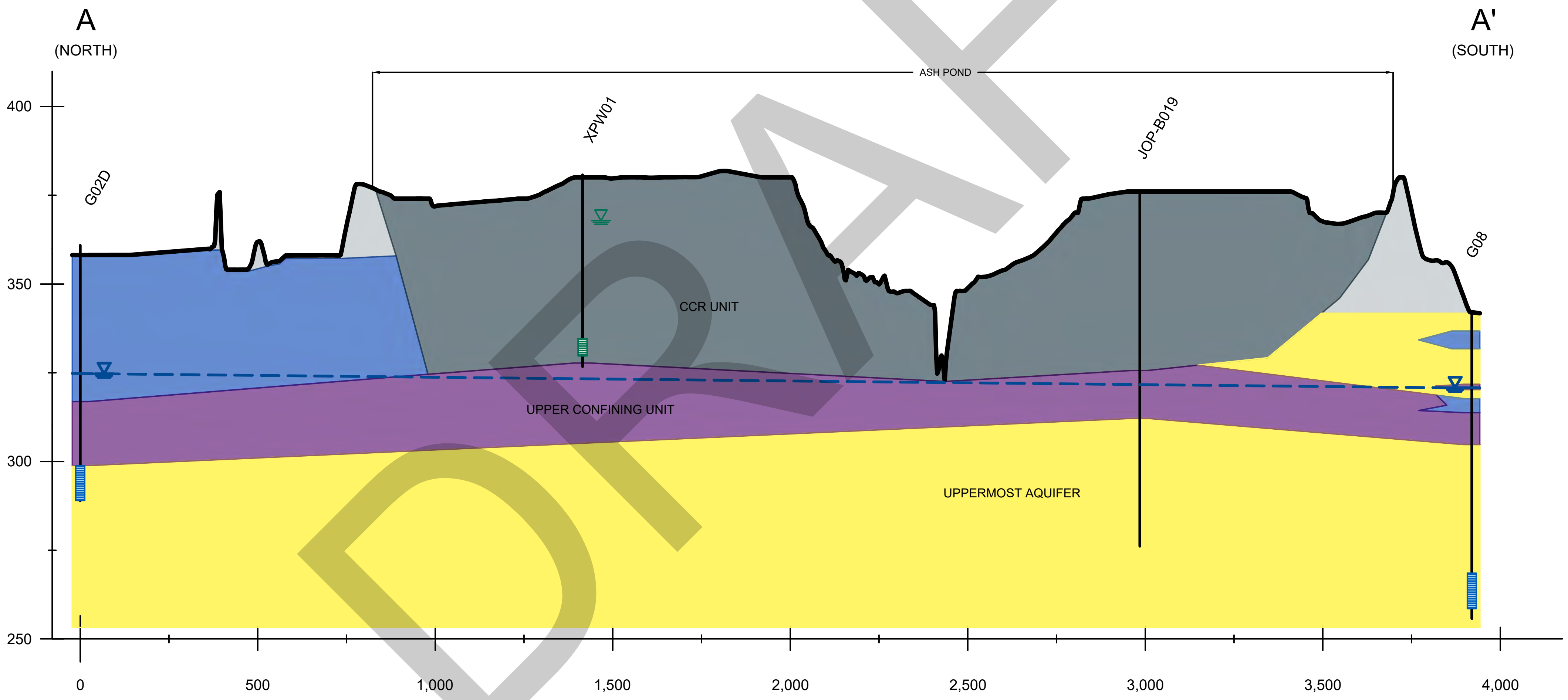
Table 2 – SE Investigation Data

Exploration ID	Northing (ft NAD83)	Easting (ft NAD83)	Ground Surface Elevation (ft NAVD88)	Total Depth (ft NAVD88)	Estimated Layer Elevations (ft NAVD88)	
					Bottom of CCR	Bottom of Clay
GEO-01	198,560.1	833,653.8	328.9	19.9	323.4	318.4
GEO-06	196,693.9	832,361.5	319.2	22.5	317.7	300.2
GEO-07	196,518.8	832,703.9	319.1	23.9	NE	295.6
GEO-08	196,378.4	833,240.6	321.4	19.9	NE	306.9
GEO-09	197,970.7	833,223.6	323.0	17.0	314.5	309.5
GEO-10	197,817.7	833,273.4	321.6	19.4	303.6	302.6
GEO-11	197,575.3	833,184.1	320.0	19.1	309.5	305.0
GEO-12	197,220.8	832,985.3	318.0	19.5	299.5	NE
GEO-13	196,909.6	832,830.1	314.5	18.0	296.5	NE
GEO-14	197,312.2	833,234.8	319.1	19.9	299.2	303.1
GEO-15	197,541.7	833,329.0	321.1	19.8	301.3	302.1
HA-01	197,986.0	832,939.4	330.9	4.3	326.4	NE
HA-02	197,899.2	833,140.2	326.3	6.0	321.3	NE
HA-03	198,550.8	833,663.0	327.1	5.0	323.6	NE
HA-04	199,050.8	833,715.1	328.0	7.0	321.5	NE
HA-05	199,281.8	833,847.8	329.9	2.5	NE	NE
HA-06	196,640.7	833,326.7	322.2	7.0	NE	NE
HA-07	196,877.1	833,168.5	315.8	2.2	314.3	NE
HA-08	196,834.6	832,982.8	314.5	4.0	311.2	NE
HA-09	196,906.5	832,831.8	324.6	3.0	NE	NE
HA-10	197,278.7	833,432.3	319.1	6.5	314.1	NE
HA-11	197,589.6	833,451.3	321.2	7.5	318.7	NE
HA-12	197,849.9	833,526.1	322.5	4.8	317.7	NE
HA-13	198,018.0	833,548.3	323.1	4.0	320.1	NE
NE = Not encountered						

APPENDIX B
Hydrogeologic Site Characterization Report and Supplemental Site Investigation Report Cross Sections

\\ramboll.sharepoint.com@SSL\DavWWWRoot\sites\vistra\Shared Documents\-CCR GW\Deliverables\Part 845 Operating Permits\Sites\Joppa\HCR\Figures\CAD working files\Joppa East Cross Sections.dwg
DATED: 10/5/2021 DESIGNER: ENGELHSA
PROJECT: 1940100806

NOTES
1. This profile was developed by interpolation between widely spaced boreholes. Only at the borehole location should it be considered as an approximately accurate representation and then only to the degree implied by the notes on the borehole logs.
2. Scale is approximate.
3. Vertical scale is exaggerated 10X.
4. Groundwater elevations measured on April 13-14, 2021.



LEGEND

- ⬛ COAL COMBUSTION RESIDUALS (CCR)
- ⬜ FILL
- 🟪 CLAY (CL/CH)
- 🟦 SILT (ML)
- 🟨 SAND (SP/SM/SW)
- WELL SCREEN INTERVAL
- UPPERMOST AQUIFER POTENTIOMETRIC SURFACE
- ▽ UPPERMOST AQUIFER GROUNDWATER ELEVATION
- ▽ POREWATER ELEVATION

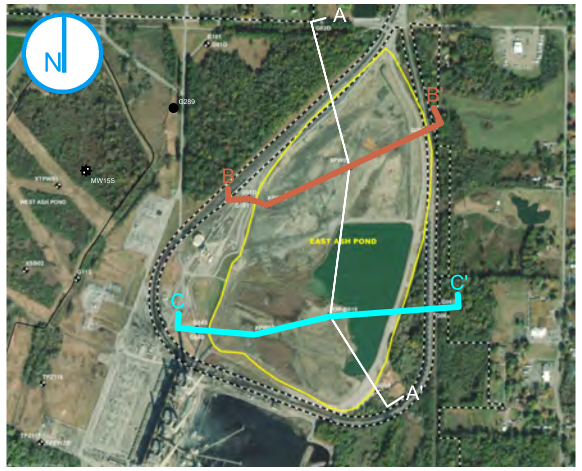
40'
0
400'

GEOLOGIC CROSS SECTIONS
A-A'

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

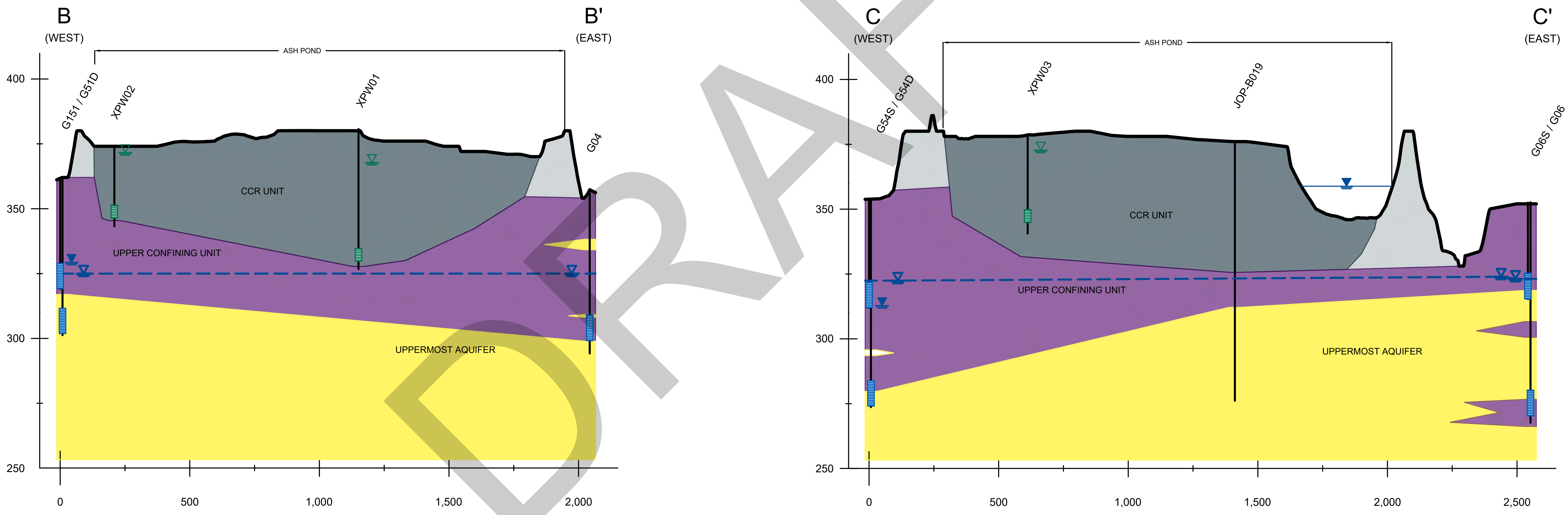
FIGURE 2-7

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



NOTES

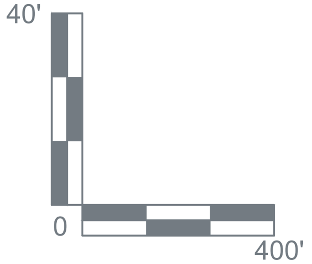
1. This profile was developed by interpolation between widely spaced boreholes. Only at the borehole location should it be considered as an approximately accurate representation and then only to the degree implied by the notes on the borehole logs.
2. Scale is approximate.
3. Vertical scale is exaggerated 10X.
4. Groundwater elevations measured on April 13-14, 2021.



LEGEND

▇	COAL COMBUSTION RESIDUALS (CCR)
▢	FILL
▇	CLAY (CL/CH)
▇	SAND (SP/SM/SW)

▤	WELL SCREEN INTERVAL
- - -	UPPERMOST AQUIFER POTENTIOMETRIC SURFACE
▼	UPPERMOST AQUIFER GROUNDWATER ELEVATION
▽	POREWATER ELEVATION
▼	BEDROCK GROUNDWATER / OTHER GROUNDWATER / SURFACE WATER ELEVATION(S)



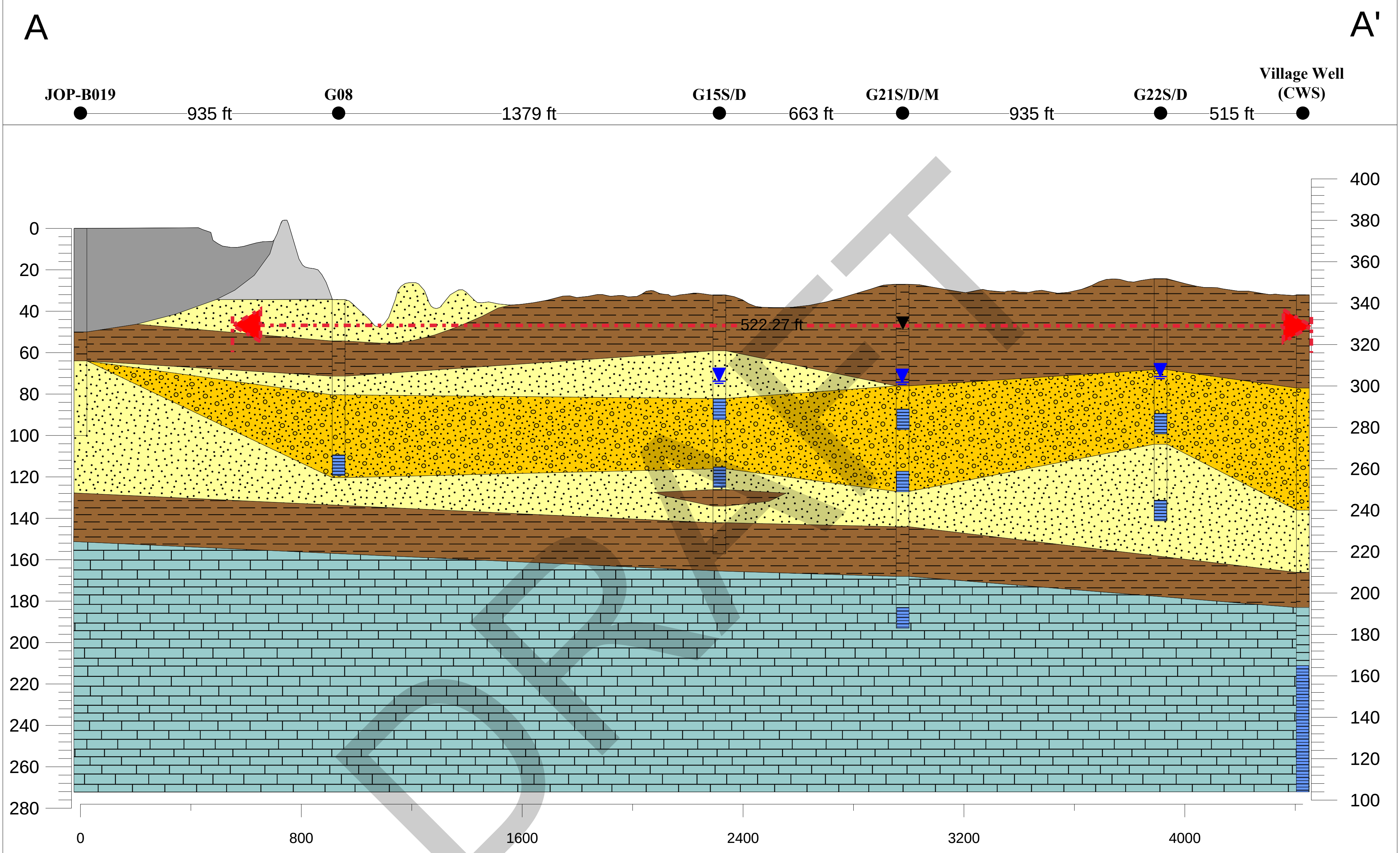
GEOLOGIC CROSS SECTIONS
B-B' & C-C'

HYDROGEOLOGIC SITE CHARACTERIZATION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-8

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



Lithology

- ▩ ASH
- ▤ CLAY
- ▨ GRAVEL
- ▢ FILL
- ▦ SAND
- ▦ LIMESTONE

Well Construction

- ▤ Screen

Notes:
1. Scale is approximate; all units of length are in feet.
2. Vertical exaggeration is 7.5x.
3. This section was created using widely spaced boreholes; thus, all interpretation away from borehole locations should be considered an approximate representation.
4. The elevation profile was derived from topographic data provided by Google Earth.
5. Water levels represent measured elevations in November of 2022. Blue symbols reflect UA potentiometric surface; measurements from the deeper UA wells are displayed. Black symbols reflect the LAU potentiometric surface.

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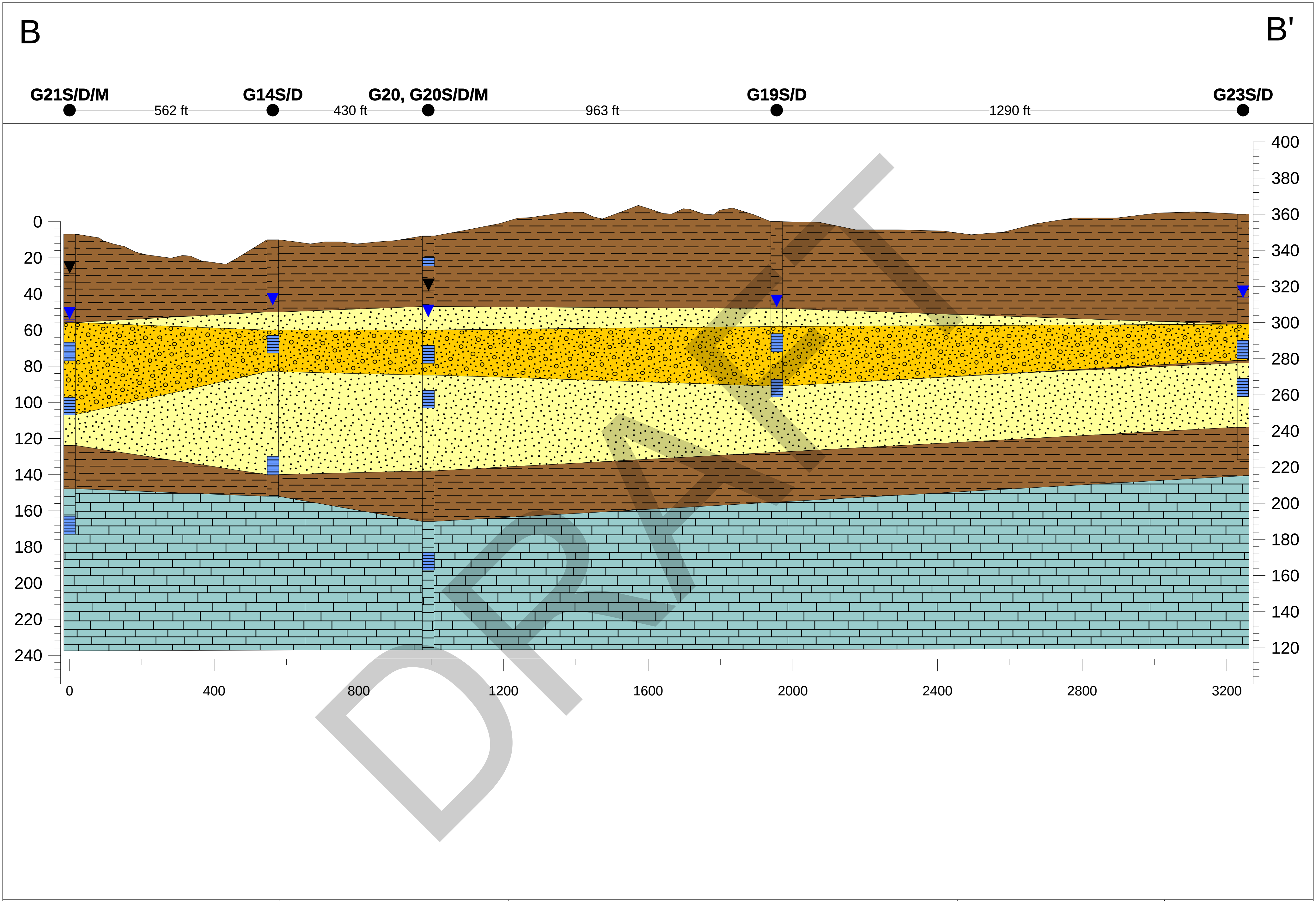
Cross Section A-A'
Joppa Power Plant
Joppa, IL

Columbus, OH	Figure
January 2023	3



Lithology

▨	CLAY	▨	GRAVEL
▨	SAND	▨	LIMESTONE

Well Construction

▤ Screen

Notes:
1. Scale is approximate; all units of length are in feet.
2. Vertical exaggeration is 5x.
3. This section was created using widely spaced boreholes; thus, all interpretation away from borehole locations should be considered an approximate representation.
4. The elevation profile was derived from topographic data provided by Google Earth.
5. Water levels represent measured elevations in November of 2022. Blue symbols reflect UA potentiometric surface; measurements from the deeper UA wells are displayed. Black symbols reflect the LAU potentiometric surface.

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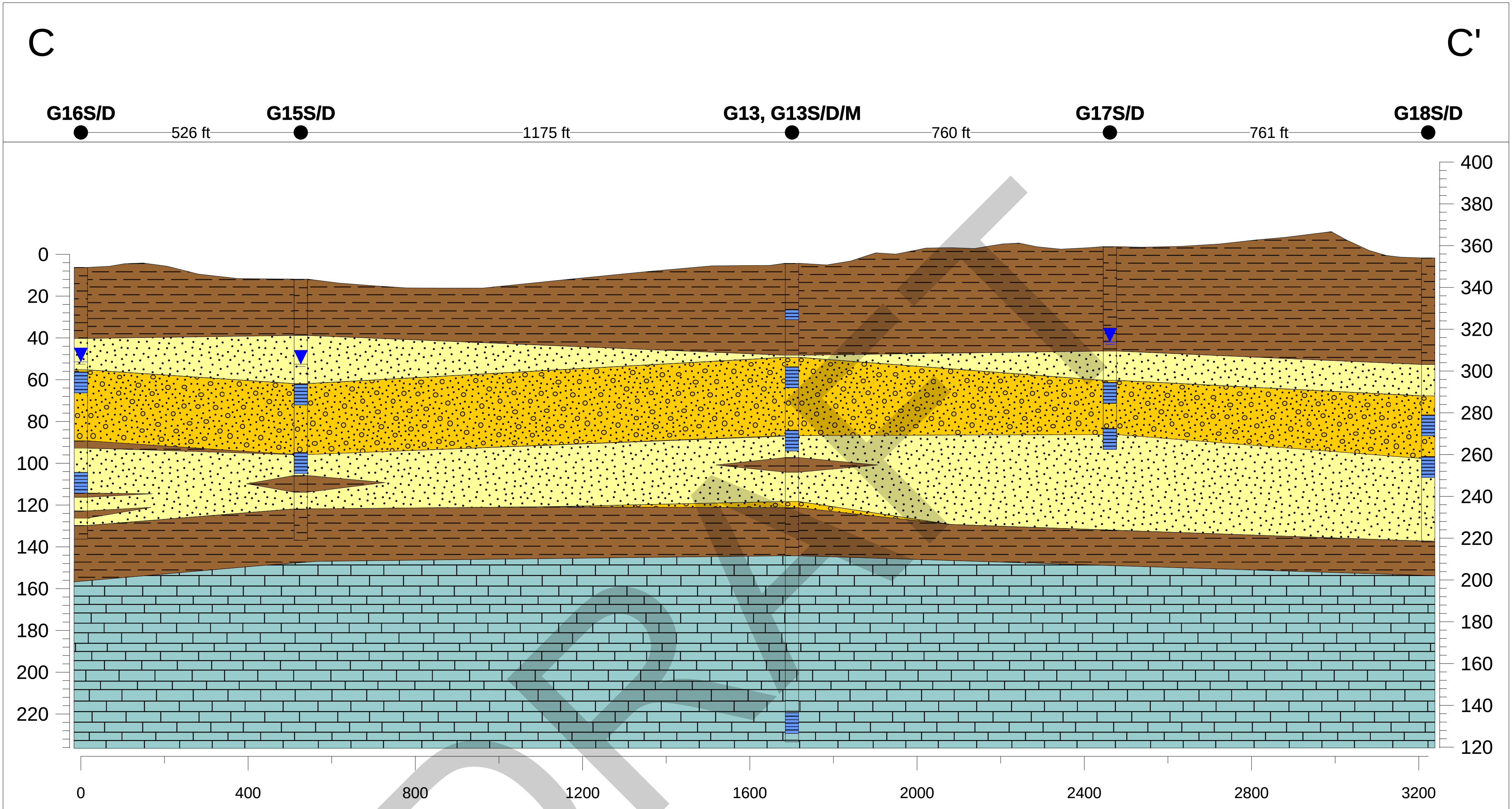
Cross Section B-B'
Joppa Power Plant
Joppa, IL

Columbus, OH

January 2023

Figure
4



Lithology

▤ CLAY
▨ GRAVEL
▨ SAND
▦ LIMESTONE

Well Construction

▤ Screen

Notes:
1. Scale is approximate; all units of length are in feet.
2. Vertical exaggeration is 5x.
3. This section was created using widely spaced boreholes; thus, all interpretation away from borehole locations should be considered an approximate representation.
4. The elevation profile was derived from topographic data provided by Google Earth.
5. Water levels represent measured elevations in November of 2022. Blue symbols reflect UA potentiometric surface; measurements from the deeper UA wells are displayed. Black symbols reflect the LAU potentiometric surface.

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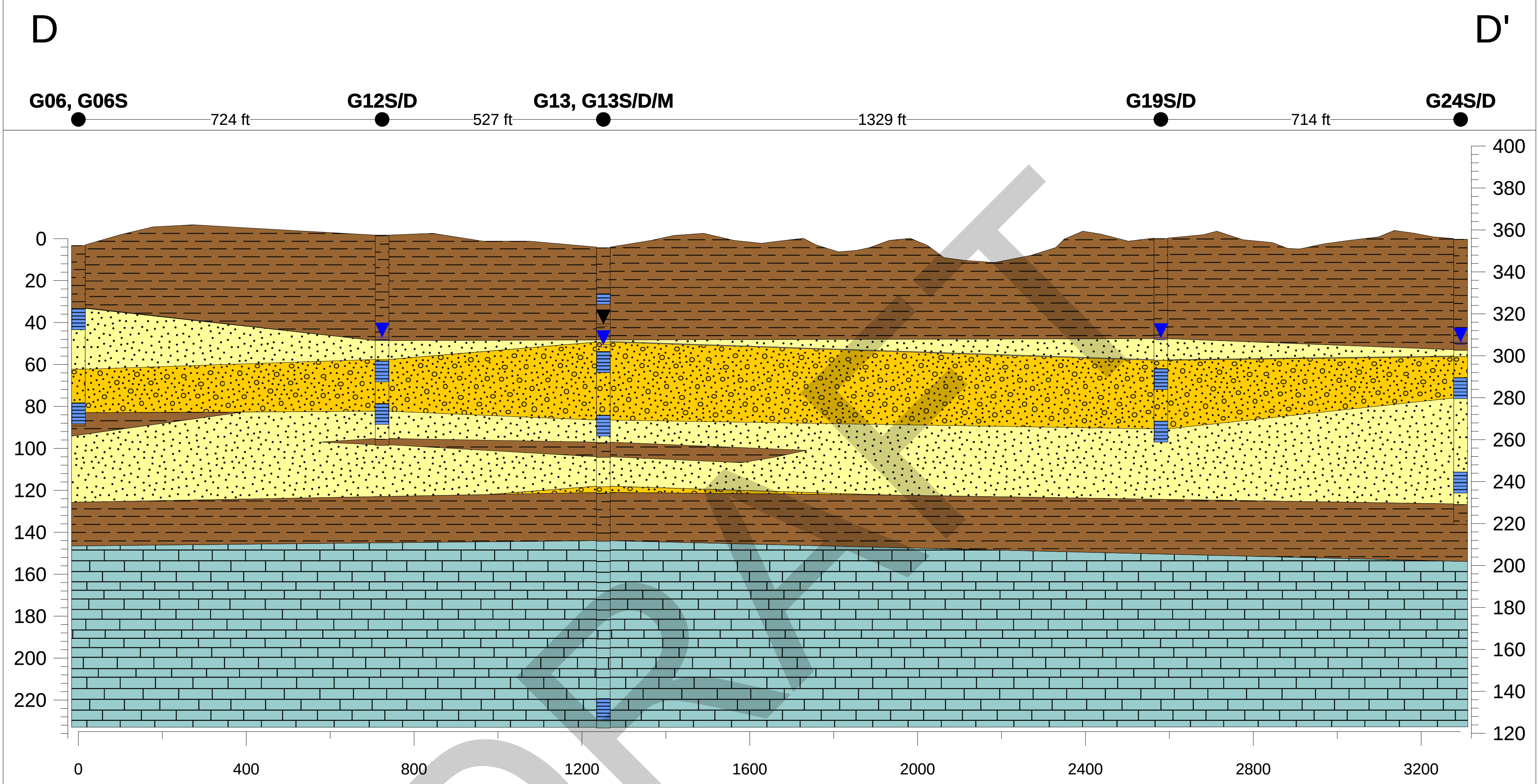
Cross Section C-C'
Joppa Power Plant
Joppa, IL

Columbus, OH

January 2023

Figure
5



Lithology

▨ CLAY

▨ GRAVEL

▨ SAND

▨ LIMESTONE

Well Construction

▤ Screen

Notes:
1. Scale is approximate; all units of length are in feet.
2. Vertical exaggeration is 5x.
3. This section was created using widely spaced boreholes; thus, all interpretation away from borehole locations should be considered an approximate representation.
4. The elevation profile was derived from topographic data provided by Google Earth.
5. Water levels represent measured elevations in November of 2022. Blue symbols reflect UA potentiometric surface; measurements from the deeper UA wells are displayed. Black symbols reflect the LAU potentiometric surface.

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Cross Section D-D'
Joppa Power Plant
Joppa, IL

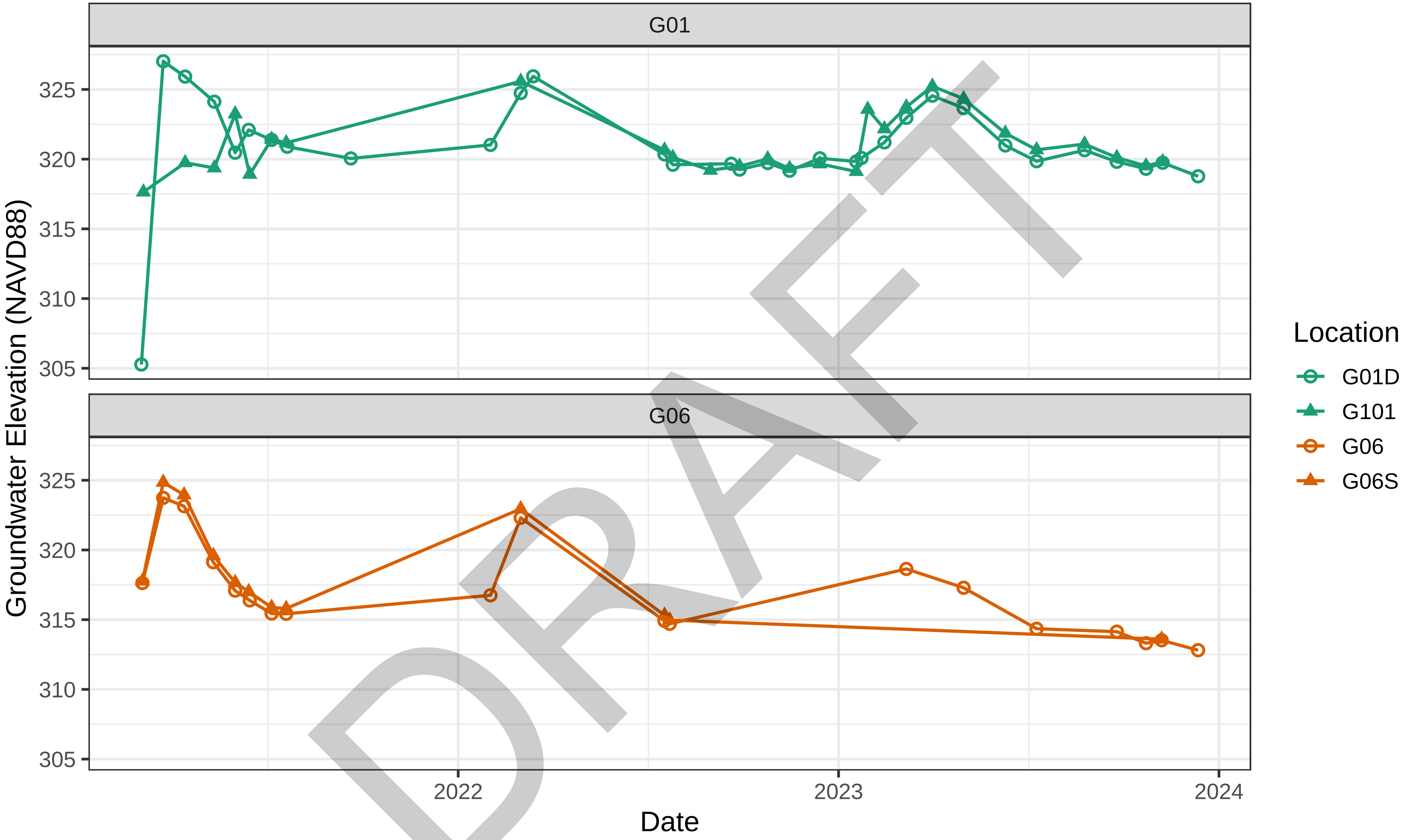
Columbus, OH

January 2023

Figure
6

APPENDIX C
Hydrographs Showing Vertical Gradients

APPENDIX C
Hydrographs Showing Vertical Gradients



RAMBOLL

Hydrographs
Nature and Extent Report
Joppa East Ash Pond
Joppa, IL

Figure
1

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584

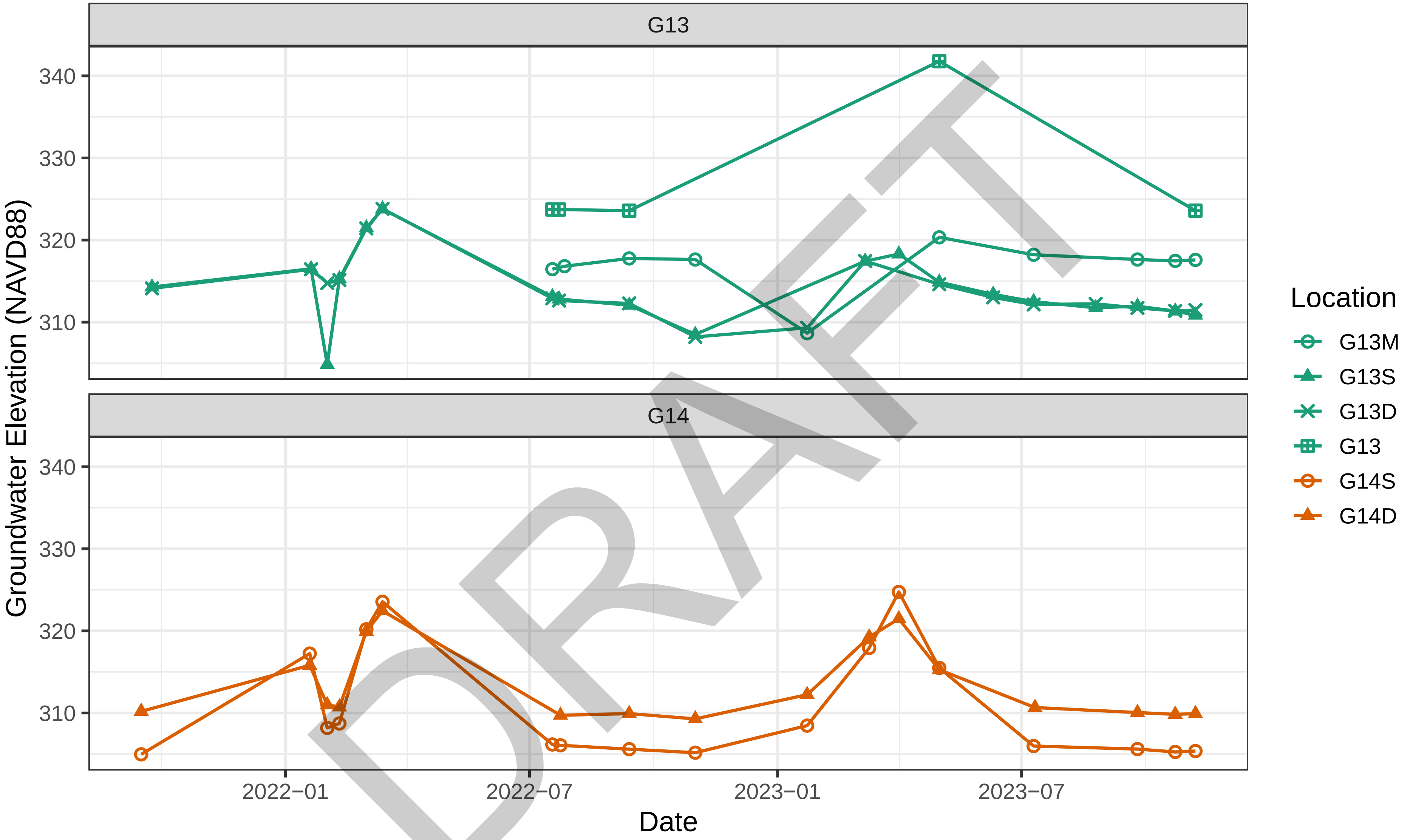
Hydrographs

Nature and Extent Report
Joppa East Ash Pond
Joppa, IL

Figure

2

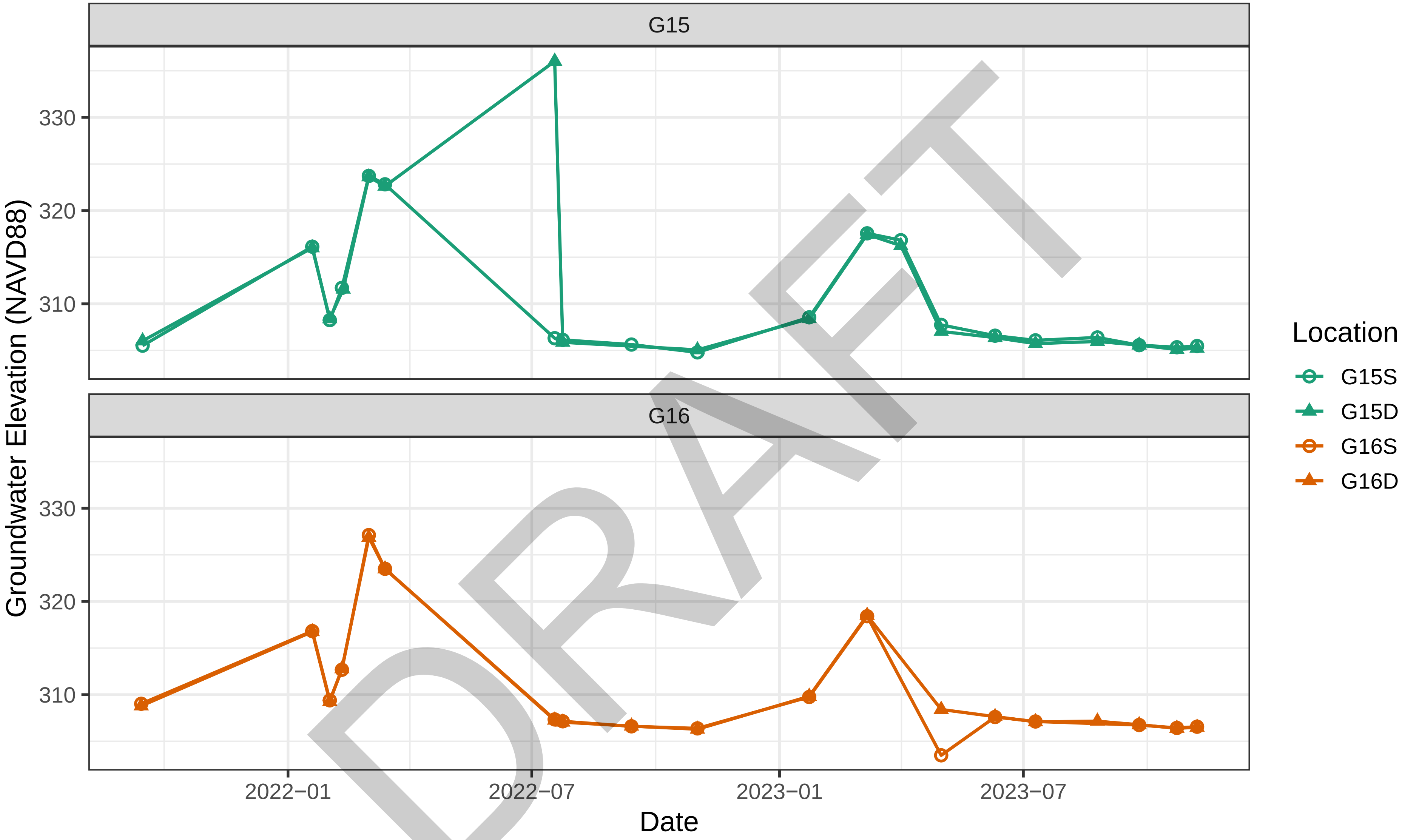
Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584



Hydrographs
Nature and Extent Report
Joppa East Ash Pond
Joppa, IL

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584

Figure
3



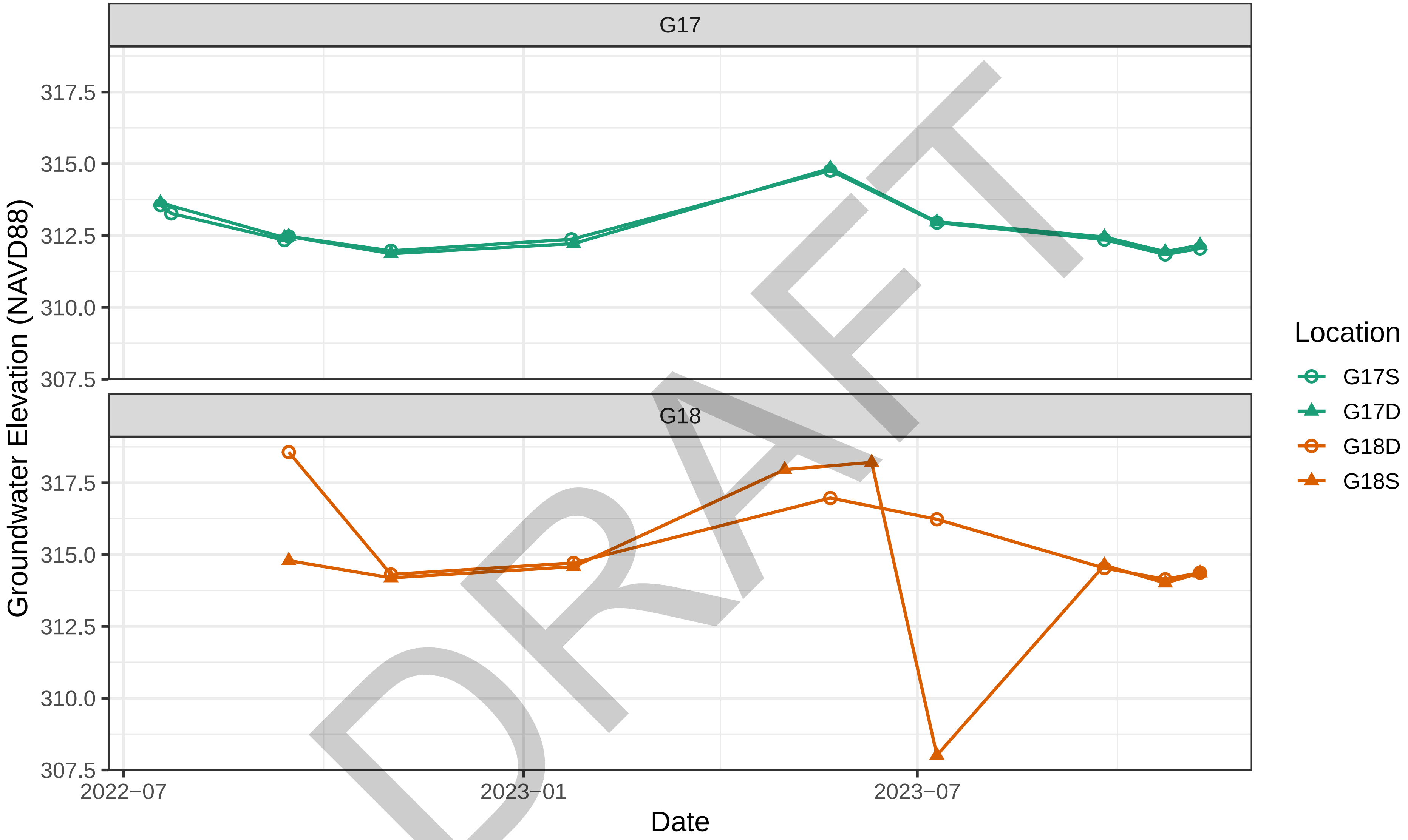
Hydrographs

Nature and Extent Report
Joppa East Ash Pond
Joppa, IL

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584

Figure

4

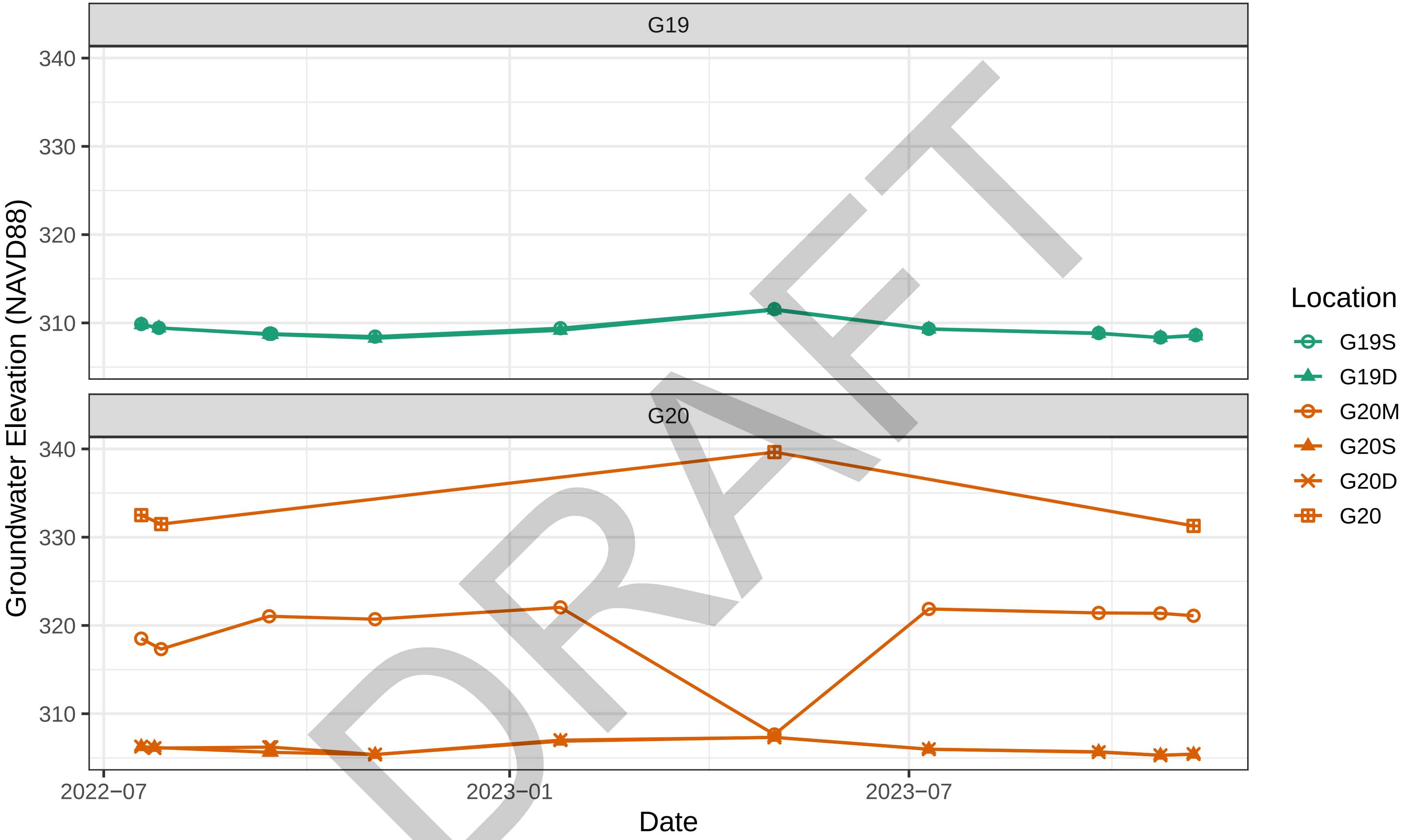


Hydrographs
Nature and Extent Report
Joppa East Ash Pond
Joppa, IL

Figure

5

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584



RAMBOLL

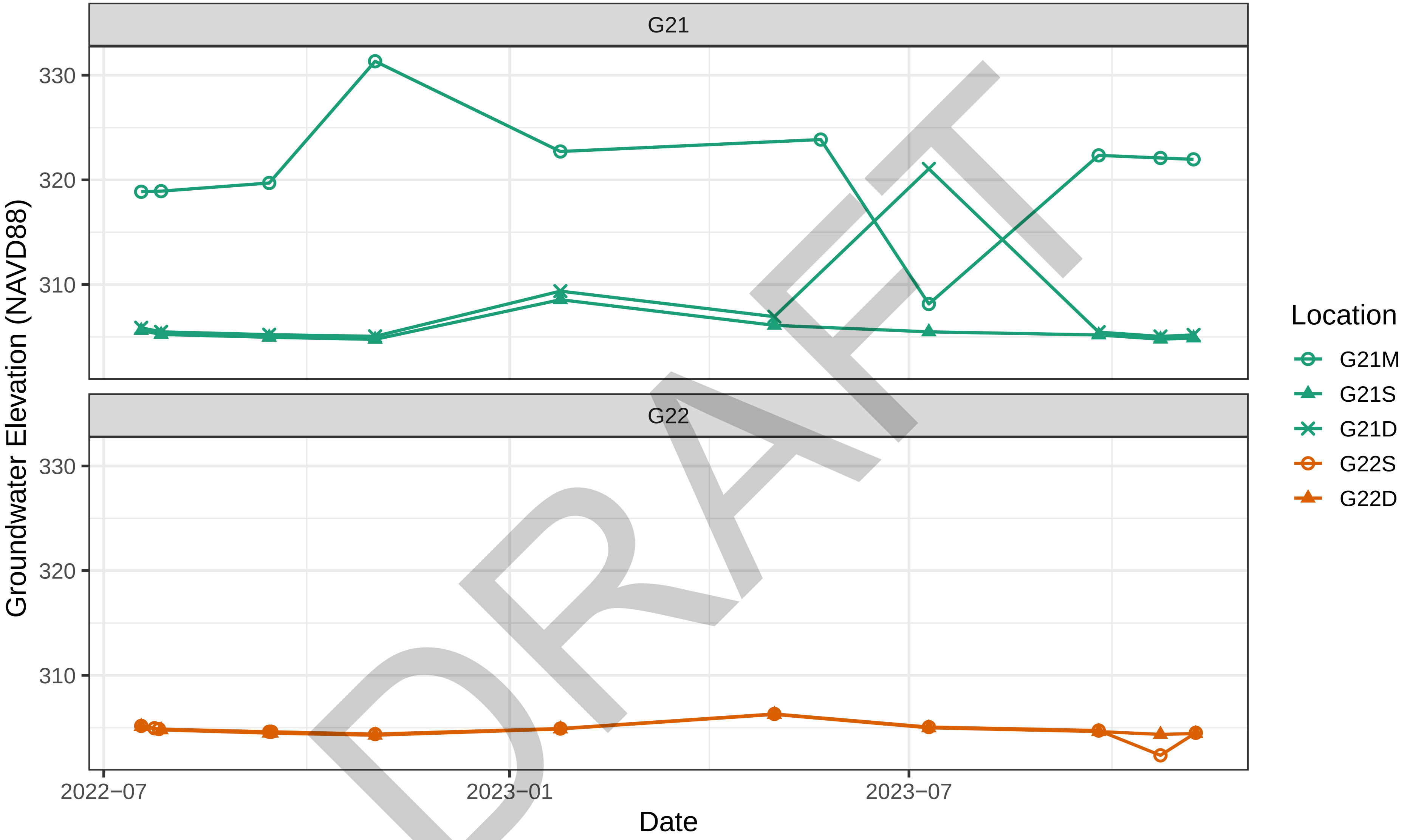
Hydrographs

Nature and Extent Report
Joppa East Ash Pond
Joppa, IL

Figure

6

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584



RAMBOLL

Hydrographs

Nature and Extent Report

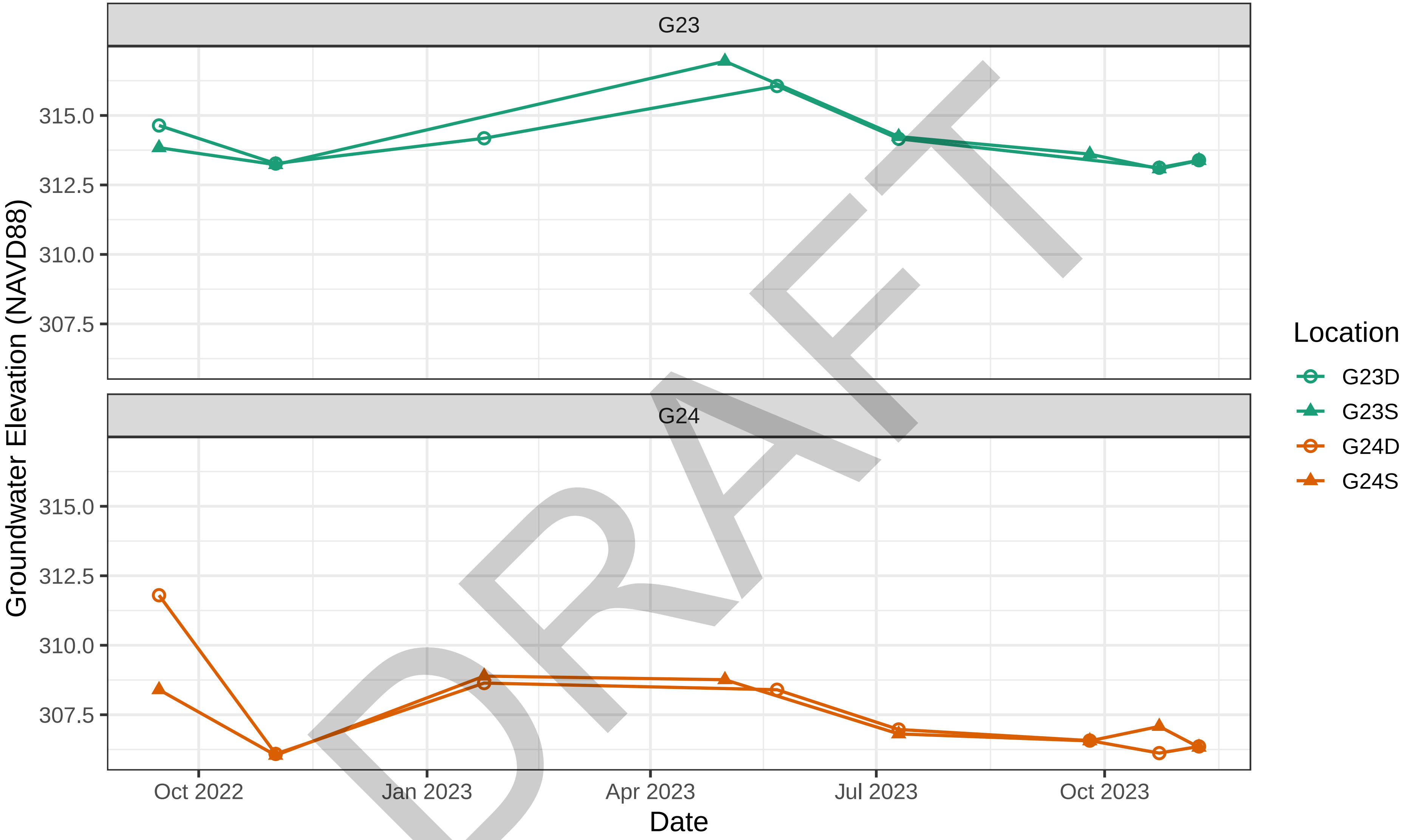
Joppa East Ash Pond

Joppa, IL

Figure

7

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584



Hydrographs

Nature and Extent Report

Joppa East Ash Pond

Joppa, IL

Figure

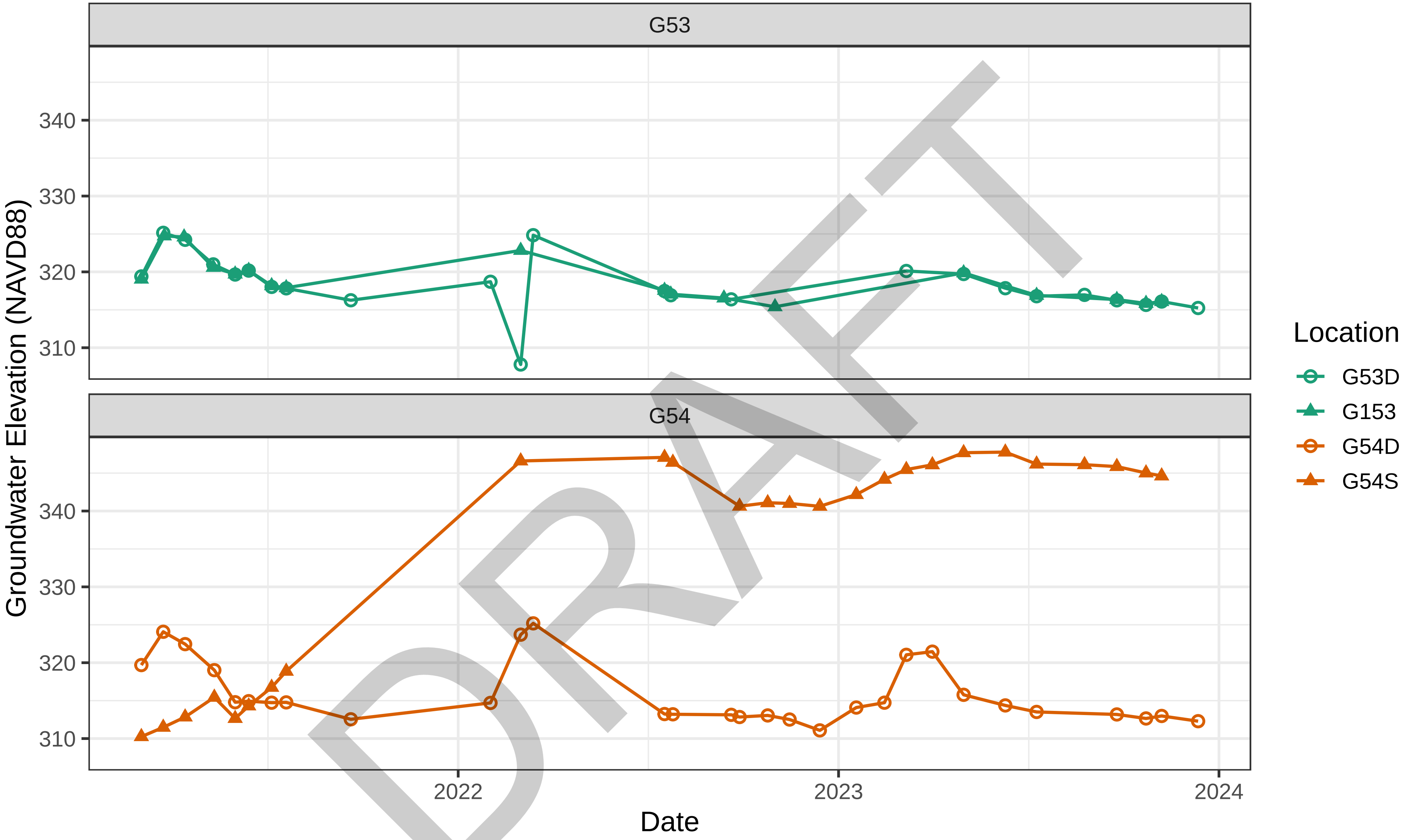
8

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584

Hydrographs
Nature and Extent Report
Joppa East Ash Pond
Joppa, IL

Figure
9

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584



Hydrographs

Nature and Extent Report

Joppa East Ash Pond

Joppa, IL

Drafter: AOC Date: 2024−04−17 Contract Number: 1940103584

Figure

10

APPENDIX D
Lower Aquifer Unit Vertical Permeability Results

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST: Specimen Setup / Take Down
ASTM D 5084

Project Number: J040515.03 Test Station: 1 Cell No.: Perm 1 Dial No.: NA

Project Name: Joppa Specific Gravity, G_s: 2.680 ☐ Assumed; ☒ Measured

Thermometer Used: TM-003

Assigned effective stress: ☐ psi ☒ None assigned

Balance Used: BA- 020

Assig. Remarks:

Oven Used: OV- 009

☒ Tube	☐ Field Extruded	☐ Remolded	☐ Tamping	☐ Constant Effort:		Blows/Tamps per Layer =
Boring No.: G13M			☐ Impact/Rammer		Rammer Wgt.(lbf)=	No. Layers =
Sample No.:	Specimen No.:		☐ Pluviated:		Tamper Force (lbf)=	Drop (in.) =
Depth (ft): 117-119	Composite No.:		☐ Kneading	☐ Undercompaction:	U_{ni} (%) =	Dia. (in.) =
			☐	Ref. Effort=	% Comp. =	± Opt. =

Type Consolidation:	☒ Isotropic	Piston:	☐ Yes ;	☒ No	☐ Attached to top cap		
	☐ Anisotropic	Piston diameter:	☐ 1/2";	☐ 1/4";	☐ 1/8";	☐	

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	314	AX-7		101G
Mass Moist Soil + Cont. (g)	69.85	75.68		826.10
Mass Dry Soil + Cont. (g)	64.39	67.92		719.67
Mass Container (g)	29.11	28.13		151.89
Water Content, $W_{o,n}$ (%)	15.5	19.5		18.7
Avg. Initial WC, $W_{o,avg}$ (%)	17.5	Final (W_{at});	☐ Slice;	☒ Whole Spec.
☐ See attached data sheet(s) for additional water contents				

SOIL MASSES:	Initial	Final
Moist + Tare (g):	668.71	674.56
Tare (g):	0.00	0.00
Spec. Moist Mass (g):	668.71	674.56

EXCESS DRY SOIL (soil stuck to stones, filter paper, membrane, etc.)

Container No:	
Mass Dry Soil + Container (g):	
Mass Container (g):	
Mass Excess Dry Soil (g):	0.00

Specimen Dimensions

	Height (in) Initial (H_o)	Final (H_{at})		Diameter (in) Initial (D_o)	Final (D_{at})
GB	0.000	0.000	T	2.878	2.875
1	3.047	3.032	M	2.876	2.875
2	3.027	3.026	B	2.875	2.878
3	3.024	3.046			
4					
5					
Avg.	3.033	3.035	Avg.	2.876	2.876

Estimated Initial Unit Weight:

Total, $\gamma_{t,o}$ (lb/ft^3) = 129.3 Dry, $\gamma_{d,o}$ (lb/ft^3)= 110.0

Estimated Final Unit Weight:

Total, $\gamma_{t,o}$ (lb/ft^3) = 130.4 Dry, $\gamma_{d,o}$ (lb/ft^3)= 109.8

Membrane / Filter Paper / Platens

Membrane (in)		Top	Bottom
Thickness:	☐ Single		
	☐ Double		
Circumference (C_{rm})			
Summary:		Thickness	Diameter
☐ Nominal Value	Average:	?Single, Double	? Cir. =

Filter Paper : Top + Bottom : ☒ Yes ; ☐ No

Whatman No. 54: ☒ Yes ;

☐ Other:

Measuring Devices:

Pi Tape: ☒ Dia. Calipers: ☒ Ht.; ☐ Dia.

Pi tape No.:

Caliper No.:

A_o (in^2) = 6.50

V_o (in^3) = 19.71

A_{at} (in^2)= 6.50

V_{at} (in^3) = 19.71

NA - Not Applicable; UK - Unknown; GB - Gage Block

Mass top cap, M_{tc} (g) = 162 ; ÷ 454 = 0.36 lbf

Mass (cap, dial, piston, etc.) (g) = NA ; NA lbf

Final Specimen Description (USCS group name & symbol, color, layering, max. part. size, slickensided, fissured, blocky, honeycombed, etc.):

☐ Photo taken (internal sliced surface & outside surface)

Other Remarks

Setup By: EKG	Take Down By: JRC	Input by: EKG	Checked By: JRC
Date: 06/03/22	Date: 06/07/22	Date: 07/07/22	Date: 07/07/22

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST: Permeation
ASTM D 5084

Project Number: J040515.03
Test Station: 1
Dial No.: NA
Specific Gravity, G_s: 2.68 ☐ Assumed; ☒ Measured

Project Name: Joppa
Cell No.: Perm 1

☒ Tube ☐ Field Extruded ☐ Remolded
Boring No.: G13M
Sample No.:
Specimen No.:
Depth (ft): 117-119
Composite No.:

Cell Pressure: 68 psi
Back Pressure: 63 psi
Effective Stress: 5.0 psi
β value (%): 98
Pressure Difference (psi): 2

Burette Area: 1.00 cm²
Area (cm²): 41.92
Permeant liquid: deaired water
Initial gradient: 21
Final Gradient: 21

Pressure Head Settings (D 5084)

Estimated k_t (cm/sec)	Max. Initial Gradient, i_o
1.0E-4 to 1.0E-5	≤5
1.0E-5 to 1.0E-6	≤10
1.0E-6 to 1.0E-7	≤20
<1.0E-7 or <3.0E-2 (m/yr)	≤30
For Special Gradtient, i	

Trial Number	Date yr: 2022 (mm/dd)	Time (min)	Δ t (min)	Temp. °C	Inflow (cm³)	Outflow (cm³)	Ratio Inflow/Outflow 0.75 to 1.25	Elevation head, Δh_e (cm)	Avg. Total Head Loss Δh_e (cm)	Q (cm³)	Q/t (cm³/min)	k (cm/min)	k (cm/s)
NA	06/07	11:29	--	23.7	2.0	22.0	20.00	20.00	NA	NA	NA	NA	NA
1	06/07	11:42	13	23.7	2.1	21.7	0.33	19.60	160.5	0.20	0.0154	1.76E-05	2.93E-07
2	06/07	12:02	20	23.7	2.2	21.6	1.00	19.40	160.2	0.10	0.0050	5.73E-06	9.56E-08
3	06/07	12:31	29	23.7	2.3	21.5	1.00	19.20	160.0	0.10	0.0034	3.96E-06	6.6E-08
4	06/07	13:33	62	23.7	2.6	21.2	1.00	18.60	159.6	0.30	0.0048	5.57E-06	9.28E-08
5	06/07	15:02	89	23.7	3.0	20.8	1.00	17.80	158.9	0.40	0.0045	5.20E-06	8.66E-08
6	06/07	15:37	35	23.7	3.2	20.6	1.00	17.40	158.3	0.20	0.0057	6.63E-06	1.11E-07
7													
8													
9													
10													
11													
12													
13													
14													
15													

Tested By: EKG
Date: 06/07/22

Calculated By: EKG
Date: 07/07/22

Checked By: JRC
Date: 07/07/22

Average $k_{20°C}$: 8.3E-08 cm/s
8.3E-10 m/s

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST: Specimen Setup / Take Down
ASTM D 5084

Project Number: J040515.03 Test Station: 4 Cell No.: Perm 2 Dial No.: NA

Project Name: Joppa Specific Gravity, G_s: 2.632 ☐ Assumed; ☒ Measured

Thermometer Used: TM-003

Assigned effective stress: ☐ ______ psi ☒ None assigned

Balance Used: BA- 020

Assig. Remarks: ______ Oven Used: OV- 009

☒ Tube ☐ Field Extruded ☐ Remolded

Boring No.: G21M

Sample No.: ______ Specimen No.: ______

Depth (ft): 126-128 Composite No.: ______

☐ 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 Consolidation:	☒ Isotropic	Piston:	☐ Yes ;	☒ No	☐ Attached to top cap					
	☐ Anisotropic	Piston diameter:	☐ 1/2";	☐ 1/4";	☐ 1/8";	☐				

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	W-2	H-3		T-08
Mass Moist Soil + Cont. (g)	120.90	127.17		825.35
Mass Dry Soil + Cont. (g)	108.35	113.27		724.35
Mass Container (g)	29.79	27.90		153.03
Water Content, $W_{o,n}$ (%)	16.0	16.3		17.7
Avg. Initial WC, $W_{o,avg}$ (%)	16.1	Final (W_{at});	☐ Slice;	☒ Whole Spec.

☐ See attached data sheet(s) for additional water contents

SOIL MASSES:	Initial	Final
Moist + Tare (g):	666.34	672.72
Tare (g):	0.00	0.00
Spec. Moist Mass (g):	666.34	672.72

EXCESS DRY SOIL (soil stuck to stones, filter paper, membrane, etc.)

Container No:	
Mass Dry Soil + Container (g):	
Mass Container (g):	
Mass Excess Dry Soil (g):	0.00

Specimen Dimensions					
Height (in)			Diameter (in)		
	Initial (H_o)	Final (H_{at})		Initial (D_o)	Final (D_{at})
GB	0.000	0.000	T	2.890	2.889
1	2.964	2.967	M	2.890	2.895
2	2.942	2.958	B	2.895	2.892
3	2.968	2.971			
4					
5					
Avg.	2.958	2.965	Avg.	2.892	2.892

Estimated Initial Unit Weight:	
Total, $\gamma_{t,o}$ (lb/ft^3) = 130.7	Dry, $\gamma_{d,o}$ (lb/ft^3)= 112.5
Estimated Final Unit Weight:	
Total, $\gamma_{t,o}$ (lb/ft^3) = 131.6	Dry, $\gamma_{d,o}$ (lb/ft^3)= 111.8

Measuring Devices:

Pi Tape: ☒ Dia. Calipers: ☒ Ht.; ☐ Dia.

Pi tape No.: ______

Caliper No.:

A_o (in^2) = 6.57

V_o (in^3) = 19.43

A_{at} (in^2)= 6.57

V_{at} (in^3) = 19.48

Membrane / Filter Paper / Platens

Membrane (in)		Top	Bottom
Thickness:	☐ Single		
	☐ Double		
Circumference (C_{rm})			
Summary:		Thickness	Diameter
☐ Nominal Value	Average:	?Single, Double	? Cir. =

Filter Paper : Top + Bottom : ☒ Yes ; ☐ No

Whatman No. 54: ☒ Yes ;

☐ Other:

Mass top cap, M_{tc} (g) = 162 ; ÷ 454 = 0.36 lbf

Mass (cap, dial, piston, etc.) (g) = NA ; NA lbf

NA - Not Applicable; UK - Unknown; GB - Gage Block

Final Specimen Description (USCS group name & symbol, color, layering, max. part. size, slickensided, fissured, blocky, honeycombed, etc.):

☐ Photo taken (internal sliced surface & outside surface)

Other Remarks ______

Setup By: EKG Take Down By: JRC Input by: EKG Checked By: JRC

Date: 04/19/22 Date: 04/27/22 Date: 05/09/22 Date: 05/09/22

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST: Permeation
ASTM D 5084

Project Number: J040515.03 Test Station: 4 Dial No.: NA Specific Gravity, G_s: 2.632 ☐ Assumed; ☒ Measured

Project Name: Joppa Cell No.: Perm 2

☒ Tube ☐ Field Extruded ☐ Remolded

Boring No.: G21M

Sample No.: Specimen No.:

Depth (ft): 126-128 Composite No.:

Cell Pressure: 58 psi

Back Pressure: 53 psi

Effective Stress: 5.0 psi

β value (%): 96

Pressure Difference (psi): 2

Burette Area: 1.00 cm^2

Area (cm^2): 42.37

Permeant liquid: deaired water

Initial gradient: 21

Final Gradient: 20

Pressure Head Settings (D 5084)

Estimated k_t (cm/sec)	Max. Initial Gradient, i_o
1.0E-4 to 1.0E-5	≤5
1.0E-5 to 1.0E-6	≤10
1.0E-6 to 1.0E-7	≤20
<1.0E-7 or <3.0E-2 (m/yr)	≤30
For Special Gradtient, i	

Trial Number	Date yr: 2022 (mm/dd)	Time (min)	Δ t (min)	Temp. °C	Inflow (cm^3)	Outflow (cm^3)	Ratio Inflow/Outflow 0.75 to 1.25	Elevation head, Δh_e (cm)	Avg. Total Head Loss Δh_e (cm)	Q (cm^3)	Q/t (cm^3/min)	k (cm/min)	k (cm/s)
NA	04/25	15:09	--	23.7	2.0	22.0	20.00	20.00	NA	NA	NA	NA	NA
1	04/25	15:30	21	23.7	2.1	21.9	1.00	19.80	160.6	0.10	0.0048	5.26E-06	8.76E-08
2	04/26	9:18	1068	22.7	5.1	18.9	1.00	13.80	157.5	3.00	0.0028	3.16E-06	5.27E-08
3	04/26	10:31	73	22.8	5.2	18.8	1.00	13.60	154.5	0.10	0.0014	1.57E-06	2.62E-08
4	04/26	11:11	40	22.8	5.3	18.7	1.00	13.40	154.3	0.10	0.0025	2.87E-06	4.79E-08
5	04/26	13:09	118	23.1	5.6	18.4	1.00	12.80	153.9	0.30	0.0025	2.93E-06	4.88E-08
6	04/26	13:54	45	23.2	5.7	18.3	1.00	12.60	153.5	0.10	0.0022	2.57E-06	4.28E-08
7	04/26	14:25	31	23.2	5.8	18.2	1.00	12.40	153.3	0.10	0.0032	3.73E-06	6.22E-08
8													
9													
10													
11													
12													
13													
14													
15													

Tested By: EKG Calculated By: EKG Checked By: JRC **Average $k_{20°C}$:** 4.9E-08 cm/s

Date: 04/25/22 Date: 05/09/22 Date: 05/09/22 4.9E-10 m/s

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST: Specimen Setup / Take Down
ASTM D 5084

Project Number: J040515.03 Test Station: 1 Cell No.: Perm 1 Dial No.: NA

Project Name: Joppa Specific Gravity, G_s: 2.537 ☐ Assumed; ☒ Measured

Thermometer Used: TM-003

Assigned effective stress: ☐ ______ psi ☒ None assigned Balance Used: BA- 020

Assig. Remarks: ______ Oven Used: OV- 009

☐ Tube	☐ Field Extruded	☒ Remolded	
Boring No.:	G21M		
Sample No.:		Specimen No.:	
Depth (ft):	132-133	Composite No.:	

☐ Tamping	☐ Constant Effort:		Blows/Tamps per Layer =	
☐ Impact/Rammer	Rammer Wgt.(lbf)=		No. Layers =	
☐ Pluviated:	Tamper Force (lbf)=		Drop (in.) =	
☐ Kneading	☐ Undercompaction:	U_{ni} (%) =	Dia. (in.) =	
☐	Ref. Effort=	% Comp. =	± Opt. =	

Type Consolidation:	☒ Isotropic	Piston: ☐ Yes ; ☒ No	☐ Attached to top cap	
	☐ Anisotropic	Piston diameter: ☐ 1/2";	☐ 1/4";	☐ 1/8"; ☐

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	321	45		T-71
Mass Moist Soil + Cont. (g)	147.88	181.24		779.87
Mass Dry Soil + Cont. (g)	127.76	155.52		661.09
Mass Container (g)	28.76	29.38		152.84
Water Content, $W_{o,n}$ (%)	20.3	20.4		23.4
Avg. Initial WC, $W_{o,avg}$ (%)	20.4	Final (W_{at});	☐ Slice;	☒ Whole Spec.
☐ See attached data sheet(s) for additional water contents				

SOIL MASSES:	Initial	Final
Moist + Tare (g):	610.23	627.27
Tare (g):	0.00	0.00
Spec. Moist Mass (g):	610.23	627.27
EXCESS DRY SOIL (soil stuck to stones, filter paper, membrane, etc.)		
Container No:		
Mass Dry Soil + Container (g):		
Mass Container (g):		
Mass Excess Dry Soil (g):		0.00

Specimen Dimensions

	Height (in) Initial (H_o)	Final (H_{at})		Diameter (in) Initial (D_o)	Final (D_{at})
GB	0.000	0.000	T	2.876	2.890
1	2.917	2.947	M	2.877	2.890
2	2.919	2.955	B	2.878	2.890
3	2.906	2.949			
4					
5					
Avg.	2.914	2.950	Avg.	2.877	2.890

Estimated Initial Unit Weight:

Total, $\gamma_{t,o}$ (lb/ft^3) = 122.7 Dry, $\gamma_{d,o}$ (lb/ft^3)= 102.0

Estimated Final Unit Weight:

Total, $\gamma_{t,o}$ (lb/ft^3) = 123.5 Dry, $\gamma_{d,o}$ (lb/ft^3)= 100.1

Measuring Devices:

Pi Tape: ☒ Dia. Calipers: ☒ Ht.; ☐ Dia.

Pi tape No.: ______

Caliper No.:

A_o (in^2) = 6.50

V_o (in^3) = 18.94

A_{at} (in^2)= 6.56

V_{at} (in^3) = 19.35

Membrane / Filter Paper / Platens

Membrane (in)		Top	Bottom
Thickness:	☐ Single		
	☐ Double		
Circumference (C_{rm})			
Summary:		Thickness	Diameter
☐ Nominal Value	Average:	?Single, Double	? Cir. =

Filter Paper : Top + Bottom : ☒ Yes ; ☐ No

Whatman No. 54: ☒ Yes ;

☐ Other:

NA - Not Applicable; UK - Unknown; GB - Gage Block

Mass top cap, M_{tc} (g) = 162 ; ÷ 454 = 0.36 lbf

Mass (cap, dial, piston, etc.) (g) = NA ; NA lbf

Final Specimen Description (USCS group name & symbol, color, layering, max. part. size, slickensided, fissured, blocky, honeycombed, etc.):

☐ Photo taken (internal sliced surface & outside surface)

Other Remarks ______

Setup By: EKG Take Down By: JRC Input by: EKG Checked By: JRC

Date: 05/02/22 Date: 05/10/22 Date: 05/11/22 Date: 05/11/22

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST: Permeation
ASTM D 5084

Project Number: J040515.03
Test Station: 1
Dial No.: NA
Specific Gravity, G_s: 2.537 ☐ Assumed; ☒ Measured

Project Name: Joppa
Cell No.: Perm 1

☐ Tube ☐ Field Extruded ☒ Remolded
Boring No.: G21M
Sample No.:
Specimen No.:
Depth (ft): 132-133
Composite No.:

Cell Pressure: 68 psi
Back Pressure: 63 psi
Effective Stress: 5.0 psi
β value (%): 97
Pressure Difference (psi): 3

Burette Area: 1.00 cm^2
Area (cm^2): 41.94
Permeant liquid: deaired water
Initial gradient: 31
Final Gradient: 30

Pressure Head Settings (D 5084)

Estimated k_t (cm/sec)	Max. Initial Gradient, i_o
1.0E-4 to 1.0E-5	≤5
1.0E-5 to 1.0E-6	≤10
1.0E-6 to 1.0E-7	≤20
<1.0E-7 or <3.0E-2 (m/yr)	≤30
For Special Gradtient, i	

Trial Number	Date yr: 2022 (mm/dd)	Time (min)	Δ t (min)	Temp. °C	Inflow (cm^3)	Outflow (cm^3)	Ratio Inflow/Outflow 0.75 to 1.25	Elevation head, Δh_e (cm)	Avg. Total Head Loss Δh_e (cm)	Q (cm^3)	Q/t (cm^3/min)	k (cm/min)	k (cm/s)
NA	05/09	13:27	--	23.6	2.0	22.0	20.00	20.00	NA	NA	NA	NA	NA
1	05/09	14:20	53	23.6	2.1	21.6	0.25	19.50	230.9	0.25	0.0047	3.61E-06	6.01E-08
2	05/09	14:56	36	23.7	2.2	21.5	1.00	19.30	230.5	0.10	0.0028	2.13E-06	3.54E-08
3	05/09	15:38	42	23.7	2.3	21.4	1.00	19.10	230.3	0.10	0.0024	1.82E-06	3.04E-08
4	05/10	9:15	1057	23.3	4.7	19.0	1.00	14.30	227.8	2.40	0.0023	1.76E-06	2.93E-08
5	05/10	10:06	51	23.3	4.8	18.9	1.00	14.10	225.3	0.10	0.0020	1.54E-06	2.56E-08
6	05/10	11:08	62	23.4	4.9	18.8	1.00	13.90	225.1	0.10	0.0016	1.26E-06	2.11E-08
7													
8													
9													
10													
11													
12													
13													
14													
15													

Tested By: EKG
Date: 05/09/22

Calculated By: EKG
Date: 05/11/22

Checked By: JRC
Date: 05/11/22

Average $k_{20°C}$: 2.6E-08 cm/s
2.6E-10 m/s

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST: Specimen Setup / Take Down
ASTM D 5084

Project Number: J040515.03 | Test Station: 2 | Cell No.: Perm 3 | Dial No.: NA

Project Name: Joppa | Specific Gravity, G_s: 2.638 ☐ Assumed; ☒ Measured

Thermometer Used: TM-003

Assigned effective stress: ☐ psi ☒ None assigned

Balance Used: BA- 020

Assig. Remarks:

Oven Used: OV- 009

☒ Tube	☐ Field Extruded	☐ Remolded	☐ Tamping	☐ Constant Effort:		Blows/Tamps per Layer =		
Boring No.:	G21M		☐ Impact/Rammer	Rammer Wgt.(lbf)=		No. Layers =		
Sample No.:		Specimen No.:	☐ Pluviated:	Tamper Force (lbf)=		Drop (in.) =		
Depth (ft):	136-138	Composite No.:	☐ Kneading	☐ Undercompaction:	U_{ni} (%) =	Dia. (in.) =		
			☐	Ref. Effort=	% Comp. =	± Opt. =		

Type Consolidation:					
☒ Isotropic	Piston:	☐ Yes ;	☒ No	☐ Attached to top cap	
☐ Anisotropic	Piston diameter:	☐ 1/2";	☐ 1/4";	☐ 1/8";	☐

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	306	33		B
Mass Moist Soil + Cont. (g)	89.37	97.84		808.40
Mass Dry Soil + Cont. (g)	77.85	84.74		668.12
Mass Container (g)	29.23	27.49		157.73
Water Content, $W_{o,n}$ (%)	23.7	22.9		27.5
Avg. Initial WC, $W_{o,avg}$ (%)	23.3	Final (W_{at});	☐ Slice;	☒ Whole Spec.

☐ See attached data sheet(s) for additional water contents

SOIL MASSES:	Initial	Final
Moist + Tare (g):	632.78	651.03
Tare (g):	0.00	0.00
Spec. Moist Mass (g):	632.78	651.03

EXCESS DRY SOIL (soil stuck to stones, filter paper, membrane, etc.)

Container No:	
Mass Dry Soil + Container (g):	
Mass Container (g):	
Mass Excess Dry Soil (g):	0.00

Specimen Dimensions	Height (in) Initial (H_o)	Final (H_{at})		Diameter (in) Initial (D_o)	Final (D_{at})
GB	0.000	0.000	T	2.885	2.930
1	2.972	3.043	M	2.890	2.950
2	2.993	3.047	B	2.885	2.920
3	2.981	3.036			
4					
5					
Avg.	2.982	3.042	Avg.	2.887	2.933

Measuring Devices:

Pi Tape: ☒ Dia. Calipers: ☒ Ht.; ☐ Dia.

Pi tape No.:

Caliper No.:

A_o (in^2) = 6.54

V_o (in^3) = 19.52

A_{at} (in^2)= 6.76

V_{at} (in^3) = 20.56

NA - Not Applicable; UK - Unknown; GB - Gage Block

Estimated Initial Unit Weight:	
Total, $\gamma_{t,o}$ (lb/ft^3) = 123.5	Dry, $\gamma_{d,o}$ (lb/ft^3)= 100.2

Estimated Final Unit Weight:	
Total, $\gamma_{t,o}$ (lb/ft^3) = 120.6	Dry, $\gamma_{d,o}$ (lb/ft^3)= 94.6

Membrane / Filter Paper / Platens

Membrane (in)		Top	Bottom
Thickness:	☐ Single		
	☐ Double		
Circumference (C_{rm})			
Summary:		Thickness	Diameter
☐ Nominal Value	Average:	?Single, Double	? Cir. =

Filter Paper : Top + Bottom : ☒ Yes ; ☐ No

Whatman No. 54: ☒ Yes ;

☐ Other:

Mass top cap, M_{tc} (g) = 162 ; ÷ 454 = 0.36 lbf

Mass (cap, dial, piston, etc.) (g) = NA ; NA lbf

Final Specimen Description (USCS group name & symbol, color, layering, max. part. size, slickensided, fissured, blocky, honeycombed, etc.):

☐ Photo taken (internal sliced surface & outside surface)

Other Remarks

Setup By: EKG | Take Down By: JRC | Input by: EKG | Checked By: JRC

Date: 04/19/22 | Date: 04/27/22 | Date: 05/09/22 | Date: 05/09/22

HYDRAULIC CONDUCTIVITY (PERMEABILITY) TEST: Permeation
ASTM D 5084

Project Number: J040515.03
Test Station: 2
Dial No.: NA
Specific Gravity, G_s: 2.638 ☐ Assumed; ☒ Measured

Project Name: Joppa
Cell No.: Perm 3

☒ Tube ☐ Field Extruded ☐ Remolded
Boring No.: G21M
Sample No.:
Specimen No.:
Depth (ft): 136-138
Composite No.:

Cell Pressure: 58 psi
Back Pressure: 53 psi
Effective Stress: 5.0 psi
β value (%): 96
Pressure Difference (psi): 3

Burette Area: 1.00 cm^2
Area (cm^2): 42.22
Permeant liquid: deaired water
Initial gradient: 30
Final Gradient: 29

Pressure Head Settings (D 5084)

Estimated k_t (cm/sec)	Max. Initial Gradient, i_o
1.0E-4 to 1.0E-5	≤5
1.0E-5 to 1.0E-6	≤10
1.0E-6 to 1.0E-7	≤20
<1.0E-7 or <3.0E-2 (m/yr)	≤30
For Special Gradtient, i	

Trial Number	Date yr: 2022 (mm/dd)	Time (min)	Δ t (min)	Temp. °C	Inflow (cm^3)	Outflow (cm^3)	Ratio Inflow/Outflow 0.75 to 1.25	Elevation head, Δh_e (cm)	Avg. Total Head Loss Δh_e (cm)	Q (cm^3)	Q/t (cm^3/min)	k (cm/min)	k (cm/s)
NA	04/25	15:16	--	23.7	2.0	22.0	20.00	20.00	NA	NA	NA	NA	NA
1	04/26	9:16	1080	22.7	3.9	19.7	0.83	15.80	229.0	2.10	0.0019	1.52E-06	2.54E-08
2	04/26	10:32	76	22.8	4.0	19.6	1.00	15.60	226.9	0.10	0.0013	1.04E-06	1.73E-08
3	04/26	13:08	156	23.1	4.2	19.4	1.00	15.20	226.6	0.20	0.0013	1.02E-06	1.69E-08
4	04/26	13:53	45	23.1	4.3	19.3	1.00	15.00	226.2	0.10	0.0022	1.76E-06	2.94E-08
5	04/26	15:28	95	23.3	4.4	19.2	1.00	14.80	226.0	0.10	0.0011	8.35E-07	1.39E-08
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													

Tested By: EKG
Date: 04/25/22

Calculated By: EKG
Date: 05/09/22

Checked By: JRC
Date: 05/09/22

Average $k_{20°C}$: 1.9E-08 cm/s
1.9E-10 m/s

APPENDIX E
Geochemical Conceptual Site Model

Geosyntec consultants

engineers | scientists | innovators

Geochemical Conceptual Site Model

Joppa Power Plant – East Ash Pond

(CCR Unit #401)

Prepared for

Electric Energy Inc
2100 Portland Road
Joppa, Illinois 62953

Prepared by

Geosyntec Consultants, Inc.
134 N. Lasalle Street, Suite 300
Chicago, Illinois 60602

Project Number: GLP8030C

April 2024

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ACRONYMS AND ABBREVIATIONS

CCR	Coal Combustion Residuals
COCs	Constituents of Concern
EAP	East Ash Pond
GCSM	Geochemical Conceptual Site Model
GWPS	Groundwater Protection Standards
HSU	hydrostratigraphic unit
I.A.C.	Illinois Administrative Code
IEPA	Illinois Environmental Protection Agency
JPP	Joppa Power Plant
LOI	loss on ignition
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
N&E	nature and extent
ORP	oxidation-reduction potential
SEP	sequential extraction procedure
TOC	total organic carbon
UA	uppermost aquifer
XRD	X-Ray diffraction

1. EXECUTIVE SUMMARY

A geochemical conceptual site model (GCSM) has been developed to describe subsurface conditions at the Joppa Power Plant (JPP) East Ash Pond (EAP) coal combustion residuals unit (Unit #401). A GCSM describes the geochemical processes that contribute to the mobilization, distribution, and attenuation of chemicals in the environment. This report describes the GCSM for parameters that have exceeded the GWPS in EAP groundwater and which will be addressed in the corrective action plan. Boron is the only constituent with exceedances observed at the EAP. COC exceedances are present in one hydrostratigraphic unit (HSU) at the site: the uppermost aquifer (UA), comprised of high permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation .

The primary source of boron to groundwaters of the UA within the monitoring network is the EAP coal combustion residual porewater, based on COC concentrations within the source and relationships to hydrogeological patterns at the site. Boron was not identified within UA solids at concentrations that would suggest that aquifer solids could provide an additional potential natural geogenic source of boron to groundwater.

Boron in the groundwater system may be attenuated via adsorption and surface complexation reactions within portions of the UA, with conditions within groundwater from the UA typically predicted to favor amorphous iron oxide stability at most locations, and the presence of iron oxides in some site solids supporting the occurrence of this mechanism. Limited variability in pH or redox conditions is observed between upgradient background and downgradient locations. The presence of clay minerals (e.g., kaolinite) in the UA solids material indicates that adsorption to clays may be another potential attenuation mechanism for boron at locations near the EAP.

2. INTRODUCTION

This report documents the development of a geochemical conceptual site model (GCSM) to describe conditions at the Joppa Power Plant (JPP) East Ash Pond (EAP). A GCSM describes the geochemical processes that contribute to the mobilization, distribution, and attenuation of chemicals in the environment. The GCSM was prepared in support of an evaluation of the nature and extent (N&E) of exceedances of constituents of concern (COCs) above the GWPS at the EAP. This document has been prepared as an appendix to the JPP EAP N&E Report prepared by Ramboll Americas Engineering Solutions. Inc. (Ramboll). Boron is the only constituent with exceedances above the GWPS at Joppa EAP addressed in this GCSM following completion of an alternative source demonstration (ASD) to address cobalt and pH exceedances (Ramboll 2023). The Illinois Environmental Protection Agency (IEPA) did not concur with the ASD. The non-concurrence was appealed, and the Illinois Pollution Control Board granted a stay on February 1, 2024. Exceedances of boron were observed at compliance monitoring wells G06, G07, G08, G09, and G10 during the second, third, and fourth quarters of 2023 (Q2 2023, Q3 2023, and Q4 2023) sampling events completed under 35 Illinois Administrative Code (IAC) § 845. Boron exceedances identified at the EAP are present exclusively in the UA.

3. SITE BACKGROUND

3.1 Site Overview

An overview of site characteristics is presented in the JPP EAP N&E Report. A site layout figure is provided in Attachment A.[1] Briefly, the Joppa EAP impoundment is located directly north of the JPP. The JPP property is bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north, the Village of Joppa to the east, and the Ohio River to the south.

A Phase I Hydrogeologic Site Assessment Report (NRT 2013), a Hydrogeologic Monitoring Plan (NRT 2017), and a Hydrogeologic Site Characterization Report (Ramboll 2021) have previously described the geologic units present in the vicinity of the Joppa EAP. These previous investigations concluded that the Joppa EAP impoundment is underlain by up to 50 ft of clay-rich deposits of the Equality and Metropolis Formations. The UA consists of high permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation. The UA is described as a hydrostratigraphic unit (HSU) of greater permeability than the overlying clay-rich deposits (NRT 2013). The UA is laterally continuous across the JPP and is approximately 85 ft thick beneath the EAP.

3.2 Groundwater Monitoring Network

A groundwater monitoring network was proposed in accordance with IAC Title 35 Section 845.630 to monitor groundwater quality which passes the waste boundary as part of the Operating Permit Application to Illinois Environmental Protection Agency (IEPA) for the EAP. The proposed groundwater monitoring network is described in the Groundwater Monitoring Plan (Ramboll 2021) and shown in Attachment B.[2] Additional wells were installed in 2021 and 2022 to delineate downgradient conditions and are shown in Attachment C. Well construction details are provided in Attachment D.[3] To aid in interpretation within this document, delineation wells are further designated as being onsite if they are located within the property boundary of the JPP, or offsite if they are located outside of the JPP property boundary.

Groundwater flow within the UA beneath the EAP is predominantly to the south, towards the Ohio River. An easterly groundwater flow component is present along the east portion of the EAP, flowing towards the eastern property boundary. A detailed discussion of the hydrology of the Site is presented in Section 2 of the JPP EAP N&E Report.

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[1] This figure is also provided as Figure 2-2 of the JPP EAP N&E Report.

[2] This figure is also provided as Figure 2-6 of the JPP EAP N&E Report.

[3] This table is also provided as Table 3-1 of the JPP EAP N&E Report.

4. GEOCHEMICAL SITE CONDITIONS

4.1 Constituent Transport and Fate

Boron is frequently present and detectable in groundwater impacted by coal combustion residuals (CCR) and typically occurs as neutrally charged boric acid H_3BO_3 at pH values up to 9.2 standard units (SU) or as the borate ion ($B[OH]^{4-}$) (Bolan et al. 2023). The speciation of boron in groundwater is controlled by pH-dependent reactions, and boron is not subject to oxidation/reduction reactions (EPRI 2017, Lemarchand et al. 2015). Boron primarily sorbs to positively charged sites on solid metal oxide phases, including iron and aluminum oxides. Adsorption to these phases increases with increasing pH, and maximum adsorption occurs between pH 7 and 9 SU (Goldberg and Glaubig 1985; Bolan et al. 2023). Boron can also sorb to organic surfaces such as humic acids or coal under favorable conditions, most extensively between pH 8 and 10 SU (LeMarchand et al. 2015). Clay minerals have been correlated with boron sorption in soils (Goldberg 1997), with this sorption mechanism presenting an additional potential attenuation mechanism for boron under favorable geochemical conditions.

4.2 CCR Characterization

Samples of the CCR solid material within the EAP were collected at three locations (co-located with the three EAP porewater wells XPW01, XPW02, and XPW03) and analyzed for boron and total metals. At each location, CCR solids were analyzed for total metals from two intervals - near the impoundment surface (4-8 ft bgs) and a deeper interval (varying between 24-48 ft bgs) (Table 1; Attachment E). Boron was present in the ash, with concentrations ranging between 35.1 to 542 mg/kg, consistent with the expectation of boron presence within CCR materials (EPRI 2005). At the three EAP locations, boron concentrations were greater in the interval near the impoundment surface.

4.3 Site Solids Characterization

Aquifer solids were characterized to determine the type and abundance of minerals present in the UA, their geochemical properties, and their effect on the geochemistry of the groundwater system. Solids were characterized using a variety of analytical techniques, the results of which are presented in Tables 1 through 3. Solids were collected from five locations within the UA adjacent to existing wells in the compliance monitoring network:

- G03, located sidegradient of the EAP to the east and expected to be unimpacted by the unit in both shallow and deeper intervals within the UA.
- G07, G08, and G09, located directly downgradient of the EAP to the south/southeast.
- G11, located sidegradient of the EAP to the west.

Sample depths are listed in Tables 1 through 3, and boring logs for these locations are provided in Attachment E. G07, G08, and G09 had identified exceedances of boron above the GWPS during the Q2 through Q4 2023 statistical evaluations.

4.3.1 Organic Carbon Content

Total organic carbon (TOC) represents only the carbon component of organic matter within a solid material, while loss on ignition (LOI) represents the combustible portions of a solid material and is often used as an approximation of organic matter in a sample. The TOC and LOI values for aquifer solids from G03, G07, and G08 are presented in Table 1. TOC and LOI values are consistently low across the site (TOC: 0.039 – 0.049 percent weight [%wt]; LOI: 0.93 – 1.58% wt), indicating that the UA solids have limited organic matter. These data are available in Attachment F.

4.3.2 Total Metals and Boron via Bulk Characterization

Total metals and boron were analyzed to determine the major and trace metal content of the aquifer solids. Boron was not detected in solids from G03, G09, and G11, and solids from G07 and G08 were not analyzed for boron (Table 2). Total iron concentrations measured in the aquifer solids sampled from across the Site range from 830 milligrams per kilogram [mg/kg] to 99,000 mg/kg, while total manganese concentrations are relatively low (6.1 mg/kg to 1,000 mg/kg) in comparison to iron concentrations (Table 2; Attachment F). Concentrations of both iron and manganese are lowest at G03 and highest at G08. Differences in iron concentrations between samples likely represent the degree of heterogeneity in iron distribution within UA material The abundance of iron within the bulk solids matrix indicates that iron-bearing minerals are present within the system. The presence of these iron-bearing minerals was confirmed via x-ray diffraction (XRD) as discussed in Section 4.3.3.

An additional sample of composited material from each boring location was submitted to Eurofins TestAmerica (Knoxville, TN) for sequential extraction procedure (SEP). SEPs are chemical extractions used to dissolve metals from specific solid-associated phases. SEPs use progressively stronger reagents to solubilize metals from increasingly recalcitrant phases. Although these procedures do not identify the specific metal phases in a soil/aquifer matrix, they do provide a means to evaluate the class of solids and relative stability in relation to oxidation/reduction (redox) potential and pH fluctuations (Tessier et al. 1979, Kuo et al. 1983, Sposito et al. 1984, Hickey and Kittrick 1984, Gruebel et al. 1988). Therefore, SEP data are useful to interpret the mechanism and potential reversibility of attenuation processes. The 7-step extraction procedure is briefly described, and the results of the SEP analysis are provided in Attachment G.

Concentrations of boron were below the detection limit in SEP extractions of the aquifer solids samples, limiting interpretation of boron solid phase associations, but consistent with the lack of total boron detected in the bulk aquifer solids (Table 2).

4.3.3 Mineralogical Analysis

X-Ray diffraction (XRD) with Rietvelt refinement was conducted for identification of minerals in aquifer solid samples. XRD is an analytical technique that provides information about the identity of the crystalline material within a sample but does not provide information about non-crystalline or amorphous phases. XRD results are normalized to 100% of the total weight, meaning that material not characterized by XRD is ignored in the percent calculation. The three analyzed solid samples were predominantly composed of quartz, ranging from 88.4 – 92.0% of the minerals present (Table 3; Attachment H). These results are consistent with the field observations documented in the boring logs provided in Attachment E. Crystalline iron oxides, including goethite and hematite were identified in the analyzed aquifer solids (goethite: 3.1 – 8.2%; hematite: 0.1 – 0.5%) (Table 3). Abundances of goethite and hematite do not correlate well with observations of total iron in the solids (i.e., samples with higher iron concentrations do not necessarily have higher abundances of iron oxide minerals as identified in the XRD results), which may be related to sample heterogeneity or the presence of non-crystalline, amorphous iron oxides that are not detected by XRD.

The aquifer solids samples also had measurable proportions of kaolinite, ranging from 0.7 – 1.6% (Table 3). Kaolinite, a clay mineral, has been correlated with boron sorption in soils (Goldberg 1997) and presents an additional potential attenuation mechanism for boron within the UA solids should geochemical conditions develop to favor adsorption to clay minerals.

4.4 Aqueous Geochemistry

EAP porewater and UA groundwater from wells across the compliance and delineation networks were analyzed for a range of geochemical parameters and presented in Figures 1 through 6. Porewater is evaluated as a mobile source endmember representing conditions within the unit since collection began in 2021. For clarity in interpretation, figures present data from the compliance well network, onsite delineation network, and offsite delineation well network locations separately. Delineation well symbology for both onsite and offsite networks generally becomes more purple further along the downgradient flow path. As boron exceedances are limited to the UA, only wells screened in the UA are included in this evaluation for clarity. The aqueous phase data used in the site evaluation is summarized in Attachment I.

4.4.1 Exceedance Parameters

EAP porewater exhibited boron concentrations from 8.06 to 16.0 milligrams per liter (mg/L), consistent with leachate from CCR units (Figures 1a - 1c) (EPRI 2017). These results are higher than concentrations reported in UA groundwater.

Boron concentrations in groundwater remained stable through time across the site and were consistent along groundwater flow paths. In background wells G01D and G02D, boron concentrations were consistently low (between 0.01 and 0.06 mg/L). Compliance wells which are generally sidegradient of the unit (i.e., G03, G11, G51D, G53D, and G54D) consistently exhibited boron concentrations slightly above background but below the GWPS of 2.0 mg/L, with reported results ranging from 0.11 to 1.03 mg/L. Boron concentrations in groundwater downgradient of the EAP were generally elevated, but exhibited a wide range of concentrations from 0.01 to 10.6 mg/L. Wells G06, G07, G08, G09, and G10 within the compliance network exhibit boron concentrations that are consistently above the GWPS and vary between 2.9 to 5.4 mg/L (Figure 1a).

Wells within both the onsite and offsite delineation networks typically exhibited higher concentrations closer to the source and decreasing concentrations downgradient (Figures 1b & 1c, respectively). Boron concentrations below the GWPS were typically observed in the farthest downgradient wells located further offsite (i.e., G23S/D, G24S/D; Figure 1c) consistent with delineation of the plume. All offsite delineation well locations are below the GWPS for boron, except G17S/D, which are closest to the EAP boundary (Figure 1c).

4.4.2 Redox/pH Summary

The oxidation-reduction (redox) potential (ORP) and pH in aqueous systems are major controls on the speciation of redox-active chemicals such as iron and manganese.

In wells across the groundwater monitoring network, pH values appear to be stable and circumneutral (Figures 2a - 2c). In upgradient background wells G01D and G02D, pH is consistently around 6.5. Similarly, downgradient compliance wells exhibit pH values between 6.5 – 7 (Figure 2a). Wells G11 and G51D, which are generally sidegradient to the west of the EAP, exhibit lower pH values near 5.5 – 6. These lower pH values are attributed to the effect of iron oxidation in groundwater west of the EAP (Ramboll 2023). Within the EAP, CCR porewater exhibits a wider range of pH values, from 7.3 to 10.7, with XPW03 exhibiting pH values consistently above 10. Further downgradient, groundwater pH is generally consistent with the observed background conditions (Figure 2a), with both onsite delineation wells (Figure 2b) and offsite delineation wells (Figure 2c) generally exhibiting pH values between 6.5 – 7.

Wells upgradient or sidegradient of the EAP (G01D, G03, G11, and G51D) typically exhibit consistently oxidizing conditions. There is an apparent redox gradient between upgradient and downgradient wells at the EAP. Upgradient groundwater is generally oxidized, while groundwater downgradient of the unit is mixed: wells directly downgradient of the EAP have a range of redox conditions, and some are observed to fluctuate between reducing and oxidizing conditions (i.e., ORP values ranging from +200 to -200 millivolts [mV]) (Figures 3a and 3b). This may be due to the influence of porewater at select locations, with more reducing conditions potentially correlated to locations with higher boron concentrations (i.e., G08, G09). The EAP CCR porewater is consistently reducing (ORP values below 0 millivolts) relative to groundwater (Figure 3a). This relationship is observed at onsite delineation wells, with wells with higher boron concentrations (i.e, G16D) also exhibiting more reducing conditions (Figure 3b). Further downgradient, higher ORP values consistent with the background are observed (Figure 3c).

4.4.2.1 *Pourbaix Diagrams*

Eh-pH or Pourbaix diagrams can be used to illustrate the predicted speciation of specific analytes at thermodynamic equilibrium under the conditions observed for a groundwater sample. Select crystalline mineral species were suppressed to be representative of anticipated groundwater conditions (e.g., in cases where mineral formation is not anticipated to be kinetically favored), except when identified in XRD data from solids at the Site. Using conditions observed at well G08 on 2 May 2023 (Table 4) to represent wells directly downgradient of the EAP with observations of boron exceedances, goethite is predicted to be stable under aquifer conditions at both upgradient and downgradient locations (Figure 4a).[4] The stability of goethite would provide a potential mineral surface for sorption of boron within the aquifer. The predicted stability of goethite is consistent with the detections of goethite in aquifer solids at abundances ranging between 3.1% and 8% (Table 3). Amorphous iron oxyhydroxides (represented by the mineral ferrihydrite in Figure 4b) are also generally stable under conditions immediately downgradient of the EAP. Ferrihydrite is a crystalline iron oxyhydroxide mineral that can precipitate over a wide range of geochemical conditions and often functions as a precursor for a range of more stable iron (oxyhydr)oxides; it can provide additional adsorptive capacity in the UA.

Similar aquifer conditions are predicted at locations further downgradient, as modeled using groundwater characteristics from G20D and G22D sampled on 3 May 2023 to represent onsite delineation wells and offsite delineation wells, respectively (Table 4). Goethite is favored at all onsite and offsite delineation network locations (Figure 4c and Figure 4e, respectively). While ferrihydrite stability is variable at the downgradient onsite delineation wells (Figure 4d), it increases as groundwater migrates offsite (Figure 4f), consistent with the observed increase in redox conditions offsite. The conditions favoring goethite and amorphous ferrihydrite stability downgradient of the EAP suggest the potential at most locations for continued attenuation capacity via sorption to iron oxides as boron migrates along the groundwater flow path.

A review of Eh-pH conditions for manganese found that solid phase manganese minerals, including manganese oxides, are not predicted to be stable under conditions either immediately downgradient of the EAP or further downgradient (Figures 5a – 5c, respectively).

4.4.2.2 *Total and Dissolved Iron and Manganese Concentrations*

The distribution of iron and manganese between total and dissolved phases can provide insights on site redox conditions and constituent behavior. Dissolved iron and manganese data are only available for the Q2 and Q3 2023 sampling events at select locations. A comparison of the total and dissolved iron and manganese data for this event is provided in Table 5. Total iron was detected at 28 of 29 locations analyzed, with reported values ranging from 0.0476 mg/L at delineation well G12D to 24.3 mg/L at downgradient well G07. Dissolved iron was detected at 8 of 29 locations analyzed, with reported values ranging from 0.214 mg/L to 1.36 mg/L. Where dissolved iron was

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[4] Field ORP measurements were converted to Eh by adding +200 millivolts to correct for the Ag/AgCl electrode.

detected, the dissolved concentration was at least 50% less than the total value. The lower dissolved iron values suggest that aqueous iron is largely associated with particles in the colloidal size fraction and is not readily undergoing true dissolution from solid mineral phases to reduced aqueous iron (Fe^{2+}). This aligns with the conditions expected based on the Pourbaix diagrams (Figures 4a, 4c, & 4e), which predicted that goethite is stable.

Total manganese was detected at 25 of 29 locations analyzed, with reported values ranging from 0.0033 mg/L at background well G02 to 10.2 mg/L at delineation well G16S (Table 5). Dissolved manganese was detected at 27 of 29 locations analyzed, with reported values ranging from 0.0032 mg/L at background well G02 to 11.1 mg/L at delineation well G16S. The reported total and dissolved manganese concentrations were generally much more similar at each monitoring location than iron, suggesting that most manganese is present within the dissolved phase. This is consistent with the predicted mobilization of manganese to the aqueous phase based on the Pourbaix diagrams (Figures 5a – 5c) and the lack of observed crystalline manganese-bearing minerals (like rhodochrosite) across the site.

4.4.3 Major Ion Distribution and Groundwater Signatures

Piper diagrams were constructed using data from both the compliance and delineation networks to visualize major ion distributions in UA groundwater. Piper diagrams are a common tool for assessing geochemical similarities or differences in terms of the major ion distributions between aqueous samples. The groundwater at monitoring wells with elevated boron concentrations (i.e., G06, G07, G08, G09, G10) tend to be more similar in their major ion distribution (Figure 6a) to EAP CCR porewaters (XPW01, XPW02, and XPW03) compared to background samples (G01D and G02D). There is an increasing contribution of sulfate and decreasing contribution of alkalinity to the ion balance when moving from upgradient wells G01 and G02, which are representative of background conditions, to downgradient wells. EAP CCR porewaters have a lower abundance of magnesium than groundwater across the monitoring network. A groundwater composition more similar to EAP CCR porewaters is observed at delineation wells with high boron concentrations (i.e., G12D, G12S; Figure 6b) compared to locations further downgradient (i.e., MW-24S, MW-24D; Figure 6c).

5. LABORATORY BATCH TESTING

Batch test studies combine soil and groundwater collected from the site to evaluate the sorption and desorption of chemical constituents. A draft memorandum discussing batch attenuation testing at the Joppa site was included as an appendix to the *Groundwater Modeling Report* (Ramboll 2022) and is provided as Attachment J to this document.

5.1 Batch Attenuation Testing

Batch attenuation testing was conducted for boron to evaluate sorption and generate site-specific distribution coefficients between the solid and aqueous phase. Aquifer solids from sample G03 and groundwater from well G07 were used for the batch attenuation tests. Each test was set up in duplicate and five soil to water ratios were evaluated (Table 6). The groundwater was spiked with boric acid to a target concentration of 5 mg/L. At the end of the test, the samples were filtered through a 0.45 micron filter and dissolved boron concentrations in the aqueous phase were analyzed. Analysis of the dissolved phase is important to adequately measure the partitioning of mass between the solid and liquid fractions of the experiment. The mass of boron in the water versus in the solids of each sample were plotted according to three sorption models: linear, Langmuir, and Freundlich. The linear data output is provided as Figure 7.

Data obtained from the batch attenuation tests was used to construct linear and non-linear isotherms and calculate attenuation distribution coefficients (K_d). The K_d values for boron for linear, Langmuir, and Freundlich isotherms are provided in Table 7. The results of one of the soil to water ratios (1 to 27.3) was excluded when calculating the distribution coefficients, because these values consistently reduced the goodness-of-fit of each isotherm and resulted in unrealistic values for K_d and isotherm fitting parameters. Removing the 1:27.3 soil to water ratio also resulted in a more conservative linear K_d.

The linear K_d of 2.4 L/kg was selected for G07 based on its goodness-of-fit ($R^2 > 0.99$) and compatibility with values reported in literature (which range from 0.19 to 1.3 L/kg; EPRI 2005, Strenge and Peterson 1989). While the Langmuir and Freundlich isotherms also had a high goodness-of-fit, they generated K_d values orders of magnitude higher than those reported in the literature. The boron K_d value of 2.4 L/kg selected for the site indicates that there may be some sorption of boron to UA solids.

5.2 Batch Desorption Testing

The loaded soil material from G03 following the adsorption phase of the testing was combined with groundwater from unimpacted downgradient well G03 to evaluate the reversibility of boron attenuation with the aquifer solids. The soil material which was used in the 1:5 soil:water ratio adsorption set up was used for the desorption tests. The soil was combined with G03 water at a 1:10 ratio and incubated for seven days. Batch reactors were set up in duplicate, with one set incubated under ambient conditions, one set incubated with daily hydrogen sparging to represent reducing conditions, and one set incubated with daily oxygen sparging to represent more oxidizing conditions.

Desorption of boron was observed under all redox conditions (Figure 8). There were no substantial differences in desorption under different redox conditions, which may be due to the limited range of redox conditions which were achieved under the experimental design (all relatively oxidizing with average ORP values from 110-189 mV; Table 8). While these redox conditions are generally reflective of background conditions (Figure 3a) and off-Site conditions (Figure 3c), current conditions at onsite delineation locations are generally more reducing (Figure 3b).

6. GEOCHEMICAL CONCEPTUAL SITE MODEL

6.1 Source and Mobilization Mechanisms

Boron is naturally abundant in coals and is concentrated within CCR, primarily as mobile polyborate (B_2O_3) surface coatings on particles (EPRI 1998). Boron was identified in the CCR solids at concentrations up to 542 mg/kg. Boron was not detected within UA aquifer solids at elevated concentrations that would indicate a natural source of boron to groundwater, and groundwater from background wells consistently exhibited very low boron concentrations. The primary source of boron to the UA is likely the EAP CCR porewater.

6.2 Potential Attenuation Mechanisms

Boron is anticipated to largely be present as the neutral $B(OH)_3$ species as groundwater pH values are below the pK_a for boric acid (9.2). The presence of iron oxyhydroxides in aquifer solids (Table 2) suggests a portion of the boron in the groundwater system may be attenuated via surface complexation reactions within the UA. Given the low abundance of total manganese in the aquifer solids (Table 1) and the predicted instability of solid manganese phases (Figures 5a – 5c), manganese oxides are not expected to be an important source of adsorption sites. Boron is also known to be slightly attenuated via interactions with clay minerals (Goldberg 1997); the XRD results identified the presence of the clay mineral kaolinite at downgradient locations where samples were collected (Table 4). Together, this suggests that chemical attenuation of boron is possible at locations downgradient of the EAP.

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TABLES

Table 1 - CCR Solid Phase Characterization
Geochemical Conceptual Site Model
Joppa Power Plant - East Ash Pond

Field Boring Location	**XPW-01**			**XPW-02**		**XPW-03**	
Sample Depth (ft bgs)	**4-6**	**46-48**	**46-48**	**4-6**	**24-26**	**6-8**	**34-36**
Constituent	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Antimony	2.8	0.38 U	0.4 U	3.25	2.19	4.07	0.41 SR
Arsenic	16.4 B	8.77 B	7.31 B	21.1 B	44.1 B	55.8 B	52.7 B
Barium	3080 B	105 B	105 B	2690 B	193 B	976 B	149 B
Beryllium	3.7	0.72	0.72	3.18	3.86	3.3	1.49
Boron	542	35.1	36.3	536	334	308	92.6
Cadmium	1.41	0.19 U	0.19 U	1.61	2.37	0.95	0.65
Calcium	141000	3280	3530	152000	34600	34700	4010 S
Chromium	49.4	18.3	18.8	57.7	55.8	44.8	31.2
Cobalt	22	8.46	8.99	22.9	11.8	11.8	8.26
Iron	31600	17900	18400	33800	57000	23200	26200 S
Lead	34.2	15.1	15.5	32	22.4	60.3	42.8
Lithium	30.9	12.2	12.3	28.2	10.4	16.2	17.5
Manganese	95.2 B	125 B	133 B	153 B	342 B	124 B	95.6 B
Mercury	0.758	0.015	0.016	0.583	0.014 U	0.029	0.33
Molybdenum	7.42	32.2	47.9	9.93	7.99	11.6	213 SR
Selenium	8.29	0.94 U	0.96 U	6.65	2.23	2.15	6.94
Thallium	0.93 U	0.32	0.26	1.13	2.11	1.33	0.46 SR

Notes

ft. bgs - feet below ground surface

mg/kg - milligrams per kilogram

U - Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

B - Analyte was detected in associated Method Blank

S - Spike Recovery was outside the recovery limits

R - Relative Percent Difference (RPD) was outside the accepted recovery limits

Total metals samples prepared via method SW 3050 and analyzed via USEPA method 6020A.

CCR - Coal Combustion Residuals

Table 2 - Bulk Characterization of Aquifer Solids
Geochemical Conceptual Site Model
Joppa Power Plant - East Ash Pond

Field Boring Location	**G03**				**G07**	**G08**	**G09M***			**G11**	
Sample Depth (ft bgs)	**30-32**	**58-60**	**58-60**	**57.5-62.5, 63.5-70**	**50-56**	**75-80**	**10-12**	**82-84**	**110-112**	**22-24**	**58-60**
Location	**Sidegradient**				**Downgradient**	**Downgradient**	**Downgradient**			**Downgradient**	
Sample Collection Date	**2/2/2021**	**2/2/2021**	**2/2/2021**	**10/14/2021**	**10/14/2021**	**10/14/2021**	**1/26/2021**	**1/27/2021**	**1/27/2021**	**1/19/2021**	**1/19/2021**
Field Boring Log Description	**Sandy Silt**	**Sand with few gravel**		**Sand and gravelly sand**	**Sand with fine to coarse gravel**	**Sand and fine to coarse gravel**	**Lean Clay**	**Gravel with little sand**	**Fine-grained sand**	**Lean clay**	**Sand with trace gravel**
Antimony	0.37 U	0.37 U	0.39 U	NA			0.39 U	0.38 U	0.38 U	0.79	0.37 U
Arsenic	2.59	0.3	0.26	7.8	5.8	28	3.34	6.34	4.44	3.5 B	1.15 B
Barium	347 B	6.01 B	5.06 B	100	170	180	93.6 B	19.6 B	11.5 B	173 B	21.6 B
Beryllium	0.71	0.28 U	0.29 U	1	1	1	0.46	0.89	0.29 U	0.74	0.3
Boron	4.63 U	4.72 U	4.81 U	NA			4.55 U	4.55 U	4.9 U	4.55 U	4.55 U
Cadmium	0.18 U	0.19 U	0.19 U	0.08	0.06	0.31	0.18 U	0.18 U	0.2 U	0.43	0.18 U
Calcium	1590	153	121	3100	1500	900	1740	277	420	1370	430
Chromium	18.7	4.69	3.91	41	43	30	16.6	19.4	7.43	15.7	6.05
Cobalt	110 SR	0.82	1.85	6	8	29	5.68	7.69	0.8	2.72	1.29
Iron	13900 S	1060	830	40000	44000	99000	13100	32000	6470	12000	2800
Lead	27.8	1.3	0.99	7	7	6	7.76	3.48	3.76	8.64	3
Lithium	12.6	0.86	0.8	7	7.6	6.7	9.67	0.78	1.72	5.69	2.03
Manganese	1320 SR	6.1	8.51	190	320	1000	338	270	57.2	60.9 B	11.6 B
Mercury	0.012 U	0.012 U	0.012 U	NA			0.021	0.012 U	0.012 U	0.011 U	0.011 U
Molybdenum	0.38	0.19 U	0.19 U	1	0.6	2.8	0.37	1.04	0.51	0.36	0.18 U
Selenium	0.91 U	0.94 U	0.96 U	0.7 U	0.7 U	0.7 U	0.91 U	0.91 U	0.98 U	0.91 U	0.91 U
Thallium	0.26	0.19 U	0.19 U	0.08	0.08	0.12	0.18 U	0.18 U	0.2 U	0.41	0.18 U
TOC%	NA			0.039	0.039	0.049	NA			NA	
LOI%	NA			1.05	0.93	1.58	NA			NA	

Notes

Sample depth is shown in feet below ground surface (ft bgs).

All results shown in mg/kg (milligram per kilogram)

NA - not analyzed

TOC - total organic carbon

LOI - loss on ignition

U - Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

B - Analyte was detected in associated Method Blank

J - Estimated value. Parameter was detected in concentrations below the reporting limit

S - Spike Recovery was outside the recovery limits

R - Relative Percent Difference (RPD) was outside the accepted recovery limits

Total metals samples prepared via method SW 3050 and analyzed via USEPA method 6020A.

* Samples from G09M were co-located with screened interval for G09.

Table 3 - X-Ray Diffraction Analysis of Aquifer Solids
Geochemical Conceptual Site Model
Joppa Power Plant - East Ash Pond

Field Boring Location			**G-03**	**G-07**	**G-08**
Sample Depth (ft bgs)			**(57.5-62.5, 63.5-70)**	**(50-56)**	**(75-80)**
Location			**Sidegradient**	**Downgradient**	**Downgradient**
Field Boring Log Description			**Sand and gravelly sand**	**Sand with fine to coarse gravel**	**Sand and fine to coarse gravel**
Mineral/Compound	**Formula**	**Mineral Type**	**(wt %)**	**(wt %)**	**(wt %)**
Quartz	SiO_2	Silicate	90.6	92.0	88.4
Microcline	$KAlSi_3O_8$	Feldspar	1.1	1.7	1.3
Albite	$NaAlSi_3O_8$	Feldspar	1.3	1.5	1.2
Geothite	$\alpha FeO.OH$	Oxide	4.9	3.1	8.2
Hematite	Fe_2O_3	Oxide	0.5	0.2	0.1
Magnetite	Fe_3O_4	Oxide	0.0	0.0	0.0
Pyrite	FeS_2	Sulfide	0.0	0.0	0.0
Kaolinite	$Al_2Si_2O_5(OH)_4$	Clay	1.6	1.6	0.7
Clay Minerals Total			1.6	1.6	0.7

Notes

Sample depth is shown in feet below ground surface (ft bgs).

wt %: percentage by weight

Table 4 - Eh-pH Diagram Input
Geochemical Conceptual Site Model
Joppa Power Plant - East Ash Pond

Well ID		**G08**	**G20D**	**G22S**
Sample Collection Date		**2-May-23**	**3-May-23**	**3-May-23**
Input Parameter	**Units**			
pH	SU	6.88	7.05	6.88
Bicarbonate Alkalinity	mg/L $CaCO_3$	154	171	161
Calcium	mg/L	140	77.7	55.4
Chloride	mg/L	16.0	14.0	22.0
Iron	mg/L	16.8	0.10	0.0255
Magnesium	mg/L	32.2	21.0	16.4
Manganese	mg/L	2.62	0.01	0.0031
Potassium	mg/L	1.67	1.8	1.22
Sodium	mg/L	41.7	23.6	31.3
Sulfate	mg/L	363	140.0	63.0
Temperature	℃	17.3	15.4	17.0

Notes
mg/L - milligram per liter
SU - standard units

Table 5 - Total and Dissolved Aqueous Iron and Manganese Results
Geochemical Conceptual Site Model
Joppa Power Plant - East Ash Pond

Well ID	Well Classification	Sample Date	Dissolved Iron (mg/L)	Total Iron (mg/L)	Dissolved Manganese (mg/L)	Total Manganese (mg/L)
G01D	Background	5/2/2023	0.214	4.09	0.33	0.345
		9/25/2023	0.0492	2.41	0.0273	0.0562
G02D	Background	5/3/2023	<0.02	0.049	0.0033	0.0032
		9/25/2023	0.0338	0.319	0.009	0.0169
G03	Downgradient	5/3/2023	<0.02	22.3	0.0193	0.234
		9/26/2023	0.0257	2.18	0.003	0.0233
G05	Downgradient	5/3/2023	0.342	1.5	0.166	0.191
		9/27/2023	0.429	1.98	0.104	0.0814
G06	Downgradient	5/3/2023	<0.02	7.34	0.0155	0.102
		9/27/2023	0.0452	1.68	0.0127	0.0403
G07	Downgradient	5/3/2023	<0.02	24.3	1.85	2.72
		9/27/2023	0.177	1.22	3.1	3.84
G08	Downgradient	5/3/2023	1.07	16.8	1.84	2.62
		9/26/2023	0.751	3.37	2.25	2.78
G09	Downgradient	5/3/2023	2.5	15.6	1.01	1.27
		9/26/2023	1.53	5.35	1.01	1.27
G10	Downgradient	5/3/2023	0.325	13.2	0.121	0.189
		9/26/2023	0.534	2.26	0.184	0.276
G11	Downgradient	5/3/2023	<0.04	3.35	0.033	0.37
		9/26/2023	0.171	0.106	0.0059	0.0115
G12D	Delineation	5/2/2023	<0.02	0.0476	0.005	0.0085
		9/28/2023	0.0599	0.065	0.0051	0.0043
G12S	Delineation	5/2/2023	<0.02	2.34	0.0064	0.0297
		9/28/2023	<0.0115	0.0957	0.0082	0.0107
G13D	Delineation	5/2/2023	<0.02	<0.02	<0.007	<0.007
		9/27/2023	0.0374	0.0621	0.0008	0.0016
G13S	Delineation	5/2/2023	<0.02	0.0461	<0.007	<0.007
		9/27/2023	0.035	0.219	0.0008	0.0018
G14D	Delineation	1/26/2023	--	1.32	--	0.0638
G14S	Delineation	1/25/2023	--	0.31	--	0.0101
G15D	Delineation	1/25/2023	--	2.16	--	0.592
G15S	Delineation	1/25/2023	--	0.112	--	0.0178
G16D	Delineation	1/25/2023	--	2.43	--	2.72
G16S	Delineation	5/2/2023	<0.02	0.428	10.2	11.1
		9/27/2023	0.084	0.921	8.75	11.7
G17D	Delineation	1/24/2023	--	0.483	--	0.0328
G17S	Delineation	1/24/2023	--	0.794	--	0.0263
G18D	Delineation	1/24/2023	--	3.4	--	0.529
G18S	Delineation	5/3/2023	<0.02	0.441	0.0028	0.0086
		9/27/2023	<0.0115	0.153	0.0012	0.0035
G19D	Delineation	5/3/2023	<0.02	1.14	0.0036	0.0286
		9/28/2023	<0.0115	0.474	0.0014	0.0312
G19S	Delineation	5/3/2023	<0.02	0.0984	0.0225	0.0344
		9/28/2023	0.487	0.205	0.0105	0.0108
G20D	Delineation	5/3/2023	<0.02	0.104	0.0138	0.0134
		9/27/2023	<0.0115	0.0589	0.0012	0.002
G20S	Delineation	5/3/2023	<0.02	0.0628	0.0031	0.0057
		9/27/2023	0.051	0.0366	0.0012	0.0015
G21D	Delineation	5/3/2023	1.36	2.65	0.197	0.261
		9/27/2023	0.985	1.36	0.14	0.208
G21S	Delineation	5/3/2023	<0.02	1.12	<0.007	0.0147
		9/27/2023	<0.0115	0.178	0.0012	0.0027
G22D	Delineation	5/3/2023	<0.02	1.13	0.0417	0.0645
		9/28/2023	0.183	0.957	0.0532	0.0551
G22S	Delineation	5/3/2023	<0.02	0.255	<0.007	0.0031
		9/28/2023	<0.0115	0.191	0.0012	0.0015
G23D	Delineation	1/24/2023	--	0.55	--	0.0757
G23S	Delineation	5/3/2023	<0.02	0.998	0.0218	0.0368
		9/27/2023	0.0544	0.411	0.0059	0.0272
G24D	Delineation	1/24/2023	--	4.54	--	0.323
G24S	Delineation	5/2/2023	<0.02	0.136	0.104	0.0943
		9/28/2023	0.0751	0.187	0.0377	0.0411
G51D	Downgradient	5/3/2023	0.785	0.823	0.29	0.324
		9/25/2023	1.31	0.542	0.0239	0.0221
G53D	Downgradient	5/3/2023	<0.02	0.33	0.126	0.133
		9/27/2023	0.101	0.232	0.172	0.118
G54D	Downgradient	5/3/2023	0.716	1.39	1.04	1.19
		9/26/2023	0.669	0.855	0.96	1.05

Notes

mg/L: milligrams per liter

Non-detect values are shown as less than the method detection limit.

For locations where Q2-Q4 2023 iron and manganese data are not available, the most recent sampling event is shown.

Table 6 - Batch Attenuation Testing Results
Geochemical Conceptual Site Model
Joppa Power Plant - East Ash Pond

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	pH	ORP
						mg/L	SU	mV
G07	**--**	**Water Control Only**	23-Dec-21	0	G07-1a	5.8	7.23	81
					G07-2a	5.4	7.30	73
					Average Result	**5.6**	**7.3**	**77**
			30-Dec-21	7	G07-1	4.1	7.14	193
					G07-2	4.3	7.09	168
					Average Result	**4.2**	**7.1**	**181**
	G03 (Sample depth (ft bgs) 57.6-62.5, 63.5-70.0)	**2:1.3 Soil:Water Ratio**	23-Dec-21	0				
			30-Dec-21	7	G03:G07 2:1-1	2.5	6.85	148
					G03:G07 2:1-2	3.1	6.75	132
					Average Result	**2.8**	**6.8**	**140**
		1:1.2 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	G03:G07 1:1-1	3.1	6.84	146
					G03:G07 1:1-2	3.1	6.95	142
					Average Result	**3.1**	**6.9**	**144**
		1:5.6 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	G03:G07 1:5-1	3.8	6.96	134
					G03:G07 1:5-2	4.3	6.91	135
					Average Result	**4.1**	**6.9**	**135**
		1:11 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	G03:G07 1:10-1	4.4	6.98	136
					G03:G07 1:10-2	4.4	6.89	131
					Average Result	**4.4**	**6.9**	**134**
		1:27.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	G03:G07 1:20-1	4.5	7.08	146
					G03:G07 1:20-2	4.4	6.92	150
					Average Result	**4.5**	**7.0**	**148**

Notes

mg/L - milligrams per liter
mV - millivolts
SU -Standard Units
ORP - oxidation/reduction potential
ft bgs - feet below ground surface

Table 7 - Boron Partition Coefficients
Geochemical Conceptual Site Model
Joppa Power Plant - East Ash Pond

Groundwater Sample ID	Geologic Material Sample ID	Analyte	Isotherm	Variable	Value
G07	**G03 (Sample depth (ft bgs) 57.6-62.5, 63.5-70.0)**	**Boron**	Linear	R^2	0.998
				K_d (L/kg)	**2.40**
			Langmuir	R^2	0.982
				q_m (mg/g)	0.06
				K_L (L/kg)	**5.66E+04**
			Freundlich	R^2	0.999
				1/n	0.83
				K_F (L/kg)	**86.4**

Notes

K_d - linear partition coefficient

K_L - Langmuir partition coefficient

K_F - Freundlich partition coefficient

q_m - inverse of the slope of the linearized Langmuir isotherm

n - non-linearity constant of the Freundlich isotherm

ft bgs - feet below ground surface

L/kg - liters per kilogram

mg/g - milligrams of boron per gram of soil

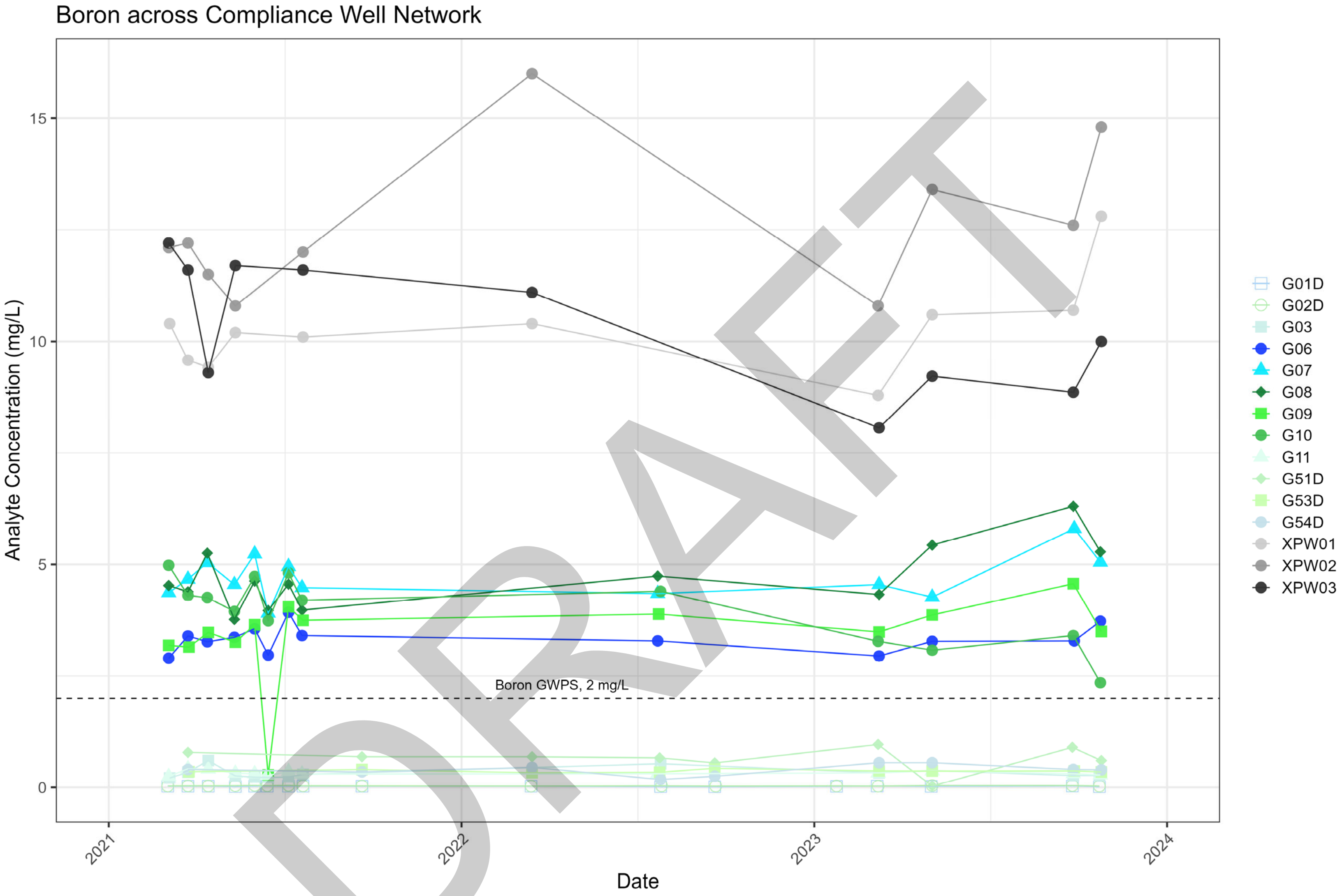
Table 8 - Batch Desorption Testing Results
Geochemical Conceptual Site Model
Joppa Power Plant - East Ash Pond

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	pH	ORP
						mg/L	SU	mV
G03	**G03 (Sample depth (ft bgs) 57.6-62.5, 63.5-70.0) - following loading as the 1:5 soil:water attenuation incubator**	**Ambient Control**	8-Mar-22	0				
			15-Mar-22	7	Unamended 1	1.2	6.62	195
					Unamended 2	0.87	6.6	183
					Average Result	**1.0**	**6.6**	**189**
		Oxygen Sparged	8-Mar-22	0				
			15-Mar-22	7	Oxygen 1	0.95	6.90	171
					Oxygen 2	0.90	6.94	170
					Average Result	**0.92**	**6.9**	**171**
		Hydrogen Sparged	8-Mar-22	0				
			15-Mar-22	7	Hydrogen 1	0.94	6.60	157
					Hydrogen 2	0.97	6.61	62
					Average Result	**0.96**	**6.6**	**110**

Notes

mg/L - milligrams per liter
mV - millivolts
SU -Standard Units
ORP - oxidation/reduction potential
ft bgs - feet below ground surface

FIGURES



Notes:
1. Background wells shown with open symbols
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard

Boron Concentration Time Series – Compliance Network

Joppa Power Plant – East Ash Pond

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Figure 1a

Columbus, Ohio

April 2024

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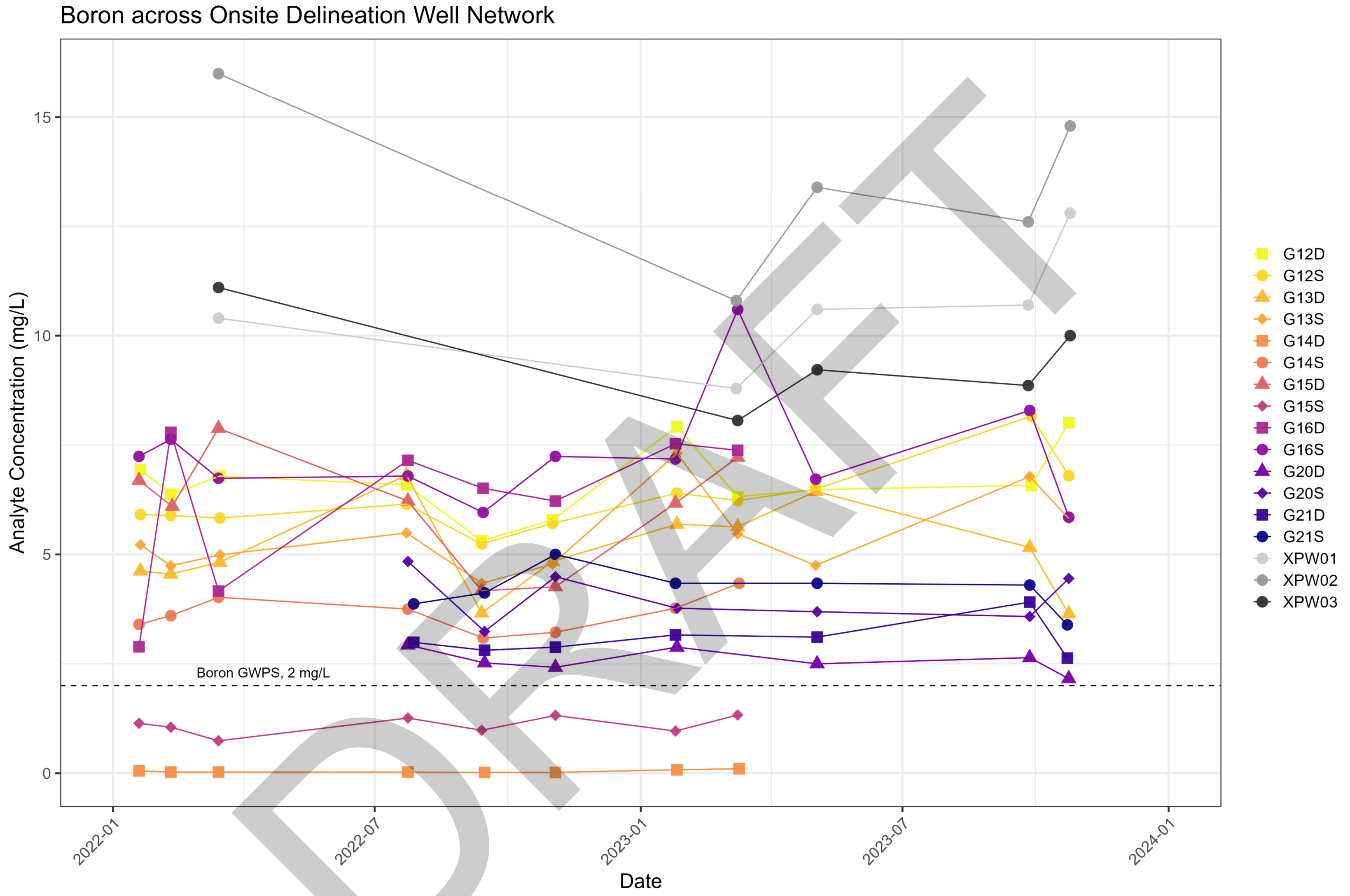

Notes:
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard

Boron Concentration Time Series –
Onsite Delineation Network
Joppa Power Plant – East Ash Pond

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consultants

Figure
1b

Columbus, Ohio
April 2024

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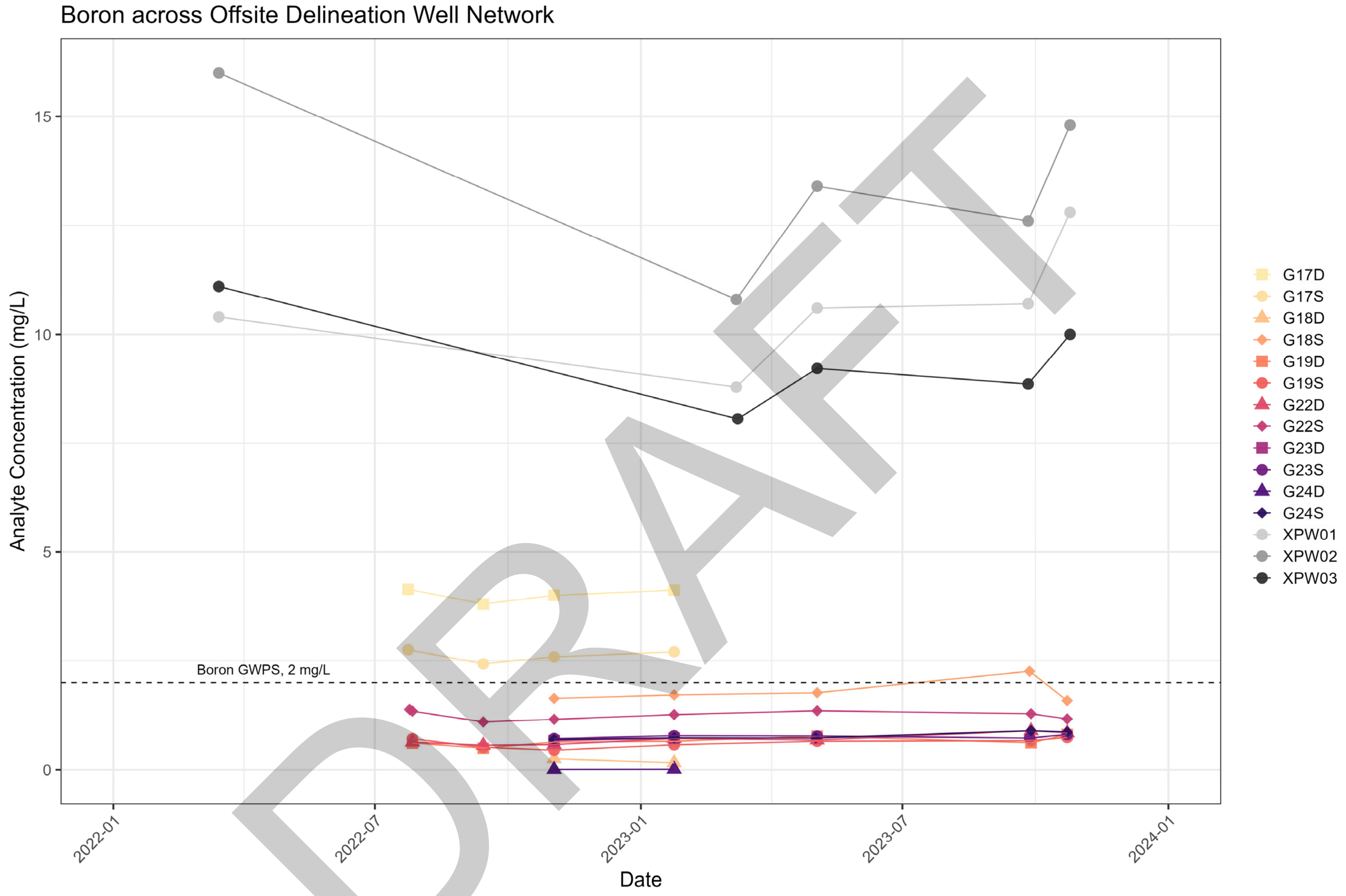

Notes:
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard

Boron Concentration Time Series –
Offsite Delineation Network
Joppa Power Plant – East Ash Pond

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Figure
1c

Columbus, Ohio
April 2024

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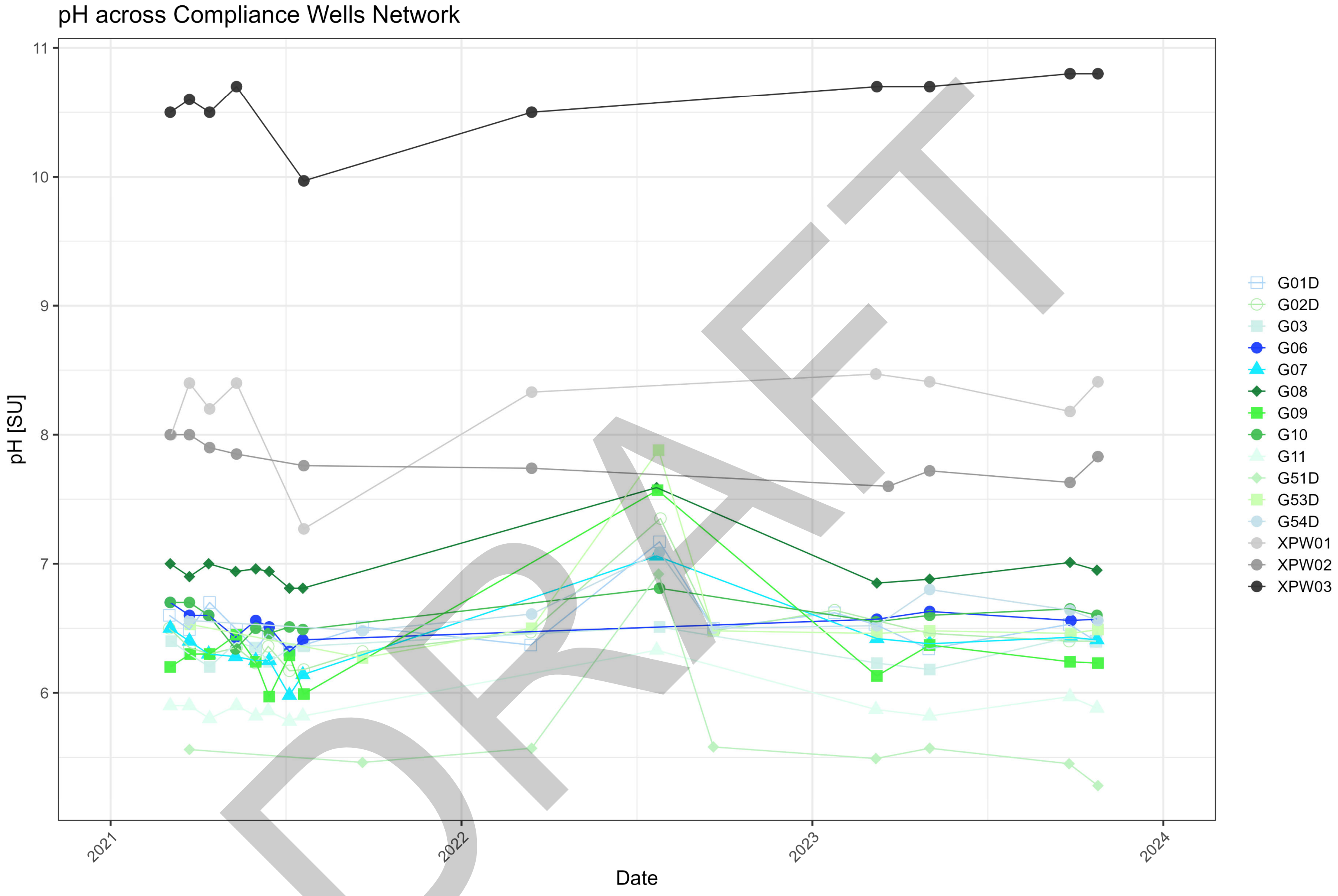

Notes:
1. Background wells shown with open symbols
2. Results shown in standard units (SU)

pH Time Series –
Compliance Network
Joppa Power Plant – East Ash Pond

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Figure
2a

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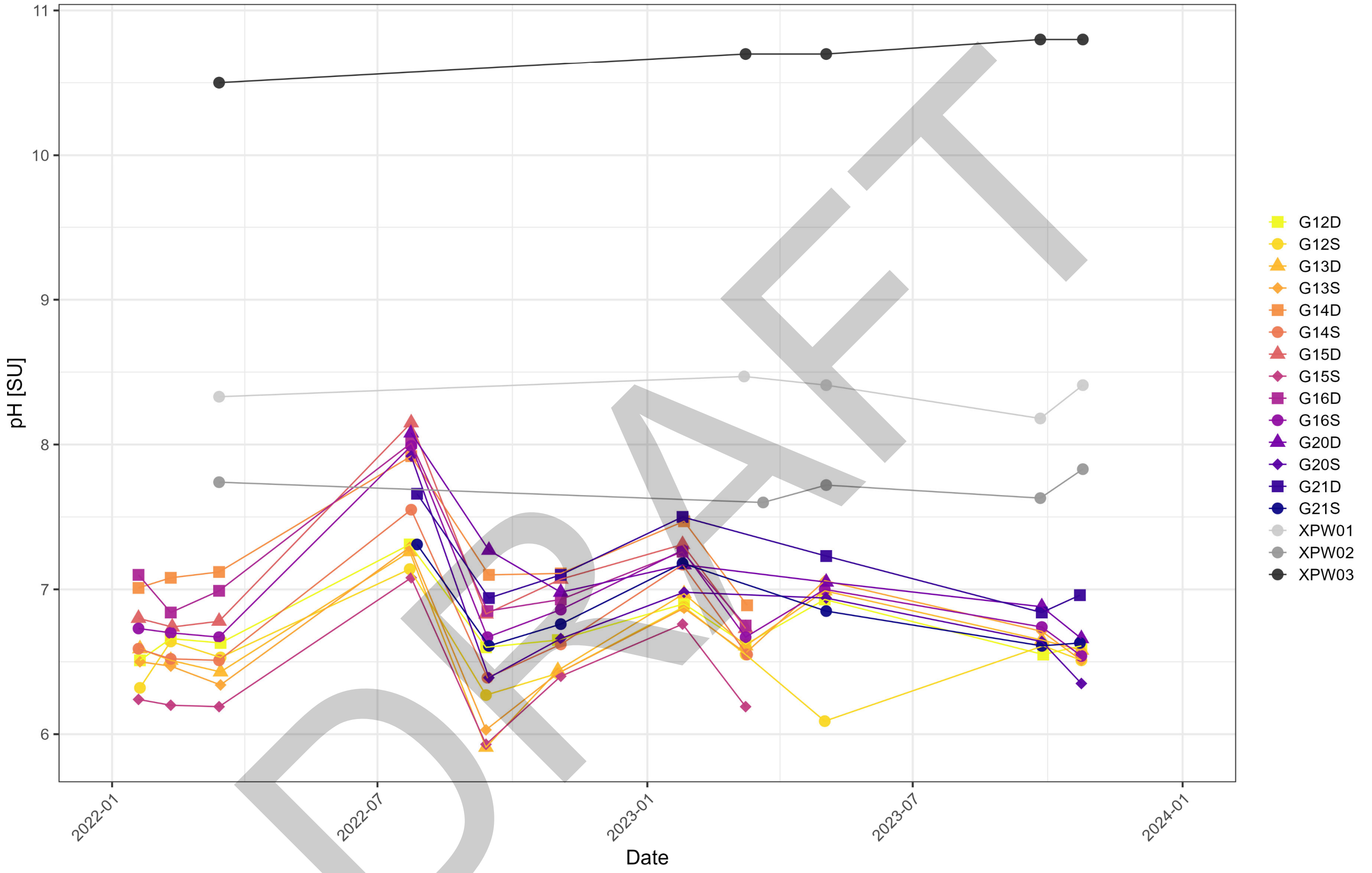
pH across Onsite Delineation Well Network



Notes:
1. Results shown in standard units (SU)

pH Time Series –
Onsite Delineation Network
Joppa Power Plant – East Ash Pond

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Figure
2b

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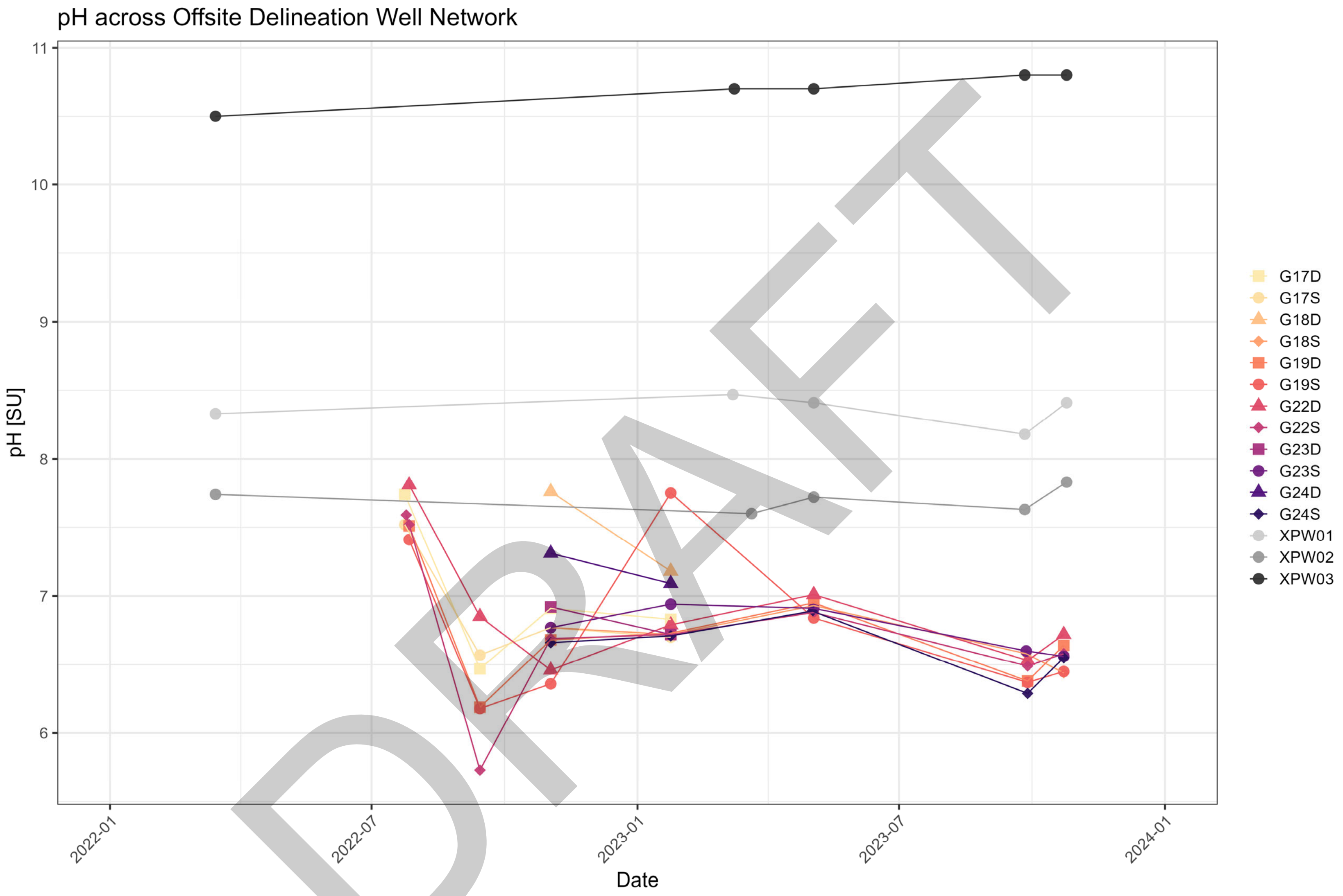

pH Time Series –
Offsite Delineation Network
Joppa Power Plant – East Ash Pond

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Figure
2c

Columbus, Ohio | April 2024

Notes:
1. Results shown in standard units (SU)

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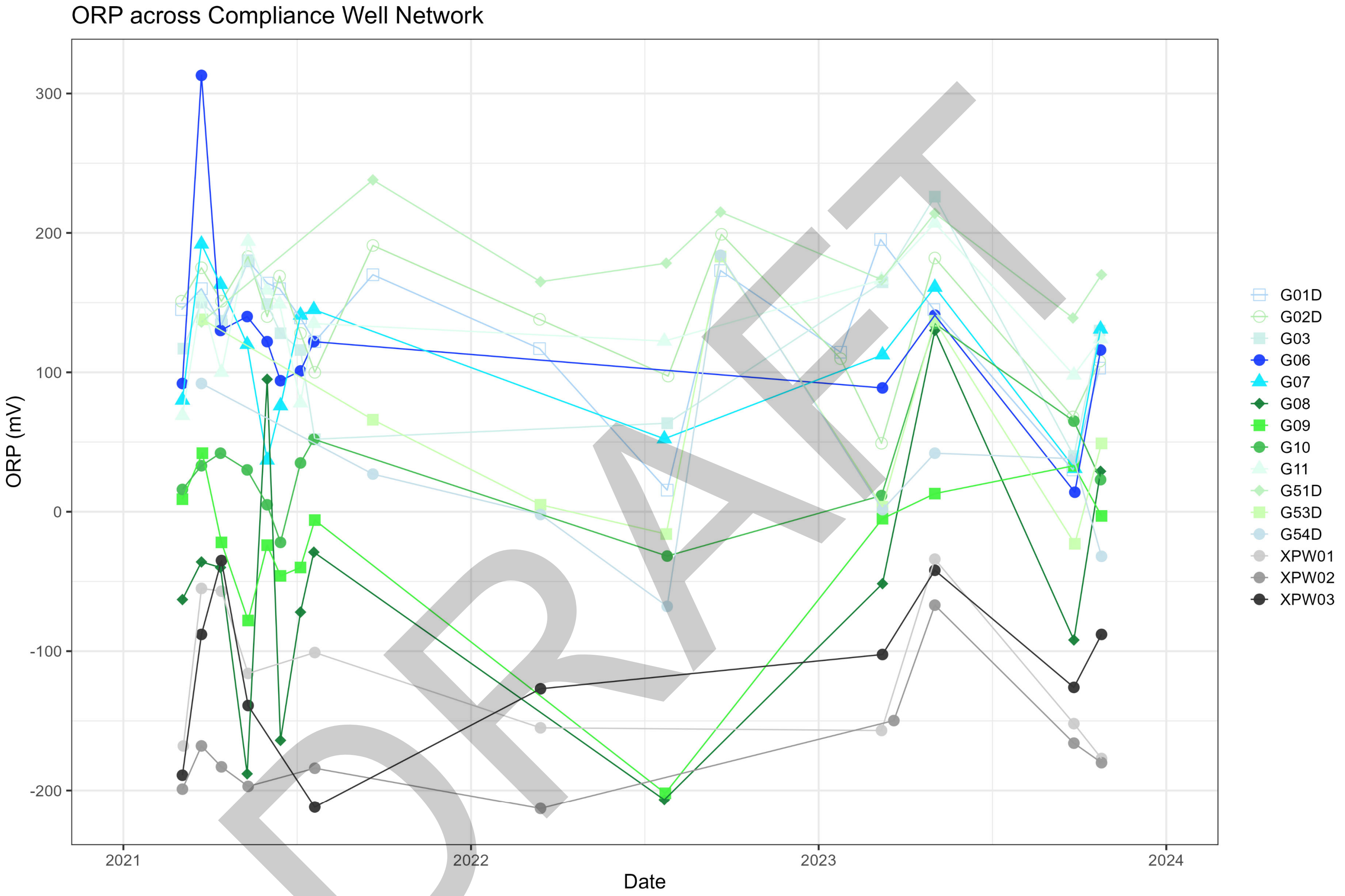

Notes:
1. Background wells shown with open symbols
ORP: Oxidation reduction potential
mV: millivolt

ORP Time Series –
Compliance Network
Joppa Power Plant – East Ash Pond

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Figure
3a

Columbus, Ohio
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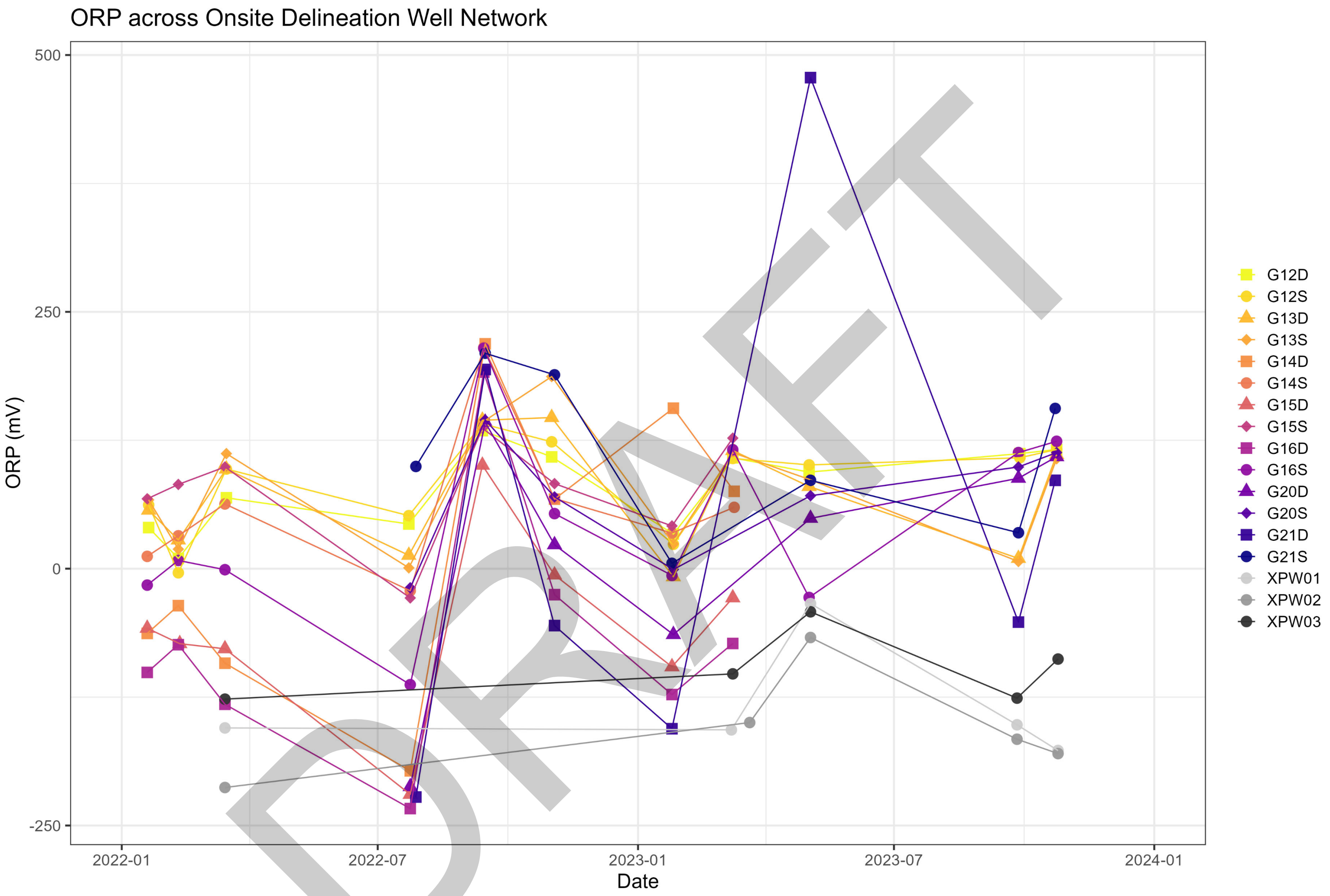

Notes:
ORP: Oxidation reduction potential
mV: millivolt

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ORP Time Series –
Onsite Delineation Network
Joppa Power Plant – East Ash Pond

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Figure
3b

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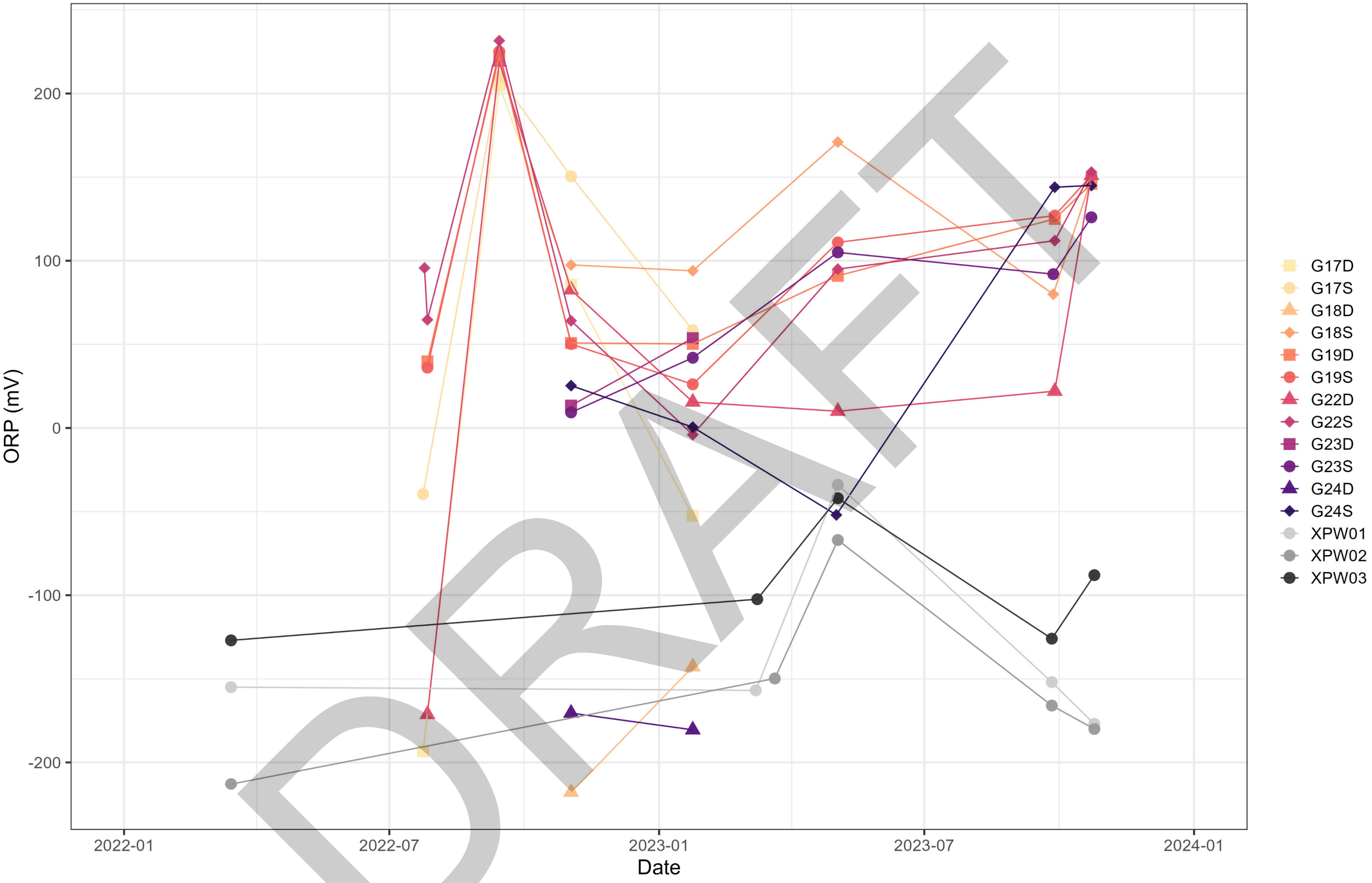
April 2024

ORP across Offsite Delineation Well Network



Notes:
ORP: Oxidation reduction potential
mV: millivolt

ORP Time Series –
Offsite Delineation Network
Joppa Power Plant – East Ash Pond

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Figure
3c

Columbus, Ohio

April 2024

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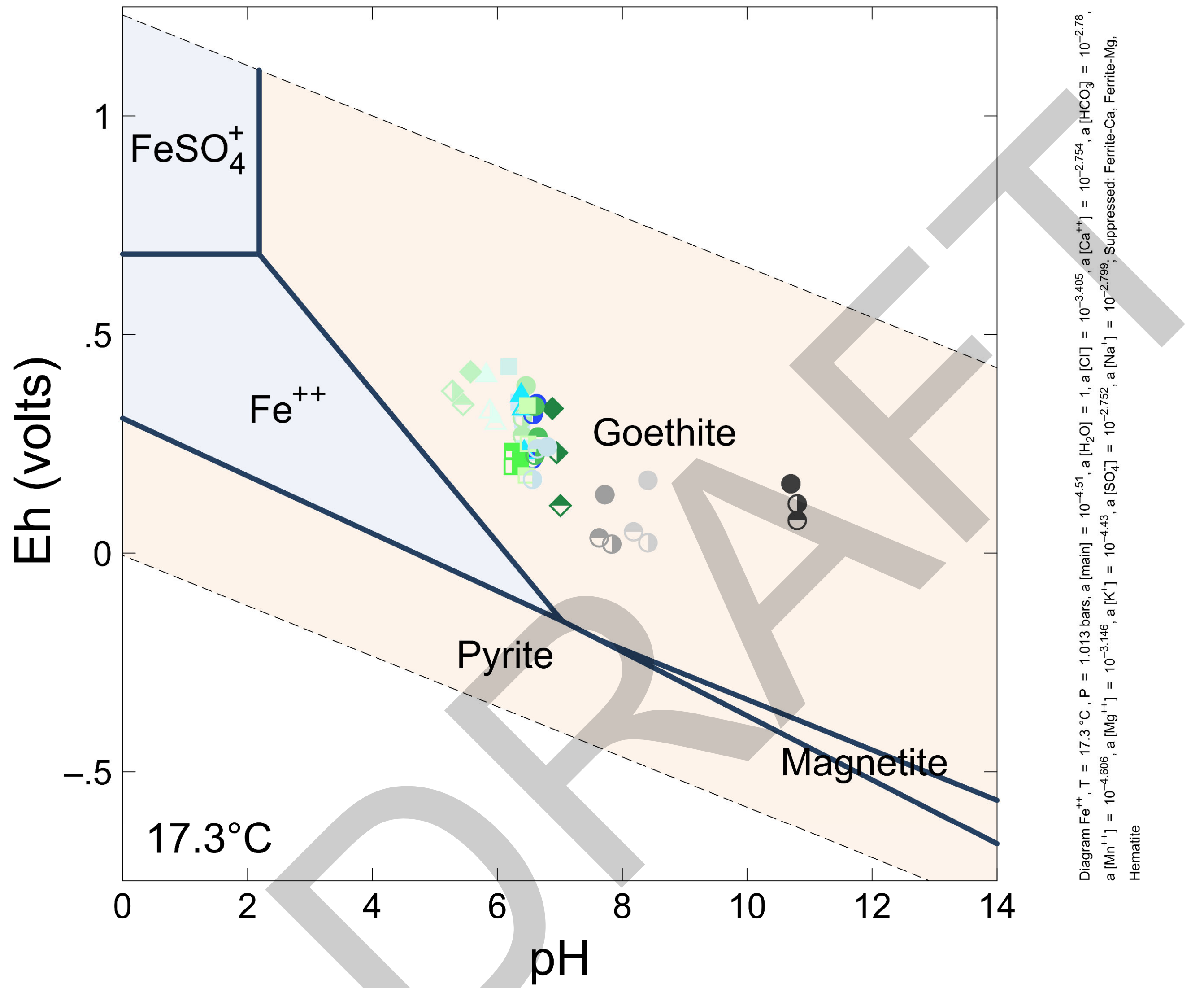

Notes:

1. Diagram was generated using conditions observed at well G08 on 5/2/23
2. The three most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Hematite, ferrite-Ca, and ferrite-Mg were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

Iron Pourbaix Diagram, Goethite – Compliance Network

Joppa Power Plant – East Ash Pond

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Figure 4a

Columbus, Ohio

April 2024

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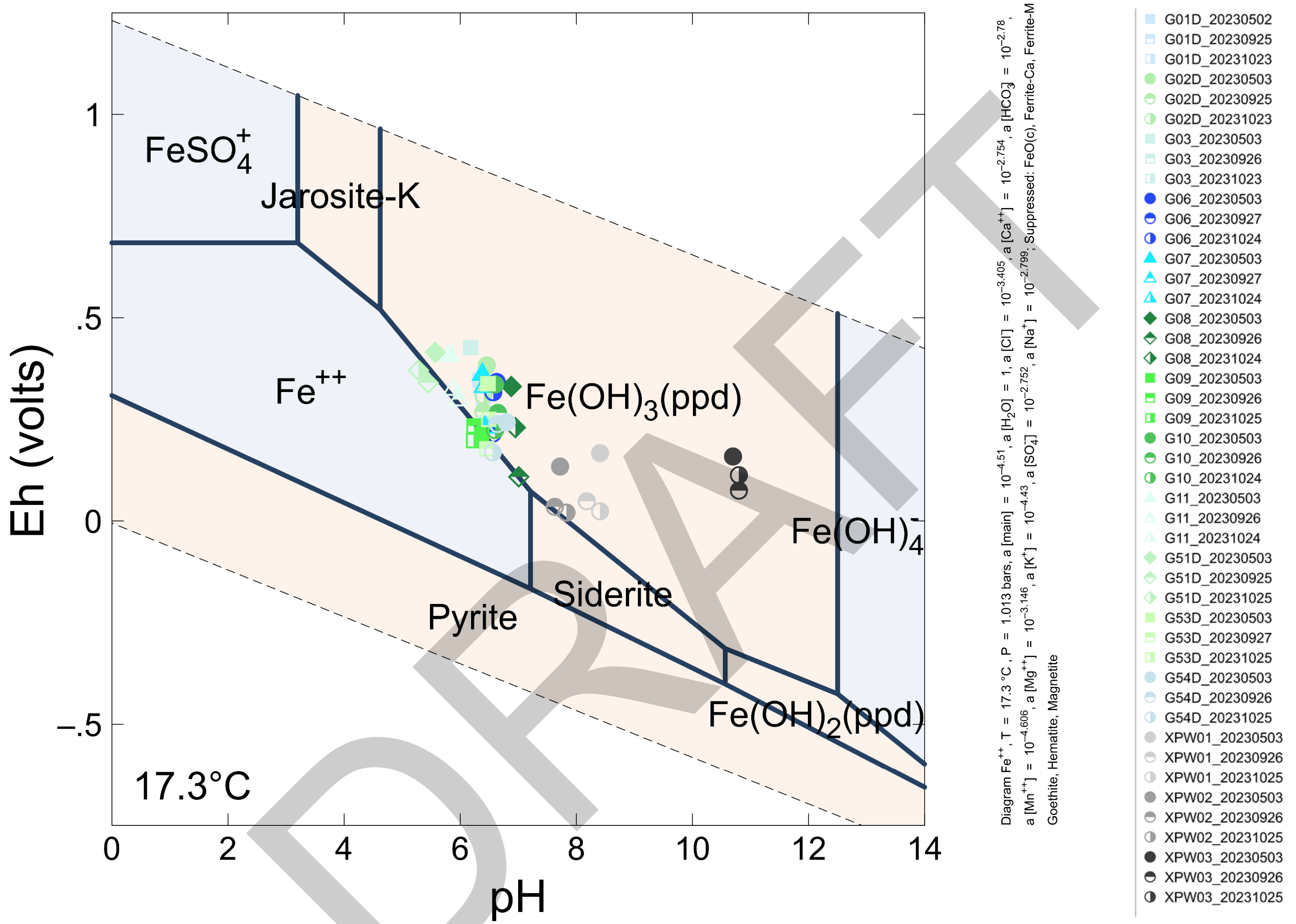

Notes:

1. Diagram was generated using conditions observed at well G08 on 5/2/23
2. The three most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Hematite, goethite, FeO(c), ferrite-Ca, and ferrite-Mg were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

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Iron Pourbaix Diagram, Ferrihydrite – Compliance Network

Joppa Power Plant – East Ash Pond

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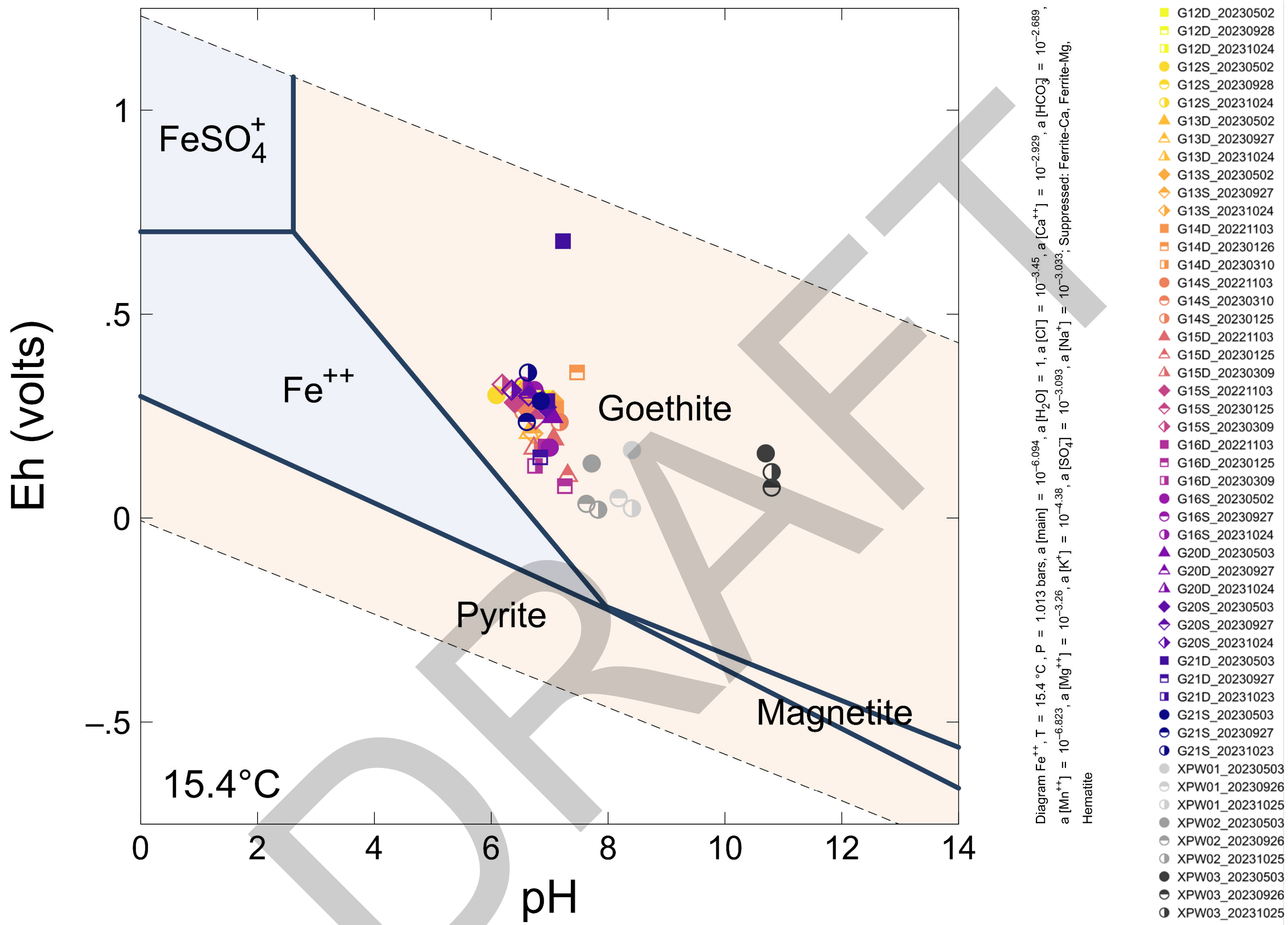
Figure 4b

Columbus, Ohio

April 2024



Notes:
1. Diagram was generated using conditions observed at well G20D on 5/3/23
2. The three most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Hematite, ferrite-Ca, and ferrite-Mg were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

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Iron Pourbaix Diagram, Goethite –
Onsite Delineation Network
Joppa Power Plant – East Ash Pond

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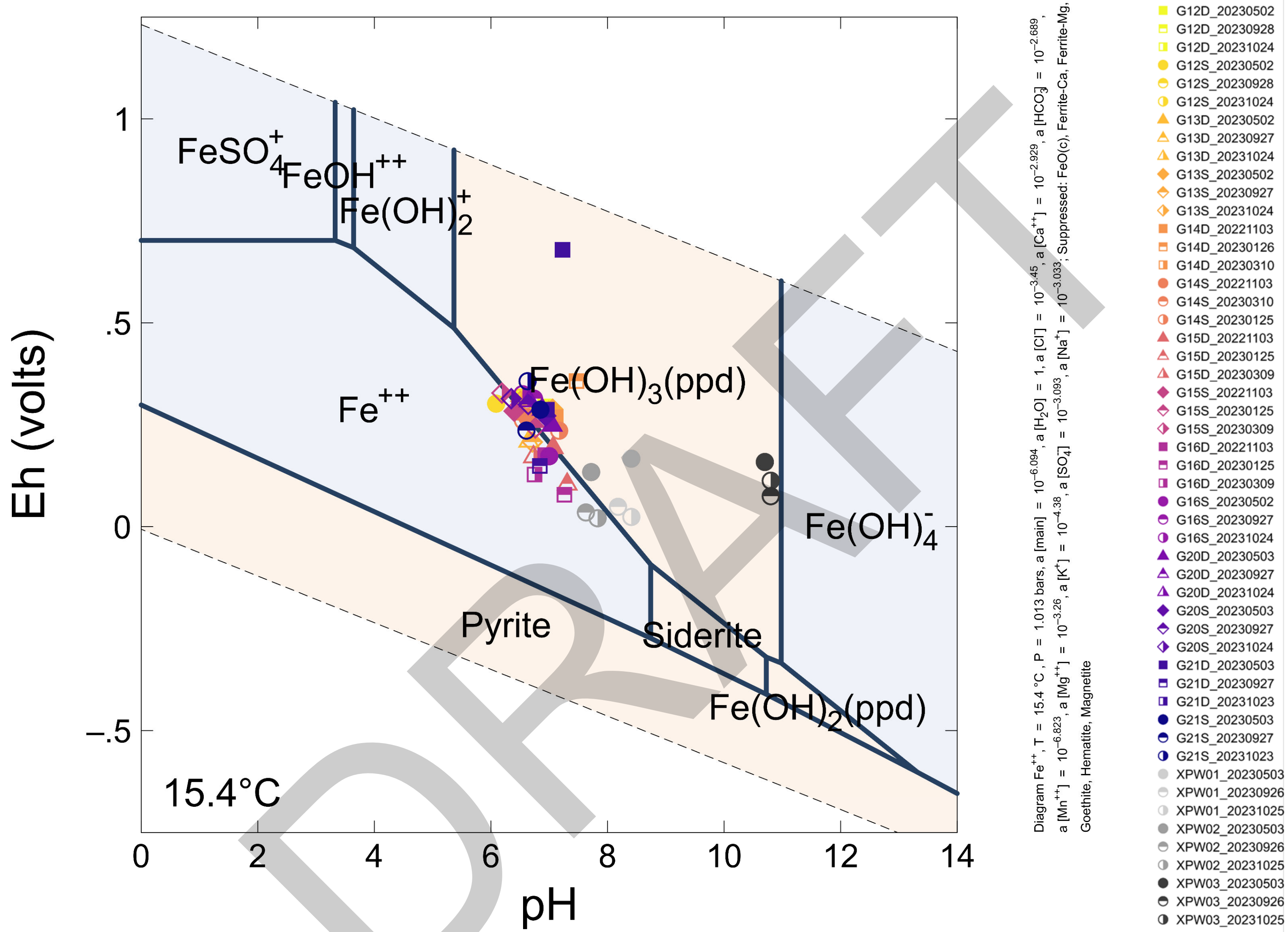
Figure
4c

Columbus, Ohio

April 2024



Notes:

1. Diagram was generated using conditions observed at well G20D on 5/3/23
2. The three most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Hematite, goethite, magnetite, FeO(c), ferrite-Ca, and ferrite-Mg were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

Iron Pourbaix Diagram, Ferrihydrite – Onsite Delineation Network
Joppa Power Plant – East Ash Pond

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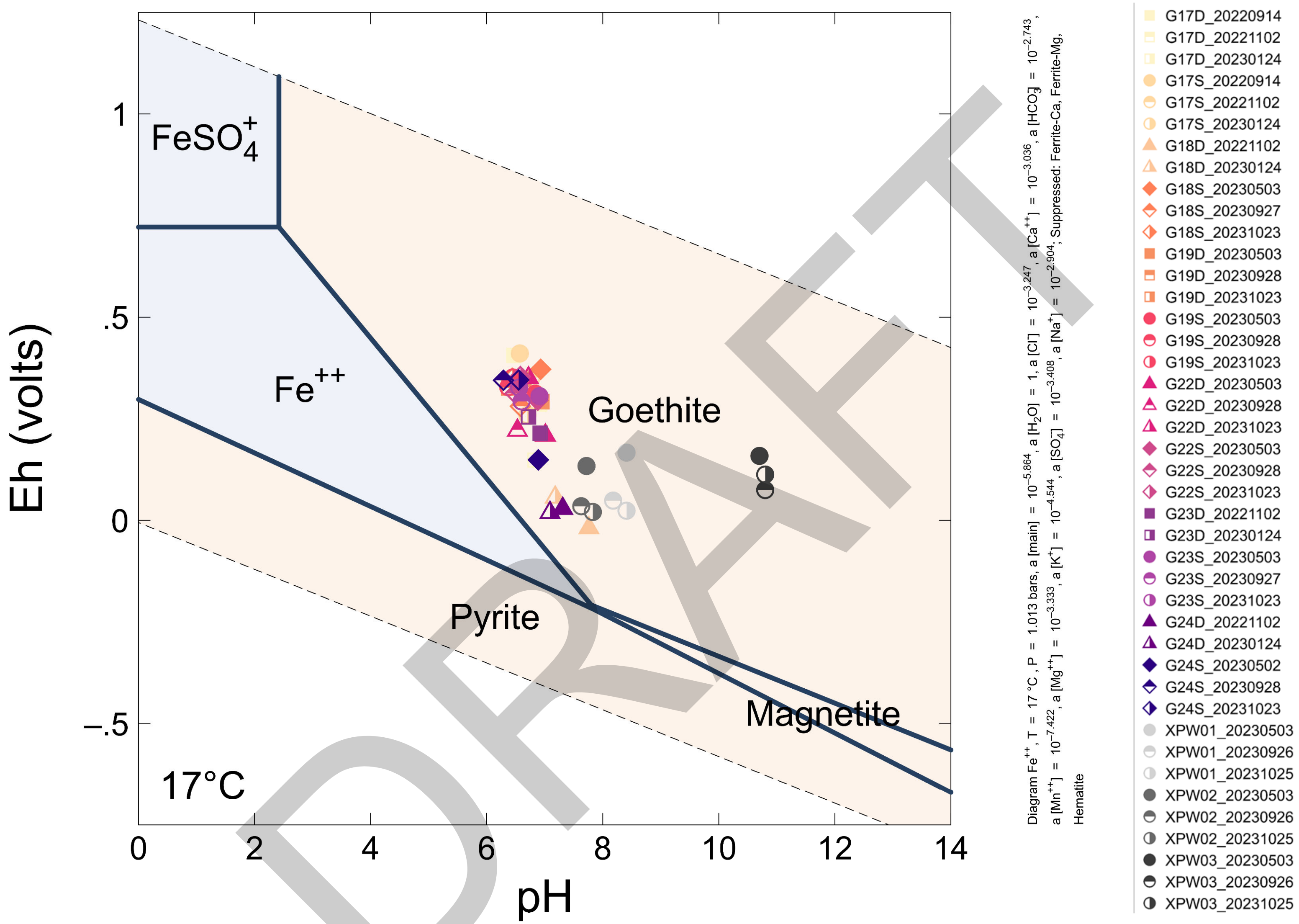
Figure 4d

Columbus, Ohio
April 2024



Notes:
1. Diagram was generated using conditions observed at well G22S on 5/3/23
2. The three most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Hematite, ferrite-Ca, and ferrite-Mg were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

Iron Pourbaix Diagram, Goethite – Offsite Delineation Network
Joppa Power Plant – East Ash Pond

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Figure
4e

Columbus, Ohio
April 2024

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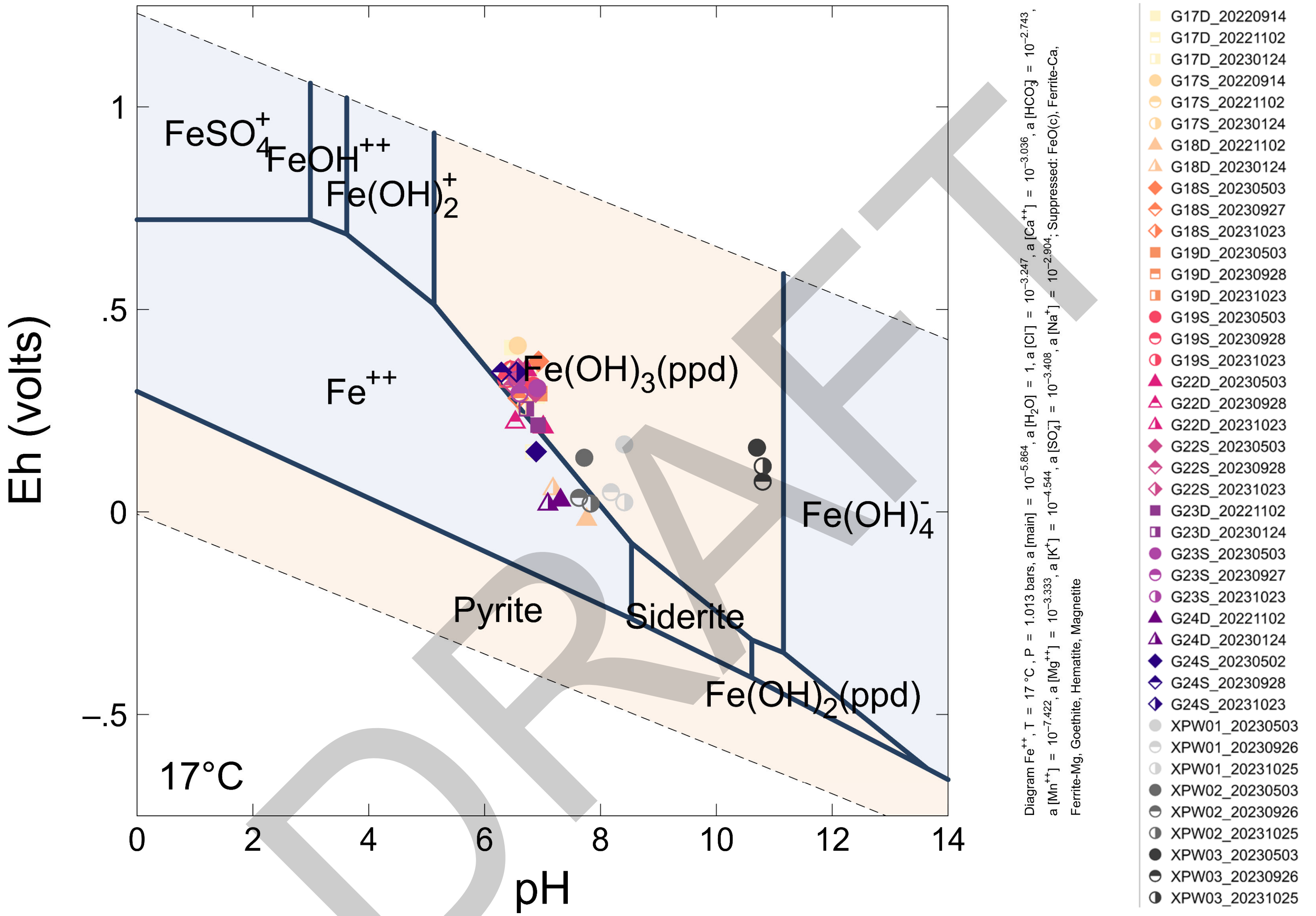

Notes:
1. Diagram was generated using conditions observed at well G22S on 5/3/23
The most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Hematite, goethite, magnetite, FeO(c), ferrite-Ca, and ferrite-Mg were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

Iron Pourbaix Diagram, Ferrihydrite – Offsite Delineation Network

Joppa Power Plant – East Ash Pond

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Figure 4f

Columbus, Ohio

April 2024

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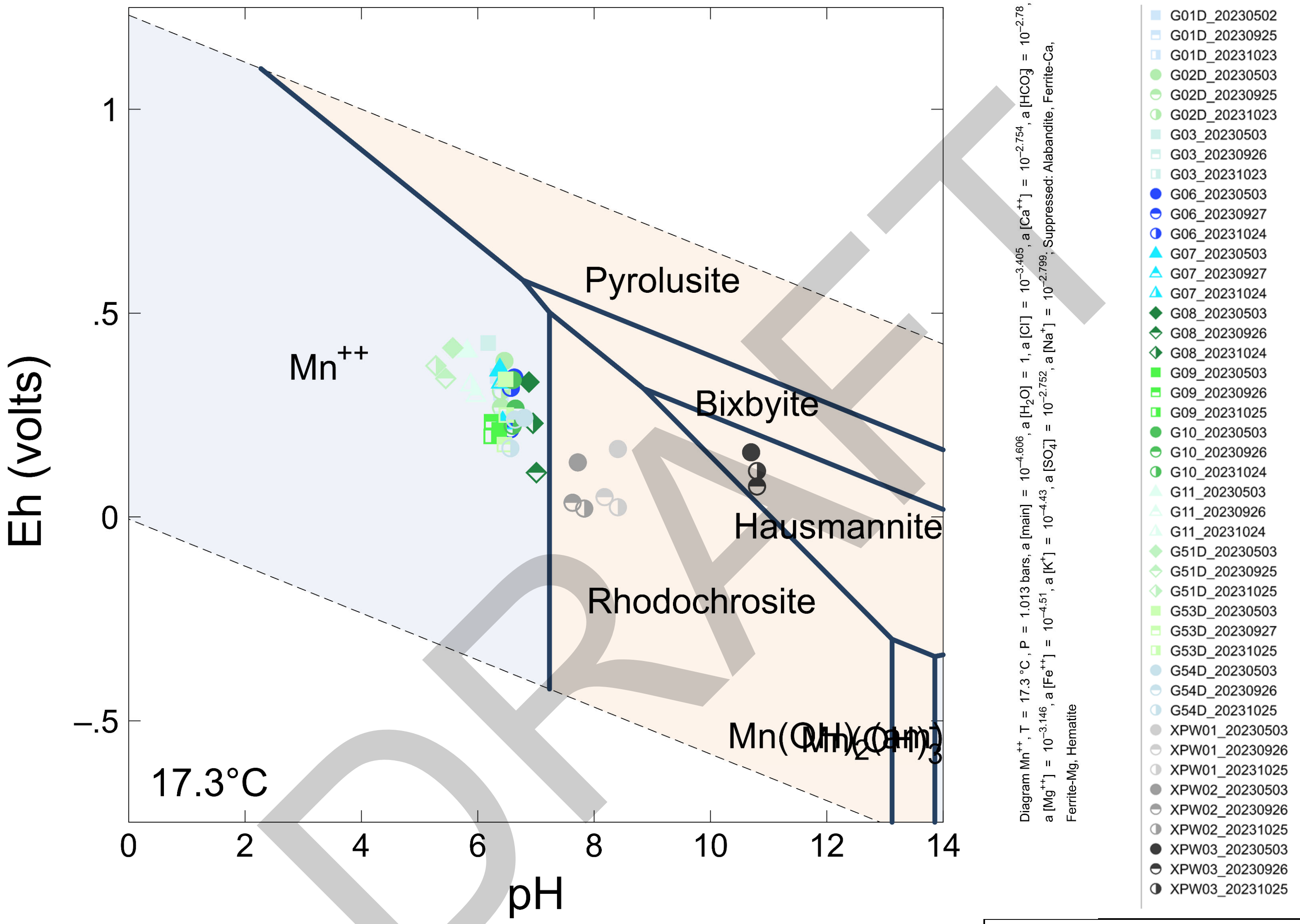

Diagram Mn^{++}, T = 17.3 °C, P = 1.013 bars, a [main] = $10^{-4.606}$, a [H_2O] = 1, a [Cl^-] = $10^{-3.405}$, a [Ca^{++}] = $10^{-2.754}$, a [HCO_3^-] = $10^{-2.78}$, a [Mg^{++}] = $10^{-3.146}$, a [Fe^{++}] = $10^{-4.51}$, a [K^+] = $10^{-4.43}$, a [SO_4^{--}] = $10^{-2.752}$, a [Na^+] = $10^{-2.799}$; Suppressed: Alabandite, Ferrite-Ca, Ferrite-Mg, Hematite

Notes:

1. Diagram was generated using conditions observed at well G08 on 5/2/23
2. The three most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Alabandite, ferrite-Ca, ferrite-Mg, and hematite were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

Manganese Pourbaix Diagram –
Compliance Network
Joppa Power Plant – East Ash Pond

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Figure
5a

Columbus, Ohio
April 2024

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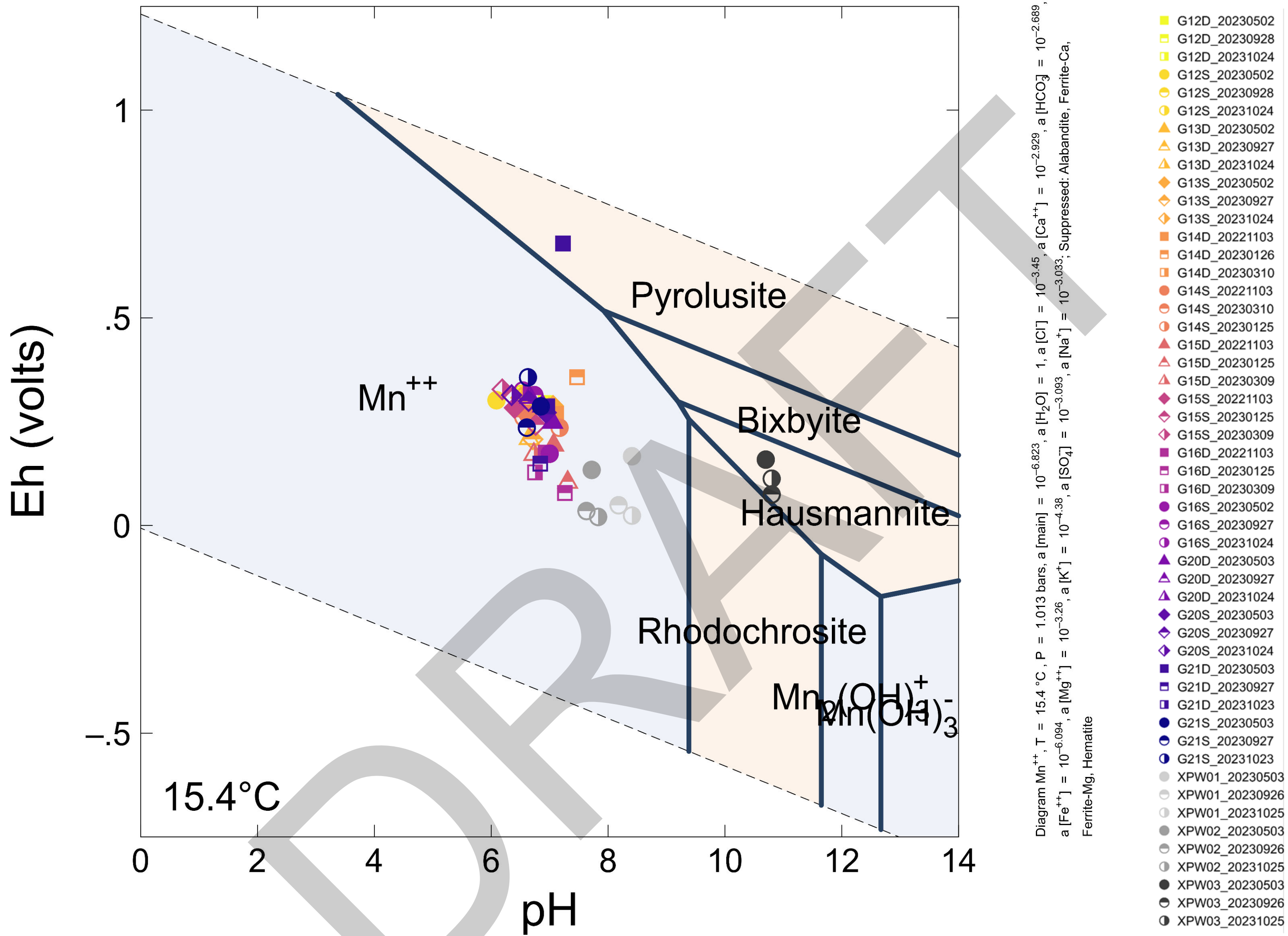

Notes:

1. Diagram was generated using conditions observed at well G20D on 5/3/23
2. The most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Alabandite, ferrite-Ca, ferrite-Mg, and hematite were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

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**Manganese Pourbaix Diagram –
Onsite Delineation Network**

Joppa Power Plant – East Ash Pond

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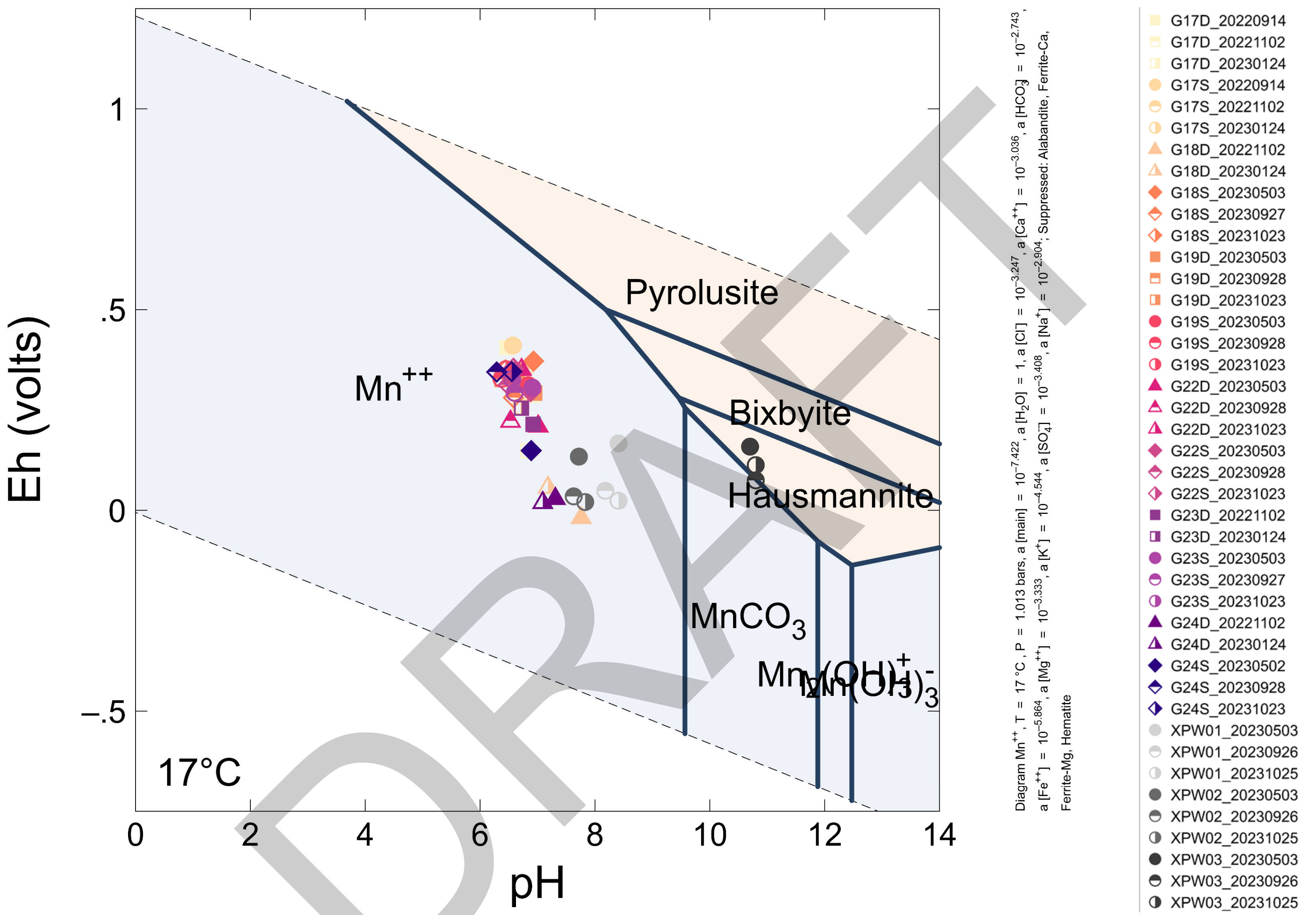
Columbus, Ohio

April 2024

Figure
5b



Notes:

1. Diagram was generated using conditions observed at well G22S on 5/3/23
2. The most recent available pH and ORP data points for each location are displayed. Eh is calculated as field ORP + 200 millivolts
3. Alabandite, ferrite-Ca, ferrite-Mg, and hematite were suppressed during model generation
4. Porewater locations XPW01, XPW02, and XPW03 are also shown

Manganese Pourbaix Diagram –
Offsite Delineation Network
Joppa Power Plant – East Ash Pond

Geosyntec consultants

Figure
5c

Columbus, Ohio
April 2024

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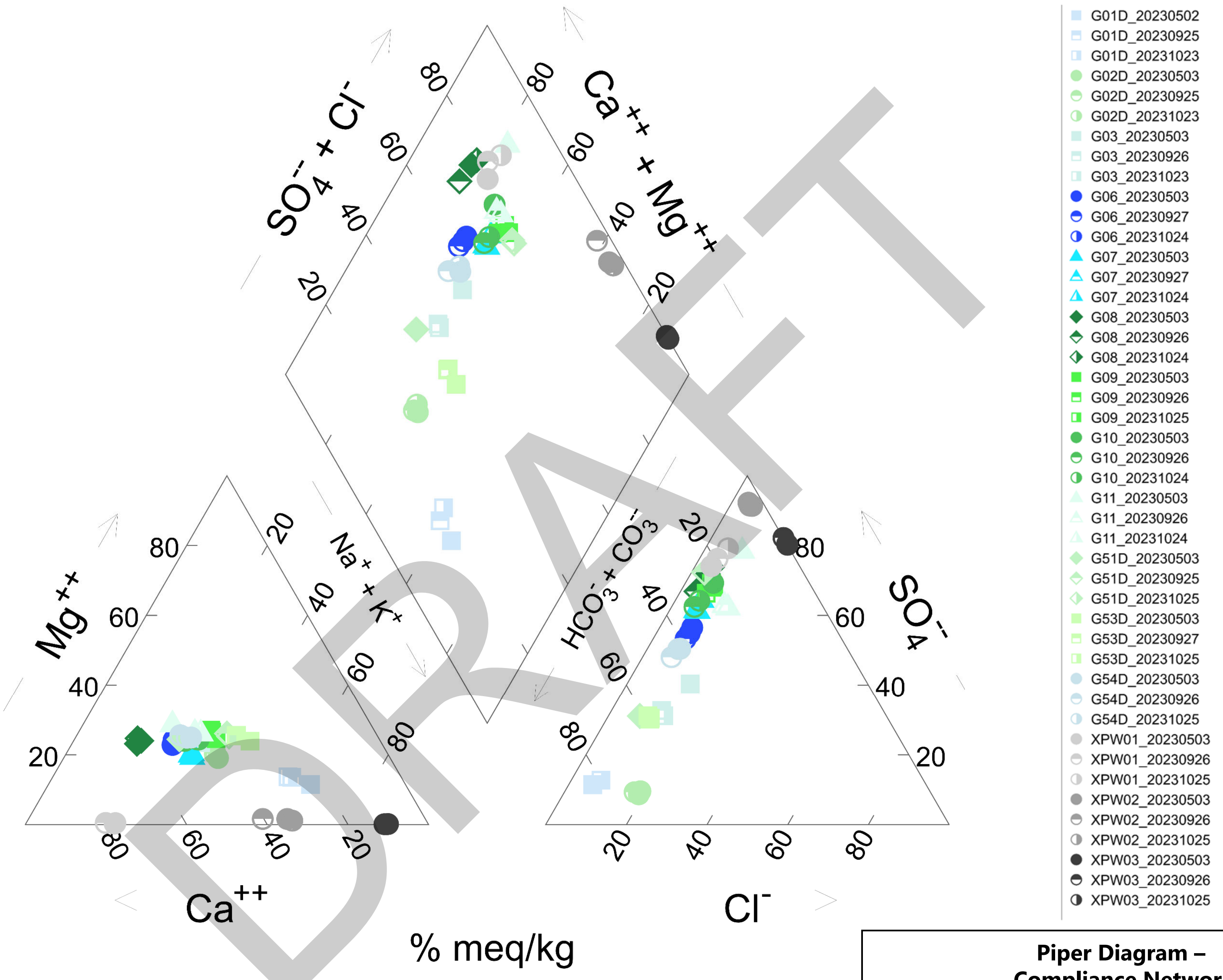

Notes:

1. The three most recent available data points for each location are displayed
2. Porewater locations XPW01, XPW02, and XPW03 are shown with gray coloring

% meq/kg: percent milliequivalents per kilogram

Piper Diagram –
Compliance Network
Joppa Power Plant – East Ash Pond

Geosyntec consultants

Figure
6a

Columbus, Ohio | April 2024

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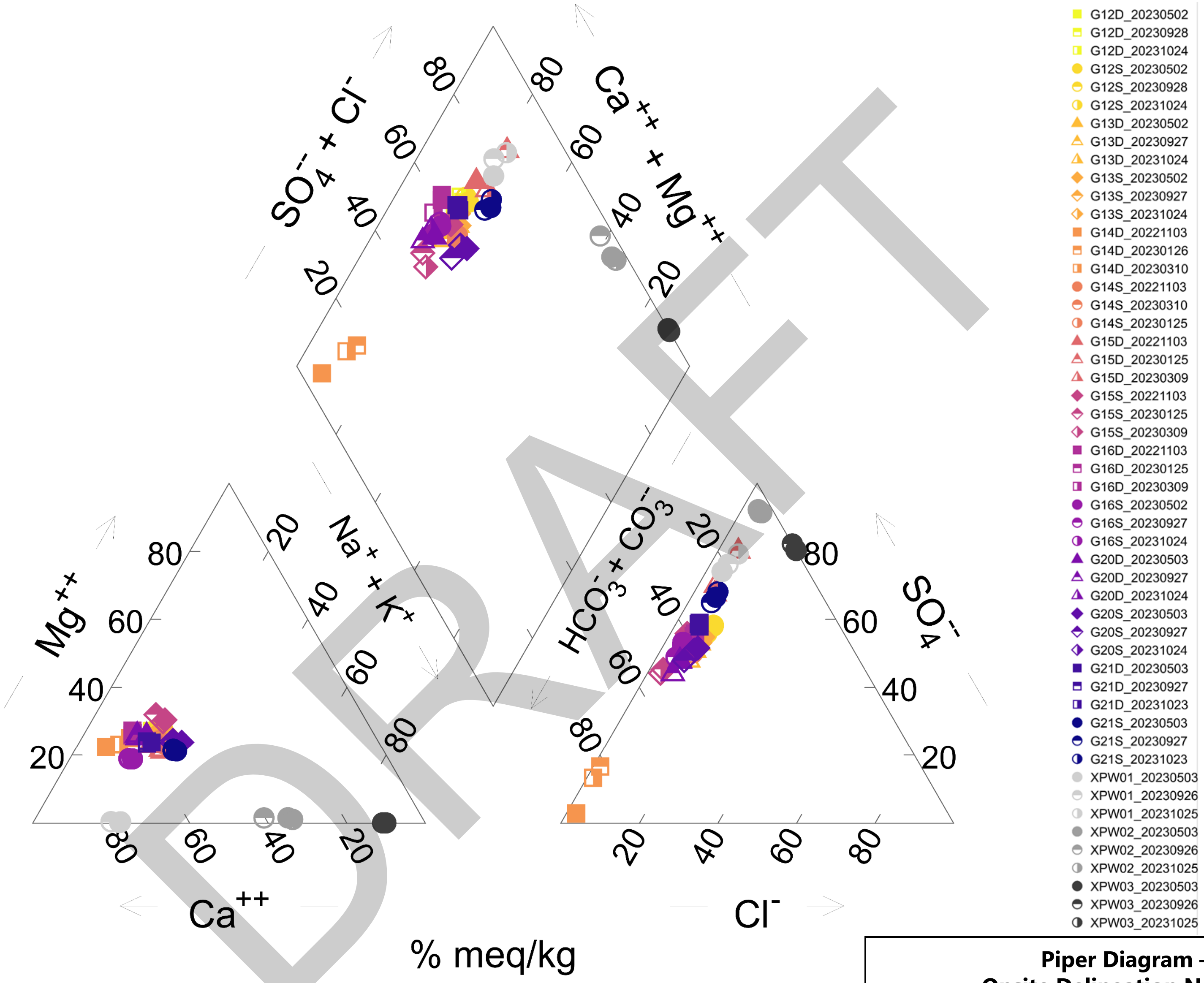


Notes:

1. The three most recent available data points for each location are displayed
2. Porewater locations XPW01, XPW02, and XPW03 are shown with gray coloring

% meq/kg: percent milliequivalents per kilogram

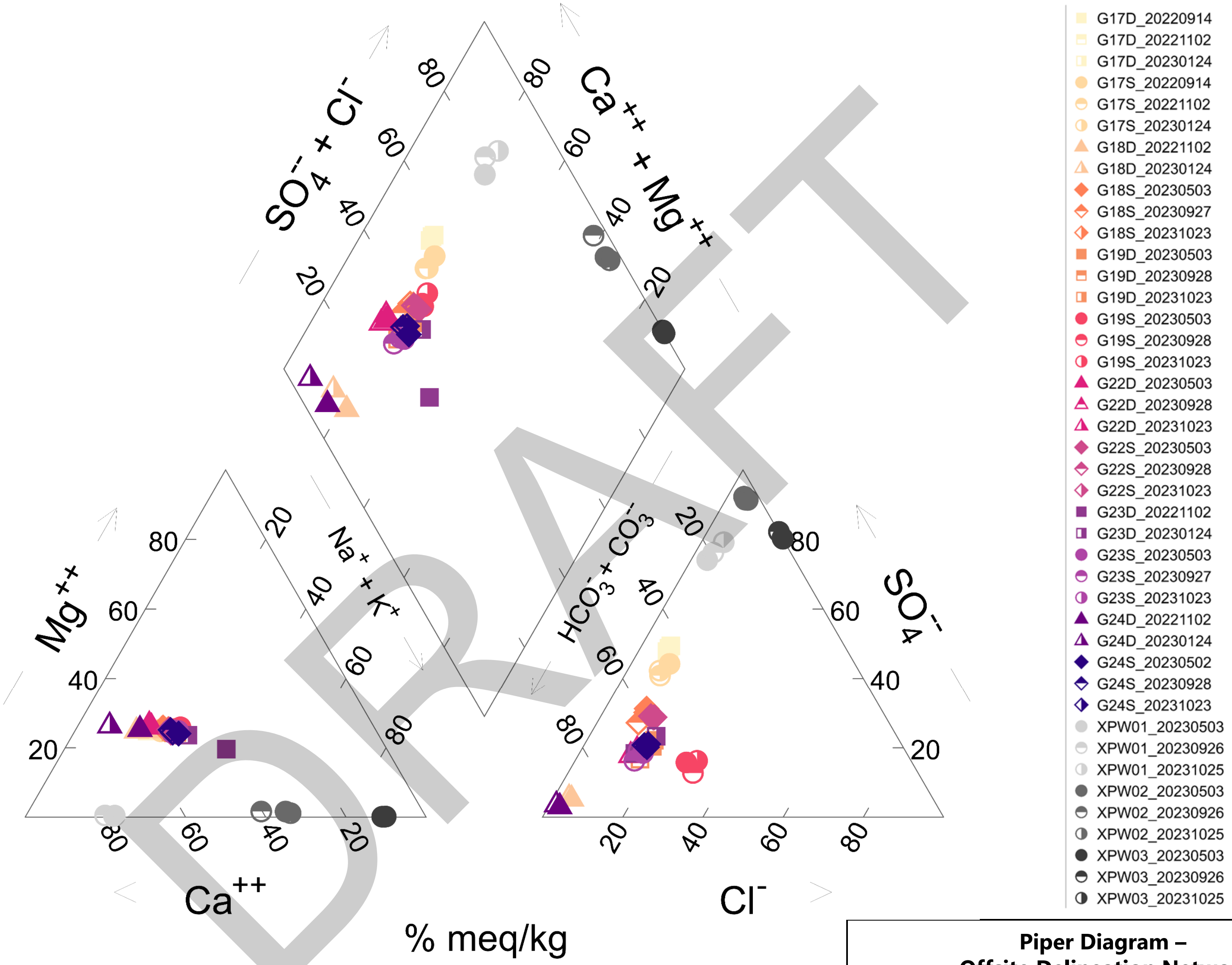
Piper Diagram –
Onsite Delineation Network
Joppa Power Plant – East Ash Pond

Geosyntec consultants

Figure
6b

Columbus, Ohio

April 2024



Notes:
1. The three most recent available data points for each location are displayed.
2. Porewater locations XPW01, XPW02, and XPW03 are shown with gray coloring
% meq/kg: percent milliequivalents per kilogram

Piper Diagram –
Offsite Delineation Network
Joppa Power Plant – East Ash Pond

Geosyntec consultants

Figure
6c

Columbus, Ohio
April 2024

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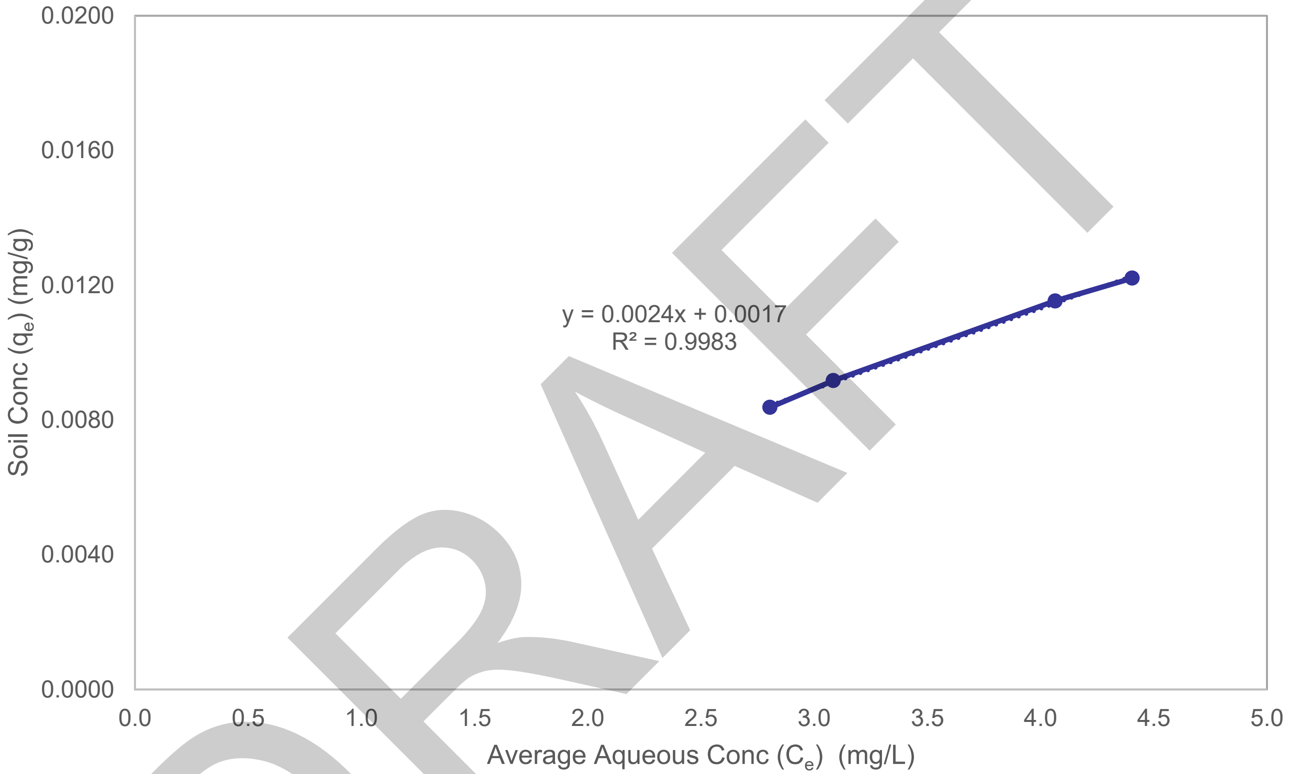

Notes:
1. The 1:27.3 soil:water average result is not shown due to the anomalous results.
mg/L: milligrams per liter
mg/g: milligrams of boron per gram of soil

Batch Adsorption Testing – Linear Isotherm

Joppa Power Plant – East Ash Pond

Geosyntec consultants

Figure
7

Columbus, Ohio

April 2024

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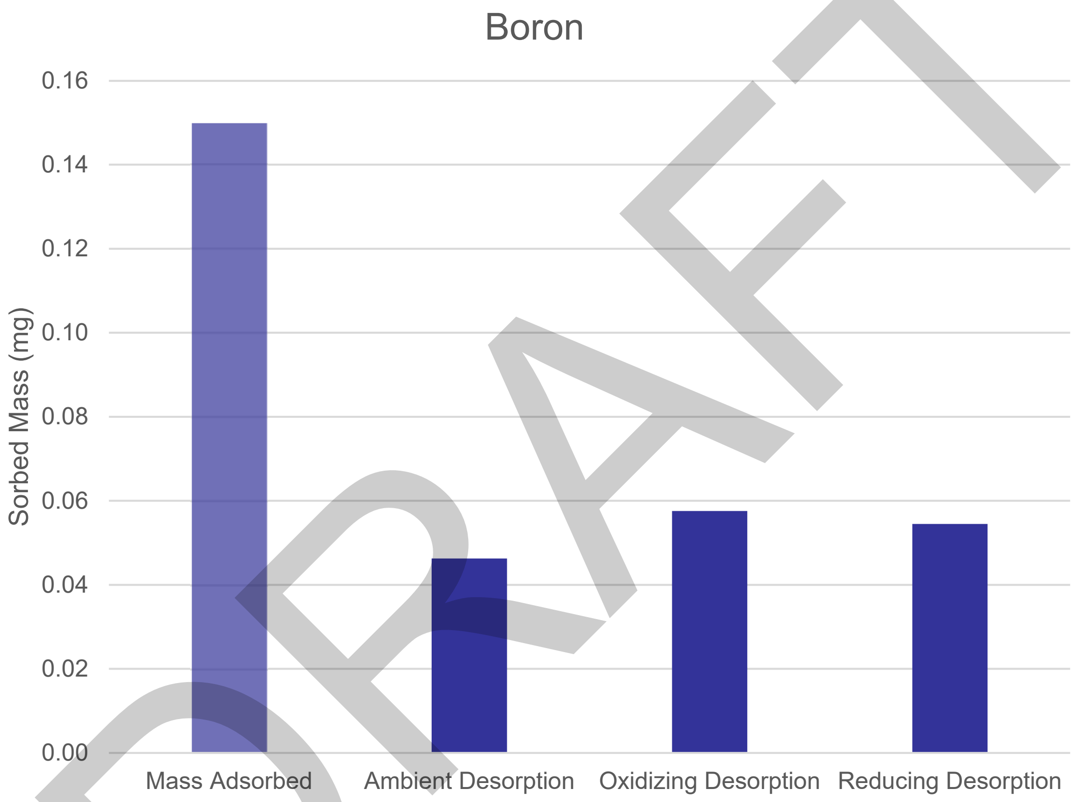


Notes:
mg – milligrams of boron

Batch Desorption Testing

Joppa Power Plant – East Ash Pond

Geosyntec consultants

Figure
8

Columbus, Ohio

April 2024

ATTACHMENT A

Site Map

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\GMP\Figure 1-2_Site Map.mxd

PROJECT: 169000XXXX | DATED: 10/15/2021 | DESIGNER: HOTCALD

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

🟨 PART 845 REGULATED UNIT (SUBJECT UNIT)
☐ OTHER UNIT
― CENTRAL DIKE
⬚ PROPERTY BOUNDARY

0 375 750 Feet

SITE MAP

GEOCHEMICAL CONCEPTUAL
SITE MODEL
EAST ASH POND

JOPPA POWER PLANT
JOPPA, ILLINOIS

ATTACHMENT A

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

ATTACHMENT B
Proposed Part 845 Groundwater Monitoring Network

PROJECT: 169000XXXX | DATED: 10/18/2021 | DESIGNER: STOLZSD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\GMP\Figure 2-1_Proposed Monitoring Well Network.mxd

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

▣ COMPLIANCE WELL
▣ BACKGROUND WELL
◒ STAFF GAUGE
▭ PART 845 REGULATED UNIT (SUBJECT UNIT)
⬚ PROPERTY BOUNDARY

0 200 400
Feet

PROPOSED PART 845 GROUNDWATER MONITORING WELL NETWORK

ATTACHMENT B

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

GEOCHEMICAL CONCEPTUAL SITE MODEL
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

ATTACHMENT C
Delineation Monitoring Well Location Map

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

▚	MONITORING WELL
🟨	REGULATED UNIT (SUBJECT UNIT)
⬚	PROPERTY BOUNDARY

DELINEATION MONITORING WELL LOCATION MAP

ATTACHMENT C

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

GEOCHEMICAL CONCEPTUAL SITE MODEL
EAST ASH POND
JOPPA POWER PLANT JOPPA, ILLINOIS

ATTACHMENT D

Monitoring Well Construction Details

Attachment D. Monitoring Well Construction Details

Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

Location	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft bgs)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
G01D	UA	2015-08-14	364.2	364.4	Top of Disk	361.5	54.19	63.85	307.3	297.6	64.4	297.1	9.7	2	37.22042921	-88.85717876
G02D	UA	2015-08-13	363.6	363.8	Top of Disk	360.8	62.21	71.84	298.6	289.0	72.4	288.5	9.6	2	37.2207148	-88.85331072
G03	UA	2021-02-02	357.9	358.0	Top of PVC	354.8	55	65	302.9	292.9	65	289.8	10	2	37.220682	-88.850376
G05	UA	2021-02-01	361.2	361.4	Top of PVC	358.4	50	60	311.2	301.2	60	298.5	10	2	37.21719	-88.849014
G06	UA	2021-01-29	355.2	355.4	Top of PVC	352.6	75	85	280.2	270.2	85	267.6	10	2	37.212929	-88.848893
G07	UA	2021-01-29	353.5	353.7	Top of PVC	350.3	50	60	303.5	293.5	60	290.3	10	2	37.211001	-88.848969
G08	UA	2021-01-28	343.5	343.7	Top of PVC	341.7	75	85	268.5	258.5	85	256.7	10	2	37.210531	-88.851015
G09	UA	2021-01-31	351.7	351.9	Top of PVC	348.7	59.5	69.5	292.2	282.2	69.5	279.2	10	2	37.210336	-88.854116
G09M	LAU	2021-01-28	351.5	351.5	Top of PVC	348.6	145	155	206.5	196.5	155	193.6	10	2	37.210341	-88.85413
G10	UA	2021-02-01	353.5	353.7	Top of PVC	350.8	60.3	70.3	293.2	283.2	70.3	280.5	10	2	37.211272	-88.855841
G11	UA	2021-01-19	366.6	366.7	Top of PVC	363.4	55.7	65.7	310.9	300.9	65.7	297.7	10	2	37.214408	-88.85633
G12S	UA	2021-09-23	360.3	360.5	Top of PVC	357.6	60	70	297.6	287.6	70	287.6	10	2	37.211564	-88.847086
G12D	UA	2021-09-23	360.2	360.4	Top of PVC	357.3	80	90	277.3	267.3	90	257.3	10	2	37.21157	-88.847103
G13S	UA	2021-09-23	354.8	354.9	Top of PVC	352.0	50	60	301.7	291.7	60	291.7	10	2	37.210142	-88.847213
G13M	LAU	2022-05-18	354.0	354.0	Top of PVC	351.6	215	225	136.6	126.5	225	122.5	10	2	37.210129	-88.847331
G13D	UA	2021-09-23	354.6	354.7	Top of PVC	351.7	80	90	271.3	261.3	90	241.3	10	2	37.210129	-88.847217
G14S	UA	2021-09-16	345.6	345.6	Top of PVC	345.5	53	63	292.5	282.5	63	282.5	10	2	37.206927	-88.847006
G14D	UA	2021-09-16	345.5	345.5	Top of PVC	345.3	120	130	225.5	215.3	130	202.3	10	2	37.206909	-88.847007
G15S	UA	2021-09-15	346.8	347.0	Top of PVC	343.8	50	60	293.8	283.8	60	283.8	10	2	37.20715	-88.848881
G15D	UA	2021-09-15	346.7	346.9	Top of PVC	344.0	83	93	261.0	251.0	93	219.0	10	2	37.207152	-88.848865
G16S	UA	2021-09-14	352.3	352.3	Top of PVC	349.6	50	60	299.6	289.6	60	289.6	10	2	37.207163	-88.850678
G16D	UA	2021-09-14	352.4	352.6	Top of PVC	349.6	98	108	251.6	241.6	108	219.6	10	2	37.207147	-88.850687
G17S	UA	2022-06-01	359.2	359.2	Top of PVC	359.6	65	75	294.6	284.6	75	282.6	10	2	37.2116	-88.845465
G17D	UA	2022-05-21	359.3	359.3	Top of PVC	359.5	87	97	272.5	262.5	97	262.5	10	2	37.211598	-88.845475
G19S	UA	2022-06-01	355.6	355.6	Top of PVC	355.9	61.75	71.75	294.2	284.2	71.75	283.9	10	2	37.208548	-88.84322
G19D	UA	2022-06-01	355.4	355.4	Top of PVC	355.8	86.75	96.75	269.1	259.1	96.75	258.8	10	2	37.208538	-88.843225
G20S	UA	2022-05-20	350.2	350.2	Top of PVC	347.5	60	70	287.5	277.5	70	275.5	10	2	37.206909	-88.845853
G20M	LAU	2022-05-19	351.1	351.1	Top of PVC	347.9	175	185	172.9	162.9	185	118.9	10	2	37.206909	-88.845833
G20D	UA	2022-05-20	350.7	350.7	Top of PVC	347.7	85	95	262.7	252.7	95	250.7	10	2	37.206909	-88.845842
G21S	UA	2022-03-31	352.0	352.0	Top of Casing	348.9	60	70	288.9	278.9	70	278.9	10	2	37.20544	-88.84803
G21M	LAU	2022-04-11	353.1	353.1	Top of Casing	349.0	156	166	193.0	183.0	166	183.0	10	2	37.205468	-88.848005
G21D	UA	2022-03-31	351.7	351.7	Top of Casing	348.9	90	100	258.9	248.9	100	248.9	10	2	37.205439	-88.84799
G22S	UA	2022-05-24	351.6	351.6	Top of PVC	351.8	65	75	286.8	276.8	75	274.8	10	2	37.204787	-88.844908
G22D	UA	2022-05-22	351.5	351.5	Top of PVC	351.8	107	117	244.8	234.8	117	234.8	10	2	37.204799	-88.844907
G51D	UA	2015-08-18	363.9	364.0	Top of PVC	361.1	49.61	59.27	311.5	301.8	59.9	301.2	9.7	2	37.216016	-88.855653
G52D	UA	2015-08-19	348.4	348.6	Top of PVC	345.9	69.85	79.55	276.0	266.3	80.01	265.9	9.7	2	37.20962587	-88.85294308
G53D	UA	2015-08-21	355.5	355.6	Top of PVC	352.2	47.29	56.89	304.9	295.3	57.33	294.2	9.6	2	37.21506911	-88.84936671
G54D	UA	2015-08-11	357.0	357.2	Top of PVC	353.7	69.96	79.66	283.8	274.1	80.14	273.6	9.7	2	37.21226413	-88.85748523
XPW01	CCR	2021-01-20	383.4	383.5	Top of PVC	380.8	48.7	53.7	334.7	329.7	53.7	327.1	5	2	37.216965	-88.852074
XPW02	CCR	2021-01-21	376.0	376.2	Top of PVC	373.2	24.7	29.7	351.3	346.3	29.7	343.6	5	2	37.215865	-88.855001
XPW03	CCR	2021-01-21	381.5	381.7	Top of PVC	378.6	31.7	36.7	349.8	344.8	36.7	342.0	5	2	37.212153	-88.85542

Notes:

All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
bgs = below ground surface
ft = foot or feet
HSU = Hydrostratigraphic Unit
UA = Uppermost Aquifer
CCR = Coal Combustion Residuals
LAU = Lower Aquifer Unit
PVC = polyvinyl chloride

ATTACHMENT E

Relevant Boring Logs

Geosyntec consultants
engineers | scientists | innovators

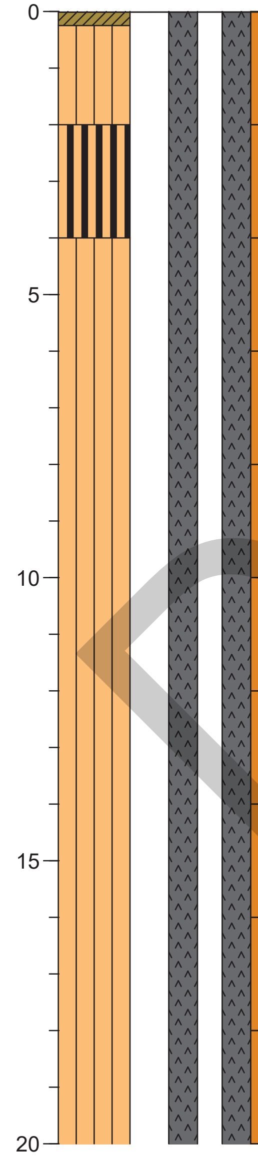
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG
Well No. G03
Page: 1 of 4

Drilling Start Date: **02/02/2021**
Drilling End Date: **02/02/2021**
Drilling Company: **Geotechnology**
Drilling Method: **Hollow Stem Auger**
Drilling Equipment: **CME 55LC**
Driller:
Logged By: **SK**

Boring Depth (ft): **67**
Boring Diameter (in): **4.25**
DTW During Drilling (ft):
DTW After Drilling (ft): **38.23**
Top of Casing Elev. (ft): **358.56**
Ground Elev. (ft): **354.84**
Location (Lat/Long): **37.22078, -88.85045**

Well Depth (ft): **67**
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	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)	
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.	
SS	23/24	2 6 6 8	12	(11') As above: trace fine gravel from 11 to 11.5' bgs.	
SS	24/24	2 6 7 10	13	(12') As above: brownish yellow (10YR 6/6).	
SS	24/24	2 3 5 5	8	(14') As above: more light gray (10YR 7/2) mottling.	
SS	24/24	2 3 5 6	8	(16') As above: trace sand.	
SS	24/24	3 4 5 9	9	(18') As above: light gray (10YR 7/2) becomes dominant.	

NOTES:

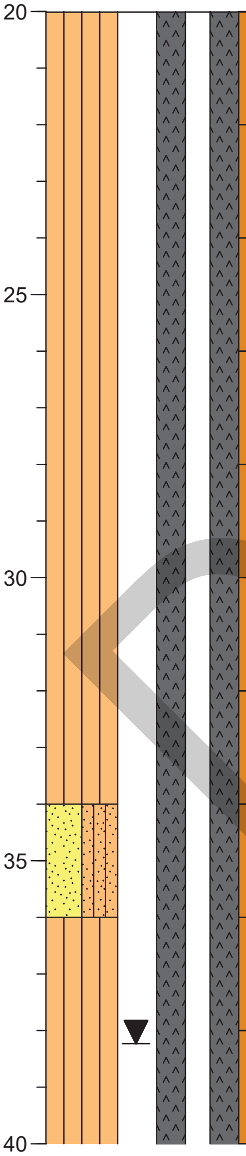
Geosyntec consultants
engineers | scientists | innovators

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)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample
20	SS	24/24	1 4 8 10	12	(20') SILT (ML); few clay, brownish yellow (10YR 6/6), very stiff, dry.	
	SS	24/24	4 6 7 4	13	(22') SANDY SILT (ML); yellowish brown (10YR 5/6), soft, dry.	
	SS	24/24	2 5 5 8	10	(24') As above: becomes moist, few red (2.5YR 4/6) silt.	
25	SS	24/24	1 5 5 6	10	(26') As above: red silt disappears.	
	SS	24/24	1 3 4 6	7	(28') As above: becomes grayish brown (10YR 5/2).	
30	SS	24/24	1 4 4 5	8	(30') As above.	30-32 Chem
	SH	24/24				32-34 Geotech
35	SS	24/24	3 4 5 6	9	(34') POORLY GRADED SAND (SP-SM); fine grained, few silt, brownish yellow (10YR 6/6), loose, moist to wet.	
	SS	24/24	2 2 3 5	5	(36') SANDY SILT (ML); light yellowish brown (10YR 6/4), soft, moist, medium plasticity.	
40	SS	24/24	2 2 3 5	5	(38') As above: becomes evenly mottled with light gray (10YR 7/2).	

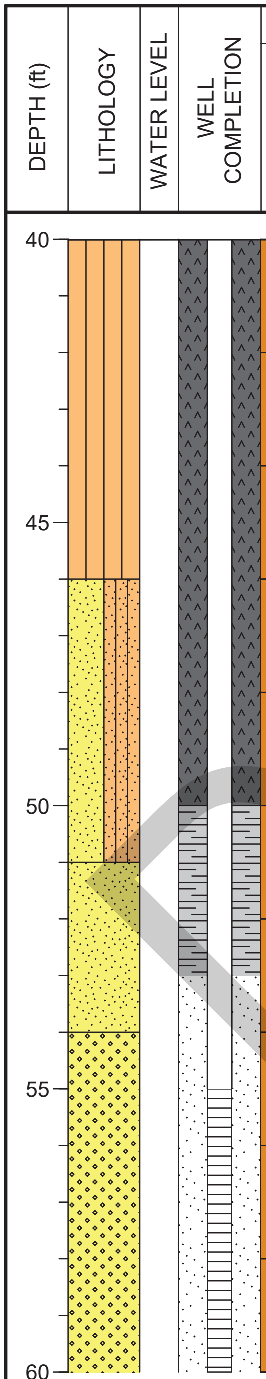
NOTES: SBG03- (32-34)-20210202: 15.5% moisture content, 730 U mg/kg total organic carbon, 112.7 pcf dry unit weight, 2.659 specific gravity, $4.7x\ 10^{-7}$, 27 LL, 16 PL, 11 PI, 0.6% gravel, 53.8% sand, 45.6% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

Geosyntec consultants
engineers | scientists | innovators

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)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
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:

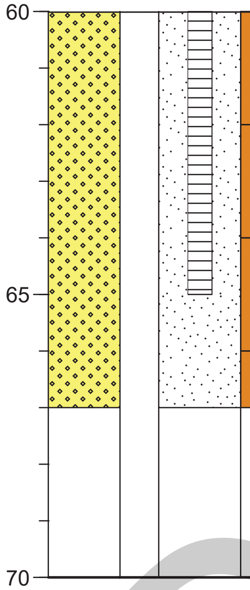
Geosyntec consultants
engineers | scientists | innovators

Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG

Well No. G03
Page: 4 of 4

Drilling Start Date:	**02/02/2021**	Boring Depth (ft):	**67**	Well Depth (ft):	**67**
Drilling End Date:	**02/02/2021**	Boring Diameter (in):	**4.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**38.23**	Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**358.56**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**354.84**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**SK**	Location (Lat/Long):	**37.22078, -88.85045**	Filter Pack:	**Sand**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	COLLECT Recovery (in)	COLLECT Blow Counts	COLLECT N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
60				SS	20/24	2 6 10 11	16	(60') WELL-GRADED SAND (SW); medium to coarse grained, few gravel, very pale brown (10YR 7/4), wet, loose.	60-62 Geotech	
				SS	24/24	1 3 13 12	16	(62') As above: reddish yellow (7.5YR 6/6).		
				SS	24/24	1 15 14 13	29	(64') GRAVELLY SAND (SW); reddish yellow (7.5YR 6/8), wet, loose.		
65										
				SS	8/12	1 4		(66') As above: brownish yellow (10YR 6/6).		
								(67') End of Boring.		
70										

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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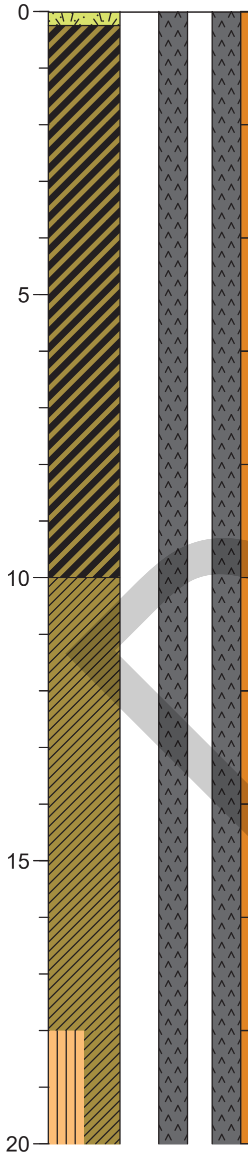
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

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
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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WELL LOG

Well No. G07
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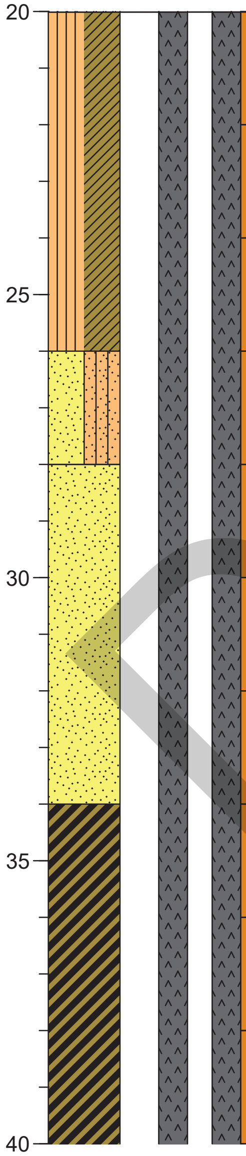
Drilling Start Date:	**01/29/2021**	Boring Depth (ft):	**62**	Well Depth (ft):	**60**
Drilling End Date:	**01/29/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
20	SS	24/24	3 4 6 7	10	(20') As above: rust spots.		
	SS	24/24	3 3 4 6	7	(22') As above: moist.		
	SS	24/24	3 3 4 5	7	(24') As above: mottled (10R 8/1).		
25	SS	24/24	3 4 7 7	11	(26') SILTY SAND (SP-SM); mostly silt, fine grained sand, some mottling as previous, poorly graded, tight, moist.		
	SS	24/24	3 6 7 7	13	(28') POORLY GRADED SAND (SP); very fine to fine grained sand, light gray (10R 8/1), tight, moist.		
30	SS	24/24	9 20 21 26	41	(30') As above. (31') POORLY GRADED SAND (SP); medium to coarse grained, loose, moist, (10R 8/1).		
	SH	18/24	10 6 9 9	15	(32') As above: color change to orange (5YR 6/8), clay at bottom.		
	SS	24/24	4 5 6 7	11	(34') FAT CLAY (CH); stiff, moist, light gray/orange mottled (10R 8/1 to 5YR 6/8).		
35	SS	24/24	3 3 5 5	8	(36') As above: medium stiffness.		
	SS	24/24	2 2 2 3	4	(38') As above.		
40							

NOTES:

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WELL LOG

Well No. **G07**
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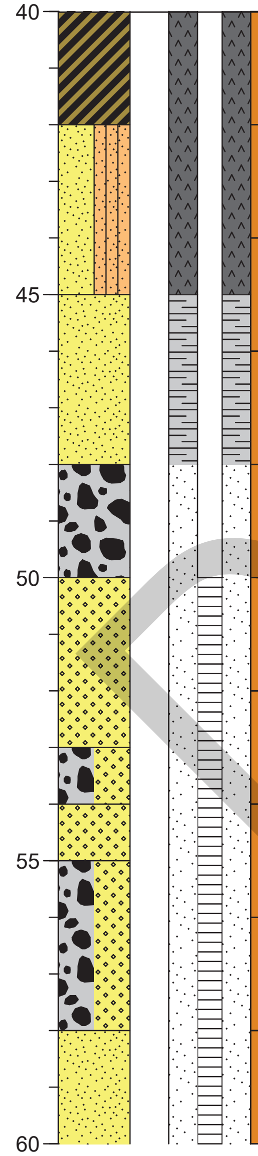
Drilling Start Date:	**01/29/2021**	Boring Depth (ft):	**62**	Well Depth (ft):	**60**
Drilling End Date:	**01/29/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**353.86**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**352.47**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**BA & CL**	Location (Lat/Long):	**37.21116, -88.8492**	Filter Pack:	**Sand**

DEPTH (ft) | LITHOLOGY | WATER LEVEL | WELL COMPLETION



DEPTH (ft)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample
40	SS	24/24	3 3 5 8	8	(40') As above.	
42	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).	
44	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).	
46	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.	
48	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.	
52	SS	24/24	9 11 14 18	25	(52') As above: (5YR 7/6).	
53					(53') DIAMICTON (GW-SW); same as above, (5YR 6/8).	
54	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.	
56	SS	24/24	7 21 14 8	35		
57					(57') As above: top 1' tan (5YR 6/8) bottom gray (10R 8/1), wet.	
58	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).	

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WELL LOG

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Drilling Start Date:	**01/29/2021**	Boring Depth (ft):	**62**	Well Depth (ft):	**60**
Drilling End Date:	**01/29/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**353.86**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**352.47**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**BA & CL**	Location (Lat/Long):	**37.21116, -88.8492**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT				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										

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WELL LOG

Well No. G08
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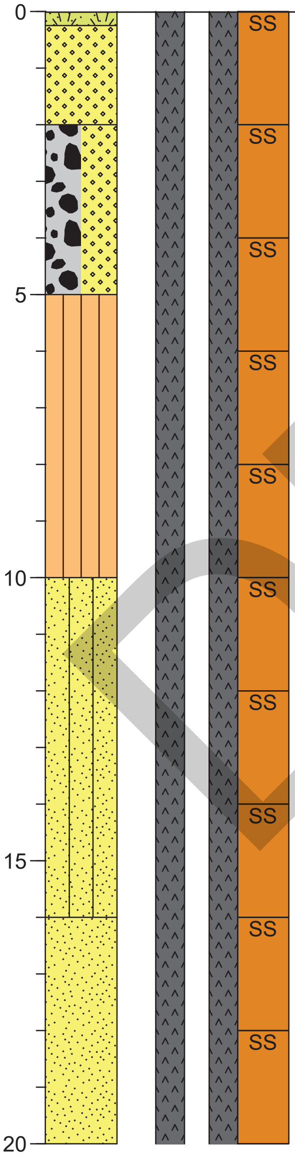
Drilling Start Date:	**01/27/2021**	Boring Depth (ft):	**86**	Well Depth (ft):	**85**
Drilling End Date:	**01/28/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**344.22**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**341.72**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**BA**	Location (Lat/Long):	**37.20984, -88.85066**	Filter Pack:	**Sand**



DEPTH (ft)	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample	DEPTH (ft)
0	SS		7 3 4 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.		
5	SS		4 3 4 4	7	(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.		
15	SS		2 3 2 4	5	(14') As above: clay seam at 15' (1-2").		
	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.		
20	SS		1 2 1 1	3			

COLLECT | MEASURE

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WELL LOG

Well No. G08
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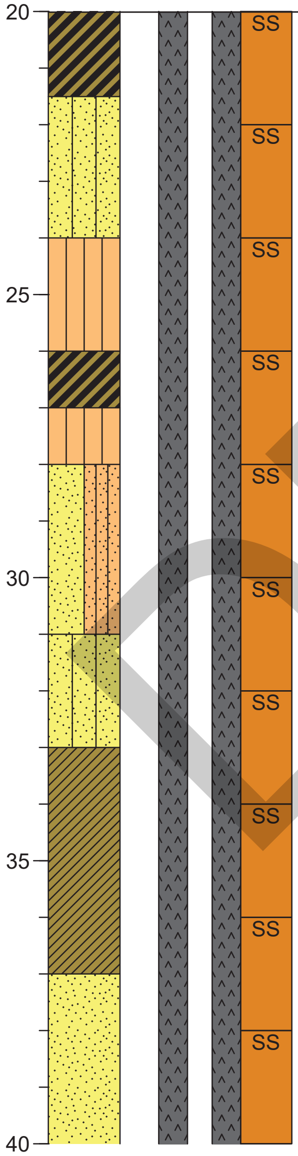
Drilling Start Date:	**01/27/2021**	Boring Depth (ft):	**86**	Well Depth (ft):	**85**
Drilling End Date:	**01/28/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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)
20	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.		
22	SS		1 1 1 1	2	(22') As above.		
24	SS		3 2 2 2	4	(24') SILT (ML); loose, dark gray, black clay seam - 2".		
25							
26	SS		2 2 1 2	3	(26') CLAY (CH); gray to green, saturated, high plasticity. (27') SILT (ML); soft, moist, gray to green.		
28	SS		1 1 1 2	2	(28') SILTY SAND (SM-SP); light gray, firm, saturated, mostly poorly graded fine to medium grained sand and silt.		
30	SS		3 2 3 4	5	(30') As above. (31') SILTY SAND (SM); tight, light gray, poorly graded, fine to medium grained sand.		
32	SS		3 3 4 4	7	(32') As above. (33') CLAY (CL); light gray, hard, low plasticity, dry.		
34	SS		4 4 3 3	7	(35') As above: some fine grained sand.		
35							
36	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.		
38	SS		3 3 3 3	6	(38') As above.		
40							

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WELL LOG

Well No. G08
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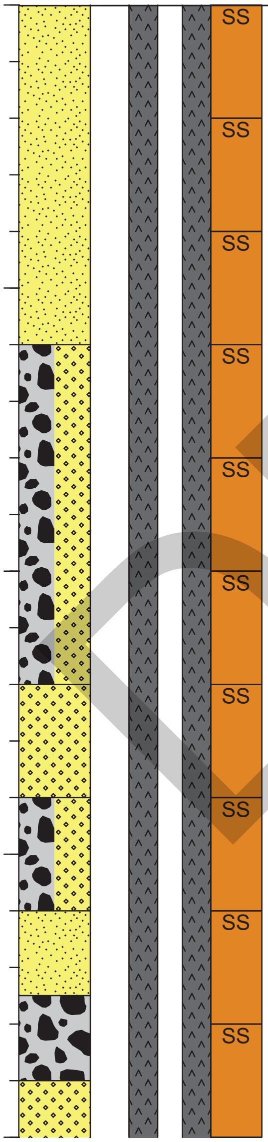
Drilling Start Date:	**01/27/2021**	Boring Depth (ft):	**86**	Well Depth (ft):	**85**
Drilling End Date:	**01/28/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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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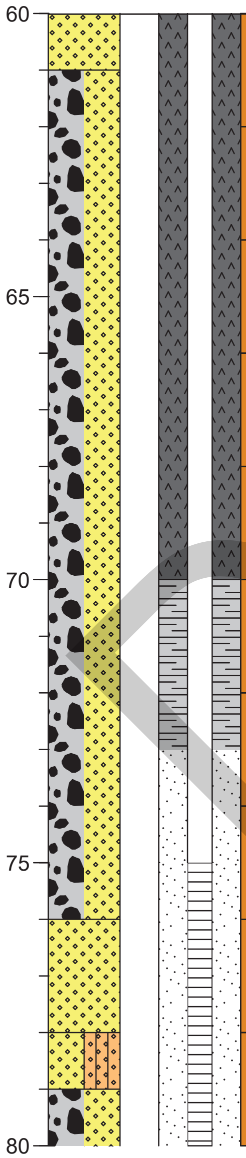
Drilling Start Date:	**01/27/2021**	Boring Depth (ft): **86**		Well Depth (ft):	**85**
Drilling End Date:	**01/28/2021**	Boring Diameter (in): **7.25**		Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem 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**



COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
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.		
SS	18/24	5 8 8 7	16	(66') As above.		
SS	18/24	5 7 7 8	14	(68') As above: saturated.		
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).		
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).		
				(79') Same fine to coarse gravel, more coarse gravel, (5YR 6/8). (GW-SW)		

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WELL LOG

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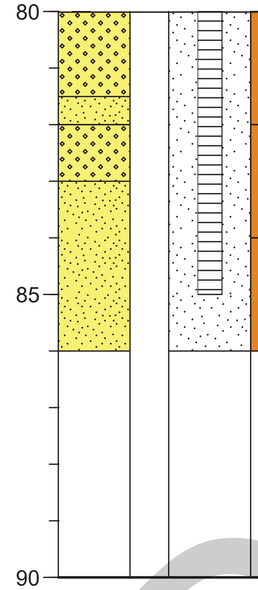
Drilling Start Date:	**01/27/2021**	Boring Depth (ft):	**86**	Well Depth (ft):	**85**
Drilling End Date:	**01/28/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	
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)		
85	SS	12/24	19 27 15 5	42	(84') As above. (85') 2cm seam of reddish/oxidized fine grained sand, dry.		
					(86') End of Boring.		
90							

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WELL LOG

Well No. **G09**
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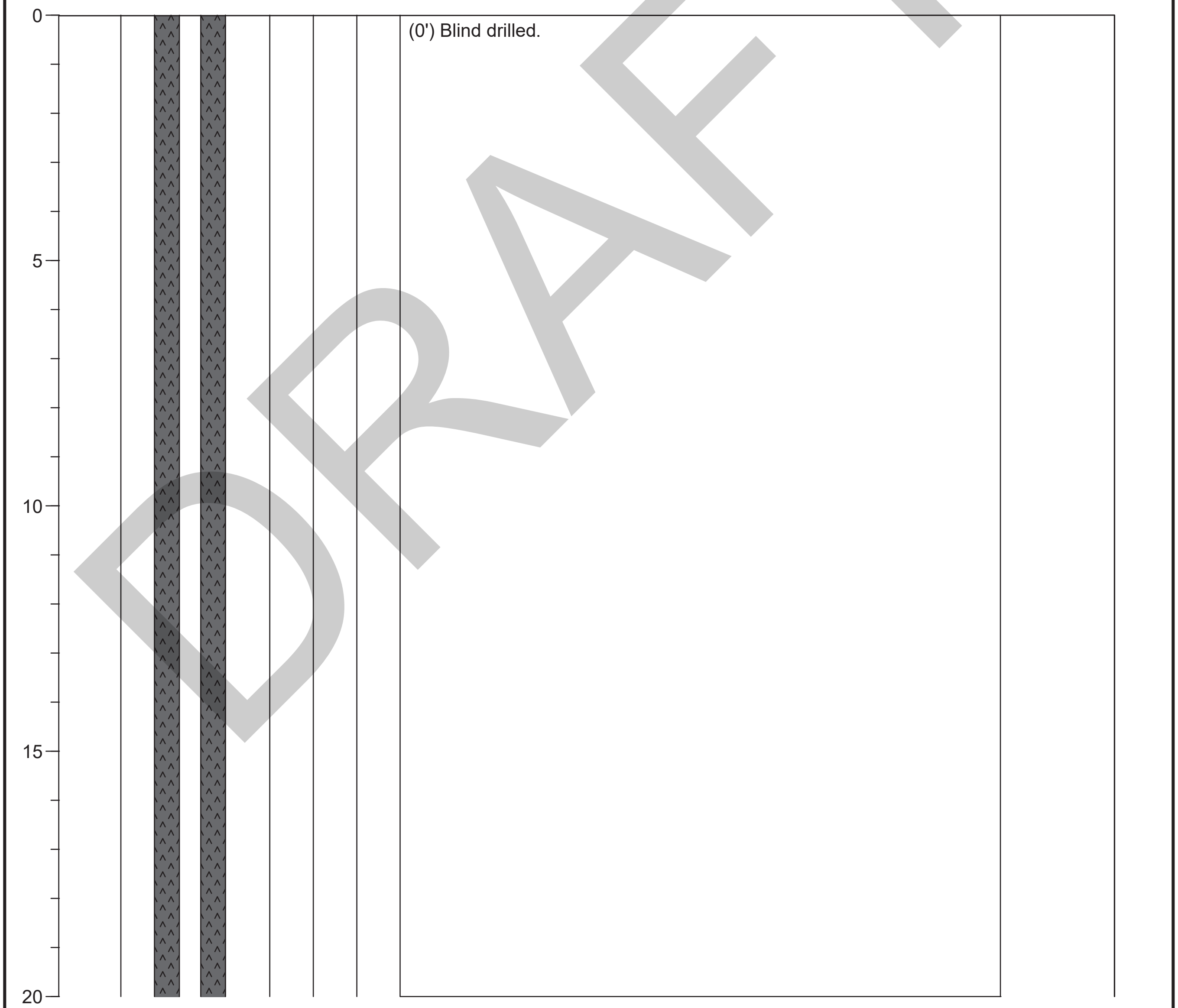
Drilling Start Date:	**01/31/2021**	Boring Depth (ft):	**72**	Well Depth (ft):	**70**
Drilling End Date:	**01/31/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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	



(0') Blind drilled.

NOTES:

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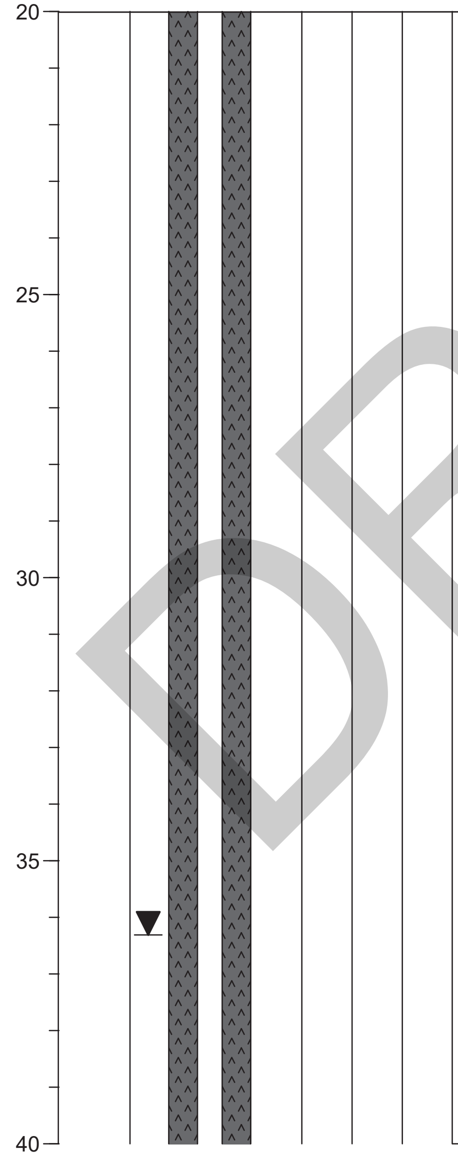
Drilling Start Date:	**01/31/2021**	Boring Depth (ft):	**72**	Well Depth (ft):	**70**
Drilling End Date:	**01/31/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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 Sample Type	COLLECT Recovery (in)	COLLECT Blow Counts	COLLECT N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
20								(20') Blind drilled.		



NOTES:

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Project: GLP0821, Joppa Ash Pond
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WELL LOG

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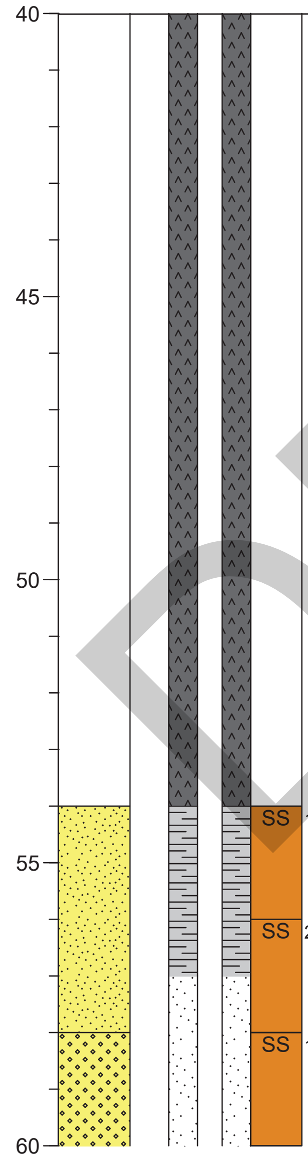
Drilling Start Date:	**01/31/2021**	Boring Depth (ft):	**72**	Well Depth (ft):	**70**
Drilling End Date:	**01/31/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
40					(40') Blind drilled.		
54	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.		
56	SS	23/24	8 13 15 20	28	(56') As above.		
58	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:

Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG

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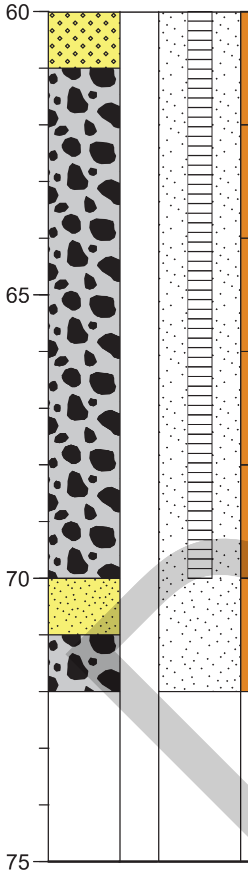
Drilling Start Date:	**01/31/2021**	Boring Depth (ft):	**72**	Well Depth (ft):	**70**
Drilling End Date:	**01/31/2021**	Boring Diameter (in):	**7.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	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)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE 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.	

NOTES:

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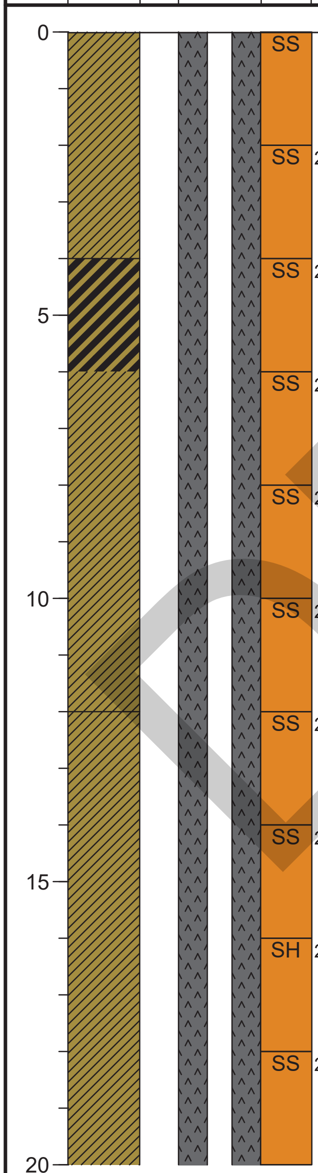
Drilling Start Date: **01/26/2021**	Boring Depth (ft): **158**	Well Depth (ft): **155**
Drilling End Date: **01/28/2021**	Boring Diameter (in): **4.25**	Well Diameter (in): **2**
Drilling Company: **Geotechnology**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Hollow Stem Auger**	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.	
	SS	22/24	4 5 6 4	11		
5	SS	24/24	2 3 3 4	6	(4') FAT CLAY (CH); light brown (7.5YR 6/4), medium dense, moist.	
	SS	24/24	0 3 3 4	6	(6') As above: lean clay, moist. (CL)	
	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
	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.	
15	SS	21/24	2 3 5 5	8	(14') As above: brown (7.5YR 5/4).	
	SH	24/24			(16') As above: light brown (7.5YR 6/3).	16-18 Geotech
20	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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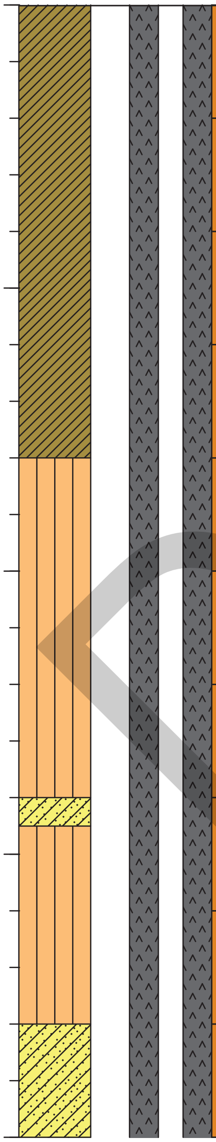
Drilling Start Date: **01/26/2021**	Boring Depth (ft): **158**	Well Depth (ft): **155**
Drilling End Date: **01/28/2021**	Boring Diameter (in): **4.25**	Well Diameter (in): **2**
Drilling Company: **Geotechnology**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Hollow Stem Auger**	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).		
	SS	24/24	2 5 7 8	12	(24') As above: fewer brown mottling.		
25	SS	24/24	3 3 6 7	9	(27-28') As above: increased reddish brown mottling.		
	SS	24/24	4 8 8 7	16	(28') SILT (ML); with few sand and clay, light gray (10YR 7/2) with some brown mottling, dry, stiff.		
30	SS	24/24	4 8 6 8	14	(30') As above: moist.		
	SS	24/24	4 5 6 7	11	(32') As above.		
	SS	24/24	2 4 4 6	8	(34') SANDY CLAY (SC); light gray (10YR 7/2) with some brown mottling, moist. (34.5') SILT (ML); with some sand, few clay, stiff.		
35	SS	24/24	3 4 5 8	9	(36') As above: trace black organics.		
	SS	24/24	5 20 18 17	38	(38') SANDY CLAY (SC); fine grained sand, few silt, gray (7.5YR 5/1), moist.		
40							

NOTES:

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WELL LOG

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Drilling Start Date:	**01/26/2021**	Boring Depth (ft):	**158**	Well Depth (ft):	**155**
Drilling End Date:	**01/28/2021**	Boring Diameter (in):	**4.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**51.93**	Riser Material:	**Sch 80 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**351.53**	Screen Material:	**Sch 80 PVC Slotted**
Driller:		Ground Elev. (ft):	**348.60**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**SK & AT**	Location (Lat/Long):	**37.21040, -88.85422**	Filter Pack:	**Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
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.		
				SS	24/24	2 3 5 6	8	(44') As above: fewer clay, more sand.		
45										
				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.		
				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).		
55										
				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, 3.5×10^{-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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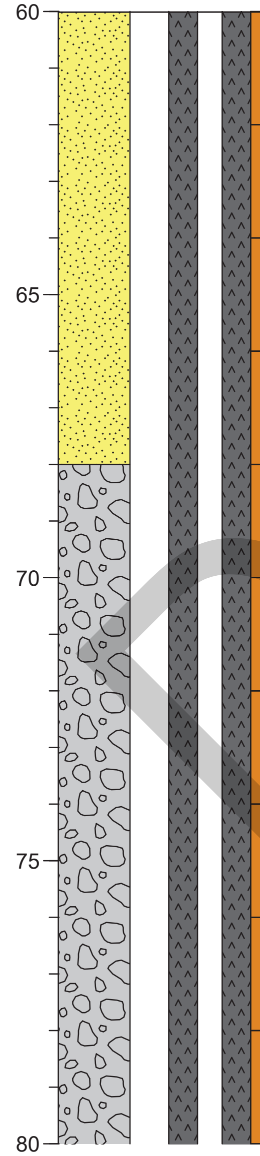
Drilling Start Date:	**01/26/2021**	Boring Depth (ft):	**158**	Well Depth (ft):	**155**
Drilling End Date:	**01/28/2021**	Boring Diameter (in):	**4.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem 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	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.	
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.	
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.	
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.	

COLLECT · MEASURE · DEPTH (ft)

NOTES:

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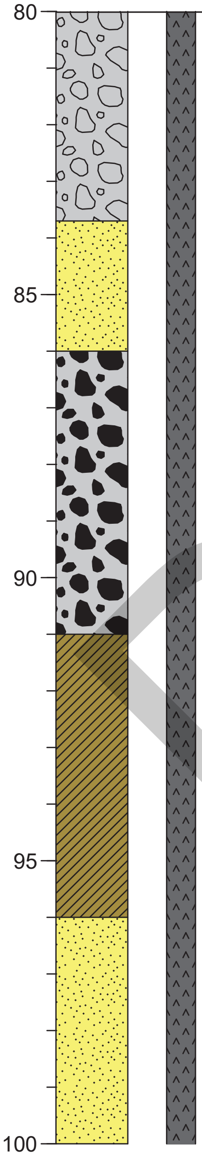
Drilling Start Date:	**01/26/2021**	Boring Depth (ft):	**158**	Well Depth (ft):	**155**
Drilling End Date:	**01/28/2021**	Boring Diameter (in):	**4.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**51.93**	Riser Material:	**Sch 80 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**351.53**	Screen Material:	**Sch 80 PVC Slotted**
Driller:		Ground Elev. (ft):	**348.60**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**SK & AT**	Location (Lat/Long):	**37.21040, -88.85422**	Filter Pack:	**Sand**

DEPTH (ft) | LITHOLOGY | WATER LEVEL | WELL COMPLETION



COLLECT					MEASURE
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
SS	12/24	2 17 19 12	36	(80') POORLY GRADED GRAVEL (GP); little sand, reddish yellow (7.5YR 6/8), very loose, wet.	80-82 Chem
SS	10/24	5 18 13 14	31		82-84 Geotech
SS	14/24		19	(83.7') POORLY GRADED SAND (SP); medium grained, trace gravel, reddish brown (7.5YR 6/8), loose, moist.	
SS	14/24	12 9 10 10	22	(86') WELL-GRADED GRAVEL (GW); few sand, trace clay, reddish brown (7.5YR 6/8), loose, wet.	
SS	14/24	25 14 8 6	14	(88') As above: clay disappears.	
SS		4 6 8 7		(91') GRAVELLY LEAN CLAY (CL); very pale brown (10YR 8/2), moist, soft.	
SS		2 3 3 4	6	(92') CLAY (CL); trace gravel, gray (7.5YR 6/1), medium dense.	
SS		2 1 3 3	4	(94') As above: gray (10YR 5/1).	
SS		1 6 23 23	29	(96') POORLY GRADED SAND (SP); fine grained, strong brown (7.5YR 5/8), loose.	
SS		5 14 25 23	39	(98') As above.	

DEPTH (ft)

NOTES: SBG09M- (82-84)-20210127: 7.6% moisture content, 740 U mg/kg total organic carbon, 100.0 pcf dry unit weight, 2.686 specific gravity, 22.7% gravel, 75.4% sand, 1.9% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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WELL LOG
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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
100	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.	
102	SS	15/24	14 12 8 15	20	(102') As above: some sand, brown (7.5YR 4/4).	
104	SS	9/24	12 12 9 14	21	(104') GRAVELLY CLAY (CL); light gray (2.5Y 7/2), stiff, moist.	
106	SS	15/24	12 12 12 20	24	(106') CLAYEY GRAVEL (GC); pinkish gray (7.5YR 7/2), medium dense, moist.	
108	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.	
110	SS	15/24	8 12 8 12	20	(110') As above: light gray (10YR 7/1).	110-112 Chem
112	SH	8/24				112-114 Geotech
114	SS	13/24	10 11 9 10	20	(114') As above: yellow (10YR 7/6), trace gravel.	
116	SS	12/24	7 9 9 12	18	(116') As above: light gray (10YR 7/2), no gravel.	116-118 Geotech (not tested)
118	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.	
120						

NOTES: SBG09M- (110-112)-20210127: 25.5% moisture content, 760 U mg/kg total organic carbon, 87.0 pcf dry unit weight, 2.675 specific gravity, 0.7% gravel, 84.1% sand, 15.2% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

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Project:	**GLP0821, Jappa Ash Pond**	
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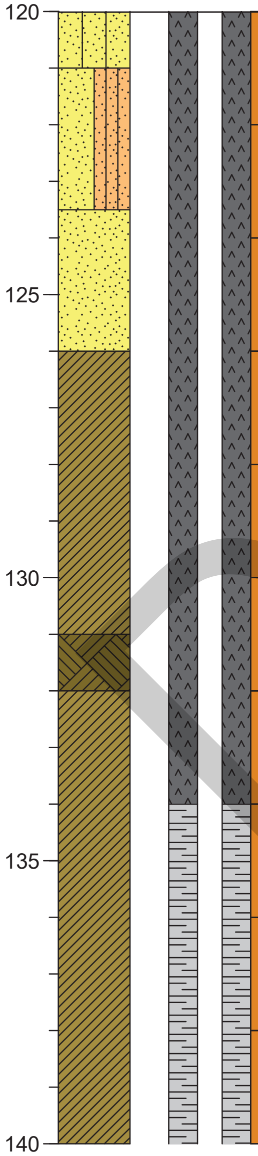
WELL LOG

Well No. **G09M**

Page: **7 of 8**

Drilling Start Date:	**01/26/2021**	Boring Depth (ft):	**158**	Well Depth (ft):	**155**
Drilling End Date:	**01/28/2021**	Boring Diameter (in):	**4.25**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**51.93**	Riser Material:	**Sch 80 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**351.53**	Screen Material:	**Sch 80 PVC Slotted**
Driller:		Ground Elev. (ft):	**348.60**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**SK & AT**	Location (Lat/Long):	**37.21040, -88.85422**	Filter Pack:	**Sand**



DEPTH (ft)	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
	Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		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)		
	SS	16/24	7 7 22 31	29			
					(123.5') As above: yellow (2.5Y 7/6). (SP)		
	SS	11/24	13 14 16 14	30	(124') POORLY GRADED SAND (SP); fine to medium grained, red (2.5YR 5/6), loose, dry.		
125							
	SS	16/24	3 5 8 10	13	(126') CLAY (CL); few silt and sand, light brownish gray (10YR 6/2), very stiff, dry.		
	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).		
	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	
	SS	22/24	1 2 6 7	8	(134') As above: light brownish gray (10YR 6/2), no sand.		
135							
	SS	20/24	2 5 5 6	10	(136') As above: very pale brown (10YR 7/3).		
	SS	13/24	4 8 7 21	15	(138') As above: light yellowish brown (5YR 6/4).		
140							

NOTES:

Geosyntec consultants
engineers | scientists | innovators

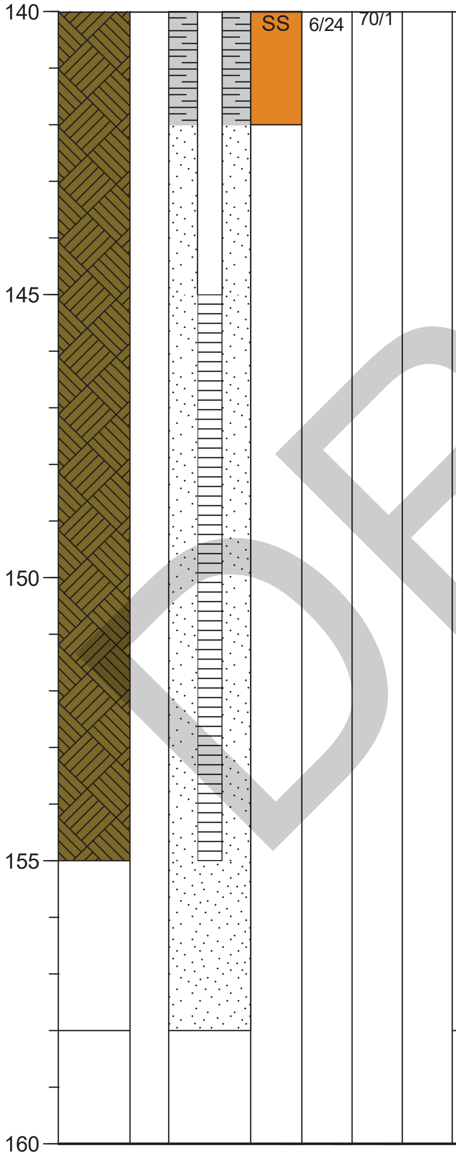
Client:	**Dynegy**
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)



(140') CALCARENITE, very pale brown (10YR 7/3), dry.

140-142 Chem

(155') End of Boring.

(158') Redrilled to 158' due to well installation difficulties.

NOTES:

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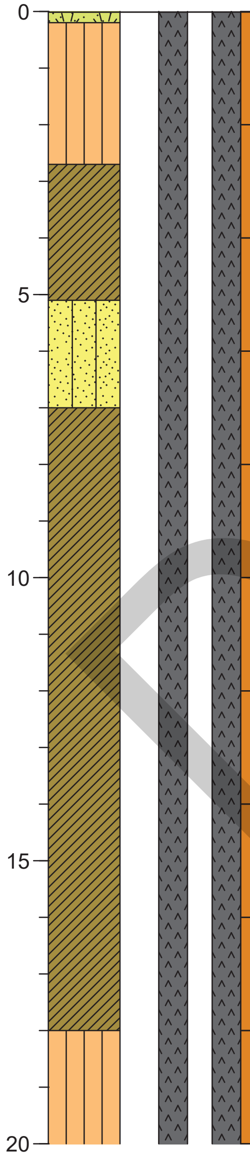
Client: Dynegy
Project: GLP0821, Joppa Ash Pond
Address: Unnamed Road, Metropolis, IL 62960

WELL LOG

Well No. G11
Page: 1 of 4

Drilling Start Date:	**01/19/2021**	Boring Depth (ft):	**66**	Well Depth (ft):	**66**
Drilling End Date:	**01/19/2021**	Boring Diameter (in):	**7.5**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**45.66**	Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**366.88**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**363.38**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**ZJF & AT**	Location (Lat/Long):	**37.21436, -88.85636**	Filter Pack:	**Sand**



DEPTH (ft)	COLLECT: Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0	SS	24/24	6 4 9 7	13	(0') TOPSOIL. (0.2') ASH (ML) (0.8') LEAN SILT (ML); trace fine sand, stiff, moist, tan (2.5Y 7/4).		
	SS	17/24	1 1 2 4	3	(2.7') LEAN CLAY (CL); some orange fine sand, soft, wet, brown (2.5Y 3/3).		
	SS	16/24	5 21 50/6	71	(5.1') SILTY SAND (SM); fine to medium grained, with coal, some organics, very dense, gray (N3), moist, well-graded.		
5	SS	17/24	5 7 5 5	12	(7.0') LEAN CLAY (CL); stiff, moist, tan (5Y 7/2) with gray (N8) mottles.		
	SS	24/24	1 3 5 6	8	(8') As above: becomes medium stiff, orange (10YR 7/12) mottles.		
10	SS	24/24	2 5 8 6	13	(10') As above: becomes stiff, black inclusions, trace organics.		
	SS	23/24	2 4 5 7	9	(12') As above.		
	SS	24/24	2 5 6 8	11	(14') As above.		
15	SS	24/24	2 4 5 6	9	(16') As above.		
	SS	24/24	3 7 9 10	16	(18') LEAN SILT (ML); trace sand, stiff, moist, tan (5Y 7/2) with orange (10YR 7/12) and black mottling.		
20							

NOTES:

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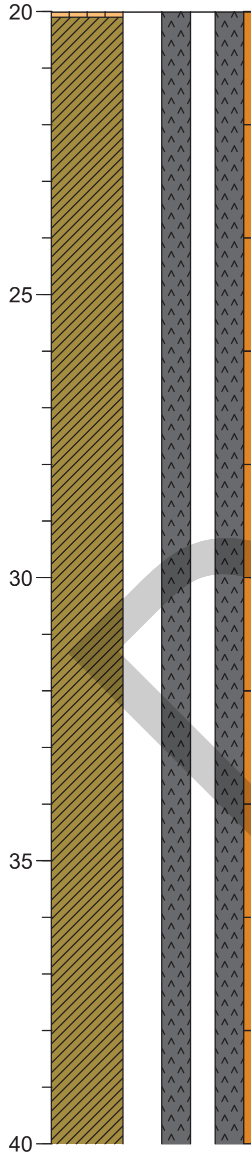
Client:	**Dynegy**
Project:	**GLP0821, Joppa Ash Pond**
Address:	**Unnamed Road, Metropolis, IL 62960**

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**



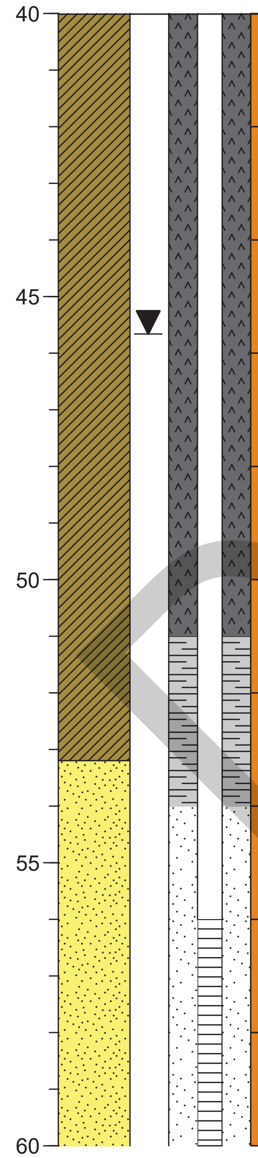
DEPTH (ft)	COLLECT Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE Lab Sample	DEPTH (ft)
20	SS	24/24	3 6 8 8	14	(20.1') LEAN CLAY (CL); trace fine sand, stiff, moist, tannish orange (10YR 7/6) with gray (N8) mottles.		
	SS	27/24	2 4 6 7	10	(22') As above.	22-24 Chem	
	SS	27/24			(24') As above.	24-26 ST	
25							
	SS	24/24	3 4 5 7	9	(26') As above.		
	SS	24/24	3 4 6 7	10	(28') As above.		
30	SS	26/24	2 4 4 6	8	(30') As above: with increased moisture.		
	SS	24/24	2 4 4 6	8	(32') As above.		
	SS	25/24	4 5 8 7	13	(34') As above: with fine sand.		
35							
	SS	26/24	2 5 5 5	10	(36') As above: orange (10YR 7/12) inclusions, gray (N8) with tan orange (10YR 7/6) mottling.		
	SS	25/24	2 4 6 6	10	(38') As above: trace silt.		
40							

NOTES: SBG11-(24-26)-20210119: 18.5% moisture content, 415 U mg/kg total organic carbon, 109.1 pcf dry unit weight, 2.688 specific gravity, 5.6×10^{-8} cm/s vertical hydraulic conductivity, 36 LL, 15 PL, 21 PI, 0.0% gravel, 11.5% sand, 88.5% fines.
*U = Analyte was not present in concentrations above method detection limit and is reported as the reporting limit

Drilling Start Date: **01/19/2021**
Drilling End Date: **01/19/2021**
Drilling Company: **Geotechnology**
Drilling Method: **Hollow Stem Auger**
Drilling Equipment: **CME 55LC**
Driller:
Logged By: **ZJF & AT**

Boring Depth (ft): **66**
Boring Diameter (in): **7.5**
DTW During Drilling (ft):
DTW After Drilling (ft): **45.66**
Top of Casing Elev. (ft): **366.88**
Ground Elev. (ft): **363.38**
Location (Lat/Long): **37.21436, -88.85636**

Well Depth (ft): **66**
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**

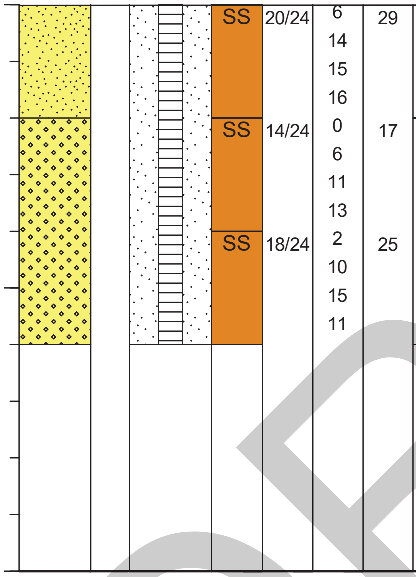


COLLECT					MEASURE
Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample
SS	25/24	2 3 4 4	7	(40') As above: becomes medium stiff.	
SS	27/24	2 4 4 6	8	(42') LEAN CLAY (CL); orange (10YR 7/6) silty fine sand seams, medium stiff, moist, gray (N8).	
SS	25/24	2 4 5 6	9	(44') As above: stiff.	
SS	25/24	3 6 9 10	15	(46') As above: seams are silt only.	
SS	24/24	3 4 5 8	9	(48') As above: no seams, trace orange (10YR 7/6) silt, increased moisture.	
SS	27/24	1 3 0 3	3	(50') As above: increased moisture.	
SS	27/24	2 3 3 6	6	(52') As above: gray (N9) sand layer. (53.2') POORLY GRADED SAND (SP); fine to medium grained, trace silt, loose, gray (N9), wet.	
SS	27/24	3 8 26 26	34	(54') As above: becomes dense, trace clay, trace orange (10YR 7/6) silt inclusions.	
SS	8/24			(56') As above.	56-58 Geotech
SS	24/24	7 14 16 13	30	(58') As above: trace gravel, no silt, some orange (10YR 7/6) fine to medium sand.	58-60 Chem

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

Geosyntec consultants engineers | scientists | innovators	**Client:** Dynegy **Project:** GLP0821, Joppa Ash Pond **Address:** Unnamed Road, Metropolis, IL 62960	**WELL LOG** **Well No.** G11 **Page:** 4 of 4

Drilling Start Date:	**01/19/2021**	Boring Depth (ft):	**66**	Well Depth (ft):	**66**
Drilling End Date:	**01/19/2021**	Boring Diameter (in):	**7.5**	Well Diameter (in):	**2**
Drilling Company:	**Geotechnology**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Hollow Stem Auger**	DTW After Drilling (ft):	**45.66**	Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CME 55LC**	Top of Casing Elev. (ft):	**366.88**	Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):	**363.38**	Seal Material(s):	**Grout & Bentonite**
Logged By:	**ZJF & AT**	Location (Lat/Long):	**37.21436, -88.85636**	Filter Pack:	**Sand**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				SS	20/24	6 14 15 16	29	(60') As above: increased orange sand.		
				SS	14/24	0 6 11 13	17	(62') WELL-GRADED SAND (SW); fine to medium grained, medium dense, wet, orangish tan (7.5YR 8/8) with some gray (N9) sand layers.		
				SS	18/24	2 10 15 11	25	(64') As above: with sandy gravel layer (~5" thick).		
65										
								(66') End of Boring.		
70										

NOTES:

ATTACHMENT F

Ash and Aquifer Solids Total Metals Analytical Data

Teklab, Inc.
Environmental Laboratory

http://www.teklabinc.com/

February 05, 2021

Allison Kreinberg
Geosyntec Consultants
941 Chatham Lane, Ste 103
Columbus, OH 43221
TEL: (614) 468-0421
FAX:

NELAP ACCREDITED TNI LABORATORY

Illinois	100226
Kansas	E-10374
Louisiana	05002
Louisiana	05003
Oklahoma	9978

RE: GLP8021 **WorkOrder:** 21011267

Dear Allison Kreinberg:

TEKLAB, INC received 12 samples on 1/25/2021 4:30:00 PM for the analysis presented in the following report.

Samples are analyzed on an as received basis unless otherwise requested and documented. The sample results contained in this report relate only to the requested analytes of interest as directed on the chain of custody. NELAP accredited fields of testing are indicated by the letters NELAP under the Certification column. Unless otherwise documented within this report, Teklab Inc. analyzes samples utilizing the most current methods in compliance with 40CFR. All tests are performed in the Collinsville, IL laboratory unless otherwise noted in the Case Narrative.

All quality control criteria applicable to the test methods employed for this project have been satisfactorily met and are in accordance with NELAP except where noted. The following report shall not be reproduced, except in full, without the written approval of Teklab, Inc.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Aaron Renner
Project Manager
(630)324-6855
arenner@teklabinc.com

Client: Geosyntec Consultants **Work Order:** 21011267

Client Project: GLP8021 **Report Date:** 05-Feb-21

This reporting package includes the following:

Definitions

Abbr	Definition
*	Analytes on report marked with an asterisk are not NELAP accredited
CCV	Continuing calibration verification is a check of a standard to determine the state of calibration of an instrument between recalibration.
CRQL	A Client Requested Quantitation Limit is a reporting limit that varies according to customer request. The CRQL may not be less than the MDL.
DF	Dilution factor is the dilution performed during analysis only and does not take into account any dilutions made during sample preparation. The reported result is final and includes all dilution factors.
DNI	Did not ignite
DUP	Laboratory duplicate is a replicate aliquot prepared under the same laboratory conditions and independently analyzed to obtain a measure of precision.
ICV	Initial calibration verification is a check of a standard to determine the state of calibration of an instrument before sample analysis is initiated.
IDPH	IL Dept. of Public Health
LCS	Laboratory control sample is a sample matrix, free from the analytes of interest,spiked with verified known amounts of analytes and analyzed exactly like a sample to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.
LCSD	Laboratory control sample duplicate is a replicate laboratory control sample that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MBLK	Method blank is a sample of a matrix similar to the batch of associated sample (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences should present at concentrations that impact the analytical results for sample analyses.
MDL	"The method detection limit is defined as the minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results."
MS	Matrix spike is an aliquot of matrix fortified (spiked) with known quantities of specific analytes that is subjected to the entire analytical procedures in order to determine the effect of the matrix on an approved test method's recovery system. The acceptable recovery range is listed in the QC Package (provided upon request).
MSD	Matrix spike duplicate means a replicate matrix spike that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MW	Molecular weight
NC	Data is not acceptable for compliance purposes
ND	Not Detected at the Reporting Limit
NELAP	NELAP Accredited
PQL	Practical quantitation limit means the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operation conditions.
RL	The reporting limit the lowest level that the data is displayed in the final report. The reporting limit may vary according to customer request or sample dilution. The reporting limit may not be less than the MDL.
RPD	Relative percent difference is a calculated difference between two recoveries (ie. MS/MSD). The acceptable recovery limit is listed in the QC Package (provided upon request).
SPK	The spike is a known mass of target analyte added to a blank sample or sub-sample; used to determine recovery deficiency or for other quality control purposes.
Surr	Surrogates are compounds which are similar to the analytes of interest in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples.
TIC	Tentatively identified compound: Analytes tentatively identified in the sample by using a library search. Only results not in the calibration standard will be reported as tentatively identified compounds. Results for tentatively identified compounds that are not present in the calibration standard, but are assigned a specific chemical name based upon the library search, are calculated using total peak areas from reconstructed ion chromatograms and a response factor of one. The nearest Internal Standard is used for the calculation. The results of any TICs must be considered estimated, and are flagged with a "T". If the estimated result is above the calibration range it is flagged "ET"
TNTC	Too numerous to count (> 200 CFU)

Definitions

Client: Geosyntec Consultants **Work Order:** 21011267

Client Project: GLP8021 **Report Date:** 05-Feb-21

Qualifiers

# -	Unknown hydrocarbon	B -	Analyte detected in associated Method Blank
C -	RL shown is a Client Requested Quantitation Limit	E -	Value above quantitation range
H -	Holding times exceeded	I -	Associated internal standard was outside method criteria
J -	Analyte detected below quantitation limits	M -	Manual Integration used to determine area response
ND -	Not Detected at the Reporting Limit	R -	RPD outside accepted recovery limits
S -	Spike Recovery outside recovery limits	T -	TIC(Tentatively identified compound)
X -	Value exceeds Maximum Contaminant Level		

Case Narrative

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21

Cooler Receipt Temp: 1.4 °C

Total Organic Carbon analysis performed by Pace Analytical Services, LLC. See attached report for results.

Locations

Collinsville

Address 5445 Horseshoe Lake Road
Collinsville, IL 62234-7425
Phone (618) 344-1004
Fax (618) 344-1005
Email jhriley@teklabinc.com

Collinsville Air

Address 5445 Horseshoe Lake Road
Collinsville, IL 62234-7425
Phone (618) 344-1004
Fax (618) 344-1005
Email EHurley@teklabinc.com

Springfield

Address 3920 Pintail Dr
Springfield, IL 62711-9415
Phone (217) 698-1004
Fax (217) 698-1005
Email KKlostermann@teklabinc.com

Chicago

Address 1319 Butterfield Rd.
Downers Grove, IL 60515
Phone (630) 324-6855
Fax
Email arenner@teklabinc.com

Kansas City

Address 8421 Nieman Road
Lenexa, KS 66214
Phone (913) 541-1998
Fax (913) 541-1998
Email jhriley@teklabinc.com

Accreditations

Client: Geosyntec Consultants
Client Project: GLP8021
Work Order: 21011267
Report Date: 05-Feb-21

State	Dept	Cert #	NELAP	Exp Date	Lab
Illinois	IEPA	100226	NELAP	1/31/2022	Collinsville
Kansas	KDHE	E-10374	NELAP	4/30/2021	Collinsville
Louisiana	LDEQ	05002	NELAP	6/30/2021	Collinsville
Louisiana	LDEQ	05003	NELAP	6/30/2021	Collinsville
Oklahoma	ODEQ	9978	NELAP	8/31/2021	Collinsville
Arkansas	ADEQ	88-0966		3/14/2021	Collinsville
Illinois	IDPH	17584		5/31/2021	Collinsville
Kentucky	UST	0073		1/31/2022	Collinsville
Missouri	MDNR	00930		5/31/2021	Collinsville
Missouri	MDNR	930		1/31/2022	Collinsville

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-001
Client Sample ID: SB-G11-(22-24)-20210119
Matrix: SOLID
Collection Date: 01/19/2021 13:30

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**16.9**	%	1	01/27/2021 17:06	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.38		**0.79**	mg/Kg-dry	10	02/01/2021 16:44	173242
Arsenic	NELAP	0.18	B	**3.50**	mg/Kg-dry	10	01/28/2021 3:21	173243
Barium	NELAP	0.18	B	**173**	mg/Kg-dry	10	01/28/2021 3:21	173243
Beryllium	NELAP	0.27		**0.74**	mg/Kg-dry	10	01/28/2021 3:21	173243
Boron	NELAP	4.55		**< 4.55**	mg/Kg-dry	10	01/28/2021 3:21	173243
Cadmium	NELAP	0.18		**0.43**	mg/Kg-dry	10	01/28/2021 3:21	173243
Calcium	*	45.5		**1370**	mg/Kg-dry	10	01/28/2021 3:21	173243
Chromium	NELAP	0.45		**15.7**	mg/Kg-dry	10	01/28/2021 3:21	173243
Cobalt	NELAP	0.18		**2.72**	mg/Kg-dry	10	01/28/2021 3:21	173243
Iron	NELAP	9.09		**12000**	mg/Kg-dry	10	01/28/2021 3:21	173243
Lead	NELAP	0.18		**8.64**	mg/Kg-dry	10	01/28/2021 3:21	173243
Lithium	*	0.27		**5.69**	mg/Kg-dry	10	01/28/2021 3:21	173243
Manganese	NELAP	0.18	B	**60.9**	mg/Kg-dry	10	01/28/2021 3:21	173243
Molybdenum	NELAP	0.18		**0.36**	mg/Kg-dry	10	01/28/2021 3:21	173243
Selenium	NELAP	0.91		**< 0.91**	mg/Kg-dry	10	01/28/2021 3:21	173243
Thallium	NELAP	0.18		**0.41**	mg/Kg-dry	10	01/28/2021 3:21	173243
Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.011		**< 0.011**	mg/Kg-dry	1	01/26/2021 10:17	173211
SEE ATTACHED FOR SUBCONTRACTING ANALYSIS								
Subcontracted Analysis	*	0		**See Attached**		1	02/01/2021 0:00	R287037

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-002
Client Sample ID: SB-G11-(58-60)-20210119
Matrix: SOLID
Collection Date: 01/19/2021 13:35

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**13.5**	%	1	01/27/2021 17:06	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.37		**< 0.37**	mg/Kg-dry	10	02/01/2021 16:53	173242
Arsenic	NELAP	0.18	B	**1.15**	mg/Kg-dry	10	01/28/2021 3:29	173243
Barium	NELAP	0.18	B	**21.6**	mg/Kg-dry	10	01/28/2021 3:29	173243
Beryllium	NELAP	0.27		**0.30**	mg/Kg-dry	10	01/28/2021 3:29	173243
Boron	NELAP	4.55		**< 4.55**	mg/Kg-dry	10	01/28/2021 3:29	173243
Cadmium	NELAP	0.18		**< 0.18**	mg/Kg-dry	10	01/28/2021 3:29	173243
Calcium	*	45.5		**430**	mg/Kg-dry	10	01/28/2021 3:29	173243
Chromium	NELAP	0.45		**6.05**	mg/Kg-dry	10	01/28/2021 3:29	173243
Cobalt	NELAP	0.18		**1.29**	mg/Kg-dry	10	01/28/2021 3:29	173243
Iron	NELAP	9.09		**2800**	mg/Kg-dry	10	01/28/2021 3:29	173243
Lead	NELAP	0.18		**3.00**	mg/Kg-dry	10	01/28/2021 3:29	173243
Lithium	*	0.27		**2.03**	mg/Kg-dry	10	01/28/2021 3:29	173243
Manganese	NELAP	0.18	B	**11.6**	mg/Kg-dry	10	01/28/2021 3:29	173243
Molybdenum	NELAP	0.18		**< 0.18**	mg/Kg-dry	10	01/28/2021 3:29	173243
Selenium	NELAP	0.91		**< 0.91**	mg/Kg-dry	10	01/28/2021 3:29	173243
Thallium	NELAP	0.18		**< 0.18**	mg/Kg-dry	10	01/28/2021 3:29	173243
Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.011		**< 0.011**	mg/Kg-dry	1	01/26/2021 10:19	173211
SEE ATTACHED FOR SUBCONTRACTING ANALYSIS								
Subcontracted Analysis	*	0		**See Attached**		1	02/01/2021 0:00	R287037

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-003
Client Sample ID: EQB-20210119
Matrix: AQUEOUS
Collection Date: 01/19/2021 0:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA 600 245.1 R3.0 (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	01/26/2021 9:58	173239
EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:35	173238
Arsenic	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:35	173238
Barium	NELAP	0.0010		**0.0195**	mg/L	5	01/28/2021 1:35	173238
Beryllium	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:35	173238
Boron	NELAP	0.0250		**< 0.0250**	mg/L	5	01/28/2021 1:35	173238
Cadmium	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:35	173238
Calcium	NELAP	0.125		**0.786**	mg/L	5	01/28/2021 1:35	173238
Chromium	NELAP	0.0015		**0.0129**	mg/L	5	01/28/2021 1:35	173238
Cobalt	NELAP	0.0010		**0.0011**	mg/L	5	01/28/2021 1:35	173238
Iron	NELAP	0.0250	B	**4.01**	mg/L	5	01/28/2021 1:35	173238
Lead	NELAP	0.0010		**0.0012**	mg/L	5	01/28/2021 1:35	173238
Lithium	*	0.0030		**< 0.0030**	mg/L	5	01/28/2021 1:35	173238
Manganese	NELAP	0.0020		**0.0405**	mg/L	5	01/28/2021 1:35	173238
Molybdenum	NELAP	0.0015		**0.0038**	mg/L	5	01/28/2021 1:35	173238
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:35	173238
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	01/28/2021 1:35	173238

Sample result(s) for FE exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.

Client:	Geosyntec Consultants	**Work Order:**	21011267
Client Project:	GLP8021	**Report Date:**	05-Feb-21
Lab ID:	21011267-004	**Client Sample ID:**	SB-XPW-01-(4-6)-20210120
Matrix:		**Collection Date:**	01/20/2021 11:30

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**24.0**	%	1	01/27/2021 17:06	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	1.96		**2.80**	mg/Kg-dry	50	02/03/2021 10:22	173242
Arsenic	NELAP	0.19	B	**16.4**	mg/Kg-dry	10	01/28/2021 3:37	173243
Barium	NELAP	0.93	B	**3080**	mg/Kg-dry	50	01/29/2021 19:48	173243
Beryllium	NELAP	1.39		**3.70**	mg/Kg-dry	50	02/03/2021 10:47	173243
Boron	NELAP	23.1		**542**	mg/Kg-dry	50	01/29/2021 19:48	173243
Cadmium	NELAP	0.19		**1.41**	mg/Kg-dry	10	01/28/2021 3:37	173243
Calcium	*	231		**141000**	mg/Kg-dry	50	01/29/2021 19:48	173243
Chromium	NELAP	2.31		**49.4**	mg/Kg-dry	50	02/03/2021 10:47	173243
Cobalt	NELAP	0.93		**22.0**	mg/Kg-dry	50	02/03/2021 10:47	173243
Iron	NELAP	46.3		**31600**	mg/Kg-dry	50	01/29/2021 19:48	173243
Lead	NELAP	0.93		**34.2**	mg/Kg-dry	50	01/29/2021 19:48	173243
Lithium	*	1.39		**30.9**	mg/Kg-dry	50	02/03/2021 10:47	173243
Manganese	NELAP	0.93	B	**95.2**	mg/Kg-dry	50	02/03/2021 10:47	173243
Molybdenum	NELAP	0.19		**7.42**	mg/Kg-dry	10	01/28/2021 3:37	173243
Selenium	NELAP	0.93		**8.29**	mg/Kg-dry	10	01/28/2021 3:37	173243
Thallium	NELAP	0.93		**< 0.93**	mg/Kg-dry	50	01/29/2021 19:48	173243
Sample result(s) for CA exceed 10 times the CCB contamination. Data is reportable per the TNI Standard.								
Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.066		**0.758**	mg/Kg-dry	5	01/26/2021 10:48	173211

Client: Geosyntec Consultants

Work Order: 21011267

Client Project: GLP8021

Report Date: 05-Feb-21

Lab ID: 21011267-005

Client Sample ID: SB-XPW-01-(46-48)-20210120-DUP

Matrix: SOLID

Collection Date: 01/20/2021 11:45

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**21.7**	%	1	01/27/2021 17:07	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.40		**< 0.40**	mg/Kg-dry	10	02/01/2021 17:10	173242
Arsenic	NELAP	0.19	B	**7.31**	mg/Kg-dry	10	01/28/2021 3:45	173243
Barium	NELAP	0.19	B	**105**	mg/Kg-dry	10	01/28/2021 3:45	173243
Beryllium	NELAP	0.29		**0.72**	mg/Kg-dry	10	01/28/2021 3:45	173243
Boron	NELAP	4.81		**36.3**	mg/Kg-dry	10	01/28/2021 3:45	173243
Cadmium	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	01/28/2021 3:45	173243
Calcium	*	48.1		**3530**	mg/Kg-dry	10	01/28/2021 3:45	173243
Chromium	NELAP	0.48		**18.8**	mg/Kg-dry	10	01/28/2021 3:45	173243
Cobalt	NELAP	0.19		**8.99**	mg/Kg-dry	10	01/28/2021 3:45	173243
Iron	NELAP	9.62		**18400**	mg/Kg-dry	10	01/28/2021 3:45	173243
Lead	NELAP	0.19		**15.5**	mg/Kg-dry	10	01/28/2021 3:45	173243
Lithium	*	0.29		**12.3**	mg/Kg-dry	10	01/28/2021 3:45	173243
Manganese	NELAP	0.19	B	**133**	mg/Kg-dry	10	01/28/2021 3:45	173243
Molybdenum	NELAP	0.19		**47.9**	mg/Kg-dry	10	01/28/2021 3:45	173243
Selenium	NELAP	0.96		**< 0.96**	mg/Kg-dry	10	01/28/2021 3:45	173243
Thallium	NELAP	0.19		**0.26**	mg/Kg-dry	10	01/28/2021 3:45	173243
Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.012		**0.016**	mg/Kg-dry	1	01/26/2021 10:28	173211

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-006
Client Sample ID: EQB-20210120
Matrix: AQUEOUS
Collection Date: 01/20/2021 12:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA 600 245.1 R3.0 (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	01/26/2021 10:01	173239
EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**0.0020**	mg/L	5	01/28/2021 1:18	173238
Arsenic	NELAP	0.0010		**0.0397**	mg/L	5	01/28/2021 1:18	173238
Barium	NELAP	0.0010		**0.847**	mg/L	5	01/28/2021 1:18	173238
Beryllium	NELAP	0.0010		**0.0045**	mg/L	5	01/28/2021 1:18	173238
Boron	NELAP	0.0250		**0.204**	mg/L	5	01/28/2021 1:18	173238
Cadmium	NELAP	0.0010		**0.0012**	mg/L	5	01/28/2021 1:18	173238
Calcium	NELAP	0.125		**27.3**	mg/L	5	01/28/2021 1:18	173238
Chromium	NELAP	0.0015		**0.0676**	mg/L	5	01/28/2021 1:18	173238
Cobalt	NELAP	0.0010		**0.0185**	mg/L	5	01/28/2021 1:18	173238
Iron	NELAP	0.0250	B	**32.6**	mg/L	5	01/28/2021 1:18	173238
Lead	NELAP	0.0010		**0.0551**	mg/L	5	01/28/2021 1:18	173238
Lithium	*	0.0030		**0.0218**	mg/L	5	01/28/2021 1:18	173238
Manganese	NELAP	0.0020		**0.388**	mg/L	5	01/28/2021 1:18	173238
Molybdenum	NELAP	0.0015		**0.0220**	mg/L	5	01/28/2021 1:18	173238
Selenium	NELAP	0.0010		**0.0013**	mg/L	5	01/28/2021 1:18	173238
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	01/28/2021 1:18	173238

Sample result(s) for FE exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-007
Client Sample ID: SB-XPW-02-(4-6)-20210120
Matrix:
Collection Date: 01/20/2021 13:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**23.0**	%	1	01/27/2021 17:07	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	1.82		**3.25**	mg/Kg-dry	50	02/03/2021 10:30	173242
Arsenic	NELAP	0.20	B	**21.1**	mg/Kg-dry	10	01/28/2021 3:53	173243
Barium	NELAP	0.98	B	**2690**	mg/Kg-dry	50	01/29/2021 19:56	173243
Beryllium	NELAP	1.47		**3.18**	mg/Kg-dry	50	02/03/2021 14:10	173243
Boron	NELAP	24.5		**536**	mg/Kg-dry	50	01/29/2021 19:56	173243
Cadmium	NELAP	0.20		**1.61**	mg/Kg-dry	10	01/28/2021 3:53	173243
Calcium	*	245		**152000**	mg/Kg-dry	50	01/29/2021 19:56	173243
Chromium	NELAP	2.45		**57.7**	mg/Kg-dry	50	02/03/2021 14:10	173243
Cobalt	NELAP	0.98		**22.9**	mg/Kg-dry	50	02/03/2021 14:10	173243
Iron	NELAP	49.0		**33800**	mg/Kg-dry	50	01/29/2021 19:56	173243
Lead	NELAP	0.98		**32.0**	mg/Kg-dry	50	01/29/2021 19:56	173243
Lithium	*	1.47		**28.2**	mg/Kg-dry	50	02/03/2021 14:10	173243
Manganese	NELAP	0.98	B	**153**	mg/Kg-dry	50	02/03/2021 14:10	173243
Molybdenum	NELAP	0.20		**9.93**	mg/Kg-dry	10	01/28/2021 3:53	173243
Selenium	NELAP	0.98		**6.65**	mg/Kg-dry	10	01/28/2021 3:53	173243
Thallium	NELAP	0.98		**1.13**	mg/Kg-dry	50	01/29/2021 19:56	173243

Sample result(s) for CA exceed 10 times the CCB contamination. Data is reportable per the TNI Standard.

Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
SW-846 7471B								
Mercury	NELAP	0.012		**0.583**	mg/Kg-dry	1	01/26/2021 10:31	173211

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-008
Client Sample ID: SB-XPW-02-(24-26)-20210120
Matrix:
Collection Date: 01/20/2021 14:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**33.2**	%	1	01/27/2021 17:07	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.40		**2.19**	mg/Kg-dry	10	02/01/2021 17:28	173242
Arsenic	NELAP	0.20	B	**44.1**	mg/Kg-dry	10	01/28/2021 4:01	173243
Barium	NELAP	0.20	B	**193**	mg/Kg-dry	10	01/28/2021 4:01	173243
Beryllium	NELAP	0.30		**3.86**	mg/Kg-dry	10	01/28/2021 4:01	173243
Boron	NELAP	5.00		**334**	mg/Kg-dry	10	01/28/2021 4:01	173243
Cadmium	NELAP	0.20		**2.37**	mg/Kg-dry	10	01/28/2021 4:01	173243
Calcium	*	50.0		**34600**	mg/Kg-dry	10	01/28/2021 4:01	173243
Chromium	NELAP	0.50		**55.8**	mg/Kg-dry	10	01/28/2021 4:01	173243
Cobalt	NELAP	0.20		**11.8**	mg/Kg-dry	10	01/28/2021 4:01	173243
Iron	NELAP	10.0		**57000**	mg/Kg-dry	10	01/28/2021 4:01	173243
Lead	NELAP	0.20		**22.4**	mg/Kg-dry	10	01/28/2021 4:01	173243
Lithium	*	0.30		**10.4**	mg/Kg-dry	10	01/28/2021 4:01	173243
Manganese	NELAP	0.20	B	**342**	mg/Kg-dry	10	01/28/2021 4:01	173243
Molybdenum	NELAP	0.20		**7.99**	mg/Kg-dry	10	01/28/2021 4:01	173243
Selenium	NELAP	1.00		**2.23**	mg/Kg-dry	10	01/28/2021 4:01	173243
Thallium	NELAP	0.20		**2.11**	mg/Kg-dry	10	01/28/2021 4:01	173243
Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.014		**< 0.014**	mg/Kg-dry	1	01/26/2021 10:33	173211

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-009
Client Sample ID: EQB-20210121
Matrix: AQUEOUS
Collection Date: 01/21/2021 7:30

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA 600 245.1 R3.0 (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	01/26/2021 10:08	173239
EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:27	173238
Arsenic	NELAP	0.0010		**0.0060**	mg/L	5	01/28/2021 1:27	173238
Barium	NELAP	0.0010		**0.113**	mg/L	5	01/28/2021 1:27	173238
Beryllium	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:27	173238
Boron	NELAP	0.0250		**0.0495**	mg/L	5	01/28/2021 1:27	173238
Cadmium	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:27	173238
Calcium	NELAP	0.125		**5.67**	mg/L	5	01/28/2021 1:27	173238
Chromium	NELAP	0.0015		**0.0208**	mg/L	5	01/28/2021 1:27	173238
Cobalt	NELAP	0.0010		**0.0027**	mg/L	5	01/28/2021 1:27	173238
Iron	NELAP	0.0250	B	**13.0**	mg/L	5	01/28/2021 1:27	173238
Lead	NELAP	0.0010		**0.0077**	mg/L	5	01/28/2021 1:27	173238
Lithium	*	0.0030		**0.0073**	mg/L	5	01/28/2021 1:27	173238
Manganese	NELAP	0.0020		**0.0720**	mg/L	5	01/28/2021 1:27	173238
Molybdenum	NELAP	0.0015		**0.0060**	mg/L	5	01/28/2021 1:27	173238
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	01/28/2021 1:27	173238
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	01/28/2021 1:27	173238

Sample result(s) for FE exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-010
Client Sample ID: SB-XPW-03-(6-8)-20210121
Matrix: SOLID
Collection Date: 01/21/2021 11:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**38.1**	%	1	01/27/2021 17:07	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	1.85		**4.07**	mg/Kg-dry	50	02/03/2021 10:39	173242
Arsenic	NELAP	0.93	B	**55.8**	mg/Kg-dry	50	01/28/2021 4:09	173243
Barium	NELAP	0.93	B	**976**	mg/Kg-dry	50	01/28/2021 4:09	173243
Beryllium	NELAP	1.39		**3.30**	mg/Kg-dry	50	01/28/2021 4:09	173243
Boron	NELAP	23.1		**308**	mg/Kg-dry	50	01/28/2021 4:09	173243
Cadmium	NELAP	0.19		**0.95**	mg/Kg-dry	10	01/29/2021 20:05	173243
Calcium	*	231		**34700**	mg/Kg-dry	50	01/28/2021 4:09	173243
Chromium	NELAP	2.31		**44.8**	mg/Kg-dry	50	01/28/2021 4:09	173243
Cobalt	NELAP	0.93		**11.8**	mg/Kg-dry	50	01/28/2021 4:09	173243
Iron	NELAP	46.3		**23200**	mg/Kg-dry	50	01/28/2021 4:09	173243
Lead	NELAP	0.93		**60.3**	mg/Kg-dry	50	01/28/2021 4:09	173243
Lithium	*	1.39		**16.2**	mg/Kg-dry	50	01/28/2021 4:09	173243
Manganese	NELAP	0.93	B	**124**	mg/Kg-dry	50	01/28/2021 4:09	173243
Molybdenum	NELAP	0.93		**11.6**	mg/Kg-dry	50	01/28/2021 4:09	173243
Selenium	NELAP	0.93		**2.15**	mg/Kg-dry	10	01/29/2021 20:05	173243
Thallium	NELAP	0.93		**1.33**	mg/Kg-dry	50	01/28/2021 4:09	173243
Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.015		**0.029**	mg/Kg-dry	1	01/26/2021 10:36	173211

Client: Geosyntec Consultants **Work Order:** 21011267
Client Project: GLP8021 **Report Date:** 05-Feb-21
Lab ID: 21011267-011 **Client Sample ID:** SB-XPW-03-(34-36)-20210121
Matrix: SOLID **Collection Date:** 01/21/2021 12:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**31.6**	%	1	01/27/2021 17:08	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.38	SR	**0.41**	mg/Kg-dry	10	02/03/2021 10:55	173503
Arsenic	NELAP	0.98	B	**52.7**	mg/Kg-dry	50	01/28/2021 4:17	173243
Barium	NELAP	0.98	B	**149**	mg/Kg-dry	50	01/28/2021 4:17	173243
Beryllium	NELAP	1.47		**1.49**	mg/Kg-dry	50	01/28/2021 4:17	173243
Boron	NELAP	24.5		**92.6**	mg/Kg-dry	50	01/28/2021 4:17	173243
Cadmium	NELAP	0.20		**0.65**	mg/Kg-dry	10	01/29/2021 20:13	173243
Calcium	*	245	S	**4010**	mg/Kg-dry	50	01/28/2021 4:17	173243
Chromium	NELAP	2.45		**31.2**	mg/Kg-dry	50	01/28/2021 4:17	173243
Cobalt	NELAP	0.98		**8.26**	mg/Kg-dry	50	01/28/2021 4:17	173243
Iron	NELAP	49.0	S	**26200**	mg/Kg-dry	50	01/28/2021 4:17	173243
Lead	NELAP	0.98		**42.8**	mg/Kg-dry	50	01/28/2021 4:17	173243
Lithium	*	1.47		**17.5**	mg/Kg-dry	50	01/28/2021 4:17	173243
Manganese	NELAP	0.98	B	**95.6**	mg/Kg-dry	50	01/28/2021 4:17	173243
Molybdenum	NELAP	0.20	SR	**213**	mg/Kg-dry	10	02/03/2021 14:51	173510
Selenium	NELAP	4.90		**6.94**	mg/Kg-dry	50	01/28/2021 4:17	173243
Thallium	NELAP	0.20	SR	**0.46**	mg/Kg-dry	10	02/03/2021 14:51	173510

Matrix spike and RPD did not recover within control limits for MO and TL due to sample composition.
Matrix spike and RPD did not recover within control limits due to sample composition.
Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.
Matrix spike control limits for CA and FE are not applicable due to high sample/spike ratio.

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
SW-846 7471B								
Mercury	NELAP	0.073		**0.330**	mg/Kg-dry	5	01/26/2021 11:03	173211

Client: Geosyntec Consultants
Work Order: 21011267
Client Project: GLP8021
Report Date: 05-Feb-21
Lab ID: 21011267-012
Client Sample ID: SB-XPW-01-(46-48)-20210120
Matrix: SOLID
Collection Date: 01/20/2021 11:45

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**20.5**	%	1	01/27/2021 17:08	R286790
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.38		**< 0.38**	mg/Kg-dry	10	02/01/2021 19:21	173242
Arsenic	NELAP	0.19	B	**8.77**	mg/Kg-dry	10	01/28/2021 6:12	173243
Barium	NELAP	0.19	B	**105**	mg/Kg-dry	10	01/28/2021 6:12	173243
Beryllium	NELAP	0.28		**0.72**	mg/Kg-dry	10	01/28/2021 6:12	173243
Boron	NELAP	4.72		**35.1**	mg/Kg-dry	10	01/28/2021 6:12	173243
Cadmium	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	01/28/2021 6:12	173243
Calcium	*	47.2		**3280**	mg/Kg-dry	10	01/28/2021 6:12	173243
Chromium	NELAP	0.47		**18.3**	mg/Kg-dry	10	01/28/2021 6:12	173243
Cobalt	NELAP	0.19		**8.46**	mg/Kg-dry	10	01/28/2021 6:12	173243
Iron	NELAP	9.43		**17900**	mg/Kg-dry	10	01/28/2021 6:12	173243
Lead	NELAP	0.19		**15.1**	mg/Kg-dry	10	01/28/2021 6:12	173243
Lithium	*	0.28		**12.2**	mg/Kg-dry	10	01/28/2021 6:12	173243
Manganese	NELAP	0.19	B	**125**	mg/Kg-dry	10	01/28/2021 6:12	173243
Molybdenum	NELAP	0.19		**32.2**	mg/Kg-dry	10	01/28/2021 6:12	173243
Selenium	NELAP	0.94		**< 0.94**	mg/Kg-dry	10	01/28/2021 6:12	173243
Thallium	NELAP	0.19		**0.32**	mg/Kg-dry	10	01/28/2021 6:12	173243
Sample result(s) for AS, BA and MN exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.012		**0.015**	mg/Kg-dry	1	01/26/2021 10:45	173211

Dates Report

Client: Geosyntec Consultants

Client Project: GLP8021

Work Order: 21011267

Report Date: 05-Feb-21

Sample ID	Client Sample ID	Collection Date	Received Date		
	Test Name			Prep Date/Time	Analysis Date/Time
21011267-001A	SB-G11-(22-24)-20210119	01/19/2021 13:30	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:06
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 3:21
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:26	02/01/2021 16:44
	SW-846 7471B			01/25/2021 17:42	01/26/2021 10:17
21011267-001B	SB-G11-(22-24)-20210119	01/19/2021 13:30	01/25/2021 16:30		
	See Attached for Subcontracting Analysis				02/01/2021 0:00
21011267-002A	SB-G11-(58-60)-20210119	01/19/2021 13:35	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:06
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 3:29
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:26	02/01/2021 16:53
	SW-846 7471B			01/25/2021 17:42	01/26/2021 10:19
21011267-002B	SB-G11-(58-60)-20210119	01/19/2021 13:35	01/25/2021 16:30		
	See Attached for Subcontracting Analysis				02/01/2021 0:00
21011267-003A	EQB-20210119	01/19/2021 0:00	01/25/2021 16:30		
	EPA 600 245.1 R3.0 (Total)			01/25/2021 17:45	01/26/2021 9:58
	EPA 600 4.1.4, 200.8 R5.4, Metals by ICPMS (Total)			01/25/2021 17:36	01/28/2021 1:35
21011267-004A	SB-XPW-01-(4-6)-20210120	01/20/2021 11:30	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:06
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 3:37
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/29/2021 19:48
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:26	02/03/2021 10:22
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	02/03/2021 10:47
	SW-846 7471B			01/25/2021 17:42	01/26/2021 10:48
21011267-005A	SB-XPW-01-(46-48)-20210120-DUP	01/20/2021 11:45	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:07
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 3:45
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:26	02/01/2021 17:10
	SW-846 7471B			01/25/2021 17:42	01/26/2021 10:28
21011267-006A	EQB-20210120	01/20/2021 12:00	01/25/2021 16:30		
	EPA 600 245.1 R3.0 (Total)			01/25/2021 17:45	01/26/2021 10:01
	EPA 600 4.1.4, 200.8 R5.4, Metals by ICPMS (Total)			01/25/2021 17:36	01/28/2021 1:18
21011267-007A	SB-XPW-02-(4-6)-20210120	01/20/2021 13:00	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:07
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 3:53
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/29/2021 19:56

Client: Geosyntec Consultants

Client Project: GLP8021

Work Order: 21011267

Report Date: 05-Feb-21

Sample ID	Client Sample ID Test Name	Collection Date	Received Date	Prep Date/Time	Analysis Date/Time
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:26	02/03/2021 10:30
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	02/03/2021 14:10
	SW-846 7471B			01/25/2021 17:42	01/26/2021 10:31
21011267-008A	SB-XPW-02-(24-26)-20210120	01/20/2021 14:00	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:07
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 4:01
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:26	02/01/2021 17:28
	SW-846 7471B			01/25/2021 17:42	01/26/2021 10:33
21011267-009A	EQB-20210121	01/21/2021 7:30	01/25/2021 16:30		
	EPA 600 245.1 R3.0 (Total)			01/25/2021 17:45	01/26/2021 10:08
	EPA 600 4.1.4, 200.8 R5.4, Metals by ICPMS (Total)			01/25/2021 17:36	01/28/2021 1:27
21011267-010A	SB-XPW-03-(6-8)-20210121	01/21/2021 11:00	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:07
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 4:09
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/29/2021 20:05
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:26	02/03/2021 10:39
	SW-846 7471B			01/25/2021 17:42	01/26/2021 10:36
21011267-011A	SB-XPW-03-(34-36)-20210121	01/21/2021 12:00	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:08
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 4:17
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/29/2021 20:13
	SW-846 3050B, 6020A, Metals by ICPMS			02/02/2021 13:37	02/03/2021 10:55
	SW-846 3050B, 6020A, Metals by ICPMS			02/02/2021 14:28	02/03/2021 14:51
	SW-846 7471B			01/25/2021 17:42	01/26/2021 11:03
21011267-012A	SB-XPW-01-(46-48)-20210120	01/20/2021 11:45	01/25/2021 16:30		
	EPA SW846 3550C, 5035A, ASTM D2974				01/27/2021 17:08
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:50	01/28/2021 6:12
	SW-846 3050B, 6020A, Metals by ICPMS			01/25/2021 19:26	02/01/2021 19:21
	SW-846 7471B			01/25/2021 17:42	01/26/2021 10:45

Client: Geosyntec Consultants

Client Project: GLP8021

Work Order: 21011267

Report Date: 05-Feb-21

EPA SW846 3550C, 5035A, ASTM D2974

Batch **R286790** **SampType:** **LCS** Units **%**

SampID: LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Percent Moisture	*	0.1		**99.0**	99.00	0	100.0	90	110	01/27/2021

Batch **R286790** **SampType:** **LCSQC** Units **%**

SampID: LCSQC

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Percent Moisture	*	0.1		**99.0**	99.00	0	100.0	90	110	01/27/2021

EPA 600 245.1 R3.0 (TOTAL)

Batch **173239** **SampType:** **MBLK** Units **mg/L**

SampID: MBLK-173239

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**< 0.00020**	0.0001	0	0	-100	100	01/26/2021

Batch **173239** **SampType:** **LCS** Units **mg/L**

SampID: LCS-173239

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00504**	0.0050	0	100.7	85	115	01/26/2021

Batch **173239** **SampType:** **MS** Units **mg/L**

SampID: 21011261-002DMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00537**	0.0050	0.0001813	103.8	75	125	01/26/2021

Batch **173239** **SampType:** **MSD** Units **mg/L** RPD Limit **15**

SampID: 21011261-002DMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Mercury		0.00020		**0.00546**	0.0050	0.0001813	105.5	0.005373	1.53	01/26/2021

Batch **173239** **SampType:** **MS** Units **mg/L**

SampID: 21011267-006AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00538**	0.0050	0	107.6	75	125	01/26/2021

Client: Geosyntec Consultants **Work Order:** 21011267

Client Project: GLP8021 **Report Date:** 05-Feb-21

EPA 600 245.1 R3.0 (TOTAL)

Batch **173239** **SampType:** **MSD** Units **mg/L** RPD Limit **15**

SampID: 21011267-006AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Mercury		0.00020		**0.00522**	0.0050	0	104.4	0.005381	2.99	01/26/2021

EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)

Batch **173238** **SampType:** **MBLK** Units **mg/L**

SampID: MBLK-173238

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**< 0.0010**	0.0004	0	0	-100	100	01/28/2021
Arsenic		0.0010		**< 0.0010**	0.0004	0	0	-100	100	01/28/2021
Barium		0.0010		**< 0.0010**	0.0007	0	0	-100	100	01/28/2021
Beryllium		0.0010		**< 0.0010**	0.0002	0	0	-100	100	01/28/2021
Boron		0.0250		**< 0.0250**	0.0093	0	0	-100	100	01/28/2021
Cadmium		0.0010		**< 0.0010**	0.0001	0	0	-100	100	01/28/2021
Calcium		0.125		**< 0.125**	0.0700	0	0	-100	100	01/28/2021
Chromium		0.0015		**< 0.0015**	0.0007	0	0	-100	100	01/28/2021
Cobalt		0.0010		**< 0.0010**	0.0001	0	0	-100	100	01/28/2021
Iron		0.0250	S	**0.0339**	0.0115	0	294.5	-100	100	01/28/2021
Lead		0.0010		**< 0.0010**	0.0006	0	0	-100	100	01/28/2021
Lithium	*	0.0030		**< 0.0030**	0.0015	0	0	-100	100	01/28/2021
Manganese		0.0020		**< 0.0020**	0.0008	0	0	-100	100	01/28/2021
Molybdenum		0.0015		**< 0.0015**	0.0006	0	0	-100	100	01/28/2021
Selenium		0.0010		**< 0.0010**	0.0006	0	0	-100	100	01/28/2021
Thallium		0.0008		**< 0.0008**	0.0010	0	0	-100	100	01/29/2021
Thallium		0.0020		**< 0.0020**	0.0010	0	0	-100	100	01/28/2021

Client: Geosyntec Consultants

Client Project: GLP8021

Work Order: 21011267

Report Date: 05-Feb-21

EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)

Batch 173238 **SampType:** LCS Units **mg/L**

SampID: LCS-173238

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**0.492**	0.5000	0	98.4	85	115	01/28/2021
Arsenic		0.0010		**0.521**	0.5000	0	104.2	85	115	01/28/2021
Barium		0.0010		**2.12**	2.000	0	105.8	85	115	01/28/2021
Beryllium		0.0010		**0.0496**	0.0500	0	99.3	85	115	01/28/2021
Boron		0.0250		**0.506**	0.5000	0	101.1	85	115	01/28/2021
Cadmium		0.0010		**0.0490**	0.0500	0	98.0	85	115	01/28/2021
Calcium		0.125		**2.25**	2.500	0	90.1	85	115	01/28/2021
Chromium		0.0015		**0.186**	0.2000	0	93.2	85	115	01/28/2021
Cobalt		0.0010		**0.471**	0.5000	0	94.1	85	115	01/28/2021
Iron		0.0250	B	**2.16**	2.000	0	107.9	85	115	01/28/2021
Lead		0.0010		**0.511**	0.5000	0	102.2	85	115	01/28/2021
Lithium	*	0.0030		**0.524**	0.5000	0	104.7	85	115	01/28/2021
Lithium	*	0.0030		**0.525**	0.5000	0	104.9	85	115	01/28/2021
Manganese		0.0020		**0.504**	0.5000	0	100.8	85	115	01/28/2021
Molybdenum		0.0015		**0.456**	0.5000	0	91.3	85	115	01/28/2021
Selenium		0.0010		**0.515**	0.5000	0	103.1	85	115	01/28/2021
Thallium		0.0008		**0.283**	0.2500	0	113.2	85	115	01/29/2021
Thallium		0.0020		**0.244**	0.2500	0	97.6	85	115	01/28/2021

EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)

Batch 173238 **SampType:** MS Units **mg/L**

SampID: 21011267-003AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**0.506**	0.5000	0	101.2	70	130	01/28/2021
Arsenic		0.0010		**0.559**	0.5000	0.0007001	111.6	70	130	01/28/2021
Barium		0.0010		**2.22**	2.000	0.01950	109.9	70	130	01/28/2021
Beryllium		0.0010		**0.0554**	0.0500	0	110.9	70	130	01/28/2021
Boron		0.0250		**0.541**	0.5000	0.01196	105.7	70	130	01/28/2021
Cadmium		0.0010		**0.0510**	0.0500	0	101.9	70	130	01/28/2021
Calcium		0.125		**3.36**	2.500	0.7864	103.1	70	130	01/28/2021
Chromium		0.0015		**0.225**	0.2000	0.01286	106.2	70	130	01/28/2021
Cobalt		0.0010		**0.534**	0.5000	0.001142	106.6	70	130	01/28/2021
Iron		0.0250	B	**6.18**	2.000	4.009	108.3	70	130	01/28/2021
Lead		0.0010		**0.512**	0.5000	0.001205	102.2	70	130	01/28/2021
Lithium	*	0.0030		**0.567**	0.5000	0	113.3	70	130	01/28/2021
Manganese		0.0020		**0.578**	0.5000	0.04049	107.5	70	130	01/28/2021
Molybdenum		0.0015		**0.500**	0.5000	0.003806	99.3	70	130	01/28/2021
Selenium		0.0010		**0.517**	0.5000	0	103.4	70	130	01/28/2021
Thallium		0.0020		**0.248**	0.2500	0	99.3	70	130	01/28/2021

Batch 173238 **SampType:** MSD Units **mg/L** RPD Limit **20**

SampID: 21011267-003AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Antimony		0.0010		**0.505**	0.5000	0	100.9	0.5059	0.28	01/28/2021
Arsenic		0.0010		**0.565**	0.5000	0.0007001	112.8	0.5588	1.06	01/28/2021
Barium		0.0010		**2.24**	2.000	0.01950	111.2	2.218	1.17	01/28/2021
Beryllium		0.0010		**0.0553**	0.0500	0	110.5	0.05543	0.31	01/28/2021
Boron		0.0250		**0.562**	0.5000	0.01196	110.0	0.5407	3.84	01/28/2021
Cadmium		0.0010		**0.0516**	0.0500	0	103.2	0.05095	1.29	01/28/2021
Calcium		0.125		**3.48**	2.500	0.7864	107.9	3.363	3.56	01/28/2021
Chromium		0.0015		**0.226**	0.2000	0.01286	106.4	0.2254	0.13	01/28/2021
Cobalt		0.0010		**0.532**	0.5000	0.001142	106.2	0.5341	0.35	01/28/2021
Iron		0.0250	B	**6.17**	2.000	4.009	108.1	6.175	0.07	01/28/2021
Lead		0.0010		**0.506**	0.5000	0.001205	100.9	0.5121	1.23	01/28/2021
Lithium	*	0.0030		**0.565**	0.5000	0	113.1	0.5665	0.19	01/28/2021
Manganese		0.0020		**0.588**	0.5000	0.04049	109.5	0.5780	1.68	01/28/2021
Molybdenum		0.0015		**0.500**	0.5000	0.003806	99.3	0.5001	0.06	01/28/2021
Selenium		0.0010		**0.525**	0.5000	0	105.1	0.5169	1.62	01/28/2021
Thallium		0.0020		**0.245**	0.2500	0	98.0	0.2482	1.27	01/28/2021

Client: Geosyntec Consultants **Work Order:** 21011267

Client Project: GLP8021 **Report Date:** 05-Feb-21

SW-846 3050B, 6020A, METALS BY ICPMS

Batch **173242** **SampType:** **MBLK** Units **mg/Kg-dry**

SampID: MBLK-173242

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.40		**< 0.40**	0.1500	0	0	-100	100	02/01/2021

Batch **173242** **SampType:** **LCS** Units **mg/Kg-dry**

SampID: LCS-173242

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.40		**55.2**	50.00	0	110.4	80	120	02/01/2021

Batch **173243** **SampType:** **MBLK** Units **mg/Kg-dry**

SampID: MBLK-173243

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Arsenic		0.20	S	**< 0.20**	0.0202	0	118.6	-100	100	01/28/2021
Barium		0.20	S	**0.36**	0.0550	0	656.6	-100	100	01/28/2021
Beryllium		0.30		**< 0.30**	0.0269	0	0	-100	100	01/28/2021
Boron		5.00		**< 5.00**	0.8000	0	0	-100	100	01/28/2021
Cadmium		0.20		**< 0.20**	0.0150	0	0	-100	100	01/28/2021
Calcium	*	50.0		**< 50.0**	18.60	0	0	-100	100	01/28/2021
Chromium		0.50		**< 0.50**	0.2000	0	0	-100	100	01/28/2021
Cobalt		0.20		**< 0.20**	0.0253	0	0	-100	100	01/28/2021
Iron		10.0		**< 10.0**	4.900	0	0	-100	100	01/28/2021
Lead		0.20		**< 0.20**	0.0310	0	0	-100	100	01/28/2021
Lithium	*	0.30		**< 0.30**	0.0607	0	0	-100	100	01/28/2021
Manganese		0.20	S	**< 0.20**	0.0670	0	120.7	-100	100	01/28/2021
Molybdenum		0.20		**< 0.20**	0.0740	0	0	-100	100	01/28/2021
Selenium		1.00		**< 1.00**	0.1375	0	0	-100	100	01/28/2021
Thallium		0.20		**< 0.20**	0.1000	0	0	-100	100	01/28/2021

Client: Geosyntec Consultants **Work Order:** 21011267

Client Project: GLP8021 **Report Date:** 05-Feb-21

SW-846 3050B, 6020A, METALS BY ICPMS

Batch **173243** **SampType:** **LCS** Units **mg/Kg-dry**

SampID: LCS-173243

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Arsenic		0.20	B	**48.3**	50.00	0	96.6	80	120	01/28/2021
Barium		0.20	B	**191**	200.0	0	95.7	80	120	01/28/2021
Beryllium		0.30		**4.41**	5.000	0	88.3	80	120	01/28/2021
Boron		5.00		**44.7**	50.00	0	89.4	80	120	01/28/2021
Cadmium		0.20		**4.44**	5.000	0	88.7	80	120	01/28/2021
Calcium	*	50.0		**222**	250.0	0	88.8	80	120	01/28/2021
Chromium		0.50		**17.1**	20.00	0	85.5	80	120	01/28/2021
Cobalt		0.20		**42.9**	50.00	0	85.9	80	120	01/28/2021
Iron		10.0		**164**	200.0	0	82.2	80	120	01/28/2021
Lead		0.20		**45.8**	50.00	0	91.5	80	120	01/28/2021
Lithium	*	0.30		**47.0**	50.00	0	94.0	80	120	01/28/2021
Manganese		0.20	B	**46.4**	50.00	0	92.8	80	120	01/28/2021
Molybdenum		0.20		**41.8**	50.00	0	83.6	80	120	01/28/2021
Selenium		1.00		**46.8**	50.00	0	93.7	80	120	01/28/2021
Thallium		0.20		**22.1**	25.00	0	88.4	80	120	01/28/2021

Batch **173243** **SampType:** **MS** Units **mg/Kg-dry**

SampID: 21011204-001AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Arsenic		0.20	B	**60.1**	49.02	5.931	110.5	75	125	01/29/2021
Selenium		0.98		**48.7**	49.02	0.5322	98.3	75	125	01/29/2021

Batch **173243** **SampType:** **MSD** Units **mg/Kg-dry** RPD Limit **20**

SampID: 21011204-001AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Arsenic		0.19	B	**62.0**	48.08	5.931	116.6	60.08	3.12	01/29/2021
Selenium		0.96		**48.9**	48.08	0.5322	100.6	48.70	0.42	01/29/2021

Client: Geosyntec Consultants **Work Order:** 21011267

Client Project: GLP8021 **Report Date:** 05-Feb-21

SW-846 3050B, 6020A, METALS BY ICPMS

Batch **173243** **SampType:** **MS** Units **mg/Kg-dry**

SampID: 21011267-011AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Arsenic		0.98	B	**108**	49.02	52.71	112.9	75	125	01/28/2021
Barium		0.98	B	**346**	196.1	149.4	100.5	75	125	01/28/2021
Beryllium		1.47		**6.69**	4.902	1.492	106.0	75	125	01/28/2021
Boron		24.5		**138**	49.02	92.60	92.3	75	125	01/28/2021
Cadmium		0.20		**5.58**	4.902	0.6534	100.5	75	125	01/29/2021
Calcium	*	245	S	**4560**	245.1	4012	225.3	75	125	01/28/2021
Chromium		2.45		**53.6**	19.61	31.15	114.6	75	125	01/28/2021
Cobalt		0.98		**56.8**	49.02	8.261	99.0	75	125	01/28/2021
Iron		49.0	S	**28400**	196.1	26200	1145	75	125	01/28/2021
Lead		0.98		**91.9**	49.02	42.76	100.3	75	125	01/28/2021
Lithium	*	1.47		**70.8**	49.02	17.51	108.7	75	125	01/28/2021
Manganese		0.98	B	**147**	49.02	95.60	104.3	75	125	01/28/2021
Selenium		4.90		**52.6**	49.02	6.940	93.2	75	125	01/28/2021

Batch **173243** **SampType:** **MSD** Units **mg/Kg-dry** RPD Limit **20**

SampID: 21011267-011AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Arsenic		1.00	B	**109**	50.00	52.71	112.3	108.0	0.76	01/28/2021
Barium		1.00	B	**356**	200.0	149.4	103.2	346.5	2.65	01/28/2021
Beryllium		1.50		**6.83**	5.000	1.492	106.7	6.686	2.09	01/28/2021
Boron		25.0		**141**	50.00	92.60	96.6	137.8	2.19	01/28/2021
Cadmium		0.20		**5.70**	5.000	0.6534	100.9	5.579	2.09	01/29/2021
Calcium	*	250	S	**4770**	250.0	4012	303.6	4565	4.43	01/28/2021
Chromium		2.50		**53.9**	20.00	31.15	113.8	53.62	0.53	01/28/2021
Cobalt		1.00		**57.9**	50.00	8.261	99.2	56.79	1.86	01/28/2021
Iron		50.0	S	**28500**	200.0	26200	1175	28440	0.37	01/28/2021
Lead		1.00		**94.7**	50.00	42.76	103.9	91.93	2.96	01/28/2021
Lithium	*	1.50		**72.9**	50.00	17.51	110.8	70.80	2.97	01/28/2021
Manganese		1.00	B	**149**	50.00	95.60	106.6	146.7	1.46	01/28/2021
Selenium		5.00		**54.6**	50.00	6.940	95.3	52.61	3.67	01/28/2021

Batch **173503** **SampType:** **MBLK** Units **mg/Kg-dry**

SampID: MBLK-173503

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.40		**< 0.40**	0.1500	0	0	-100	100	02/03/2021

Quality Control Results

Client: Geosyntec Consultants **Work Order:** 21011267

Client Project: GLP8021 **Report Date:** 05-Feb-21

SW-846 3050B, 6020A, METALS BY ICPMS

Batch 173503 **SampType:** **LCS** Units **mg/Kg-dry**

SampID: LCS-173503

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.40		**54.0**	50.00	0	108.0	80	120	02/03/2021

Batch 173503 **SampType:** **MS** Units **mg/Kg-dry**

SampID: 21011267-011AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.36	S	**26.8**	45.45	0.4149	58.1	75	125	02/03/2021

Batch 173503 **SampType:** **MSD** Units **mg/Kg-dry** RPD Limit **20**

SampID: 21011267-011AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Antimony		0.37	SR	**13.1**	46.30	0.4149	27.5	26.80	68.47	02/03/2021

Batch 173510 **SampType:** **MBLK** Units **mg/Kg-dry**

SampID: MBLK-173510

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Molybdenum		0.20		**< 0.20**	0.0740	0	0	-100	100	02/03/2021
Thallium		0.20		**< 0.20**	0.1000	0	0	-100	100	02/03/2021

Batch 173510 **SampType:** **LCS** Units **mg/Kg-dry**

SampID: LCS-173510

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Molybdenum		0.20		**44.0**	50.00	0	88.0	80	120	02/04/2021
Thallium		0.20		**21.3**	25.00	0	85.2	80	120	02/04/2021

Batch 173510 **SampType:** **MS** Units **mg/Kg-dry**

SampID: 21011267-011AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Molybdenum		0.19	SE	**276**	46.30	213.1	136.8	75	125	02/03/2021
Thallium		0.19	S	**12.1**	23.15	0.4640	50.3	75	125	02/03/2021

Batch 173510 **SampType:** **MSD** Units **mg/Kg-dry** RPD Limit **20**

SampID: 21011267-011AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Molybdenum		0.19	SR	**77.7**	47.17	213.1	-287.0	276.4	112.21	02/03/2021
Thallium		0.19	SR	**2.91**	23.58	0.4640	10.4	12.11	122.41	02/03/2021

Client: Geosyntec Consultants

Client Project: GLP8021

Work Order: 21011267

Report Date: 05-Feb-21

SW-846 7471B

Batch **173211** **SampType:** **MBLK** Units **mg/Kg**

SampID: MBLK-173211

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.010		**< 0.010**	0.0045	0	0	-100	100	01/26/2021

Batch **173211** **SampType:** **LCS** Units **mg/Kg**

SampID: LCS-173211

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.010		**0.259**	0.2500	0	103.7	85	115	01/26/2021

Batch **173211** **SampType:** **MS** Units **mg/Kg-dry**

SampID: 21011006-001AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.270		**3.29**	1.348	1.648	122.0	75	125	01/26/2021

Batch **173211** **SampType:** **MSD** Units **mg/Kg-dry** RPD Limit **15**

SampID: 21011006-001AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Mercury		0.287		**3.26**	1.433	1.648	112.2	3.293	1.12	01/26/2021

Batch **173211** **SampType:** **MS** Units **mg/Kg-dry**

SampID: 21011267-011AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.073		**0.689**	0.3654	0.3298	98.2	75	125	01/26/2021

Batch **173211** **SampType:** **MSD** Units **mg/Kg-dry** RPD Limit **15**

SampID: 21011267-011AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Mercury		0.070		**0.649**	0.3522	0.3298	90.7	0.6885	5.87	01/26/2021

Receiving Check List

Client: Geosyntec Consultants

Client Project: GLP8021

Work Order: 21011267

Report Date: 05-Feb-21

Carrier: Jacob Wilson

Received By: EAH

Completed by:
On:
25-Jan-21
Amanda R. Ham

Reviewed by:
On:
25-Jan-21
Shelly A Hennessy
Shelly A. Hennessy

Pages to follow: Chain of custody 2 Extra pages included 12

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐	Temp °C 1.4
Type of thermal preservation?	None ☐	Ice ☑	Blue Ice ☐	Dry Ice ☐
Chain of custody present?	Yes ☑	No ☐		
Chain of custody signed when relinquished and received?	Yes ☑	No ☐		
Chain of custody agrees with sample labels?	Yes ☑	No ☐		
Samples in proper container/bottle?	Yes ☑	No ☐		
Sample containers intact?	Yes ☑	No ☐		
Sufficient sample volume for indicated test?	Yes ☑	No ☐		
All samples received within holding time?	Yes ☑	No ☐		
Reported field parameters measured:	Field ☐	Lab ☐	NA ☑	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐		

When thermal preservation is required, samples are compliant with a temperature between 0.1°C - 6.0°C, or when samples are received on ice the same day as collected.

Water – at least one vial per sample has zero headspace?	Yes ☐	No ☐	No VOA vials ☑	
Water - TOX containers have zero headspace?	Yes ☐	No ☐	No TOX containers ☑	
Water - pH acceptable upon receipt?	Yes ☑	No ☐	NA ☐	
NPDES/CWA TCN interferences checked/treated in the field?	Yes ☐	No ☐	NA ☑	

Any No responses must be detailed below or on the COC.

pH strip #74534. - aham - 1/25/2021 5:31:46 PM

CHAIN OF CUSTODY

pg. 1 of 2 Work order # 21011267

TEKLAB, INC. 5445 Horseshoe Lake Road - Collinsville, IL 62234 - Phone: (618) 344-1004 - Fax: (618) 344-1005

Client: Geosyntec Consultants
Address: 1 McBride and Son Center Drive, Suite 202
City / State / Zip Chesterfield, MO 63005
Contact: Allison Kreinberg **Phone:** (636) 812-0809
E-Mail: AKreinberg@Geosyntec.com **Fax:**

Samples on: ☒ ICE ☐ BLUE ICE ☐ NO ICE 1.4 °C **LTG#** 1
Preserved in: ☐ LAB ☒ FIELD **FOR LAB USE ONLY**
Lab Notes EAH 1/25/21 - pH 74534

Client Comments:
*Sb As Ba Be B Cd Ca Cr Co Pb Fe Li Mn Hg Mo Se Tl - Metals per Allison Kreinberg. AH 1/25/21

Courier

Are these samples known to be involved in litigation? If yes, a surcharge will apply ☐ Yes ☐ No
Are these samples known to be hazardous? ☐ Yes ☐ No
Are there any required reporting limits to be met on the requested analysis?. If yes, please provide limits in the comment section. ☐ Yes ☐ No

Project Name/Number AT ~~GLP2021~~ GLP8021
Sample Collector's Name Amanda Taye

Results Requested
☒ Standard ☐ 1-2 Day (100% Surcharge)
☐ Other ____ ☐ 3 Day (50% Surcharge)

Billing Instructions

Lab Use Only	Sample Identification	Date/Time Sampled	UNPRES	HNO3	NaOH	H2SO4	HCL	MeOH	NaHSO4	OTHER	Aqueous	Drinking Water	Soil	Sludge	Special Waste	Groundwater	* Metals	TOC
21011267-001	SB-G11-(22-24)-20210119	1-19-21 1330	2										X				1	1
002	SB-G11-(58-60)-20210119	1-19-21 1335	2										X				1	1
003	EQB-20210119	1-19-21		1							X						1	
004	SB-XPW-01-(4-6)-20210120	1-20-21 1130	1										X				1	
005	SB-XPW-01-(~~4-6~~ 4-4.5)-20210120-DUP	1-20-21 1145	1										X				1	
006	EQB-20210120	1-20-21 1200		1							X						1	
007	SB-XPW-02-(4-6)-20210120	1-20-21 1300	1										X				1	
008	SB-XPW-05-(2-4)-20210120	1-20-21 1400	1										X				1	
009	EQB-20210121	1-21-21 0730		1							X						1	
010	SB-XPW-03-[illegible]-20210121	1-21-21 1100	1										X				1	

Relinquished By	Date/Time	Received By	Date/Time
	1/25/21 1320		1/25/21 1320
	1/25/21 1630	Elizabeth A Hurley	1/25/21 1630

The individual signing this agreement on behalf of the client, acknowledges that he/she has read and understands the terms and conditions of this agreement, and that he/she has the authority to sign on behalf of the client. See www.teklabinc.com for terms and conditions.

BottleOrder: 63216

EAH 1/25/21

CHAIN OF CUSTODY

pg. 2 of 2 Work order # 21011267

TEKLAB, INC. 5445 Horseshoe Lake Road - Collinsville, IL 62234 - Phone: (618) 344-1004 - Fax: (618) 344-1005

Client: Geosyntec Consultants
Address: 1 McBride and Son Center Drive, Suite 202
City / State / Zip Chesterfield, MO 63005
Contact: Allison Kreinberg **Phone:** (636) 812-0809
E-Mail: AKreinberg@Geosyntec.com **Fax:**

Samples on: ☐ ICE ☐ BLUE ICE ☐ NO ICE ____ °C **LTG#** ____
Preserved in: ☐ LAB ☐ FIELD **FOR LAB USE ONLY**
Lab Notes

Client Comments:

Are these samples known to be involved in litigation? If yes, a surcharge will apply ☐ Yes ☐ No
Are these samples known to be hazardous? ☐ Yes ☐ No
Are there any required reporting limits to be met on the requested analysis?. If yes, please provide limits in the comment section. ☐ Yes ☐ No

Project Name/Number

Sample Collector's Name Amanda Taye

Results Requested
☒ Standard ☐ 1-2 Day (100% Surcharge)
☐ Other ____ ☐ 3 Day (50% Surcharge)

Billing Instructions

			# and Type of Containers								MATRIX						INDICATE ANALYSIS REQUESTED	
Lab Use Only	**Sample Identification**	**Date/Time Sampled**	UNPRES	HNO3	NaOH	H2SO4	HCL	MeOH	NaHSO4	OTHER	Aqueous	Drinking Water	Soil	Sludge	Special Waste	Groundwater	Metals	TOC
	~~SB-XPW-03~~																	
21011267 011	SB-XPW-03-(34-36)-20210121	1-21-21 1200	1										X				1	
011 ~~012~~	SB-XPW-03-(34-36)-20210121-MS	1-21-21 1200	1										X				1	
TE AH 1/25 011 ~~013~~	SB-XPW-03-(34-36)-20210121-MSD	1-21-21 1200	1										X				1	
012 ~~014~~ TE AH 1/25	SB-XPW-01-(46-48)-20210120	1-20-21 1145	1										X				1	

Relinquished By	Date/Time	Received By	Date/Time
	1/25/21 1320		1/25/21 1320
	1/25/21 1630		1/25/21 1630

The individual signing this agreement on behalf of the client, acknowledges that he/she has read and understands the terms and conditions of this agreement, and that he/she has the authority to sign on behalf of the client. See www.teklabinc.com for terms and conditions.

BottleOrder: 63216

www.pacelabs.com

Pace Analytical Services, LLC
1241 Bellevue Street - Suite 9
Green Bay, WI 54302
(920)469-2436

February 02, 2021

Elizabeth Hurley
Teklab, Inc
5445 Horseshoe Lake Rd
Collinsville, IL 62234

RE: Project: 21011267
Pace Project No.: 40221510

Dear Elizabeth Hurley:

Enclosed are the analytical results for sample(s) received by the laboratory on January 27, 2021. The results relate only to the samples included in this report. Results reported herein conform to the applicable TNI/NELAC Standards and the laboratory's Quality Manual, where applicable, unless otherwise noted in the body of the report.

The test results provided in this final report were generated by each of the following laboratories within the Pace Network:

- Pace Analytical Services - Green Bay

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Brian Basten
brian.basten@pacelabs.com
(920)469-2436
Project Manager

Enclosures

cc: Mike Austin, Teklab, Inc

NELAP ACCREDITED TNI LABORATORY

CERTIFICATIONS

Project:	21011267
Pace Project No.:	40221510

Pace Analytical Services Green Bay

1241 Bellevue Street, Green Bay, WI 54302

Florida/NELAP Certification #:	E87948
Illinois Certification #:	200050
Kentucky UST Certification #:	82
Louisiana Certification #:	04168
Minnesota Certification #:	055-999-334
New York Certification #:	12064
North Dakota Certification #:	R-150
Virginia VELAP ID:	460263
South Carolina Certification #:	83006001
Texas Certification #:	T104704529-14-1
Wisconsin Certification #:	405132750
Wisconsin DATCP Certification #:	105-444
USDA Soil Permit #:	P330-16-00157
Federal Fish & Wildlife Permit #:	LE51774A-0

SAMPLE SUMMARY

Project: 21011267
Pace Project No.: 40221510

Lab ID	Sample ID	Matrix	Date Collected	Date Received
40221510001	**21011267-001**	Solid	01/19/21 13:30	01/27/21 09:35
40221510002	**21011267-002**	Solid	01/19/21 13:35	01/27/21 09:35

SAMPLE ANALYTE COUNT

Project: 21011267
Pace Project No.: 40221510

Lab ID	Sample ID	Method	Analysts	Analytes Reported
40221510001	**21011267-001**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4
40221510002	**21011267-002**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4

PASI-G = Pace Analytical Services - Green Bay

ANALYTICAL RESULTS

Project: 21011267
Pace Project No.: 40221510

Sample: 21011267-001 **Lab ID: 40221510001** Collected: 01/19/21 13:30 Received: 01/27/21 09:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**16.3**	%	0.10	0.10	1		01/27/21 14:27		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**7.0**	%	0.10	0.10	1		02/01/21 11:45		
Total Organic Carbon	**401J**	mg/kg	710	212	1		02/01/21 11:45	7440-44-0	
Total Organic Carbon	**430J**	mg/kg	715	213	1		02/01/21 11:50	7440-44-0	
Mean Total Organic Carbon	**415J**	mg/kg	713	213	1		02/01/21 11:45	7440-44-0	C4

Sample: 21011267-002 **Lab ID: 40221510002** Collected: 01/19/21 13:35 Received: 01/27/21 09:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**12.1**	%	0.10	0.10	1		01/27/21 14:27		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**5.4**	%	0.10	0.10	1		02/01/21 12:07		
Total Organic Carbon	**<202**	mg/kg	678	202	1		02/01/21 12:07	7440-44-0	
Total Organic Carbon	**<203**	mg/kg	680	203	1		02/01/21 12:13	7440-44-0	
Mean Total Organic Carbon	**<203**	mg/kg	679	203	1		02/01/21 12:07	7440-44-0	C4

QUALITY CONTROL DATA

Project: 21011267
Pace Project No.: 40221510

QC Batch: 376626
QC Batch Method: ASTM D2974-87
Analysis Method: ASTM D2974-87
Analysis Description: Dry Weight/Percent Moisture
Laboratory: Pace Analytical Services - Green Bay

Associated Lab Samples: 40221510001, 40221510002

SAMPLE DUPLICATE: 2174826

Parameter	Units	40221488001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	6.7	6.7	0	10	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

QUALITY CONTROL DATA

Project: 21011267
Pace Project No.: 40221510

QC Batch: 376725
QC Batch Method: EPA 9060 Modified
Analysis Method: EPA 9060 Modified
Analysis Description: 9060 TOC Average
Laboratory: Pace Analytical Services - Green Bay
Associated Lab Samples: 40221510001, 40221510002

METHOD BLANK: 2175468
Matrix: Solid
Associated Lab Samples: 40221510001, 40221510002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mean Total Organic Carbon	mg/kg	<179	600	02/01/21 10:01	

LABORATORY CONTROL SAMPLE: 2175469

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mean Total Organic Carbon	mg/kg	120000	117000	98	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 2175470 2175471

Parameter	Units	40221231003 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mean Total Organic Carbon	mg/kg	8080	33000	33100	40900	41000	100	99	50-150	0	30	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 2175472 2175473

Parameter	Units	40221567002 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mean Total Organic Carbon	mg/kg	4250	21100	21000	50800	33900	221	141	50-150	40	30	M0,R1

QUALIFIERS

Project:	21011267
Pace Project No.:	40221510

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above LOD.

J - Estimated concentration at or above the LOD and below the LOQ.

LOD - Limit of Detection adjusted for dilution factor, percent moisture, initial weight and final volume.

LOQ - Limit of Quantitation adjusted for dilution factor, percent moisture, initial weight and final volume.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected at or above the adjusted LOD.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

ANALYTE QUALIFIERS

C4	Sample container did not meet EPA or method requirements.
M0	Matrix spike recovery and/or matrix spike duplicate recovery was outside laboratory control limits.
R1	RPD value was outside control limits.

QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: 21011267
Pace Project No.: 40221510

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
40221510001	**21011267-001**	ASTM D2974-87	376626		
40221510002	**21011267-002**	ASTM D2974-87	376626		
40221510001	**21011267-001**	EPA 9060 Modified	376725		
40221510001	**21011267-001**	EPA 9060 Modified	376726		
40221510002	**21011267-002**	EPA 9060 Modified	376725		
40221510002	**21011267-002**	EPA 9060 Modified	376726		

Pg ___ of ___

40221510

TEKLAB, INC. Chain of Custody

5445 Horseshoe Lake Road, Collinsville, IL 62234 Phone (618) 344-1004 Fax (618) 344-1005

Are the samples chilled? YES ☑ NO ☐ With: ☑ Ice ☐ Blue Ice Preserved in: ☐ Lab ☐ Field

Teklab Inc
5445 Horseshoe Lake Road
Collinsville, IL 62234

Cooler Temp:
Sampler: Client
QC Level: 2

Comments: **Please Issue reports and invoices via email only**
Please analyze for TOC on a standard turnaround time.
Batch QC is required for all analyses requested.
Any changes to analysis/methods must be approved.

Project#: 21011267
Contact: Aaron Renner
Requested Due Date: Standard TAT
Email: arenner@teklabinc.com
Billing/PO: 30689
Phone: (630) 324-6855

PLEASE NOTE:

NELAP accreditation is required on the requested analytes and must be documented as such on the final report. If your laboratory does not currently hold a NELAP accreditation for the requested method and/or analytes, please contact Teklab immediately. If your laboratory loses accreditation or is suspended for any analyte/method during the life of the contract, you must contact Teklab immediately.

Lab Use	Sample ID	Sample Date/Time	Preservative	Matrix	TOC											
001	21011267-001	1/19/21 13:30	Unpres	Soil	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
002	21011267-002	1/19/21 13:35	Unpres	Soil	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Wastewater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

*Relinquished By	Date/Time	Received By	Date/Time
Fedex	1/26/21 1700 (EKH)		
FedEx	1/27/21 0935	Nicole Hauf Pace	1/27/21 0935

Teklab maintains a strict policy of client confidentiality and as such does not provide client/sampler information without proper authorization. and proprietary rights, Teklab, Inc. protects clients' confidential information as directed by local, state or federal laws. (Teklab QAM Section 9.1, TNI V1 M2 Section 4.1.5 c)

SubCocRevA
3/2/2016

Pace Analytical Services, LLC
1241 Bellevue Street, Suite 9
Green Bay, WI 54302

Sample Preservation Receipt Form

Client Name: TekLab

Project # 40221510

All containers needing preservation have been checked and noted below: ☐Yes ☐No [✓ N/A]

Lab Lot# of pH paper:

Lab Std #ID of preservation (if pH adjusted):

Initial when completed:

Date/ Time:

Pace Lab #	Glass								Plastic					Vials						Jars				General										
	AG1U	BG1U	AG1H	AG4S	AG4U	AG5U	AG2S	BG3U	BP1U	BP3U	BP3B	BP3N	BP3S	VG9A	DG9T	VG9U	VG9H	VG9M	VG9D	JGFU	JG9U	WGFU	WPFU	SP5T	ZPLC	GN	VOA Vials (>6mm) *	H2SO4 pH ≤2	NaOH+Zn Act pH ≥9	NaOH pH ≥12	HNO3 pH ≤2	pH after adjusted	Volume (mL)
001																						|											2.5 / 5 / 10
002																						|											2.5 / 5 / 10
003																																	2.5 / 5 / 10
004																																	2.5 / 5 / 10
005																																	2.5 / 5 / 10
006																																	2.5 / 5 / 10
007																																	2.5 / 5 / 10
008																																	2.5 / 5 / 10
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018																																	2.5 / 5 / 10
019																																	2.5 / 5 / 10
020																																	2.5 / 5 / 10

11/27/21
KW

Exceptions to preservation check: VOA, Coliform, [✓ TOC], TOX, TOH, O&G, WI DRO, Phenolics, Other:__________ Headspace in VOA Vials (>6mm) : ☐Yes ☐No [✓ N/A] ***If yes look in headspace column**

AG1U	1 liter amber glass
BG1U	1 liter clear glass
AG1H	1 liter amber glass HCL
AG4S	125 mL amber glass H2SO4
AG4U	120 mL amber glass unpres
AG5U	100 mL amber glass unpres
AG2S	500 mL amber glass H2SO4
BG3U	250 mL clear glass unpres

BP1U	1 liter plastic unpres
BP3U	250 mL plastic unpres
BP3B	250 mL plastic NaOH
BP3N	250 mL plastic HNO3
BP3S	250 mL plastic H2SO4

VG9A	40 mL clear ascorbic
DG9T	40 mL amber Na Thio
VG9U	40 mL clear vial unpres
VG9H	40 mL clear vial HCL
VG9M	40 mL clear vial MeOH
VG9D	40 mL clear vial DI

JGFU	4 oz amber jar unpres
JG9U	9 oz amber jar unpres
WGFU	4 oz clear jar unpres
WPFU	4 oz plastic jar unpres
SP5T	120 mL plastic Na Thiosulfate
ZPLC	ziploc bag
GN	

Page 1 of 2

Pace Analytical® 1241 Bellevue Street, Green Bay, WI 54302	Document Name: **Sample Condition Upon Receipt (SCUR)**	Document Revised: 26Mar2020
	Document No.: **ENV-FRM-GBAY-0014-Rev.00**	Author: Pace Green Bay Quality Office

Sample Condition Upon Receipt Form (SCUR)

Project #:

WO# : 40221510

40221510

Client Name: Feltab

Courier: ☐ CS Logistics ☑ Fed Ex ☐ Speedee ☐ UPS ☐ Waltco ☐ Client ☐ Pace Other:

Tracking #: 9450 9224 5723

Custody Seal on Cooler/Box Present: ☐ yes ☑ no Seals intact: ☐ yes ☐ no

Custody Seal on Samples Present: ☐ yes ☑ no Seals intact: ☐ yes ☐ no

Packing Material: ☐ Bubble Wrap ☑ Bubble Bags ☐ None ☐ Other

Thermometer Used SR - 97 **Type of Ice:** [✓ Wet] Blue Dry None ☑ Samples on ice, cooling process has begun

Cooler Temperature Uncorr: 2 /Corr: 2

Temp Blank Present: ☐ yes ☑ no **Biological Tissue is Frozen:** ☐ yes ☐ no

Temp should be above freezing to 6°C.
Biota Samples may be received at ≤ 0°C if shipped on Dry Ice.

Person examining contents:
Date: 1/27/21 /Initials: NM

Labeled By Initials: N

Chain of Custody Present:	☑ Yes ☐ No ☐ N/A	1.
Chain of Custody Filled Out:	☐ Yes ☑ No ☐ N/A	2. pg# 1/27/21 NM
Chain of Custody Relinquished:	☑ Yes ☐ No ☐ N/A	3.
Sampler [✓ Name] & [✓ Signature] on COC:	☐ Yes ☑ No ☐ N/A	4.
Samples Arrived within Hold Time:	☑ Yes ☐ No	5.
- VOA Samples frozen upon receipt	☐ Yes ☐ No	Date/Time:
Short Hold Time Analysis (<72hr):	☐ Yes ☑ No	6.
Rush Turn Around Time Requested:	☐ Yes ☑ No	7.
Sufficient Volume: For Analysis: ☑ Yes ☐ No	MS/MSD: ☐ Yes ☑ No ☐ N/A	8.
Correct Containers Used:	☑ Yes ☐ No	9.
-Pace Containers Used:	☐ Yes ☑ No ☐ N/A	
-Pace IR Containers Used:	☐ Yes ☑ No ☐ N/A	
Containers Intact:	☑ Yes ☐ No	10.
Filtered volume received for Dissolved tests	☐ Yes ☐ No ☑ N/A	11.
Sample Labels match COC: 1/27/21 NM	~~☑ Yes~~ ☑ No ☐ N/A	12. Client id includes "B" at end 1/27/21 NM
-Includes date/time/ID/Analysis	Matrix: S	
Trip Blank Present:	☐ Yes ☐ No ☑ N/A	13.
Trip Blank Custody Seals Present	☐ Yes ☐ No ☑ N/A	
Pace Trip Blank Lot # (if purchased):		

Client Notification/ Resolution:

If checked, see attached form for additional comments ☐

Person Contacted: Date/Time:

Comments/ Resolution:

PM Review is documented electronically in LIMs. By releasing the project, the PM acknowledges they have reviewed the sample logi

Teklab, Inc.
Environmental Laboratory
http://www.teklabinc.com/

February 17, 2021

Allison Kreinberg
Geosyntec Consultants
941 Chatham Lane, Ste 103
Columbus, OH 43221
TEL: (614) 468-0421
FAX:

Illinois	100226
Kansas	E-10374
Louisiana	05002
Louisiana	05003
Oklahoma	9978

RE: Vistra Joppa GLP8021

WorkOrder: 21020428

Dear Allison Kreinberg:

TEKLAB, INC received 9 samples on 2/5/2021 3:45:00 PM for the analysis presented in the following report.

Samples are analyzed on an as received basis unless otherwise requested and documented. The sample results contained in this report relate only to the requested analytes of interest as directed on the chain of custody. NELAP accredited fields of testing are indicated by the letters NELAP under the Certification column. Unless otherwise documented within this report, Teklab Inc. analyzes samples utilizing the most current methods in compliance with 40CFR. All tests are performed in the Collinsville, IL laboratory unless otherwise noted in the Case Narrative.

All quality control criteria applicable to the test methods employed for this project have been satisfactorily met and are in accordance with NELAP except where noted. The following report shall not be reproduced, except in full, without the written approval of Teklab, Inc.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Aaron Renner
Project Manager
(630)324-6855
arenner@teklabinc.com

This reporting package includes the following:

Definitions

Client: Geosyntec Consultants
Work Order: 21020428
Client Project: Vistra Joppa GLP8021
Report Date: 17-Feb-21

Abbr	Definition
*	Analytes on report marked with an asterisk are not NELAP accredited
CCV	Continuing calibration verification is a check of a standard to determine the state of calibration of an instrument between recalibration.
CRQL	A Client Requested Quantitation Limit is a reporting limit that varies according to customer request. The CRQL may not be less than the MDL.
DF	Dilution factor is the dilution performed during analysis only and does not take into account any dilutions made during sample preparation. The reported result is final and includes all dilution factors.
DNI	Did not ignite
DUP	Laboratory duplicate is a replicate aliquot prepared under the same laboratory conditions and independently analyzed to obtain a measure of precision.
ICV	Initial calibration verification is a check of a standard to determine the state of calibration of an instrument before sample analysis is initiated.
IDPH	IL Dept. of Public Health
LCS	Laboratory control sample is a sample matrix, free from the analytes of interest,spiked with verified known amounts of analytes and analyzed exactly like a sample to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.
LCSD	Laboratory control sample duplicate is a replicate laboratory control sample that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MBLK	Method blank is a sample of a matrix similar to the batch of associated sample (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences should present at concentrations that impact the analytical results for sample analyses.
MDL	"The method detection limit is defined as the minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results."
MS	Matrix spike is an aliquot of matrix fortified (spiked) with known quantities of specific analytes that is subjected to the entire analytical procedures in order to determine the effect of the matrix on an approved test method's recovery system. The acceptable recovery range is listed in the QC Package (provided upon request).
MSD	Matrix spike duplicate means a replicate matrix spike that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MW	Molecular weight
NC	Data is not acceptable for compliance purposes
ND	Not Detected at the Reporting Limit
NELAP	NELAP Accredited
PQL	Practical quantitation limit means the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operation conditions.
RL	The reporting limit the lowest level that the data is displayed in the final report. The reporting limit may vary according to customer request or sample dilution. The reporting limit may not be less than the MDL.
RPD	Relative percent difference is a calculated difference between two recoveries (ie. MS/MSD). The acceptable recovery limit is listed in the QC Package (provided upon request).
SPK	The spike is a known mass of target analyte added to a blank sample or sub-sample; used to determine recovery deficiency or for other quality control purposes.
Surr	Surrogates are compounds which are similar to the analytes of interest in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples.
TIC	Tentatively identified compound: Analytes tentatively identified in the sample by using a library search. Only results not in the calibration standard will be reported as tentatively identified compounds. Results for tentatively identified compounds that are not present in the calibration standard, but are assigned a specific chemical name based upon the library search, are calculated using total peak areas from reconstructed ion chromatograms and a response factor of one. The nearest Internal Standard is used for the calculation. The results of any TICs must be considered estimated, and are flagged with a "T". If the estimated result is above the calibration range it is flagged "ET"
TNTC	Too numerous to count (> 200 CFU)

Definitions

Client:	Geosyntec Consultants	**Work Order:**	21020428
Client Project:	Vistra Joppa GLP8021	**Report Date:**	17-Feb-21

Qualifiers

# -	Unknown hydrocarbon	B -	Analyte detected in associated Method Blank
C -	RL shown is a Client Requested Quantitation Limit	E -	Value above quantitation range
H -	Holding times exceeded	I -	Associated internal standard was outside method criteria
J -	Analyte detected below quantitation limits	M -	Manual Integration used to determine area response
ND -	Not Detected at the Reporting Limit	R -	RPD outside accepted recovery limits
S -	Spike Recovery outside recovery limits	T -	TIC(Tentatively identified compound)
X -	Value exceeds Maximum Contaminant Level		

Case Narrative

http://www.teklabinc.com/

Client: Geosyntec Consultants
Work Order: 21020428
Client Project: Vistra Joppa GLP8021
Report Date: 17-Feb-21

Cooler Receipt Temp: 6.8 °C

Total Organic Carbon analysis performed by Pace Analytical Services, LLC. See attached report for QC summary.

Locations

Collinsville

Address 5445 Horseshoe Lake Road
Collinsville, IL 62234-7425
Phone (618) 344-1004
Fax (618) 344-1005
Email jhriley@teklabinc.com

Springfield

Address 3920 Pintail Dr
Springfield, IL 62711-9415
Phone (217) 698-1004
Fax (217) 698-1005
Email KKlostermann@teklabinc.com

Kansas City

Address 8421 Nieman Road
Lenexa, KS 66214
Phone (913) 541-1998
Fax (913) 541-1998
Email jhriley@teklabinc.com

Collinsville Air

Address 5445 Horseshoe Lake Road
Collinsville, IL 62234-7425
Phone (618) 344-1004
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Accreditations

Client: Geosyntec Consultants

Client Project: Vistra Joppa GLP8021

Work Order: 21020428

Report Date: 17-Feb-21

State	Dept	Cert #	NELAP	Exp Date	Lab
Illinois	IEPA	100226	NELAP	1/31/2022	Collinsville
Kansas	KDHE	E-10374	NELAP	4/30/2021	Collinsville
Louisiana	LDEQ	05002	NELAP	6/30/2021	Collinsville
Louisiana	LDEQ	05003	NELAP	6/30/2021	Collinsville
Oklahoma	ODEQ	9978	NELAP	8/31/2021	Collinsville
Arkansas	ADEQ	88-0966		3/14/2021	Collinsville
Illinois	IDPH	17584		5/31/2021	Collinsville
Kentucky	UST	0073		1/31/2022	Collinsville
Missouri	MDNR	00930		5/31/2021	Collinsville
Missouri	MDNR	930		1/31/2022	Collinsville

Client:	Geosyntec Consultants	**Work Order:**	21020428
Client Project:	Vistra Joppa GLP8021	**Report Date:**	17-Feb-21
Lab ID:	21020428-001	**Client Sample ID:**	SB-G09M-(10-12)-20210126
Matrix:	SOLID	**Collection Date:**	01/26/2021 11:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**17.7**	%	1	02/10/2021 13:44	R287331
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.39		**< 0.39**	mg/Kg-dry	10	02/16/2021 15:23	173868
Arsenic	NELAP	0.18		**3.34**	mg/Kg-dry	10	02/09/2021 0:06	173655
Barium	NELAP	0.18	B	**93.6**	mg/Kg-dry	10	02/09/2021 0:06	173655
Beryllium	NELAP	0.27		**0.46**	mg/Kg-dry	10	02/09/2021 0:06	173655
Boron	NELAP	4.55	B	**< 4.55**	mg/Kg-dry	10	02/09/2021 0:06	173655
Cadmium	NELAP	0.18		**< 0.18**	mg/Kg-dry	10	02/09/2021 0:06	173655
Calcium	*	45.5		**1740**	mg/Kg-dry	10	02/09/2021 0:06	173655
Chromium	NELAP	0.45		**16.6**	mg/Kg-dry	10	02/09/2021 0:06	173655
Cobalt	NELAP	0.18		**5.68**	mg/Kg-dry	10	02/09/2021 0:06	173655
Iron	NELAP	9.09		**13100**	mg/Kg-dry	10	02/09/2021 0:06	173655
Lead	NELAP	0.18		**7.76**	mg/Kg-dry	10	02/09/2021 0:06	173655
Lithium	*	0.27		**9.67**	mg/Kg-dry	10	02/09/2021 0:06	173655
Manganese	NELAP	0.18		**338**	mg/Kg-dry	10	02/09/2021 0:06	173655
Molybdenum	NELAP	0.18		**0.37**	mg/Kg-dry	10	02/09/2021 0:06	173655
Selenium	NELAP	0.91		**< 0.91**	mg/Kg-dry	10	02/09/2021 0:06	173655
Thallium	NELAP	0.18		**< 0.18**	mg/Kg-dry	10	02/09/2021 0:06	173655
Sample result(s) for BA exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
Contamination present in the MBLK for B. Sample results below the reporting limit are reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.012		**0.021**	mg/Kg-dry	1	02/09/2021 13:27	173704
SW-846 METHOD 9060M, TOTAL ORGANIC CARBON								
Total Organic Carbon (TOC)	*	740		**950**	mg/Kg-dry	1	02/11/2021 0:00	R287399
Sample container did not meet EPA or method requirements.								

Client: Geosyntec Consultants
Work Order: 21020428
Client Project: Vistra Joppa GLP8021
Report Date: 17-Feb-21
Lab ID: 21020428-002
Client Sample ID: SB-G09M-(82-84)-20210127
Matrix: SOLID
Collection Date: 01/27/2021 9:30

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**19.4**	%	1	02/10/2021 13:44	R287331
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.38		**< 0.38**	mg/Kg-dry	10	02/16/2021 15:31	173868
Arsenic	NELAP	0.18		**6.34**	mg/Kg-dry	10	02/09/2021 0:15	173655
Barium	NELAP	0.18	B	**19.6**	mg/Kg-dry	10	02/09/2021 0:15	173655
Beryllium	NELAP	0.27		**0.89**	mg/Kg-dry	10	02/09/2021 0:15	173655
Boron	NELAP	4.55	B	**< 4.55**	mg/Kg-dry	10	02/09/2021 0:15	173655
Cadmium	NELAP	0.18		**< 0.18**	mg/Kg-dry	10	02/09/2021 0:15	173655
Calcium	*	45.5		**277**	mg/Kg-dry	10	02/09/2021 0:15	173655
Chromium	NELAP	0.45		**19.4**	mg/Kg-dry	10	02/09/2021 0:15	173655
Cobalt	NELAP	0.18		**7.69**	mg/Kg-dry	10	02/09/2021 0:15	173655
Iron	NELAP	9.09		**32000**	mg/Kg-dry	10	02/09/2021 0:15	173655
Lead	NELAP	0.18		**3.48**	mg/Kg-dry	10	02/09/2021 0:15	173655
Lithium	*	0.27		**0.78**	mg/Kg-dry	10	02/09/2021 0:15	173655
Manganese	NELAP	0.18		**270**	mg/Kg-dry	10	02/09/2021 0:15	173655
Molybdenum	NELAP	0.18		**1.04**	mg/Kg-dry	10	02/09/2021 0:15	173655
Selenium	NELAP	0.91		**< 0.91**	mg/Kg-dry	10	02/09/2021 0:15	173655
Thallium	NELAP	0.18		**< 0.18**	mg/Kg-dry	10	02/09/2021 0:15	173655
Sample result(s) for BA exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
Contamination present in the MBLK for B. Sample results below the reporting limit are reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.012		**< 0.012**	mg/Kg-dry	1	02/09/2021 13:34	173704
SW-846 METHOD 9060M, TOTAL ORGANIC CARBON								
Total Organic Carbon (TOC)	*	740		**< 740**	mg/Kg-dry	1	02/10/2021 0:00	R287399
Sample container did not meet EPA or method requirements.								

Client: Geosyntec Consultants
Work Order: 21020428
Client Project: Vistra Joppa GLP8021
Report Date: 17-Feb-21
Lab ID: 21020428-003
Client Sample ID: SB-G09M-(110-112)-20210127
Matrix: SOLID
Collection Date: 01/27/2021 11:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**22.0**	%	1	02/10/2021 13:44	R287331
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.38		**< 0.38**	mg/Kg-dry	10	02/16/2021 15:39	173868
Arsenic	NELAP	0.20		**4.44**	mg/Kg-dry	10	02/09/2021 0:23	173655
Barium	NELAP	0.20	B	**11.5**	mg/Kg-dry	10	02/09/2021 0:23	173655
Beryllium	NELAP	0.29		**< 0.29**	mg/Kg-dry	10	02/09/2021 0:23	173655
Boron	NELAP	4.90	B	**< 4.90**	mg/Kg-dry	10	02/09/2021 0:23	173655
Cadmium	NELAP	0.20		**< 0.20**	mg/Kg-dry	10	02/09/2021 0:23	173655
Calcium	*	49.0		**420**	mg/Kg-dry	10	02/09/2021 0:23	173655
Chromium	NELAP	0.49		**7.43**	mg/Kg-dry	10	02/09/2021 0:23	173655
Cobalt	NELAP	0.20		**0.80**	mg/Kg-dry	10	02/09/2021 0:23	173655
Iron	NELAP	9.80		**6470**	mg/Kg-dry	10	02/09/2021 0:23	173655
Lead	NELAP	0.20		**3.76**	mg/Kg-dry	10	02/09/2021 0:23	173655
Lithium	*	0.29		**1.72**	mg/Kg-dry	10	02/09/2021 0:23	173655
Manganese	NELAP	0.20		**57.2**	mg/Kg-dry	10	02/09/2021 0:23	173655
Molybdenum	NELAP	0.20		**0.51**	mg/Kg-dry	10	02/09/2021 0:23	173655
Selenium	NELAP	0.98		**< 0.98**	mg/Kg-dry	10	02/09/2021 0:23	173655
Thallium	NELAP	0.20		**< 0.20**	mg/Kg-dry	10	02/09/2021 0:23	173655
Sample result(s) for BA exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
Contamination present in the MBLK for B. Sample results below the reporting limit are reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.012		**< 0.012**	mg/Kg-dry	1	02/09/2021 13:37	173704
SW-846 METHOD 9060M, TOTAL ORGANIC CARBON								
Total Organic Carbon (TOC)	*	760		**< 760**	mg/Kg-dry	1	02/10/2021 0:00	R287399
Sample container did not meet EPA or method requirements.								

Client: Geosyntec Consultants

Client Project: Vistra Joppa GLP8021

Lab ID: 21020428-004

Matrix: SOLID

Work Order: 21020428

Report Date: 17-Feb-21

Client Sample ID: SB-G09M-(142-144)-20210128

Collection Date: 01/28/2021 15:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**65.3**	%	1	02/10/2021 13:44	R287331
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.38		**< 0.38**	mg/Kg-dry	10	02/16/2021 15:47	173868
Arsenic	NELAP	0.19		**1.88**	mg/Kg-dry	10	02/09/2021 0:31	173655
Barium	NELAP	0.19	B	**41.9**	mg/Kg-dry	10	02/09/2021 0:31	173655
Beryllium	NELAP	0.29		**< 0.29**	mg/Kg-dry	10	02/09/2021 0:31	173655
Boron	NELAP	4.81	B	**< 4.81**	mg/Kg-dry	10	02/09/2021 0:31	173655
Cadmium	NELAP	0.19		**2.75**	mg/Kg-dry	10	02/09/2021 0:31	173655
Calcium	*	48.1		**333000**	mg/Kg-dry	10	02/09/2021 0:31	173655
Chromium	NELAP	0.48		**6.32**	mg/Kg-dry	10	02/09/2021 0:31	173655
Cobalt	NELAP	0.19		**2.94**	mg/Kg-dry	10	02/09/2021 0:31	173655
Iron	NELAP	9.62		**2920**	mg/Kg-dry	10	02/09/2021 0:31	173655
Lead	NELAP	0.19		**2.02**	mg/Kg-dry	10	02/09/2021 0:31	173655
Lithium	*	0.29		**2.03**	mg/Kg-dry	10	02/09/2021 0:31	173655
Manganese	NELAP	0.19		**346**	mg/Kg-dry	10	02/09/2021 0:31	173655
Molybdenum	NELAP	0.19		**0.24**	mg/Kg-dry	10	02/09/2021 0:31	173655
Selenium	NELAP	0.96		**< 0.96**	mg/Kg-dry	10	02/09/2021 0:31	173655
Thallium	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	02/09/2021 0:31	173655

Sample result(s) for BA exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.

Contamination present in the MBLK for B. Sample results below the reporting limit are reportable per the TNI Standard.

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
SW-846 7471B								
Mercury	NELAP	0.027		**< 0.027**	mg/Kg-dry	1	02/09/2021 13:39	173704
SW-846 METHOD 9060M, TOTAL ORGANIC CARBON								
Total Organic Carbon (TOC)	*	1700		**21000**	mg/Kg-dry	1	02/10/2021 0:00	R287399

Sample container did not meet EPA or method requirements.

Client: Geosyntec Consultants
Work Order: 21020428
Client Project: Vistra Joppa GLP8021
Report Date: 17-Feb-21
Lab ID: 21020428-005
Client Sample ID: EQB-20210128
Matrix: AQUEOUS
Collection Date: 01/28/2021 16:00

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA 600 245.1 R3.0 (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	02/09/2021 12:55	173695
EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**< 0.0010**	mg/L	5	02/10/2021 22:31	173688
Arsenic	NELAP	0.0010		**0.0023**	mg/L	5	02/10/2021 22:31	173688
Barium	NELAP	0.0010		**0.0226**	mg/L	5	02/10/2021 22:31	173688
Beryllium	NELAP	0.0010		**< 0.0010**	mg/L	5	02/10/2021 22:31	173688
Boron	NELAP	0.0250		**< 0.0250**	mg/L	5	02/10/2021 22:31	173688
Cadmium	NELAP	0.0010		**0.0017**	mg/L	5	02/10/2021 22:31	173688
Calcium	NELAP	0.125	S	**241**	mg/L	5	02/12/2021 7:11	173688
Chromium	NELAP	0.0015		**0.0159**	mg/L	5	02/10/2021 22:31	173688
Cobalt	NELAP	0.0010		**0.0028**	mg/L	5	02/10/2021 22:31	173688
Iron	NELAP	0.0250		**5.79**	mg/L	5	02/10/2021 22:31	173688
Lead	NELAP	0.0010		**0.0023**	mg/L	5	02/10/2021 22:31	173688
Lithium	*	0.0030		**< 0.0030**	mg/L	5	02/10/2021 22:31	173688
Manganese	NELAP	0.0020		**0.215**	mg/L	5	02/10/2021 22:31	173688
Molybdenum	NELAP	0.0015		**0.0033**	mg/L	5	02/10/2021 22:31	173688
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	02/10/2021 22:31	173688
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	02/10/2021 22:31	173688

Matrix spike control limits for CA are not applicable due to high sample/spike ratio.

Client: Geosyntec Consultants **Work Order:** 21020428

Client Project: Vistra Joppa GLP8021 **Report Date:** 17-Feb-21

Lab ID: 21020428-006 **Client Sample ID:** SB-G03-(30-32)-20210202

Matrix: SOLID **Collection Date:** 02/02/2021 11:10

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**18.2**	%	1	02/10/2021 13:45	R287331
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.37		**< 0.37**	mg/Kg-dry	10	02/16/2021 15:55	173868
Arsenic	NELAP	0.18		**2.59**	mg/Kg-dry	10	02/09/2021 0:39	173655
Barium	NELAP	0.18	B	**347**	mg/Kg-dry	10	02/10/2021 17:55	173655
Beryllium	NELAP	0.27		**0.71**	mg/Kg-dry	10	02/09/2021 0:39	173655
Boron	NELAP	4.63	BS	**< 4.63**	mg/Kg-dry	10	02/12/2021 12:53	173799
Cadmium	NELAP	0.18		**< 0.18**	mg/Kg-dry	10	02/09/2021 0:39	173655
Calcium	*	45.5		**1590**	mg/Kg-dry	10	02/09/2021 0:39	173655
Chromium	NELAP	0.46		**18.7**	mg/Kg-dry	10	02/12/2021 12:53	173799
Cobalt	NELAP	0.19	SR	**110**	mg/Kg-dry	10	02/12/2021 12:53	173799
Iron	NELAP	9.09	S	**13900**	mg/Kg-dry	10	02/09/2021 0:39	173655
Lead	NELAP	0.18		**27.8**	mg/Kg-dry	10	02/10/2021 17:55	173655
Lithium	*	0.27		**12.6**	mg/Kg-dry	10	02/09/2021 0:39	173655
Manganese	NELAP	0.91	SR	**1320**	mg/Kg-dry	50	02/09/2021 18:16	173655
Molybdenum	NELAP	0.18		**0.38**	mg/Kg-dry	10	02/09/2021 0:39	173655
Selenium	NELAP	0.91		**< 0.91**	mg/Kg-dry	10	02/09/2021 0:39	173655
Thallium	NELAP	0.18		**0.26**	mg/Kg-dry	10	02/09/2021 0:39	173655
CO - RPD for MS/MSD was outside control limits due to sample composition. *Matrix spike did not recover within control limits for B and CO due to sample composition.* *Matrix spike control limits for Mn are not applicable due to high sample/spike ratio.* *Mn - RPD for MS/MSD was outside control limits due to sample composition.* *Sample result(s) for BA exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.* *Contamination present in the MBLK for B. Sample results below the reporting limit are reportable per the TNI Standard.* *Matrix spike control limits for FE are not applicable due to high sample/spike ratio.*								
SW-846 7471B								
Mercury	NELAP	0.012		**< 0.012**	mg/Kg-dry	1	02/09/2021 13:41	173704
SW-846 METHOD 9060M, TOTAL ORGANIC CARBON								
Total Organic Carbon (TOC)	*	730		**< 730**	mg/Kg-dry	1	02/10/2021 0:00	R287399
Sample container did not meet EPA or method requirements.								

Client:	Geosyntec Consultants	**Work Order:**	21020428
Client Project:	Vistra Joppa GLP8021	**Report Date:**	17-Feb-21
Lab ID:	21020428-007	**Client Sample ID:**	SB-G03-(58-60)-20210202
Matrix:	SOLID	**Collection Date:**	02/02/2021 13:30

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**18.1**	%	1	02/10/2021 13:45	R287331
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.37		**< 0.37**	mg/Kg-dry	10	02/16/2021 18:13	173868
Arsenic	NELAP	0.19		**0.30**	mg/Kg-dry	10	02/09/2021 2:33	173655
Barium	NELAP	0.19	B	**6.01**	mg/Kg-dry	10	02/09/2021 2:33	173655
Beryllium	NELAP	0.28		**< 0.28**	mg/Kg-dry	10	02/09/2021 2:33	173655
Boron	NELAP	4.72	B	**< 4.72**	mg/Kg-dry	10	02/09/2021 2:33	173655
Cadmium	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	02/09/2021 2:33	173655
Calcium	*	47.2		**153**	mg/Kg-dry	10	02/09/2021 2:33	173655
Chromium	NELAP	0.47		**4.69**	mg/Kg-dry	10	02/09/2021 2:33	173655
Cobalt	NELAP	0.19		**0.82**	mg/Kg-dry	10	02/09/2021 2:33	173655
Iron	NELAP	9.43		**1060**	mg/Kg-dry	10	02/09/2021 2:33	173655
Lead	NELAP	0.19		**1.30**	mg/Kg-dry	10	02/09/2021 2:33	173655
Lithium	*	0.28		**0.86**	mg/Kg-dry	10	02/09/2021 2:33	173655
Manganese	NELAP	0.19		**6.10**	mg/Kg-dry	10	02/09/2021 2:33	173655
Molybdenum	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	02/09/2021 2:33	173655
Selenium	NELAP	0.94		**< 0.94**	mg/Kg-dry	10	02/09/2021 2:33	173655
Thallium	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	02/09/2021 2:33	173655
Sample result(s) for BA exceed 10 times the method blank contamination. Data is reportable per the TNI Standard. *Contamination present in the MBLK for B. Sample results below the reporting limit are reportable per the TNI Standard.*								
SW-846 7471B								
Mercury	NELAP	0.012		**< 0.012**	mg/Kg-dry	1	02/09/2021 13:48	173704
SW-846 METHOD 9060M, TOTAL ORGANIC CARBON								
Total Organic Carbon (TOC)	*	740		**< 740**	mg/Kg-dry	1	02/10/2021 0:00	R287399
Sample container did not meet EPA or method requirements.								

Client:	Geosyntec Consultants	**Work Order:**	21020428
Client Project:	Vistra Joppa GLP8021	**Report Date:**	17-Feb-21
Lab ID:	21020428-008	**Client Sample ID:**	SB-G03-(58-60)-20210202-DUP
Matrix:	SOLID	**Collection Date:**	02/02/2021 13:30

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA SW846 3550C, 5035A, ASTM D2974								
Percent Moisture	*	0.1		**17.0**	%	1	02/10/2021 13:53	R287331
SW-846 3050B, 6020A, METALS BY ICPMS								
Antimony	NELAP	0.39		**< 0.39**	mg/Kg-dry	10	02/16/2021 18:21	173868
Arsenic	NELAP	0.19		**0.26**	mg/Kg-dry	10	02/09/2021 2:41	173655
Barium	NELAP	0.19	B	**5.06**	mg/Kg-dry	10	02/09/2021 2:41	173655
Beryllium	NELAP	0.29		**< 0.29**	mg/Kg-dry	10	02/09/2021 2:41	173655
Boron	NELAP	4.81	B	**< 4.81**	mg/Kg-dry	10	02/09/2021 2:41	173655
Cadmium	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	02/09/2021 2:41	173655
Calcium	*	48.1		**121**	mg/Kg-dry	10	02/09/2021 2:41	173655
Chromium	NELAP	0.48		**3.91**	mg/Kg-dry	10	02/09/2021 2:41	173655
Cobalt	NELAP	0.19		**1.85**	mg/Kg-dry	10	02/09/2021 2:41	173655
Iron	NELAP	9.62		**830**	mg/Kg-dry	10	02/09/2021 2:41	173655
Lead	NELAP	0.19		**0.99**	mg/Kg-dry	10	02/09/2021 2:41	173655
Lithium	*	0.29		**0.80**	mg/Kg-dry	10	02/09/2021 2:41	173655
Manganese	NELAP	0.19		**8.51**	mg/Kg-dry	10	02/09/2021 2:41	173655
Molybdenum	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	02/09/2021 2:41	173655
Selenium	NELAP	0.96		**< 0.96**	mg/Kg-dry	10	02/09/2021 2:41	173655
Thallium	NELAP	0.19		**< 0.19**	mg/Kg-dry	10	02/09/2021 2:41	173655
Sample result(s) for BA exceed 10 times the method blank contamination. Data is reportable per the TNI Standard.								
Contamination present in the MBLK for B. Sample results below the reporting limit are reportable per the TNI Standard.								
SW-846 7471B								
Mercury	NELAP	0.012		**< 0.012**	mg/Kg-dry	1	02/09/2021 13:50	173704
SW-846 METHOD 9060M, TOTAL ORGANIC CARBON								
Total Organic Carbon (TOC)	*	720		**< 720**	mg/Kg-dry	1	02/11/2021 0:00	R287399
Sample container did not meet EPA or method requirements.								

Client:	Geosyntec Consultants	**Work Order:**	21020428
Client Project:	Vistra Joppa GLP8021	**Report Date:**	17-Feb-21
Lab ID:	21020428-009	**Client Sample ID:**	EQB-20210202
Matrix:	AQUEOUS	**Collection Date:**	02/02/2021 13:45

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
EPA 600 245.1 R3.0 (TOTAL)								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	02/09/2021 12:57	173695
EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)								
Antimony	NELAP	0.0010		**< 0.0010**	mg/L	5	02/10/2021 23:44	173688
Arsenic	NELAP	0.0010		**< 0.0010**	mg/L	5	02/10/2021 23:44	173688
Barium	NELAP	0.0010		**0.0177**	mg/L	5	02/10/2021 23:44	173688
Beryllium	NELAP	0.0010		**< 0.0010**	mg/L	5	02/10/2021 23:44	173688
Boron	NELAP	0.0250		**< 0.0250**	mg/L	5	02/10/2021 23:44	173688
Cadmium	NELAP	0.0010		**< 0.0010**	mg/L	5	02/10/2021 23:44	173688
Calcium	NELAP	0.125		**1.44**	mg/L	5	02/12/2021 7:02	173688
Chromium	NELAP	0.0015		**0.0059**	mg/L	5	02/10/2021 23:44	173688
Cobalt	NELAP	0.0010		**0.0013**	mg/L	5	02/10/2021 23:44	173688
Iron	NELAP	0.0250		**2.86**	mg/L	5	02/10/2021 23:44	173688
Lead	NELAP	0.0010		**0.0017**	mg/L	5	02/10/2021 23:44	173688
Lithium	*	0.0030		**< 0.0030**	mg/L	5	02/10/2021 23:44	173688
Manganese	NELAP	0.0020		**0.0331**	mg/L	5	02/10/2021 23:44	173688
Molybdenum	NELAP	0.0015		**< 0.0015**	mg/L	5	02/10/2021 23:44	173688
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	02/10/2021 23:44	173688
Thallium	NELAP	0.0020		**< 0.0020**	mg/L	5	02/10/2021 23:44	173688

Sample Summary

Client: Geosyntec Consultants

Client Project: Vistra Joppa GLP8021

Work Order: 21020428

Report Date: 17-Feb-21

Lab Sample ID	Client Sample ID	Matrix	Fractions	Collection Date
21020428-001	SB-G09M-(10-12)-20210126	Solid	2	01/26/2021 11:00
21020428-002	SB-G09M-(82-84)-20210127	Solid	2	01/27/2021 9:30
21020428-003	SB-G09M-(110-112)-20210127	Solid	2	01/27/2021 11:00
21020428-004	SB-G09M-(142-144)-20210128	Solid	2	01/28/2021 15:00
21020428-005	EQB-20210128	Aqueous	1	01/28/2021 16:00
21020428-006	SB-G03-(30-32)-20210202	Solid	2	02/02/2021 11:10
21020428-007	SB-G03-(58-60)-20210202	Solid	2	02/02/2021 13:30
21020428-008	SB-G03-(58-60)-20210202-DUP	Solid	2	02/02/2021 13:30
21020428-009	EQB-20210202	Aqueous	1	02/02/2021 13:45

Sample ID	Client Sample ID	Collection Date	Received Date		
	Test Name			Prep Date/Time	Analysis Date/Time
21020428-001A	SB-G09M-(10-12)-20210126	01/26/2021 11:00	02/05/2021 15:45		
	EPA SW846 3550C, 5035A, ASTM D2974				02/10/2021 13:44
	SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/09/2021 0:06
	SW-846 3050B, 6020A, Metals by ICPMS			02/12/2021 15:59	02/16/2021 15:23
	SW-846 7471B			02/08/2021 14:46	02/09/2021 13:27
21020428-001B	SB-G09M-(10-12)-20210126	01/26/2021 11:00	02/05/2021 15:45		
	SW-846 Method 9060M, Total Organic Carbon				02/11/2021 0:00
21020428-002A	SB-G09M-(82-84)-20210127	01/27/2021 9:30	02/05/2021 15:45		
	EPA SW846 3550C, 5035A, ASTM D2974				02/10/2021 13:44
	SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/09/2021 0:15
	SW-846 3050B, 6020A, Metals by ICPMS			02/12/2021 15:59	02/16/2021 15:31
	SW-846 7471B			02/08/2021 14:46	02/09/2021 13:34
21020428-002B	SB-G09M-(82-84)-20210127	01/27/2021 9:30	02/05/2021 15:45		
	SW-846 Method 9060M, Total Organic Carbon				02/10/2021 0:00
21020428-003A	SB-G09M-(110-112)-20210127	01/27/2021 11:00	02/05/2021 15:45		
	EPA SW846 3550C, 5035A, ASTM D2974				02/10/2021 13:44
	SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/09/2021 0:23
	SW-846 3050B, 6020A, Metals by ICPMS			02/12/2021 15:59	02/16/2021 15:39
	SW-846 7471B			02/08/2021 14:46	02/09/2021 13:37
21020428-003B	SB-G09M-(110-112)-20210127	01/27/2021 11:00	02/05/2021 15:45		
	SW-846 Method 9060M, Total Organic Carbon				02/10/2021 0:00
21020428-004A	SB-G09M-(142-144)-20210128	01/28/2021 15:00	02/05/2021 15:45		
	EPA SW846 3550C, 5035A, ASTM D2974				02/10/2021 13:44
	SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/09/2021 0:31
	SW-846 3050B, 6020A, Metals by ICPMS			02/12/2021 16:00	02/16/2021 15:47
	SW-846 7471B			02/08/2021 14:46	02/09/2021 13:39
21020428-004B	SB-G09M-(142-144)-20210128	01/28/2021 15:00	02/05/2021 15:45		
	SW-846 Method 9060M, Total Organic Carbon				02/10/2021 0:00
21020428-005A	EQB-20210128	01/28/2021 16:00	02/05/2021 15:45		
	EPA 600 245.1 R3.0 (Total)			02/08/2021 13:29	02/09/2021 12:55
	EPA 600 4.1.4, 200.8 R5.4, Metals by ICPMS (Total)			02/08/2021 12:15	02/10/2021 22:31
	EPA 600 4.1.4, 200.8 R5.4, Metals by ICPMS (Total)			02/08/2021 12:15	02/12/2021 7:11
21020428-006A	SB-G03-(30-32)-20210202	02/02/2021 11:10	02/05/2021 15:45		
	EPA SW846 3550C, 5035A, ASTM D2974				02/10/2021 13:45
	SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/09/2021 0:39
	SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/09/2021 18:16

Dates Report

Client: Geosyntec Consultants
Work Order: 21020428

Client Project: Vistra Joppa GLP8021
Report Date: 17-Feb-21

Sample ID	Client Sample ID	Test Name	Collection Date	Received Date	Prep Date/Time	Analysis Date/Time
		SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/10/2021 17:55
		SW-846 3050B, 6020A, Metals by ICPMS			02/11/2021 10:09	02/12/2021 12:53
		SW-846 3050B, 6020A, Metals by ICPMS			02/12/2021 16:00	02/16/2021 15:55
		SW-846 7471B			02/08/2021 14:46	02/09/2021 13:41
21020428-006B	SB-G03-(30-32)-20210202		02/02/2021 11:10	02/05/2021 15:45		
		SW-846 Method 9060M, Total Organic Carbon				02/10/2021 0:00
21020428-007A	SB-G03-(58-60)-20210202		02/02/2021 13:30	02/05/2021 15:45		
		EPA SW846 3550C, 5035A, ASTM D2974				02/10/2021 13:45
		SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/09/2021 2:33
		SW-846 3050B, 6020A, Metals by ICPMS			02/12/2021 16:00	02/16/2021 18:13
		SW-846 7471B			02/08/2021 14:46	02/09/2021 13:48
21020428-007B	SB-G03-(58-60)-20210202		02/02/2021 13:30	02/05/2021 15:45		
		SW-846 Method 9060M, Total Organic Carbon				02/10/2021 0:00
21020428-008A	SB-G03-(58-60)-20210202-DUP		02/02/2021 13:30	02/05/2021 15:45		
		EPA SW846 3550C, 5035A, ASTM D2974				02/10/2021 13:53
		SW-846 3050B, 6020A, Metals by ICPMS			02/05/2021 18:07	02/09/2021 2:41
		SW-846 3050B, 6020A, Metals by ICPMS			02/12/2021 16:00	02/16/2021 18:21
		SW-846 7471B			02/08/2021 14:46	02/09/2021 13:50
21020428-008B	SB-G03-(58-60)-20210202-DUP		02/02/2021 13:30	02/05/2021 15:45		
		SW-846 Method 9060M, Total Organic Carbon				02/11/2021 0:00
21020428-009A	EQB-20210202		02/02/2021 13:45	02/05/2021 15:45		
		EPA 600 245.1 R3.0 (Total)			02/08/2021 13:29	02/09/2021 12:57
		EPA 600 4.1.4, 200.8 R5.4, Metals by ICPMS (Total)			02/08/2021 12:15	02/10/2021 23:44
		EPA 600 4.1.4, 200.8 R5.4, Metals by ICPMS (Total)			02/08/2021 12:15	02/12/2021 7:02

Client: Geosyntec Consultants
Client Project: Vistra Joppa GLP8021

Work Order: 21020428
Report Date: 17-Feb-21

EPA SW846 3550C, 5035A, ASTM D2974

Batch **R287331** **SampType:** **LCS** Units **%**
SampID: LCS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Percent Moisture	*	0.1		**99.0**	99.00	0	100.0	90	110	02/10/2021

Batch **R287331** **SampType:** **LCSQC** Units **%**
SampID: LCSQC

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Percent Moisture	*	0.1		**99.0**	99.00	0	100.0	90	110	02/10/2021

EPA 600 245.1 R3.0 (TOTAL)

Batch **173695** **SampType:** **MBLK** Units **mg/L**
SampID: MBLK-173695

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**< 0.00020**	0.0001	0	0	-100	100	02/09/2021

Batch **173695** **SampType:** **LCS** Units **mg/L**
SampID: LCS-173695

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00498**	0.0050	0	99.6	85	115	02/09/2021

Batch **173695** **SampType:** **MS** Units **mg/L**
SampID: 21020428-009AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.00020		**0.00478**	0.0050	0	95.6	75	125	02/09/2021

Batch **173695** **SampType:** **MSD** Units **mg/L** RPD Limit **15**
SampID: 21020428-009AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Mercury		0.00020		**0.00470**	0.0050	0	94.0	0.004778	1.62	02/09/2021

Client: Geosyntec Consultants **Work Order:** 21020428

Client Project: Vistra Joppa GLP8021 **Report Date:** 17-Feb-21

EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)

Batch **173688** **SampType:** **MBLK** Units **mg/L**

SampID: MBLK-173688

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**< 0.0010**	0.0004	0	0	-100	100	02/10/2021
Arsenic		0.0010		**< 0.0010**	0.0004	0	0	-100	100	02/10/2021
Barium		0.0010		**< 0.0010**	0.0007	0	0	-100	100	02/10/2021
Beryllium		0.0010		**< 0.0010**	0.0002	0	0	-100	100	02/10/2021
Boron		0.0250		**< 0.0250**	0.0093	0	0	-100	100	02/10/2021
Cadmium		0.0010		**< 0.0010**	0.0001	0	0	-100	100	02/10/2021
Calcium		0.125		**< 0.125**	0.0700	0	0	-100	100	02/12/2021
Chromium		0.0015		**< 0.0015**	0.0007	0	0	-100	100	02/10/2021
Cobalt		0.0010		**< 0.0010**	0.0001	0	0	-100	100	02/10/2021
Iron		0.0250		**< 0.0250**	0.0115	0	0	-100	100	02/10/2021
Lead		0.0010		**< 0.0010**	0.0006	0	0	-100	100	02/10/2021
Lithium	*	0.0030		**< 0.0030**	0.0015	0	0	-100	100	02/10/2021
Manganese		0.0020		**< 0.0020**	0.0008	0	0	-100	100	02/10/2021
Molybdenum		0.0015		**< 0.0015**	0.0006	0	0	-100	100	02/10/2021
Selenium		0.0010		**< 0.0010**	0.0006	0	0	-100	100	02/10/2021
Thallium		0.0008		**< 0.0008**	0.0010	0	0	-100	100	02/12/2021
Thallium		0.0020		**< 0.0020**	0.0010	0	0	-100	100	02/10/2021

Client: Geosyntec Consultants

Work Order: 21020428

Client Project: Vistra Joppa GLP8021

Report Date: 17-Feb-21

EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)

Batch **173688** **SampType:** **LCS** Units **mg/L**

SampID: LCS-173688

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**0.524**	0.5000	0	104.8	80	120	02/10/2021
Arsenic		0.0010		**0.542**	0.5000	0	108.5	80	120	02/10/2021
Barium		0.0010		**2.12**	2.000	0	106.0	80	120	02/10/2021
Beryllium		0.0010		**0.0536**	0.0500	0	107.2	80	120	02/10/2021
Boron		0.0250		**0.513**	0.5000	0	102.7	80	120	02/10/2021
Cadmium		0.0010		**0.0511**	0.0500	0	102.1	80	120	02/10/2021
Calcium		0.125		**2.47**	2.500	0	98.9	80	120	02/12/2021
Chromium		0.0015		**0.212**	0.2000	0	106.0	80	120	02/10/2021
Cobalt		0.0010		**0.526**	0.5000	0	105.3	80	120	02/10/2021
Iron		0.0250		**2.05**	2.000	0	102.6	80	120	02/10/2021
Lead		0.0010		**0.514**	0.5000	0	102.7	80	120	02/10/2021
Lithium	*	0.0030		**0.533**	0.5000	0	106.7	80	120	02/10/2021
Manganese		0.0020		**0.523**	0.5000	0	104.7	80	120	02/10/2021
Molybdenum		0.0015		**0.512**	0.5000	0	102.4	80	120	02/10/2021
Selenium		0.0010		**0.497**	0.5000	0	99.5	80	120	02/10/2021
Thallium		0.0020		**0.245**	0.2500	0	98.0	80	120	02/10/2021
Thallium		0.0008		**0.239**	0.2500	0	95.6	80	120	02/12/2021

Client: Geosyntec Consultants

Client Project: Vistra Joppa GLP8021

Work Order: 21020428

Report Date: 17-Feb-21

EPA 600 4.1.4, 200.8 R5.4, METALS BY ICPMS (TOTAL)

Batch **173688** **SampType:** **MS** Units **mg/L**

SampID: 21020428-005AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.0010		**0.516**	0.5000	0	103.2	70	130	02/10/2021
Arsenic		0.0010		**0.538**	0.5000	0.002305	107.2	70	130	02/10/2021
Barium		0.0010		**2.12**	2.000	0.02255	105.0	70	130	02/10/2021
Beryllium		0.0010		**0.0531**	0.0500	0.0004103	105.4	70	130	02/10/2021
Boron		0.0250		**0.503**	0.5000	0	100.7	70	130	02/10/2021
Cadmium		0.0010		**0.0540**	0.0500	0.001651	104.7	70	130	02/10/2021
Calcium		0.125	S	**243**	2.500	241.3	63.9	70	130	02/12/2021
Chromium		0.0015		**0.221**	0.2000	0.01592	102.7	70	130	02/10/2021
Cobalt		0.0010		**0.501**	0.5000	0.002804	99.7	70	130	02/10/2021
Iron		0.0250		**7.53**	2.000	5.794	87.0	70	130	02/10/2021
Lead		0.0010		**0.515**	0.5000	0.002336	102.6	70	130	02/10/2021
Lithium	*	0.0030		**0.527**	0.5000	0.002176	105.0	70	130	02/10/2021
Manganese		0.0020		**0.720**	0.5000	0.2146	101.1	70	130	02/10/2021
Molybdenum		0.0015		**0.522**	0.5000	0.003348	103.8	70	130	02/10/2021
Selenium		0.0010		**0.492**	0.5000	0	98.5	70	130	02/10/2021
Thallium		0.0020		**0.253**	0.2500	0	101.1	70	130	02/10/2021

Batch **173688** **SampType:** **MSD** Units **mg/L** RPD Limit **20**

SampID: 21020428-005AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Antimony		0.0010		**0.511**	0.5000	0	102.1	0.5161	1.06	02/10/2021
Arsenic		0.0010		**0.533**	0.5000	0.002305	106.1	0.5384	1.00	02/10/2021
Barium		0.0010		**2.12**	2.000	0.02255	104.9	2.123	0.11	02/10/2021
Beryllium		0.0010		**0.0541**	0.0500	0.0004103	107.4	0.05313	1.82	02/10/2021
Boron		0.0250		**0.521**	0.5000	0	104.1	0.5034	3.38	02/10/2021
Cadmium		0.0010		**0.0528**	0.0500	0.001651	102.4	0.05399	2.14	02/10/2021
Calcium		0.125	S	**248**	2.500	241.3	263.5	242.9	2.03	02/12/2021
Chromium		0.0015		**0.219**	0.2000	0.01592	101.8	0.2212	0.81	02/10/2021
Cobalt		0.0010		**0.497**	0.5000	0.002804	98.8	0.5011	0.88	02/10/2021
Iron		0.0250		**7.59**	2.000	5.794	89.9	7.535	0.76	02/10/2021
Lead		0.0010		**0.521**	0.5000	0.002336	103.8	0.5152	1.20	02/10/2021
Lithium	*	0.0030		**0.541**	0.5000	0.002176	107.8	0.5273	2.63	02/10/2021
Manganese		0.0020		**0.719**	0.5000	0.2146	101.0	0.7199	0.06	02/10/2021
Molybdenum		0.0015		**0.521**	0.5000	0.003348	103.5	0.5225	0.32	02/10/2021
Selenium		0.0010		**0.487**	0.5000	0	97.4	0.4923	1.04	02/10/2021
Thallium		0.0020		**0.256**	0.2500	0	102.4	0.2529	1.19	02/10/2021

SW-846 3050B, 6020A, METALS BY ICPMS

Batch **173655** **SampType:** **MBLK** Units **mg/Kg-dry**

SampID: MBLK-173655

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Arsenic		0.20		**< 0.20**	0.0202	0	0	-100	100	02/08/2021
Barium		0.20	S	**< 0.20**	0.0550	0	123.7	-100	100	02/08/2021
Beryllium		0.30		**< 0.30**	0.0269	0	0	-100	100	02/08/2021
Boron		5.00	S	**< 5.00**	0.8000	0	120.1	-100	100	02/08/2021
Cadmium		0.20		**< 0.20**	0.0150	0	0	-100	100	02/08/2021
Calcium	*	50.0		**< 50.0**	18.60	0	0	-100	100	02/08/2021
Chromium		0.50		**< 0.50**	0.2000	0	0	-100	100	02/08/2021
Cobalt		0.20		**< 0.20**	0.0253	0	0	-100	100	02/08/2021
Iron		10.0		**< 10.0**	4.900	0	0	-100	100	02/08/2021
Lead		0.20		**< 0.20**	0.0310	0	0	-100	100	02/08/2021
Lithium	*	0.30		**< 0.30**	0.0607	0	0	-100	100	02/08/2021
Manganese		0.20		**< 0.20**	0.0670	0	0	-100	100	02/08/2021
Molybdenum		0.20		**< 0.20**	0.0740	0	0	-100	100	02/08/2021
Selenium		1.00		**< 1.00**	0.1375	0	0	-100	100	02/08/2021
Thallium		0.20		**< 0.20**	0.1000	0	0	-100	100	02/08/2021

Batch **173655** **SampType:** **LCS** Units **mg/Kg-dry**

SampID: LCS-173655

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Arsenic		0.20		**51.7**	50.00	0	103.3	80	120	02/09/2021
Barium		0.20	B	**208**	200.0	0	104.0	80	120	02/09/2021
Beryllium		0.30		**5.08**	5.000	0	101.6	80	120	02/09/2021
Boron		5.00	B	**50.7**	50.00	0	101.5	80	120	02/09/2021
Cadmium		0.20		**4.88**	5.000	0	97.6	80	120	02/09/2021
Calcium	*	50.0		**245**	250.0	0	98.2	80	120	02/09/2021
Chromium		0.50		**20.1**	20.00	0	100.7	80	120	02/09/2021
Cobalt		0.20		**49.2**	50.00	0	98.3	80	120	02/09/2021
Iron		10.0		**195**	200.0	0	97.5	80	120	02/09/2021
Lead		0.20		**49.8**	50.00	0	99.7	80	120	02/09/2021
Lithium	*	0.30		**55.7**	50.00	0	111.4	80	120	02/09/2021
Manganese		0.20		**52.0**	50.00	0	104.0	80	120	02/09/2021
Molybdenum		0.20		**48.3**	50.00	0	96.7	80	120	02/09/2021
Selenium		1.00		**47.4**	50.00	0	94.8	80	120	02/09/2021
Thallium		0.20		**23.9**	25.00	0	95.4	80	120	02/09/2021

SW-846 3050B, 6020A, METALS BY ICPMS

Batch 173655 **SampType:** MS Units **mg/Kg-dry**
SampID: 21020428-006AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Arsenic		0.20		**50.6**	50.00	2.586	96.1	75	125	02/09/2021
Barium		0.20	B	**552**	200.0	347.0	102.6	75	125	02/10/2021
Beryllium		0.30		**5.60**	5.000	0.7113	97.7	75	125	02/09/2021
Cadmium		0.20		**4.94**	5.000	0	98.8	75	125	02/09/2021
Calcium	*	50.0		**1890**	250.0	1589	121.3	75	125	02/09/2021
Iron		10.0	S	**15700**	200.0	13880	895.3	75	125	02/09/2021
Lead		0.20		**78.0**	50.00	27.78	100.5	75	125	02/10/2021
Lithium	*	0.30		**68.1**	50.00	12.58	111.0	75	125	02/09/2021
Manganese		1.00	S	**1350**	50.00	1319	66.2	75	125	02/09/2021
Molybdenum		0.20		**41.5**	50.00	0.3801	82.2	75	125	02/09/2021
Selenium		1.00		**43.9**	50.00	0	87.7	75	125	02/09/2021
Thallium		0.20		**23.0**	25.00	0.2649	90.9	75	125	02/09/2021

Batch 173655 **SampType:** MSD Units **mg/Kg-dry** RPD Limit **20**
SampID: 21020428-006AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Arsenic		0.19		**47.5**	47.17	2.586	95.1	50.65	6.51	02/09/2021
Barium		0.19	B	**530**	188.7	347.0	96.8	552.2	4.18	02/10/2021
Beryllium		0.28		**5.42**	4.717	0.7113	99.8	5.596	3.20	02/09/2021
Cadmium		0.19		**4.59**	4.717	0	97.2	4.942	7.46	02/09/2021
Calcium	*	47.2		**1880**	235.8	1589	122.5	1892	0.75	02/09/2021
Iron		9.43	S	**16100**	188.7	13880	1179	15670	2.73	02/09/2021
Lead		0.19		**73.4**	47.17	27.78	96.7	78.03	6.16	02/10/2021
Lithium	*	0.28		**65.1**	47.17	12.58	111.4	68.10	4.44	02/09/2021
Manganese		0.94	SR	**2030**	47.17	1319	1513	1352	40.20	02/09/2021
Molybdenum		0.19		**39.1**	47.17	0.3801	82.2	41.47	5.78	02/09/2021
Selenium		0.94		**40.7**	47.17	0	86.3	43.85	7.49	02/09/2021
Thallium		0.19		**22.0**	23.58	0.2649	92.2	23.00	4.41	02/09/2021

Batch 173799 **SampType:** MBLK Units **mg/Kg-dry**
SampID: MBLK-173799

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Boron		5.00	S	**< 5.00**	0.8000	0	102.0	-100	100	02/12/2021
Chromium		0.50		**< 0.50**	0.2000	0	0	-100	100	02/12/2021
Cobalt		0.20		**< 0.20**	0.0253	0	0	-100	100	02/12/2021

SW-846 3050B, 6020A, METALS BY ICPMS

Batch 173799 **SampType:** **LCS** Units **mg/Kg-dry**
SampID: LCS-173799

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Boron		5.00	B	**55.2**	50.00	0	110.5	80	120	02/12/2021
Chromium		0.50		**22.4**	20.00	0	112.2	80	120	02/12/2021
Cobalt		0.20		**56.3**	50.00	0	112.6	80	120	02/12/2021

Batch 173799 **SampType:** **MS** Units **mg/Kg-dry**
SampID: 21020428-006AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Boron		4.81	BS	**29.3**	48.08	0.8586	59.2	75	125	02/12/2021
Chromium		0.48		**37.4**	19.23	18.68	97.5	75	125	02/12/2021
Cobalt		0.19	S	**180**	48.08	109.8	145.8	75	125	02/12/2021

Batch 173799 **SampType:** **MSD** Units **mg/Kg-dry** RPD Limit **20**
SampID: 21020428-006AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Boron		4.63	BS	**27.0**	46.30	0.8586	56.6	29.31	8.02	02/12/2021
Chromium		0.46		**36.1**	18.52	18.68	94.1	37.43	3.59	02/12/2021
Cobalt		0.19	SR	**224**	46.30	109.8	246.0	179.9	21.71	02/12/2021

Batch 173868 **SampType:** **MBLK** Units **mg/Kg-dry**
SampID: MBLK-173868

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.40		**< 0.40**	0.1500	0	0	-100	100	02/16/2021

Batch 173868 **SampType:** **LCS** Units **mg/Kg-dry**
SampID: LCS-173868

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.40		**46.0**	50.00	0	91.9	80	120	02/16/2021

Batch 173868 **SampType:** **MS** Units **mg/Kg-dry**
SampID: 21020428-006AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Antimony		0.38		**43.4**	48.08	0.2009	89.9	75	125	02/16/2021

Client: Geosyntec Consultants

Client Project: Vistra Joppa GLP8021

Work Order: 21020428

Report Date: 17-Feb-21

SW-846 3050B, 6020A, METALS BY ICPMS

Batch 173868 **SampType:** MSD Units **mg/Kg-dry** RPD Limit **20**
SampID: 21020428-006AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Antimony		0.37		**41.8**	46.30	0.2009	89.9	43.40	3.71	02/16/2021

SW-846 7471B

Batch 173704 **SampType:** MBLK Units **mg/Kg**
SampID: MBLK-173704

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.010		**< 0.010**	0.0045	0	0	-100	100	02/09/2021

Batch 173704 **SampType:** LCS Units **mg/Kg**
SampID: LCS-173704

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.010		**0.250**	0.2500	0	99.8	85	115	02/09/2021

Batch 173704 **SampType:** MS Units **mg/Kg-dry**
SampID: 21020428-006AMS

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	Low Limit	High Limit	Date Analyzed
Mercury		0.012		**0.317**	0.2878	0.008627	107.1	75	125	02/09/2021

Batch 173704 **SampType:** MSD Units **mg/Kg-dry** RPD Limit **15**
SampID: 21020428-006AMSD

Analyses	Cert	RL	Qual	Result	Spike	SPK Ref Val	%REC	RPD Ref Val	%RPD	Date Analyzed
Mercury		0.012		**0.319**	0.2983	0.008627	104.0	0.3167	0.64	02/09/2021

Teklab Inc.
Environmental Laboratory

Receiving Check List

http://www.teklabinc.com/

Client: Geosyntec Consultants
Client Project: Vistra Joppa GLP8021

Work Order: 21020428
Report Date: 17-Feb-21

Carrier: Tim Mathis

Received By: MEK

Completed by: Mary E. Kemp
On:
05-Feb-21
Mary E. Kemp

Reviewed by: Marvin L. Darling II
On:
05-Feb-21
Marvin L. Darling

Pages to follow: Chain of custody 2 Extra pages included 14

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐	Temp °C 6.8
Type of thermal preservation?	None ☐	Ice ☑	Blue Ice ☐	Dry Ice ☐
Chain of custody present?	Yes ☑	No ☐		
Chain of custody signed when relinquished and received?	Yes ☑	No ☐		
Chain of custody agrees with sample labels?	Yes ☑	No ☐		
Samples in proper container/bottle?	Yes ☐	No ☑		
Sample containers intact?	Yes ☑	No ☐		
Sufficient sample volume for indicated test?	Yes ☑	No ☐		
All samples received within holding time?	Yes ☑	No ☐		
Reported field parameters measured:	Field ☐	Lab ☐	NA ☑	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐		

When thermal preservation is required, samples are compliant with a temperature between 0.1°C - 6.0°C, or when samples are received on ice the same day as collected.

Water – at least one vial per sample has zero headspace?	Yes ☐	No ☐	No VOA vials ☑
Water - TOX containers have zero headspace?	Yes ☐	No ☐	No TOX containers ☑
Water - pH acceptable upon receipt?	Yes ☑	No ☐	NA ☐
NPDES/CWA TCN interferences checked/treated in the field?	Yes ☐	No ☐	NA ☑

Any No responses must be detailed below or on the COC.

pH strip #74446. - MKemp - 2/5/2021 4:58:00 PM

EQB-20210128 sample received in an incorrect container for TOC analysis. Allison Kreinberg was notified of this error via VM. MEK/mld 2/5/21

CHAIN OF CUSTODY

pg. 1 of 2 Work order # 21020428

TEKLAB, INC. 5445 Horseshoe Lake Road - Collinsville, IL 62234 - Phone: (618) 344-1004 - Fax: (618) 344-1005

Client: Geosyntec Consultants
Address: 1 McBride and Son Center Drive, Suite 202
City / State / Zip Chesterfield, MO 63005
Contact: Allison Kreinberg **Phone:** (636) 812-0809
E-Mail: AKreinberg@Geosyntec.com **Fax:**

Are these samples known to be involved in litigation? If yes, a surcharge will apply ☐ Yes ☒ No
Are these samples known to be hazardous? ☐ Yes ☒ No
Are there any required reporting limits to be met on the requested analysis?. If yes, please provide limits in the *comment* section. ☐ Yes ☒ No

Samples on: ☑ ICE ☐ BLUE ICE ☐ NO ICE 0.8 °C LTG# 5
Preserved in: ☐ LAB ☑ FIELD **FOR LAB USE ONLY**
Lab Notes PHV ~~7~~4446 PRt 2/5/21

Client Comments: Bottleware labeled "G09M" are written as G09 on sample bottles, Please use G09M [redacted] Toc/metals sample combined into one jar at G0 Two jars provided for G09M Samples

Project Name/Number Vistra Joppa GZP 2021
Sample Collector's Name Sean Kosty / Amanda Toye

Results Requested ☒ Standard ☐ 1-2 Day (100% Surcharge) ☐ Other ____ ☐ 3 Day (50% Surcharge)

Billing Instructions

Lab Use Only	Sample Identification	Date/Time Sampled	UNPRES	HNO3	NaOH	H2SO4	HCL	MeOH	NaHSO4	OTHER	Aqueous	Drinking Water	Soil	Sludge	Special Waste	Groundwater	Metals	TOC
21020428-001	SB-G09M-(10-12)-20210126	1/26/21 11:00	X 2										X				X	X
002	SB-G09M-(82-84)-20210127	1/27/21 9:30	X 2										X				X	X
003	SB-G09M-(110-112)-20210127	1/27/21 11:00	X 2										X				X	X
004	SB-G09M-(142-144)-20210128	1/28/21 15:00	X 2										X				X	X
005	[redacted] BQB-20210128 SK	1/28/21 16:00		1							X						X	X
006	SB-G03-(30-32)-20210202	2/2/21 11:10	X										X				X	X
006 007	SB-G03-(30-32)-20210202-MS	2/2/21 11:10	X										X				X	X
006 008	SB-G03-(30-32)-20210202-MSD	2/2/21 11:10	X										X				X	X
007 009	SB-G03-(58-60)-20210202	2/2/21 13:30	X										X				X	X
008 010	SB-G03-(58-60)-20210202-DUP	2/2/21 13:30	X										X				X	X

MEK 2/5/21 TE

Relinquished By	Date/Time	Received By	Date/Time
			2/5/21 1425
	2/5/21 1425		2.5.21 15—
	2.5.21	Mary Kamp	2/5/21 1545

The individual signing this agreement on behalf of the client, acknowledges that he/she has read and understands the terms and conditions of this agreement, and that he/she has the authority to sign on behalf of the client. See www.teklabinc.com for terms and conditions.

BottleOrder: 63216

PRK 2/5/21

CHAIN OF CUSTODY

pg. 2 of 2 Work order # 21020428

TEKLAB, INC. 5445 Horseshoe Lake Road - Collinsville, IL 62234 - Phone: (618) 344-1004 - Fax: (618) 344-1005

Client: Geosyntec Consultants
Address: 1 McBride and Son Center Drive, Suite 202
City / State / Zip Chesterfield, MO 63005
Contact: Allison Kreinberg **Phone:** (636) 812-0809
E-Mail: AKreinberg@Geosyntec.com **Fax:**

Samples on: ▨ ICE ▨ BLUE ICE ▨ NO ICE ______ °C LTG# ______
Preserved in: ▨ LAB ▨ FIELD **FOR LAB USE ONLY**
Lab Notes

Client Comments:

Are these samples known to be involved in litigation? If yes, a surcharge will apply ☐ Yes ☒ No
Are these samples known to be hazardous? ☐ Yes ☒ No
Are there any required reporting limits to be met on the requested analysis?. If yes, please provide limits in the comment section. ☐ Yes ☒ No

Project Name/Number Vistra Joppa GLP8021
Sample Collector's Name Sean Kardy

Results Requested
☒ Standard ☐ 1-2 Day (100% Surcharge)
☐ Other ______ ☐ 3 Day (50% Surcharge)

Billing Instructions

Lab Use Only	Sample Identification	Date/Time Sampled	UNPRES	HNO3	NaOH	H2SO4	HCL	MeOH	NaHSO4	OTHER	Aqueous	Drinking Water	Soil	Sludge	Special Waste	Groundwater	Metals	TOC
21020428-009	EQB-20210202	2/2/21, 13:45		1							X						X	X

Relinquished By	Date/Time	Received By	Date/Time
			2/5/21 1425
	2/5/21 1455		2.5.21 1455
	2.5.21 ~~145~~	Mary Kamp	2/5/21 1545

The individual signing this agreement on behalf of the client, acknowledges that he/she has read and understands the terms and conditions of this agreement, and that he/she has the authority to sign on behalf of the client. See www.teklabinc.com for terms and conditions.

BottleOrder: 63216

www.pacelabs.com

Pace Analytical Services, LLC
1241 Bellevue Street - Suite 9
Green Bay, WI 54302
(920)469-2436

February 12, 2021

Elizabeth Hurley
Teklab, Inc
5445 Horseshoe Lake Rd
Collinsville, IL 62234

RE: Project: 21020428
Pace Project No.: 40221986

Dear Elizabeth Hurley:

Enclosed are the analytical results for sample(s) received by the laboratory on February 09, 2021. The results relate only to the samples included in this report. Results reported herein conform to the applicable TNI/NELAC Standards and the laboratory's Quality Manual, where applicable, unless otherwise noted in the body of the report.

The test results provided in this final report were generated by each of the following laboratories within the Pace Network:

- Pace Analytical Services - Green Bay

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Brian Basten
brian.basten@pacelabs.com
(920)469-2436
Project Manager

Enclosures

cc: Mike Austin, Teklab, Inc

CERTIFICATIONS

Project:	21020428
Pace Project No.:	40221986

Pace Analytical Services Green Bay

1241 Bellevue Street, Green Bay, WI 54302
Florida/NELAP Certification #: E87948
Illinois Certification #: 200050
Kentucky UST Certification #: 82
Louisiana Certification #: 04168
Minnesota Certification #: 055-999-334
New York Certification #: 12064
North Dakota Certification #: R-150
Virginia VELAP ID: 460263
South Carolina Certification #: 83006001
Texas Certification #: T104704529-14-1
Wisconsin Certification #: 405132750
Wisconsin DATCP Certification #: 105-444
USDA Soil Permit #: P330-16-00157
Federal Fish & Wildlife Permit #: LE51774A-0

SAMPLE SUMMARY

Project: 21020428
Pace Project No.: 40221986

Lab ID	Sample ID	Matrix	Date Collected	Date Received
40221986001	**21020428-001**	Solid	01/26/21 11:00	02/09/21 11:35
40221986002	**21020428-002**	Solid	01/27/21 09:30	02/09/21 11:35
40221986003	**21020428-003**	Solid	01/27/21 11:00	02/09/21 11:35
40221986004	**21020428-004**	Solid	01/28/21 15:00	02/09/21 11:35
40221986005	**21020428-006**	Solid	02/02/21 11:10	02/09/21 11:35
40221986006	**21020428-007**	Solid	02/02/21 13:30	02/09/21 11:35
40221986007	**21020428-008**	Solid	02/02/21 13:30	02/09/21 11:35

SAMPLE ANALYTE COUNT

Project: 21020428
Pace Project No.: 40221986

Lab ID	Sample ID	Method	Analysts	Analytes Reported
40221986001	**21020428-001**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4
40221986002	**21020428-002**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4
40221986003	**21020428-003**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4
40221986004	**21020428-004**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4
40221986005	**21020428-006**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4
40221986006	**21020428-007**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4
40221986007	**21020428-008**	ASTM D2974-87	MMX	1
		EPA 9060 Modified	TJJ	4

PASI-G = Pace Analytical Services - Green Bay

ANALYTICAL RESULTS

Project: 21020428
Pace Project No.: 40221986

Sample: 21020428-001 **Lab ID: 40221986001** Collected: 01/26/21 11:00 Received: 02/09/21 11:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**18.5**	%	0.10	0.10	1		02/09/21 15:26		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**4.0**	%	0.10	0.10	1		02/11/21 04:58		
Total Organic Carbon	**969**	mg/kg	737	220	1		02/11/21 04:58	7440-44-0	
Total Organic Carbon	**931**	mg/kg	740	221	1		02/11/21 05:03	7440-44-0	
Mean Total Organic Carbon	**950**	mg/kg	738	220	1		02/11/21 04:58	7440-44-0	C4

Sample: 21020428-002 **Lab ID: 40221986002** Collected: 01/27/21 09:30 Received: 02/09/21 11:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**17.7**	%	0.10	0.10	1		02/09/21 15:27		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**6.1**	%	0.10	0.10	1		02/10/21 11:53		
Total Organic Carbon	**492J**	mg/kg	736	220	1		02/10/21 11:53	7440-44-0	
Total Organic Carbon	**464J**	mg/kg	736	220	1		02/10/21 11:59	7440-44-0	
Mean Total Organic Carbon	**478J**	mg/kg	736	220	1		02/10/21 11:53	7440-44-0	C4

Sample: 21020428-003 **Lab ID: 40221986003** Collected: 01/27/21 11:00 Received: 02/09/21 11:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**21.9**	%	0.10	0.10	1		02/09/21 15:27		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**4.8**	%	0.10	0.10	1		02/10/21 12:05		
Total Organic Carbon	**595J**	mg/kg	767	229	1		02/10/21 12:05	7440-44-0	

ANALYTICAL RESULTS

Project: 21020428
Pace Project No.: 40221986

Sample: 21020428-003 **Lab ID: 40221986003** Collected: 01/27/21 11:00 Received: 02/09/21 11:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Total Organic Carbon	**624J**	mg/kg	762	227	1		02/10/21 12:11	7440-44-0	
Mean Total Organic Carbon	**610J**	mg/kg	765	228	1		02/10/21 12:05	7440-44-0	C4

Sample: 21020428-004 **Lab ID: 40221986004** Collected: 01/28/21 15:00 Received: 02/09/21 11:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**15.9**	%	0.10	0.10	1		02/09/21 15:27		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**36.9**	%	0.10	0.10	1		02/10/21 12:17		
Total Organic Carbon	**24800**	mg/kg	1660	496	1		02/10/21 12:17	7440-44-0	
Total Organic Carbon	**17100**	mg/kg	1690	506	1		02/10/21 12:24	7440-44-0	
Mean Total Organic Carbon	**20900**	mg/kg	1680	501	1		02/10/21 12:17	7440-44-0	C4

Sample: 21020428-006 **Lab ID: 40221986005** Collected: 02/02/21 11:10 Received: 02/09/21 11:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**17.7**	%	0.10	0.10	1		02/09/21 15:27		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**1.8**	%	0.10	0.10	1		02/10/21 12:30		
Total Organic Carbon	**493J**	mg/kg	727	217	1		02/10/21 12:30	7440-44-0	
Total Organic Carbon	**502J**	mg/kg	726	217	1		02/10/21 12:36	7440-44-0	
Mean Total Organic Carbon	**497J**	mg/kg	726	217	1		02/10/21 12:30	7440-44-0	C4

ANALYTICAL RESULTS

Project: 21020428
Pace Project No.: 40221986

Sample: 21020428-007 **Lab ID: 40221986006** Collected: 02/02/21 13:30 Received: 02/09/21 11:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**18.1**	%	0.10	0.10	1		02/09/21 15:27		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**14.7**	%	0.10	0.10	1		02/10/21 13:05		
Total Organic Carbon	**<221**	mg/kg	740	221	1		02/10/21 13:05	7440-44-0	
Total Organic Carbon	**<220**	mg/kg	737	220	1		02/10/21 13:10	7440-44-0	
Mean Total Organic Carbon	**<220**	mg/kg	738	220	1		02/10/21 13:05	7440-44-0	C4

Sample: 21020428-008 **Lab ID: 40221986007** Collected: 02/02/21 13:30 Received: 02/09/21 11:35 Matrix: Solid

Results reported on a "dry weight" basis and are adjusted for percent moisture, sample size and any dilutions.

Parameters	Results	Units	LOQ	LOD	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974-87 Pace Analytical Services - Green Bay								
Percent Moisture	**17.2**	%	0.10	0.10	1		02/09/21 15:27		
Total Organic Carbon	Analytical Method: EPA 9060 Modified Pace Analytical Services - Green Bay								
Surrogates									
RPD%	**30.6**	%	0.10	0.10	1		02/11/21 05:31		
Total Organic Carbon	**<216**	mg/kg	723	216	1		02/11/21 05:31	7440-44-0	
Total Organic Carbon	**<215**	mg/kg	720	215	1		02/11/21 05:36	7440-44-0	
Mean Total Organic Carbon	**<215**	mg/kg	722	215	1		02/11/21 05:31	7440-44-0	C4

QUALITY CONTROL DATA

Project: 21020428
Pace Project No.: 40221986

QC Batch: 377476
QC Batch Method: ASTM D2974-87
Analysis Method: ASTM D2974-87
Analysis Description: Dry Weight/Percent Moisture
Laboratory: Pace Analytical Services - Green Bay
Associated Lab Samples: 40221986001, 40221986002, 40221986003, 40221986004, 40221986005, 40221986006, 40221986007

SAMPLE DUPLICATE: 2179074

Parameter	Units	40221986005 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	17.7	17.7	0	10	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

QUALITY CONTROL DATA

Project: 21020428
Pace Project No.: 40221986

QC Batch: 377488
QC Batch Method: EPA 9060 Modified
Analysis Method: EPA 9060 Modified
Analysis Description: 9060 TOC Average
Laboratory: Pace Analytical Services - Green Bay
Associated Lab Samples: 40221986001, 40221986002, 40221986003, 40221986004, 40221986005, 40221986006, 40221986007

METHOD BLANK: 2179146 Matrix: Solid
Associated Lab Samples: 40221986001, 40221986002, 40221986003, 40221986004, 40221986005, 40221986006, 40221986007

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mean Total Organic Carbon	mg/kg	<179	600	02/10/21 08:59	

LABORATORY CONTROL SAMPLE: 2179147

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mean Total Organic Carbon	mg/kg	120000	113000	94	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 2179148 2179149

Parameter	Units	40221986001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mean Total Organic Carbon	mg/kg	950	7400	7390	8270	8130	99	97	50-150	2	30	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 2179150 2179151

Parameter	Units	40221986005 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mean Total Organic Carbon	mg/kg	497J	7250	7240	7150	6620	92	85	50-150	8	30	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

QUALIFIERS

Project: 21020428
Pace Project No.: 40221986

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above LOD.

J - Estimated concentration at or above the LOD and below the LOQ.

LOD - Limit of Detection adjusted for dilution factor, percent moisture, initial weight and final volume.

LOQ - Limit of Quantitation adjusted for dilution factor, percent moisture, initial weight and final volume.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected at or above the adjusted LOD.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

ANALYTE QUALIFIERS

C4	Sample container did not meet EPA or method requirements.

QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: 21020428
Pace Project No.: 40221986

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
40221986001	**21020428-001**	ASTM D2974-87	377476		
40221986002	**21020428-002**	ASTM D2974-87	377476		
40221986003	**21020428-003**	ASTM D2974-87	377476		
40221986004	**21020428-004**	ASTM D2974-87	377476		
40221986005	**21020428-006**	ASTM D2974-87	377476		
40221986006	**21020428-007**	ASTM D2974-87	377476		
40221986007	**21020428-008**	ASTM D2974-87	377476		
40221986001	**21020428-001**	EPA 9060 Modified	377488		
40221986001	**21020428-001**	EPA 9060 Modified	377489		
40221986002	**21020428-002**	EPA 9060 Modified	377488		
40221986002	**21020428-002**	EPA 9060 Modified	377489		
40221986003	**21020428-003**	EPA 9060 Modified	377488		
40221986003	**21020428-003**	EPA 9060 Modified	377489		
40221986004	**21020428-004**	EPA 9060 Modified	377488		
40221986004	**21020428-004**	EPA 9060 Modified	377489		
40221986005	**21020428-006**	EPA 9060 Modified	377488		
40221986005	**21020428-006**	EPA 9060 Modified	377489		
40221986006	**21020428-007**	EPA 9060 Modified	377488		
40221986006	**21020428-007**	EPA 9060 Modified	377489		
40221986007	**21020428-008**	EPA 9060 Modified	377488		
40221986007	**21020428-008**	EPA 9060 Modified	377489		

Pg ___ of ___

4024984

TEKLAB, INC. Chain of Custody

5445 Horseshoe Lake Road, Collinsville, IL 62234 Phone (618) 344-1004 Fax (618) 344-1005

Are the samples chilled? YES ☐ NO ☐ With: ☐ Ice ☐ Blue Ice Preserved in: ☐ Lab ☐ Field

Teklab Inc
5445 Horseshoe Lake Road
Collinsville, IL 62234

Cooler Temp: .
Sampler:
QC Level: 3

Project#: 21020428
Contact: Aaron Renner
Requested Due Date: STD TAT
Email: arenner@teklabinc.com
Billing/PO: 30746

Comments: **Please Issue reports and invoices via email only**
Please analyze for Total Organic Carbon SW-846 Method 9060M
on your standard turnaround time.
Batch QC is required for all analyses requested.

`Any changes to analysis/methods must be approved by Teklab, Inc.`

Phone: ((630) 324-6855

PLEASE NOTE:

NELAP accreditation is required on the requested analytes and must be documented as such on the final report. If your laboratory does not currently hold a NELAP accreditation for the requested method and/or analytes, please contact Teklab immediately. If your laboratory loses accreditation or is suspended for any analyte/method during the life of the contract, you must contact Teklab immediately.

Lab Use	Sample ID	Sample Date/Time	Preservative	Matrix	TOC	MS/MSD										
001	21020428-001	1/26/21 11:00	Unpres	Soil	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
002	21020428-002	1/27/21 9:30	Unpres	Soil	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
003	21020428-003	1/27/21 11:00	Unpres	Soil	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
004	21020428-004	1/28/21 15:00	Unpres	Soil	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
005	21020428-006	2/2/21 11:10	Unpres	Soil	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
006	21020428-007	2/2/21 13:30	Unpres	Soil	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
007	21020428-008	2/2/21 13:30	Unpres	Soil	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Aqueous	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Aqueous	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Aqueous	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
			Unpres	Aqueous	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

*Relinquished By	Date/Time	Received By	Date/Time
Mary Kemp	2/8/21 1700		
FedEx	2/9/21 1135	Nicole Hreel Pace	2/9/21 1135

Teklab maintains a strict policy of client confidentiality and as such does not provide client/sampler information without proper authorization. and proprietary rights, Teklab, Inc. protects clients' confidential information as directed by local, state or federal laws. (Teklab QAM Section 9.1, TNI V1 M2 Section 4.1.5 c)

Pace Analytical Services, LLC
1241 Bellevue Street, Suite 9
Green Bay, WI 54302

Sample Preservation Receipt Form

Client Name: Teklab

Project # 40221986

All containers needing preservation have been checked and noted below: ☐Yes ☐No [✓ N/A]

Lab Lot# of pH paper:

Lab Std #ID of preservation (if pH adjusted):

Initial when completed:

Date/ Time:

Pace Lab #	Glass								Plastic					Vials						Jars				General			VOA Vials (>6mm) *	H2SO4 pH ≤2	NaOH+Zn Act pH ≥9	NaOH pH ≥12	HNO3 pH ≤2	pH after adjusted	Volume (mL)
	AG1U	BG1U	AG1H	AG4S	AG4U	AG5U	AG2S	BG3U	BP1U	BP3U	BP3B	BP3N	BP3S	VG9A	DG9T	VG9U	VG9H	VG9M	VG9D	JGFU	JG9U	WGFU	WPFU	SP5T	ZPLC	GN							
001																						1											2.5 / 5 / 10
002																						1											2.5 / 5 / 10
003																						1											2.5 / 5 / 10
004																						1											2.5 / 5 / 10
005																						2											2.5 / 5 / 10
006																						1											2.5 / 5 / 10
007																						1											2.5 / 5 / 10
008																																	2.5 / 5 / 10
009																																	2.5 / 5 / 10
010																																	2.5 / 5 / 10
011																																	2.5 / 5 / 10
012																																	2.5 / 5 / 10
013																																	2.5 / 5 / 10
014																																	2.5 / 5 / 10
015																																	2.5 / 5 / 10
016																																	2.5 / 5 / 10
017																																	2.5 / 5 / 10
018																																	2.5 / 5 / 10
019																																	2.5 / 5 / 10
020																																	2.5 / 5 / 10

2/9/21

Exceptions to preservation check: VOA, Coliform, TOC, TOX, TOH, O&G, WI DRO, Phenolics, Other:__________ Headspace in VOA Vials (>6mm) : ☐Yes ☐No [✓ N/A] ***If yes look in headspace column**

AG1U	1 liter amber glass
BG1U	1 liter clear glass
AG1H	1 liter amber glass HCL
AG4S	125 mL amber glass H2SO4
AG4U	120 mL amber glass unpres
AG5U	100 mL amber glass unpres
AG2S	500 mL amber glass H2SO4
BG3U	250 mL clear glass unpres

BP1U	1 liter plastic unpres
BP3U	250 mL plastic unpres
BP3B	250 mL plastic NaOH
BP3N	250 mL plastic HNO3
BP3S	250 mL plastic H2SO4

VG9A	40 mL clear ascorbic
DG9T	40 mL amber Na Thio
VG9U	40 mL clear vial unpres
VG9H	40 mL clear vial HCL
VG9M	40 mL clear vial MeOH
VG9D	40 mL clear vial DI

JGFU	4 oz amber jar unpres
JG9U	9 oz amber jar unpres
WGFU	4 oz clear jar unpres
WPFU	4 oz plastic jar unpres
SP5T	120 mL plastic Na Thiosulfate
ZPLC	ziploc bag
GN	

Pace Analytical® 1241 Bellevue Street, Green Bay, WI 54302	Document Name: **Sample Condition Upon Receipt (SCUR)**	Document Revised: 26Mar2020
	Document No.: **ENV-FRM-GBAY-0014-Rev.00**	Author: Pace Green Bay Quality Office

Sample Condition Upon Receipt Form (SCUR)

Project #:

WO# : 40221986

40221986

Client Name: Teklab

Courier: ☐ CS Logistics ☑ Fed Ex ☐ Speedee ☐ UPS ☐ Waltco ☐ Client ☐ Pace Other:

Tracking #: 9450 9224 6086

Custody Seal on Cooler/Box Present: ☐ yes ☑ no Seals intact: ☐ yes ☐ no

Custody Seal on Samples Present: ☐ yes ☑ no Seals intact: ☐ yes ☐ no

Packing Material: ☑ Bubble Wrap ☑ Bubble Bags ☐ None ☐ Other

Thermometer Used SR - 97 **Type of Ice:** [✓ Wet] Blue Dry None ☑ Samples on ice, cooling process has begun

Cooler Temperature Uncorr: 0 /Corr: 0

Temp Blank Present: ☐ yes ☑ no **Biological Tissue is Frozen:** ☐ yes ☐ no

Temp should be above freezing to 6°C.
Biota Samples may be received at ≤ 0°C if shipped on Dry Ice.

Person examining contents:
Date: 2/9/21 /Initials: NM
Labeled By Initials:

Chain of Custody Present:	☑Yes ☐No ☐N/A	1.
Chain of Custody Filled Out:	☐Yes ☑No ☐N/A	2. pg # 2/9/21 NM
Chain of Custody Relinquished:	☑Yes ☐No ☐N/A	3.
Sampler Name & Signature on COC:	☐Yes ☐No ☑N/A	4. Subwork 2/9/21 NM
Samples Arrived within Hold Time:	☑Yes ☐No	5.
- VOA Samples frozen upon receipt	☐Yes ☐No	Date/Time:
Short Hold Time Analysis (<72hr):	☐Yes ☑No	6.
Rush Turn Around Time Requested:	☐Yes ☑No	7.
Sufficient Volume: For Analysis: ☑Yes ☐No MS/MSD:	☑Yes ☐No ☐N/A	8.
Correct Containers Used: 2/9/21 NM	~~☑Yes~~ [✓ ☑No]	9. TOC=AG 2/9/21 NM
-Pace Containers Used:	☐Yes ☑No ☐N/A	
-Pace IR Containers Used:	☐Yes ☐No ☑N/A	
Containers Intact:	☑Yes ☐No	10.
Filtered volume received for Dissolved tests	☐Yes ☐No ☑N/A	11.
Sample Labels match COC:	☐Yes ☑No ☐N/A	12. All sample ids include alpha-COC does not 2/9/21 NM
-Includes date/time/ID/Analysis Matrix: S		
Trip Blank Present:	☐Yes ☐No ☑N/A	13.
Trip Blank Custody Seals Present	☐Yes ☐No ☑N/A	
Pace Trip Blank Lot # (if purchased):		

Client Notification/ Resolution: If checked, see attached form for additional comments ☐

Person Contacted: Date/Time:

Comments/ Resolution:

PM Review is documented electronically in LIMs. By releasing the project, the PM acknowledges they have reviewed the sample logi

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : Joppa MNA

02-November-2021

SiREM Laboratory
Attn : Michael Healey

130 Stone Road W, Guelph
Canada, N1G 3Z2
Phone: 519-822-2265, Fax:519-822-3151

Date Rec. : 15 October 2021
LR Report: **CA12704-OCT21**
Reference: P.O# 800003210A

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: G-03 (57.5-62.5, 63.5-70.0)	6: G-07 (50.0-56.0)	7: G-08 (75.0-80.0)
Sample Date & Time					14-Oct-21 13:00	14-Oct-21 14:30	14-Oct-21 16:00
TOC [%]	22-Oct-21	02:07	22-Oct-21	15:11	0.039	0.039	0.049
Ag [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	< 0.5	< 0.5	< 0.5
Al [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	13000	17000	9700
As [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	7.8	5.8	28
Ba [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	100	170	180
Be [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	1	1	1
Bi [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	< 0.09	< 0.09	< 0.09
Ca [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	3100	1500	900
Cd [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	0.08	0.06	0.31
Co [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	6	8	29
Cr [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	41	43	30
Cu [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	5.5	10	8.2
Fe [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	40000	44000	99000
K [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	2300	3500	1700
Li [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	7.0	7.6	6.7
Mg [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	1700	530	440
Mn [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	190	320	1000
Mo [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	1.0	0.6	2.8
Na [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	460	430	300
Ni [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	13	27	29
P [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	470	460	1200
Pb [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	7	7	6
S [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	610	410	910
Sb [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	< 0.8	< 0.8	< 0.8
Se [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	< 0.7	< 0.7	< 0.7
Sn [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	< 6	< 6	< 6
Sr [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	18	41	19
Ti [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	1400	1700	460
Tl [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	0.08	0.08	0.12

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: G-03 (57.5-62.5, 63.5-70.0)	6: G-07 (50.0-56.0)	7: G-08 (75.0-80.0)
U [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	1.39	1.85	1.83
V [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	40	34	32
Y [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	7.25	8.94	15.6
Zn [µg/g]	25-Oct-21	14:17	28-Oct-21	10:00	44	140	91
LOI [%]	20-Oct-21	20:55	22-Oct-21	08:22	1.05	0.93	1.58

Catharine Arnold

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
CATHARINE ARNOLD
CHEMIST

Catharine Arnold, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

ATTACHMENT G

Sequential Extraction Procedure Analytical Data

Environment Testing America

ANALYTICAL REPORT

Eurofins Knoxville
5815 Middlebrook Pike
Knoxville, TN 37921
Tel: (865)291-3000

Laboratory Job ID: 140-25875-1
Client Project/Site: Joppa MNA

For:
Sirem, div of Geosyntec Consultants
130 Stone Rd West
Guelph, Ontario N1G 3Z2

Attn: Michael Healey

Ryan Henry

Authorized for release by:
3/21/2022 11:16:44 AM

Ryan Henry, Project Manager I
(865)291-3000
williamr.henry@eurofinset.com

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

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Table of Contents

Definitions/Glossary

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Qualifiers

Metals

Qualifier	Qualifier Description
B	Compound was found in the blank and sample.
F3	Duplicate RPD exceeds the control limit
F5	Duplicate RPD exceeds limit, and one or both sample results are less than 5 times RL, and the absolute difference between results is < the upper reporting limits for both.
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.
L	A negative instrument reading had an absolute value greater than the reporting limit

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Job ID: 140-25875-1

Laboratory: Eurofins Knoxville

Narrative

Job Narrative
140-25875-1

Receipt
The samples were received on 12/24/2021 at 8:00am and arrived in good condition, and where required, properly preserved and on ice.

Metals
7 Step Sequential Extraction Procedure

These soil samples were prepared and analyzed using Eurofins TestAmerica Knoxville standard operating procedure KNOX-MT-0008, “7 Step Sequential Extraction Procedure”. SW-846 Method 6010B as incorporated in Eurofins TestAmerica Knoxville standard operating procedure KNOX-MT-0007 was used to perform the final instrument analyses.

An aliquot of each sample was sequentially extracted using the steps listed below:

- Step 1 - Exchangeable Fraction: A 5 gram aliquot of sample was extracted with 25 mL of 1M magnesium sulfate (MgSO4), centrifuged and filtered. 5 mL of the resulting leachate was digested using method 3010A and analyzed by method 6010B. Results are reported in mg/kg on a dry weight basis.
- Step 2 - Carbonate Fraction: The sample residue from step 1 was extracted with 25 mL of 1M sodium acetate/acetic acid (NaOAc/HOAc) at pH 5, centrifuged and filtered. 5 mL of the resulting leachate was digested using method 3010A and analyzed by method 6010B. Results are reported in mg/kg on a dry weight basis.
- Step 3 - Non-crystalline Materials Fraction: The sample residue from step 2 was extracted with 25 mL of 0.2M ammonium oxalate (pH 3), centrifuged and filtered. 5 mL of the resulting leachate was digested using method 3010A and analyzed by method 6010B. Results are reported in mg/kg on a dry weight basis.
- Step 4 - Metal Hydroxide Fraction: The sample residue from step 3 was extracted with 25 mL of 1M hydroxylamine hydrochloride solution in 25% v/v acetic acid, centrifuged and filtered. 5 mL of the resulting leachate was digested using method 3010A and analyzed by method 6010B. Results are reported in mg/kg on a dry weight basis.
- Step 5 - Organic-bound Fraction: The sample residue from step 4 was extracted three times with 25 mL of 5% sodium hypochlorite (NaClO) at pH 9.5, centrifuged and filtered. The resulting leachates were combined and 5 mL were digested using method 3010A and analyzed by method 6010B. Results are reported in mg/kg on a dry weight basis.
- Step 6 - Acid/Sulfide Fraction: The sample residue from step 5 was extracted with 25 mL of a 3:1:2 v/v solution of HCl-HNO3-H2O, centrifuged and filtered. 5 mL of the resulting leachate was diluted to 50 mL with reagent water and analyzed by method 6010B. Results are reported in mg/kg on a dry weight basis.
- Step 7 - Residual Fraction: A 1.0 g aliquot of the sample residue from step 6 was digested using HF, HNO3, HCl and H3BO3. The digestate was analyzed by ICP using method 6010B. Results are reported in mg/kg on a dry weight basis.

In addition, a 1.0 g aliquot of the original sample was digested using HF, HNO3, HCl and H3BO3. The digestate was analyzed by ICP using method 6010B. Total metal results are reported in mg/kg on a dry weight basis.

Results were calculated using the following equation:

Result, µg/g or mg/Kg, dry weight = $(C \times V \times V1 \times D) / (W \times S \times V2)$

Where:
C = Concentration from instrument readout, µg/mL
V = Final volume of digestate, mL
D = Instrument dilution factor
V1 = Total volume of leachate, mL
V2 = Volume of leachate digested, mL
W = Wet weight of sample, g
S = Percent solids/100

A method blank, laboratory control sample and laboratory control sample duplicate were prepared and analyzed with each SEP step in order to provide information about both the presence of elements of interest in the extraction solutions, and the recovery of elements of

Job ID: 140-25875-1 (Continued)

Laboratory: Eurofins Knoxville (Continued)

interest from the extraction solutions. Results outside of laboratory QC limits do not reflect out of control performance, but rather the effect of the extraction solution upon the analyte.

A laboratory sample duplicate was prepared and analyzed with each batch of samples in order to provide information regarding the reproducibility of the procedure.

SEP Report Notes:

The final report lists the results for each step, the result for the total digestion of the sample, and a sum of the results of steps 1 through 7 by element.

Magnesium was not reported for step 1 because the extraction solution for this step (magnesium sulfate) contains high levels of magnesium. Sodium was not reported for steps 2 and 5 since the extraction solutions for these steps contain high levels of sodium. The sum of steps 1 through 7 is much higher than the total result for sodium and magnesium due to the magnesium and sodium introduced by the extraction solutions.

The digestates for steps 1, 2 and 5 were analyzed at a dilution due to instrument problems caused by the high solids content of the digestates. The reporting limits were adjusted accordingly.

Method 6010B: The following samples were diluted due to the presence of silicon which interferes with Arsenic: G-03 (57.5-62.5, 63.5-70.0) (140-25875-1), G-07 (50.0-56.0) (140-25875-2) and G-08 (75.0-80.0) (140-25875-3). Elevated reporting limits (RLs) are provided.

Method 6010B: The serial dilution performed for the following samples associated with batch 140-59793 was outside control limits: G-03 (57.5-62.5, 63.5-70.0) (140-25875-1)

Method 6010B SEP: The sample duplicate (DUP) precision for preparation batch 140-59371, 140-59412, 140-59413 and 140-59446 and analytical batch 140-59667 was outside control limits. Sample matrix interference and/or non-homogeneity are suspected because the associated laboratory control sample / laboratory control sample duplicate (LCS/LCSD) precision was within acceptance limits.

Method 6010B SEP: The following samples were diluted due to the presence of Iron which interferes with Arsenic. G-03 (57.5-62.5, 63.5-70.0) (140-25875-1) and G-08 (75.0-80.0) (140-25875-3). Elevated reporting limits (RLs) are provided.

Method 6010B SEP: The sample duplicate (DUP) precision for preparation batch 140-59631 and analytical batch 140-59767 was outside control limits. Sample matrix interference and/or non-homogeneity are suspected because the associated laboratory control sample / laboratory control sample duplicate (LCS/LCSD) precision was within acceptance limits.

Method 6010B SEP: The following samples were diluted due to the presence of silicon which interferes with Arsenic: G-03 (57.5-62.5, 63.5-70.0) (140-25875-1) and G-08 (75.0-80.0) (140-25875-3). Elevated reporting limits (RLs) are provided.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

General Chemistry
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Sample Summary

Client: Sirem, div of Geosyntec Consultants
Job ID: 140-25875-1
Project/Site: Joppa MNA

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Solid	12/23/21 13:00	12/24/21 08:00
140-25875-2	G-07 (50.0-56.0)	Solid	12/23/21 13:15	12/24/21 08:00
140-25875-3	G-08 (75.0-80.0)	Solid	12/23/21 13:30	12/24/21 08:00

Client Sample Results

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)

Date Collected: 12/23/21 13:00
Date Received: 12/24/21 08:00

Lab Sample ID: 140-25875-1

Matrix: Solid
Percent Solids: 86.8

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Method: 6010B SEP - SEP Metals (ICP) - Step 1

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**0.61**	**J**	2.3	0.60	mg/Kg	☼	03/01/22 08:00	03/09/22 11:40	4
Boron	ND		46	46	mg/Kg	☼	03/01/22 08:00	03/09/22 11:40	4
Cobalt	ND		12	0.21	mg/Kg	☼	03/01/22 08:00	03/09/22 11:40	4
Lithium	ND		12	0.69	mg/Kg	☼	03/01/22 08:00	03/09/22 11:40	4
Molybdenum	ND		9.2	0.38	mg/Kg	☼	03/01/22 08:00	03/09/22 11:40	4

Method: 6010B SEP - SEP Metals (ICP) - Step 2

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**0.51**	**J**	1.7	0.45	mg/Kg	☼	03/02/22 08:00	03/09/22 12:10	3
Boron	ND		35	35	mg/Kg	☼	03/02/22 08:00	03/09/22 12:10	3
Cobalt	ND		8.6	0.22	mg/Kg	☼	03/02/22 08:00	03/09/22 12:10	3
Lithium	ND		8.6	0.52	mg/Kg	☼	03/02/22 08:00	03/09/22 12:10	3
Molybdenum	ND		6.9	0.28	mg/Kg	☼	03/02/22 08:00	03/09/22 12:10	3

Method: 6010B SEP - SEP Metals (ICP) - Step 3

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**0.40**	**J**	0.58	0.15	mg/Kg	☼	03/03/22 08:20	03/10/22 10:45	1
Boron	ND		12	12	mg/Kg	☼	03/03/22 08:20	03/10/22 10:45	1
Cobalt	**0.85**	**J**	2.9	0.052	mg/Kg	☼	03/03/22 08:20	03/10/22 10:45	1
Lithium	ND		2.9	0.17	mg/Kg	☼	03/03/22 08:20	03/10/22 10:45	1
Molybdenum	ND		2.3	0.095	mg/Kg	☼	03/03/22 08:20	03/10/22 10:45	1

Method: 6010B SEP - SEP Metals (ICP) - Step 4

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**2.4**	**B**	0.58	0.25	mg/Kg	☼	03/04/22 08:00	03/10/22 11:49	1
Boron	ND		12	12	mg/Kg	☼	03/04/22 08:00	03/10/22 11:49	1
Cobalt	**1.4**	**J**	2.9	0.061	mg/Kg	☼	03/04/22 08:00	03/10/22 11:49	1
Lithium	**0.27**	**J**	2.9	0.17	mg/Kg	☼	03/04/22 08:00	03/10/22 11:49	1
Molybdenum	**0.10**	**J**	2.3	0.095	mg/Kg	☼	03/04/22 08:00	03/10/22 11:49	1

Method: 6010B SEP - SEP Metals (ICP) - Step 5

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		8.6	2.2	mg/Kg	☼	03/09/22 08:00	03/11/22 13:19	5
Boron	ND		170	170	mg/Kg	☼	03/09/22 08:00	03/11/22 13:19	5
Cobalt	ND		43	0.69	mg/Kg	☼	03/09/22 08:00	03/11/22 13:19	5
Lithium	ND		43	2.5	mg/Kg	☼	03/09/22 08:00	03/11/22 13:19	5
Molybdenum	ND		35	1.4	mg/Kg	☼	03/09/22 08:00	03/11/22 13:19	5

Method: 6010B SEP - SEP Metals (ICP) - Step 6

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**7.5**		1.2	0.35	mg/Kg	☼	03/09/22 08:00	03/11/22 15:07	2
Boron	ND		12	12	mg/Kg	☼	03/09/22 08:00	03/11/22 14:23	1
Cobalt	**3.5**		2.9	0.053	mg/Kg	☼	03/09/22 08:00	03/11/22 14:23	1
Lithium	**1.1**	**J**	2.9	0.17	mg/Kg	☼	03/09/22 08:00	03/11/22 14:23	1
Molybdenum	**0.40**	**J**	2.3	0.11	mg/Kg	☼	03/09/22 08:00	03/11/22 14:23	1

Method: 6010B SEP - SEP Metals (ICP) - Step 7

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**3.2**	**B**	1.2	0.30	mg/Kg	☼	03/10/22 08:05	03/15/22 13:23	2
Cobalt	ND		2.9	0.030	mg/Kg	☼	03/10/22 08:05	03/15/22 12:37	1
Lithium	**3.2**		2.9	0.17	mg/Kg	☼	03/10/22 08:05	03/15/22 12:37	1

Client Sample Results

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)

Date Collected: 12/23/21 13:00
Date Received: 12/24/21 08:00

Lab Sample ID: 140-25875-1
Matrix: Solid
Percent Solids: 86.8

Method: 6010B SEP - SEP Metals (ICP) - Step 7 (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Molybdenum	ND		2.3	0.095	mg/Kg	☼	03/10/22 08:05	03/15/22 12:37	1

Method: 6010B SEP - SEP Metals (ICP) - Sum of Steps 1-7

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**15**		0.50	0.13	mg/Kg			03/18/22 13:19	1
Cobalt	**5.7**		2.5	0.023	mg/Kg			03/18/22 13:19	1
Lithium	**4.5**		2.5	0.15	mg/Kg			03/18/22 13:19	1
Molybdenum	**0.50**	**J**	2.0	0.082	mg/Kg			03/18/22 13:19	1

Method: 6010B - SEP Metals (ICP) - Total

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**7.9**	**B**	1.2	0.30	mg/Kg	☼	02/28/22 08:00	03/16/22 14:31	2
Cobalt	**5.6**		2.9	0.030	mg/Kg	☼	02/28/22 08:00	03/16/22 13:45	1
Lithium	**5.4**		2.9	0.17	mg/Kg	☼	02/28/22 08:00	03/16/22 13:45	1
Molybdenum	**0.65**	**J**	2.3	0.095	mg/Kg	☼	02/28/22 08:00	03/16/22 13:45	1

Client Sample ID: G-07 (50.0-56.0)

Lab Sample ID: 140-25875-2

Date Collected: 12/23/21 13:15
Matrix: Solid
Date Received: 12/24/21 08:00
Percent Solids: 89.1

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Method: 6010B SEP - SEP Metals (ICP) - Step 1

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		2.2	0.58	mg/Kg	☼	03/01/22 08:00	03/09/22 11:55	4
Boron	ND		45	45	mg/Kg	☼	03/01/22 08:00	03/09/22 11:55	4
Cobalt	ND		11	0.20	mg/Kg	☼	03/01/22 08:00	03/09/22 11:55	4
Lithium	ND		11	0.67	mg/Kg	☼	03/01/22 08:00	03/09/22 11:55	4
Molybdenum	ND		9.0	0.37	mg/Kg	☼	03/01/22 08:00	03/09/22 11:55	4

Method: 6010B SEP - SEP Metals (ICP) - Step 2

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		1.7	0.44	mg/Kg	☼	03/02/22 08:00	03/09/22 12:35	3
Boron	ND		34	34	mg/Kg	☼	03/02/22 08:00	03/09/22 12:35	3
Cobalt	ND		8.4	0.21	mg/Kg	☼	03/02/22 08:00	03/09/22 12:35	3
Lithium	ND		8.4	0.51	mg/Kg	☼	03/02/22 08:00	03/09/22 12:35	3
Molybdenum	ND		6.7	0.28	mg/Kg	☼	03/02/22 08:00	03/09/22 12:35	3

Method: 6010B SEP - SEP Metals (ICP) - Step 3

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**0.39**	**J**	0.56	0.15	mg/Kg	☼	03/03/22 08:20	03/10/22 11:00	1
Boron	ND		11	11	mg/Kg	☼	03/03/22 08:20	03/10/22 11:00	1
Cobalt	**0.76**	**J**	2.8	0.051	mg/Kg	☼	03/03/22 08:20	03/10/22 11:00	1
Lithium	ND		2.8	0.17	mg/Kg	☼	03/03/22 08:20	03/10/22 11:00	1
Molybdenum	ND		2.2	0.092	mg/Kg	☼	03/03/22 08:20	03/10/22 11:00	1

Method: 6010B SEP - SEP Metals (ICP) - Step 4

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**1.7**	**B**	0.56	0.25	mg/Kg	☼	03/04/22 08:00	03/10/22 12:13	1
Boron	ND		11	11	mg/Kg	☼	03/04/22 08:00	03/10/22 12:13	1
Cobalt	**0.97**	**J**	2.8	0.059	mg/Kg	☼	03/04/22 08:00	03/10/22 12:13	1
Lithium	**0.18**	**J**	2.8	0.17	mg/Kg	☼	03/04/22 08:00	03/10/22 12:13	1
Molybdenum	ND		2.2	0.092	mg/Kg	☼	03/04/22 08:00	03/10/22 12:13	1

Method: 6010B SEP - SEP Metals (ICP) - Step 5

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		8.4	2.1	mg/Kg	☼	03/09/22 08:00	03/11/22 13:34	5
Boron	ND		170	170	mg/Kg	☼	03/09/22 08:00	03/11/22 13:34	5
Cobalt	ND		42	0.67	mg/Kg	☼	03/09/22 08:00	03/11/22 13:34	5
Lithium	ND		42	2.5	mg/Kg	☼	03/09/22 08:00	03/11/22 13:34	5
Molybdenum	ND		34	1.4	mg/Kg	☼	03/09/22 08:00	03/11/22 13:34	5

Method: 6010B SEP - SEP Metals (ICP) - Step 6

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**2.4**		0.56	0.17	mg/Kg	☼	03/09/22 08:00	03/11/22 14:49	1
Boron	ND		11	11	mg/Kg	☼	03/09/22 08:00	03/11/22 14:49	1
Cobalt	**1.8**	**J**	2.8	0.052	mg/Kg	☼	03/09/22 08:00	03/11/22 14:49	1
Lithium	**0.64**	**J**	2.8	0.17	mg/Kg	☼	03/09/22 08:00	03/11/22 14:49	1
Molybdenum	ND		2.2	0.11	mg/Kg	☼	03/09/22 08:00	03/11/22 14:49	1

Method: 6010B SEP - SEP Metals (ICP) - Step 7

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**1.3**	**B**	0.56	0.15	mg/Kg	☼	03/10/22 08:05	03/15/22 12:47	1
Cobalt	ND		2.8	0.029	mg/Kg	☼	03/10/22 08:05	03/15/22 12:47	1
Lithium	**2.8**		2.8	0.17	mg/Kg	☼	03/10/22 08:05	03/15/22 12:47	1

Client Sample Results

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Client Sample ID: G-07 (50.0-56.0)

Date Collected: 12/23/21 13:15
Date Received: 12/24/21 08:00

Lab Sample ID: 140-25875-2
Matrix: Solid
Percent Solids: 89.1

Method: 6010B SEP - SEP Metals (ICP) - Step 7 (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Molybdenum	ND		2.2	0.092	mg/Kg	☼	03/10/22 08:05	03/15/22 12:47	1

Method: 6010B SEP - SEP Metals (ICP) - Sum of Steps 1-7

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**5.8**		0.50	0.13	mg/Kg			03/18/22 13:19	1
Cobalt	**3.6**		2.5	0.023	mg/Kg			03/18/22 13:19	1
Lithium	**3.7**		2.5	0.15	mg/Kg			03/18/22 13:19	1
Molybdenum	ND		2.0	0.082	mg/Kg			03/18/22 13:19	1

Method: 6010B - SEP Metals (ICP) - Total

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**7.7**	**B**	1.1	0.29	mg/Kg	☼	02/28/22 08:00	03/16/22 14:46	2
Cobalt	**6.1**		2.8	0.029	mg/Kg	☼	02/28/22 08:00	03/16/22 14:00	1
Lithium	**4.0**		2.8	0.17	mg/Kg	☼	02/28/22 08:00	03/16/22 14:00	1
Molybdenum	**0.21**	**J**	2.2	0.092	mg/Kg	☼	02/28/22 08:00	03/16/22 14:00	1

Client Sample Results

Client: Sirem, div of Geosyntec Consultants
Job ID: 140-25875-1
Project/Site: Joppa MNA

Client Sample ID: G-08 (75.0-80.0)

Date Collected: 12/23/21 13:30
Date Received: 12/24/21 08:00

Lab Sample ID: 140-25875-3

Matrix: Solid
Percent Solids: 89.5

Method: 6010B SEP - SEP Metals (ICP) - Step 1

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		2.2	0.58	mg/Kg	☼	03/01/22 08:00	03/09/22 12:00	4
Boron	ND		45	45	mg/Kg	☼	03/01/22 08:00	03/09/22 12:00	4
Cobalt	ND		11	0.20	mg/Kg	☼	03/01/22 08:00	03/09/22 12:00	4
Lithium	ND		11	0.67	mg/Kg	☼	03/01/22 08:00	03/09/22 12:00	4
Molybdenum	ND		8.9	0.37	mg/Kg	☼	03/01/22 08:00	03/09/22 12:00	4

Method: 6010B SEP - SEP Metals (ICP) - Step 2

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		1.7	0.44	mg/Kg	☼	03/02/22 08:00	03/09/22 12:40	3
Boron	ND		34	34	mg/Kg	☼	03/02/22 08:00	03/09/22 12:40	3
Cobalt	ND		8.4	0.21	mg/Kg	☼	03/02/22 08:00	03/09/22 12:40	3
Lithium	ND		8.4	0.50	mg/Kg	☼	03/02/22 08:00	03/09/22 12:40	3
Molybdenum	ND		6.7	0.27	mg/Kg	☼	03/02/22 08:00	03/09/22 12:40	3

Method: 6010B SEP - SEP Metals (ICP) - Step 3

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**0.64**		0.56	0.15	mg/Kg	☼	03/03/22 08:20	03/10/22 11:15	1
Boron	ND		11	11	mg/Kg	☼	03/03/22 08:20	03/10/22 11:15	1
Cobalt	**1.8**	**J**	2.8	0.050	mg/Kg	☼	03/03/22 08:20	03/10/22 11:15	1
Lithium	ND		2.8	0.17	mg/Kg	☼	03/03/22 08:20	03/10/22 11:15	1
Molybdenum	**0.24**	**J**	2.2	0.092	mg/Kg	☼	03/03/22 08:20	03/10/22 11:15	1

Method: 6010B SEP - SEP Metals (ICP) - Step 4

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**2.8**	**B**	0.56	0.25	mg/Kg	☼	03/04/22 08:00	03/10/22 12:18	1
Boron	ND		11	11	mg/Kg	☼	03/04/22 08:00	03/10/22 12:18	1
Cobalt	**4.4**		2.8	0.059	mg/Kg	☼	03/04/22 08:00	03/10/22 12:18	1
Lithium	ND		2.8	0.17	mg/Kg	☼	03/04/22 08:00	03/10/22 12:18	1
Molybdenum	**0.24**	**J**	2.2	0.092	mg/Kg	☼	03/04/22 08:00	03/10/22 12:18	1

Method: 6010B SEP - SEP Metals (ICP) - Step 5

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**4.5**	**J**	8.4	2.1	mg/Kg	☼	03/09/22 08:00	03/11/22 13:49	5
Boron	ND		170	170	mg/Kg	☼	03/09/22 08:00	03/11/22 13:49	5
Cobalt	ND		42	0.67	mg/Kg	☼	03/09/22 08:00	03/11/22 13:49	5
Lithium	ND		42	2.5	mg/Kg	☼	03/09/22 08:00	03/11/22 13:49	5
Molybdenum	ND		34	1.4	mg/Kg	☼	03/09/22 08:00	03/11/22 13:49	5

Method: 6010B SEP - SEP Metals (ICP) - Step 6

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**10**		1.1	0.34	mg/Kg	☼	03/09/22 08:00	03/11/22 15:22	2
Boron	ND	L	11	11	mg/Kg	☼	03/09/22 08:00	03/11/22 14:54	1
Cobalt	**7.6**		2.8	0.051	mg/Kg	☼	03/09/22 08:00	03/11/22 14:54	1
Lithium	**0.31**	**J**	2.8	0.17	mg/Kg	☼	03/09/22 08:00	03/11/22 14:54	1
Molybdenum	**0.35**	**J**	2.2	0.11	mg/Kg	☼	03/09/22 08:00	03/11/22 14:54	1

Method: 6010B SEP - SEP Metals (ICP) - Step 7

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**4.7**	**B**	1.1	0.29	mg/Kg	☼	03/10/22 08:05	03/15/22 13:33	2
Cobalt	**0.81**	**J**	2.8	0.029	mg/Kg	☼	03/10/22 08:05	03/15/22 13:07	1
Lithium	**3.2**		2.8	0.17	mg/Kg	☼	03/10/22 08:05	03/16/22 13:17	1

Client Sample Results

Client Sample ID: G-08 (75.0-80.0)

Lab Sample ID: 140-25875-3

Date Collected: 12/23/21 13:30
Matrix: Solid
Date Received: 12/24/21 08:00
Percent Solids: 89.5

Method: 6010B SEP - SEP Metals (ICP) - Step 7 (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Molybdenum	ND		2.2	0.092	mg/Kg	☼	03/10/22 08:05	03/15/22 13:07	1

Method: 6010B SEP - SEP Metals (ICP) - Sum of Steps 1-7

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**23**		0.50	0.13	mg/Kg			03/18/22 13:19	1
Cobalt	**15**		2.5	0.023	mg/Kg			03/18/22 13:19	1
Lithium	**3.5**		2.5	0.15	mg/Kg			03/18/22 13:19	1
Molybdenum	**0.83**	**J**	2.0	0.082	mg/Kg			03/18/22 13:19	1

Method: 6010B - SEP Metals (ICP) - Total

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**22**	**B**	1.1	0.29	mg/Kg	☼	02/28/22 08:00	03/16/22 14:51	2
Cobalt	**14**		2.8	0.029	mg/Kg	☼	02/28/22 08:00	03/16/22 14:05	1
Lithium	**3.1**		2.8	0.17	mg/Kg	☼	02/28/22 08:00	03/16/22 14:05	1
Molybdenum	**1.5**	**J**	2.2	0.092	mg/Kg	☼	02/28/22 08:00	03/16/22 14:05	1

Default Detection Limits

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Method: 6010B SEP - SEP Metals (ICP) - Step 1

Prep: 3010A

SEP: Exchangeable

Analyte	RL	MDL	Units
Arsenic	0.50	0.13	mg/Kg
Boron	10	10	mg/Kg
Cobalt	2.5	0.045	mg/Kg
Lithium	2.5	0.15	mg/Kg
Molybdenum	2.0	0.082	mg/Kg

Method: 6010B SEP - SEP Metals (ICP) - Step 2

Prep: 3010A

SEP: Carbonate

Analyte	RL	MDL	Units
Arsenic	0.50	0.13	mg/Kg
Boron	10	10	mg/Kg
Cobalt	2.5	0.063	mg/Kg
Lithium	2.5	0.15	mg/Kg
Molybdenum	2.0	0.082	mg/Kg

Method: 6010B SEP - SEP Metals (ICP) - Step 3

Prep: 3010A

SEP: Non-Crystalline

Analyte	RL	MDL	Units
Arsenic	0.50	0.13	mg/Kg
Boron	10	10	mg/Kg
Cobalt	2.5	0.045	mg/Kg
Lithium	2.5	0.15	mg/Kg
Molybdenum	2.0	0.082	mg/Kg

Method: 6010B SEP - SEP Metals (ICP) - Step 4

Prep: 3010A

SEP: Metal Hydroxide

Analyte	RL	MDL	Units
Arsenic	0.50	0.22	mg/Kg
Boron	10	10	mg/Kg
Cobalt	2.5	0.053	mg/Kg
Lithium	2.5	0.15	mg/Kg
Molybdenum	2.0	0.082	mg/Kg

Method: 6010B SEP - SEP Metals (ICP) - Step 5

Prep: 3010A

SEP: Organic-Bound

Analyte	RL	MDL	Units
Arsenic	1.5	0.38	mg/Kg
Boron	30	30	mg/Kg
Cobalt	7.5	0.12	mg/Kg
Lithium	7.5	0.44	mg/Kg
Molybdenum	6.0	0.25	mg/Kg

Method: 6010B SEP - SEP Metals (ICP) - Step 6

SEP: Acid/Sulfide

Default Detection Limits

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Method: 6010B SEP - SEP Metals (ICP) - Step 6

SEP: Acid/Sulfide

Analyte	RL	MDL	Units
Arsenic	0.50	0.15	mg/Kg
Boron	10	10	mg/Kg
Cobalt	2.5	0.046	mg/Kg
Lithium	2.5	0.15	mg/Kg
Molybdenum	2.0	0.099	mg/Kg

Method: 6010B SEP - SEP Metals (ICP) - Step 7

Prep: Residual

Analyte	RL	MDL	Units
Arsenic	0.50	0.13	mg/Kg
Cobalt	2.5	0.026	mg/Kg
Lithium	2.5	0.15	mg/Kg
Molybdenum	2.0	0.082	mg/Kg

Method: 6010B SEP - SEP Metals (ICP) - Sum of Steps 1-7

Analyte	RL	MDL	Units
Arsenic	0.50	0.13	mg/Kg
Cobalt	2.5	0.023	mg/Kg
Lithium	2.5	0.15	mg/Kg
Molybdenum	2.0	0.082	mg/Kg

Method: 6010B - SEP Metals (ICP) - Total

Prep: Total

Analyte	RL	MDL	Units
Arsenic	0.50	0.13	mg/Kg
Cobalt	2.5	0.026	mg/Kg
Lithium	2.5	0.15	mg/Kg
Molybdenum	2.0	0.082	mg/Kg

QC Sample Results

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Method: 6010B - SEP Metals (ICP) - Total

Lab Sample ID: MB 140-59245/1-A
Matrix: Solid
Analysis Batch: 59793

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 59245

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	0.256	J	0.50	0.13	mg/Kg		02/28/22 08:00	03/16/22 12:47	1
Cobalt	ND		2.5	0.026	mg/Kg		02/28/22 08:00	03/16/22 12:47	1
Lithium	ND		2.5	0.15	mg/Kg		02/28/22 08:00	03/16/22 12:47	1
Molybdenum	ND		2.0	0.082	mg/Kg		02/28/22 08:00	03/16/22 12:47	1

Lab Sample ID: LCS 140-59245/2-A
Matrix: Solid
Analysis Batch: 59793

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 59245

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	5.00	5.15		mg/Kg		103	80 - 120
Cobalt	5.00	5.11		mg/Kg		102	80 - 125
Lithium	5.00	4.82		mg/Kg		96	80 - 120
Molybdenum	25.0	26.5		mg/Kg		106	80 - 125

Lab Sample ID: LCSD 140-59245/3-A
Matrix: Solid
Analysis Batch: 59793

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA
Prep Batch: 59245

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	5.00	5.24		mg/Kg		105	80 - 120	2	30
Cobalt	5.00	5.14		mg/Kg		103	80 - 125	1	30
Lithium	5.00	4.81		mg/Kg		96	80 - 120	0	30
Molybdenum	25.0	26.8		mg/Kg		107	80 - 125	1	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59793

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Total/NA
Prep Batch: 59245

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Cobalt	5.6		4.09		mg/Kg	☼	30	30
Lithium	5.4		5.78		mg/Kg	☼	6	30
Molybdenum	0.65	J	0.874	J	mg/Kg	☼	30	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59793

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Total/NA
Prep Batch: 59245

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Arsenic	7.9	B	8.12		mg/Kg	☼	3	30

Method: 6010B SEP - SEP Metals (ICP)

Lab Sample ID: MB 140-59247/1-B ^4
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: Method Blank
Prep Type: Step 1
Prep Batch: 59310

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		2.0	0.52	mg/Kg		03/01/22 08:00	03/09/22 10:38	4
Boron	ND		40	40	mg/Kg		03/01/22 08:00	03/09/22 10:38	4

Method: 6010B SEP - SEP Metals (ICP) (Continued)

Lab Sample ID: MB 140-59247/1-B ^4
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: Method Blank
Prep Type: Step 1
Prep Batch: 59310

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Cobalt	ND		10	0.18	mg/Kg		03/01/22 08:00	03/09/22 10:38	4
Lithium	ND		10	0.60	mg/Kg		03/01/22 08:00	03/09/22 10:38	4
Molybdenum	ND		8.0	0.33	mg/Kg		03/01/22 08:00	03/09/22 10:38	4

Lab Sample ID: LCS 140-59247/2-B ^5
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: Lab Control Sample
Prep Type: Step 1
Prep Batch: 59310

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	5.00	4.76		mg/Kg		95	80 - 120
Boron	50.0	ND		mg/Kg		98	
Cobalt	5.00	4.92	J	mg/Kg		98	80 - 120
Lithium	5.00	4.99	J	mg/Kg		100	80 - 120
Molybdenum	25.0	24.7		mg/Kg		99	80 - 120

Lab Sample ID: LCSD 140-59247/3-B ^5
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: Lab Control Sample Dup
Prep Type: Step 1
Prep Batch: 59310

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	5.00	4.65		mg/Kg		93	80 - 120	6	30
Boron	50.0	ND		mg/Kg		96		2	
Cobalt	5.00	4.87	J	mg/Kg		97	80 - 120	2	30
Lithium	5.00	4.86	J	mg/Kg		97	80 - 120	3	30
Molybdenum	25.0	24.4		mg/Kg		98	80 - 120	2	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Step 1
Prep Batch: 59310

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Arsenic	0.61	J	ND		mg/Kg	☼	NC	30
Boron	ND		ND		mg/Kg	☼	NC	
Cobalt	ND		ND		mg/Kg	☼	NC	30
Lithium	ND		ND		mg/Kg	☼	NC	30
Molybdenum	ND		ND		mg/Kg	☼	NC	30

Lab Sample ID: MB 140-59318/1-B ^3
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: Method Blank
Prep Type: Step 2
Prep Batch: 59356

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		1.5	0.39	mg/Kg		03/02/22 08:00	03/09/22 11:02	3
Boron	ND		30	30	mg/Kg		03/02/22 08:00	03/09/22 11:02	3
Cobalt	ND		7.5	0.19	mg/Kg		03/02/22 08:00	03/09/22 11:02	3
Lithium	ND		7.5	0.45	mg/Kg		03/02/22 08:00	03/09/22 11:02	3
Molybdenum	ND		6.0	0.25	mg/Kg		03/02/22 08:00	03/09/22 11:02	3

QC Sample Results

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Method: 6010B SEP - SEP Metals (ICP) (Continued)

Lab Sample ID: LCS 140-59318/2-B ^5
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: Lab Control Sample
Prep Type: Step 2
Prep Batch: 59356

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	5.00	4.42		mg/Kg		88	60 - 120
Boron	50.0	ND		mg/Kg		92	
Cobalt	5.00	4.69	J	mg/Kg		94	80 - 120
Lithium	5.00	4.40	J	mg/Kg		88	80 - 120
Molybdenum	25.0	20.5		mg/Kg		82	70 - 120

Lab Sample ID: LCSD 140-59318/3-B ^5
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: Lab Control Sample Dup
Prep Type: Step 2
Prep Batch: 59356

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	5.00	4.32		mg/Kg		86	60 - 120	2	30
Boron	50.0	ND		mg/Kg		90		1	
Cobalt	5.00	4.70	J	mg/Kg		94	80 - 120	0	30
Lithium	5.00	4.26	J	mg/Kg		85	80 - 120	3	30
Molybdenum	25.0	20.6		mg/Kg		82	70 - 120	0	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59628

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Step 2
Prep Batch: 59356

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Arsenic	0.51	J	0.472	J	mg/Kg	☼	8	30
Boron	ND		ND		mg/Kg	☼	NC	
Cobalt	ND		ND		mg/Kg	☼	NC	30
Lithium	ND		ND		mg/Kg	☼	NC	30
Molybdenum	ND		ND		mg/Kg	☼	NC	30

Lab Sample ID: MB 140-59371/1-B
Matrix: Solid
Analysis Batch: 59667

Client Sample ID: Method Blank
Prep Type: Step 3
Prep Batch: 59412

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.50	0.13	mg/Kg		03/03/22 08:20	03/10/22 10:16	1
Boron	ND		10	10	mg/Kg		03/03/22 08:20	03/10/22 10:16	1
Cobalt	ND		2.5	0.045	mg/Kg		03/03/22 08:20	03/10/22 10:16	1
Lithium	ND		2.5	0.15	mg/Kg		03/03/22 08:20	03/10/22 10:16	1
Molybdenum	ND		2.0	0.082	mg/Kg		03/03/22 08:20	03/10/22 10:16	1

Lab Sample ID: LCS 140-59371/2-B
Matrix: Solid
Analysis Batch: 59667

Client Sample ID: Lab Control Sample
Prep Type: Step 3
Prep Batch: 59412

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	5.00	4.73		mg/Kg		95	80 - 120
Boron	50.0	47.7		mg/Kg		95	
Cobalt	5.00	4.83		mg/Kg		97	80 - 120
Lithium	5.00	4.43		mg/Kg		89	80 - 120
Molybdenum	25.0	24.8		mg/Kg		99	80 - 120

Method: 6010B SEP - SEP Metals (ICP) (Continued)

Lab Sample ID: LCSD 140-59371/3-B
Client Sample ID: Lab Control Sample Dup
Matrix: Solid
Prep Type: Step 3
Analysis Batch: 59667
Prep Batch: 59412

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	5.00	4.83		mg/Kg		97	80 - 120	2	30
Boron	50.0	48.9		mg/Kg		98		3	
Cobalt	5.00	4.85		mg/Kg		97	80 - 120	0	30
Lithium	5.00	4.43		mg/Kg		89	80 - 120	0	30
Molybdenum	25.0	24.9		mg/Kg		100	80 - 120	1	30

Lab Sample ID: 140-25875-1 DU
Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Matrix: Solid
Prep Type: Step 3
Analysis Batch: 59667
Prep Batch: 59412

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Arsenic	0.40	J	0.393	J	mg/Kg	☼	2	30
Boron	ND		ND		mg/Kg	☼	NC	
Cobalt	0.85	J	1.31	J F5	mg/Kg	☼	43	30
Lithium	ND		ND		mg/Kg	☼	NC	30
Molybdenum	ND		0.0985	J	mg/Kg	☼	NC	30

Lab Sample ID: MB 140-59413/1-B
Client Sample ID: Method Blank
Matrix: Solid
Prep Type: Step 4
Analysis Batch: 59667
Prep Batch: 59446

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	0.293	J	0.50	0.22	mg/Kg		03/04/22 08:00	03/10/22 11:20	1
Boron	ND		10	10	mg/Kg		03/04/22 08:00	03/10/22 11:20	1
Cobalt	ND		2.5	0.053	mg/Kg		03/04/22 08:00	03/10/22 11:20	1
Lithium	ND		2.5	0.15	mg/Kg		03/04/22 08:00	03/10/22 11:20	1
Molybdenum	ND		2.0	0.082	mg/Kg		03/04/22 08:00	03/10/22 11:20	1

Lab Sample ID: LCS 140-59413/2-B
Client Sample ID: Lab Control Sample
Matrix: Solid
Prep Type: Step 4
Analysis Batch: 59667
Prep Batch: 59446

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	5.00	5.60		mg/Kg		112	80 - 130
Boron	50.0	51.8		mg/Kg		104	
Cobalt	5.00	5.25		mg/Kg		105	80 - 120
Lithium	5.00	5.00		mg/Kg		100	80 - 120
Molybdenum	25.0	27.4		mg/Kg		110	80 - 120

Lab Sample ID: LCSD 140-59413/3-B
Client Sample ID: Lab Control Sample Dup
Matrix: Solid
Prep Type: Step 4
Analysis Batch: 59667
Prep Batch: 59446

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	5.00	5.70		mg/Kg		114	80 - 130	2	30
Boron	50.0	51.8		mg/Kg		104		0	
Cobalt	5.00	5.43		mg/Kg		109	80 - 120	3	30
Lithium	5.00	4.94		mg/Kg		99	80 - 120	1	30
Molybdenum	25.0	28.1		mg/Kg		112	80 - 120	3	30

1 2 3 4 5 6 7 8 9 10 11 12 13

Method: 6010B SEP - SEP Metals (ICP) (Continued)

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59667

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Step 4
Prep Batch: 59446

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Arsenic	2.4	B	1.74	F3	mg/Kg	☼	34	30
Boron	ND		ND		mg/Kg	☼	NC	
Cobalt	1.4	J	1.16	J	mg/Kg	☼	16	30
Lithium	0.27	J	0.195	J F5	mg/Kg	☼	33	30
Molybdenum	0.10	J	0.108	J	mg/Kg	☼	7	30

Lab Sample ID: MB 140-59468/1-B ^5
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: Method Blank
Prep Type: Step 5
Prep Batch: 59579

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		7.5	1.9	mg/Kg		03/09/22 08:00	03/11/22 12:48	5
Boron	ND		150	150	mg/Kg		03/09/22 08:00	03/11/22 12:48	5
Cobalt	ND		38	0.60	mg/Kg		03/09/22 08:00	03/11/22 12:48	5
Lithium	ND		38	2.2	mg/Kg		03/09/22 08:00	03/11/22 12:48	5
Molybdenum	ND		30	1.3	mg/Kg		03/09/22 08:00	03/11/22 12:48	5

Lab Sample ID: LCS 140-59468/2-B ^5
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: Lab Control Sample
Prep Type: Step 5
Prep Batch: 59579

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	15.0	11.9		mg/Kg		79	60 - 100
Boron	150	165		mg/Kg		110	
Cobalt	15.0	0.960	J	mg/Kg		6	1 - 60
Lithium	15.0	15.7	J	mg/Kg		105	80 - 150
Molybdenum	75.0	58.0		mg/Kg		77	60 - 100

Lab Sample ID: LCSD 140-59468/3-B ^5
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: Lab Control Sample Dup
Prep Type: Step 5
Prep Batch: 59579

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	15.0	12.1		mg/Kg		81	60 - 100	2	30
Boron	150	167		mg/Kg		111		1	
Cobalt	15.0	1.16	J	mg/Kg		8	1 - 60	18	30
Lithium	15.0	16.7	J	mg/Kg		111	80 - 150	6	30
Molybdenum	75.0	57.8		mg/Kg		77	60 - 100	0	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Step 5
Prep Batch: 59579

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Arsenic	ND		ND		mg/Kg	☼	NC	30
Boron	ND		ND		mg/Kg	☼	NC	
Cobalt	ND		ND		mg/Kg	☼	NC	30
Lithium	ND		ND		mg/Kg	☼	NC	30
Molybdenum	ND		ND		mg/Kg	☼	NC	30

QC Sample Results

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Method: 6010B SEP - SEP Metals (ICP) (Continued)

Lab Sample ID: MB 140-59581/1-A
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: Method Blank
Prep Type: Step 6
Prep Batch: 59581

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.50	0.15	mg/Kg		03/09/22 08:00	03/11/22 13:54	1
Boron	ND		10	10	mg/Kg		03/09/22 08:00	03/11/22 13:54	1
Cobalt	ND		2.5	0.046	mg/Kg		03/09/22 08:00	03/11/22 13:54	1
Lithium	ND		2.5	0.15	mg/Kg		03/09/22 08:00	03/11/22 13:54	1
Molybdenum	ND		2.0	0.099	mg/Kg		03/09/22 08:00	03/11/22 13:54	1

Lab Sample ID: LCS 140-59581/2-A
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: Lab Control Sample
Prep Type: Step 6
Prep Batch: 59581

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	5.00	5.22		mg/Kg		104	80 - 120
Boron	50.0	53.8		mg/Kg		108	
Cobalt	5.00	5.16		mg/Kg		103	80 - 120
Lithium	5.00	4.99		mg/Kg		100	80 - 120
Molybdenum	25.0	25.2		mg/Kg		101	80 - 120

Lab Sample ID: LCSD 140-59581/3-A
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: Lab Control Sample Dup
Prep Type: Step 6
Prep Batch: 59581

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	5.00	5.29		mg/Kg		106	80 - 120	1	30
Boron	50.0	54.7		mg/Kg		109		2	
Cobalt	5.00	5.28		mg/Kg		106	80 - 120	2	30
Lithium	5.00	5.02		mg/Kg		100	80 - 120	1	30
Molybdenum	25.0	25.7		mg/Kg		103	80 - 120	2	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Step 6
Prep Batch: 59581

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Boron	ND		ND	L	mg/Kg	☼	NC	
Cobalt	3.5		3.14		mg/Kg	☼	12	30
Lithium	1.1	J	0.934	J	mg/Kg	☼	14	30
Molybdenum	0.40	J	0.477	J	mg/Kg	☼	17	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59699

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Step 6
Prep Batch: 59581

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Arsenic	7.5		5.84		mg/Kg	☼	25	30

Method: 6010B SEP - SEP Metals (ICP) (Continued)

Lab Sample ID: MB 140-59631/1-A
Matrix: Solid
Analysis Batch: 59767

Client Sample ID: Method Blank
Prep Type: Step 7
Prep Batch: 59631

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	0.319	J	0.50	0.13	mg/Kg		03/10/22 08:05	03/15/22 12:07	1
Cobalt	ND		2.5	0.026	mg/Kg		03/10/22 08:05	03/15/22 12:07	1
Lithium	ND		2.5	0.15	mg/Kg		03/10/22 08:05	03/15/22 12:07	1
Molybdenum	ND		2.0	0.082	mg/Kg		03/10/22 08:05	03/15/22 12:07	1

Lab Sample ID: LCS 140-59631/2-A
Matrix: Solid
Analysis Batch: 59767

Client Sample ID: Lab Control Sample
Prep Type: Step 7
Prep Batch: 59631

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	5.00	5.11		mg/Kg		102	80 - 120
Cobalt	5.00	4.91		mg/Kg		98	80 - 125
Lithium	5.00	4.76		mg/Kg		95	80 - 120
Molybdenum	25.0	24.8		mg/Kg		99	80 - 125

Lab Sample ID: LCSD 140-59631/3-A
Matrix: Solid
Analysis Batch: 59767

Client Sample ID: Lab Control Sample Dup
Prep Type: Step 7
Prep Batch: 59631

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	5.00	5.13		mg/Kg		103	80 - 120	0	30
Cobalt	5.00	4.95		mg/Kg		99	80 - 125	1	30
Lithium	5.00	4.91		mg/Kg		98	80 - 120	4	30
Molybdenum	25.0	25.0		mg/Kg		100	80 - 125	1	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59767

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Step 7
Prep Batch: 59631

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Cobalt	ND		0.312	J	mg/Kg	☼	NC	30
Lithium	3.2		3.25		mg/Kg	☼	3	30
Molybdenum	ND		0.805	J	mg/Kg	☼	NC	30

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Analysis Batch: 59767

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Prep Type: Step 7
Prep Batch: 59631

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Arsenic	3.2	B	11.2	F3	mg/Kg	☼	111	30

Metals

Prep Batch: 59245

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Total/NA	Solid	Total	
140-25875-2	G-07 (50.0-56.0)	Total/NA	Solid	Total	
140-25875-3	G-08 (75.0-80.0)	Total/NA	Solid	Total	
MB 140-59245/1-A	Method Blank	Total/NA	Solid	Total	
LCS 140-59245/2-A	Lab Control Sample	Total/NA	Solid	Total	
LCSD 140-59245/3-A	Lab Control Sample Dup	Total/NA	Solid	Total	
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Total/NA	Solid	Total	

SEP Batch: 59247

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 1	Solid	Exchangeable	
140-25875-2	G-07 (50.0-56.0)	Step 1	Solid	Exchangeable	
140-25875-3	G-08 (75.0-80.0)	Step 1	Solid	Exchangeable	
MB 140-59247/1-B ^4	Method Blank	Step 1	Solid	Exchangeable	
LCS 140-59247/2-B ^5	Lab Control Sample	Step 1	Solid	Exchangeable	
LCSD 140-59247/3-B ^5	Lab Control Sample Dup	Step 1	Solid	Exchangeable	
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 1	Solid	Exchangeable	

Prep Batch: 59310

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 1	Solid	3010A	59247
140-25875-2	G-07 (50.0-56.0)	Step 1	Solid	3010A	59247
140-25875-3	G-08 (75.0-80.0)	Step 1	Solid	3010A	59247
MB 140-59247/1-B ^4	Method Blank	Step 1	Solid	3010A	59247
LCS 140-59247/2-B ^5	Lab Control Sample	Step 1	Solid	3010A	59247
LCSD 140-59247/3-B ^5	Lab Control Sample Dup	Step 1	Solid	3010A	59247
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 1	Solid	3010A	59247

SEP Batch: 59318

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 2	Solid	Carbonate	
140-25875-2	G-07 (50.0-56.0)	Step 2	Solid	Carbonate	
140-25875-3	G-08 (75.0-80.0)	Step 2	Solid	Carbonate	
MB 140-59318/1-B ^3	Method Blank	Step 2	Solid	Carbonate	
LCS 140-59318/2-B ^5	Lab Control Sample	Step 2	Solid	Carbonate	
LCSD 140-59318/3-B ^5	Lab Control Sample Dup	Step 2	Solid	Carbonate	
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 2	Solid	Carbonate	

Prep Batch: 59356

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 2	Solid	3010A	59318
140-25875-2	G-07 (50.0-56.0)	Step 2	Solid	3010A	59318
140-25875-3	G-08 (75.0-80.0)	Step 2	Solid	3010A	59318
MB 140-59318/1-B ^3	Method Blank	Step 2	Solid	3010A	59318
LCS 140-59318/2-B ^5	Lab Control Sample	Step 2	Solid	3010A	59318
LCSD 140-59318/3-B ^5	Lab Control Sample Dup	Step 2	Solid	3010A	59318
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 2	Solid	3010A	59318

SEP Batch: 59371

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 3	Solid	Non-Crystalline	

Metals (Continued)

SEP Batch: 59371 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-2	G-07 (50.0-56.0)	Step 3	Solid	Non-Crystalline	
140-25875-3	G-08 (75.0-80.0)	Step 3	Solid	Non-Crystalline	
MB 140-59371/1-B	Method Blank	Step 3	Solid	Non-Crystalline	
LCS 140-59371/2-B	Lab Control Sample	Step 3	Solid	Non-Crystalline	
LCSD 140-59371/3-B	Lab Control Sample Dup	Step 3	Solid	Non-Crystalline	
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 3	Solid	Non-Crystalline	

Prep Batch: 59412

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 3	Solid	3010A	59371
140-25875-2	G-07 (50.0-56.0)	Step 3	Solid	3010A	59371
140-25875-3	G-08 (75.0-80.0)	Step 3	Solid	3010A	59371
MB 140-59371/1-B	Method Blank	Step 3	Solid	3010A	59371
LCS 140-59371/2-B	Lab Control Sample	Step 3	Solid	3010A	59371
LCSD 140-59371/3-B	Lab Control Sample Dup	Step 3	Solid	3010A	59371
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 3	Solid	3010A	59371

SEP Batch: 59413

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 4	Solid	Metal Hydroxide	
140-25875-2	G-07 (50.0-56.0)	Step 4	Solid	Metal Hydroxide	
140-25875-3	G-08 (75.0-80.0)	Step 4	Solid	Metal Hydroxide	
MB 140-59413/1-B	Method Blank	Step 4	Solid	Metal Hydroxide	
LCS 140-59413/2-B	Lab Control Sample	Step 4	Solid	Metal Hydroxide	
LCSD 140-59413/3-B	Lab Control Sample Dup	Step 4	Solid	Metal Hydroxide	
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 4	Solid	Metal Hydroxide	

Prep Batch: 59446

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 4	Solid	3010A	59413
140-25875-2	G-07 (50.0-56.0)	Step 4	Solid	3010A	59413
140-25875-3	G-08 (75.0-80.0)	Step 4	Solid	3010A	59413
MB 140-59413/1-B	Method Blank	Step 4	Solid	3010A	59413
LCS 140-59413/2-B	Lab Control Sample	Step 4	Solid	3010A	59413
LCSD 140-59413/3-B	Lab Control Sample Dup	Step 4	Solid	3010A	59413
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 4	Solid	3010A	59413

SEP Batch: 59468

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 5	Solid	Organic-Bound	
140-25875-2	G-07 (50.0-56.0)	Step 5	Solid	Organic-Bound	
140-25875-3	G-08 (75.0-80.0)	Step 5	Solid	Organic-Bound	
MB 140-59468/1-B ^5	Method Blank	Step 5	Solid	Organic-Bound	
LCS 140-59468/2-B ^5	Lab Control Sample	Step 5	Solid	Organic-Bound	
LCSD 140-59468/3-B ^5	Lab Control Sample Dup	Step 5	Solid	Organic-Bound	
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 5	Solid	Organic-Bound	

Prep Batch: 59579

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 5	Solid	3010A	59468
140-25875-2	G-07 (50.0-56.0)	Step 5	Solid	3010A	59468

Metals (Continued)

Prep Batch: 59579 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-3	G-08 (75.0-80.0)	Step 5	Solid	3010A	59468
MB 140-59468/1-B ^5	Method Blank	Step 5	Solid	3010A	59468
LCS 140-59468/2-B ^5	Lab Control Sample	Step 5	Solid	3010A	59468
LCSD 140-59468/3-B ^5	Lab Control Sample Dup	Step 5	Solid	3010A	59468
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 5	Solid	3010A	59468

SEP Batch: 59581

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 6	Solid	Acid/Sulfide	
140-25875-2	G-07 (50.0-56.0)	Step 6	Solid	Acid/Sulfide	
140-25875-3	G-08 (75.0-80.0)	Step 6	Solid	Acid/Sulfide	
MB 140-59581/1-A	Method Blank	Step 6	Solid	Acid/Sulfide	
LCS 140-59581/2-A	Lab Control Sample	Step 6	Solid	Acid/Sulfide	
LCSD 140-59581/3-A	Lab Control Sample Dup	Step 6	Solid	Acid/Sulfide	
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 6	Solid	Acid/Sulfide	

Analysis Batch: 59628

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 1	Solid	6010B SEP	59310
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 2	Solid	6010B SEP	59356
140-25875-2	G-07 (50.0-56.0)	Step 1	Solid	6010B SEP	59310
140-25875-2	G-07 (50.0-56.0)	Step 2	Solid	6010B SEP	59356
140-25875-3	G-08 (75.0-80.0)	Step 1	Solid	6010B SEP	59310
140-25875-3	G-08 (75.0-80.0)	Step 2	Solid	6010B SEP	59356
MB 140-59247/1-B ^4	Method Blank	Step 1	Solid	6010B SEP	59310
MB 140-59318/1-B ^3	Method Blank	Step 2	Solid	6010B SEP	59356
LCS 140-59247/2-B ^5	Lab Control Sample	Step 1	Solid	6010B SEP	59310
LCS 140-59318/2-B ^5	Lab Control Sample	Step 2	Solid	6010B SEP	59356
LCSD 140-59247/3-B ^5	Lab Control Sample Dup	Step 1	Solid	6010B SEP	59310
LCSD 140-59318/3-B ^5	Lab Control Sample Dup	Step 2	Solid	6010B SEP	59356
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 1	Solid	6010B SEP	59310
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 2	Solid	6010B SEP	59356

Prep Batch: 59631

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 7	Solid	Residual	
140-25875-2	G-07 (50.0-56.0)	Step 7	Solid	Residual	
140-25875-3	G-08 (75.0-80.0)	Step 7	Solid	Residual	
MB 140-59631/1-A	Method Blank	Step 7	Solid	Residual	
LCS 140-59631/2-A	Lab Control Sample	Step 7	Solid	Residual	
LCSD 140-59631/3-A	Lab Control Sample Dup	Step 7	Solid	Residual	
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 7	Solid	Residual	

Analysis Batch: 59667

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 3	Solid	6010B SEP	59412
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 4	Solid	6010B SEP	59446
140-25875-2	G-07 (50.0-56.0)	Step 3	Solid	6010B SEP	59412
140-25875-2	G-07 (50.0-56.0)	Step 4	Solid	6010B SEP	59446
140-25875-3	G-08 (75.0-80.0)	Step 3	Solid	6010B SEP	59412
140-25875-3	G-08 (75.0-80.0)	Step 4	Solid	6010B SEP	59446

Metals (Continued)

Analysis Batch: 59667 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 140-59371/1-B	Method Blank	Step 3	Solid	6010B SEP	59412
MB 140-59413/1-B	Method Blank	Step 4	Solid	6010B SEP	59446
LCS 140-59371/2-B	Lab Control Sample	Step 3	Solid	6010B SEP	59412
LCS 140-59413/2-B	Lab Control Sample	Step 4	Solid	6010B SEP	59446
LCSD 140-59371/3-B	Lab Control Sample Dup	Step 3	Solid	6010B SEP	59412
LCSD 140-59413/3-B	Lab Control Sample Dup	Step 4	Solid	6010B SEP	59446
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 3	Solid	6010B SEP	59412
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 4	Solid	6010B SEP	59446

Analysis Batch: 59699

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 5	Solid	6010B SEP	59579
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 6	Solid	6010B SEP	59581
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 6	Solid	6010B SEP	59581
140-25875-2	G-07 (50.0-56.0)	Step 5	Solid	6010B SEP	59579
140-25875-2	G-07 (50.0-56.0)	Step 6	Solid	6010B SEP	59581
140-25875-3	G-08 (75.0-80.0)	Step 5	Solid	6010B SEP	59579
140-25875-3	G-08 (75.0-80.0)	Step 6	Solid	6010B SEP	59581
140-25875-3	G-08 (75.0-80.0)	Step 6	Solid	6010B SEP	59581
MB 140-59468/1-B ^5	Method Blank	Step 5	Solid	6010B SEP	59579
MB 140-59581/1-A	Method Blank	Step 6	Solid	6010B SEP	59581
LCS 140-59468/2-B ^5	Lab Control Sample	Step 5	Solid	6010B SEP	59579
LCS 140-59581/2-A	Lab Control Sample	Step 6	Solid	6010B SEP	59581
LCSD 140-59468/3-B ^5	Lab Control Sample Dup	Step 5	Solid	6010B SEP	59579
LCSD 140-59581/3-A	Lab Control Sample Dup	Step 6	Solid	6010B SEP	59581
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 5	Solid	6010B SEP	59579
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 6	Solid	6010B SEP	59581
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 6	Solid	6010B SEP	59581

Analysis Batch: 59767

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 7	Solid	6010B SEP	59631
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Step 7	Solid	6010B SEP	59631
140-25875-2	G-07 (50.0-56.0)	Step 7	Solid	6010B SEP	59631
140-25875-3	G-08 (75.0-80.0)	Step 7	Solid	6010B SEP	59631
140-25875-3	G-08 (75.0-80.0)	Step 7	Solid	6010B SEP	59631
MB 140-59631/1-A	Method Blank	Step 7	Solid	6010B SEP	59631
LCS 140-59631/2-A	Lab Control Sample	Step 7	Solid	6010B SEP	59631
LCSD 140-59631/3-A	Lab Control Sample Dup	Step 7	Solid	6010B SEP	59631
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 7	Solid	6010B SEP	59631
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Step 7	Solid	6010B SEP	59631

Analysis Batch: 59793

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Total/NA	Solid	6010B	59245
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Total/NA	Solid	6010B	59245
140-25875-2	G-07 (50.0-56.0)	Total/NA	Solid	6010B	59245
140-25875-2	G-07 (50.0-56.0)	Total/NA	Solid	6010B	59245
140-25875-3	G-08 (75.0-80.0)	Step 7	Solid	6010B SEP	59631
140-25875-3	G-08 (75.0-80.0)	Total/NA	Solid	6010B	59245
140-25875-3	G-08 (75.0-80.0)	Total/NA	Solid	6010B	59245

Metals (Continued)

Analysis Batch: 59793 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 140-59245/1-A	Method Blank	Total/NA	Solid	6010B	59245
LCS 140-59245/2-A	Lab Control Sample	Total/NA	Solid	6010B	59245
LCSD 140-59245/3-A	Lab Control Sample Dup	Total/NA	Solid	6010B	59245
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Total/NA	Solid	6010B	59245
140-25875-1 DU	G-03 (57.5-62.5, 63.5-70.0)	Total/NA	Solid	6010B	59245

Analysis Batch: 59866

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Sum of Steps 1-7	Solid	6010B SEP	
140-25875-2	G-07 (50.0-56.0)	Sum of Steps 1-7	Solid	6010B SEP	
140-25875-3	G-08 (75.0-80.0)	Sum of Steps 1-7	Solid	6010B SEP	

General Chemistry

Analysis Batch: 57767

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-25875-1	G-03 (57.5-62.5, 63.5-70.0)	Total/NA	Solid	Moisture	
140-25875-2	G-07 (50.0-56.0)	Total/NA	Solid	Moisture	
140-25875-3	G-08 (75.0-80.0)	Total/NA	Solid	Moisture	

Lab Chronicle

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Lab Sample ID: 140-25875-1
Date Collected: 12/23/21 13:00
Matrix: Solid
Date Received: 12/24/21 08:00

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Sum of Steps 1-7	Analysis	6010B SEP		1			59866	03/18/22 13:19	DKW	TAL KNX
	Instrument ID: NOEQUIP									
Total/NA	Analysis	Moisture		1			57767	01/10/22 09:51	BKD	TAL KNX
	Instrument ID: NOEQUIP									

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Lab Sample ID: 140-25875-1
Date Collected: 12/23/21 13:00
Matrix: Solid
Date Received: 12/24/21 08:00
Percent Solids: 86.8

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		1			59793	03/16/22 13:45	JGT	TAL KNX
	Instrument ID: DUO									
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		2			59793	03/16/22 14:31	JGT	TAL KNX
	Instrument ID: DUO									
Step 1	SEP	Exchangeable			5.00 g	25 mL	59247	02/28/22 08:00	WRL	TAL KNX
Step 1	Prep	3010A			5 mL	50 mL	59310	03/01/22 08:00	WRL	TAL KNX
Step 1	Analysis	6010B SEP		4			59628	03/09/22 11:40	JGT	TAL KNX
	Instrument ID: DUO									
Step 2	SEP	Carbonate			5.000 g	25 mL	59318	03/01/22 08:00	WRL	TAL KNX
Step 2	Prep	3010A			5 mL	50 mL	59356	03/02/22 08:00	KNC	TAL KNX
Step 2	Analysis	6010B SEP		3			59628	03/09/22 12:10	JGT	TAL KNX
	Instrument ID: DUO									
Step 3	SEP	Non-Crystalline			5.00 g	25 mL	59371	03/02/22 08:26	WRL	TAL KNX
Step 3	Prep	3010A			5.00 mL	50 mL	59412	03/03/22 08:20	WRL	TAL KNX
Step 3	Analysis	6010B SEP		1			59667	03/10/22 10:45	JGT	TAL KNX
	Instrument ID: DUO									
Step 4	SEP	Metal Hydroxide			5.00 g	25 mL	59413	03/03/22 08:32	WRL	TAL KNX
Step 4	Prep	3010A			5 mL	50 mL	59446	03/04/22 08:00	KNC	TAL KNX
Step 4	Analysis	6010B SEP		1			59667	03/10/22 11:49	JGT	TAL KNX
	Instrument ID: DUO									
Step 5	SEP	Organic-Bound			5.00 g	75 mL	59468	03/07/22 08:00	WRL	TAL KNX
Step 5	Prep	3010A			5 mL	50 mL	59579	03/09/22 08:00	KNC	TAL KNX
Step 5	Analysis	6010B SEP		5			59699	03/11/22 13:19	JGT	TAL KNX
	Instrument ID: DUO									
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		1			59699	03/11/22 14:23	JGT	TAL KNX
	Instrument ID: DUO									
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		2			59699	03/11/22 15:07	JGT	TAL KNX
	Instrument ID: DUO									
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		1			59767	03/15/22 12:37	KNC	TAL KNX
	Instrument ID: DUO									

Lab Chronicle

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Date Collected: 12/23/21 13:00
Date Received: 12/24/21 08:00

Lab Sample ID: 140-25875-1
Matrix: Solid
Percent Solids: 86.8

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		2			59767	03/15/22 13:23	KNC	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: G-07 (50.0-56.0)
Date Collected: 12/23/21 13:15
Date Received: 12/24/21 08:00

Lab Sample ID: 140-25875-2
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Sum of Steps 1-7	Analysis	6010B SEP		1			59866	03/18/22 13:19	DKW	TAL KNX
	Instrument ID:	NOEQUIP								
Total/NA	Analysis	Moisture		1			57767	01/10/22 09:51	BKD	TAL KNX
	Instrument ID:	NOEQUIP								

Client Sample ID: G-07 (50.0-56.0)
Date Collected: 12/23/21 13:15
Date Received: 12/24/21 08:00

Lab Sample ID: 140-25875-2
Matrix: Solid
Percent Solids: 89.1

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		1			59793	03/16/22 14:00	JGT	TAL KNX
	Instrument ID:	DUO								
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		2			59793	03/16/22 14:46	JGT	TAL KNX
	Instrument ID:	DUO								
Step 1	SEP	Exchangeable			5.00 g	25 mL	59247	02/28/22 08:00	WRL	TAL KNX
Step 1	Prep	3010A			5 mL	50 mL	59310	03/01/22 08:00	WRL	TAL KNX
Step 1	Analysis	6010B SEP		4			59628	03/09/22 11:55	JGT	TAL KNX
	Instrument ID:	DUO								
Step 2	SEP	Carbonate			5.000 g	25 mL	59318	03/01/22 08:00	WRL	TAL KNX
Step 2	Prep	3010A			5 mL	50 mL	59356	03/02/22 08:00	KNC	TAL KNX
Step 2	Analysis	6010B SEP		3			59628	03/09/22 12:35	JGT	TAL KNX
	Instrument ID:	DUO								
Step 3	SEP	Non-Crystalline			5.00 g	25 mL	59371	03/02/22 08:26	WRL	TAL KNX
Step 3	Prep	3010A			5.00 mL	50 mL	59412	03/03/22 08:20	WRL	TAL KNX
Step 3	Analysis	6010B SEP		1			59667	03/10/22 11:00	JGT	TAL KNX
	Instrument ID:	DUO								
Step 4	SEP	Metal Hydroxide			5.00 g	25 mL	59413	03/03/22 08:32	WRL	TAL KNX
Step 4	Prep	3010A			5 mL	50 mL	59446	03/04/22 08:00	KNC	TAL KNX
Step 4	Analysis	6010B SEP		1			59667	03/10/22 12:13	JGT	TAL KNX
	Instrument ID:	DUO								
Step 5	SEP	Organic-Bound			5.00 g	75 mL	59468	03/07/22 08:00	WRL	TAL KNX
Step 5	Prep	3010A			5 mL	50 mL	59579	03/09/22 08:00	KNC	TAL KNX
Step 5	Analysis	6010B SEP		5			59699	03/11/22 13:34	JGT	TAL KNX
	Instrument ID:	DUO								

1 2 3 4 5 6 7 8 9 10 11 12 13

Client Sample ID: G-07 (50.0-56.0)
Lab Sample ID: 140-25875-2

Date Collected: 12/23/21 13:15
Matrix: Solid
Date Received: 12/24/21 08:00
Percent Solids: 89.1

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		1			59699	03/11/22 14:49	JGT	TAL KNX
	Instrument ID: DUO									
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		1			59767	03/15/22 12:47	KNC	TAL KNX
	Instrument ID: DUO									

Client Sample ID: G-08 (75.0-80.0)
Lab Sample ID: 140-25875-3

Date Collected: 12/23/21 13:30
Matrix: Solid
Date Received: 12/24/21 08:00

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Sum of Steps 1-7	Analysis	6010B SEP		1			59866	03/18/22 13:19	DKW	TAL KNX
	Instrument ID: NOEQUIP									
Total/NA	Analysis	Moisture		1			57767	01/10/22 09:51	BKD	TAL KNX
	Instrument ID: NOEQUIP									

Client Sample ID: G-08 (75.0-80.0)
Lab Sample ID: 140-25875-3

Date Collected: 12/23/21 13:30
Matrix: Solid
Date Received: 12/24/21 08:00
Percent Solids: 89.5

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		1			59793	03/16/22 14:05	JGT	TAL KNX
	Instrument ID: DUO									
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		2			59793	03/16/22 14:51	JGT	TAL KNX
	Instrument ID: DUO									
Step 1	SEP	Exchangeable			5.00 g	25 mL	59247	02/28/22 08:00	WRL	TAL KNX
Step 1	Prep	3010A			5 mL	50 mL	59310	03/01/22 08:00	WRL	TAL KNX
Step 1	Analysis	6010B SEP		4			59628	03/09/22 12:00	JGT	TAL KNX
	Instrument ID: DUO									
Step 2	SEP	Carbonate			5.000 g	25 mL	59318	03/01/22 08:00	WRL	TAL KNX
Step 2	Prep	3010A			5 mL	50 mL	59356	03/02/22 08:00	KNC	TAL KNX
Step 2	Analysis	6010B SEP		3			59628	03/09/22 12:40	JGT	TAL KNX
	Instrument ID: DUO									
Step 3	SEP	Non-Crystalline			5.00 g	25 mL	59371	03/02/22 08:26	WRL	TAL KNX
Step 3	Prep	3010A			5.00 mL	50 mL	59412	03/03/22 08:20	WRL	TAL KNX
Step 3	Analysis	6010B SEP		1			59667	03/10/22 11:15	JGT	TAL KNX
	Instrument ID: DUO									
Step 4	SEP	Metal Hydroxide			5.00 g	25 mL	59413	03/03/22 08:32	WRL	TAL KNX
Step 4	Prep	3010A			5 mL	50 mL	59446	03/04/22 08:00	KNC	TAL KNX
Step 4	Analysis	6010B SEP		1			59667	03/10/22 12:18	JGT	TAL KNX
	Instrument ID: DUO									

Lab Chronicle

Client: Sirem, div of Geosyntec Consultants Job ID: 140-25875-1
Project/Site: Joppa MNA

Client Sample ID: G-08 (75.0-80.0) Lab Sample ID: 140-25875-3

Date Collected: 12/23/21 13:30 **Matrix: Solid**
Date Received: 12/24/21 08:00 **Percent Solids: 89.5**

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 5	SEP	Organic-Bound			5.00 g	75 mL	59468	03/07/22 08:00	WRL	TAL KNX
Step 5	Prep	3010A			5 mL	50 mL	59579	03/09/22 08:00	KNC	TAL KNX
Step 5	Analysis	6010B SEP		5			59699	03/11/22 13:49	JGT	TAL KNX
	Instrument ID: DUO									
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		1			59699	03/11/22 14:54	JGT	TAL KNX
	Instrument ID: DUO									
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		2			59699	03/11/22 15:22	JGT	TAL KNX
	Instrument ID: DUO									
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		1			59767	03/15/22 13:07	KNC	TAL KNX
	Instrument ID: DUO									
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		2			59767	03/15/22 13:33	KNC	TAL KNX
	Instrument ID: DUO									
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		1			59793	03/16/22 13:17	JGT	TAL KNX
	Instrument ID: DUO									

Client Sample ID: Method Blank Lab Sample ID: MB 140-59245/1-A

Date Collected: N/A **Matrix: Solid**
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		1			59793	03/16/22 12:47	JGT	TAL KNX
	Instrument ID: DUO									

Client Sample ID: Method Blank Lab Sample ID: MB 140-59247/1-B ^4

Date Collected: N/A **Matrix: Solid**
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 1	SEP	Exchangeable			5.00 g	25 mL	59247	02/28/22 08:00	WRL	TAL KNX
Step 1	Prep	3010A			5 mL	50 mL	59310	03/01/22 08:00	WRL	TAL KNX
Step 1	Analysis	6010B SEP		4			59628	03/09/22 10:38	JGT	TAL KNX
	Instrument ID: DUO									

Lab Chronicle

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Client Sample ID: Method Blank

Lab Sample ID: MB 140-59318/1-B ^3
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 2	SEP	Carbonate			5.000 g	25 mL	59318	03/01/22 08:00	WRL	TAL KNX
Step 2	Prep	3010A			5 mL	50 mL	59356	03/02/22 08:00	KNC	TAL KNX
Step 2	Analysis	6010B SEP		3			59628	03/09/22 11:02	JGT	TAL KNX

Instrument ID: DUO

Client Sample ID: Method Blank

Lab Sample ID: MB 140-59371/1-B
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 3	SEP	Non-Crystalline			5.00 g	25 mL	59371	03/02/22 08:26	WRL	TAL KNX
Step 3	Prep	3010A			5.00 mL	50 mL	59412	03/03/22 08:20	WRL	TAL KNX
Step 3	Analysis	6010B SEP		1			59667	03/10/22 10:16	JGT	TAL KNX

Instrument ID: DUO

Client Sample ID: Method Blank

Lab Sample ID: MB 140-59413/1-B
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 4	SEP	Metal Hydroxide			5.00 g	25 mL	59413	03/03/22 08:32	WRL	TAL KNX
Step 4	Prep	3010A			5 mL	50 mL	59446	03/04/22 08:00	KNC	TAL KNX
Step 4	Analysis	6010B SEP		1			59667	03/10/22 11:20	JGT	TAL KNX

Instrument ID: DUO

Client Sample ID: Method Blank

Lab Sample ID: MB 140-59468/1-B ^5
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 5	SEP	Organic-Bound			5.00 g	75 mL	59468	03/07/22 08:00	WRL	TAL KNX
Step 5	Prep	3010A			5 mL	50 mL	59579	03/09/22 08:00	KNC	TAL KNX
Step 5	Analysis	6010B SEP		5			59699	03/11/22 12:48	JGT	TAL KNX

Instrument ID: DUO

Client Sample ID: Method Blank

Lab Sample ID: MB 140-59581/1-A
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		1			59699	03/11/22 13:54	JGT	TAL KNX

Instrument ID: DUO

Lab Chronicle

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Client Sample ID: Method Blank

Lab Sample ID: MB 140-59631/1-A

Date Collected: N/A
Date Received: N/A

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		1			59767	03/15/22 12:07	KNC	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-59245/2-A

Date Collected: N/A
Date Received: N/A

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		1			59793	03/16/22 12:52	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-59247/2-B ^5

Date Collected: N/A
Date Received: N/A

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 1	SEP	Exchangeable			5.00 g	25 mL	59247	02/28/22 08:00	WRL	TAL KNX
Step 1	Prep	3010A			5 mL	50 mL	59310	03/01/22 08:00	WRL	TAL KNX
Step 1	Analysis	6010B SEP		5			59628	03/09/22 10:43	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-59318/2-B ^5

Date Collected: N/A
Date Received: N/A

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 2	SEP	Carbonate			5.000 g	25 mL	59318	03/01/22 08:00	WRL	TAL KNX
Step 2	Prep	3010A			5 mL	50 mL	59356	03/02/22 08:00	KNC	TAL KNX
Step 2	Analysis	6010B SEP		5			59628	03/09/22 11:07	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-59371/2-B

Date Collected: N/A
Date Received: N/A

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 3	SEP	Non-Crystalline			5.00 g	25 mL	59371	03/02/22 08:26	WRL	TAL KNX
Step 3	Prep	3010A			5.00 mL	50 mL	59412	03/03/22 08:20	WRL	TAL KNX
Step 3	Analysis	6010B SEP		1			59667	03/10/22 10:21	JGT	TAL KNX
	Instrument ID:	DUO								

Lab Chronicle

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-59413/2-B
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 4	SEP	Metal Hydroxide			5.00 g	25 mL	59413	03/03/22 08:32	WRL	TAL KNX
Step 4	Prep	3010A			5 mL	50 mL	59446	03/04/22 08:00	KNC	TAL KNX
Step 4	Analysis	6010B SEP		1			59667	03/10/22 11:25	JGT	TAL KNX

Instrument ID: DUO

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-59468/2-B ^5
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 5	SEP	Organic-Bound			5.00 g	75 mL	59468	03/07/22 08:00	WRL	TAL KNX
Step 5	Prep	3010A			5 mL	50 mL	59579	03/09/22 08:00	KNC	TAL KNX
Step 5	Analysis	6010B SEP		5			59699	03/11/22 12:53	JGT	TAL KNX

Instrument ID: DUO

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-59581/2-A
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		1			59699	03/11/22 13:59	JGT	TAL KNX

Instrument ID: DUO

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-59631/2-A
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		1			59767	03/15/22 12:12	KNC	TAL KNX

Instrument ID: DUO

Client Sample ID: Lab Control Sample Dup

Lab Sample ID: LCSD 140-59245/3-A
Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		1			59793	03/16/22 12:57	JGT	TAL KNX

Instrument ID: DUO

Lab Chronicle

1 2 3 4 5 6 7 8 9 10 11 12 13

Client Sample ID: Lab Control Sample Dup
Lab Sample ID: LCSD 140-59247/3-B ^5

Date Collected: N/A
Date Received: N/A
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 1	SEP	Exchangeable			5.00 g	25 mL	59247	02/28/22 08:00	WRL	TAL KNX
Step 1	Prep	3010A			5 mL	50 mL	59310	03/01/22 08:00	WRL	TAL KNX
Step 1	Analysis	6010B SEP		5			59628	03/09/22 10:48	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample Dup
Lab Sample ID: LCSD 140-59318/3-B ^5

Date Collected: N/A
Date Received: N/A
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 2	SEP	Carbonate			5.000 g	25 mL	59318	03/01/22 08:00	WRL	TAL KNX
Step 2	Prep	3010A			5 mL	50 mL	59356	03/02/22 08:00	KNC	TAL KNX
Step 2	Analysis	6010B SEP		5			59628	03/09/22 11:12	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample Dup
Lab Sample ID: LCSD 140-59371/3-B

Date Collected: N/A
Date Received: N/A
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 3	SEP	Non-Crystalline			5.00 g	25 mL	59371	03/02/22 08:26	WRL	TAL KNX
Step 3	Prep	3010A			5.00 mL	50 mL	59412	03/03/22 08:20	WRL	TAL KNX
Step 3	Analysis	6010B SEP		1			59667	03/10/22 10:26	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample Dup
Lab Sample ID: LCSD 140-59413/3-B

Date Collected: N/A
Date Received: N/A
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 4	SEP	Metal Hydroxide			5.00 g	25 mL	59413	03/03/22 08:32	WRL	TAL KNX
Step 4	Prep	3010A			5 mL	50 mL	59446	03/04/22 08:00	KNC	TAL KNX
Step 4	Analysis	6010B SEP		1			59667	03/10/22 11:30	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample Dup
Lab Sample ID: LCSD 140-59468/3-B ^5

Date Collected: N/A
Date Received: N/A
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 5	SEP	Organic-Bound			5.00 g	75 mL	59468	03/07/22 08:00	WRL	TAL KNX
Step 5	Prep	3010A			5 mL	50 mL	59579	03/09/22 08:00	KNC	TAL KNX
Step 5	Analysis	6010B SEP		5			59699	03/11/22 12:58	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample Dup

Lab Sample ID: LCSD 140-59581/3-A

Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		1			59699	03/11/22 14:04	JGT	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: Lab Control Sample Dup

Lab Sample ID: LCSD 140-59631/3-A

Date Collected: N/A
Matrix: Solid
Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		1			59767	03/15/22 12:17	KNC	TAL KNX
	Instrument ID:	DUO								

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)

Lab Sample ID: 140-25875-1 DU

Date Collected: 12/23/21 13:00
Matrix: Solid
Date Received: 12/24/21 08:00
Percent Solids: 86.8

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		1			59793	03/16/22 13:55	JGT	TAL KNX
	Instrument ID:	DUO								
Total/NA	Prep	Total			1.00 g	50 mL	59245	02/28/22 08:00	WRL	TAL KNX
Total/NA	Analysis	6010B		2			59793	03/16/22 14:41	JGT	TAL KNX
	Instrument ID:	DUO								
Step 1	SEP	Exchangeable			5.00 g	25 mL	59247	02/28/22 08:00	WRL	TAL KNX
Step 1	Prep	3010A			5 mL	50 mL	59310	03/01/22 08:00	WRL	TAL KNX
Step 1	Analysis	6010B SEP		4			59628	03/09/22 11:50	JGT	TAL KNX
	Instrument ID:	DUO								
Step 2	SEP	Carbonate			5.000 g	25 mL	59318	03/01/22 08:00	WRL	TAL KNX
Step 2	Prep	3010A			5 mL	50 mL	59356	03/02/22 08:00	KNC	TAL KNX
Step 2	Analysis	6010B SEP		3			59628	03/09/22 12:30	JGT	TAL KNX
	Instrument ID:	DUO								
Step 3	SEP	Non-Crystalline			5.00 g	25 mL	59371	03/02/22 08:26	WRL	TAL KNX
Step 3	Prep	3010A			5.00 mL	50 mL	59412	03/03/22 08:20	WRL	TAL KNX
Step 3	Analysis	6010B SEP		1			59667	03/10/22 10:50	JGT	TAL KNX
	Instrument ID:	DUO								
Step 4	SEP	Metal Hydroxide			5.00 g	25 mL	59413	03/03/22 08:32	WRL	TAL KNX
Step 4	Prep	3010A			5 mL	50 mL	59446	03/04/22 08:00	KNC	TAL KNX
Step 4	Analysis	6010B SEP		1			59667	03/10/22 11:53	JGT	TAL KNX
	Instrument ID:	DUO								
Step 5	SEP	Organic-Bound			5.00 g	75 mL	59468	03/07/22 08:00	WRL	TAL KNX
Step 5	Prep	3010A			5 mL	50 mL	59579	03/09/22 08:00	KNC	TAL KNX
Step 5	Analysis	6010B SEP		5			59699	03/11/22 13:29	JGT	TAL KNX
	Instrument ID:	DUO								

Lab Chronicle

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Client Sample ID: G-03 (57.5-62.5, 63.5-70.0)
Date Collected: 12/23/21 13:00
Date Received: 12/24/21 08:00

Lab Sample ID: 140-25875-1 DU
Matrix: Solid
Percent Solids: 86.8

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		1			59699	03/11/22 14:33	JGT	TAL KNX
	Instrument ID: DUO									
Step 6	SEP	Acid/Sulfide			5 g	250 mL	59581	03/09/22 08:00	WRL	TAL KNX
Step 6	Analysis	6010B SEP		2			59699	03/11/22 15:12	JGT	TAL KNX
	Instrument ID: DUO									
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		1			59767	03/15/22 12:42	KNC	TAL KNX
	Instrument ID: DUO									
Step 7	Prep	Residual			1.00 g	50 mL	59631	03/10/22 08:05	WRL	TAL KNX
Step 7	Analysis	6010B SEP		2			59767	03/15/22 13:28	KNC	TAL KNX
	Instrument ID: DUO									

Laboratory References:

TAL KNX = Eurofins Knoxville, 5815 Middlebrook Pike, Knoxville, TN 37921, TEL (865)291-3000

Accreditation/Certification Summary

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Laboratory: Eurofins Knoxville

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
	AFCEE	N/A	
ANAB	Dept. of Defense ELAP	L2311	02-13-25
ANAB	Dept. of Energy	L2311.01	02-13-25
ANAB	ISO/IEC 17025	L2311	02-13-25
Arkansas DEQ	State	88-0688	06-17-22
California	State	2423	06-30-22
Colorado	State	TN00009	02-28-23
Connecticut	State	PH-0223	09-30-23
Florida	NELAP	E87177	06-30-22
Georgia (DW)	State	906	12-11-22
Hawaii	State	NA	12-11-22
Kansas	NELAP	E-10349	10-31-22
Kentucky (DW)	State	90101	12-31-22
Louisiana	NELAP	83979	06-30-22
Louisiana (DW)	State	LA019	12-31-22
Maryland	State	277	03-31-22
Michigan	State	9933	12-11-22
Nevada	State	TN00009	07-31-22
New Hampshire	NELAP	299919	01-17-23
New Jersey	NELAP	TN001	06-30-22
New York	NELAP	10781	03-31-22
North Carolina (DW)	State	21705	07-31-22
North Carolina (WW/SW)	State	64	12-31-22
Ohio VAP	State	CL0059	06-02-23
Oklahoma	State	9415	08-31-22
Oregon	NELAP	TNI0189	12-31-22
Pennsylvania	NELAP	68-00576	12-31-22
Tennessee	State	02014	12-11-22
Texas	NELAP	T104704380-18-12	08-31-22
US Fish & Wildlife	US Federal Programs	058448	07-31-22
USDA	US Federal Programs	P330-19-00236	08-20-22
Utah	NELAP	TN00009	07-31-22
Virginia	NELAP	460176	09-14-22
Washington	State	C593	01-19-23
West Virginia (DW)	State	9955C	12-31-22
West Virginia DEP	State	345	04-30-22
Wisconsin	State	998044300	08-31-22

Method Summary

Client: Sirem, div of Geosyntec Consultants
Project/Site: Joppa MNA

Job ID: 140-25875-1

Method	Method Description	Protocol	Laboratory
6010B	SEP Metals (ICP) - Total	SW846	TAL KNX
6010B SEP	SEP Metals (ICP)	SW846	TAL KNX
Moisture	Percent Moisture	EPA	TAL KNX
3010A	Preparation, Total Metals	SW846	TAL KNX
Acid/Sulfide	Sequential Extraction Procedure, Acid/Sulfide Fraction	TAL-KNOX	TAL KNX
Carbonate	Sequential Extraction Procedure, Carbonate Fraction	TAL-KNOX	TAL KNX
Exchangeable	Sequential Extraction Procedure, Exchangeable Fraction	TAL-KNOX	TAL KNX
Metal Hydroxide	Sequential Extraction Procedure, Metal Hydroxide Fraction	TAL-KNOX	TAL KNX
Non-Crystalline	Sequential Extraction Procedure, Non-crystalline Materials	TAL-KNOX	TAL KNX
Organic-Bound	Sequential Extraction Procedure, Organic Bound Fraction	TAL-KNOX	TAL KNX
Residual	Sequential Extraction Procedure, Residual Fraction	TAL-KNOX	TAL KNX
Total	Preparation, Total Material	TAL-KNOX	TAL KNX

Protocol References:

EPA = US Environmental Protection Agency
SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.
TAL-KNOX = TestAmerica Laboratories, Knoxville, Facility Standard Operating Procedure.

Laboratory References:

TAL KNX = Eurofins Knoxville, 5815 Middlebrook Pike, Knoxville, TN 37921, TEL (865)291-3000

Eurofins TestAmerica, Knoxville
5815 Middlebrook Pike

Knoxville, TN 37921-5947
phone 865.291.3000 fax 865.584.4315

Chain of Custody Record

eurofins | Environment Testing TestAmerica

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

TestAmerica Laboratories, Inc. d/b/a Eurofins TestAmerica

	Project Manager: Michael Healey			COC No:
Client Contact	Email: mhealey@siremlab.com	**Site Contact:**	**Date:** 23Dec21	____ of ____ COCs
SiREM Lab	**Tel/Fax:** 519-515-0852	**Lab Contact:** Rachel Hallman	**Carrier:**	TALS Project #:
130 Stone Road	**Analysis Turnaround Time**			Sampler:
Guelph/ON/Canada/N1G 3Z2	☑ CALENDAR DAYS ☐ WORKING DAYS			**For Lab Use Only:**
(519) 822-2265 Phone	TAT if different from Below ______			Walk-in Client:
(xxx) xxx-xxxx FAX	☑ 2 weeks			Lab Sampling:
Project Name: Joppa MNA	☐ 1 week			
Site:	☐ 2 days			Job / SDG No.:
P O #	☐ 1 day			

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	SEP (Sequential Extraction Procedu	Sample Specific Notes:
G-03 (57.5-62.5, 63.5-70.0)	12/23/21	1:00	G	Soil	1	N	X	Contact Rachel Hallman/Michael Healey Prior to Analysis
G-07 (50.0-56.0)	12/23/21	1:15	G	Soil	1	N	X	
G-08 (75.0-80.0)	12/23/21	1:30	G	Soil	1	N	X	

Rec @ RT 0.5°c CT 0.4°c
no custody seal
1 cooler RD 12.24.21
UPS# 1Z 522 7VR 15 9311 1219

140-25875 Chain of Custody

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ______

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

☑ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☐ Disposal by Lab ☑ Archive for ______ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☐ No | Custody Seal No.: | Cooler Temp. (°C): Obs'd:______ Corr'd:______ | Therm ID No.:______

Relinquished by: Rachel Hallman	Company: SiREM	Date/Time: 23Dec21	Received by:	Company: ETAKNX	Date/Time: 12.24.21 8:00
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:

Form No. CA-C-WI-002, Rev. 4.26, dated 7/25/2019

EUROFINS/TESTAMERICA KNOXVILLE SAMPLE RECEIPT/CONDITION UPON RECEIPT ANOMALY CHECKLIST

Log In Number:

Review Items	Yes	No	NA	**If No, what was the problem?**	**Comments/Actions Taken**
1. Are the shipping containers intact?	✓			☐ **Containers, Broken**	
2. Were ambient air containers received intact?			✓	☐ Checked in lab	
3. The coolers/containers custody seal if present, is it intact?			✓	☐ Yes ☐ NA	
4. Is the cooler temperature within limits? (> freezing temp. of water to 6 °C, VOST: 10°C) Thermometer ID : SC-71 Correction factor: -0.1°C	✓			☐ **Cooler Out of Temp, Client Contacted, Proceed/Cancel** ☐ **Cooler Out of Temp, Same Day Receipt**	
5. Were all of the sample containers received intact?	✓			☐ **Containers, Broken**	
6. Were samples received in appropriate containers?	✓			☐ **Containers, Improper; Client Contacted; Proceed/Cancel**	
7. Do sample container labels match COC? (IDs, Dates, Times)	✓			☐ **COC & Samples Do Not Match** ☐ **COC Incorrect/Incomplete** ☐ **COC Not Received**	
8. Were all of the samples listed on the COC received?	✓			☐ **Sample Received, Not on COC** ☐ **Sample on COC, Not Received**	
9. Is the date/time of sample collection noted?	✓			☐ **COC; No Date/Time; Client Contacted**	**Labeling Verified by:** **Date:**
10. Was the sampler identified on the COC?			✓	☐ **Sampler Not Listed on COC**	
11. Is the client and project name/# identified?	✓			☐ **COC Incorrect/Incomplete**	**pH test strip lot number:**
12. Are tests/parameters listed for each sample?	✓			☐ **COC No tests on COC**	
13. Is the matrix of the samples noted?	✓			☐ **COC Incorrect/Incomplete**	
14. Was COC relinquished? (Signed/Dated/Timed)	✓			☐ **COC Incorrect/Incomplete**	
15. Were samples received within holding time?	✓			☐ **Holding Time - Receipt**	
16. Were samples received with correct chemical preservative (excluding Encore)?			✓	☐ **pH Adjusted, pH Included (See box 16A)** ☐ **Incorrect Preservative**	
17. Were VOA samples received without headspace?			✓	☐ **Headspace (VOA only)**	
18. Did you check for residual chlorine, if necessary? (e.g. 1613B, 1668) Chlorine test strip lot number:			✓	☐ **Residual Chlorine**	
19. For 1613B water samples is pH<9?			✓	☐ If no, notify lab to adjust	
20. For rad samples was sample activity info. Provided?			✓	☐ Project missing info	

	Box 16A: pH Preservation	Box 18A: Residual Chlorine
Preservative:		
Lot Number:		
Exp Date:		
Analyst:		
Date:		
Time:		

Project #: 14006346 PM Instructions:

Sample Receiving Associate: R D Date: 12.24.21

QA026R32.doc, 062719

1 2 3 4 5 6 7 8 9 10 11 12 13

ATTACHMENT H

X-Ray Diffraction Analytical Data

SGS

Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for: *Environmental Services*

Project Number/ LIMS No. *Custom XRD/MI4515-NOV21*

Sample Receipt: *November 9, 2021*

Sample Analysis: *November 11, 2021*

Reporting Date: *November 16, 2021*

Instrument: BRUKER AXS D8 Advance Diffractometer

Test Conditions: Co radiation, 35 kV, 40 mA
Regular Scanning: Step: 0.02°, Step time: 1s, 2θ range: 3-80°

Interpretations : PDF2/PDF4 powder diffraction databases issued by the International Center for Diffraction Data (ICDD). DiffracPlus Eva and Topas software.

Detection Limit : 0.5-2%. Strongly dependent on crystallinity.

Contents:

1) Method Summary
2) Quantitative XRD Results
3) XRD Pattern(s)

Kim Gibbs

Kim Gibbs, H.B.Sc., P.Geo.
Senior Mineralogist

Huyun Zhou

Huyun Zhou, Ph.D., P.Geo.
Senior Mineralogist

ACCREDITATION: SGS Minerals Services Lakefield is accredited to the requirements of ISO/IEC 17025 for specific tests as listed on our scope of accreditation, including geochemical, mineralogical and trade mineral tests. To view a list of the accredited methods, please visit the following website and search SGS Canada - Minerals Services - Lakefield: http://palcan.scc.ca/SpecsSearch/GLSearchForm.do.

Method Summary

The Rietveld Method of Mineral Identification by XRD (ME-LR-MIN-MET-MN-D05) method used by SGS Minerals Services is accredited to the requirements of ISO/IEC 17025.

Mineral Identification and Interpretation:

Mineral identification and interpretation involves matching the diffraction pattern of an unknown material to patterns of single-phase reference materials. The reference patterns are compiled by the Joint Committee on Powder Diffraction Standards - International Center for Diffraction Data (JCPDS-ICDD) database and released on software as Powder Diffraction Files (PDF).

Interpretations do not reflect the presence of non-crystalline and/or amorphous compounds, except when internal standards have been added by request. Mineral proportions may be strongly influenced by crystallinity, crystal structure and preferred orientations. Mineral or compound identification and quantitative analysis results should be accompanied by supporting chemical assay data or other additional tests.

Quantitative Rietveld Analysis:

Quantitative Rietveld Analysis is performed by using Topas 4.2 (Bruker AXS), a graphics based profile analysis program built around a non-linear least squares fitting system, to determine the amount of different phases present in a multicomponent sample. Whole pattern analyses are predicated by the fact that the X-ray diffraction pattern is a total sum of both instrumental and specimen factors. Unlike other peak intensity-based methods, the Rietveld method uses a least squares approach to refine a theoretical line profile until it matches the obtained experimental patterns.

Rietveld refinement is completed with a set of minerals specifically identified for the sample. Zero values indicate that the mineral was included in the refinement calculations, but the calculated concentration was less than 0.05wt%. Minerals not identified by the analyst are not included in refinement calculations for specific samples and are indicated with a dash.

Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

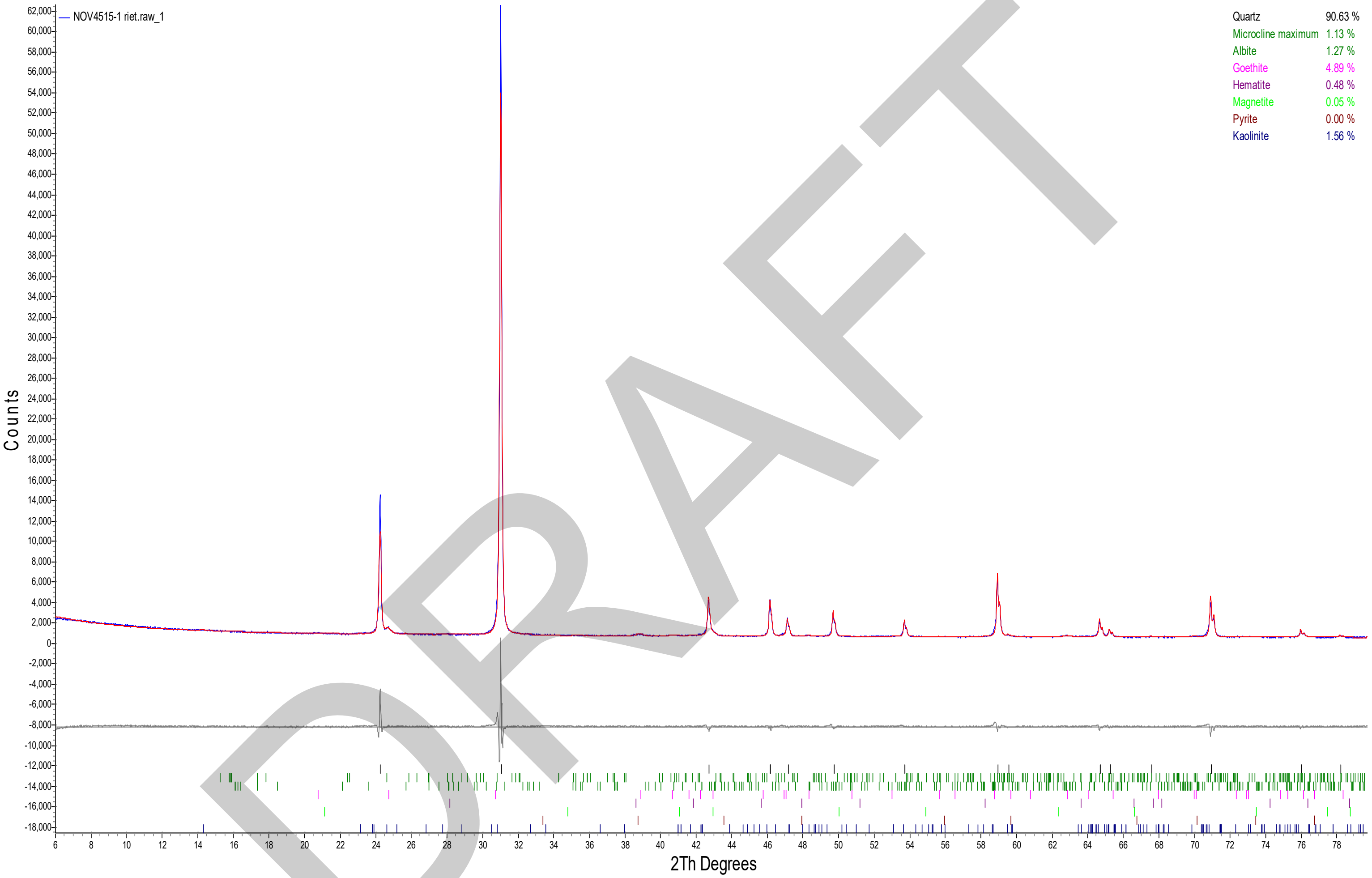
Mineral/Compound	G-03 (57.5-62.5, 63.5-70.0) NOV4515-1 (wt %)	G-07 (50.0-56.0) NOV4515-2 (wt %)	G-08 (75.0-80.0) NOV4515-3 (wt %)
Quartz	90.6	92.0	88.4
Microcline	1.1	1.7	1.3
Albite	1.3	1.5	1.2
Goethite	4.9	3.1	8.2
Hematite	0.5	0.2	0.1
Magnetite	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0
Kaolinite	1.6	1.6	0.7
TOTAL	100	100	100

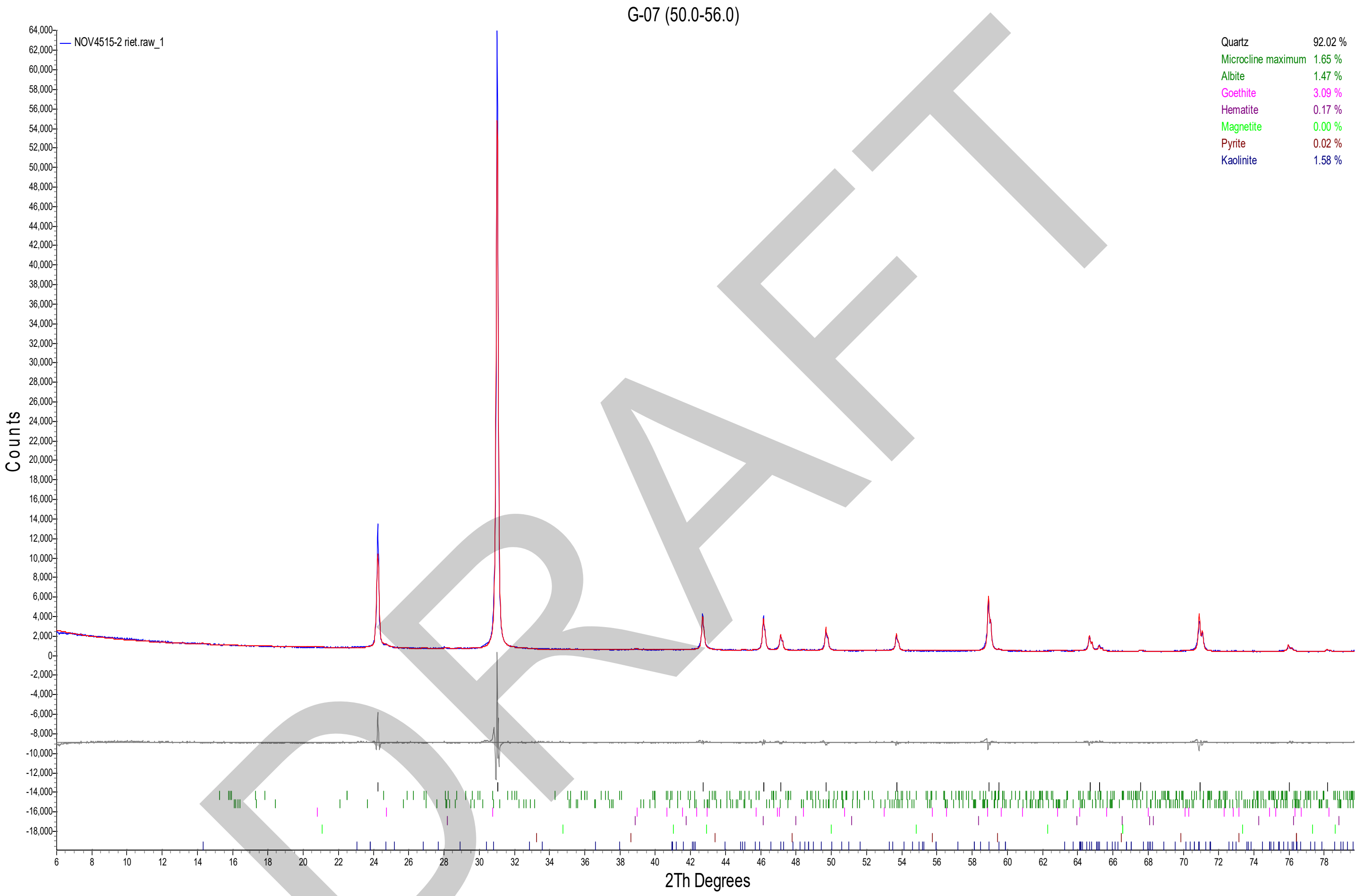
Zero values indicate that the mineral was included in the refinement, but the calculated concentration is below a measurable value.

The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been de

Mineral/Compound	Formula
Quartz	SiO_2
Microcline	$KAlSi_3O_8$
Albite	$NaAlSi_3O_8$
Goethite	$\alpha FeO\cdot OH$
Hematite	Fe_2O_3
Magnetite	Fe_3O_4
Pyrite	FeS_2
Kaolinite	$Al_2Si_2O_5(OH)_4$

G-03 (57.5-62.5, 63.5-70.0)





G-07 (50.0-56.0)

NOV4515-2 riet.raw_1
Quartz 92.02 %
Microcline maximum 1.65 %
Albite 1.47 %
Goethite 3.09 %
Hematite 0.17 %
Magnetite 0.00 %
Pyrite 0.02 %
Kaolinite 1.58 %
Counts
64,000
62,000
60,000
58,000
56,000
54,000
52,000
50,000
48,000
46,000
44,000
42,000
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
-10,000
-12,000
-14,000
-16,000
-18,000
6
8
10
12
14
16
18
20
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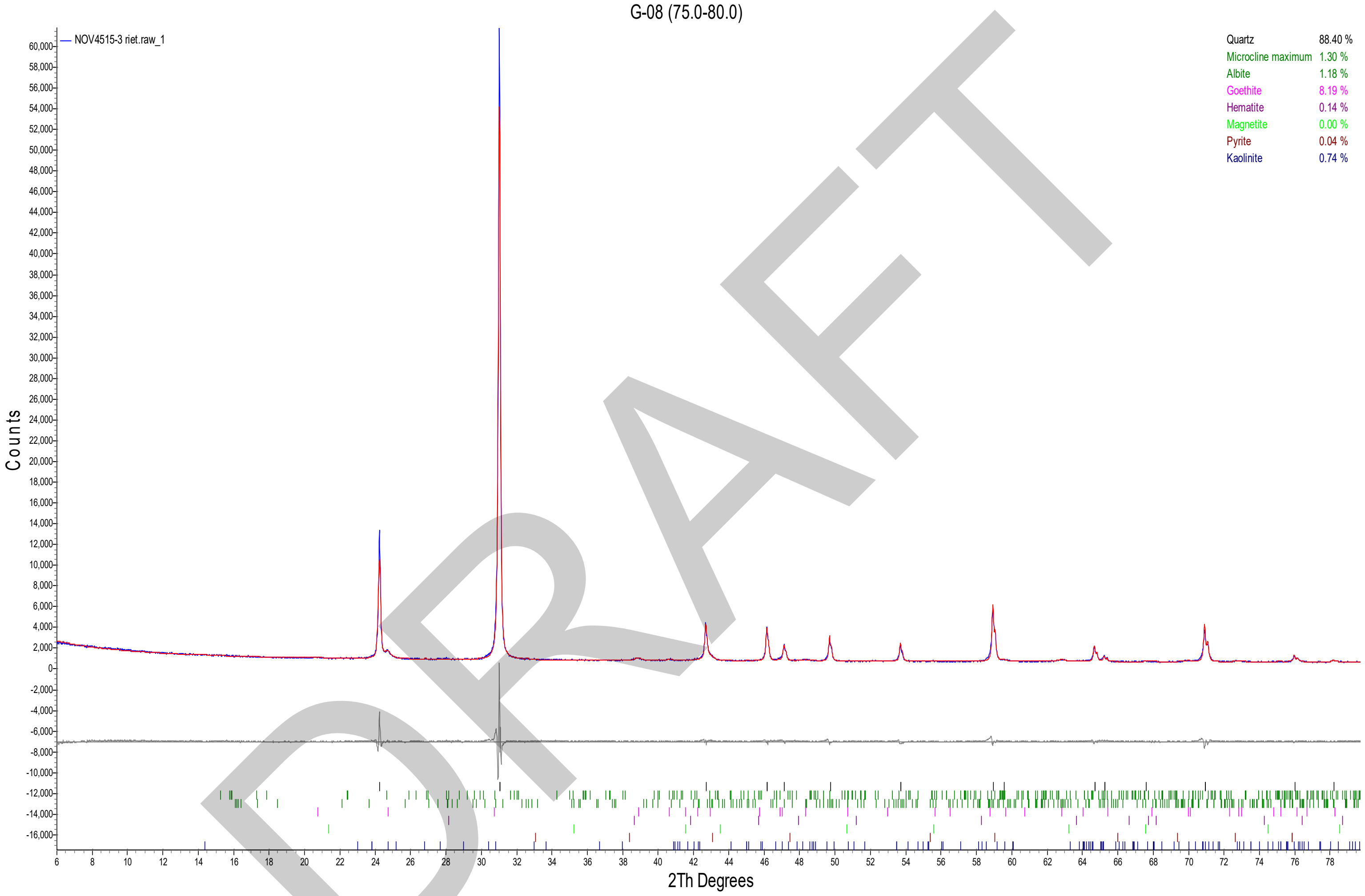
Environmental Services
Custom XRD/MI4515-NOV21
16-Nov-21



ATTACHMENT I

Aqueous Phase Data Summary

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW01	Porewater	2021/03/05	pH (field)	SU	8.0
CCR	XPW01	Porewater	2021/03/24	pH (field)	SU	8.4
CCR	XPW01	Porewater	2021/04/14	pH (field)	SU	8.2
CCR	XPW01	Porewater	2021/05/12	pH (field)	SU	8.4
CCR	XPW01	Porewater	2021/07/21	pH (field)	SU	7.3
CCR	XPW01	Porewater	2022/03/15	pH (field)	SU	8.3
CCR	XPW01	Porewater	2023/03/08	pH (field)	SU	8.5
CCR	XPW01	Porewater	2023/05/03	pH (field)	SU	8.4
CCR	XPW01	Porewater	2023/09/26	pH (field)	SU	8.2
CCR	XPW01	Porewater	2023/10/25	pH (field)	SU	8.4
CCR	XPW01	Porewater	2021/03/05	Oxidation Reduction Potential	mV	-168
CCR	XPW01	Porewater	2021/03/24	Oxidation Reduction Potential	mV	-55.0
CCR	XPW01	Porewater	2021/04/14	Oxidation Reduction Potential	mV	-57.0
CCR	XPW01	Porewater	2021/05/12	Oxidation Reduction Potential	mV	-116
CCR	XPW01	Porewater	2021/07/21	Oxidation Reduction Potential	mV	-101
CCR	XPW01	Porewater	2022/03/15	Oxidation Reduction Potential	mV	-155
CCR	XPW01	Porewater	2023/03/08	Oxidation Reduction Potential	mV	-157
CCR	XPW01	Porewater	2023/05/03	Oxidation Reduction Potential	mV	-34.0
CCR	XPW01	Porewater	2023/09/26	Oxidation Reduction Potential	mV	-152
CCR	XPW01	Porewater	2023/10/25	Oxidation Reduction Potential	mV	-177
CCR	XPW01	Porewater	2021/03/05	Eh	V	0.027
CCR	XPW01	Porewater	2021/03/24	Eh	V	0.14
CCR	XPW01	Porewater	2021/04/14	Eh	V	0.14
CCR	XPW01	Porewater	2021/05/12	Eh	V	0.078
CCR	XPW01	Porewater	2021/07/21	Eh	V	0.093
CCR	XPW01	Porewater	2022/03/15	Eh	V	0.040
CCR	XPW01	Porewater	2023/03/08	Eh	V	0.038
CCR	XPW01	Porewater	2023/05/03	Eh	V	0.16
CCR	XPW01	Porewater	2023/09/26	Eh	V	0.041
CCR	XPW01	Porewater	2023/10/25	Eh	V	0.015
CCR	XPW01	Porewater	2021/03/05	Alkalinity, bicarbonate	mg/L CaCO3	155
CCR	XPW01	Porewater	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	141
CCR	XPW01	Porewater	2021/04/14	Alkalinity, bicarbonate	mg/L CaCO3	136
CCR	XPW01	Porewater	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	145
CCR	XPW01	Porewater	2021/07/21	Alkalinity, bicarbonate	mg/L CaCO3	142
CCR	XPW01	Porewater	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	104
CCR	XPW01	Porewater	2023/03/08	Alkalinity, bicarbonate	mg/L CaCO3	64.0
CCR	XPW01	Porewater	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	130
CCR	XPW01	Porewater	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	118
CCR	XPW01	Porewater	2023/10/25	Alkalinity, bicarbonate	mg/L CaCO3	84.0
CCR	XPW01	Porewater	2022/03/15	Alkalinity, carbonate	mg/L CaCO3	11.0
CCR	XPW01	Porewater	2023/03/08	Alkalinity, carbonate	mg/L CaCO3	38.0
CCR	XPW01	Porewater	2023/09/26	Alkalinity, carbonate	mg/L CaCO3	2.00
CCR	XPW01	Porewater	2023/10/25	Alkalinity, carbonate	mg/L CaCO3	27.0
CCR	XPW01	Porewater	2021/03/05	Barium, total	mg/L	0.165
CCR	XPW01	Porewater	2021/03/24	Barium, total	mg/L	0.161
CCR	XPW01	Porewater	2021/04/14	Barium, total	mg/L	0.154
CCR	XPW01	Porewater	2021/05/12	Barium, total	mg/L	0.162
CCR	XPW01	Porewater	2021/07/21	Barium, total	mg/L	0.175
CCR	XPW01	Porewater	2022/03/15	Barium, total	mg/L	0.113
CCR	XPW01	Porewater	2023/03/08	Barium, total	mg/L	0.128
CCR	XPW01	Porewater	2023/05/03	Barium, total	mg/L	0.137
CCR	XPW01	Porewater	2023/09/26	Barium, total	mg/L	0.126
CCR	XPW01	Porewater	2023/10/25	Barium, total	mg/L	0.160
CCR	XPW01	Porewater	2021/03/05	Boron, total	mg/L	10.4

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW01	Porewater	2021/03/24	Boron, total	mg/L	9.58
CCR	XPW01	Porewater	2021/04/14	Boron, total	mg/L	9.42
CCR	XPW01	Porewater	2021/05/12	Boron, total	mg/L	10.2
CCR	XPW01	Porewater	2021/07/21	Boron, total	mg/L	10.1
CCR	XPW01	Porewater	2022/03/15	Boron, total	mg/L	10.4
CCR	XPW01	Porewater	2023/03/08	Boron, total	mg/L	8.79
CCR	XPW01	Porewater	2023/05/03	Boron, total	mg/L	10.6
CCR	XPW01	Porewater	2023/09/26	Boron, total	mg/L	10.7
CCR	XPW01	Porewater	2023/10/25	Boron, total	mg/L	12.8
CCR	XPW01	Porewater	2021/03/05	Calcium, total	mg/L	162
CCR	XPW01	Porewater	2021/03/24	Calcium, total	mg/L	158
CCR	XPW01	Porewater	2021/04/14	Calcium, total	mg/L	156
CCR	XPW01	Porewater	2021/05/12	Calcium, total	mg/L	166
CCR	XPW01	Porewater	2021/07/21	Calcium, total	mg/L	160
CCR	XPW01	Porewater	2022/03/15	Calcium, total	mg/L	159
CCR	XPW01	Porewater	2023/03/08	Calcium, total	mg/L	164
CCR	XPW01	Porewater	2023/05/03	Calcium, total	mg/L	151
CCR	XPW01	Porewater	2023/09/26	Calcium, total	mg/L	168
CCR	XPW01	Porewater	2023/10/25	Calcium, total	mg/L	175
CCR	XPW01	Porewater	2021/03/05	Chloride, total	mg/L	10.0
CCR	XPW01	Porewater	2021/03/24	Chloride, total	mg/L	9.00
CCR	XPW01	Porewater	2021/04/14	Chloride, total	mg/L	7.00
CCR	XPW01	Porewater	2021/05/12	Chloride, total	mg/L	6.00
CCR	XPW01	Porewater	2021/07/21	Chloride, total	mg/L	6.00
CCR	XPW01	Porewater	2022/03/15	Chloride, total	mg/L	5.00
CCR	XPW01	Porewater	2023/03/08	Chloride, total	mg/L	11.0
CCR	XPW01	Porewater	2023/05/03	Chloride, total	mg/L	14.0
CCR	XPW01	Porewater	2023/09/26	Chloride, total	mg/L	16.0
CCR	XPW01	Porewater	2023/10/25	Chloride, total	mg/L	18.0
CCR	XPW01	Porewater	2021/03/05	Cobalt, total	mg/L	<0.0001
CCR	XPW01	Porewater	2021/03/24	Cobalt, total	mg/L	<0.0001
CCR	XPW01	Porewater	2021/04/14	Cobalt, total	mg/L	<0.0001
CCR	XPW01	Porewater	2021/05/12	Cobalt, total	mg/L	<0.001
CCR	XPW01	Porewater	2021/07/21	Cobalt, total	mg/L	<0.0001
CCR	XPW01	Porewater	2022/03/15	Cobalt, total	mg/L	<0.0001
CCR	XPW01	Porewater	2023/03/08	Cobalt, total	mg/L	0.000200
CCR	XPW01	Porewater	2023/05/03	Cobalt, total	mg/L	0.000200
CCR	XPW01	Porewater	2023/09/26	Cobalt, total	mg/L	0.000100
CCR	XPW01	Porewater	2023/10/25	Cobalt, total	mg/L	<0.0001
CCR	XPW01	Porewater	2023/05/03	Iron, dissolved	mg/L	0.152
CCR	XPW01	Porewater	2023/09/26	Iron, dissolved	mg/L	0.999
CCR	XPW01	Porewater	2021/03/05	Magnesium, total	mg/L	2.25
CCR	XPW01	Porewater	2021/03/24	Magnesium, total	mg/L	1.70
CCR	XPW01	Porewater	2021/04/14	Magnesium, total	mg/L	1.28
CCR	XPW01	Porewater	2021/05/12	Magnesium, total	mg/L	1.31
CCR	XPW01	Porewater	2021/07/21	Magnesium, total	mg/L	0.917
CCR	XPW01	Porewater	2022/03/15	Magnesium, total	mg/L	0.443
CCR	XPW01	Porewater	2023/03/08	Magnesium, total	mg/L	0.254
CCR	XPW01	Porewater	2023/05/03	Magnesium, total	mg/L	0.405
CCR	XPW01	Porewater	2023/09/26	Magnesium, total	mg/L	0.493
CCR	XPW01	Porewater	2023/10/25	Magnesium, total	mg/L	0.260
CCR	XPW01	Porewater	2023/05/03	Manganese, dissolved	mg/L	0.291
CCR	XPW01	Porewater	2023/09/26	Manganese, dissolved	mg/L	0.833
CCR	XPW01	Porewater	2023/05/03	Phosphate, dissolved	mg/L	1.49
CCR	XPW01	Porewater	2023/09/26	Phosphate, dissolved	mg/L	0.783

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW01	Porewater	2021/03/05	Potassium, total	mg/L	31.1
CCR	XPW01	Porewater	2021/03/24	Potassium, total	mg/L	38.1
CCR	XPW01	Porewater	2021/04/14	Potassium, total	mg/L	34.7
CCR	XPW01	Porewater	2021/05/12	Potassium, total	mg/L	36.9
CCR	XPW01	Porewater	2021/07/21	Potassium, total	mg/L	35.1
CCR	XPW01	Porewater	2022/03/15	Potassium, total	mg/L	36.9
CCR	XPW01	Porewater	2023/03/08	Potassium, total	mg/L	37.2
CCR	XPW01	Porewater	2023/05/03	Potassium, total	mg/L	38.5
CCR	XPW01	Porewater	2023/09/26	Potassium, total	mg/L	37.5
CCR	XPW01	Porewater	2023/10/25	Potassium, total	mg/L	39.4
CCR	XPW01	Porewater	2023/05/03	Silicon, dissolved	mg/L	4.35
CCR	XPW01	Porewater	2023/09/26	Silicon, dissolved	mg/L	4.46
CCR	XPW01	Porewater	2021/03/05	Sodium, total	mg/L	35.5
CCR	XPW01	Porewater	2021/03/24	Sodium, total	mg/L	37.2
CCR	XPW01	Porewater	2021/04/14	Sodium, total	mg/L	28.3
CCR	XPW01	Porewater	2021/05/12	Sodium, total	mg/L	29.3
CCR	XPW01	Porewater	2021/07/21	Sodium, total	mg/L	26.3
CCR	XPW01	Porewater	2022/03/15	Sodium, total	mg/L	27.4
CCR	XPW01	Porewater	2023/03/08	Sodium, total	mg/L	27.2
CCR	XPW01	Porewater	2023/05/03	Sodium, total	mg/L	27.0
CCR	XPW01	Porewater	2023/09/26	Sodium, total	mg/L	25.6
CCR	XPW01	Porewater	2023/10/25	Sodium, total	mg/L	33.8
CCR	XPW01	Porewater	2021/03/05	Sulfate, total	mg/L	345
CCR	XPW01	Porewater	2021/03/24	Sulfate, total	mg/L	355
CCR	XPW01	Porewater	2021/04/14	Sulfate, total	mg/L	355
CCR	XPW01	Porewater	2021/05/12	Sulfate, total	mg/L	309
CCR	XPW01	Porewater	2021/07/21	Sulfate, total	mg/L	328
CCR	XPW01	Porewater	2022/03/15	Sulfate, total	mg/L	360
CCR	XPW01	Porewater	2023/03/08	Sulfate, total	mg/L	414
CCR	XPW01	Porewater	2023/05/03	Sulfate, total	mg/L	345
CCR	XPW01	Porewater	2023/09/26	Sulfate, total	mg/L	365
CCR	XPW01	Porewater	2023/10/25	Sulfate, total	mg/L	343
CCR	XPW01	Porewater	2021/03/05	Temperature (Celsius)	degrees C	15.3
CCR	XPW01	Porewater	2021/03/24	Temperature (Celsius)	degrees C	17.1
CCR	XPW01	Porewater	2021/04/14	Temperature (Celsius)	degrees C	16.0
CCR	XPW01	Porewater	2021/05/12	Temperature (Celsius)	degrees C	16.7
CCR	XPW01	Porewater	2021/07/21	Temperature (Celsius)	degrees C	17.6
CCR	XPW01	Porewater	2022/03/15	Temperature (Celsius)	degrees C	15.8
CCR	XPW01	Porewater	2023/03/08	Temperature (Celsius)	degrees C	15.9
CCR	XPW01	Porewater	2023/05/03	Temperature (Celsius)	degrees C	16.7
CCR	XPW01	Porewater	2023/09/26	Temperature (Celsius)	degrees C	18.1
CCR	XPW01	Porewater	2023/10/25	Temperature (Celsius)	degrees C	19.3
CCR	XPW01	Porewater	2021/03/05	Total Dissolved Solids	mg/L	674
CCR	XPW01	Porewater	2021/03/24	Total Dissolved Solids	mg/L	702
CCR	XPW01	Porewater	2021/04/14	Total Dissolved Solids	mg/L	724
CCR	XPW01	Porewater	2021/05/12	Total Dissolved Solids	mg/L	658
CCR	XPW01	Porewater	2021/07/21	Total Dissolved Solids	mg/L	658
CCR	XPW01	Porewater	2022/03/15	Total Dissolved Solids	mg/L	698
CCR	XPW01	Porewater	2023/03/08	Total Dissolved Solids	mg/L	708
CCR	XPW01	Porewater	2023/05/03	Total Dissolved Solids	mg/L	708
CCR	XPW01	Porewater	2023/09/26	Total Dissolved Solids	mg/L	670
CCR	XPW01	Porewater	2023/10/25	Total Dissolved Solids	mg/L	722
CCR	XPW02	Porewater	2021/03/04	pH (field)	SU	8.0
CCR	XPW02	Porewater	2021/03/24	pH (field)	SU	8.0
CCR	XPW02	Porewater	2021/04/14	pH (field)	SU	7.9

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW02	Porewater	2021/05/12	pH (field)	SU	7.8
CCR	XPW02	Porewater	2021/07/21	pH (field)	SU	7.8
CCR	XPW02	Porewater	2022/03/15	pH (field)	SU	7.7
CCR	XPW02	Porewater	2023/03/21	pH (field)	SU	7.6
CCR	XPW02	Porewater	2023/05/03	pH (field)	SU	7.7
CCR	XPW02	Porewater	2023/09/26	pH (field)	SU	7.6
CCR	XPW02	Porewater	2023/10/25	pH (field)	SU	7.8
CCR	XPW02	Porewater	2021/03/04	Oxidation Reduction Potential	mV	-199
CCR	XPW02	Porewater	2021/03/24	Oxidation Reduction Potential	mV	-168
CCR	XPW02	Porewater	2021/04/14	Oxidation Reduction Potential	mV	-183
CCR	XPW02	Porewater	2021/05/12	Oxidation Reduction Potential	mV	-197
CCR	XPW02	Porewater	2021/07/21	Oxidation Reduction Potential	mV	-184
CCR	XPW02	Porewater	2022/03/15	Oxidation Reduction Potential	mV	-213
CCR	XPW02	Porewater	2023/03/21	Oxidation Reduction Potential	mV	-150
CCR	XPW02	Porewater	2023/05/03	Oxidation Reduction Potential	mV	-67.0
CCR	XPW02	Porewater	2023/09/26	Oxidation Reduction Potential	mV	-166
CCR	XPW02	Porewater	2023/10/25	Oxidation Reduction Potential	mV	-180
CCR	XPW02	Porewater	2021/03/04	Eh	V	-0.0041
CCR	XPW02	Porewater	2021/03/24	Eh	V	0.026
CCR	XPW02	Porewater	2021/04/14	Eh	V	0.011
CCR	XPW02	Porewater	2021/05/12	Eh	V	-0.0028
CCR	XPW02	Porewater	2021/07/21	Eh	V	0.0098
CCR	XPW02	Porewater	2022/03/15	Eh	V	-0.018
CCR	XPW02	Porewater	2023/03/21	Eh	V	0.046
CCR	XPW02	Porewater	2023/05/03	Eh	V	0.13
CCR	XPW02	Porewater	2023/09/26	Eh	V	0.028
CCR	XPW02	Porewater	2023/10/25	Eh	V	0.013
CCR	XPW02	Porewater	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	121
CCR	XPW02	Porewater	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	128
CCR	XPW02	Porewater	2021/04/14	Alkalinity, bicarbonate	mg/L CaCO3	128
CCR	XPW02	Porewater	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	123
CCR	XPW02	Porewater	2021/07/21	Alkalinity, bicarbonate	mg/L CaCO3	139
CCR	XPW02	Porewater	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	144
CCR	XPW02	Porewater	2023/03/08	Alkalinity, bicarbonate	mg/L CaCO3	145
CCR	XPW02	Porewater	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	139
CCR	XPW02	Porewater	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	130
CCR	XPW02	Porewater	2023/10/25	Alkalinity, bicarbonate	mg/L CaCO3	119
CCR	XPW02	Porewater	2021/03/04	Barium, total	mg/L	0.0342
CCR	XPW02	Porewater	2021/03/24	Barium, total	mg/L	0.0271
CCR	XPW02	Porewater	2021/04/14	Barium, total	mg/L	0.0283
CCR	XPW02	Porewater	2021/05/12	Barium, total	mg/L	0.0287
CCR	XPW02	Porewater	2021/07/21	Barium, total	mg/L	0.0226
CCR	XPW02	Porewater	2022/03/15	Barium, total	mg/L	0.0230
CCR	XPW02	Porewater	2023/03/08	Barium, total	mg/L	0.0208
CCR	XPW02	Porewater	2023/05/03	Barium, total	mg/L	0.0212
CCR	XPW02	Porewater	2023/09/26	Barium, total	mg/L	0.0198
CCR	XPW02	Porewater	2023/10/25	Barium, total	mg/L	0.0249
CCR	XPW02	Porewater	2021/03/04	Boron, total	mg/L	12.1
CCR	XPW02	Porewater	2021/03/24	Boron, total	mg/L	12.2
CCR	XPW02	Porewater	2021/04/14	Boron, total	mg/L	11.5
CCR	XPW02	Porewater	2021/05/12	Boron, total	mg/L	10.8
CCR	XPW02	Porewater	2021/07/21	Boron, total	mg/L	12.0
CCR	XPW02	Porewater	2022/03/15	Boron, total	mg/L	16.0
CCR	XPW02	Porewater	2023/03/08	Boron, total	mg/L	10.8
CCR	XPW02	Porewater	2023/05/03	Boron, total	mg/L	13.4

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW02	Porewater	2023/09/26	Boron, total	mg/L	12.6
CCR	XPW02	Porewater	2023/10/25	Boron, total	mg/L	14.8
CCR	XPW02	Porewater	2021/03/04	Calcium, total	mg/L	591
CCR	XPW02	Porewater	2021/03/24	Calcium, total	mg/L	484
CCR	XPW02	Porewater	2021/04/14	Calcium, total	mg/L	551
CCR	XPW02	Porewater	2021/05/12	Calcium, total	mg/L	495
CCR	XPW02	Porewater	2021/07/21	Calcium, total	mg/L	494
CCR	XPW02	Porewater	2022/03/15	Calcium, total	mg/L	483
CCR	XPW02	Porewater	2023/03/08	Calcium, total	mg/L	479
CCR	XPW02	Porewater	2023/05/03	Calcium, total	mg/L	451
CCR	XPW02	Porewater	2023/09/26	Calcium, total	mg/L	497
CCR	XPW02	Porewater	2023/10/25	Calcium, total	mg/L	488
CCR	XPW02	Porewater	2021/03/04	Chloride, total	mg/L	130
CCR	XPW02	Porewater	2021/03/24	Chloride, total	mg/L	176
CCR	XPW02	Porewater	2021/04/14	Chloride, total	mg/L	110
CCR	XPW02	Porewater	2021/05/12	Chloride, total	mg/L	134
CCR	XPW02	Porewater	2021/07/21	Chloride, total	mg/L	179
CCR	XPW02	Porewater	2022/03/15	Chloride, total	mg/L	115
CCR	XPW02	Porewater	2023/03/08	Chloride, total	mg/L	146
CCR	XPW02	Porewater	2023/05/03	Chloride, total	mg/L	104
CCR	XPW02	Porewater	2023/09/26	Chloride, total	mg/L	86.0
CCR	XPW02	Porewater	2023/10/25	Chloride, total	mg/L	119
CCR	XPW02	Porewater	2021/03/04	Cobalt, total	mg/L	<0.0001
CCR	XPW02	Porewater	2021/03/24	Cobalt, total	mg/L	<0.0001
CCR	XPW02	Porewater	2021/04/14	Cobalt, total	mg/L	<0.0001
CCR	XPW02	Porewater	2021/05/12	Cobalt, total	mg/L	<0.001
CCR	XPW02	Porewater	2021/07/21	Cobalt, total	mg/L	<0.0001
CCR	XPW02	Porewater	2022/03/15	Cobalt, total	mg/L	<0.0001
CCR	XPW02	Porewater	2023/03/08	Cobalt, total	mg/L	0.000300
CCR	XPW02	Porewater	2023/05/03	Cobalt, total	mg/L	0.000200
CCR	XPW02	Porewater	2023/09/26	Cobalt, total	mg/L	<0.0001
CCR	XPW02	Porewater	2023/10/25	Cobalt, total	mg/L	<0.0001
CCR	XPW02	Porewater	2023/05/03	Iron, dissolved	mg/L	2.60
CCR	XPW02	Porewater	2023/09/26	Iron, dissolved	mg/L	2.75
CCR	XPW02	Porewater	2021/03/04	Magnesium, total	mg/L	10.9
CCR	XPW02	Porewater	2021/03/24	Magnesium, total	mg/L	11.3
CCR	XPW02	Porewater	2021/04/14	Magnesium, total	mg/L	11.3
CCR	XPW02	Porewater	2021/05/12	Magnesium, total	mg/L	11.8
CCR	XPW02	Porewater	2021/07/21	Magnesium, total	mg/L	11.1
CCR	XPW02	Porewater	2022/03/15	Magnesium, total	mg/L	10.7
CCR	XPW02	Porewater	2023/03/08	Magnesium, total	mg/L	8.75
CCR	XPW02	Porewater	2023/05/03	Magnesium, total	mg/L	12.3
CCR	XPW02	Porewater	2023/09/26	Magnesium, total	mg/L	11.2
CCR	XPW02	Porewater	2023/10/25	Magnesium, total	mg/L	9.32
CCR	XPW02	Porewater	2023/05/03	Manganese, dissolved	mg/L	0.675
CCR	XPW02	Porewater	2023/09/26	Manganese, dissolved	mg/L	0.725
CCR	XPW02	Porewater	2023/05/03	Phosphate, dissolved	mg/L	0.307
CCR	XPW02	Porewater	2023/09/26	Phosphate, dissolved	mg/L	0.166
CCR	XPW02	Porewater	2021/03/04	Potassium, total	mg/L	23.4
CCR	XPW02	Porewater	2021/03/24	Potassium, total	mg/L	26.3
CCR	XPW02	Porewater	2021/04/14	Potassium, total	mg/L	25.3
CCR	XPW02	Porewater	2021/05/12	Potassium, total	mg/L	24.5
CCR	XPW02	Porewater	2021/07/21	Potassium, total	mg/L	24.7
CCR	XPW02	Porewater	2022/03/15	Potassium, total	mg/L	27.1
CCR	XPW02	Porewater	2023/03/08	Potassium, total	mg/L	23.9

Attachment I. Site Groundwater Data
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Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW02	Porewater	2023/05/03	Potassium, total	mg/L	27.4
CCR	XPW02	Porewater	2023/09/26	Potassium, total	mg/L	27.3
CCR	XPW02	Porewater	2023/10/25	Potassium, total	mg/L	26.4
CCR	XPW02	Porewater	2023/05/03	Silicon, dissolved	mg/L	7.07
CCR	XPW02	Porewater	2023/09/26	Silicon, dissolved	mg/L	7.30
CCR	XPW02	Porewater	2021/03/04	Sodium, total	mg/L	888
CCR	XPW02	Porewater	2021/03/24	Sodium, total	mg/L	798
CCR	XPW02	Porewater	2021/04/14	Sodium, total	mg/L	705
CCR	XPW02	Porewater	2021/05/12	Sodium, total	mg/L	641
CCR	XPW02	Porewater	2021/07/21	Sodium, total	mg/L	762
CCR	XPW02	Porewater	2022/03/15	Sodium, total	mg/L	828
CCR	XPW02	Porewater	2023/03/08	Sodium, total	mg/L	882
CCR	XPW02	Porewater	2023/05/03	Sodium, total	mg/L	953
CCR	XPW02	Porewater	2023/09/26	Sodium, total	mg/L	805
CCR	XPW02	Porewater	2023/10/25	Sodium, total	mg/L	1,090
CCR	XPW02	Porewater	2021/03/04	Sulfate, total	mg/L	2,380
CCR	XPW02	Porewater	2021/03/24	Sulfate, total	mg/L	2,830
CCR	XPW02	Porewater	2021/04/14	Sulfate, total	mg/L	2,410
CCR	XPW02	Porewater	2021/05/12	Sulfate, total	mg/L	2,410
CCR	XPW02	Porewater	2021/07/21	Sulfate, total	mg/L	2,330
CCR	XPW02	Porewater	2022/03/15	Sulfate, total	mg/L	2,590
CCR	XPW02	Porewater	2023/03/08	Sulfate, total	mg/L	2,450
CCR	XPW02	Porewater	2023/05/03	Sulfate, total	mg/L	2,650
CCR	XPW02	Porewater	2023/09/26	Sulfate, total	mg/L	2,580
CCR	XPW02	Porewater	2023/10/25	Sulfate, total	mg/L	2,660
CCR	XPW02	Porewater	2021/03/04	Temperature (Celsius)	degrees C	15.9
CCR	XPW02	Porewater	2021/03/24	Temperature (Celsius)	degrees C	16.7
CCR	XPW02	Porewater	2021/04/14	Temperature (Celsius)	degrees C	16.7
CCR	XPW02	Porewater	2021/05/12	Temperature (Celsius)	degrees C	16.8
CCR	XPW02	Porewater	2021/07/21	Temperature (Celsius)	degrees C	17.4
CCR	XPW02	Porewater	2022/03/15	Temperature (Celsius)	degrees C	16.2
CCR	XPW02	Porewater	2023/03/21	Temperature (Celsius)	degrees C	14.5
CCR	XPW02	Porewater	2023/05/03	Temperature (Celsius)	degrees C	17.0
CCR	XPW02	Porewater	2023/09/26	Temperature (Celsius)	degrees C	17.7
CCR	XPW02	Porewater	2023/10/25	Temperature (Celsius)	degrees C	18.7
CCR	XPW02	Porewater	2021/03/04	Total Dissolved Solids	mg/L	4,040
CCR	XPW02	Porewater	2021/03/24	Total Dissolved Solids	mg/L	4,020
CCR	XPW02	Porewater	2021/04/14	Total Dissolved Solids	mg/L	3,970
CCR	XPW02	Porewater	2021/05/12	Total Dissolved Solids	mg/L	3,860
CCR	XPW02	Porewater	2021/07/21	Total Dissolved Solids	mg/L	3,880
CCR	XPW02	Porewater	2022/03/15	Total Dissolved Solids	mg/L	4,050
CCR	XPW02	Porewater	2023/03/08	Total Dissolved Solids	mg/L	4,460
CCR	XPW02	Porewater	2023/05/03	Total Dissolved Solids	mg/L	3,970
CCR	XPW02	Porewater	2023/09/26	Total Dissolved Solids	mg/L	4,400
CCR	XPW02	Porewater	2023/10/25	Total Dissolved Solids	mg/L	4,360
CCR	XPW03	Porewater	2021/03/04	pH (field)	SU	10.5
CCR	XPW03	Porewater	2021/03/24	pH (field)	SU	10.6
CCR	XPW03	Porewater	2021/04/14	pH (field)	SU	10.5
CCR	XPW03	Porewater	2021/05/12	pH (field)	SU	10.7
CCR	XPW03	Porewater	2021/07/21	pH (field)	SU	10.0
CCR	XPW03	Porewater	2022/03/15	pH (field)	SU	10.5
CCR	XPW03	Porewater	2023/03/09	pH (field)	SU	10.7
CCR	XPW03	Porewater	2023/05/03	pH (field)	SU	10.7
CCR	XPW03	Porewater	2023/09/26	pH (field)	SU	10.8
CCR	XPW03	Porewater	2023/10/25	pH (field)	SU	10.8

Attachment I. Site Groundwater Data
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Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW03	Porewater	2021/03/04	Oxidation Reduction Potential	mV	-189
CCR	XPW03	Porewater	2021/03/24	Oxidation Reduction Potential	mV	-88.0
CCR	XPW03	Porewater	2021/04/14	Oxidation Reduction Potential	mV	-35.0
CCR	XPW03	Porewater	2021/05/12	Oxidation Reduction Potential	mV	-139
CCR	XPW03	Porewater	2021/07/21	Oxidation Reduction Potential	mV	-212
CCR	XPW03	Porewater	2022/03/15	Oxidation Reduction Potential	mV	-127
CCR	XPW03	Porewater	2023/03/09	Oxidation Reduction Potential	mV	-102
CCR	XPW03	Porewater	2023/05/03	Oxidation Reduction Potential	mV	-42.0
CCR	XPW03	Porewater	2023/09/26	Oxidation Reduction Potential	mV	-126
CCR	XPW03	Porewater	2023/10/25	Oxidation Reduction Potential	mV	-88.0
CCR	XPW03	Porewater	2021/03/04	Eh	V	0.0060
CCR	XPW03	Porewater	2021/03/24	Eh	V	0.11
CCR	XPW03	Porewater	2021/04/14	Eh	V	0.16
CCR	XPW03	Porewater	2021/05/12	Eh	V	0.055
CCR	XPW03	Porewater	2021/07/21	Eh	V	-0.019
CCR	XPW03	Porewater	2022/03/15	Eh	V	0.069
CCR	XPW03	Porewater	2023/03/09	Eh	V	0.092
CCR	XPW03	Porewater	2023/05/03	Eh	V	0.15
CCR	XPW03	Porewater	2023/09/26	Eh	V	0.067
CCR	XPW03	Porewater	2023/10/25	Eh	V	0.10
CCR	XPW03	Porewater	2021/03/04	Alkalinity, carbonate	mg/L CaCO3	74.0
CCR	XPW03	Porewater	2021/03/24	Alkalinity, carbonate	mg/L CaCO3	76.0
CCR	XPW03	Porewater	2021/04/14	Alkalinity, carbonate	mg/L CaCO3	80.0
CCR	XPW03	Porewater	2021/05/12	Alkalinity, carbonate	mg/L CaCO3	69.0
CCR	XPW03	Porewater	2021/07/21	Alkalinity, carbonate	mg/L CaCO3	120
CCR	XPW03	Porewater	2022/03/15	Alkalinity, carbonate	mg/L CaCO3	79.0
CCR	XPW03	Porewater	2023/03/09	Alkalinity, carbonate	mg/L CaCO3	85.0
CCR	XPW03	Porewater	2023/05/03	Alkalinity, carbonate	mg/L CaCO3	90.0
CCR	XPW03	Porewater	2023/09/26	Alkalinity, carbonate	mg/L CaCO3	96.0
CCR	XPW03	Porewater	2023/10/25	Alkalinity, carbonate	mg/L CaCO3	74.0
CCR	XPW03	Porewater	2021/03/04	Barium, total	mg/L	0.0116
CCR	XPW03	Porewater	2021/03/24	Barium, total	mg/L	0.0124
CCR	XPW03	Porewater	2021/04/14	Barium, total	mg/L	0.0118
CCR	XPW03	Porewater	2021/05/12	Barium, total	mg/L	0.0120
CCR	XPW03	Porewater	2021/07/21	Barium, total	mg/L	0.0114
CCR	XPW03	Porewater	2022/03/15	Barium, total	mg/L	0.00950
CCR	XPW03	Porewater	2023/03/09	Barium, total	mg/L	0.0120
CCR	XPW03	Porewater	2023/05/03	Barium, total	mg/L	0.0149
CCR	XPW03	Porewater	2023/09/26	Barium, total	mg/L	0.0115
CCR	XPW03	Porewater	2023/10/25	Barium, total	mg/L	0.0164
CCR	XPW03	Porewater	2021/03/04	Boron, total	mg/L	12.2
CCR	XPW03	Porewater	2021/03/24	Boron, total	mg/L	11.6
CCR	XPW03	Porewater	2021/04/14	Boron, total	mg/L	9.30
CCR	XPW03	Porewater	2021/05/12	Boron, total	mg/L	11.7
CCR	XPW03	Porewater	2021/07/21	Boron, total	mg/L	11.6
CCR	XPW03	Porewater	2022/03/15	Boron, total	mg/L	11.1
CCR	XPW03	Porewater	2023/03/09	Boron, total	mg/L	8.06
CCR	XPW03	Porewater	2023/05/03	Boron, total	mg/L	9.22
CCR	XPW03	Porewater	2023/09/26	Boron, total	mg/L	8.86
CCR	XPW03	Porewater	2023/10/25	Boron, total	mg/L	10.0
CCR	XPW03	Porewater	2021/03/04	Calcium, total	mg/L	17.3
CCR	XPW03	Porewater	2021/03/24	Calcium, total	mg/L	15.9
CCR	XPW03	Porewater	2021/04/14	Calcium, total	mg/L	15.1
CCR	XPW03	Porewater	2021/05/12	Calcium, total	mg/L	16.4
CCR	XPW03	Porewater	2021/07/21	Calcium, total	mg/L	15.3

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW03	Porewater	2022/03/15	Calcium, total	mg/L	12.9
CCR	XPW03	Porewater	2023/03/09	Calcium, total	mg/L	11.0
CCR	XPW03	Porewater	2023/05/03	Calcium, total	mg/L	13.4
CCR	XPW03	Porewater	2023/09/26	Calcium, total	mg/L	11.8
CCR	XPW03	Porewater	2023/10/25	Calcium, total	mg/L	12.1
CCR	XPW03	Porewater	2021/03/04	Chloride, total	mg/L	25.0
CCR	XPW03	Porewater	2021/03/24	Chloride, total	mg/L	25.0
CCR	XPW03	Porewater	2021/04/14	Chloride, total	mg/L	27.0
CCR	XPW03	Porewater	2021/05/12	Chloride, total	mg/L	25.0
CCR	XPW03	Porewater	2021/07/21	Chloride, total	mg/L	26.0
CCR	XPW03	Porewater	2022/03/15	Chloride, total	mg/L	25.0
CCR	XPW03	Porewater	2023/03/09	Chloride, total	mg/L	25.0
CCR	XPW03	Porewater	2023/05/03	Chloride, total	mg/L	26.0
CCR	XPW03	Porewater	2023/09/26	Chloride, total	mg/L	24.0
CCR	XPW03	Porewater	2023/10/25	Chloride, total	mg/L	26.0
CCR	XPW03	Porewater	2021/03/04	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2021/03/24	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2021/04/14	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2021/05/12	Cobalt, total	mg/L	<0.001
CCR	XPW03	Porewater	2021/07/21	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2022/03/15	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2023/03/09	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2023/05/03	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2023/09/26	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2023/10/25	Cobalt, total	mg/L	<0.0001
CCR	XPW03	Porewater	2023/05/03	Iron, dissolved	mg/L	0.0210
CCR	XPW03	Porewater	2023/09/26	Iron, dissolved	mg/L	<0.0115
CCR	XPW03	Porewater	2021/03/04	Magnesium, total	mg/L	<0.0175
CCR	XPW03	Porewater	2021/03/24	Magnesium, total	mg/L	<0.0175
CCR	XPW03	Porewater	2021/04/14	Magnesium, total	mg/L	<0.0175
CCR	XPW03	Porewater	2021/05/12	Magnesium, total	mg/L	<0.1
CCR	XPW03	Porewater	2021/07/21	Magnesium, total	mg/L	<0.0055
CCR	XPW03	Porewater	2022/03/15	Magnesium, total	mg/L	<0.006
CCR	XPW03	Porewater	2023/03/09	Magnesium, total	mg/L	0.0210
CCR	XPW03	Porewater	2023/05/03	Magnesium, total	mg/L	0.0300
CCR	XPW03	Porewater	2023/09/26	Magnesium, total	mg/L	0.0310
CCR	XPW03	Porewater	2023/10/25	Magnesium, total	mg/L	0.0380
CCR	XPW03	Porewater	2023/05/03	Manganese, dissolved	mg/L	0.00300
CCR	XPW03	Porewater	2023/09/26	Manganese, dissolved	mg/L	<0.0008
CCR	XPW03	Porewater	2023/05/03	Phosphate, dissolved	mg/L	0.430
CCR	XPW03	Porewater	2023/09/26	Phosphate, dissolved	mg/L	0.335
CCR	XPW03	Porewater	2021/03/04	Potassium, total	mg/L	25.1
CCR	XPW03	Porewater	2021/03/24	Potassium, total	mg/L	28.9
CCR	XPW03	Porewater	2021/04/14	Potassium, total	mg/L	27.5
CCR	XPW03	Porewater	2021/05/12	Potassium, total	mg/L	27.5
CCR	XPW03	Porewater	2021/07/21	Potassium, total	mg/L	26.9
CCR	XPW03	Porewater	2022/03/15	Potassium, total	mg/L	27.6
CCR	XPW03	Porewater	2023/03/09	Potassium, total	mg/L	23.8
CCR	XPW03	Porewater	2023/05/03	Potassium, total	mg/L	26.2
CCR	XPW03	Porewater	2023/09/26	Potassium, total	mg/L	26.6
CCR	XPW03	Porewater	2023/10/25	Potassium, total	mg/L	25.4
CCR	XPW03	Porewater	2023/05/03	Silicon, dissolved	mg/L	4.98
CCR	XPW03	Porewater	2023/09/26	Silicon, dissolved	mg/L	5.13
CCR	XPW03	Porewater	2021/03/04	Sodium, total	mg/L	145
CCR	XPW03	Porewater	2021/03/24	Sodium, total	mg/L	115

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
CCR	XPW03	Porewater	2021/04/14	Sodium, total	mg/L	105
CCR	XPW03	Porewater	2021/05/12	Sodium, total	mg/L	113
CCR	XPW03	Porewater	2021/07/21	Sodium, total	mg/L	104
CCR	XPW03	Porewater	2022/03/15	Sodium, total	mg/L	104
CCR	XPW03	Porewater	2023/03/09	Sodium, total	mg/L	99.6
CCR	XPW03	Porewater	2023/05/03	Sodium, total	mg/L	110
CCR	XPW03	Porewater	2023/09/26	Sodium, total	mg/L	102
CCR	XPW03	Porewater	2023/10/25	Sodium, total	mg/L	109
CCR	XPW03	Porewater	2021/03/04	Sulfate, total	mg/L	133
CCR	XPW03	Porewater	2021/03/24	Sulfate, total	mg/L	138
CCR	XPW03	Porewater	2021/04/14	Sulfate, total	mg/L	152
CCR	XPW03	Porewater	2021/05/12	Sulfate, total	mg/L	155
CCR	XPW03	Porewater	2021/07/21	Sulfate, total	mg/L	148
CCR	XPW03	Porewater	2022/03/15	Sulfate, total	mg/L	152
CCR	XPW03	Porewater	2023/03/09	Sulfate, total	mg/L	142
CCR	XPW03	Porewater	2023/05/03	Sulfate, total	mg/L	144
CCR	XPW03	Porewater	2023/09/26	Sulfate, total	mg/L	149
CCR	XPW03	Porewater	2023/10/25	Sulfate, total	mg/L	142
CCR	XPW03	Porewater	2021/03/04	Temperature (Celsius)	degrees C	15.7
CCR	XPW03	Porewater	2021/03/24	Temperature (Celsius)	degrees C	17.4
CCR	XPW03	Porewater	2021/04/14	Temperature (Celsius)	degrees C	15.9
CCR	XPW03	Porewater	2021/05/12	Temperature (Celsius)	degrees C	16.6
CCR	XPW03	Porewater	2021/07/21	Temperature (Celsius)	degrees C	19.0
CCR	XPW03	Porewater	2022/03/15	Temperature (Celsius)	degrees C	14.6
CCR	XPW03	Porewater	2023/03/09	Temperature (Celsius)	degrees C	16.4
CCR	XPW03	Porewater	2023/05/03	Temperature (Celsius)	degrees C	16.9
CCR	XPW03	Porewater	2023/09/26	Temperature (Celsius)	degrees C	18.5
CCR	XPW03	Porewater	2023/10/25	Temperature (Celsius)	degrees C	19.3
CCR	XPW03	Porewater	2021/03/04	Total Dissolved Solids	mg/L	412
CCR	XPW03	Porewater	2021/03/24	Total Dissolved Solids	mg/L	412
CCR	XPW03	Porewater	2021/04/14	Total Dissolved Solids	mg/L	454
CCR	XPW03	Porewater	2021/05/12	Total Dissolved Solids	mg/L	432
CCR	XPW03	Porewater	2021/07/21	Total Dissolved Solids	mg/L	436
CCR	XPW03	Porewater	2022/03/15	Total Dissolved Solids	mg/L	414
CCR	XPW03	Porewater	2023/03/09	Total Dissolved Solids	mg/L	416
CCR	XPW03	Porewater	2023/05/03	Total Dissolved Solids	mg/L	412
CCR	XPW03	Porewater	2023/09/26	Total Dissolved Solids	mg/L	386
CCR	XPW03	Porewater	2023/10/25	Total Dissolved Solids	mg/L	392
LAU	G13M	Delin	2022/07/29	pH (field)	SU	9.2
LAU	G13M	Delin	2022/09/15	pH (field)	SU	7.5
LAU	G13M	Delin	2022/11/01	pH (field)	SU	7.6
LAU	G13M	Delin	2023/01/26	pH (field)	SU	7.4
LAU	G13M	Delin	2022/07/29	Oxidation Reduction Potential	mV	-384
LAU	G13M	Delin	2022/09/15	Oxidation Reduction Potential	mV	-122
LAU	G13M	Delin	2022/11/01	Oxidation Reduction Potential	mV	-95.1
LAU	G13M	Delin	2023/01/26	Oxidation Reduction Potential	mV	-183
LAU	G13M	Delin	2022/07/29	Eh	V	-0.20
LAU	G13M	Delin	2022/09/15	Eh	V	0.066
LAU	G13M	Delin	2022/11/01	Eh	V	0.095
LAU	G13M	Delin	2023/01/26	Eh	V	0.013
LAU	G13M	Delin	2022/07/29	Alkalinity, bicarbonate	mg/L CaCO3	120
LAU	G13M	Delin	2022/09/15	Alkalinity, bicarbonate	mg/L CaCO3	235
LAU	G13M	Delin	2022/11/01	Alkalinity, bicarbonate	mg/L CaCO3	235
LAU	G13M	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	266
LAU	G13M	Delin	2022/07/29	Barium, total	mg/L	0.0339

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
LAU	G13M	Delin	2022/09/15	Barium, total	mg/L	0.0792
LAU	G13M	Delin	2022/11/01	Barium, total	mg/L	0.0957
LAU	G13M	Delin	2023/01/26	Barium, total	mg/L	0.228
LAU	G13M	Delin	2022/07/29	Boron, total	mg/L	0.0453
LAU	G13M	Delin	2022/09/15	Boron, total	mg/L	0.0456
LAU	G13M	Delin	2022/11/01	Boron, total	mg/L	0.0180
LAU	G13M	Delin	2023/01/26	Boron, total	mg/L	0.0288
LAU	G13M	Delin	2022/07/29	Calcium, total	mg/L	25.0
LAU	G13M	Delin	2022/09/15	Calcium, total	mg/L	70.6
LAU	G13M	Delin	2022/11/01	Calcium, total	mg/L	70.7
LAU	G13M	Delin	2023/01/26	Calcium, total	mg/L	81.5
LAU	G13M	Delin	2022/07/29	Chloride, total	mg/L	24.0
LAU	G13M	Delin	2022/09/15	Chloride, total	mg/L	11.0
LAU	G13M	Delin	2022/11/01	Chloride, total	mg/L	9.00
LAU	G13M	Delin	2023/01/26	Chloride, total	mg/L	6.00
LAU	G13M	Delin	2022/07/29	Cobalt, total	mg/L	<0.0001
LAU	G13M	Delin	2022/09/15	Cobalt, total	mg/L	<0.0001
LAU	G13M	Delin	2022/11/01	Cobalt, total	mg/L	<0.0001
LAU	G13M	Delin	2023/01/26	Cobalt, total	mg/L	<0.0001
LAU	G13M	Delin	2022/07/29	Magnesium, total	mg/L	16.3
LAU	G13M	Delin	2022/09/15	Magnesium, total	mg/L	16.3
LAU	G13M	Delin	2022/11/01	Magnesium, total	mg/L	16.7
LAU	G13M	Delin	2023/01/26	Magnesium, total	mg/L	18.6
LAU	G13M	Delin	2022/07/29	Potassium, total	mg/L	5.45
LAU	G13M	Delin	2022/09/15	Potassium, total	mg/L	2.89
LAU	G13M	Delin	2022/11/01	Potassium, total	mg/L	2.48
LAU	G13M	Delin	2023/01/26	Potassium, total	mg/L	1.44
LAU	G13M	Delin	2022/07/29	Sodium, total	mg/L	19.7
LAU	G13M	Delin	2022/09/15	Sodium, total	mg/L	14.2
LAU	G13M	Delin	2022/11/01	Sodium, total	mg/L	12.6
LAU	G13M	Delin	2023/01/26	Sodium, total	mg/L	10.5
LAU	G13M	Delin	2022/07/29	Sulfate, total	mg/L	8.00
LAU	G13M	Delin	2022/09/15	Sulfate, total	mg/L	<6
LAU	G13M	Delin	2022/11/01	Sulfate, total	mg/L	<6
LAU	G13M	Delin	2023/01/26	Sulfate, total	mg/L	7.00
LAU	G13M	Delin	2022/07/29	Temperature (Celsius)	degrees C	25.8
LAU	G13M	Delin	2022/09/15	Temperature (Celsius)	degrees C	25.6
LAU	G13M	Delin	2022/11/01	Temperature (Celsius)	degrees C	23.4
LAU	G13M	Delin	2023/01/26	Temperature (Celsius)	degrees C	13.3
LAU	G13M	Delin	2022/07/29	Total Dissolved Solids	mg/L	198
LAU	G13M	Delin	2022/09/15	Total Dissolved Solids	mg/L	258
LAU	G13M	Delin	2022/11/01	Total Dissolved Solids	mg/L	288
LAU	G13M	Delin	2023/01/26	Total Dissolved Solids	mg/L	304
LAU	G20M	Delin	2022/07/29	pH (field)	SU	8.3
LAU	G20M	Delin	2022/09/15	pH (field)	SU	8.3
LAU	G20M	Delin	2022/11/03	pH (field)	SU	7.5
LAU	G20M	Delin	2023/01/26	pH (field)	SU	7.6
LAU	G20M	Delin	2022/07/29	Oxidation Reduction Potential	mV	-266
LAU	G20M	Delin	2022/09/15	Oxidation Reduction Potential	mV	-176
LAU	G20M	Delin	2022/11/03	Oxidation Reduction Potential	mV	-139
LAU	G20M	Delin	2023/01/26	Oxidation Reduction Potential	mV	-232
LAU	G20M	Delin	2022/07/29	Eh	V	-0.076
LAU	G20M	Delin	2022/09/15	Eh	V	0.016
LAU	G20M	Delin	2022/11/03	Eh	V	0.054
LAU	G20M	Delin	2023/01/26	Eh	V	-0.036

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Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
LAU	G20M	Delin	2022/07/29	Alkalinity, bicarbonate	mg/L CaCO3	206
LAU	G20M	Delin	2022/09/15	Alkalinity, bicarbonate	mg/L CaCO3	133
LAU	G20M	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	249
LAU	G20M	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	259
LAU	G20M	Delin	2022/07/29	Barium, total	mg/L	0.0892
LAU	G20M	Delin	2022/09/15	Barium, total	mg/L	0.0832
LAU	G20M	Delin	2022/11/03	Barium, total	mg/L	0.0983
LAU	G20M	Delin	2023/01/26	Barium, total	mg/L	0.0970
LAU	G20M	Delin	2022/07/29	Boron, total	mg/L	0.0479
LAU	G20M	Delin	2022/09/15	Boron, total	mg/L	0.0487
LAU	G20M	Delin	2022/11/03	Boron, total	mg/L	0.0220
LAU	G20M	Delin	2023/01/26	Boron, total	mg/L	0.0302
LAU	G20M	Delin	2022/07/29	Calcium, total	mg/L	47.1
LAU	G20M	Delin	2022/09/15	Calcium, total	mg/L	24.4
LAU	G20M	Delin	2022/11/03	Calcium, total	mg/L	64.9
LAU	G20M	Delin	2023/01/26	Calcium, total	mg/L	73.3
LAU	G20M	Delin	2022/07/29	Chloride, total	mg/L	16.0
LAU	G20M	Delin	2022/09/15	Chloride, total	mg/L	18.0
LAU	G20M	Delin	2022/11/03	Chloride, total	mg/L	6.00
LAU	G20M	Delin	2023/01/26	Chloride, total	mg/L	5.00
LAU	G20M	Delin	2022/07/29	Cobalt, total	mg/L	<0.0001
LAU	G20M	Delin	2022/09/15	Cobalt, total	mg/L	0.000200
LAU	G20M	Delin	2022/11/03	Cobalt, total	mg/L	<0.0001
LAU	G20M	Delin	2023/01/26	Cobalt, total	mg/L	<0.0001
LAU	G20M	Delin	2022/07/29	Magnesium, total	mg/L	14.0
LAU	G20M	Delin	2022/09/15	Magnesium, total	mg/L	12.9
LAU	G20M	Delin	2022/11/03	Magnesium, total	mg/L	14.1
LAU	G20M	Delin	2023/01/26	Magnesium, total	mg/L	16.2
LAU	G20M	Delin	2022/07/29	Potassium, total	mg/L	2.83
LAU	G20M	Delin	2022/09/15	Potassium, total	mg/L	3.09
LAU	G20M	Delin	2022/11/03	Potassium, total	mg/L	1.99
LAU	G20M	Delin	2023/01/26	Potassium, total	mg/L	1.72
LAU	G20M	Delin	2022/07/29	Sodium, total	mg/L	25.0
LAU	G20M	Delin	2022/09/15	Sodium, total	mg/L	29.4
LAU	G20M	Delin	2022/11/03	Sodium, total	mg/L	30.9
LAU	G20M	Delin	2023/01/26	Sodium, total	mg/L	20.8
LAU	G20M	Delin	2022/07/29	Sulfate, total	mg/L	<6
LAU	G20M	Delin	2022/09/15	Sulfate, total	mg/L	7.00
LAU	G20M	Delin	2022/11/03	Sulfate, total	mg/L	<6
LAU	G20M	Delin	2023/01/26	Sulfate, total	mg/L	<6
LAU	G20M	Delin	2022/07/29	Temperature (Celsius)	degrees C	21.9
LAU	G20M	Delin	2022/09/15	Temperature (Celsius)	degrees C	20
LAU	G20M	Delin	2022/11/03	Temperature (Celsius)	degrees C	19.1
LAU	G20M	Delin	2023/01/26	Temperature (Celsius)	degrees C	14.0
LAU	G20M	Delin	2022/07/29	Total Dissolved Solids	mg/L	252
LAU	G20M	Delin	2022/09/15	Total Dissolved Solids	mg/L	210
LAU	G20M	Delin	2022/11/03	Total Dissolved Solids	mg/L	260
LAU	G20M	Delin	2023/01/26	Total Dissolved Solids	mg/L	270
LAU	G21M	Delin	2022/07/29	pH (field)	SU	10.0
LAU	G21M	Delin	2022/09/15	pH (field)	SU	11.7
LAU	G21M	Delin	2022/11/02	pH (field)	SU	11.5
LAU	G21M	Delin	2023/01/25	pH (field)	SU	12.3
LAU	G21M	Delin	2022/07/29	Oxidation Reduction Potential	mV	-218
LAU	G21M	Delin	2022/09/15	Oxidation Reduction Potential	mV	150
LAU	G21M	Delin	2022/11/02	Oxidation Reduction Potential	mV	-26.0

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Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
LAU	G21M	Delin	2023/01/25	Oxidation Reduction Potential	mV	-210
LAU	G21M	Delin	2022/07/29	Eh	V	-0.026
LAU	G21M	Delin	2022/09/15	Eh	V	0.34
LAU	G21M	Delin	2022/11/02	Eh	V	0.17
LAU	G21M	Delin	2023/01/25	Eh	V	-0.011
LAU	G21M	Delin	2022/07/29	Alkalinity, bicarbonate	mg/L CaCO3	40.0
LAU	G21M	Delin	2022/07/29	Alkalinity, carbonate	mg/L CaCO3	55.0
LAU	G21M	Delin	2022/09/15	Alkalinity, carbonate	mg/L CaCO3	91.0
LAU	G21M	Delin	2022/11/02	Alkalinity, carbonate	mg/L CaCO3	66.0
LAU	G21M	Delin	2023/01/25	Alkalinity, carbonate	mg/L CaCO3	99.0
LAU	G21M	Delin	2022/07/29	Barium, total	mg/L	0.0265
LAU	G21M	Delin	2022/09/15	Barium, total	mg/L	0.231
LAU	G21M	Delin	2022/11/02	Barium, total	mg/L	0.229
LAU	G21M	Delin	2023/01/25	Barium, total	mg/L	0.267
LAU	G21M	Delin	2022/07/29	Boron, total	mg/L	0.0240
LAU	G21M	Delin	2022/09/15	Boron, total	mg/L	0.0230
LAU	G21M	Delin	2022/11/02	Boron, total	mg/L	<0.0092
LAU	G21M	Delin	2023/01/25	Boron, total	mg/L	<0.0092
LAU	G21M	Delin	2022/07/29	Calcium, total	mg/L	7.07
LAU	G21M	Delin	2022/09/15	Calcium, total	mg/L	217
LAU	G21M	Delin	2022/11/02	Calcium, total	mg/L	261
LAU	G21M	Delin	2023/01/25	Calcium, total	mg/L	279
LAU	G21M	Delin	2022/07/29	Chloride, total	mg/L	5.00
LAU	G21M	Delin	2022/09/15	Chloride, total	mg/L	8.00
LAU	G21M	Delin	2022/11/02	Chloride, total	mg/L	8.00
LAU	G21M	Delin	2023/01/25	Chloride, total	mg/L	8.00
LAU	G21M	Delin	2022/07/29	Cobalt, total	mg/L	0.000200
LAU	G21M	Delin	2022/09/15	Cobalt, total	mg/L	<0.0001
LAU	G21M	Delin	2022/11/02	Cobalt, total	mg/L	<0.0001
LAU	G21M	Delin	2023/01/25	Cobalt, total	mg/L	<0.0001
LAU	G21M	Delin	2022/07/29	Magnesium, total	mg/L	6.60
LAU	G21M	Delin	2022/09/15	Magnesium, total	mg/L	0.362
LAU	G21M	Delin	2022/11/02	Magnesium, total	mg/L	0.502
LAU	G21M	Delin	2023/01/25	Magnesium, total	mg/L	0.334
LAU	G21M	Delin	2022/07/29	Potassium, total	mg/L	25.6
LAU	G21M	Delin	2022/09/15	Potassium, total	mg/L	54.2
LAU	G21M	Delin	2022/11/02	Potassium, total	mg/L	49.0
LAU	G21M	Delin	2023/01/25	Potassium, total	mg/L	46.1
LAU	G21M	Delin	2022/07/29	Sodium, total	mg/L	16.6
LAU	G21M	Delin	2022/09/15	Sodium, total	mg/L	30.3
LAU	G21M	Delin	2022/11/02	Sodium, total	mg/L	31.2
LAU	G21M	Delin	2023/01/25	Sodium, total	mg/L	28.2
LAU	G21M	Delin	2022/07/29	Sulfate, total	mg/L	8.00
LAU	G21M	Delin	2022/09/15	Sulfate, total	mg/L	<12
LAU	G21M	Delin	2022/11/02	Sulfate, total	mg/L	<6
LAU	G21M	Delin	2023/01/25	Sulfate, total	mg/L	<6
LAU	G21M	Delin	2022/07/29	Temperature (Celsius)	degrees C	18.9
LAU	G21M	Delin	2022/09/15	Temperature (Celsius)	degrees C	17.6
LAU	G21M	Delin	2022/11/02	Temperature (Celsius)	degrees C	16.5
LAU	G21M	Delin	2023/01/25	Temperature (Celsius)	degrees C	10.5
LAU	G21M	Delin	2022/07/29	Total Dissolved Solids	mg/L	112
LAU	G21M	Delin	2022/09/15	Total Dissolved Solids	mg/L	734
LAU	G21M	Delin	2022/11/02	Total Dissolved Solids	mg/L	828
LAU	G21M	Delin	2023/01/25	Total Dissolved Solids	mg/L	776
LAU	G09M	MWO	2021/03/04	pH (field)	SU	6.9

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Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
LAU	G09M	MWO	2021/03/25	pH (field)	SU	6.8
LAU	G09M	MWO	2021/04/14	pH (field)	SU	6.9
LAU	G09M	MWO	2021/05/12	pH (field)	SU	7.0
LAU	G09M	MWO	2021/07/21	pH (field)	SU	6.9
LAU	G09M	MWO	2022/07/25	pH (field)	SU	8.3
LAU	G09M	MWO	2022/09/14	pH (field)	SU	7.3
LAU	G09M	MWO	2022/11/01	pH (field)	SU	7.1
LAU	G09M	MWO	2021/03/04	Oxidation Reduction Potential	mV	-130
LAU	G09M	MWO	2021/03/25	Oxidation Reduction Potential	mV	-126
LAU	G09M	MWO	2021/04/14	Oxidation Reduction Potential	mV	-151
LAU	G09M	MWO	2021/05/12	Oxidation Reduction Potential	mV	-158
LAU	G09M	MWO	2021/07/21	Oxidation Reduction Potential	mV	-153
LAU	G09M	MWO	2022/07/25	Oxidation Reduction Potential	mV	-195
LAU	G09M	MWO	2022/09/14	Oxidation Reduction Potential	mV	175
LAU	G09M	MWO	2022/11/01	Oxidation Reduction Potential	mV	-130
LAU	G09M	MWO	2021/03/04	Eh	V	0.064
LAU	G09M	MWO	2021/03/25	Eh	V	0.068
LAU	G09M	MWO	2021/04/14	Eh	V	0.044
LAU	G09M	MWO	2021/05/12	Eh	V	0.037
LAU	G09M	MWO	2021/07/21	Eh	V	0.041
LAU	G09M	MWO	2022/07/25	Eh	V	-0.0014
LAU	G09M	MWO	2022/09/14	Eh	V	0.37
LAU	G09M	MWO	2022/11/01	Eh	V	0.064
LAU	G09M	MWO	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	355
LAU	G09M	MWO	2021/03/25	Alkalinity, bicarbonate	mg/L CaCO3	354
LAU	G09M	MWO	2021/04/14	Alkalinity, bicarbonate	mg/L CaCO3	345
LAU	G09M	MWO	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	258
LAU	G09M	MWO	2021/07/21	Alkalinity, bicarbonate	mg/L CaCO3	171
LAU	G09M	MWO	2022/07/25	Alkalinity, bicarbonate	mg/L CaCO3	256
LAU	G09M	MWO	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	255
LAU	G09M	MWO	2022/11/01	Alkalinity, bicarbonate	mg/L CaCO3	259
LAU	G09M	MWO	2021/03/04	Barium, total	mg/L	0.442
LAU	G09M	MWO	2021/03/25	Barium, total	mg/L	0.437
LAU	G09M	MWO	2021/04/14	Barium, total	mg/L	0.407
LAU	G09M	MWO	2021/05/12	Barium, total	mg/L	0.340
LAU	G09M	MWO	2021/07/21	Barium, total	mg/L	0.316
LAU	G09M	MWO	2022/07/25	Barium, total	mg/L	0.292
LAU	G09M	MWO	2022/09/14	Barium, total	mg/L	0.288
LAU	G09M	MWO	2022/11/01	Barium, total	mg/L	0.311
LAU	G09M	MWO	2021/03/04	Boron, total	mg/L	0.0507
LAU	G09M	MWO	2021/03/25	Boron, total	mg/L	0.0299
LAU	G09M	MWO	2021/04/14	Boron, total	mg/L	0.0544
LAU	G09M	MWO	2021/05/12	Boron, total	mg/L	0.0191
LAU	G09M	MWO	2021/07/21	Boron, total	mg/L	0.0376
LAU	G09M	MWO	2022/07/25	Boron, total	mg/L	0.0210
LAU	G09M	MWO	2022/09/14	Boron, total	mg/L	0.0274
LAU	G09M	MWO	2022/11/01	Boron, total	mg/L	0.0269
LAU	G09M	MWO	2021/03/04	Calcium, total	mg/L	114
LAU	G09M	MWO	2021/03/25	Calcium, total	mg/L	98.6
LAU	G09M	MWO	2021/04/14	Calcium, total	mg/L	134
LAU	G09M	MWO	2021/05/12	Calcium, total	mg/L	73.7
LAU	G09M	MWO	2021/07/21	Calcium, total	mg/L	99.9
LAU	G09M	MWO	2022/07/25	Calcium, total	mg/L	91.8
LAU	G09M	MWO	2022/09/14	Calcium, total	mg/L	70.5
LAU	G09M	MWO	2022/11/01	Calcium, total	mg/L	73.7

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
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HSU	Location	Well Type	Date	Parameter	Unit	Result
LAU	G09M	MWO	2021/03/04	Chloride, total	mg/L	7.00
LAU	G09M	MWO	2021/03/25	Chloride, total	mg/L	7.00
LAU	G09M	MWO	2021/04/14	Chloride, total	mg/L	7.00
LAU	G09M	MWO	2021/05/12	Chloride, total	mg/L	5.00
LAU	G09M	MWO	2021/07/21	Chloride, total	mg/L	7.00
LAU	G09M	MWO	2022/07/25	Chloride, total	mg/L	7.00
LAU	G09M	MWO	2022/09/14	Chloride, total	mg/L	6.00
LAU	G09M	MWO	2022/11/01	Chloride, total	mg/L	5.00
LAU	G09M	MWO	2021/03/04	Cobalt, total	mg/L	0.00970
LAU	G09M	MWO	2021/03/25	Cobalt, total	mg/L	0.00660
LAU	G09M	MWO	2021/04/14	Cobalt, total	mg/L	0.00410
LAU	G09M	MWO	2021/05/12	Cobalt, total	mg/L	0.00162
LAU	G09M	MWO	2021/07/21	Cobalt, total	mg/L	0.0105
LAU	G09M	MWO	2022/07/25	Cobalt, total	mg/L	0.00770
LAU	G09M	MWO	2022/09/14	Cobalt, total	mg/L	0.00210
LAU	G09M	MWO	2022/11/01	Cobalt, total	mg/L	0.00160
LAU	G09M	MWO	2021/03/04	Magnesium, total	mg/L	19.6
LAU	G09M	MWO	2021/03/25	Magnesium, total	mg/L	21.7
LAU	G09M	MWO	2021/04/14	Magnesium, total	mg/L	23.9
LAU	G09M	MWO	2021/05/12	Magnesium, total	mg/L	18.6
LAU	G09M	MWO	2021/07/21	Magnesium, total	mg/L	20.1
LAU	G09M	MWO	2022/07/25	Magnesium, total	mg/L	18.8
LAU	G09M	MWO	2022/09/14	Magnesium, total	mg/L	16.7
LAU	G09M	MWO	2022/11/01	Magnesium, total	mg/L	18.1
LAU	G09M	MWO	2021/03/04	Potassium, total	mg/L	2.08
LAU	G09M	MWO	2021/03/25	Potassium, total	mg/L	1.79
LAU	G09M	MWO	2021/04/14	Potassium, total	mg/L	1.74
LAU	G09M	MWO	2021/05/12	Potassium, total	mg/L	1.06
LAU	G09M	MWO	2021/07/21	Potassium, total	mg/L	2.32
LAU	G09M	MWO	2022/07/25	Potassium, total	mg/L	2.56
LAU	G09M	MWO	2022/09/14	Potassium, total	mg/L	1.38
LAU	G09M	MWO	2022/11/01	Potassium, total	mg/L	1.31
LAU	G09M	MWO	2021/03/04	Sodium, total	mg/L	26.3
LAU	G09M	MWO	2021/03/25	Sodium, total	mg/L	25.9
LAU	G09M	MWO	2021/04/14	Sodium, total	mg/L	32.1
LAU	G09M	MWO	2021/05/12	Sodium, total	mg/L	10.7
LAU	G09M	MWO	2021/07/21	Sodium, total	mg/L	11.7
LAU	G09M	MWO	2022/07/25	Sodium, total	mg/L	10.9
LAU	G09M	MWO	2022/09/14	Sodium, total	mg/L	9.88
LAU	G09M	MWO	2022/11/01	Sodium, total	mg/L	9.78
LAU	G09M	MWO	2021/03/04	Sulfate, total	mg/L	20.0
LAU	G09M	MWO	2021/03/25	Sulfate, total	mg/L	<6
LAU	G09M	MWO	2021/04/14	Sulfate, total	mg/L	<6
LAU	G09M	MWO	2021/05/12	Sulfate, total	mg/L	<6
LAU	G09M	MWO	2021/07/21	Sulfate, total	mg/L	<6
LAU	G09M	MWO	2022/07/25	Sulfate, total	mg/L	<6
LAU	G09M	MWO	2022/09/14	Sulfate, total	mg/L	6.00
LAU	G09M	MWO	2022/11/01	Sulfate, total	mg/L	<6
LAU	G09M	MWO	2021/03/04	Temperature (Celsius)	degrees C	16.8
LAU	G09M	MWO	2021/03/25	Temperature (Celsius)	degrees C	17.3
LAU	G09M	MWO	2021/04/14	Temperature (Celsius)	degrees C	15.9
LAU	G09M	MWO	2021/05/12	Temperature (Celsius)	degrees C	16.3
LAU	G09M	MWO	2021/07/21	Temperature (Celsius)	degrees C	17.4
LAU	G09M	MWO	2022/07/25	Temperature (Celsius)	degrees C	17.5
LAU	G09M	MWO	2022/09/14	Temperature (Celsius)	degrees C	17.8

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HSU	Location	Well Type	Date	Parameter	Unit	Result
LAU	G09M	MWO	2022/11/01	Temperature (Celsius)	degrees C	17.6
LAU	G09M	MWO	2021/03/04	Total Dissolved Solids	mg/L	444
LAU	G09M	MWO	2021/03/25	Total Dissolved Solids	mg/L	432
LAU	G09M	MWO	2021/04/14	Total Dissolved Solids	mg/L	506
LAU	G09M	MWO	2021/05/12	Total Dissolved Solids	mg/L	282
LAU	G09M	MWO	2021/07/21	Total Dissolved Solids	mg/L	316
LAU	G09M	MWO	2022/07/25	Total Dissolved Solids	mg/L	265
LAU	G09M	MWO	2022/09/14	Total Dissolved Solids	mg/L	305
LAU	G09M	MWO	2022/11/01	Total Dissolved Solids	mg/L	270
UA	G01D	B	2015/12/03	pH (field)	SU	6.7
UA	G01D	B	2016/03/15	pH (field)	SU	6.7
UA	G01D	B	2016/06/15	pH (field)	SU	6.9
UA	G01D	B	2016/09/14	pH (field)	SU	6.8
UA	G01D	B	2016/12/14	pH (field)	SU	6.8
UA	G01D	B	2017/03/07	pH (field)	SU	6.2
UA	G01D	B	2017/06/15	pH (field)	SU	6.7
UA	G01D	B	2017/07/20	pH (field)	SU	6.8
UA	G01D	B	2017/11/30	pH (field)	SU	6.8
UA	G01D	B	2018/06/19	pH (field)	SU	6.8
UA	G01D	B	2018/09/05	pH (field)	SU	7.0
UA	G01D	B	2019/03/27	pH (field)	SU	6.7
UA	G01D	B	2019/09/09	pH (field)	SU	6.4
UA	G01D	B	2020/03/30	pH (field)	SU	6.8
UA	G01D	B	2020/09/23	pH (field)	SU	6.7
UA	G01D	B	2021/03/03	pH (field)	SU	6.6
UA	G01D	B	2021/03/24	pH (field)	SU	6.5
UA	G01D	B	2021/04/14	pH (field)	SU	6.7
UA	G01D	B	2021/05/12	pH (field)	SU	6.5
UA	G01D	B	2021/06/01	pH (field)	SU	6.3
UA	G01D	B	2021/06/14	pH (field)	SU	6.5
UA	G01D	B	2021/07/06	pH (field)	SU	6.3
UA	G01D	B	2021/07/21	pH (field)	SU	6.4
UA	G01D	B	2021/09/20	pH (field)	SU	6.5
UA	G01D	B	2022/03/14	pH (field)	SU	6.4
UA	G01D	B	2022/07/26	pH (field)	SU	7.2
UA	G01D	B	2022/09/20	pH (field)	SU	6.5
UA	G01D	B	2023/01/24	pH (field)	SU	6.6
UA	G01D	B	2023/03/07	pH (field)	SU	6.5
UA	G01D	B	2023/05/02	pH (field)	SU	6.3
UA	G01D	B	2023/09/25	pH (field)	SU	6.5
UA	G01D	B	2023/10/23	pH (field)	SU	6.4
UA	G01D	B	2015/12/03	Oxidation Reduction Potential	mV	60.0
UA	G01D	B	2016/03/15	Oxidation Reduction Potential	mV	-103
UA	G01D	B	2016/06/15	Oxidation Reduction Potential	mV	-110
UA	G01D	B	2016/09/14	Oxidation Reduction Potential	mV	-26.0
UA	G01D	B	2016/12/14	Oxidation Reduction Potential	mV	113
UA	G01D	B	2017/03/07	Oxidation Reduction Potential	mV	80.0
UA	G01D	B	2017/06/15	Oxidation Reduction Potential	mV	123
UA	G01D	B	2017/07/20	Oxidation Reduction Potential	mV	102
UA	G01D	B	2017/11/30	Oxidation Reduction Potential	mV	21.0
UA	G01D	B	2018/06/19	Oxidation Reduction Potential	mV	29.0
UA	G01D	B	2018/09/05	Oxidation Reduction Potential	mV	131
UA	G01D	B	2019/03/27	Oxidation Reduction Potential	mV	118
UA	G01D	B	2019/09/09	Oxidation Reduction Potential	mV	193
UA	G01D	B	2020/03/30	Oxidation Reduction Potential	mV	138

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HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G01D	B	2020/09/23	Oxidation Reduction Potential	mV	202
UA	G01D	B	2021/03/03	Oxidation Reduction Potential	mV	145
UA	G01D	B	2021/03/24	Oxidation Reduction Potential	mV	160
UA	G01D	B	2021/04/14	Oxidation Reduction Potential	mV	134
UA	G01D	B	2021/05/12	Oxidation Reduction Potential	mV	180
UA	G01D	B	2021/06/01	Oxidation Reduction Potential	mV	164
UA	G01D	B	2021/06/14	Oxidation Reduction Potential	mV	160
UA	G01D	B	2021/07/06	Oxidation Reduction Potential	mV	139
UA	G01D	B	2021/07/21	Oxidation Reduction Potential	mV	122
UA	G01D	B	2021/09/20	Oxidation Reduction Potential	mV	170
UA	G01D	B	2022/03/14	Oxidation Reduction Potential	mV	117
UA	G01D	B	2022/07/26	Oxidation Reduction Potential	mV	15.5
UA	G01D	B	2022/09/20	Oxidation Reduction Potential	mV	173
UA	G01D	B	2023/01/24	Oxidation Reduction Potential	mV	114
UA	G01D	B	2023/03/07	Oxidation Reduction Potential	mV	195
UA	G01D	B	2023/05/02	Oxidation Reduction Potential	mV	145
UA	G01D	B	2023/09/25	Oxidation Reduction Potential	mV	30.0
UA	G01D	B	2023/10/23	Oxidation Reduction Potential	mV	103
UA	G01D	B	2015/12/03	Eh	V	0.25
UA	G01D	B	2016/03/15	Eh	V	0.090
UA	G01D	B	2016/06/15	Eh	V	0.084
UA	G01D	B	2016/09/14	Eh	V	0.17
UA	G01D	B	2016/12/14	Eh	V	0.31
UA	G01D	B	2017/03/07	Eh	V	0.28
UA	G01D	B	2017/06/15	Eh	V	0.32
UA	G01D	B	2017/07/20	Eh	V	0.30
UA	G01D	B	2017/11/30	Eh	V	0.22
UA	G01D	B	2018/06/19	Eh	V	0.22
UA	G01D	B	2018/09/05	Eh	V	0.32
UA	G01D	B	2019/03/27	Eh	V	0.31
UA	G01D	B	2019/09/09	Eh	V	0.39
UA	G01D	B	2020/03/30	Eh	V	0.33
UA	G01D	B	2020/09/23	Eh	V	0.40
UA	G01D	B	2021/03/03	Eh	V	0.34
UA	G01D	B	2021/03/24	Eh	V	0.35
UA	G01D	B	2021/04/14	Eh	V	0.33
UA	G01D	B	2021/05/12	Eh	V	0.37
UA	G01D	B	2021/06/01	Eh	V	0.36
UA	G01D	B	2021/06/14	Eh	V	0.35
UA	G01D	B	2021/07/06	Eh	V	0.33
UA	G01D	B	2021/07/21	Eh	V	0.32
UA	G01D	B	2021/09/20	Eh	V	0.36
UA	G01D	B	2022/03/14	Eh	V	0.31
UA	G01D	B	2022/07/26	Eh	V	0.20
UA	G01D	B	2022/09/20	Eh	V	0.37
UA	G01D	B	2023/01/24	Eh	V	0.31
UA	G01D	B	2023/03/07	Eh	V	0.39
UA	G01D	B	2023/05/02	Eh	V	0.34
UA	G01D	B	2023/09/25	Eh	V	0.22
UA	G01D	B	2023/10/23	Eh	V	0.30
UA	G01D	B	2017/07/20	Alkalinity, bicarbonate	mg/L CaCO3	224
UA	G01D	B	2020/03/30	Alkalinity, bicarbonate	mg/L CaCO3	230
UA	G01D	B	2021/03/03	Alkalinity, bicarbonate	mg/L CaCO3	209
UA	G01D	B	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	219
UA	G01D	B	2021/04/14	Alkalinity, bicarbonate	mg/L CaCO3	240

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HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G01D	B	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	200
UA	G01D	B	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	198
UA	G01D	B	2021/06/14	Alkalinity, bicarbonate	mg/L CaCO3	219
UA	G01D	B	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	209
UA	G01D	B	2021/07/21	Alkalinity, bicarbonate	mg/L CaCO3	204
UA	G01D	B	2021/09/20	Alkalinity, bicarbonate	mg/L CaCO3	215
UA	G01D	B	2022/03/14	Alkalinity, bicarbonate	mg/L CaCO3	223
UA	G01D	B	2022/07/26	Alkalinity, bicarbonate	mg/L CaCO3	228
UA	G01D	B	2023/01/24	Alkalinity, bicarbonate	mg/L CaCO3	220
UA	G01D	B	2023/03/07	Alkalinity, bicarbonate	mg/L CaCO3	223
UA	G01D	B	2023/05/02	Alkalinity, bicarbonate	mg/L CaCO3	240
UA	G01D	B	2023/09/25	Alkalinity, bicarbonate	mg/L CaCO3	260
UA	G01D	B	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	242
UA	G01D	B	2015/12/03	Barium, total	mg/L	0.254
UA	G01D	B	2016/03/15	Barium, total	mg/L	0.283
UA	G01D	B	2016/06/15	Barium, total	mg/L	0.204
UA	G01D	B	2016/09/14	Barium, total	mg/L	0.190
UA	G01D	B	2016/12/14	Barium, total	mg/L	0.163
UA	G01D	B	2017/03/07	Barium, total	mg/L	0.155
UA	G01D	B	2017/06/15	Barium, total	mg/L	0.140
UA	G01D	B	2017/07/20	Barium, total	mg/L	0.140
UA	G01D	B	2018/06/19	Barium, total	mg/L	0.202
UA	G01D	B	2018/09/05	Barium, total	mg/L	0.147
UA	G01D	B	2019/03/27	Barium, total	mg/L	0.129
UA	G01D	B	2019/09/09	Barium, total	mg/L	0.123
UA	G01D	B	2020/03/30	Barium, total	mg/L	0.130
UA	G01D	B	2020/09/23	Barium, total	mg/L	0.123
UA	G01D	B	2021/03/03	Barium, total	mg/L	0.137
UA	G01D	B	2021/03/24	Barium, total	mg/L	0.136
UA	G01D	B	2021/04/14	Barium, total	mg/L	0.112
UA	G01D	B	2021/05/12	Barium, total	mg/L	0.133
UA	G01D	B	2021/06/01	Barium, total	mg/L	0.134
UA	G01D	B	2021/06/14	Barium, total	mg/L	0.136
UA	G01D	B	2021/07/06	Barium, total	mg/L	0.136
UA	G01D	B	2021/07/21	Barium, total	mg/L	0.125
UA	G01D	B	2021/09/20	Barium, total	mg/L	0.145
UA	G01D	B	2022/03/14	Barium, total	mg/L	0.128
UA	G01D	B	2022/07/26	Barium, total	mg/L	0.146
UA	G01D	B	2022/09/20	Barium, total	mg/L	0.142
UA	G01D	B	2023/01/24	Barium, total	mg/L	0.189
UA	G01D	B	2023/03/07	Barium, total	mg/L	0.134
UA	G01D	B	2023/05/02	Barium, total	mg/L	0.213
UA	G01D	B	2023/09/25	Barium, total	mg/L	0.193
UA	G01D	B	2023/10/23	Barium, total	mg/L	0.188
UA	G01D	B	2015/12/03	Boron, total	mg/L	<0.01
UA	G01D	B	2016/03/15	Boron, total	mg/L	0.0360
UA	G01D	B	2016/06/15	Boron, total	mg/L	0.0296
UA	G01D	B	2016/09/14	Boron, total	mg/L	0.0416
UA	G01D	B	2016/12/14	Boron, total	mg/L	<0.01
UA	G01D	B	2017/03/07	Boron, total	mg/L	<0.01
UA	G01D	B	2017/06/15	Boron, total	mg/L	<0.01
UA	G01D	B	2017/07/20	Boron, total	mg/L	<0.01
UA	G01D	B	2017/11/30	Boron, total	mg/L	<0.01
UA	G01D	B	2018/06/19	Boron, total	mg/L	<0.0092
UA	G01D	B	2018/09/05	Boron, total	mg/L	<0.0092

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Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G01D	B	2019/03/27	Boron, total	mg/L	<0.0092
UA	G01D	B	2019/09/09	Boron, total	mg/L	<0.0092
UA	G01D	B	2020/03/30	Boron, total	mg/L	<0.0092
UA	G01D	B	2020/09/23	Boron, total	mg/L	<0.0092
UA	G01D	B	2021/03/03	Boron, total	mg/L	<0.0092
UA	G01D	B	2021/03/24	Boron, total	mg/L	<0.0092
UA	G01D	B	2021/04/14	Boron, total	mg/L	<0.0092
UA	G01D	B	2021/05/12	Boron, total	mg/L	0.0167
UA	G01D	B	2021/06/01	Boron, total	mg/L	<0.0092
UA	G01D	B	2021/06/14	Boron, total	mg/L	<0.0092
UA	G01D	B	2021/07/06	Boron, total	mg/L	<0.0092
UA	G01D	B	2021/07/21	Boron, total	mg/L	<0.0092
UA	G01D	B	2021/09/20	Boron, total	mg/L	<0.0092
UA	G01D	B	2022/03/14	Boron, total	mg/L	<0.0092
UA	G01D	B	2022/07/26	Boron, total	mg/L	0.0150
UA	G01D	B	2022/09/20	Boron, total	mg/L	0.0140
UA	G01D	B	2023/01/24	Boron, total	mg/L	0.0220
UA	G01D	B	2023/03/07	Boron, total	mg/L	0.0290
UA	G01D	B	2023/05/02	Boron, total	mg/L	0.0210
UA	G01D	B	2023/09/25	Boron, total	mg/L	<0.0092
UA	G01D	B	2023/10/23	Boron, total	mg/L	0.0140
UA	G01D	B	2015/12/03	Calcium, total	mg/L	37.9
UA	G01D	B	2016/03/15	Calcium, total	mg/L	45.5
UA	G01D	B	2016/06/15	Calcium, total	mg/L	43.9
UA	G01D	B	2016/09/14	Calcium, total	mg/L	40.8
UA	G01D	B	2016/12/14	Calcium, total	mg/L	35.9
UA	G01D	B	2017/03/07	Calcium, total	mg/L	34.9
UA	G01D	B	2017/06/15	Calcium, total	mg/L	32.1
UA	G01D	B	2017/07/20	Calcium, total	mg/L	29.5
UA	G01D	B	2017/11/30	Calcium, total	mg/L	37.2
UA	G01D	B	2018/06/19	Calcium, total	mg/L	29.5
UA	G01D	B	2018/09/05	Calcium, total	mg/L	30.5
UA	G01D	B	2019/03/27	Calcium, total	mg/L	25.1
UA	G01D	B	2019/09/09	Calcium, total	mg/L	25.6
UA	G01D	B	2020/03/30	Calcium, total	mg/L	22.7
UA	G01D	B	2020/09/23	Calcium, total	mg/L	24.4
UA	G01D	B	2021/03/03	Calcium, total	mg/L	25.8
UA	G01D	B	2021/03/24	Calcium, total	mg/L	24.8
UA	G01D	B	2021/04/14	Calcium, total	mg/L	23.3
UA	G01D	B	2021/05/12	Calcium, total	mg/L	24.9
UA	G01D	B	2021/06/01	Calcium, total	mg/L	24.4
UA	G01D	B	2021/06/14	Calcium, total	mg/L	24.4
UA	G01D	B	2021/07/06	Calcium, total	mg/L	23.3
UA	G01D	B	2021/07/21	Calcium, total	mg/L	26.0
UA	G01D	B	2021/09/20	Calcium, total	mg/L	26.0
UA	G01D	B	2022/03/14	Calcium, total	mg/L	26.1
UA	G01D	B	2022/07/26	Calcium, total	mg/L	25.6
UA	G01D	B	2022/09/20	Calcium, total	mg/L	25.5
UA	G01D	B	2023/01/24	Calcium, total	mg/L	27.4
UA	G01D	B	2023/03/07	Calcium, total	mg/L	23.0
UA	G01D	B	2023/05/02	Calcium, total	mg/L	28.8
UA	G01D	B	2023/09/25	Calcium, total	mg/L	31.1
UA	G01D	B	2023/10/23	Calcium, total	mg/L	33.0
UA	G01D	B	2015/12/03	Chloride, total	mg/L	13.0
UA	G01D	B	2016/03/15	Chloride, total	mg/L	20.0

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G01D	B	2016/06/15	Chloride, total	mg/L	21.0
UA	G01D	B	2016/09/14	Chloride, total	mg/L	21.0
UA	G01D	B	2016/12/14	Chloride, total	mg/L	14.0
UA	G01D	B	2017/03/07	Chloride, total	mg/L	16.0
UA	G01D	B	2017/06/15	Chloride, total	mg/L	15.0
UA	G01D	B	2017/07/20	Chloride, total	mg/L	12.0
UA	G01D	B	2017/11/30	Chloride, total	mg/L	18.0
UA	G01D	B	2018/06/19	Chloride, total	mg/L	13.0
UA	G01D	B	2018/09/05	Chloride, total	mg/L	14.0
UA	G01D	B	2019/03/27	Chloride, total	mg/L	8.00
UA	G01D	B	2019/09/09	Chloride, total	mg/L	8.00
UA	G01D	B	2020/03/30	Chloride, total	mg/L	8.00
UA	G01D	B	2020/09/23	Chloride, total	mg/L	10.0
UA	G01D	B	2021/03/03	Chloride, total	mg/L	10.0
UA	G01D	B	2021/03/24	Chloride, total	mg/L	9.00
UA	G01D	B	2021/04/14	Chloride, total	mg/L	6.00
UA	G01D	B	2021/05/12	Chloride, total	mg/L	7.00
UA	G01D	B	2021/06/01	Chloride, total	mg/L	7.00
UA	G01D	B	2021/06/14	Chloride, total	mg/L	9.00
UA	G01D	B	2021/07/06	Chloride, total	mg/L	10.0
UA	G01D	B	2021/07/21	Chloride, total	mg/L	9.00
UA	G01D	B	2021/09/20	Chloride, total	mg/L	9.00
UA	G01D	B	2022/03/14	Chloride, total	mg/L	8.00
UA	G01D	B	2022/07/26	Chloride, total	mg/L	5.00
UA	G01D	B	2022/09/20	Chloride, total	mg/L	8.00
UA	G01D	B	2023/01/24	Chloride, total	mg/L	9.00
UA	G01D	B	2023/03/07	Chloride, total	mg/L	5.00
UA	G01D	B	2023/05/02	Chloride, total	mg/L	10.0
UA	G01D	B	2023/09/25	Chloride, total	mg/L	11.0
UA	G01D	B	2023/10/23	Chloride, total	mg/L	13.0
UA	G01D	B	2015/12/03	Cobalt, total	mg/L	0.00600
UA	G01D	B	2016/03/15	Cobalt, total	mg/L	0.0136
UA	G01D	B	2016/06/15	Cobalt, total	mg/L	0.0128
UA	G01D	B	2016/09/14	Cobalt, total	mg/L	0.0113
UA	G01D	B	2016/12/14	Cobalt, total	mg/L	0.00770
UA	G01D	B	2017/03/07	Cobalt, total	mg/L	0.00610
UA	G01D	B	2017/06/15	Cobalt, total	mg/L	0.00470
UA	G01D	B	2017/07/20	Cobalt, total	mg/L	0.00350
UA	G01D	B	2018/06/19	Cobalt, total	mg/L	0.00570
UA	G01D	B	2018/09/05	Cobalt, total	mg/L	0.00220
UA	G01D	B	2019/03/27	Cobalt, total	mg/L	0.00140
UA	G01D	B	2019/09/09	Cobalt, total	mg/L	0.00140
UA	G01D	B	2020/03/30	Cobalt, total	mg/L	0.00180
UA	G01D	B	2020/09/23	Cobalt, total	mg/L	0.00160
UA	G01D	B	2021/03/03	Cobalt, total	mg/L	0.00150
UA	G01D	B	2021/03/24	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2021/04/14	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2021/05/12	Cobalt, total	mg/L	<0.001
UA	G01D	B	2021/06/01	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2021/06/14	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2021/07/06	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2021/07/21	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2021/09/20	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2022/03/14	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2022/07/26	Cobalt, total	mg/L	0.000800

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G01D	B	2022/09/20	Cobalt, total	mg/L	0.000700
UA	G01D	B	2023/01/24	Cobalt, total	mg/L	0.00420
UA	G01D	B	2023/03/07	Cobalt, total	mg/L	0.00220
UA	G01D	B	2023/05/02	Cobalt, total	mg/L	0.00580
UA	G01D	B	2023/09/25	Cobalt, total	mg/L	0.000800
UA	G01D	B	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G01D	B	2023/05/02	Iron, dissolved	mg/L	0.214
UA	G01D	B	2023/09/25	Iron, dissolved	mg/L	0.0492
UA	G01D	B	2017/07/20	Magnesium, total	mg/L	9.87
UA	G01D	B	2020/03/30	Magnesium, total	mg/L	7.60
UA	G01D	B	2021/03/03	Magnesium, total	mg/L	7.79
UA	G01D	B	2021/03/24	Magnesium, total	mg/L	7.06
UA	G01D	B	2021/04/14	Magnesium, total	mg/L	7.56
UA	G01D	B	2021/05/12	Magnesium, total	mg/L	7.55
UA	G01D	B	2021/06/01	Magnesium, total	mg/L	7.36
UA	G01D	B	2021/06/14	Magnesium, total	mg/L	7.41
UA	G01D	B	2021/07/06	Magnesium, total	mg/L	7.18
UA	G01D	B	2021/07/21	Magnesium, total	mg/L	7.54
UA	G01D	B	2022/03/14	Magnesium, total	mg/L	7.77
UA	G01D	B	2022/07/26	Magnesium, total	mg/L	7.74
UA	G01D	B	2023/01/24	Magnesium, total	mg/L	9.75
UA	G01D	B	2023/03/07	Magnesium, total	mg/L	7.66
UA	G01D	B	2023/05/02	Magnesium, total	mg/L	8.43
UA	G01D	B	2023/09/25	Magnesium, total	mg/L	9.32
UA	G01D	B	2023/10/23	Magnesium, total	mg/L	9.70
UA	G01D	B	2023/05/02	Manganese, dissolved	mg/L	0.330
UA	G01D	B	2023/09/25	Manganese, dissolved	mg/L	0.0273
UA	G01D	B	2023/05/02	Phosphate, dissolved	mg/L	0.0740
UA	G01D	B	2023/09/25	Phosphate, dissolved	mg/L	0.0460
UA	G01D	B	2017/07/20	Potassium, total	mg/L	1.33
UA	G01D	B	2020/03/30	Potassium, total	mg/L	1.35
UA	G01D	B	2021/03/03	Potassium, total	mg/L	1.24
UA	G01D	B	2021/03/24	Potassium, total	mg/L	1.05
UA	G01D	B	2021/04/14	Potassium, total	mg/L	0.979
UA	G01D	B	2021/05/12	Potassium, total	mg/L	1.13
UA	G01D	B	2021/06/01	Potassium, total	mg/L	1.26
UA	G01D	B	2021/06/14	Potassium, total	mg/L	1.26
UA	G01D	B	2021/07/06	Potassium, total	mg/L	1.43
UA	G01D	B	2021/07/21	Potassium, total	mg/L	1.24
UA	G01D	B	2022/03/14	Potassium, total	mg/L	1.22
UA	G01D	B	2022/07/26	Potassium, total	mg/L	1.24
UA	G01D	B	2023/01/24	Potassium, total	mg/L	1.79
UA	G01D	B	2023/03/07	Potassium, total	mg/L	1.06
UA	G01D	B	2023/05/02	Potassium, total	mg/L	1.28
UA	G01D	B	2023/09/25	Potassium, total	mg/L	1.24
UA	G01D	B	2023/10/23	Potassium, total	mg/L	1.34
UA	G01D	B	2023/05/02	Silicon, dissolved	mg/L	7.50
UA	G01D	B	2023/09/25	Silicon, dissolved	mg/L	6.88
UA	G01D	B	2017/07/20	Sodium, total	mg/L	79.9
UA	G01D	B	2020/03/30	Sodium, total	mg/L	91.0
UA	G01D	B	2021/03/03	Sodium, total	mg/L	79.0
UA	G01D	B	2021/03/24	Sodium, total	mg/L	73.9
UA	G01D	B	2021/04/14	Sodium, total	mg/L	94.5
UA	G01D	B	2021/05/12	Sodium, total	mg/L	82.5
UA	G01D	B	2021/06/01	Sodium, total	mg/L	75.3

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G01D	B	2021/06/14	Sodium, total	mg/L	78.8
UA	G01D	B	2021/07/06	Sodium, total	mg/L	77.6
UA	G01D	B	2021/07/21	Sodium, total	mg/L	75.1
UA	G01D	B	2022/03/14	Sodium, total	mg/L	77.2
UA	G01D	B	2022/07/26	Sodium, total	mg/L	76.2
UA	G01D	B	2023/01/24	Sodium, total	mg/L	74.3
UA	G01D	B	2023/03/07	Sodium, total	mg/L	85.8
UA	G01D	B	2023/05/02	Sodium, total	mg/L	90.3
UA	G01D	B	2023/09/25	Sodium, total	mg/L	77.1
UA	G01D	B	2023/10/23	Sodium, total	mg/L	77.9
UA	G01D	B	2015/12/03	Sulfate, total	mg/L	20.0
UA	G01D	B	2016/03/15	Sulfate, total	mg/L	126
UA	G01D	B	2016/06/15	Sulfate, total	mg/L	157
UA	G01D	B	2016/09/14	Sulfate, total	mg/L	129
UA	G01D	B	2016/12/14	Sulfate, total	mg/L	53.0
UA	G01D	B	2017/03/07	Sulfate, total	mg/L	72.0
UA	G01D	B	2017/06/15	Sulfate, total	mg/L	56.0
UA	G01D	B	2017/07/20	Sulfate, total	mg/L	31.0
UA	G01D	B	2017/11/30	Sulfate, total	mg/L	117
UA	G01D	B	2018/06/19	Sulfate, total	mg/L	70.0
UA	G01D	B	2018/09/05	Sulfate, total	mg/L	94.0
UA	G01D	B	2019/03/27	Sulfate, total	mg/L	30.0
UA	G01D	B	2019/09/09	Sulfate, total	mg/L	37.0
UA	G01D	B	2020/03/30	Sulfate, total	mg/L	35.0
UA	G01D	B	2020/09/23	Sulfate, total	mg/L	34.0
UA	G01D	B	2021/03/03	Sulfate, total	mg/L	18.0
UA	G01D	B	2021/03/24	Sulfate, total	mg/L	21.0
UA	G01D	B	2021/04/14	Sulfate, total	mg/L	39.0
UA	G01D	B	2021/05/12	Sulfate, total	mg/L	20.0
UA	G01D	B	2021/06/01	Sulfate, total	mg/L	18.0
UA	G01D	B	2021/06/14	Sulfate, total	mg/L	20.0
UA	G01D	B	2021/07/06	Sulfate, total	mg/L	20.0
UA	G01D	B	2021/07/21	Sulfate, total	mg/L	18.0
UA	G01D	B	2021/09/20	Sulfate, total	mg/L	18.0
UA	G01D	B	2022/03/14	Sulfate, total	mg/L	22.0
UA	G01D	B	2022/07/26	Sulfate, total	mg/L	36.0
UA	G01D	B	2022/09/20	Sulfate, total	mg/L	23.0
UA	G01D	B	2023/01/24	Sulfate, total	mg/L	24.0
UA	G01D	B	2023/03/07	Sulfate, total	mg/L	36.0
UA	G01D	B	2023/05/02	Sulfate, total	mg/L	26.0
UA	G01D	B	2023/09/25	Sulfate, total	mg/L	28.0
UA	G01D	B	2023/10/23	Sulfate, total	mg/L	30.0
UA	G01D	B	2015/12/03	Temperature (Celsius)	degrees C	16.1
UA	G01D	B	2016/03/15	Temperature (Celsius)	degrees C	18.3
UA	G01D	B	2016/06/15	Temperature (Celsius)	degrees C	16.9
UA	G01D	B	2016/09/14	Temperature (Celsius)	degrees C	18.4
UA	G01D	B	2016/12/14	Temperature (Celsius)	degrees C	15.5
UA	G01D	B	2017/03/07	Temperature (Celsius)	degrees C	14.1
UA	G01D	B	2017/06/15	Temperature (Celsius)	degrees C	17.5
UA	G01D	B	2017/07/20	Temperature (Celsius)	degrees C	17.6
UA	G01D	B	2017/11/30	Temperature (Celsius)	degrees C	15.0
UA	G01D	B	2018/06/19	Temperature (Celsius)	degrees C	17.6
UA	G01D	B	2018/09/05	Temperature (Celsius)	degrees C	17.8
UA	G01D	B	2019/03/27	Temperature (Celsius)	degrees C	15.4
UA	G01D	B	2019/09/09	Temperature (Celsius)	degrees C	17.6

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G01D	B	2020/03/30	Temperature (Celsius)	degrees C	15.8
UA	G01D	B	2020/09/23	Temperature (Celsius)	degrees C	16.3
UA	G01D	B	2021/03/03	Temperature (Celsius)	degrees C	15.7
UA	G01D	B	2021/03/24	Temperature (Celsius)	degrees C	16.2
UA	G01D	B	2021/04/14	Temperature (Celsius)	degrees C	16.3
UA	G01D	B	2021/05/12	Temperature (Celsius)	degrees C	15.9
UA	G01D	B	2021/06/01	Temperature (Celsius)	degrees C	15.8
UA	G01D	B	2021/06/14	Temperature (Celsius)	degrees C	17.3
UA	G01D	B	2021/07/06	Temperature (Celsius)	degrees C	16.9
UA	G01D	B	2021/07/21	Temperature (Celsius)	degrees C	16.6
UA	G01D	B	2021/09/20	Temperature (Celsius)	degrees C	16.7
UA	G01D	B	2022/03/14	Temperature (Celsius)	degrees C	15.9
UA	G01D	B	2022/07/26	Temperature (Celsius)	degrees C	25.8
UA	G01D	B	2022/09/20	Temperature (Celsius)	degrees C	19.6
UA	G01D	B	2023/01/24	Temperature (Celsius)	degrees C	13.8
UA	G01D	B	2023/03/07	Temperature (Celsius)	degrees C	14.5
UA	G01D	B	2023/05/02	Temperature (Celsius)	degrees C	15.5
UA	G01D	B	2023/09/25	Temperature (Celsius)	degrees C	18.1
UA	G01D	B	2023/10/23	Temperature (Celsius)	degrees C	16.9
UA	G01D	B	2015/12/03	Total Dissolved Solids	mg/L	216
UA	G01D	B	2016/03/15	Total Dissolved Solids	mg/L	496
UA	G01D	B	2016/06/15	Total Dissolved Solids	mg/L	518
UA	G01D	B	2016/09/14	Total Dissolved Solids	mg/L	498
UA	G01D	B	2016/12/14	Total Dissolved Solids	mg/L	294
UA	G01D	B	2017/03/07	Total Dissolved Solids	mg/L	384
UA	G01D	B	2017/06/15	Total Dissolved Solids	mg/L	372
UA	G01D	B	2017/07/20	Total Dissolved Solids	mg/L	368
UA	G01D	B	2017/11/30	Total Dissolved Solids	mg/L	450
UA	G01D	B	2018/06/19	Total Dissolved Solids	mg/L	394
UA	G01D	B	2018/09/05	Total Dissolved Solids	mg/L	414
UA	G01D	B	2019/03/27	Total Dissolved Solids	mg/L	310
UA	G01D	B	2019/09/09	Total Dissolved Solids	mg/L	336
UA	G01D	B	2020/03/30	Total Dissolved Solids	mg/L	296
UA	G01D	B	2020/09/23	Total Dissolved Solids	mg/L	294
UA	G01D	B	2021/03/03	Total Dissolved Solids	mg/L	308
UA	G01D	B	2021/03/24	Total Dissolved Solids	mg/L	300
UA	G01D	B	2021/04/14	Total Dissolved Solids	mg/L	308
UA	G01D	B	2021/05/12	Total Dissolved Solids	mg/L	280
UA	G01D	B	2021/06/01	Total Dissolved Solids	mg/L	260
UA	G01D	B	2021/06/14	Total Dissolved Solids	mg/L	268
UA	G01D	B	2021/07/06	Total Dissolved Solids	mg/L	262
UA	G01D	B	2021/07/21	Total Dissolved Solids	mg/L	286
UA	G01D	B	2021/09/20	Total Dissolved Solids	mg/L	294
UA	G01D	B	2022/03/14	Total Dissolved Solids	mg/L	318
UA	G01D	B	2022/07/26	Total Dissolved Solids	mg/L	324
UA	G01D	B	2022/09/20	Total Dissolved Solids	mg/L	302
UA	G01D	B	2023/01/24	Total Dissolved Solids	mg/L	332
UA	G01D	B	2023/03/07	Total Dissolved Solids	mg/L	308
UA	G01D	B	2023/05/02	Total Dissolved Solids	mg/L	336
UA	G01D	B	2023/09/25	Total Dissolved Solids	mg/L	350
UA	G01D	B	2023/10/23	Total Dissolved Solids	mg/L	308
UA	G02D	B	2015/12/03	pH (field)	SU	6.7
UA	G02D	B	2016/03/15	pH (field)	SU	6.6
UA	G02D	B	2016/06/15	pH (field)	SU	6.8
UA	G02D	B	2016/09/14	pH (field)	SU	6.6

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G02D	B	2016/12/14	pH (field)	SU	6.3
UA	G02D	B	2017/03/08	pH (field)	SU	6.9
UA	G02D	B	2017/06/14	pH (field)	SU	6.3
UA	G02D	B	2017/07/20	pH (field)	SU	6.7
UA	G02D	B	2017/11/30	pH (field)	SU	6.9
UA	G02D	B	2018/06/19	pH (field)	SU	6.7
UA	G02D	B	2018/09/05	pH (field)	SU	6.6
UA	G02D	B	2019/03/27	pH (field)	SU	6.6
UA	G02D	B	2019/09/09	pH (field)	SU	6.5
UA	G02D	B	2020/03/30	pH (field)	SU	6.6
UA	G02D	B	2020/09/23	pH (field)	SU	6.6
UA	G02D	B	2021/03/03	pH (field)	SU	6.5
UA	G02D	B	2021/03/24	pH (field)	SU	6.3
UA	G02D	B	2021/04/14	pH (field)	SU	6.3
UA	G02D	B	2021/05/12	pH (field)	SU	6.3
UA	G02D	B	2021/06/01	pH (field)	SU	6.2
UA	G02D	B	2021/06/14	pH (field)	SU	6.4
UA	G02D	B	2021/07/06	pH (field)	SU	6.2
UA	G02D	B	2021/07/21	pH (field)	SU	6.2
UA	G02D	B	2021/09/20	pH (field)	SU	6.3
UA	G02D	B	2022/03/14	pH (field)	SU	6.5
UA	G02D	B	2022/07/27	pH (field)	SU	7.3
UA	G02D	B	2022/09/21	pH (field)	SU	6.5
UA	G02D	B	2023/01/24	pH (field)	SU	6.6
UA	G02D	B	2023/03/08	pH (field)	SU	6.6
UA	G02D	B	2023/05/03	pH (field)	SU	6.5
UA	G02D	B	2023/09/25	pH (field)	SU	6.4
UA	G02D	B	2023/10/23	pH (field)	SU	6.4
UA	G02D	B	2015/12/03	Oxidation Reduction Potential	mV	146
UA	G02D	B	2016/03/15	Oxidation Reduction Potential	mV	28.0
UA	G02D	B	2016/06/15	Oxidation Reduction Potential	mV	82.0
UA	G02D	B	2016/09/14	Oxidation Reduction Potential	mV	69.0
UA	G02D	B	2016/12/14	Oxidation Reduction Potential	mV	218
UA	G02D	B	2017/03/08	Oxidation Reduction Potential	mV	254
UA	G02D	B	2017/06/14	Oxidation Reduction Potential	mV	95.0
UA	G02D	B	2017/07/20	Oxidation Reduction Potential	mV	132
UA	G02D	B	2017/11/30	Oxidation Reduction Potential	mV	70.0
UA	G02D	B	2018/06/19	Oxidation Reduction Potential	mV	187
UA	G02D	B	2018/09/05	Oxidation Reduction Potential	mV	169
UA	G02D	B	2019/03/27	Oxidation Reduction Potential	mV	130
UA	G02D	B	2019/09/09	Oxidation Reduction Potential	mV	186
UA	G02D	B	2020/03/30	Oxidation Reduction Potential	mV	179
UA	G02D	B	2020/09/23	Oxidation Reduction Potential	mV	246
UA	G02D	B	2021/03/03	Oxidation Reduction Potential	mV	151
UA	G02D	B	2021/03/24	Oxidation Reduction Potential	mV	175
UA	G02D	B	2021/04/14	Oxidation Reduction Potential	mV	151
UA	G02D	B	2021/05/12	Oxidation Reduction Potential	mV	183
UA	G02D	B	2021/06/01	Oxidation Reduction Potential	mV	140
UA	G02D	B	2021/06/14	Oxidation Reduction Potential	mV	169
UA	G02D	B	2021/07/06	Oxidation Reduction Potential	mV	128
UA	G02D	B	2021/07/21	Oxidation Reduction Potential	mV	100
UA	G02D	B	2021/09/20	Oxidation Reduction Potential	mV	191
UA	G02D	B	2022/03/14	Oxidation Reduction Potential	mV	138
UA	G02D	B	2022/07/27	Oxidation Reduction Potential	mV	97.3
UA	G02D	B	2022/09/21	Oxidation Reduction Potential	mV	199

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G02D	B	2023/01/24	Oxidation Reduction Potential	mV	110
UA	G02D	B	2023/03/08	Oxidation Reduction Potential	mV	49.1
UA	G02D	B	2023/05/03	Oxidation Reduction Potential	mV	182
UA	G02D	B	2023/09/25	Oxidation Reduction Potential	mV	68.0
UA	G02D	B	2023/10/23	Oxidation Reduction Potential	mV	108
UA	G02D	B	2015/12/03	Eh	V	0.34
UA	G02D	B	2016/03/15	Eh	V	0.22
UA	G02D	B	2016/06/15	Eh	V	0.28
UA	G02D	B	2016/09/14	Eh	V	0.26
UA	G02D	B	2016/12/14	Eh	V	0.41
UA	G02D	B	2017/03/08	Eh	V	0.45
UA	G02D	B	2017/06/14	Eh	V	0.29
UA	G02D	B	2017/07/20	Eh	V	0.33
UA	G02D	B	2017/11/30	Eh	V	0.27
UA	G02D	B	2018/06/19	Eh	V	0.38
UA	G02D	B	2018/09/05	Eh	V	0.36
UA	G02D	B	2019/03/27	Eh	V	0.33
UA	G02D	B	2019/09/09	Eh	V	0.38
UA	G02D	B	2020/03/30	Eh	V	0.37
UA	G02D	B	2020/09/23	Eh	V	0.44
UA	G02D	B	2021/03/03	Eh	V	0.35
UA	G02D	B	2021/03/24	Eh	V	0.37
UA	G02D	B	2021/04/14	Eh	V	0.35
UA	G02D	B	2021/05/12	Eh	V	0.38
UA	G02D	B	2021/06/01	Eh	V	0.34
UA	G02D	B	2021/06/14	Eh	V	0.36
UA	G02D	B	2021/07/06	Eh	V	0.32
UA	G02D	B	2021/07/21	Eh	V	0.30
UA	G02D	B	2021/09/20	Eh	V	0.39
UA	G02D	B	2022/03/14	Eh	V	0.33
UA	G02D	B	2022/07/27	Eh	V	0.29
UA	G02D	B	2022/09/21	Eh	V	0.39
UA	G02D	B	2023/01/24	Eh	V	0.31
UA	G02D	B	2023/03/08	Eh	V	0.25
UA	G02D	B	2023/05/03	Eh	V	0.38
UA	G02D	B	2023/09/25	Eh	V	0.26
UA	G02D	B	2023/10/23	Eh	V	0.30
UA	G02D	B	2017/07/20	Alkalinity, bicarbonate	mg/L CaCO3	159
UA	G02D	B	2020/03/30	Alkalinity, bicarbonate	mg/L CaCO3	165
UA	G02D	B	2021/03/03	Alkalinity, bicarbonate	mg/L CaCO3	159
UA	G02D	B	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	154
UA	G02D	B	2021/04/14	Alkalinity, bicarbonate	mg/L CaCO3	148
UA	G02D	B	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	153
UA	G02D	B	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	151
UA	G02D	B	2021/06/14	Alkalinity, bicarbonate	mg/L CaCO3	150
UA	G02D	B	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	151
UA	G02D	B	2021/07/21	Alkalinity, bicarbonate	mg/L CaCO3	148
UA	G02D	B	2021/09/20	Alkalinity, bicarbonate	mg/L CaCO3	156
UA	G02D	B	2022/03/14	Alkalinity, bicarbonate	mg/L CaCO3	138
UA	G02D	B	2022/07/27	Alkalinity, bicarbonate	mg/L CaCO3	147
UA	G02D	B	2023/01/24	Alkalinity, bicarbonate	mg/L CaCO3	136
UA	G02D	B	2023/03/08	Alkalinity, bicarbonate	mg/L CaCO3	141
UA	G02D	B	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	140
UA	G02D	B	2023/09/25	Alkalinity, bicarbonate	mg/L CaCO3	152
UA	G02D	B	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	145

Attachment I. Site Groundwater Data

Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G02D	B	2015/12/03	Barium, total	mg/L	0.232
UA	G02D	B	2016/03/15	Barium, total	mg/L	0.218
UA	G02D	B	2016/06/15	Barium, total	mg/L	0.203
UA	G02D	B	2016/09/14	Barium, total	mg/L	0.206
UA	G02D	B	2016/12/14	Barium, total	mg/L	0.224
UA	G02D	B	2017/03/08	Barium, total	mg/L	0.211
UA	G02D	B	2017/06/14	Barium, total	mg/L	0.192
UA	G02D	B	2017/07/20	Barium, total	mg/L	0.211
UA	G02D	B	2018/06/19	Barium, total	mg/L	0.245
UA	G02D	B	2018/09/05	Barium, total	mg/L	0.209
UA	G02D	B	2019/03/27	Barium, total	mg/L	0.235
UA	G02D	B	2019/09/09	Barium, total	mg/L	0.208
UA	G02D	B	2020/03/30	Barium, total	mg/L	0.202
UA	G02D	B	2020/09/23	Barium, total	mg/L	0.253
UA	G02D	B	2021/03/03	Barium, total	mg/L	0.207
UA	G02D	B	2021/03/24	Barium, total	mg/L	0.206
UA	G02D	B	2021/04/14	Barium, total	mg/L	0.187
UA	G02D	B	2021/05/12	Barium, total	mg/L	0.208
UA	G02D	B	2021/06/01	Barium, total	mg/L	0.191
UA	G02D	B	2021/06/14	Barium, total	mg/L	0.202
UA	G02D	B	2021/07/06	Barium, total	mg/L	0.189
UA	G02D	B	2021/07/21	Barium, total	mg/L	0.181
UA	G02D	B	2021/09/20	Barium, total	mg/L	0.189
UA	G02D	B	2022/03/14	Barium, total	mg/L	0.148
UA	G02D	B	2022/07/27	Barium, total	mg/L	0.182
UA	G02D	B	2022/09/21	Barium, total	mg/L	0.171
UA	G02D	B	2023/01/24	Barium, total	mg/L	0.190
UA	G02D	B	2023/03/08	Barium, total	mg/L	0.171
UA	G02D	B	2023/05/03	Barium, total	mg/L	0.210
UA	G02D	B	2023/09/25	Barium, total	mg/L	0.229
UA	G02D	B	2023/10/23	Barium, total	mg/L	0.170
UA	G02D	B	2015/12/03	Boron, total	mg/L	0.0536
UA	G02D	B	2016/03/15	Boron, total	mg/L	0.0494
UA	G02D	B	2016/06/15	Boron, total	mg/L	0.0508
UA	G02D	B	2016/09/14	Boron, total	mg/L	0.0534
UA	G02D	B	2016/12/14	Boron, total	mg/L	0.0552
UA	G02D	B	2017/03/08	Boron, total	mg/L	0.0546
UA	G02D	B	2017/06/14	Boron, total	mg/L	0.0467
UA	G02D	B	2017/07/20	Boron, total	mg/L	0.0440
UA	G02D	B	2017/11/30	Boron, total	mg/L	0.0496
UA	G02D	B	2018/06/19	Boron, total	mg/L	0.0404
UA	G02D	B	2018/09/05	Boron, total	mg/L	0.0468
UA	G02D	B	2019/03/27	Boron, total	mg/L	0.0473
UA	G02D	B	2019/09/09	Boron, total	mg/L	0.0429
UA	G02D	B	2020/03/30	Boron, total	mg/L	0.0449
UA	G02D	B	2020/09/23	Boron, total	mg/L	0.0442
UA	G02D	B	2021/03/03	Boron, total	mg/L	0.0296
UA	G02D	B	2021/03/24	Boron, total	mg/L	0.0330
UA	G02D	B	2021/04/14	Boron, total	mg/L	0.0318
UA	G02D	B	2021/05/12	Boron, total	mg/L	0.0356
UA	G02D	B	2021/06/01	Boron, total	mg/L	0.0433
UA	G02D	B	2021/06/14	Boron, total	mg/L	0.0352
UA	G02D	B	2021/07/06	Boron, total	mg/L	0.0431
UA	G02D	B	2021/07/21	Boron, total	mg/L	0.0329
UA	G02D	B	2021/09/20	Boron, total	mg/L	0.0313

Attachment I. Site Groundwater Data
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Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G02D	B	2022/03/14	Boron, total	mg/L	0.0283
UA	G02D	B	2022/07/27	Boron, total	mg/L	0.0322
UA	G02D	B	2022/09/21	Boron, total	mg/L	0.0266
UA	G02D	B	2023/01/24	Boron, total	mg/L	0.0311
UA	G02D	B	2023/03/08	Boron, total	mg/L	0.0270
UA	G02D	B	2023/05/03	Boron, total	mg/L	0.0412
UA	G02D	B	2023/09/25	Boron, total	mg/L	0.0401
UA	G02D	B	2023/10/23	Boron, total	mg/L	0.0276
UA	G02D	B	2015/12/03	Calcium, total	mg/L	39.9
UA	G02D	B	2016/03/15	Calcium, total	mg/L	39.8
UA	G02D	B	2016/06/15	Calcium, total	mg/L	38.6
UA	G02D	B	2016/09/14	Calcium, total	mg/L	34.7
UA	G02D	B	2016/12/14	Calcium, total	mg/L	40.4
UA	G02D	B	2017/03/08	Calcium, total	mg/L	40.0
UA	G02D	B	2017/06/14	Calcium, total	mg/L	33.2
UA	G02D	B	2017/07/20	Calcium, total	mg/L	37.5
UA	G02D	B	2017/11/30	Calcium, total	mg/L	40.1
UA	G02D	B	2018/06/19	Calcium, total	mg/L	33.9
UA	G02D	B	2018/09/05	Calcium, total	mg/L	36.3
UA	G02D	B	2019/03/27	Calcium, total	mg/L	38.7
UA	G02D	B	2019/09/09	Calcium, total	mg/L	40.3
UA	G02D	B	2020/03/30	Calcium, total	mg/L	33.5
UA	G02D	B	2020/09/23	Calcium, total	mg/L	45.8
UA	G02D	B	2021/03/03	Calcium, total	mg/L	34.5
UA	G02D	B	2021/03/24	Calcium, total	mg/L	34.4
UA	G02D	B	2021/04/14	Calcium, total	mg/L	32.4
UA	G02D	B	2021/05/12	Calcium, total	mg/L	34.6
UA	G02D	B	2021/06/01	Calcium, total	mg/L	32.6
UA	G02D	B	2021/06/14	Calcium, total	mg/L	34.6
UA	G02D	B	2021/07/06	Calcium, total	mg/L	32.3
UA	G02D	B	2021/07/21	Calcium, total	mg/L	36.6
UA	G02D	B	2021/09/20	Calcium, total	mg/L	34.3
UA	G02D	B	2022/03/14	Calcium, total	mg/L	38.2
UA	G02D	B	2022/07/27	Calcium, total	mg/L	36.0
UA	G02D	B	2022/09/21	Calcium, total	mg/L	35.3
UA	G02D	B	2023/01/24	Calcium, total	mg/L	35.9
UA	G02D	B	2023/03/08	Calcium, total	mg/L	37.3
UA	G02D	B	2023/05/03	Calcium, total	mg/L	38.7
UA	G02D	B	2023/09/25	Calcium, total	mg/L	33.7
UA	G02D	B	2023/10/23	Calcium, total	mg/L	34.0
UA	G02D	B	2015/12/03	Chloride, total	mg/L	24.0
UA	G02D	B	2016/03/15	Chloride, total	mg/L	24.0
UA	G02D	B	2016/06/15	Chloride, total	mg/L	21.0
UA	G02D	B	2016/09/14	Chloride, total	mg/L	24.0
UA	G02D	B	2016/12/14	Chloride, total	mg/L	24.0
UA	G02D	B	2017/03/08	Chloride, total	mg/L	24.0
UA	G02D	B	2017/06/14	Chloride, total	mg/L	25.0
UA	G02D	B	2017/07/20	Chloride, total	mg/L	22.0
UA	G02D	B	2017/11/30	Chloride, total	mg/L	23.0
UA	G02D	B	2018/06/19	Chloride, total	mg/L	23.0
UA	G02D	B	2018/09/05	Chloride, total	mg/L	23.0
UA	G02D	B	2019/03/27	Chloride, total	mg/L	20.0
UA	G02D	B	2019/09/09	Chloride, total	mg/L	18.0
UA	G02D	B	2020/03/30	Chloride, total	mg/L	20.0
UA	G02D	B	2020/09/23	Chloride, total	mg/L	19.0

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G02D	B	2021/03/03	Chloride, total	mg/L	21.0
UA	G02D	B	2021/03/24	Chloride, total	mg/L	22.0
UA	G02D	B	2021/04/14	Chloride, total	mg/L	24.0
UA	G02D	B	2021/05/12	Chloride, total	mg/L	18.0
UA	G02D	B	2021/06/01	Chloride, total	mg/L	18.0
UA	G02D	B	2021/06/14	Chloride, total	mg/L	20.0
UA	G02D	B	2021/07/06	Chloride, total	mg/L	21.0
UA	G02D	B	2021/07/21	Chloride, total	mg/L	22.0
UA	G02D	B	2021/09/20	Chloride, total	mg/L	20.0
UA	G02D	B	2022/03/14	Chloride, total	mg/L	22.0
UA	G02D	B	2022/07/27	Chloride, total	mg/L	24.0
UA	G02D	B	2022/09/21	Chloride, total	mg/L	21.0
UA	G02D	B	2023/01/24	Chloride, total	mg/L	23.0
UA	G02D	B	2023/03/08	Chloride, total	mg/L	21.0
UA	G02D	B	2023/05/03	Chloride, total	mg/L	21.0
UA	G02D	B	2023/09/25	Chloride, total	mg/L	21.0
UA	G02D	B	2023/10/23	Chloride, total	mg/L	22.0
UA	G02D	B	2015/12/03	Cobalt, total	mg/L	0.00240
UA	G02D	B	2016/03/15	Cobalt, total	mg/L	<0.0002
UA	G02D	B	2016/06/15	Cobalt, total	mg/L	<0.0002
UA	G02D	B	2016/09/14	Cobalt, total	mg/L	<0.0002
UA	G02D	B	2016/12/14	Cobalt, total	mg/L	0.00190
UA	G02D	B	2017/03/08	Cobalt, total	mg/L	<0.0002
UA	G02D	B	2017/06/14	Cobalt, total	mg/L	<0.0002
UA	G02D	B	2017/07/20	Cobalt, total	mg/L	<0.0002
UA	G02D	B	2018/06/19	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2018/09/05	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2019/03/27	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2019/09/09	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2020/03/30	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2020/09/23	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2021/03/03	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2021/03/24	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2021/04/14	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2021/05/12	Cobalt, total	mg/L	<0.001
UA	G02D	B	2021/06/01	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2021/06/14	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2021/07/06	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2021/07/21	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2021/09/20	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2022/03/14	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2022/07/27	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2022/09/21	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2023/01/24	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2023/03/08	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2023/05/03	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2023/09/25	Cobalt, total	mg/L	0.000400
UA	G02D	B	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G02D	B	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G02D	B	2023/09/25	Iron, dissolved	mg/L	0.0338
UA	G02D	B	2017/07/20	Magnesium, total	mg/L	11.4
UA	G02D	B	2020/03/30	Magnesium, total	mg/L	9.96
UA	G02D	B	2021/03/03	Magnesium, total	mg/L	9.98
UA	G02D	B	2021/03/24	Magnesium, total	mg/L	9.76
UA	G02D	B	2021/04/14	Magnesium, total	mg/L	9.39

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G02D	B	2021/05/12	Magnesium, total	mg/L	10.4
UA	G02D	B	2021/06/01	Magnesium, total	mg/L	9.39
UA	G02D	B	2021/06/14	Magnesium, total	mg/L	9.84
UA	G02D	B	2021/07/06	Magnesium, total	mg/L	9.77
UA	G02D	B	2021/07/21	Magnesium, total	mg/L	10.1
UA	G02D	B	2022/03/14	Magnesium, total	mg/L	10.6
UA	G02D	B	2022/07/27	Magnesium, total	mg/L	10.1
UA	G02D	B	2023/01/24	Magnesium, total	mg/L	10.2
UA	G02D	B	2023/03/08	Magnesium, total	mg/L	10.3
UA	G02D	B	2023/05/03	Magnesium, total	mg/L	10.4
UA	G02D	B	2023/09/25	Magnesium, total	mg/L	9.66
UA	G02D	B	2023/10/23	Magnesium, total	mg/L	9.66
UA	G02D	B	2023/05/03	Manganese, dissolved	mg/L	0.00330
UA	G02D	B	2023/09/25	Manganese, dissolved	mg/L	0.00900
UA	G02D	B	2023/05/03	Phosphate, dissolved	mg/L	<0.034
UA	G02D	B	2023/09/25	Phosphate, dissolved	mg/L	<0.005
UA	G02D	B	2017/07/20	Potassium, total	mg/L	1.10
UA	G02D	B	2020/03/30	Potassium, total	mg/L	1.23
UA	G02D	B	2021/03/03	Potassium, total	mg/L	1.15
UA	G02D	B	2021/03/24	Potassium, total	mg/L	1.06
UA	G02D	B	2021/04/14	Potassium, total	mg/L	1.05
UA	G02D	B	2021/05/12	Potassium, total	mg/L	1.17
UA	G02D	B	2021/06/01	Potassium, total	mg/L	1.18
UA	G02D	B	2021/06/14	Potassium, total	mg/L	1.19
UA	G02D	B	2021/07/06	Potassium, total	mg/L	1.24
UA	G02D	B	2021/07/21	Potassium, total	mg/L	1.14
UA	G02D	B	2022/03/14	Potassium, total	mg/L	1.23
UA	G02D	B	2022/07/27	Potassium, total	mg/L	1.12
UA	G02D	B	2023/01/24	Potassium, total	mg/L	1.11
UA	G02D	B	2023/03/08	Potassium, total	mg/L	1.12
UA	G02D	B	2023/05/03	Potassium, total	mg/L	1.14
UA	G02D	B	2023/09/25	Potassium, total	mg/L	1.08
UA	G02D	B	2023/10/23	Potassium, total	mg/L	1.10
UA	G02D	B	2023/05/03	Silicon, dissolved	mg/L	5.93
UA	G02D	B	2023/09/25	Silicon, dissolved	mg/L	6.20
UA	G02D	B	2017/07/20	Sodium, total	mg/L	34.8
UA	G02D	B	2020/03/30	Sodium, total	mg/L	46.3
UA	G02D	B	2021/03/03	Sodium, total	mg/L	43.8
UA	G02D	B	2021/03/24	Sodium, total	mg/L	39.7
UA	G02D	B	2021/04/14	Sodium, total	mg/L	46.7
UA	G02D	B	2021/05/12	Sodium, total	mg/L	53.6
UA	G02D	B	2021/06/01	Sodium, total	mg/L	46.0
UA	G02D	B	2021/06/14	Sodium, total	mg/L	43.9
UA	G02D	B	2021/07/06	Sodium, total	mg/L	42.0
UA	G02D	B	2021/07/21	Sodium, total	mg/L	38.7
UA	G02D	B	2022/03/14	Sodium, total	mg/L	31.7
UA	G02D	B	2022/07/27	Sodium, total	mg/L	36.4
UA	G02D	B	2023/01/24	Sodium, total	mg/L	29.0
UA	G02D	B	2023/03/08	Sodium, total	mg/L	28.3
UA	G02D	B	2023/05/03	Sodium, total	mg/L	39.1
UA	G02D	B	2023/09/25	Sodium, total	mg/L	32.9
UA	G02D	B	2023/10/23	Sodium, total	mg/L	32.9
UA	G02D	B	2015/12/03	Sulfate, total	mg/L	16.0
UA	G02D	B	2016/03/15	Sulfate, total	mg/L	17.0
UA	G02D	B	2016/06/15	Sulfate, total	mg/L	15.0

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G02D	B	2016/09/14	Sulfate, total	mg/L	22.0
UA	G02D	B	2016/12/14	Sulfate, total	mg/L	22.0
UA	G02D	B	2017/03/08	Sulfate, total	mg/L	18.0
UA	G02D	B	2017/06/14	Sulfate, total	mg/L	20.0
UA	G02D	B	2017/07/20	Sulfate, total	mg/L	12.0
UA	G02D	B	2017/11/30	Sulfate, total	mg/L	17.0
UA	G02D	B	2018/06/19	Sulfate, total	mg/L	17.0
UA	G02D	B	2018/09/05	Sulfate, total	mg/L	19.0
UA	G02D	B	2019/03/27	Sulfate, total	mg/L	20.0
UA	G02D	B	2019/09/09	Sulfate, total	mg/L	20.0
UA	G02D	B	2020/03/30	Sulfate, total	mg/L	22.0
UA	G02D	B	2020/09/23	Sulfate, total	mg/L	22.0
UA	G02D	B	2021/03/03	Sulfate, total	mg/L	21.0
UA	G02D	B	2021/03/24	Sulfate, total	mg/L	18.0
UA	G02D	B	2021/04/14	Sulfate, total	mg/L	19.0
UA	G02D	B	2021/05/12	Sulfate, total	mg/L	27.0
UA	G02D	B	2021/06/01	Sulfate, total	mg/L	23.0
UA	G02D	B	2021/06/14	Sulfate, total	mg/L	23.0
UA	G02D	B	2021/07/06	Sulfate, total	mg/L	22.0
UA	G02D	B	2021/07/21	Sulfate, total	mg/L	20.0
UA	G02D	B	2021/09/20	Sulfate, total	mg/L	19.0
UA	G02D	B	2022/03/14	Sulfate, total	mg/L	11.0
UA	G02D	B	2022/07/27	Sulfate, total	mg/L	19.0
UA	G02D	B	2022/09/21	Sulfate, total	mg/L	15.0
UA	G02D	B	2023/01/24	Sulfate, total	mg/L	12.0
UA	G02D	B	2023/03/08	Sulfate, total	mg/L	11.0
UA	G02D	B	2023/05/03	Sulfate, total	mg/L	13.0
UA	G02D	B	2023/09/25	Sulfate, total	mg/L	15.0
UA	G02D	B	2023/10/23	Sulfate, total	mg/L	15.0
UA	G02D	B	2015/12/03	Temperature (Celsius)	degrees C	14.8
UA	G02D	B	2016/03/15	Temperature (Celsius)	degrees C	17.4
UA	G02D	B	2016/06/15	Temperature (Celsius)	degrees C	16.2
UA	G02D	B	2016/09/14	Temperature (Celsius)	degrees C	23.0
UA	G02D	B	2016/12/14	Temperature (Celsius)	degrees C	15.4
UA	G02D	B	2017/03/08	Temperature (Celsius)	degrees C	13.8
UA	G02D	B	2017/06/14	Temperature (Celsius)	degrees C	17.7
UA	G02D	B	2017/07/20	Temperature (Celsius)	degrees C	16.8
UA	G02D	B	2017/11/30	Temperature (Celsius)	degrees C	14.8
UA	G02D	B	2018/06/19	Temperature (Celsius)	degrees C	16.7
UA	G02D	B	2018/09/05	Temperature (Celsius)	degrees C	15.8
UA	G02D	B	2019/03/27	Temperature (Celsius)	degrees C	14.5
UA	G02D	B	2019/09/09	Temperature (Celsius)	degrees C	16.0
UA	G02D	B	2020/03/30	Temperature (Celsius)	degrees C	14.8
UA	G02D	B	2020/09/23	Temperature (Celsius)	degrees C	15.2
UA	G02D	B	2021/03/03	Temperature (Celsius)	degrees C	14.6
UA	G02D	B	2021/03/24	Temperature (Celsius)	degrees C	14.9
UA	G02D	B	2021/04/14	Temperature (Celsius)	degrees C	14.7
UA	G02D	B	2021/05/12	Temperature (Celsius)	degrees C	14.9
UA	G02D	B	2021/06/01	Temperature (Celsius)	degrees C	14.9
UA	G02D	B	2021/06/14	Temperature (Celsius)	degrees C	15.6
UA	G02D	B	2021/07/06	Temperature (Celsius)	degrees C	15.8
UA	G02D	B	2021/07/21	Temperature (Celsius)	degrees C	15.4
UA	G02D	B	2021/09/20	Temperature (Celsius)	degrees C	15.7
UA	G02D	B	2022/03/14	Temperature (Celsius)	degrees C	14.7
UA	G02D	B	2022/07/27	Temperature (Celsius)	degrees C	16.5

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G02D	B	2022/09/21	Temperature (Celsius)	degrees C	15.5
UA	G02D	B	2023/01/24	Temperature (Celsius)	degrees C	13.7
UA	G02D	B	2023/03/08	Temperature (Celsius)	degrees C	14.2
UA	G02D	B	2023/05/03	Temperature (Celsius)	degrees C	14.3
UA	G02D	B	2023/09/25	Temperature (Celsius)	degrees C	16.1
UA	G02D	B	2023/10/23	Temperature (Celsius)	degrees C	15.4
UA	G02D	B	2015/12/03	Total Dissolved Solids	mg/L	244
UA	G02D	B	2016/03/15	Total Dissolved Solids	mg/L	256
UA	G02D	B	2016/06/15	Total Dissolved Solids	mg/L	248
UA	G02D	B	2016/09/14	Total Dissolved Solids	mg/L	276
UA	G02D	B	2016/12/14	Total Dissolved Solids	mg/L	266
UA	G02D	B	2017/03/08	Total Dissolved Solids	mg/L	270
UA	G02D	B	2017/06/14	Total Dissolved Solids	mg/L	198
UA	G02D	B	2017/07/20	Total Dissolved Solids	mg/L	264
UA	G02D	B	2017/11/30	Total Dissolved Solids	mg/L	246
UA	G02D	B	2018/06/19	Total Dissolved Solids	mg/L	232
UA	G02D	B	2018/09/05	Total Dissolved Solids	mg/L	252
UA	G02D	B	2019/03/27	Total Dissolved Solids	mg/L	262
UA	G02D	B	2019/09/09	Total Dissolved Solids	mg/L	264
UA	G02D	B	2020/03/30	Total Dissolved Solids	mg/L	222
UA	G02D	B	2020/09/23	Total Dissolved Solids	mg/L	234
UA	G02D	B	2021/03/03	Total Dissolved Solids	mg/L	266
UA	G02D	B	2021/03/24	Total Dissolved Solids	mg/L	244
UA	G02D	B	2021/04/14	Total Dissolved Solids	mg/L	242
UA	G02D	B	2021/05/12	Total Dissolved Solids	mg/L	232
UA	G02D	B	2021/06/01	Total Dissolved Solids	mg/L	246
UA	G02D	B	2021/06/14	Total Dissolved Solids	mg/L	216
UA	G02D	B	2021/07/06	Total Dissolved Solids	mg/L	230
UA	G02D	B	2021/07/21	Total Dissolved Solids	mg/L	246
UA	G02D	B	2021/09/20	Total Dissolved Solids	mg/L	240
UA	G02D	B	2022/03/14	Total Dissolved Solids	mg/L	260
UA	G02D	B	2022/07/27	Total Dissolved Solids	mg/L	234
UA	G02D	B	2022/09/21	Total Dissolved Solids	mg/L	220
UA	G02D	B	2023/01/24	Total Dissolved Solids	mg/L	140
UA	G02D	B	2023/03/08	Total Dissolved Solids	mg/L	218
UA	G02D	B	2023/05/03	Total Dissolved Solids	mg/L	230
UA	G02D	B	2023/09/25	Total Dissolved Solids	mg/L	226
UA	G02D	B	2023/10/23	Total Dissolved Solids	mg/L	204
UA	G03	C	2021/03/05	pH (field)	SU	6.4
UA	G03	C	2021/03/24	pH (field)	SU	6.3
UA	G03	C	2021/04/14	pH (field)	SU	6.2
UA	G03	C	2021/05/12	pH (field)	SU	6.4
UA	G03	C	2021/06/01	pH (field)	SU	6.3
UA	G03	C	2021/06/15	pH (field)	SU	6.2
UA	G03	C	2021/07/06	pH (field)	SU	6.3
UA	G03	C	2021/07/21	pH (field)	SU	6.4
UA	G03	C	2022/07/26	pH (field)	SU	6.5
UA	G03	C	2023/03/09	pH (field)	SU	6.2
UA	G03	C	2023/05/03	pH (field)	SU	6.2
UA	G03	C	2023/09/26	pH (field)	SU	6.4
UA	G03	C	2023/10/23	pH (field)	SU	6.4
UA	G03	C	2021/03/05	Oxidation Reduction Potential	mV	117
UA	G03	C	2021/03/24	Oxidation Reduction Potential	mV	150
UA	G03	C	2021/04/14	Oxidation Reduction Potential	mV	137
UA	G03	C	2021/05/12	Oxidation Reduction Potential	mV	180

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G03	C	2021/06/01	Oxidation Reduction Potential	mV	149
UA	G03	C	2021/06/15	Oxidation Reduction Potential	mV	128
UA	G03	C	2021/07/06	Oxidation Reduction Potential	mV	116
UA	G03	C	2021/07/21	Oxidation Reduction Potential	mV	52.0
UA	G03	C	2022/07/26	Oxidation Reduction Potential	mV	63.5
UA	G03	C	2023/03/09	Oxidation Reduction Potential	mV	165
UA	G03	C	2023/05/03	Oxidation Reduction Potential	mV	226
UA	G03	C	2023/09/26	Oxidation Reduction Potential	mV	40.0
UA	G03	C	2023/10/23	Oxidation Reduction Potential	mV	130
UA	G03	C	2021/03/05	Eh	V	0.31
UA	G03	C	2021/03/24	Eh	V	0.35
UA	G03	C	2021/04/14	Eh	V	0.33
UA	G03	C	2021/05/12	Eh	V	0.38
UA	G03	C	2021/06/01	Eh	V	0.34
UA	G03	C	2021/06/15	Eh	V	0.32
UA	G03	C	2021/07/06	Eh	V	0.31
UA	G03	C	2021/07/21	Eh	V	0.25
UA	G03	C	2022/07/26	Eh	V	0.26
UA	G03	C	2023/03/09	Eh	V	0.36
UA	G03	C	2023/05/03	Eh	V	0.42
UA	G03	C	2023/09/26	Eh	V	0.23
UA	G03	C	2023/10/23	Eh	V	0.32
UA	G03	C	2021/03/05	Alkalinity, bicarbonate	mg/L CaCO3	142
UA	G03	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	146
UA	G03	C	2021/04/14	Alkalinity, bicarbonate	mg/L CaCO3	163
UA	G03	C	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	139
UA	G03	C	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	125
UA	G03	C	2021/06/15	Alkalinity, bicarbonate	mg/L CaCO3	148
UA	G03	C	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	140
UA	G03	C	2021/07/21	Alkalinity, bicarbonate	mg/L CaCO3	141
UA	G03	C	2022/07/26	Alkalinity, bicarbonate	mg/L CaCO3	154
UA	G03	C	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	139
UA	G03	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	135
UA	G03	C	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	144
UA	G03	C	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	138
UA	G03	C	2021/03/05	Barium, total	mg/L	0.112
UA	G03	C	2021/03/24	Barium, total	mg/L	0.0821
UA	G03	C	2021/04/14	Barium, total	mg/L	0.0787
UA	G03	C	2021/05/12	Barium, total	mg/L	0.0728
UA	G03	C	2021/06/01	Barium, total	mg/L	0.0787
UA	G03	C	2021/06/15	Barium, total	mg/L	0.0705
UA	G03	C	2021/07/06	Barium, total	mg/L	0.0564
UA	G03	C	2021/07/21	Barium, total	mg/L	0.0555
UA	G03	C	2022/07/26	Barium, total	mg/L	0.0423
UA	G03	C	2023/03/09	Barium, total	mg/L	0.0637
UA	G03	C	2023/05/03	Barium, total	mg/L	0.100
UA	G03	C	2023/09/26	Barium, total	mg/L	0.0748
UA	G03	C	2023/10/23	Barium, total	mg/L	0.0652
UA	G03	C	2021/03/05	Boron, total	mg/L	0.213
UA	G03	C	2021/03/24	Boron, total	mg/L	0.343
UA	G03	C	2021/04/14	Boron, total	mg/L	0.603
UA	G03	C	2021/05/12	Boron, total	mg/L	0.260
UA	G03	C	2021/06/01	Boron, total	mg/L	0.232
UA	G03	C	2021/06/15	Boron, total	mg/L	0.225
UA	G03	C	2021/07/06	Boron, total	mg/L	0.235

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G03	C	2021/07/21	Boron, total	mg/L	0.294
UA	G03	C	2022/07/26	Boron, total	mg/L	0.532
UA	G03	C	2023/03/09	Boron, total	mg/L	0.330
UA	G03	C	2023/05/03	Boron, total	mg/L	0.380
UA	G03	C	2023/09/26	Boron, total	mg/L	0.267
UA	G03	C	2023/10/23	Boron, total	mg/L	0.269
UA	G03	C	2021/03/05	Calcium, total	mg/L	46.1
UA	G03	C	2021/03/24	Calcium, total	mg/L	53.5
UA	G03	C	2021/04/14	Calcium, total	mg/L	77.8
UA	G03	C	2021/05/12	Calcium, total	mg/L	47.7
UA	G03	C	2021/06/01	Calcium, total	mg/L	46.0
UA	G03	C	2021/06/15	Calcium, total	mg/L	46.7
UA	G03	C	2021/07/06	Calcium, total	mg/L	42.1
UA	G03	C	2021/07/21	Calcium, total	mg/L	50.0
UA	G03	C	2022/07/26	Calcium, total	mg/L	70.2
UA	G03	C	2023/03/09	Calcium, total	mg/L	46.5
UA	G03	C	2023/05/03	Calcium, total	mg/L	52.6
UA	G03	C	2023/09/26	Calcium, total	mg/L	41.8
UA	G03	C	2023/10/23	Calcium, total	mg/L	42.8
UA	G03	C	2021/03/05	Chloride, total	mg/L	20.0
UA	G03	C	2021/03/24	Chloride, total	mg/L	24.0
UA	G03	C	2021/04/14	Chloride, total	mg/L	33.0
UA	G03	C	2021/05/12	Chloride, total	mg/L	29.0
UA	G03	C	2021/06/01	Chloride, total	mg/L	19.0
UA	G03	C	2021/06/15	Chloride, total	mg/L	22.0
UA	G03	C	2021/07/06	Chloride, total	mg/L	22.0
UA	G03	C	2021/07/21	Chloride, total	mg/L	24.0
UA	G03	C	2022/07/26	Chloride, total	mg/L	34.0
UA	G03	C	2023/03/09	Chloride, total	mg/L	22.0
UA	G03	C	2023/05/03	Chloride, total	mg/L	28.0
UA	G03	C	2023/09/26	Chloride, total	mg/L	19.0
UA	G03	C	2023/10/23	Chloride, total	mg/L	20.0
UA	G03	C	2021/03/05	Cobalt, total	mg/L	0.00630
UA	G03	C	2021/03/24	Cobalt, total	mg/L	0.00370
UA	G03	C	2021/04/14	Cobalt, total	mg/L	0.00440
UA	G03	C	2021/05/12	Cobalt, total	mg/L	0.00257
UA	G03	C	2021/06/01	Cobalt, total	mg/L	0.00200
UA	G03	C	2021/06/15	Cobalt, total	mg/L	<0.0001
UA	G03	C	2021/07/06	Cobalt, total	mg/L	<0.0001
UA	G03	C	2021/07/21	Cobalt, total	mg/L	<0.0001
UA	G03	C	2022/07/26	Cobalt, total	mg/L	0.00250
UA	G03	C	2023/03/09	Cobalt, total	mg/L	0.00330
UA	G03	C	2023/05/03	Cobalt, total	mg/L	0.0146
UA	G03	C	2023/09/26	Cobalt, total	mg/L	0.00140
UA	G03	C	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G03	C	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G03	C	2023/09/26	Iron, dissolved	mg/L	0.0257
UA	G03	C	2021/03/05	Magnesium, total	mg/L	15.1
UA	G03	C	2021/03/24	Magnesium, total	mg/L	17.6
UA	G03	C	2021/04/14	Magnesium, total	mg/L	28.3
UA	G03	C	2021/05/12	Magnesium, total	mg/L	15.8
UA	G03	C	2021/06/01	Magnesium, total	mg/L	14.9
UA	G03	C	2021/06/15	Magnesium, total	mg/L	15.1
UA	G03	C	2021/07/06	Magnesium, total	mg/L	14.0
UA	G03	C	2021/07/21	Magnesium, total	mg/L	15.7

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G03	C	2022/07/26	Magnesium, total	mg/L	22.9
UA	G03	C	2023/03/09	Magnesium, total	mg/L	15.2
UA	G03	C	2023/05/03	Magnesium, total	mg/L	16.6
UA	G03	C	2023/09/26	Magnesium, total	mg/L	13.8
UA	G03	C	2023/10/23	Magnesium, total	mg/L	14.0
UA	G03	C	2023/05/03	Manganese, dissolved	mg/L	0.0193
UA	G03	C	2023/09/26	Manganese, dissolved	mg/L	0.00300
UA	G03	C	2023/05/03	Phosphate, dissolved	mg/L	0.0550
UA	G03	C	2023/09/26	Phosphate, dissolved	mg/L	0.0150
UA	G03	C	2021/03/05	Potassium, total	mg/L	1.57
UA	G03	C	2021/03/24	Potassium, total	mg/L	1.42
UA	G03	C	2021/04/14	Potassium, total	mg/L	1.79
UA	G03	C	2021/05/12	Potassium, total	mg/L	1.15
UA	G03	C	2021/06/01	Potassium, total	mg/L	1.46
UA	G03	C	2021/06/15	Potassium, total	mg/L	1.26
UA	G03	C	2021/07/06	Potassium, total	mg/L	1.13
UA	G03	C	2021/07/21	Potassium, total	mg/L	1.39
UA	G03	C	2022/07/26	Potassium, total	mg/L	1.54
UA	G03	C	2023/03/09	Potassium, total	mg/L	1.19
UA	G03	C	2023/05/03	Potassium, total	mg/L	1.70
UA	G03	C	2023/09/26	Potassium, total	mg/L	0.988
UA	G03	C	2023/10/23	Potassium, total	mg/L	1.09
UA	G03	C	2023/05/03	Silicon, dissolved	mg/L	6.36
UA	G03	C	2023/09/26	Silicon, dissolved	mg/L	6.10
UA	G03	C	2021/03/05	Sodium, total	mg/L	38.4
UA	G03	C	2021/03/24	Sodium, total	mg/L	48.2
UA	G03	C	2021/04/14	Sodium, total	mg/L	65.0
UA	G03	C	2021/05/12	Sodium, total	mg/L	42.0
UA	G03	C	2021/06/01	Sodium, total	mg/L	36.8
UA	G03	C	2021/06/15	Sodium, total	mg/L	40.4
UA	G03	C	2021/07/06	Sodium, total	mg/L	38.0
UA	G03	C	2021/07/21	Sodium, total	mg/L	40.2
UA	G03	C	2022/07/26	Sodium, total	mg/L	53.5
UA	G03	C	2023/03/09	Sodium, total	mg/L	35.0
UA	G03	C	2023/05/03	Sodium, total	mg/L	41.9
UA	G03	C	2023/09/26	Sodium, total	mg/L	32.2
UA	G03	C	2023/10/23	Sodium, total	mg/L	34.1
UA	G03	C	2021/03/05	Sulfate, total	mg/L	66.0
UA	G03	C	2021/03/24	Sulfate, total	mg/L	104
UA	G03	C	2021/04/14	Sulfate, total	mg/L	168
UA	G03	C	2021/05/12	Sulfate, total	mg/L	112
UA	G03	C	2021/06/01	Sulfate, total	mg/L	73.0
UA	G03	C	2021/06/15	Sulfate, total	mg/L	79.0
UA	G03	C	2021/07/06	Sulfate, total	mg/L	77.0
UA	G03	C	2021/07/21	Sulfate, total	mg/L	92.0
UA	G03	C	2022/07/26	Sulfate, total	mg/L	164
UA	G03	C	2023/03/09	Sulfate, total	mg/L	82.0
UA	G03	C	2023/05/03	Sulfate, total	mg/L	97.0
UA	G03	C	2023/09/26	Sulfate, total	mg/L	67.0
UA	G03	C	2023/10/23	Sulfate, total	mg/L	61.0
UA	G03	C	2021/03/05	Temperature (Celsius)	degrees C	15.2
UA	G03	C	2021/03/24	Temperature (Celsius)	degrees C	15.7
UA	G03	C	2021/04/14	Temperature (Celsius)	degrees C	15.6
UA	G03	C	2021/05/12	Temperature (Celsius)	degrees C	15.7
UA	G03	C	2021/06/01	Temperature (Celsius)	degrees C	15.6

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G03	C	2021/06/15	Temperature (Celsius)	degrees C	15.9
UA	G03	C	2021/07/06	Temperature (Celsius)	degrees C	15.9
UA	G03	C	2021/07/21	Temperature (Celsius)	degrees C	16.2
UA	G03	C	2022/07/26	Temperature (Celsius)	degrees C	19.4
UA	G03	C	2023/03/09	Temperature (Celsius)	degrees C	15.4
UA	G03	C	2023/05/03	Temperature (Celsius)	degrees C	15.3
UA	G03	C	2023/09/26	Temperature (Celsius)	degrees C	17.8
UA	G03	C	2023/10/23	Temperature (Celsius)	degrees C	16.4
UA	G03	C	2021/03/05	Total Dissolved Solids	mg/L	284
UA	G03	C	2021/03/24	Total Dissolved Solids	mg/L	342
UA	G03	C	2021/04/14	Total Dissolved Solids	mg/L	422
UA	G03	C	2021/05/12	Total Dissolved Solids	mg/L	304
UA	G03	C	2021/06/01	Total Dissolved Solids	mg/L	294
UA	G03	C	2021/06/15	Total Dissolved Solids	mg/L	298
UA	G03	C	2021/07/06	Total Dissolved Solids	mg/L	282
UA	G03	C	2021/07/21	Total Dissolved Solids	mg/L	310
UA	G03	C	2022/07/26	Total Dissolved Solids	mg/L	458
UA	G03	C	2023/03/09	Total Dissolved Solids	mg/L	300
UA	G03	C	2023/05/03	Total Dissolved Solids	mg/L	350
UA	G03	C	2023/09/26	Total Dissolved Solids	mg/L	295
UA	G03	C	2023/10/23	Total Dissolved Solids	mg/L	254
UA	G05	C	2021/03/04	pH (field)	SU	6.5
UA	G05	C	2021/03/24	pH (field)	SU	6.4
UA	G05	C	2021/04/13	pH (field)	SU	6.5
UA	G05	C	2021/05/11	pH (field)	SU	6.4
UA	G05	C	2021/06/01	pH (field)	SU	6.5
UA	G05	C	2021/06/15	pH (field)	SU	6.3
UA	G05	C	2021/07/06	pH (field)	SU	6.4
UA	G05	C	2021/07/20	pH (field)	SU	6.3
UA	G05	C	2022/07/26	pH (field)	SU	6.6
UA	G05	C	2023/03/09	pH (field)	SU	6.5
UA	G05	C	2023/05/03	pH (field)	SU	6.5
UA	G05	C	2023/09/27	pH (field)	SU	6.4
UA	G05	C	2023/10/24	pH (field)	SU	6.4
UA	G05	C	2021/03/04	Oxidation Reduction Potential	mV	56.0
UA	G05	C	2021/03/24	Oxidation Reduction Potential	mV	35.0
UA	G05	C	2021/04/13	Oxidation Reduction Potential	mV	18.0
UA	G05	C	2021/05/11	Oxidation Reduction Potential	mV	42.0
UA	G05	C	2021/06/01	Oxidation Reduction Potential	mV	452
UA	G05	C	2021/06/15	Oxidation Reduction Potential	mV	59.0
UA	G05	C	2021/07/06	Oxidation Reduction Potential	mV	102
UA	G05	C	2021/07/20	Oxidation Reduction Potential	mV	134
UA	G05	C	2022/07/26	Oxidation Reduction Potential	mV	-79.5
UA	G05	C	2023/03/09	Oxidation Reduction Potential	mV	47.4
UA	G05	C	2023/05/03	Oxidation Reduction Potential	mV	128
UA	G05	C	2023/09/27	Oxidation Reduction Potential	mV	-17.0
UA	G05	C	2023/10/24	Oxidation Reduction Potential	mV	45.0
UA	G05	C	2021/03/04	Eh	V	0.25
UA	G05	C	2021/03/24	Eh	V	0.23
UA	G05	C	2021/04/13	Eh	V	0.21
UA	G05	C	2021/05/11	Eh	V	0.24
UA	G05	C	2021/06/01	Eh	V	0.65
UA	G05	C	2021/06/15	Eh	V	0.25
UA	G05	C	2021/07/06	Eh	V	0.30
UA	G05	C	2021/07/20	Eh	V	0.33

Attachment I. Site Groundwater Data
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Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G05	C	2022/07/26	Eh	V	0.11
UA	G05	C	2023/03/09	Eh	V	0.24
UA	G05	C	2023/05/03	Eh	V	0.32
UA	G05	C	2023/09/27	Eh	V	0.18
UA	G05	C	2023/10/24	Eh	V	0.24
UA	G05	C	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	180
UA	G05	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	198
UA	G05	C	2021/04/13	Alkalinity, bicarbonate	mg/L CaCO3	206
UA	G05	C	2021/05/11	Alkalinity, bicarbonate	mg/L CaCO3	193
UA	G05	C	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	190
UA	G05	C	2021/06/15	Alkalinity, bicarbonate	mg/L CaCO3	203
UA	G05	C	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	178
UA	G05	C	2021/07/20	Alkalinity, bicarbonate	mg/L CaCO3	186
UA	G05	C	2022/07/26	Alkalinity, bicarbonate	mg/L CaCO3	181
UA	G05	C	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	179
UA	G05	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	163
UA	G05	C	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	195
UA	G05	C	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	188
UA	G05	C	2021/03/04	Barium, total	mg/L	0.130
UA	G05	C	2021/03/24	Barium, total	mg/L	0.129
UA	G05	C	2021/04/13	Barium, total	mg/L	0.126
UA	G05	C	2021/05/11	Barium, total	mg/L	0.132
UA	G05	C	2021/06/01	Barium, total	mg/L	0.144
UA	G05	C	2021/06/15	Barium, total	mg/L	0.132
UA	G05	C	2021/07/06	Barium, total	mg/L	0.139
UA	G05	C	2021/07/20	Barium, total	mg/L	0.133
UA	G05	C	2022/07/26	Barium, total	mg/L	0.141
UA	G05	C	2023/03/09	Barium, total	mg/L	0.175
UA	G05	C	2023/05/03	Barium, total	mg/L	0.212
UA	G05	C	2023/09/27	Barium, total	mg/L	0.169
UA	G05	C	2023/10/24	Barium, total	mg/L	0.177
UA	G05	C	2021/03/04	Boron, total	mg/L	0.181
UA	G05	C	2021/03/24	Boron, total	mg/L	0.195
UA	G05	C	2021/04/13	Boron, total	mg/L	0.190
UA	G05	C	2021/05/11	Boron, total	mg/L	0.158
UA	G05	C	2021/06/01	Boron, total	mg/L	0.157
UA	G05	C	2021/06/15	Boron, total	mg/L	0.140
UA	G05	C	2021/07/06	Boron, total	mg/L	0.148
UA	G05	C	2021/07/20	Boron, total	mg/L	0.131
UA	G05	C	2022/07/26	Boron, total	mg/L	0.0645
UA	G05	C	2023/03/09	Boron, total	mg/L	0.0541
UA	G05	C	2023/05/03	Boron, total	mg/L	0.0478
UA	G05	C	2023/09/27	Boron, total	mg/L	0.0436
UA	G05	C	2023/10/24	Boron, total	mg/L	0.0485
UA	G05	C	2021/03/04	Calcium, total	mg/L	55.3
UA	G05	C	2021/03/24	Calcium, total	mg/L	59.4
UA	G05	C	2021/04/13	Calcium, total	mg/L	68.5
UA	G05	C	2021/05/11	Calcium, total	mg/L	60.3
UA	G05	C	2021/06/01	Calcium, total	mg/L	57.1
UA	G05	C	2021/06/15	Calcium, total	mg/L	58.6
UA	G05	C	2021/07/06	Calcium, total	mg/L	51.8
UA	G05	C	2021/07/20	Calcium, total	mg/L	55.9
UA	G05	C	2022/07/26	Calcium, total	mg/L	50.6
UA	G05	C	2023/03/09	Calcium, total	mg/L	52.6
UA	G05	C	2023/05/03	Calcium, total	mg/L	54.4

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G05	C	2023/09/27	Calcium, total	mg/L	52.2
UA	G05	C	2023/10/24	Calcium, total	mg/L	50.4
UA	G05	C	2021/03/04	Chloride, total	mg/L	13.0
UA	G05	C	2021/03/24	Chloride, total	mg/L	15.0
UA	G05	C	2021/04/13	Chloride, total	mg/L	21.0
UA	G05	C	2021/05/11	Chloride, total	mg/L	19.0
UA	G05	C	2021/06/01	Chloride, total	mg/L	21.0
UA	G05	C	2021/06/15	Chloride, total	mg/L	18.0
UA	G05	C	2021/07/06	Chloride, total	mg/L	22.0
UA	G05	C	2021/07/20	Chloride, total	mg/L	20.0
UA	G05	C	2022/07/26	Chloride, total	mg/L	15.0
UA	G05	C	2023/03/09	Chloride, total	mg/L	22.0
UA	G05	C	2023/05/03	Chloride, total	mg/L	24.0
UA	G05	C	2023/09/27	Chloride, total	mg/L	20.0
UA	G05	C	2023/10/24	Chloride, total	mg/L	22.0
UA	G05	C	2021/03/04	Cobalt, total	mg/L	0.0101
UA	G05	C	2021/03/24	Cobalt, total	mg/L	0.00960
UA	G05	C	2021/04/13	Cobalt, total	mg/L	0.00950
UA	G05	C	2021/05/11	Cobalt, total	mg/L	0.00870
UA	G05	C	2021/06/01	Cobalt, total	mg/L	0.00780
UA	G05	C	2021/06/15	Cobalt, total	mg/L	0.00570
UA	G05	C	2021/07/06	Cobalt, total	mg/L	0.00910
UA	G05	C	2021/07/20	Cobalt, total	mg/L	0.00590
UA	G05	C	2022/07/26	Cobalt, total	mg/L	0.00750
UA	G05	C	2023/03/09	Cobalt, total	mg/L	0.00740
UA	G05	C	2023/05/03	Cobalt, total	mg/L	0.0103
UA	G05	C	2023/09/27	Cobalt, total	mg/L	0.00230
UA	G05	C	2023/10/24	Cobalt, total	mg/L	0.00200
UA	G05	C	2023/05/03	Iron, dissolved	mg/L	0.342
UA	G05	C	2023/09/27	Iron, dissolved	mg/L	0.429
UA	G05	C	2021/03/04	Magnesium, total	mg/L	17.2
UA	G05	C	2021/03/24	Magnesium, total	mg/L	18.8
UA	G05	C	2021/04/13	Magnesium, total	mg/L	19.5
UA	G05	C	2021/05/11	Magnesium, total	mg/L	19.4
UA	G05	C	2021/06/01	Magnesium, total	mg/L	18.6
UA	G05	C	2021/06/15	Magnesium, total	mg/L	18.4
UA	G05	C	2021/07/06	Magnesium, total	mg/L	17.6
UA	G05	C	2021/07/20	Magnesium, total	mg/L	18.5
UA	G05	C	2022/07/26	Magnesium, total	mg/L	17.6
UA	G05	C	2023/03/09	Magnesium, total	mg/L	19.4
UA	G05	C	2023/05/03	Magnesium, total	mg/L	19.3
UA	G05	C	2023/09/27	Magnesium, total	mg/L	18.8
UA	G05	C	2023/10/24	Magnesium, total	mg/L	18.0
UA	G05	C	2023/05/03	Manganese, dissolved	mg/L	0.166
UA	G05	C	2023/09/27	Manganese, dissolved	mg/L	0.104
UA	G05	C	2023/05/03	Phosphate, dissolved	mg/L	0.0400
UA	G05	C	2023/09/27	Phosphate, dissolved	mg/L	<0.005
UA	G05	C	2021/03/04	Potassium, total	mg/L	1.37
UA	G05	C	2021/03/24	Potassium, total	mg/L	1.78
UA	G05	C	2021/04/13	Potassium, total	mg/L	2.14
UA	G05	C	2021/05/11	Potassium, total	mg/L	1.97
UA	G05	C	2021/06/01	Potassium, total	mg/L	2.18
UA	G05	C	2021/06/15	Potassium, total	mg/L	1.58
UA	G05	C	2021/07/06	Potassium, total	mg/L	2.04
UA	G05	C	2021/07/20	Potassium, total	mg/L	1.75

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G05	C	2022/07/26	Potassium, total	mg/L	1.07
UA	G05	C	2023/03/09	Potassium, total	mg/L	1.59
UA	G05	C	2023/05/03	Potassium, total	mg/L	1.68
UA	G05	C	2023/09/27	Potassium, total	mg/L	1.59
UA	G05	C	2023/10/24	Potassium, total	mg/L	1.56
UA	G05	C	2023/05/03	Silicon, dissolved	mg/L	15.1
UA	G05	C	2023/09/27	Silicon, dissolved	mg/L	14.5
UA	G05	C	2021/03/04	Sodium, total	mg/L	44.1
UA	G05	C	2021/03/24	Sodium, total	mg/L	47.3
UA	G05	C	2021/04/13	Sodium, total	mg/L	53.7
UA	G05	C	2021/05/11	Sodium, total	mg/L	49.6
UA	G05	C	2021/06/01	Sodium, total	mg/L	45.5
UA	G05	C	2021/06/15	Sodium, total	mg/L	45.5
UA	G05	C	2021/07/06	Sodium, total	mg/L	45.9
UA	G05	C	2021/07/20	Sodium, total	mg/L	43.4
UA	G05	C	2022/07/26	Sodium, total	mg/L	35.4
UA	G05	C	2023/03/09	Sodium, total	mg/L	41.8
UA	G05	C	2023/05/03	Sodium, total	mg/L	46.7
UA	G05	C	2023/09/27	Sodium, total	mg/L	42.6
UA	G05	C	2023/10/24	Sodium, total	mg/L	41.8
UA	G05	C	2021/03/04	Sulfate, total	mg/L	94.0
UA	G05	C	2021/03/24	Sulfate, total	mg/L	92.0
UA	G05	C	2021/04/13	Sulfate, total	mg/L	95.0
UA	G05	C	2021/05/11	Sulfate, total	mg/L	109
UA	G05	C	2021/06/01	Sulfate, total	mg/L	83.0
UA	G05	C	2021/06/15	Sulfate, total	mg/L	91.0
UA	G05	C	2021/07/06	Sulfate, total	mg/L	90.0
UA	G05	C	2021/07/20	Sulfate, total	mg/L	87.0
UA	G05	C	2022/07/26	Sulfate, total	mg/L	68.0
UA	G05	C	2023/03/09	Sulfate, total	mg/L	90.0
UA	G05	C	2023/05/03	Sulfate, total	mg/L	112
UA	G05	C	2023/09/27	Sulfate, total	mg/L	82.0
UA	G05	C	2023/10/24	Sulfate, total	mg/L	92.0
UA	G05	C	2021/03/04	Temperature (Celsius)	degrees C	15.7
UA	G05	C	2021/03/24	Temperature (Celsius)	degrees C	16.6
UA	G05	C	2021/04/13	Temperature (Celsius)	degrees C	16.3
UA	G05	C	2021/05/11	Temperature (Celsius)	degrees C	16.1
UA	G05	C	2021/06/01	Temperature (Celsius)	degrees C	16.4
UA	G05	C	2021/06/15	Temperature (Celsius)	degrees C	16.1
UA	G05	C	2021/07/06	Temperature (Celsius)	degrees C	17.3
UA	G05	C	2021/07/20	Temperature (Celsius)	degrees C	17.5
UA	G05	C	2022/07/26	Temperature (Celsius)	degrees C	18.4
UA	G05	C	2023/03/09	Temperature (Celsius)	degrees C	13.9
UA	G05	C	2023/05/03	Temperature (Celsius)	degrees C	17.1
UA	G05	C	2023/09/27	Temperature (Celsius)	degrees C	17.4
UA	G05	C	2023/10/24	Temperature (Celsius)	degrees C	17.7
UA	G05	C	2021/03/04	Total Dissolved Solids	mg/L	370
UA	G05	C	2021/03/24	Total Dissolved Solids	mg/L	370
UA	G05	C	2021/04/13	Total Dissolved Solids	mg/L	368
UA	G05	C	2021/05/11	Total Dissolved Solids	mg/L	348
UA	G05	C	2021/06/01	Total Dissolved Solids	mg/L	366
UA	G05	C	2021/06/15	Total Dissolved Solids	mg/L	366
UA	G05	C	2021/07/06	Total Dissolved Solids	mg/L	334
UA	G05	C	2021/07/20	Total Dissolved Solids	mg/L	378
UA	G05	C	2022/07/26	Total Dissolved Solids	mg/L	348

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G05	C	2023/03/09	Total Dissolved Solids	mg/L	360
UA	G05	C	2023/05/03	Total Dissolved Solids	mg/L	388
UA	G05	C	2023/09/27	Total Dissolved Solids	mg/L	360
UA	G05	C	2023/10/24	Total Dissolved Solids	mg/L	358
UA	G06	C	2021/03/04	pH (field)	SU	6.7
UA	G06	C	2021/03/24	pH (field)	SU	6.6
UA	G06	C	2021/04/13	pH (field)	SU	6.6
UA	G06	C	2021/05/11	pH (field)	SU	6.4
UA	G06	C	2021/06/01	pH (field)	SU	6.6
UA	G06	C	2021/06/15	pH (field)	SU	6.5
UA	G06	C	2021/07/06	pH (field)	SU	6.3
UA	G06	C	2021/07/20	pH (field)	SU	6.4
UA	G06	C	2023/03/09	pH (field)	SU	6.6
UA	G06	C	2023/05/03	pH (field)	SU	6.6
UA	G06	C	2023/09/27	pH (field)	SU	6.6
UA	G06	C	2023/10/24	pH (field)	SU	6.6
UA	G06	C	2021/03/04	Oxidation Reduction Potential	mV	92.0
UA	G06	C	2021/03/24	Oxidation Reduction Potential	mV	313
UA	G06	C	2021/04/13	Oxidation Reduction Potential	mV	130
UA	G06	C	2021/05/11	Oxidation Reduction Potential	mV	140
UA	G06	C	2021/06/01	Oxidation Reduction Potential	mV	122
UA	G06	C	2021/06/15	Oxidation Reduction Potential	mV	94.0
UA	G06	C	2021/07/06	Oxidation Reduction Potential	mV	101
UA	G06	C	2021/07/20	Oxidation Reduction Potential	mV	122
UA	G06	C	2023/03/09	Oxidation Reduction Potential	mV	88.8
UA	G06	C	2023/05/03	Oxidation Reduction Potential	mV	141
UA	G06	C	2023/09/27	Oxidation Reduction Potential	mV	14.0
UA	G06	C	2023/10/24	Oxidation Reduction Potential	mV	116
UA	G06	C	2021/03/04	Eh	V	0.29
UA	G06	C	2021/03/24	Eh	V	0.51
UA	G06	C	2021/04/13	Eh	V	0.33
UA	G06	C	2021/05/11	Eh	V	0.34
UA	G06	C	2021/06/01	Eh	V	0.32
UA	G06	C	2021/06/15	Eh	V	0.29
UA	G06	C	2021/07/06	Eh	V	0.30
UA	G06	C	2021/07/20	Eh	V	0.32
UA	G06	C	2023/03/09	Eh	V	0.28
UA	G06	C	2023/05/03	Eh	V	0.34
UA	G06	C	2023/09/27	Eh	V	0.21
UA	G06	C	2023/10/24	Eh	V	0.31
UA	G06	C	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	163
UA	G06	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	168
UA	G06	C	2021/04/13	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G06	C	2021/05/11	Alkalinity, bicarbonate	mg/L CaCO3	156
UA	G06	C	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	167
UA	G06	C	2021/06/15	Alkalinity, bicarbonate	mg/L CaCO3	170
UA	G06	C	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	163
UA	G06	C	2021/07/20	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G06	C	2022/07/23	Alkalinity, bicarbonate	mg/L CaCO3	164
UA	G06	C	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	161
UA	G06	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	166
UA	G06	C	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G06	C	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	168
UA	G06	C	2021/03/04	Barium, total	mg/L	0.0484
UA	G06	C	2021/03/24	Barium, total	mg/L	0.0490

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G06	C	2021/04/13	Barium, total	mg/L	0.0382
UA	G06	C	2021/05/11	Barium, total	mg/L	0.0311
UA	G06	C	2021/06/01	Barium, total	mg/L	0.0323
UA	G06	C	2021/06/15	Barium, total	mg/L	0.0280
UA	G06	C	2021/07/06	Barium, total	mg/L	0.0272
UA	G06	C	2021/07/20	Barium, total	mg/L	0.0244
UA	G06	C	2022/07/23	Barium, total	mg/L	0.0342
UA	G06	C	2023/03/09	Barium, total	mg/L	0.0257
UA	G06	C	2023/05/03	Barium, total	mg/L	0.0454
UA	G06	C	2023/09/27	Barium, total	mg/L	0.0251
UA	G06	C	2023/10/24	Barium, total	mg/L	0.0363
UA	G06	C	2021/03/04	Boron, total	mg/L	2.90
UA	G06	C	2021/03/24	Boron, total	mg/L	3.40
UA	G06	C	2021/04/13	Boron, total	mg/L	3.27
UA	G06	C	2021/05/11	Boron, total	mg/L	3.37
UA	G06	C	2021/06/01	Boron, total	mg/L	3.56
UA	G06	C	2021/06/15	Boron, total	mg/L	2.97
UA	G06	C	2021/07/06	Boron, total	mg/L	3.93
UA	G06	C	2021/07/20	Boron, total	mg/L	3.41
UA	G06	C	2022/07/23	Boron, total	mg/L	3.29
UA	G06	C	2023/03/09	Boron, total	mg/L	2.95
UA	G06	C	2023/05/03	Boron, total	mg/L	3.28
UA	G06	C	2023/09/27	Boron, total	mg/L	3.29
UA	G06	C	2023/10/24	Boron, total	mg/L	3.73
UA	G06	C	2021/03/04	Calcium, total	mg/L	90.2
UA	G06	C	2021/03/24	Calcium, total	mg/L	90.1
UA	G06	C	2021/04/13	Calcium, total	mg/L	124
UA	G06	C	2021/05/11	Calcium, total	mg/L	93.4
UA	G06	C	2021/06/01	Calcium, total	mg/L	92.6
UA	G06	C	2021/06/15	Calcium, total	mg/L	91.5
UA	G06	C	2021/07/06	Calcium, total	mg/L	86.7
UA	G06	C	2021/07/20	Calcium, total	mg/L	90.6
UA	G06	C	2022/07/23	Calcium, total	mg/L	89.9
UA	G06	C	2023/03/09	Calcium, total	mg/L	87.6
UA	G06	C	2023/05/03	Calcium, total	mg/L	92.5
UA	G06	C	2023/09/27	Calcium, total	mg/L	84.9
UA	G06	C	2023/10/24	Calcium, total	mg/L	82.5
UA	G06	C	2021/03/04	Chloride, total	mg/L	22.0
UA	G06	C	2021/03/24	Chloride, total	mg/L	23.0
UA	G06	C	2021/04/13	Chloride, total	mg/L	22.0
UA	G06	C	2021/05/11	Chloride, total	mg/L	22.0
UA	G06	C	2021/06/01	Chloride, total	mg/L	22.0
UA	G06	C	2021/06/15	Chloride, total	mg/L	21.0
UA	G06	C	2021/07/06	Chloride, total	mg/L	22.0
UA	G06	C	2021/07/20	Chloride, total	mg/L	21.0
UA	G06	C	2022/07/23	Chloride, total	mg/L	25.0
UA	G06	C	2023/03/09	Chloride, total	mg/L	21.0
UA	G06	C	2023/05/03	Chloride, total	mg/L	22.0
UA	G06	C	2023/09/27	Chloride, total	mg/L	21.0
UA	G06	C	2023/10/24	Chloride, total	mg/L	22.0
UA	G06	C	2021/03/04	Cobalt, total	mg/L	0.00260
UA	G06	C	2021/03/24	Cobalt, total	mg/L	0.00340
UA	G06	C	2021/04/13	Cobalt, total	mg/L	0.00210
UA	G06	C	2021/05/11	Cobalt, total	mg/L	<0.001
UA	G06	C	2021/06/01	Cobalt, total	mg/L	<0.0001

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G06	C	2021/06/15	Cobalt, total	mg/L	<0.0001
UA	G06	C	2021/07/06	Cobalt, total	mg/L	<0.0001
UA	G06	C	2021/07/20	Cobalt, total	mg/L	<0.0001
UA	G06	C	2022/07/23	Cobalt, total	mg/L	0.00160
UA	G06	C	2023/03/09	Cobalt, total	mg/L	0.000600
UA	G06	C	2023/05/03	Cobalt, total	mg/L	0.00400
UA	G06	C	2023/09/27	Cobalt, total	mg/L	0.000800
UA	G06	C	2023/10/24	Cobalt, total	mg/L	<0.0001
UA	G06	C	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G06	C	2023/09/27	Iron, dissolved	mg/L	0.0452
UA	G06	C	2021/03/04	Magnesium, total	mg/L	25.1
UA	G06	C	2021/03/24	Magnesium, total	mg/L	26.6
UA	G06	C	2021/04/13	Magnesium, total	mg/L	26.0
UA	G06	C	2021/05/11	Magnesium, total	mg/L	26.8
UA	G06	C	2021/06/01	Magnesium, total	mg/L	25.3
UA	G06	C	2021/06/15	Magnesium, total	mg/L	25.2
UA	G06	C	2021/07/06	Magnesium, total	mg/L	23.7
UA	G06	C	2021/07/20	Magnesium, total	mg/L	24.4
UA	G06	C	2022/07/23	Magnesium, total	mg/L	24.5
UA	G06	C	2023/03/09	Magnesium, total	mg/L	24.1
UA	G06	C	2023/05/03	Magnesium, total	mg/L	24.4
UA	G06	C	2023/09/27	Magnesium, total	mg/L	24.2
UA	G06	C	2023/10/24	Magnesium, total	mg/L	22.9
UA	G06	C	2023/05/03	Manganese, dissolved	mg/L	0.0155
UA	G06	C	2023/09/27	Manganese, dissolved	mg/L	0.0127
UA	G06	C	2023/05/03	Phosphate, dissolved	mg/L	0.0640
UA	G06	C	2023/09/27	Phosphate, dissolved	mg/L	0.0550
UA	G06	C	2021/03/04	Potassium, total	mg/L	2.48
UA	G06	C	2021/03/24	Potassium, total	mg/L	2.60
UA	G06	C	2021/04/13	Potassium, total	mg/L	2.48
UA	G06	C	2021/05/11	Potassium, total	mg/L	2.50
UA	G06	C	2021/06/01	Potassium, total	mg/L	2.50
UA	G06	C	2021/06/15	Potassium, total	mg/L	2.57
UA	G06	C	2021/07/06	Potassium, total	mg/L	2.57
UA	G06	C	2021/07/20	Potassium, total	mg/L	2.37
UA	G06	C	2022/07/23	Potassium, total	mg/L	2.43
UA	G06	C	2023/03/09	Potassium, total	mg/L	2.20
UA	G06	C	2023/05/03	Potassium, total	mg/L	2.49
UA	G06	C	2023/09/27	Potassium, total	mg/L	2.43
UA	G06	C	2023/10/24	Potassium, total	mg/L	2.42
UA	G06	C	2023/05/03	Silicon, dissolved	mg/L	6.48
UA	G06	C	2023/09/27	Silicon, dissolved	mg/L	6.24
UA	G06	C	2021/03/04	Sodium, total	mg/L	49.8
UA	G06	C	2021/03/24	Sodium, total	mg/L	50.9
UA	G06	C	2021/04/13	Sodium, total	mg/L	65.6
UA	G06	C	2021/05/11	Sodium, total	mg/L	52.8
UA	G06	C	2021/06/01	Sodium, total	mg/L	46.4
UA	G06	C	2021/06/15	Sodium, total	mg/L	50.7
UA	G06	C	2021/07/06	Sodium, total	mg/L	50.0
UA	G06	C	2021/07/20	Sodium, total	mg/L	47.0
UA	G06	C	2022/07/23	Sodium, total	mg/L	45.3
UA	G06	C	2023/03/09	Sodium, total	mg/L	42.1
UA	G06	C	2023/05/03	Sodium, total	mg/L	49.7
UA	G06	C	2023/09/27	Sodium, total	mg/L	45.6
UA	G06	C	2023/10/24	Sodium, total	mg/L	44.6

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G06	C	2021/03/04	Sulfate, total	mg/L	250
UA	G06	C	2021/03/24	Sulfate, total	mg/L	215
UA	G06	C	2021/04/13	Sulfate, total	mg/L	229
UA	G06	C	2021/05/11	Sulfate, total	mg/L	219
UA	G06	C	2021/06/01	Sulfate, total	mg/L	216
UA	G06	C	2021/06/15	Sulfate, total	mg/L	230
UA	G06	C	2021/07/06	Sulfate, total	mg/L	223
UA	G06	C	2021/07/20	Sulfate, total	mg/L	213
UA	G06	C	2022/07/23	Sulfate, total	mg/L	216
UA	G06	C	2023/03/09	Sulfate, total	mg/L	221
UA	G06	C	2023/05/03	Sulfate, total	mg/L	208
UA	G06	C	2023/09/27	Sulfate, total	mg/L	187
UA	G06	C	2023/10/24	Sulfate, total	mg/L	196
UA	G06	C	2021/03/04	Temperature (Celsius)	degrees C	14.9
UA	G06	C	2021/03/24	Temperature (Celsius)	degrees C	16.0
UA	G06	C	2021/04/13	Temperature (Celsius)	degrees C	15.1
UA	G06	C	2021/05/11	Temperature (Celsius)	degrees C	15.0
UA	G06	C	2021/06/01	Temperature (Celsius)	degrees C	15.0
UA	G06	C	2021/06/15	Temperature (Celsius)	degrees C	15.1
UA	G06	C	2021/07/06	Temperature (Celsius)	degrees C	15.4
UA	G06	C	2021/07/20	Temperature (Celsius)	degrees C	15.4
UA	G06	C	2023/03/09	Temperature (Celsius)	degrees C	14.8
UA	G06	C	2023/05/03	Temperature (Celsius)	degrees C	15.7
UA	G06	C	2023/09/27	Temperature (Celsius)	degrees C	16.2
UA	G06	C	2023/10/24	Temperature (Celsius)	degrees C	15.7
UA	G06	C	2021/03/04	Total Dissolved Solids	mg/L	546
UA	G06	C	2021/03/24	Total Dissolved Solids	mg/L	536
UA	G06	C	2021/04/13	Total Dissolved Solids	mg/L	534
UA	G06	C	2021/05/11	Total Dissolved Solids	mg/L	500
UA	G06	C	2021/06/01	Total Dissolved Solids	mg/L	546
UA	G06	C	2021/06/15	Total Dissolved Solids	mg/L	542
UA	G06	C	2021/07/06	Total Dissolved Solids	mg/L	500
UA	G06	C	2021/07/20	Total Dissolved Solids	mg/L	548
UA	G06	C	2022/07/23	Total Dissolved Solids	mg/L	518
UA	G06	C	2023/03/09	Total Dissolved Solids	mg/L	502
UA	G06	C	2023/05/03	Total Dissolved Solids	mg/L	525
UA	G06	C	2023/09/27	Total Dissolved Solids	mg/L	486
UA	G06	C	2023/10/24	Total Dissolved Solids	mg/L	474
UA	G07	C	2021/03/04	pH (field)	SU	6.5
UA	G07	C	2021/03/24	pH (field)	SU	6.4
UA	G07	C	2021/04/13	pH (field)	SU	6.3
UA	G07	C	2021/05/11	pH (field)	SU	6.3
UA	G07	C	2021/06/01	pH (field)	SU	6.2
UA	G07	C	2021/06/15	pH (field)	SU	6.2
UA	G07	C	2021/07/06	pH (field)	SU	6.0
UA	G07	C	2021/07/20	pH (field)	SU	6.1
UA	G07	C	2022/07/23	pH (field)	SU	7.1
UA	G07	C	2023/03/09	pH (field)	SU	6.4
UA	G07	C	2023/05/03	pH (field)	SU	6.4
UA	G07	C	2023/09/27	pH (field)	SU	6.4
UA	G07	C	2023/10/24	pH (field)	SU	6.4
UA	G07	C	2021/03/04	Oxidation Reduction Potential	mV	80.0
UA	G07	C	2021/03/24	Oxidation Reduction Potential	mV	192
UA	G07	C	2021/04/13	Oxidation Reduction Potential	mV	163
UA	G07	C	2021/05/11	Oxidation Reduction Potential	mV	120

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G07	C	2021/06/01	Oxidation Reduction Potential	mV	37.0
UA	G07	C	2021/06/15	Oxidation Reduction Potential	mV	76.0
UA	G07	C	2021/07/06	Oxidation Reduction Potential	mV	141
UA	G07	C	2021/07/20	Oxidation Reduction Potential	mV	145
UA	G07	C	2022/07/23	Oxidation Reduction Potential	mV	52.3
UA	G07	C	2023/03/09	Oxidation Reduction Potential	mV	112
UA	G07	C	2023/05/03	Oxidation Reduction Potential	mV	161
UA	G07	C	2023/09/27	Oxidation Reduction Potential	mV	31.0
UA	G07	C	2023/10/24	Oxidation Reduction Potential	mV	131
UA	G07	C	2021/03/04	Eh	V	0.28
UA	G07	C	2021/03/24	Eh	V	0.39
UA	G07	C	2021/04/13	Eh	V	0.36
UA	G07	C	2021/05/11	Eh	V	0.32
UA	G07	C	2021/06/01	Eh	V	0.23
UA	G07	C	2021/06/15	Eh	V	0.27
UA	G07	C	2021/07/06	Eh	V	0.34
UA	G07	C	2021/07/20	Eh	V	0.34
UA	G07	C	2022/07/23	Eh	V	0.25
UA	G07	C	2023/03/09	Eh	V	0.31
UA	G07	C	2023/05/03	Eh	V	0.36
UA	G07	C	2023/09/27	Eh	V	0.23
UA	G07	C	2023/10/24	Eh	V	0.33
UA	G07	C	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	169
UA	G07	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	171
UA	G07	C	2021/04/13	Alkalinity, bicarbonate	mg/L CaCO3	164
UA	G07	C	2021/05/11	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G07	C	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G07	C	2021/06/15	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G07	C	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	166
UA	G07	C	2021/07/20	Alkalinity, bicarbonate	mg/L CaCO3	166
UA	G07	C	2022/07/23	Alkalinity, bicarbonate	mg/L CaCO3	169
UA	G07	C	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G07	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	171
UA	G07	C	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G07	C	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	164
UA	G07	C	2021/03/04	Barium, total	mg/L	0.0958
UA	G07	C	2021/03/24	Barium, total	mg/L	0.0643
UA	G07	C	2021/04/13	Barium, total	mg/L	0.0497
UA	G07	C	2021/05/11	Barium, total	mg/L	0.0448
UA	G07	C	2021/06/01	Barium, total	mg/L	0.0540
UA	G07	C	2021/06/15	Barium, total	mg/L	0.0429
UA	G07	C	2021/07/06	Barium, total	mg/L	0.0373
UA	G07	C	2021/07/20	Barium, total	mg/L	0.0470
UA	G07	C	2022/07/23	Barium, total	mg/L	0.178
UA	G07	C	2023/03/09	Barium, total	mg/L	0.0879
UA	G07	C	2023/05/03	Barium, total	mg/L	0.215
UA	G07	C	2023/09/27	Barium, total	mg/L	0.0366
UA	G07	C	2023/10/24	Barium, total	mg/L	0.0429
UA	G07	C	2021/03/04	Boron, total	mg/L	4.37
UA	G07	C	2021/03/24	Boron, total	mg/L	4.67
UA	G07	C	2021/04/13	Boron, total	mg/L	5.04
UA	G07	C	2021/05/11	Boron, total	mg/L	4.55
UA	G07	C	2021/06/01	Boron, total	mg/L	5.23
UA	G07	C	2021/06/15	Boron, total	mg/L	3.91
UA	G07	C	2021/07/06	Boron, total	mg/L	4.95

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G07	C	2021/07/20	Boron, total	mg/L	4.48
UA	G07	C	2022/07/23	Boron, total	mg/L	4.35
UA	G07	C	2023/03/09	Boron, total	mg/L	4.55
UA	G07	C	2023/05/03	Boron, total	mg/L	4.27
UA	G07	C	2023/09/27	Boron, total	mg/L	5.80
UA	G07	C	2023/10/24	Boron, total	mg/L	5.05
UA	G07	C	2021/03/04	Calcium, total	mg/L	93.9
UA	G07	C	2021/03/24	Calcium, total	mg/L	92.8
UA	G07	C	2021/04/13	Calcium, total	mg/L	126
UA	G07	C	2021/05/11	Calcium, total	mg/L	90.4
UA	G07	C	2021/06/01	Calcium, total	mg/L	96.6
UA	G07	C	2021/06/15	Calcium, total	mg/L	89.3
UA	G07	C	2021/07/06	Calcium, total	mg/L	84.8
UA	G07	C	2021/07/20	Calcium, total	mg/L	96.5
UA	G07	C	2022/07/23	Calcium, total	mg/L	91.9
UA	G07	C	2023/03/09	Calcium, total	mg/L	97.4
UA	G07	C	2023/05/03	Calcium, total	mg/L	97.3
UA	G07	C	2023/09/27	Calcium, total	mg/L	97.1
UA	G07	C	2023/10/24	Calcium, total	mg/L	95.7
UA	G07	C	2021/03/04	Chloride, total	mg/L	21.0
UA	G07	C	2021/03/24	Chloride, total	mg/L	21.0
UA	G07	C	2021/04/13	Chloride, total	mg/L	20.0
UA	G07	C	2021/05/11	Chloride, total	mg/L	19.0
UA	G07	C	2021/06/01	Chloride, total	mg/L	22.0
UA	G07	C	2021/06/15	Chloride, total	mg/L	20.0
UA	G07	C	2021/07/06	Chloride, total	mg/L	21.0
UA	G07	C	2021/07/20	Chloride, total	mg/L	21.0
UA	G07	C	2022/07/23	Chloride, total	mg/L	24.0
UA	G07	C	2023/03/09	Chloride, total	mg/L	23.0
UA	G07	C	2023/05/03	Chloride, total	mg/L	22.0
UA	G07	C	2023/09/27	Chloride, total	mg/L	21.0
UA	G07	C	2023/10/24	Chloride, total	mg/L	21.0
UA	G07	C	2021/03/04	Cobalt, total	mg/L	0.00620
UA	G07	C	2021/03/24	Cobalt, total	mg/L	0.00350
UA	G07	C	2021/04/13	Cobalt, total	mg/L	0.00240
UA	G07	C	2021/05/11	Cobalt, total	mg/L	0.00185
UA	G07	C	2021/06/01	Cobalt, total	mg/L	0.00230
UA	G07	C	2021/06/15	Cobalt, total	mg/L	0.00130
UA	G07	C	2021/07/06	Cobalt, total	mg/L	0.00120
UA	G07	C	2021/07/20	Cobalt, total	mg/L	0.00140
UA	G07	C	2022/07/23	Cobalt, total	mg/L	0.00450
UA	G07	C	2023/03/09	Cobalt, total	mg/L	0.00290
UA	G07	C	2023/05/03	Cobalt, total	mg/L	0.00780
UA	G07	C	2023/09/27	Cobalt, total	mg/L	0.00110
UA	G07	C	2023/10/24	Cobalt, total	mg/L	<0.0001
UA	G07	C	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G07	C	2023/09/27	Iron, dissolved	mg/L	0.177
UA	G07	C	2021/03/04	Magnesium, total	mg/L	22.9
UA	G07	C	2021/03/24	Magnesium, total	mg/L	24.2
UA	G07	C	2021/04/13	Magnesium, total	mg/L	24.4
UA	G07	C	2021/05/11	Magnesium, total	mg/L	22.9
UA	G07	C	2021/06/01	Magnesium, total	mg/L	22.9
UA	G07	C	2021/06/15	Magnesium, total	mg/L	21.8
UA	G07	C	2021/07/06	Magnesium, total	mg/L	20.5
UA	G07	C	2021/07/20	Magnesium, total	mg/L	23.0

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G07	C	2022/07/23	Magnesium, total	mg/L	23.2
UA	G07	C	2023/03/09	Magnesium, total	mg/L	24.3
UA	G07	C	2023/05/03	Magnesium, total	mg/L	23.4
UA	G07	C	2023/09/27	Magnesium, total	mg/L	24.8
UA	G07	C	2023/10/24	Magnesium, total	mg/L	23.7
UA	G07	C	2023/05/03	Manganese, dissolved	mg/L	1.85
UA	G07	C	2023/09/27	Manganese, dissolved	mg/L	3.10
UA	G07	C	2023/05/03	Phosphate, dissolved	mg/L	0.0430
UA	G07	C	2023/09/27	Phosphate, dissolved	mg/L	0.0460
UA	G07	C	2021/03/04	Potassium, total	mg/L	4.08
UA	G07	C	2021/03/24	Potassium, total	mg/L	3.87
UA	G07	C	2021/04/13	Potassium, total	mg/L	3.98
UA	G07	C	2021/05/11	Potassium, total	mg/L	3.90
UA	G07	C	2021/06/01	Potassium, total	mg/L	4.32
UA	G07	C	2021/06/15	Potassium, total	mg/L	3.97
UA	G07	C	2021/07/06	Potassium, total	mg/L	3.87
UA	G07	C	2021/07/20	Potassium, total	mg/L	4.03
UA	G07	C	2022/07/23	Potassium, total	mg/L	4.45
UA	G07	C	2023/03/09	Potassium, total	mg/L	3.96
UA	G07	C	2023/05/03	Potassium, total	mg/L	4.36
UA	G07	C	2023/09/27	Potassium, total	mg/L	4.10
UA	G07	C	2023/10/24	Potassium, total	mg/L	4.00
UA	G07	C	2023/05/03	Silicon, dissolved	mg/L	9.28
UA	G07	C	2023/09/27	Silicon, dissolved	mg/L	8.30
UA	G07	C	2021/03/04	Sodium, total	mg/L	71.1
UA	G07	C	2021/03/24	Sodium, total	mg/L	71.4
UA	G07	C	2021/04/13	Sodium, total	mg/L	90.4
UA	G07	C	2021/05/11	Sodium, total	mg/L	68.6
UA	G07	C	2021/06/01	Sodium, total	mg/L	67.5
UA	G07	C	2021/06/15	Sodium, total	mg/L	66.7
UA	G07	C	2021/07/06	Sodium, total	mg/L	66.5
UA	G07	C	2021/07/20	Sodium, total	mg/L	67.4
UA	G07	C	2022/07/23	Sodium, total	mg/L	64.8
UA	G07	C	2023/03/09	Sodium, total	mg/L	64.2
UA	G07	C	2023/05/03	Sodium, total	mg/L	69.9
UA	G07	C	2023/09/27	Sodium, total	mg/L	69.0
UA	G07	C	2023/10/24	Sodium, total	mg/L	67.2
UA	G07	C	2021/03/04	Sulfate, total	mg/L	285
UA	G07	C	2021/03/24	Sulfate, total	mg/L	258
UA	G07	C	2021/04/13	Sulfate, total	mg/L	274
UA	G07	C	2021/05/11	Sulfate, total	mg/L	248
UA	G07	C	2021/06/01	Sulfate, total	mg/L	257
UA	G07	C	2021/06/15	Sulfate, total	mg/L	246
UA	G07	C	2021/07/06	Sulfate, total	mg/L	258
UA	G07	C	2021/07/20	Sulfate, total	mg/L	252
UA	G07	C	2022/07/23	Sulfate, total	mg/L	246
UA	G07	C	2023/03/09	Sulfate, total	mg/L	308
UA	G07	C	2023/05/03	Sulfate, total	mg/L	260
UA	G07	C	2023/09/27	Sulfate, total	mg/L	268
UA	G07	C	2023/10/24	Sulfate, total	mg/L	285
UA	G07	C	2021/03/04	Temperature (Celsius)	degrees C	15.3
UA	G07	C	2021/03/24	Temperature (Celsius)	degrees C	15.5
UA	G07	C	2021/04/13	Temperature (Celsius)	degrees C	15.2
UA	G07	C	2021/05/11	Temperature (Celsius)	degrees C	15.1
UA	G07	C	2021/06/01	Temperature (Celsius)	degrees C	15.1

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G07	C	2021/06/15	Temperature (Celsius)	degrees C	15.2
UA	G07	C	2021/07/06	Temperature (Celsius)	degrees C	15.5
UA	G07	C	2021/07/20	Temperature (Celsius)	degrees C	15.3
UA	G07	C	2022/07/23	Temperature (Celsius)	degrees C	16
UA	G07	C	2023/03/09	Temperature (Celsius)	degrees C	15.0
UA	G07	C	2023/05/03	Temperature (Celsius)	degrees C	15.6
UA	G07	C	2023/09/27	Temperature (Celsius)	degrees C	16.0
UA	G07	C	2023/10/24	Temperature (Celsius)	degrees C	15.8
UA	G07	C	2021/03/04	Total Dissolved Solids	mg/L	636
UA	G07	C	2021/03/24	Total Dissolved Solids	mg/L	600
UA	G07	C	2021/04/13	Total Dissolved Solids	mg/L	624
UA	G07	C	2021/05/11	Total Dissolved Solids	mg/L	570
UA	G07	C	2021/06/01	Total Dissolved Solids	mg/L	594
UA	G07	C	2021/06/15	Total Dissolved Solids	mg/L	562
UA	G07	C	2021/07/06	Total Dissolved Solids	mg/L	562
UA	G07	C	2021/07/20	Total Dissolved Solids	mg/L	598
UA	G07	C	2022/07/23	Total Dissolved Solids	mg/L	550
UA	G07	C	2023/03/09	Total Dissolved Solids	mg/L	630
UA	G07	C	2023/05/03	Total Dissolved Solids	mg/L	590
UA	G07	C	2023/09/27	Total Dissolved Solids	mg/L	612
UA	G07	C	2023/10/24	Total Dissolved Solids	mg/L	618
UA	G08	C	2021/03/04	pH (field)	SU	7.0
UA	G08	C	2021/03/24	pH (field)	SU	6.9
UA	G08	C	2021/04/13	pH (field)	SU	7.0
UA	G08	C	2021/05/11	pH (field)	SU	6.9
UA	G08	C	2021/06/01	pH (field)	SU	7.0
UA	G08	C	2021/06/15	pH (field)	SU	6.9
UA	G08	C	2021/07/06	pH (field)	SU	6.8
UA	G08	C	2021/07/20	pH (field)	SU	6.8
UA	G08	C	2022/07/23	pH (field)	SU	7.6
UA	G08	C	2023/03/09	pH (field)	SU	6.8
UA	G08	C	2023/05/03	pH (field)	SU	6.9
UA	G08	C	2023/09/26	pH (field)	SU	7.0
UA	G08	C	2023/10/24	pH (field)	SU	7.0
UA	G08	C	2021/03/04	Oxidation Reduction Potential	mV	-63.0
UA	G08	C	2021/03/24	Oxidation Reduction Potential	mV	-36.0
UA	G08	C	2021/04/13	Oxidation Reduction Potential	mV	-40.0
UA	G08	C	2021/05/11	Oxidation Reduction Potential	mV	-188
UA	G08	C	2021/06/01	Oxidation Reduction Potential	mV	95.0
UA	G08	C	2021/06/15	Oxidation Reduction Potential	mV	-164
UA	G08	C	2021/07/06	Oxidation Reduction Potential	mV	-72.0
UA	G08	C	2021/07/20	Oxidation Reduction Potential	mV	-29.0
UA	G08	C	2022/07/23	Oxidation Reduction Potential	mV	-207
UA	G08	C	2023/03/09	Oxidation Reduction Potential	mV	-51.6
UA	G08	C	2023/05/03	Oxidation Reduction Potential	mV	130
UA	G08	C	2023/09/26	Oxidation Reduction Potential	mV	-92.0
UA	G08	C	2023/10/24	Oxidation Reduction Potential	mV	29.0
UA	G08	C	2021/03/04	Eh	V	0.13
UA	G08	C	2021/03/24	Eh	V	0.16
UA	G08	C	2021/04/13	Eh	V	0.15
UA	G08	C	2021/05/11	Eh	V	0.0065
UA	G08	C	2021/06/01	Eh	V	0.29
UA	G08	C	2021/06/15	Eh	V	0.031
UA	G08	C	2021/07/06	Eh	V	0.12
UA	G08	C	2021/07/20	Eh	V	0.17

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G08	C	2022/07/23	Eh	V	-0.012
UA	G08	C	2023/03/09	Eh	V	0.14
UA	G08	C	2023/05/03	Eh	V	0.32
UA	G08	C	2023/09/26	Eh	V	0.10
UA	G08	C	2023/10/24	Eh	V	0.22
UA	G08	C	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	213
UA	G08	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	190
UA	G08	C	2021/04/13	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G08	C	2021/05/11	Alkalinity, bicarbonate	mg/L CaCO3	185
UA	G08	C	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	201
UA	G08	C	2021/06/15	Alkalinity, bicarbonate	mg/L CaCO3	198
UA	G08	C	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	190
UA	G08	C	2021/07/20	Alkalinity, bicarbonate	mg/L CaCO3	187
UA	G08	C	2022/07/23	Alkalinity, bicarbonate	mg/L CaCO3	191
UA	G08	C	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	174
UA	G08	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	154
UA	G08	C	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	178
UA	G08	C	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	147
UA	G08	C	2021/03/04	Barium, total	mg/L	0.166
UA	G08	C	2021/03/24	Barium, total	mg/L	0.0946
UA	G08	C	2021/04/13	Barium, total	mg/L	0.0772
UA	G08	C	2021/05/11	Barium, total	mg/L	0.0685
UA	G08	C	2021/06/01	Barium, total	mg/L	0.0588
UA	G08	C	2021/06/15	Barium, total	mg/L	0.0608
UA	G08	C	2021/07/06	Barium, total	mg/L	0.0575
UA	G08	C	2021/07/20	Barium, total	mg/L	0.0635
UA	G08	C	2022/07/23	Barium, total	mg/L	0.0387
UA	G08	C	2023/03/09	Barium, total	mg/L	0.0495
UA	G08	C	2023/05/03	Barium, total	mg/L	0.0974
UA	G08	C	2023/09/26	Barium, total	mg/L	0.0333
UA	G08	C	2023/10/24	Barium, total	mg/L	0.105
UA	G08	C	2021/03/04	Boron, total	mg/L	4.53
UA	G08	C	2021/03/24	Boron, total	mg/L	4.39
UA	G08	C	2021/04/13	Boron, total	mg/L	5.25
UA	G08	C	2021/05/11	Boron, total	mg/L	3.77
UA	G08	C	2021/06/01	Boron, total	mg/L	4.63
UA	G08	C	2021/06/15	Boron, total	mg/L	3.97
UA	G08	C	2021/07/06	Boron, total	mg/L	4.56
UA	G08	C	2021/07/20	Boron, total	mg/L	3.98
UA	G08	C	2022/07/23	Boron, total	mg/L	4.74
UA	G08	C	2023/03/09	Boron, total	mg/L	4.33
UA	G08	C	2023/05/03	Boron, total	mg/L	5.43
UA	G08	C	2023/09/26	Boron, total	mg/L	6.30
UA	G08	C	2023/10/24	Boron, total	mg/L	5.28
UA	G08	C	2021/03/04	Calcium, total	mg/L	111
UA	G08	C	2021/03/24	Calcium, total	mg/L	115
UA	G08	C	2021/04/13	Calcium, total	mg/L	142
UA	G08	C	2021/05/11	Calcium, total	mg/L	101
UA	G08	C	2021/06/01	Calcium, total	mg/L	114
UA	G08	C	2021/06/15	Calcium, total	mg/L	111
UA	G08	C	2021/07/06	Calcium, total	mg/L	109
UA	G08	C	2021/07/20	Calcium, total	mg/L	116
UA	G08	C	2022/07/23	Calcium, total	mg/L	118
UA	G08	C	2023/03/09	Calcium, total	mg/L	119
UA	G08	C	2023/05/03	Calcium, total	mg/L	140

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G08	C	2023/09/26	Calcium, total	mg/L	132
UA	G08	C	2023/10/24	Calcium, total	mg/L	140
UA	G08	C	2021/03/04	Chloride, total	mg/L	14.0
UA	G08	C	2021/03/24	Chloride, total	mg/L	16.0
UA	G08	C	2021/04/13	Chloride, total	mg/L	15.0
UA	G08	C	2021/05/11	Chloride, total	mg/L	12.0
UA	G08	C	2021/06/01	Chloride, total	mg/L	15.0
UA	G08	C	2021/06/15	Chloride, total	mg/L	15.0
UA	G08	C	2021/07/06	Chloride, total	mg/L	16.0
UA	G08	C	2021/07/20	Chloride, total	mg/L	16.0
UA	G08	C	2022/07/23	Chloride, total	mg/L	16.0
UA	G08	C	2023/03/09	Chloride, total	mg/L	15.0
UA	G08	C	2023/05/03	Chloride, total	mg/L	16.0
UA	G08	C	2023/09/26	Chloride, total	mg/L	14.0
UA	G08	C	2023/10/24	Chloride, total	mg/L	17.0
UA	G08	C	2021/03/04	Cobalt, total	mg/L	0.0103
UA	G08	C	2021/03/24	Cobalt, total	mg/L	0.00640
UA	G08	C	2021/04/13	Cobalt, total	mg/L	0.00410
UA	G08	C	2021/05/11	Cobalt, total	mg/L	0.00220
UA	G08	C	2021/06/01	Cobalt, total	mg/L	0.00410
UA	G08	C	2021/06/15	Cobalt, total	mg/L	0.00290
UA	G08	C	2021/07/06	Cobalt, total	mg/L	0.00400
UA	G08	C	2021/07/20	Cobalt, total	mg/L	0.00450
UA	G08	C	2022/07/23	Cobalt, total	mg/L	0.00280
UA	G08	C	2023/03/09	Cobalt, total	mg/L	0.00360
UA	G08	C	2023/05/03	Cobalt, total	mg/L	0.0113
UA	G08	C	2023/09/26	Cobalt, total	mg/L	0.00370
UA	G08	C	2023/10/24	Cobalt, total	mg/L	0.00660
UA	G08	C	2023/05/03	Iron, dissolved	mg/L	1.07
UA	G08	C	2023/09/26	Iron, dissolved	mg/L	0.751
UA	G08	C	2021/03/04	Magnesium, total	mg/L	27.2
UA	G08	C	2021/03/24	Magnesium, total	mg/L	29.0
UA	G08	C	2021/04/13	Magnesium, total	mg/L	31.9
UA	G08	C	2021/05/11	Magnesium, total	mg/L	25.4
UA	G08	C	2021/06/01	Magnesium, total	mg/L	27.2
UA	G08	C	2021/06/15	Magnesium, total	mg/L	27.2
UA	G08	C	2021/07/06	Magnesium, total	mg/L	26.2
UA	G08	C	2021/07/20	Magnesium, total	mg/L	27.1
UA	G08	C	2022/07/23	Magnesium, total	mg/L	29.0
UA	G08	C	2023/03/09	Magnesium, total	mg/L	28.9
UA	G08	C	2023/05/03	Magnesium, total	mg/L	32.2
UA	G08	C	2023/09/26	Magnesium, total	mg/L	32.9
UA	G08	C	2023/10/24	Magnesium, total	mg/L	34.2
UA	G08	C	2023/05/03	Manganese, dissolved	mg/L	1.84
UA	G08	C	2023/09/26	Manganese, dissolved	mg/L	2.25
UA	G08	C	2023/05/03	Phosphate, dissolved	mg/L	0.0860
UA	G08	C	2023/09/26	Phosphate, dissolved	mg/L	0.0340
UA	G08	C	2021/03/04	Potassium, total	mg/L	1.70
UA	G08	C	2021/03/24	Potassium, total	mg/L	1.67
UA	G08	C	2021/04/13	Potassium, total	mg/L	1.60
UA	G08	C	2021/05/11	Potassium, total	mg/L	1.45
UA	G08	C	2021/06/01	Potassium, total	mg/L	1.48
UA	G08	C	2021/06/15	Potassium, total	mg/L	1.53
UA	G08	C	2021/07/06	Potassium, total	mg/L	1.62
UA	G08	C	2021/07/20	Potassium, total	mg/L	1.44

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G08	C	2022/07/23	Potassium, total	mg/L	1.46
UA	G08	C	2023/03/09	Potassium, total	mg/L	1.47
UA	G08	C	2023/05/03	Potassium, total	mg/L	1.67
UA	G08	C	2023/09/26	Potassium, total	mg/L	1.62
UA	G08	C	2023/10/24	Potassium, total	mg/L	1.98
UA	G08	C	2023/05/03	Silicon, dissolved	mg/L	6.19
UA	G08	C	2023/09/26	Silicon, dissolved	mg/L	6.01
UA	G08	C	2021/03/04	Sodium, total	mg/L	29.3
UA	G08	C	2021/03/24	Sodium, total	mg/L	30.2
UA	G08	C	2021/04/13	Sodium, total	mg/L	33.6
UA	G08	C	2021/05/11	Sodium, total	mg/L	24.3
UA	G08	C	2021/06/01	Sodium, total	mg/L	25.4
UA	G08	C	2021/06/15	Sodium, total	mg/L	27.3
UA	G08	C	2021/07/06	Sodium, total	mg/L	26.9
UA	G08	C	2021/07/20	Sodium, total	mg/L	24.0
UA	G08	C	2022/07/23	Sodium, total	mg/L	30.5
UA	G08	C	2023/03/09	Sodium, total	mg/L	28.5
UA	G08	C	2023/05/03	Sodium, total	mg/L	41.7
UA	G08	C	2023/09/26	Sodium, total	mg/L	38.4
UA	G08	C	2023/10/24	Sodium, total	mg/L	44.3
UA	G08	C	2021/03/04	Sulfate, total	mg/L	241
UA	G08	C	2021/03/24	Sulfate, total	mg/L	225
UA	G08	C	2021/04/13	Sulfate, total	mg/L	286
UA	G08	C	2021/05/11	Sulfate, total	mg/L	203
UA	G08	C	2021/06/01	Sulfate, total	mg/L	204
UA	G08	C	2021/06/15	Sulfate, total	mg/L	226
UA	G08	C	2021/07/06	Sulfate, total	mg/L	227
UA	G08	C	2021/07/20	Sulfate, total	mg/L	227
UA	G08	C	2022/07/23	Sulfate, total	mg/L	229
UA	G08	C	2023/03/09	Sulfate, total	mg/L	297
UA	G08	C	2023/05/03	Sulfate, total	mg/L	363
UA	G08	C	2023/09/26	Sulfate, total	mg/L	320
UA	G08	C	2023/10/24	Sulfate, total	mg/L	389
UA	G08	C	2021/03/04	Temperature (Celsius)	degrees C	15.6
UA	G08	C	2021/03/24	Temperature (Celsius)	degrees C	16.6
UA	G08	C	2021/04/13	Temperature (Celsius)	degrees C	16.3
UA	G08	C	2021/05/11	Temperature (Celsius)	degrees C	16.4
UA	G08	C	2021/06/01	Temperature (Celsius)	degrees C	16.0
UA	G08	C	2021/06/15	Temperature (Celsius)	degrees C	16.1
UA	G08	C	2021/07/06	Temperature (Celsius)	degrees C	16.6
UA	G08	C	2021/07/20	Temperature (Celsius)	degrees C	16.3
UA	G08	C	2022/07/23	Temperature (Celsius)	degrees C	16.7
UA	G08	C	2023/03/09	Temperature (Celsius)	degrees C	15.4
UA	G08	C	2023/05/03	Temperature (Celsius)	degrees C	17.3
UA	G08	C	2023/09/26	Temperature (Celsius)	degrees C	17.3
UA	G08	C	2023/10/24	Temperature (Celsius)	degrees C	18.2
UA	G08	C	2021/03/04	Total Dissolved Solids	mg/L	604
UA	G08	C	2021/03/24	Total Dissolved Solids	mg/L	592
UA	G08	C	2021/04/13	Total Dissolved Solids	mg/L	620
UA	G08	C	2021/05/11	Total Dissolved Solids	mg/L	508
UA	G08	C	2021/06/01	Total Dissolved Solids	mg/L	568
UA	G08	C	2021/06/15	Total Dissolved Solids	mg/L	540
UA	G08	C	2021/07/06	Total Dissolved Solids	mg/L	548
UA	G08	C	2021/07/20	Total Dissolved Solids	mg/L	556
UA	G08	C	2022/07/23	Total Dissolved Solids	mg/L	584

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G08	C	2023/03/09	Total Dissolved Solids	mg/L	612
UA	G08	C	2023/05/03	Total Dissolved Solids	mg/L	714
UA	G08	C	2023/09/26	Total Dissolved Solids	mg/L	680
UA	G08	C	2023/10/24	Total Dissolved Solids	mg/L	660
UA	G09	C	2021/03/04	pH (field)	SU	6.2
UA	G09	C	2021/03/25	pH (field)	SU	6.3
UA	G09	C	2021/04/14	pH (field)	SU	6.3
UA	G09	C	2021/05/12	pH (field)	SU	6.4
UA	G09	C	2021/06/01	pH (field)	SU	6.2
UA	G09	C	2021/06/15	pH (field)	SU	6.0
UA	G09	C	2021/07/06	pH (field)	SU	6.3
UA	G09	C	2021/07/21	pH (field)	SU	6.0
UA	G09	C	2022/07/24	pH (field)	SU	7.6
UA	G09	C	2023/03/09	pH (field)	SU	6.1
UA	G09	C	2023/05/03	pH (field)	SU	6.4
UA	G09	C	2023/09/26	pH (field)	SU	6.2
UA	G09	C	2023/10/25	pH (field)	SU	6.2
UA	G09	C	2021/03/04	Oxidation Reduction Potential	mV	9.00
UA	G09	C	2021/03/25	Oxidation Reduction Potential	mV	42.0
UA	G09	C	2021/04/14	Oxidation Reduction Potential	mV	-22.0
UA	G09	C	2021/05/12	Oxidation Reduction Potential	mV	-78.0
UA	G09	C	2021/06/01	Oxidation Reduction Potential	mV	-24.0
UA	G09	C	2021/06/15	Oxidation Reduction Potential	mV	-46.0
UA	G09	C	2021/07/06	Oxidation Reduction Potential	mV	-40.0
UA	G09	C	2021/07/21	Oxidation Reduction Potential	mV	-6.00
UA	G09	C	2022/07/24	Oxidation Reduction Potential	mV	-202
UA	G09	C	2023/03/09	Oxidation Reduction Potential	mV	-5.00
UA	G09	C	2023/05/03	Oxidation Reduction Potential	mV	13.0
UA	G09	C	2023/09/26	Oxidation Reduction Potential	mV	33.0
UA	G09	C	2023/10/25	Oxidation Reduction Potential	mV	-3.00
UA	G09	C	2021/03/04	Eh	V	0.20
UA	G09	C	2021/03/25	Eh	V	0.24
UA	G09	C	2021/04/14	Eh	V	0.17
UA	G09	C	2021/05/12	Eh	V	0.12
UA	G09	C	2021/06/01	Eh	V	0.17
UA	G09	C	2021/06/15	Eh	V	0.15
UA	G09	C	2021/07/06	Eh	V	0.15
UA	G09	C	2021/07/21	Eh	V	0.19
UA	G09	C	2022/07/24	Eh	V	-0.0081
UA	G09	C	2023/03/09	Eh	V	0.19
UA	G09	C	2023/05/03	Eh	V	0.21
UA	G09	C	2023/09/26	Eh	V	0.23
UA	G09	C	2023/10/25	Eh	V	0.19
UA	G09	C	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	188
UA	G09	C	2021/03/25	Alkalinity, bicarbonate	mg/L CaCO3	190
UA	G09	C	2021/04/14	Alkalinity, bicarbonate	mg/L CaCO3	180
UA	G09	C	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	165
UA	G09	C	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G09	C	2021/06/15	Alkalinity, bicarbonate	mg/L CaCO3	179
UA	G09	C	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	163
UA	G09	C	2021/07/21	Alkalinity, bicarbonate	mg/L CaCO3	164
UA	G09	C	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	129
UA	G09	C	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	116
UA	G09	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	110
UA	G09	C	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	119

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G09	C	2023/10/25	Alkalinity, bicarbonate	mg/L CaCO3	110
UA	G09	C	2021/03/04	Barium, total	mg/L	0.0675
UA	G09	C	2021/03/25	Barium, total	mg/L	0.0984
UA	G09	C	2021/04/14	Barium, total	mg/L	0.0673
UA	G09	C	2021/05/12	Barium, total	mg/L	0.0586
UA	G09	C	2021/06/01	Barium, total	mg/L	0.0548
UA	G09	C	2021/06/15	Barium, total	mg/L	0.0136
UA	G09	C	2021/07/06	Barium, total	mg/L	0.0444
UA	G09	C	2021/07/21	Barium, total	mg/L	0.0454
UA	G09	C	2022/07/24	Barium, total	mg/L	0.0565
UA	G09	C	2023/03/09	Barium, total	mg/L	0.0378
UA	G09	C	2023/05/03	Barium, total	mg/L	0.0560
UA	G09	C	2023/09/26	Barium, total	mg/L	0.0271
UA	G09	C	2023/10/25	Barium, total	mg/L	0.0312
UA	G09	C	2021/03/04	Boron, total	mg/L	3.19
UA	G09	C	2021/03/25	Boron, total	mg/L	3.15
UA	G09	C	2021/04/14	Boron, total	mg/L	3.48
UA	G09	C	2021/05/12	Boron, total	mg/L	3.26
UA	G09	C	2021/06/01	Boron, total	mg/L	3.65
UA	G09	C	2021/06/15	Boron, total	mg/L	0.282
UA	G09	C	2021/07/06	Boron, total	mg/L	4.05
UA	G09	C	2021/07/21	Boron, total	mg/L	3.75
UA	G09	C	2022/07/24	Boron, total	mg/L	3.89
UA	G09	C	2023/03/09	Boron, total	mg/L	3.49
UA	G09	C	2023/05/03	Boron, total	mg/L	3.87
UA	G09	C	2023/09/26	Boron, total	mg/L	4.57
UA	G09	C	2023/10/25	Boron, total	mg/L	3.50
UA	G09	C	2021/03/04	Calcium, total	mg/L	103
UA	G09	C	2021/03/25	Calcium, total	mg/L	95.2
UA	G09	C	2021/04/14	Calcium, total	mg/L	110
UA	G09	C	2021/05/12	Calcium, total	mg/L	87.7
UA	G09	C	2021/06/01	Calcium, total	mg/L	91.3
UA	G09	C	2021/06/15	Calcium, total	mg/L	137
UA	G09	C	2021/07/06	Calcium, total	mg/L	79.0
UA	G09	C	2021/07/21	Calcium, total	mg/L	92.1
UA	G09	C	2022/07/24	Calcium, total	mg/L	80.8
UA	G09	C	2023/03/09	Calcium, total	mg/L	75.5
UA	G09	C	2023/05/03	Calcium, total	mg/L	67.2
UA	G09	C	2023/09/26	Calcium, total	mg/L	64.8
UA	G09	C	2023/10/25	Calcium, total	mg/L	62.3
UA	G09	C	2021/03/04	Chloride, total	mg/L	24.0
UA	G09	C	2021/03/25	Chloride, total	mg/L	29.0
UA	G09	C	2021/04/14	Chloride, total	mg/L	25.0
UA	G09	C	2021/05/12	Chloride, total	mg/L	22.0
UA	G09	C	2021/06/01	Chloride, total	mg/L	23.0
UA	G09	C	2021/06/15	Chloride, total	mg/L	21.0
UA	G09	C	2021/07/06	Chloride, total	mg/L	22.0
UA	G09	C	2021/07/21	Chloride, total	mg/L	21.0
UA	G09	C	2022/07/24	Chloride, total	mg/L	23.0
UA	G09	C	2023/03/09	Chloride, total	mg/L	19.0
UA	G09	C	2023/05/03	Chloride, total	mg/L	20.0
UA	G09	C	2023/09/26	Chloride, total	mg/L	17.0
UA	G09	C	2023/10/25	Chloride, total	mg/L	17.0
UA	G09	C	2021/03/04	Cobalt, total	mg/L	0.0108
UA	G09	C	2021/03/25	Cobalt, total	mg/L	0.0159

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G09	C	2021/04/14	Cobalt, total	mg/L	0.0131
UA	G09	C	2021/05/12	Cobalt, total	mg/L	0.0103
UA	G09	C	2021/06/01	Cobalt, total	mg/L	0.00960
UA	G09	C	2021/06/15	Cobalt, total	mg/L	0.00110
UA	G09	C	2021/07/06	Cobalt, total	mg/L	0.00890
UA	G09	C	2021/07/21	Cobalt, total	mg/L	0.00850
UA	G09	C	2022/07/24	Cobalt, total	mg/L	0.00860
UA	G09	C	2023/03/09	Cobalt, total	mg/L	0.00550
UA	G09	C	2023/05/03	Cobalt, total	mg/L	0.00710
UA	G09	C	2023/09/26	Cobalt, total	mg/L	0.00500
UA	G09	C	2023/10/25	Cobalt, total	mg/L	0.00270
UA	G09	C	2023/05/03	Iron, dissolved	mg/L	2.50
UA	G09	C	2023/09/26	Iron, dissolved	mg/L	1.53
UA	G09	C	2021/03/04	Magnesium, total	mg/L	33.8
UA	G09	C	2021/03/25	Magnesium, total	mg/L	32.0
UA	G09	C	2021/04/14	Magnesium, total	mg/L	33.7
UA	G09	C	2021/05/12	Magnesium, total	mg/L	32.1
UA	G09	C	2021/06/01	Magnesium, total	mg/L	31.4
UA	G09	C	2021/06/15	Magnesium, total	mg/L	49.3
UA	G09	C	2021/07/06	Magnesium, total	mg/L	28.7
UA	G09	C	2021/07/21	Magnesium, total	mg/L	32.0
UA	G09	C	2022/07/24	Magnesium, total	mg/L	30.6
UA	G09	C	2023/03/09	Magnesium, total	mg/L	28.9
UA	G09	C	2023/05/03	Magnesium, total	mg/L	24.7
UA	G09	C	2023/09/26	Magnesium, total	mg/L	26.1
UA	G09	C	2023/10/25	Magnesium, total	mg/L	24.6
UA	G09	C	2023/05/03	Manganese, dissolved	mg/L	1.01
UA	G09	C	2023/09/26	Manganese, dissolved	mg/L	1.01
UA	G09	C	2023/05/03	Phosphate, dissolved	mg/L	0.0490
UA	G09	C	2023/09/26	Phosphate, dissolved	mg/L	0.114
UA	G09	C	2021/03/04	Potassium, total	mg/L	2.78
UA	G09	C	2021/03/25	Potassium, total	mg/L	2.67
UA	G09	C	2021/04/14	Potassium, total	mg/L	2.25
UA	G09	C	2021/05/12	Potassium, total	mg/L	1.99
UA	G09	C	2021/06/01	Potassium, total	mg/L	1.87
UA	G09	C	2021/06/15	Potassium, total	mg/L	1.56
UA	G09	C	2021/07/06	Potassium, total	mg/L	1.65
UA	G09	C	2021/07/21	Potassium, total	mg/L	1.55
UA	G09	C	2022/07/24	Potassium, total	mg/L	1.36
UA	G09	C	2023/03/09	Potassium, total	mg/L	1.03
UA	G09	C	2023/05/03	Potassium, total	mg/L	0.987
UA	G09	C	2023/09/26	Potassium, total	mg/L	0.926
UA	G09	C	2023/10/25	Potassium, total	mg/L	0.860
UA	G09	C	2023/05/03	Silicon, dissolved	mg/L	15.6
UA	G09	C	2023/09/26	Silicon, dissolved	mg/L	15.2
UA	G09	C	2021/03/04	Sodium, total	mg/L	72.0
UA	G09	C	2021/03/25	Sodium, total	mg/L	74.2
UA	G09	C	2021/04/14	Sodium, total	mg/L	87.2
UA	G09	C	2021/05/12	Sodium, total	mg/L	71.2
UA	G09	C	2021/06/01	Sodium, total	mg/L	65.3
UA	G09	C	2021/06/15	Sodium, total	mg/L	58.5
UA	G09	C	2021/07/06	Sodium, total	mg/L	68.3
UA	G09	C	2021/07/21	Sodium, total	mg/L	64.3
UA	G09	C	2022/07/24	Sodium, total	mg/L	62.4
UA	G09	C	2023/03/09	Sodium, total	mg/L	53.6

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G09	C	2023/05/03	Sodium, total	mg/L	66.3
UA	G09	C	2023/09/26	Sodium, total	mg/L	59.1
UA	G09	C	2023/10/25	Sodium, total	mg/L	57.7
UA	G09	C	2021/03/04	Sulfate, total	mg/L	351
UA	G09	C	2021/03/25	Sulfate, total	mg/L	286
UA	G09	C	2021/04/14	Sulfate, total	mg/L	297
UA	G09	C	2021/05/12	Sulfate, total	mg/L	272
UA	G09	C	2021/06/01	Sulfate, total	mg/L	284
UA	G09	C	2021/06/15	Sulfate, total	mg/L	294
UA	G09	C	2021/07/06	Sulfate, total	mg/L	289
UA	G09	C	2021/07/21	Sulfate, total	mg/L	286
UA	G09	C	2022/07/24	Sulfate, total	mg/L	278
UA	G09	C	2023/03/09	Sulfate, total	mg/L	295
UA	G09	C	2023/05/03	Sulfate, total	mg/L	241
UA	G09	C	2023/09/26	Sulfate, total	mg/L	229
UA	G09	C	2023/10/25	Sulfate, total	mg/L	245
UA	G09	C	2021/03/04	Temperature (Celsius)	degrees C	16.6
UA	G09	C	2021/03/25	Temperature (Celsius)	degrees C	16.1
UA	G09	C	2021/04/14	Temperature (Celsius)	degrees C	16.2
UA	G09	C	2021/05/12	Temperature (Celsius)	degrees C	16.3
UA	G09	C	2021/06/01	Temperature (Celsius)	degrees C	16.5
UA	G09	C	2021/06/15	Temperature (Celsius)	degrees C	16.6
UA	G09	C	2021/07/06	Temperature (Celsius)	degrees C	17.3
UA	G09	C	2021/07/21	Temperature (Celsius)	degrees C	16.8
UA	G09	C	2022/07/24	Temperature (Celsius)	degrees C	17.2
UA	G09	C	2023/03/09	Temperature (Celsius)	degrees C	16.2
UA	G09	C	2023/05/03	Temperature (Celsius)	degrees C	16.9
UA	G09	C	2023/09/26	Temperature (Celsius)	degrees C	17.7
UA	G09	C	2023/10/25	Temperature (Celsius)	degrees C	18.1
UA	G09	C	2021/03/04	Total Dissolved Solids	mg/L	728
UA	G09	C	2021/03/25	Total Dissolved Solids	mg/L	688
UA	G09	C	2021/04/14	Total Dissolved Solids	mg/L	712
UA	G09	C	2021/05/12	Total Dissolved Solids	mg/L	656
UA	G09	C	2021/06/01	Total Dissolved Solids	mg/L	672
UA	G09	C	2021/06/15	Total Dissolved Solids	mg/L	632
UA	G09	C	2021/07/06	Total Dissolved Solids	mg/L	614
UA	G09	C	2021/07/21	Total Dissolved Solids	mg/L	652
UA	G09	C	2022/07/24	Total Dissolved Solids	mg/L	595
UA	G09	C	2023/03/09	Total Dissolved Solids	mg/L	562
UA	G09	C	2023/05/03	Total Dissolved Solids	mg/L	534
UA	G09	C	2023/09/26	Total Dissolved Solids	mg/L	500
UA	G09	C	2023/10/25	Total Dissolved Solids	mg/L	472
UA	G10	C	2021/03/04	pH (field)	SU	6.7
UA	G10	C	2021/03/24	pH (field)	SU	6.7
UA	G10	C	2021/04/13	pH (field)	SU	6.6
UA	G10	C	2021/05/11	pH (field)	SU	6.3
UA	G10	C	2021/06/01	pH (field)	SU	6.5
UA	G10	C	2021/06/15	pH (field)	SU	6.5
UA	G10	C	2021/07/06	pH (field)	SU	6.5
UA	G10	C	2021/07/20	pH (field)	SU	6.5
UA	G10	C	2022/07/26	pH (field)	SU	6.8
UA	G10	C	2023/03/08	pH (field)	SU	6.6
UA	G10	C	2023/05/03	pH (field)	SU	6.6
UA	G10	C	2023/09/26	pH (field)	SU	6.7
UA	G10	C	2023/10/24	pH (field)	SU	6.6

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G10	C	2021/03/04	Oxidation Reduction Potential	mV	16.0
UA	G10	C	2021/03/24	Oxidation Reduction Potential	mV	33.0
UA	G10	C	2021/04/13	Oxidation Reduction Potential	mV	42.0
UA	G10	C	2021/05/11	Oxidation Reduction Potential	mV	30.0
UA	G10	C	2021/06/01	Oxidation Reduction Potential	mV	5.00
UA	G10	C	2021/06/15	Oxidation Reduction Potential	mV	-22.0
UA	G10	C	2021/07/06	Oxidation Reduction Potential	mV	35.0
UA	G10	C	2021/07/20	Oxidation Reduction Potential	mV	52.0
UA	G10	C	2022/07/26	Oxidation Reduction Potential	mV	-31.8
UA	G10	C	2023/03/08	Oxidation Reduction Potential	mV	11.6
UA	G10	C	2023/05/03	Oxidation Reduction Potential	mV	135
UA	G10	C	2023/09/26	Oxidation Reduction Potential	mV	65.0
UA	G10	C	2023/10/24	Oxidation Reduction Potential	mV	23.0
UA	G10	C	2021/03/04	Eh	V	0.21
UA	G10	C	2021/03/24	Eh	V	0.23
UA	G10	C	2021/04/13	Eh	V	0.24
UA	G10	C	2021/05/11	Eh	V	0.22
UA	G10	C	2021/06/01	Eh	V	0.20
UA	G10	C	2021/06/15	Eh	V	0.17
UA	G10	C	2021/07/06	Eh	V	0.23
UA	G10	C	2021/07/20	Eh	V	0.25
UA	G10	C	2022/07/26	Eh	V	0.16
UA	G10	C	2023/03/08	Eh	V	0.21
UA	G10	C	2023/05/03	Eh	V	0.33
UA	G10	C	2023/09/26	Eh	V	0.26
UA	G10	C	2023/10/24	Eh	V	0.22
UA	G10	C	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	108
UA	G10	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	132
UA	G10	C	2021/04/13	Alkalinity, bicarbonate	mg/L CaCO3	133
UA	G10	C	2021/05/11	Alkalinity, bicarbonate	mg/L CaCO3	134
UA	G10	C	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	127
UA	G10	C	2021/06/15	Alkalinity, bicarbonate	mg/L CaCO3	149
UA	G10	C	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	144
UA	G10	C	2021/07/20	Alkalinity, bicarbonate	mg/L CaCO3	141
UA	G10	C	2022/07/26	Alkalinity, bicarbonate	mg/L CaCO3	131
UA	G10	C	2023/03/08	Alkalinity, bicarbonate	mg/L CaCO3	203
UA	G10	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	160
UA	G10	C	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	232
UA	G10	C	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	222
UA	G10	C	2021/03/04	Barium, total	mg/L	0.0608
UA	G10	C	2021/03/24	Barium, total	mg/L	0.0553
UA	G10	C	2021/04/13	Barium, total	mg/L	0.0496
UA	G10	C	2021/05/11	Barium, total	mg/L	0.0453
UA	G10	C	2021/06/01	Barium, total	mg/L	0.0444
UA	G10	C	2021/06/15	Barium, total	mg/L	0.0439
UA	G10	C	2021/07/06	Barium, total	mg/L	0.0356
UA	G10	C	2021/07/20	Barium, total	mg/L	0.0368
UA	G10	C	2022/07/26	Barium, total	mg/L	0.0499
UA	G10	C	2023/03/08	Barium, total	mg/L	0.0395
UA	G10	C	2023/05/03	Barium, total	mg/L	0.0624
UA	G10	C	2023/09/26	Barium, total	mg/L	0.0336
UA	G10	C	2023/10/24	Barium, total	mg/L	0.0385
UA	G10	C	2021/03/04	Boron, total	mg/L	4.98
UA	G10	C	2021/03/24	Boron, total	mg/L	4.31
UA	G10	C	2021/04/13	Boron, total	mg/L	4.26

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G10	C	2021/05/11	Boron, total	mg/L	3.95
UA	G10	C	2021/06/01	Boron, total	mg/L	4.73
UA	G10	C	2021/06/15	Boron, total	mg/L	3.74
UA	G10	C	2021/07/06	Boron, total	mg/L	4.81
UA	G10	C	2021/07/20	Boron, total	mg/L	4.20
UA	G10	C	2022/07/26	Boron, total	mg/L	4.40
UA	G10	C	2023/03/08	Boron, total	mg/L	3.28
UA	G10	C	2023/05/03	Boron, total	mg/L	3.08
UA	G10	C	2023/09/26	Boron, total	mg/L	3.41
UA	G10	C	2023/10/24	Boron, total	mg/L	2.35
UA	G10	C	2021/03/04	Calcium, total	mg/L	107
UA	G10	C	2021/03/24	Calcium, total	mg/L	115
UA	G10	C	2021/04/13	Calcium, total	mg/L	142
UA	G10	C	2021/05/11	Calcium, total	mg/L	120
UA	G10	C	2021/06/01	Calcium, total	mg/L	124
UA	G10	C	2021/06/15	Calcium, total	mg/L	128
UA	G10	C	2021/07/06	Calcium, total	mg/L	119
UA	G10	C	2021/07/20	Calcium, total	mg/L	132
UA	G10	C	2022/07/26	Calcium, total	mg/L	115
UA	G10	C	2023/03/08	Calcium, total	mg/L	116
UA	G10	C	2023/05/03	Calcium, total	mg/L	124
UA	G10	C	2023/09/26	Calcium, total	mg/L	120
UA	G10	C	2023/10/24	Calcium, total	mg/L	117
UA	G10	C	2021/03/04	Chloride, total	mg/L	35.0
UA	G10	C	2021/03/24	Chloride, total	mg/L	31.0
UA	G10	C	2021/04/13	Chloride, total	mg/L	29.0
UA	G10	C	2021/05/11	Chloride, total	mg/L	25.0
UA	G10	C	2021/06/01	Chloride, total	mg/L	29.0
UA	G10	C	2021/06/15	Chloride, total	mg/L	26.0
UA	G10	C	2021/07/06	Chloride, total	mg/L	26.0
UA	G10	C	2021/07/20	Chloride, total	mg/L	26.0
UA	G10	C	2022/07/26	Chloride, total	mg/L	29.0
UA	G10	C	2023/03/08	Chloride, total	mg/L	30.0
UA	G10	C	2023/05/03	Chloride, total	mg/L	27.0
UA	G10	C	2023/09/26	Chloride, total	mg/L	24.0
UA	G10	C	2023/10/24	Chloride, total	mg/L	26.0
UA	G10	C	2021/03/04	Cobalt, total	mg/L	0.0109
UA	G10	C	2021/03/24	Cobalt, total	mg/L	0.0122
UA	G10	C	2021/04/13	Cobalt, total	mg/L	0.0100
UA	G10	C	2021/05/11	Cobalt, total	mg/L	0.00754
UA	G10	C	2021/06/01	Cobalt, total	mg/L	0.00710
UA	G10	C	2021/06/15	Cobalt, total	mg/L	0.00500
UA	G10	C	2021/07/06	Cobalt, total	mg/L	0.00490
UA	G10	C	2021/07/20	Cobalt, total	mg/L	0.00450
UA	G10	C	2022/07/26	Cobalt, total	mg/L	0.00430
UA	G10	C	2023/03/08	Cobalt, total	mg/L	0.00440
UA	G10	C	2023/05/03	Cobalt, total	mg/L	0.00580
UA	G10	C	2023/09/26	Cobalt, total	mg/L	0.00210
UA	G10	C	2023/10/24	Cobalt, total	mg/L	0.00220
UA	G10	C	2023/05/03	Iron, dissolved	mg/L	0.325
UA	G10	C	2023/09/26	Iron, dissolved	mg/L	0.534
UA	G10	C	2021/03/04	Magnesium, total	mg/L	35.7
UA	G10	C	2021/03/24	Magnesium, total	mg/L	39.3
UA	G10	C	2021/04/13	Magnesium, total	mg/L	37.2
UA	G10	C	2021/05/11	Magnesium, total	mg/L	41.1

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G10	C	2021/06/01	Magnesium, total	mg/L	38.5
UA	G10	C	2021/06/15	Magnesium, total	mg/L	40.8
UA	G10	C	2021/07/06	Magnesium, total	mg/L	37.3
UA	G10	C	2021/07/20	Magnesium, total	mg/L	40.0
UA	G10	C	2022/07/26	Magnesium, total	mg/L	36.6
UA	G10	C	2023/03/08	Magnesium, total	mg/L	36.6
UA	G10	C	2023/05/03	Magnesium, total	mg/L	36.9
UA	G10	C	2023/09/26	Magnesium, total	mg/L	39.1
UA	G10	C	2023/10/24	Magnesium, total	mg/L	38.3
UA	G10	C	2023/05/03	Manganese, dissolved	mg/L	0.121
UA	G10	C	2023/09/26	Manganese, dissolved	mg/L	0.184
UA	G10	C	2023/05/03	Phosphate, dissolved	mg/L	0.0710
UA	G10	C	2023/09/26	Phosphate, dissolved	mg/L	0.0610
UA	G10	C	2021/03/04	Potassium, total	mg/L	2.54
UA	G10	C	2021/03/24	Potassium, total	mg/L	2.91
UA	G10	C	2021/04/13	Potassium, total	mg/L	2.48
UA	G10	C	2021/05/11	Potassium, total	mg/L	2.13
UA	G10	C	2021/06/01	Potassium, total	mg/L	2.27
UA	G10	C	2021/06/15	Potassium, total	mg/L	2.25
UA	G10	C	2021/07/06	Potassium, total	mg/L	2.09
UA	G10	C	2021/07/20	Potassium, total	mg/L	2.06
UA	G10	C	2022/07/26	Potassium, total	mg/L	2.13
UA	G10	C	2023/03/08	Potassium, total	mg/L	6.00
UA	G10	C	2023/05/03	Potassium, total	mg/L	5.42
UA	G10	C	2023/09/26	Potassium, total	mg/L	9.99
UA	G10	C	2023/10/24	Potassium, total	mg/L	11.3
UA	G10	C	2023/05/03	Silicon, dissolved	mg/L	11.9
UA	G10	C	2023/09/26	Silicon, dissolved	mg/L	11.6
UA	G10	C	2021/03/04	Sodium, total	mg/L	60.3
UA	G10	C	2021/03/24	Sodium, total	mg/L	62.1
UA	G10	C	2021/04/13	Sodium, total	mg/L	68.5
UA	G10	C	2021/05/11	Sodium, total	mg/L	56.8
UA	G10	C	2021/06/01	Sodium, total	mg/L	55.0
UA	G10	C	2021/06/15	Sodium, total	mg/L	59.3
UA	G10	C	2021/07/06	Sodium, total	mg/L	57.6
UA	G10	C	2021/07/20	Sodium, total	mg/L	56.5
UA	G10	C	2022/07/26	Sodium, total	mg/L	54.8
UA	G10	C	2023/03/08	Sodium, total	mg/L	80.4
UA	G10	C	2023/05/03	Sodium, total	mg/L	77.5
UA	G10	C	2023/09/26	Sodium, total	mg/L	86.9
UA	G10	C	2023/10/24	Sodium, total	mg/L	85.6
UA	G10	C	2021/03/04	Sulfate, total	mg/L	391
UA	G10	C	2021/03/24	Sulfate, total	mg/L	369
UA	G10	C	2021/04/13	Sulfate, total	mg/L	382
UA	G10	C	2021/05/11	Sulfate, total	mg/L	364
UA	G10	C	2021/06/01	Sulfate, total	mg/L	401
UA	G10	C	2021/06/15	Sulfate, total	mg/L	407
UA	G10	C	2021/07/06	Sulfate, total	mg/L	415
UA	G10	C	2021/07/20	Sulfate, total	mg/L	410
UA	G10	C	2022/07/26	Sulfate, total	mg/L	388
UA	G10	C	2023/03/08	Sulfate, total	mg/L	425
UA	G10	C	2023/05/03	Sulfate, total	mg/L	365
UA	G10	C	2023/09/26	Sulfate, total	mg/L	356
UA	G10	C	2023/10/24	Sulfate, total	mg/L	375
UA	G10	C	2021/03/04	Temperature (Celsius)	degrees C	16.0

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G10	C	2021/03/24	Temperature (Celsius)	degrees C	17.1
UA	G10	C	2021/04/13	Temperature (Celsius)	degrees C	16.6
UA	G10	C	2021/05/11	Temperature (Celsius)	degrees C	16.6
UA	G10	C	2021/06/01	Temperature (Celsius)	degrees C	16.5
UA	G10	C	2021/06/15	Temperature (Celsius)	degrees C	16.8
UA	G10	C	2021/07/06	Temperature (Celsius)	degrees C	18.0
UA	G10	C	2021/07/20	Temperature (Celsius)	degrees C	17.6
UA	G10	C	2022/07/26	Temperature (Celsius)	degrees C	17.7
UA	G10	C	2023/03/08	Temperature (Celsius)	degrees C	15.9
UA	G10	C	2023/05/03	Temperature (Celsius)	degrees C	17.1
UA	G10	C	2023/09/26	Temperature (Celsius)	degrees C	17.5
UA	G10	C	2023/10/24	Temperature (Celsius)	degrees C	17.4
UA	G10	C	2021/03/04	Total Dissolved Solids	mg/L	798
UA	G10	C	2021/03/24	Total Dissolved Solids	mg/L	752
UA	G10	C	2021/04/13	Total Dissolved Solids	mg/L	754
UA	G10	C	2021/05/11	Total Dissolved Solids	mg/L	746
UA	G10	C	2021/06/01	Total Dissolved Solids	mg/L	810
UA	G10	C	2021/06/15	Total Dissolved Solids	mg/L	760
UA	G10	C	2021/07/06	Total Dissolved Solids	mg/L	750
UA	G10	C	2021/07/20	Total Dissolved Solids	mg/L	806
UA	G10	C	2022/07/26	Total Dissolved Solids	mg/L	772
UA	G10	C	2023/03/08	Total Dissolved Solids	mg/L	795
UA	G10	C	2023/05/03	Total Dissolved Solids	mg/L	760
UA	G10	C	2023/09/26	Total Dissolved Solids	mg/L	705
UA	G10	C	2023/10/24	Total Dissolved Solids	mg/L	800
UA	G11	C	2021/03/04	pH (field)	SU	5.9
UA	G11	C	2021/03/24	pH (field)	SU	5.9
UA	G11	C	2021/04/14	pH (field)	SU	5.8
UA	G11	C	2021/05/12	pH (field)	SU	5.9
UA	G11	C	2021/06/01	pH (field)	SU	5.8
UA	G11	C	2021/06/14	pH (field)	SU	5.9
UA	G11	C	2021/07/06	pH (field)	SU	5.8
UA	G11	C	2021/07/20	pH (field)	SU	5.8
UA	G11	C	2022/07/23	pH (field)	SU	6.3
UA	G11	C	2023/03/08	pH (field)	SU	5.9
UA	G11	C	2023/05/03	pH (field)	SU	5.8
UA	G11	C	2023/09/26	pH (field)	SU	6.0
UA	G11	C	2023/10/24	pH (field)	SU	5.9
UA	G11	C	2021/03/04	Oxidation Reduction Potential	mV	69.0
UA	G11	C	2021/03/24	Oxidation Reduction Potential	mV	154
UA	G11	C	2021/04/14	Oxidation Reduction Potential	mV	100
UA	G11	C	2021/05/12	Oxidation Reduction Potential	mV	194
UA	G11	C	2021/06/01	Oxidation Reduction Potential	mV	159
UA	G11	C	2021/06/14	Oxidation Reduction Potential	mV	149
UA	G11	C	2021/07/06	Oxidation Reduction Potential	mV	78.0
UA	G11	C	2021/07/20	Oxidation Reduction Potential	mV	135
UA	G11	C	2022/07/23	Oxidation Reduction Potential	mV	122
UA	G11	C	2023/03/08	Oxidation Reduction Potential	mV	166
UA	G11	C	2023/05/03	Oxidation Reduction Potential	mV	207
UA	G11	C	2023/09/26	Oxidation Reduction Potential	mV	98.0
UA	G11	C	2023/10/24	Oxidation Reduction Potential	mV	124
UA	G11	C	2021/03/04	Eh	V	0.26
UA	G11	C	2021/03/24	Eh	V	0.35
UA	G11	C	2021/04/14	Eh	V	0.29
UA	G11	C	2021/05/12	Eh	V	0.39

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G11	C	2021/06/01	Eh	V	0.35
UA	G11	C	2021/06/14	Eh	V	0.34
UA	G11	C	2021/07/06	Eh	V	0.27
UA	G11	C	2021/07/20	Eh	V	0.33
UA	G11	C	2022/07/23	Eh	V	0.32
UA	G11	C	2023/03/08	Eh	V	0.36
UA	G11	C	2023/05/03	Eh	V	0.40
UA	G11	C	2023/09/26	Eh	V	0.29
UA	G11	C	2023/10/24	Eh	V	0.32
UA	G11	C	2021/03/04	Alkalinity, bicarbonate	mg/L CaCO3	108
UA	G11	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	101
UA	G11	C	2021/04/14	Alkalinity, bicarbonate	mg/L CaCO3	94.0
UA	G11	C	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	86.0
UA	G11	C	2021/06/01	Alkalinity, bicarbonate	mg/L CaCO3	91.0
UA	G11	C	2021/06/14	Alkalinity, bicarbonate	mg/L CaCO3	98.0
UA	G11	C	2021/07/06	Alkalinity, bicarbonate	mg/L CaCO3	96.0
UA	G11	C	2021/07/20	Alkalinity, bicarbonate	mg/L CaCO3	94.0
UA	G11	C	2022/07/23	Alkalinity, bicarbonate	mg/L CaCO3	89.0
UA	G11	C	2023/03/08	Alkalinity, bicarbonate	mg/L CaCO3	90.0
UA	G11	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	81.0
UA	G11	C	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	94.0
UA	G11	C	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	87.0
UA	G11	C	2021/03/04	Barium, total	mg/L	0.0287
UA	G11	C	2021/03/24	Barium, total	mg/L	0.0244
UA	G11	C	2021/04/14	Barium, total	mg/L	0.0195
UA	G11	C	2021/05/12	Barium, total	mg/L	0.0167
UA	G11	C	2021/06/01	Barium, total	mg/L	0.0166
UA	G11	C	2021/06/14	Barium, total	mg/L	0.0139
UA	G11	C	2021/07/06	Barium, total	mg/L	0.0109
UA	G11	C	2021/07/20	Barium, total	mg/L	0.0119
UA	G11	C	2022/07/23	Barium, total	mg/L	0.0164
UA	G11	C	2023/03/08	Barium, total	mg/L	0.0146
UA	G11	C	2023/05/03	Barium, total	mg/L	0.0770
UA	G11	C	2023/09/26	Barium, total	mg/L	0.0231
UA	G11	C	2023/10/24	Barium, total	mg/L	0.0217
UA	G11	C	2021/03/04	Boron, total	mg/L	0.247
UA	G11	C	2021/03/24	Boron, total	mg/L	0.420
UA	G11	C	2021/04/14	Boron, total	mg/L	0.411
UA	G11	C	2021/05/12	Boron, total	mg/L	0.321
UA	G11	C	2021/06/01	Boron, total	mg/L	0.309
UA	G11	C	2021/06/14	Boron, total	mg/L	0.266
UA	G11	C	2021/07/06	Boron, total	mg/L	0.358
UA	G11	C	2021/07/20	Boron, total	mg/L	0.302
UA	G11	C	2022/07/23	Boron, total	mg/L	0.310
UA	G11	C	2023/03/08	Boron, total	mg/L	0.327
UA	G11	C	2023/05/03	Boron, total	mg/L	0.373
UA	G11	C	2023/09/26	Boron, total	mg/L	0.308
UA	G11	C	2023/10/24	Boron, total	mg/L	0.282
UA	G11	C	2021/03/04	Calcium, total	mg/L	125
UA	G11	C	2021/03/24	Calcium, total	mg/L	178
UA	G11	C	2021/04/14	Calcium, total	mg/L	177
UA	G11	C	2021/05/12	Calcium, total	mg/L	166
UA	G11	C	2021/06/01	Calcium, total	mg/L	165
UA	G11	C	2021/06/14	Calcium, total	mg/L	136
UA	G11	C	2021/07/06	Calcium, total	mg/L	135

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G11	C	2021/07/20	Calcium, total	mg/L	149
UA	G11	C	2022/07/23	Calcium, total	mg/L	115
UA	G11	C	2023/03/08	Calcium, total	mg/L	75.6
UA	G11	C	2023/05/03	Calcium, total	mg/L	122
UA	G11	C	2023/09/26	Calcium, total	mg/L	59.9
UA	G11	C	2023/10/24	Calcium, total	mg/L	54.4
UA	G11	C	2021/03/04	Chloride, total	mg/L	44.0
UA	G11	C	2021/03/24	Chloride, total	mg/L	35.0
UA	G11	C	2021/04/14	Chloride, total	mg/L	33.0
UA	G11	C	2021/05/12	Chloride, total	mg/L	30.0
UA	G11	C	2021/06/01	Chloride, total	mg/L	33.0
UA	G11	C	2021/06/14	Chloride, total	mg/L	39.0
UA	G11	C	2021/07/06	Chloride, total	mg/L	42.0
UA	G11	C	2021/07/20	Chloride, total	mg/L	39.0
UA	G11	C	2022/07/23	Chloride, total	mg/L	44.0
UA	G11	C	2023/03/08	Chloride, total	mg/L	36.0
UA	G11	C	2023/05/03	Chloride, total	mg/L	37.0
UA	G11	C	2023/09/26	Chloride, total	mg/L	29.0
UA	G11	C	2023/10/24	Chloride, total	mg/L	30.0
UA	G11	C	2021/03/04	Cobalt, total	mg/L	0.00390
UA	G11	C	2021/03/24	Cobalt, total	mg/L	0.00790
UA	G11	C	2021/04/14	Cobalt, total	mg/L	0.00310
UA	G11	C	2021/05/12	Cobalt, total	mg/L	0.00393
UA	G11	C	2021/06/01	Cobalt, total	mg/L	0.00290
UA	G11	C	2021/06/14	Cobalt, total	mg/L	<0.0001
UA	G11	C	2021/07/06	Cobalt, total	mg/L	<0.0001
UA	G11	C	2021/07/20	Cobalt, total	mg/L	<0.0001
UA	G11	C	2022/07/23	Cobalt, total	mg/L	0.00200
UA	G11	C	2023/03/08	Cobalt, total	mg/L	0.00100
UA	G11	C	2023/05/03	Cobalt, total	mg/L	0.0185
UA	G11	C	2023/09/26	Cobalt, total	mg/L	0.000600
UA	G11	C	2023/10/24	Cobalt, total	mg/L	<0.0001
UA	G11	C	2023/05/03	Iron, dissolved	mg/L	<0.04
UA	G11	C	2023/09/26	Iron, dissolved	mg/L	0.171
UA	G11	C	2021/03/04	Magnesium, total	mg/L	41.6
UA	G11	C	2021/03/24	Magnesium, total	mg/L	72.4
UA	G11	C	2021/04/14	Magnesium, total	mg/L	65.6
UA	G11	C	2021/05/12	Magnesium, total	mg/L	67.7
UA	G11	C	2021/06/01	Magnesium, total	mg/L	58.6
UA	G11	C	2021/06/14	Magnesium, total	mg/L	49.2
UA	G11	C	2021/07/06	Magnesium, total	mg/L	48.3
UA	G11	C	2021/07/20	Magnesium, total	mg/L	51.8
UA	G11	C	2022/07/23	Magnesium, total	mg/L	40.9
UA	G11	C	2023/03/08	Magnesium, total	mg/L	27.8
UA	G11	C	2023/05/03	Magnesium, total	mg/L	43.2
UA	G11	C	2023/09/26	Magnesium, total	mg/L	21.3
UA	G11	C	2023/10/24	Magnesium, total	mg/L	19.8
UA	G11	C	2023/05/03	Manganese, dissolved	mg/L	0.0330
UA	G11	C	2023/09/26	Manganese, dissolved	mg/L	0.00590
UA	G11	C	2023/05/03	Phosphate, dissolved	mg/L	0.0740
UA	G11	C	2023/09/26	Phosphate, dissolved	mg/L	0.0950
UA	G11	C	2021/03/04	Potassium, total	mg/L	1.19
UA	G11	C	2021/03/24	Potassium, total	mg/L	2.10
UA	G11	C	2021/04/14	Potassium, total	mg/L	2.13
UA	G11	C	2021/05/12	Potassium, total	mg/L	2.47

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G11	C	2021/06/01	Potassium, total	mg/L	2.53
UA	G11	C	2021/06/14	Potassium, total	mg/L	1.60
UA	G11	C	2021/07/06	Potassium, total	mg/L	1.34
UA	G11	C	2021/07/20	Potassium, total	mg/L	1.14
UA	G11	C	2022/07/23	Potassium, total	mg/L	1.06
UA	G11	C	2023/03/08	Potassium, total	mg/L	0.952
UA	G11	C	2023/05/03	Potassium, total	mg/L	1.03
UA	G11	C	2023/09/26	Potassium, total	mg/L	1.01
UA	G11	C	2023/10/24	Potassium, total	mg/L	0.918
UA	G11	C	2023/05/03	Silicon, dissolved	mg/L	18.1
UA	G11	C	2023/09/26	Silicon, dissolved	mg/L	13.0
UA	G11	C	2021/03/04	Sodium, total	mg/L	61.4
UA	G11	C	2021/03/24	Sodium, total	mg/L	93.4
UA	G11	C	2021/04/14	Sodium, total	mg/L	94.1
UA	G11	C	2021/05/12	Sodium, total	mg/L	76.0
UA	G11	C	2021/06/01	Sodium, total	mg/L	66.1
UA	G11	C	2021/06/14	Sodium, total	mg/L	60.6
UA	G11	C	2021/07/06	Sodium, total	mg/L	60.2
UA	G11	C	2021/07/20	Sodium, total	mg/L	58.4
UA	G11	C	2022/07/23	Sodium, total	mg/L	54.7
UA	G11	C	2023/03/08	Sodium, total	mg/L	48.7
UA	G11	C	2023/05/03	Sodium, total	mg/L	62.5
UA	G11	C	2023/09/26	Sodium, total	mg/L	43.8
UA	G11	C	2023/10/24	Sodium, total	mg/L	43.2
UA	G11	C	2021/03/04	Sulfate, total	mg/L	400
UA	G11	C	2021/03/24	Sulfate, total	mg/L	658
UA	G11	C	2021/04/14	Sulfate, total	mg/L	761
UA	G11	C	2021/05/12	Sulfate, total	mg/L	730
UA	G11	C	2021/06/01	Sulfate, total	mg/L	671
UA	G11	C	2021/06/14	Sulfate, total	mg/L	505
UA	G11	C	2021/07/06	Sulfate, total	mg/L	474
UA	G11	C	2021/07/20	Sulfate, total	mg/L	487
UA	G11	C	2022/07/23	Sulfate, total	mg/L	352
UA	G11	C	2023/03/08	Sulfate, total	mg/L	303
UA	G11	C	2023/05/03	Sulfate, total	mg/L	416
UA	G11	C	2023/09/26	Sulfate, total	mg/L	192
UA	G11	C	2023/10/24	Sulfate, total	mg/L	180
UA	G11	C	2021/03/04	Temperature (Celsius)	degrees C	16.3
UA	G11	C	2021/03/24	Temperature (Celsius)	degrees C	16.5
UA	G11	C	2021/04/14	Temperature (Celsius)	degrees C	16.1
UA	G11	C	2021/05/12	Temperature (Celsius)	degrees C	16.5
UA	G11	C	2021/06/01	Temperature (Celsius)	degrees C	16.4
UA	G11	C	2021/06/14	Temperature (Celsius)	degrees C	16.6
UA	G11	C	2021/07/06	Temperature (Celsius)	degrees C	16.7
UA	G11	C	2021/07/20	Temperature (Celsius)	degrees C	16.9
UA	G11	C	2022/07/23	Temperature (Celsius)	degrees C	17.3
UA	G11	C	2023/03/08	Temperature (Celsius)	degrees C	16.0
UA	G11	C	2023/05/03	Temperature (Celsius)	degrees C	16.5
UA	G11	C	2023/09/26	Temperature (Celsius)	degrees C	17.8
UA	G11	C	2023/10/24	Temperature (Celsius)	degrees C	18.0
UA	G11	C	2021/03/04	Total Dissolved Solids	mg/L	804
UA	G11	C	2021/03/24	Total Dissolved Solids	mg/L	1,110
UA	G11	C	2021/04/14	Total Dissolved Solids	mg/L	1,200
UA	G11	C	2021/05/12	Total Dissolved Solids	mg/L	1,130
UA	G11	C	2021/06/01	Total Dissolved Solids	mg/L	1,120

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G11	C	2021/06/14	Total Dissolved Solids	mg/L	850
UA	G11	C	2021/07/06	Total Dissolved Solids	mg/L	862
UA	G11	C	2021/07/20	Total Dissolved Solids	mg/L	874
UA	G11	C	2022/07/23	Total Dissolved Solids	mg/L	766
UA	G11	C	2023/03/08	Total Dissolved Solids	mg/L	570
UA	G11	C	2023/05/03	Total Dissolved Solids	mg/L	808
UA	G11	C	2023/09/26	Total Dissolved Solids	mg/L	428
UA	G11	C	2023/10/24	Total Dissolved Solids	mg/L	402
UA	G51D	C	2015/12/03	pH (field)	SU	6.2
UA	G51D	C	2016/03/15	pH (field)	SU	5.9
UA	G51D	C	2016/06/15	pH (field)	SU	5.8
UA	G51D	C	2016/09/14	pH (field)	SU	5.6
UA	G51D	C	2016/12/14	pH (field)	SU	5.9
UA	G51D	C	2017/03/08	pH (field)	SU	6.2
UA	G51D	C	2017/06/15	pH (field)	SU	5.6
UA	G51D	C	2017/07/20	pH (field)	SU	5.9
UA	G51D	C	2017/11/30	pH (field)	SU	5.6
UA	G51D	C	2018/06/19	pH (field)	SU	5.7
UA	G51D	C	2018/09/05	pH (field)	SU	6.0
UA	G51D	C	2019/03/27	pH (field)	SU	5.7
UA	G51D	C	2019/09/09	pH (field)	SU	5.3
UA	G51D	C	2020/03/30	pH (field)	SU	5.6
UA	G51D	C	2020/09/23	pH (field)	SU	5.7
UA	G51D	C	2021/03/24	pH (field)	SU	5.6
UA	G51D	C	2021/09/20	pH (field)	SU	5.5
UA	G51D	C	2022/03/15	pH (field)	SU	5.6
UA	G51D	C	2022/07/25	pH (field)	SU	6.9
UA	G51D	C	2022/09/20	pH (field)	SU	5.6
UA	G51D	C	2023/03/08	pH (field)	SU	5.5
UA	G51D	C	2023/05/03	pH (field)	SU	5.6
UA	G51D	C	2023/09/25	pH (field)	SU	5.4
UA	G51D	C	2023/10/25	pH (field)	SU	5.3
UA	G51D	C	2015/12/03	Oxidation Reduction Potential	mV	133
UA	G51D	C	2016/03/15	Oxidation Reduction Potential	mV	122
UA	G51D	C	2016/06/15	Oxidation Reduction Potential	mV	213
UA	G51D	C	2016/09/14	Oxidation Reduction Potential	mV	231
UA	G51D	C	2016/12/14	Oxidation Reduction Potential	mV	134
UA	G51D	C	2017/03/08	Oxidation Reduction Potential	mV	282
UA	G51D	C	2017/06/15	Oxidation Reduction Potential	mV	168
UA	G51D	C	2017/07/20	Oxidation Reduction Potential	mV	180
UA	G51D	C	2017/11/30	Oxidation Reduction Potential	mV	168
UA	G51D	C	2018/06/19	Oxidation Reduction Potential	mV	247
UA	G51D	C	2018/09/05	Oxidation Reduction Potential	mV	217
UA	G51D	C	2019/03/27	Oxidation Reduction Potential	mV	130
UA	G51D	C	2019/09/09	Oxidation Reduction Potential	mV	157
UA	G51D	C	2020/03/30	Oxidation Reduction Potential	mV	261
UA	G51D	C	2020/09/23	Oxidation Reduction Potential	mV	292
UA	G51D	C	2021/03/24	Oxidation Reduction Potential	mV	136
UA	G51D	C	2021/09/20	Oxidation Reduction Potential	mV	238
UA	G51D	C	2022/03/15	Oxidation Reduction Potential	mV	165
UA	G51D	C	2022/07/25	Oxidation Reduction Potential	mV	178
UA	G51D	C	2022/09/20	Oxidation Reduction Potential	mV	215
UA	G51D	C	2023/03/08	Oxidation Reduction Potential	mV	166
UA	G51D	C	2023/05/03	Oxidation Reduction Potential	mV	214
UA	G51D	C	2023/09/25	Oxidation Reduction Potential	mV	139

Attachment I. Site Groundwater Data
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Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G51D	C	2023/10/25	Oxidation Reduction Potential	mV	170
UA	G51D	C	2015/12/03	Eh	V	0.33
UA	G51D	C	2016/03/15	Eh	V	0.32
UA	G51D	C	2016/06/15	Eh	V	0.41
UA	G51D	C	2016/09/14	Eh	V	0.42
UA	G51D	C	2016/12/14	Eh	V	0.33
UA	G51D	C	2017/03/08	Eh	V	0.48
UA	G51D	C	2017/06/15	Eh	V	0.36
UA	G51D	C	2017/07/20	Eh	V	0.37
UA	G51D	C	2017/11/30	Eh	V	0.36
UA	G51D	C	2018/06/19	Eh	V	0.44
UA	G51D	C	2018/09/05	Eh	V	0.41
UA	G51D	C	2019/03/27	Eh	V	0.32
UA	G51D	C	2019/09/09	Eh	V	0.35
UA	G51D	C	2020/03/30	Eh	V	0.46
UA	G51D	C	2020/09/23	Eh	V	0.49
UA	G51D	C	2021/03/24	Eh	V	0.33
UA	G51D	C	2021/09/20	Eh	V	0.43
UA	G51D	C	2022/03/15	Eh	V	0.36
UA	G51D	C	2022/07/25	Eh	V	0.37
UA	G51D	C	2022/09/20	Eh	V	0.41
UA	G51D	C	2023/03/08	Eh	V	0.36
UA	G51D	C	2023/05/03	Eh	V	0.41
UA	G51D	C	2023/09/25	Eh	V	0.33
UA	G51D	C	2023/10/25	Eh	V	0.36
UA	G51D	C	2017/07/20	Alkalinity, bicarbonate	mg/L CaCO3	52.0
UA	G51D	C	2020/03/30	Alkalinity, bicarbonate	mg/L CaCO3	52.0
UA	G51D	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	54.0
UA	G51D	C	2021/09/20	Alkalinity, bicarbonate	mg/L CaCO3	50.0
UA	G51D	C	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	53.0
UA	G51D	C	2022/07/25	Alkalinity, bicarbonate	mg/L CaCO3	46.0
UA	G51D	C	2023/03/08	Alkalinity, bicarbonate	mg/L CaCO3	46.0
UA	G51D	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	148
UA	G51D	C	2023/09/25	Alkalinity, bicarbonate	mg/L CaCO3	55.0
UA	G51D	C	2023/10/25	Alkalinity, bicarbonate	mg/L CaCO3	52.0
UA	G51D	C	2015/12/03	Barium, total	mg/L	0.129
UA	G51D	C	2016/03/15	Barium, total	mg/L	0.0702
UA	G51D	C	2016/06/15	Barium, total	mg/L	0.0628
UA	G51D	C	2016/09/14	Barium, total	mg/L	0.0536
UA	G51D	C	2016/12/14	Barium, total	mg/L	0.0459
UA	G51D	C	2017/03/08	Barium, total	mg/L	0.0493
UA	G51D	C	2017/06/15	Barium, total	mg/L	0.0442
UA	G51D	C	2017/07/20	Barium, total	mg/L	0.0462
UA	G51D	C	2018/06/19	Barium, total	mg/L	0.0756
UA	G51D	C	2018/09/05	Barium, total	mg/L	0.0395
UA	G51D	C	2019/03/27	Barium, total	mg/L	0.0495
UA	G51D	C	2019/09/09	Barium, total	mg/L	0.0377
UA	G51D	C	2020/03/30	Barium, total	mg/L	0.0445
UA	G51D	C	2020/09/23	Barium, total	mg/L	0.0445
UA	G51D	C	2021/03/24	Barium, total	mg/L	0.0400
UA	G51D	C	2021/09/20	Barium, total	mg/L	0.0405
UA	G51D	C	2022/03/15	Barium, total	mg/L	0.0433
UA	G51D	C	2022/07/25	Barium, total	mg/L	0.0582
UA	G51D	C	2022/09/20	Barium, total	mg/L	0.0321
UA	G51D	C	2023/03/08	Barium, total	mg/L	0.0417

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G51D	C	2023/05/03	Barium, total	mg/L	0.273
UA	G51D	C	2023/09/25	Barium, total	mg/L	0.0349
UA	G51D	C	2023/10/25	Barium, total	mg/L	0.0433
UA	G51D	C	2015/12/03	Boron, total	mg/L	0.117
UA	G51D	C	2016/03/15	Boron, total	mg/L	0.184
UA	G51D	C	2016/06/15	Boron, total	mg/L	0.213
UA	G51D	C	2016/09/14	Boron, total	mg/L	0.263
UA	G51D	C	2016/12/14	Boron, total	mg/L	0.171
UA	G51D	C	2017/03/08	Boron, total	mg/L	0.309
UA	G51D	C	2017/06/15	Boron, total	mg/L	0.580
UA	G51D	C	2017/07/20	Boron, total	mg/L	0.332
UA	G51D	C	2017/11/30	Boron, total	mg/L	0.302
UA	G51D	C	2018/06/19	Boron, total	mg/L	0.337
UA	G51D	C	2018/09/05	Boron, total	mg/L	0.263
UA	G51D	C	2019/03/27	Boron, total	mg/L	0.778
UA	G51D	C	2019/09/09	Boron, total	mg/L	0.501
UA	G51D	C	2020/03/30	Boron, total	mg/L	0.697
UA	G51D	C	2020/09/23	Boron, total	mg/L	0.863
UA	G51D	C	2021/03/24	Boron, total	mg/L	0.786
UA	G51D	C	2021/09/20	Boron, total	mg/L	0.689
UA	G51D	C	2022/03/15	Boron, total	mg/L	0.689
UA	G51D	C	2022/07/25	Boron, total	mg/L	0.663
UA	G51D	C	2022/09/20	Boron, total	mg/L	0.551
UA	G51D	C	2023/03/08	Boron, total	mg/L	0.963
UA	G51D	C	2023/05/03	Boron, total	mg/L	0.0297
UA	G51D	C	2023/09/25	Boron, total	mg/L	0.899
UA	G51D	C	2023/10/25	Boron, total	mg/L	0.603
UA	G51D	C	2015/12/03	Calcium, total	mg/L	39.2
UA	G51D	C	2016/03/15	Calcium, total	mg/L	39.7
UA	G51D	C	2016/06/15	Calcium, total	mg/L	42.3
UA	G51D	C	2016/09/14	Calcium, total	mg/L	29.6
UA	G51D	C	2016/12/14	Calcium, total	mg/L	30.0
UA	G51D	C	2017/03/08	Calcium, total	mg/L	32.6
UA	G51D	C	2017/06/15	Calcium, total	mg/L	34.0
UA	G51D	C	2017/07/20	Calcium, total	mg/L	31.8
UA	G51D	C	2017/11/30	Calcium, total	mg/L	34.4
UA	G51D	C	2018/06/19	Calcium, total	mg/L	31.1
UA	G51D	C	2018/09/05	Calcium, total	mg/L	29.1
UA	G51D	C	2019/03/27	Calcium, total	mg/L	34.7
UA	G51D	C	2019/09/09	Calcium, total	mg/L	31.3
UA	G51D	C	2020/03/30	Calcium, total	mg/L	31.2
UA	G51D	C	2020/09/23	Calcium, total	mg/L	42.1
UA	G51D	C	2021/03/24	Calcium, total	mg/L	31.7
UA	G51D	C	2021/09/20	Calcium, total	mg/L	31.2
UA	G51D	C	2022/03/15	Calcium, total	mg/L	31.0
UA	G51D	C	2022/07/25	Calcium, total	mg/L	31.8
UA	G51D	C	2022/09/20	Calcium, total	mg/L	28.9
UA	G51D	C	2023/03/08	Calcium, total	mg/L	29.7
UA	G51D	C	2023/05/03	Calcium, total	mg/L	48.2
UA	G51D	C	2023/09/25	Calcium, total	mg/L	28.7
UA	G51D	C	2023/10/25	Calcium, total	mg/L	31.5
UA	G51D	C	2015/12/03	Chloride, total	mg/L	9.00
UA	G51D	C	2016/03/15	Chloride, total	mg/L	9.00
UA	G51D	C	2016/06/15	Chloride, total	mg/L	7.00
UA	G51D	C	2016/09/14	Chloride, total	mg/L	9.00

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Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G51D	C	2016/12/14	Chloride, total	mg/L	11.0
UA	G51D	C	2017/03/08	Chloride, total	mg/L	8.00
UA	G51D	C	2017/06/15	Chloride, total	mg/L	9.00
UA	G51D	C	2017/07/20	Chloride, total	mg/L	8.00
UA	G51D	C	2017/11/30	Chloride, total	mg/L	8.00
UA	G51D	C	2018/06/19	Chloride, total	mg/L	7.00
UA	G51D	C	2018/09/05	Chloride, total	mg/L	7.00
UA	G51D	C	2019/03/27	Chloride, total	mg/L	6.00
UA	G51D	C	2019/09/09	Chloride, total	mg/L	6.00
UA	G51D	C	2020/03/30	Chloride, total	mg/L	6.00
UA	G51D	C	2020/09/23	Chloride, total	mg/L	6.00
UA	G51D	C	2021/03/24	Chloride, total	mg/L	5.00
UA	G51D	C	2021/09/20	Chloride, total	mg/L	6.00
UA	G51D	C	2022/03/15	Chloride, total	mg/L	5.00
UA	G51D	C	2022/07/25	Chloride, total	mg/L	5.00
UA	G51D	C	2022/09/20	Chloride, total	mg/L	4.00
UA	G51D	C	2023/03/08	Chloride, total	mg/L	5.00
UA	G51D	C	2023/05/03	Chloride, total	mg/L	11.0
UA	G51D	C	2023/09/25	Chloride, total	mg/L	4.00
UA	G51D	C	2023/10/25	Chloride, total	mg/L	4.00
UA	G51D	C	2015/12/03	Cobalt, total	mg/L	0.0141
UA	G51D	C	2016/03/15	Cobalt, total	mg/L	0.0249
UA	G51D	C	2016/06/15	Cobalt, total	mg/L	0.0198
UA	G51D	C	2016/09/14	Cobalt, total	mg/L	0.0110
UA	G51D	C	2016/12/14	Cobalt, total	mg/L	0.0119
UA	G51D	C	2017/03/08	Cobalt, total	mg/L	0.00820
UA	G51D	C	2017/06/15	Cobalt, total	mg/L	0.00520
UA	G51D	C	2017/07/20	Cobalt, total	mg/L	0.00550
UA	G51D	C	2018/06/19	Cobalt, total	mg/L	0.00380
UA	G51D	C	2018/09/05	Cobalt, total	mg/L	0.00430
UA	G51D	C	2019/03/27	Cobalt, total	mg/L	0.00260
UA	G51D	C	2019/09/09	Cobalt, total	mg/L	0.00170
UA	G51D	C	2020/03/30	Cobalt, total	mg/L	0.00240
UA	G51D	C	2020/09/23	Cobalt, total	mg/L	0.00200
UA	G51D	C	2021/03/24	Cobalt, total	mg/L	0.00220
UA	G51D	C	2021/09/20	Cobalt, total	mg/L	0.00180
UA	G51D	C	2022/03/15	Cobalt, total	mg/L	0.00160
UA	G51D	C	2022/07/25	Cobalt, total	mg/L	0.00140
UA	G51D	C	2022/09/20	Cobalt, total	mg/L	0.000900
UA	G51D	C	2023/03/08	Cobalt, total	mg/L	0.000600
UA	G51D	C	2023/05/03	Cobalt, total	mg/L	0.00930
UA	G51D	C	2023/09/25	Cobalt, total	mg/L	0.000800
UA	G51D	C	2023/10/25	Cobalt, total	mg/L	<0.0001
UA	G51D	C	2023/05/03	Iron, dissolved	mg/L	0.785
UA	G51D	C	2023/09/25	Iron, dissolved	mg/L	1.31
UA	G51D	C	2017/07/20	Magnesium, total	mg/L	14.4
UA	G51D	C	2020/03/30	Magnesium, total	mg/L	13.4
UA	G51D	C	2021/03/24	Magnesium, total	mg/L	12.5
UA	G51D	C	2022/03/15	Magnesium, total	mg/L	12.9
UA	G51D	C	2022/07/25	Magnesium, total	mg/L	12.8
UA	G51D	C	2023/03/08	Magnesium, total	mg/L	12.3
UA	G51D	C	2023/05/03	Magnesium, total	mg/L	14.3
UA	G51D	C	2023/09/25	Magnesium, total	mg/L	12.2
UA	G51D	C	2023/10/25	Magnesium, total	mg/L	13.0
UA	G51D	C	2023/05/03	Manganese, dissolved	mg/L	0.290

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G51D	C	2023/09/25	Manganese, dissolved	mg/L	0.0239
UA	G51D	C	2023/05/03	Phosphate, dissolved	mg/L	0.249
UA	G51D	C	2023/09/25	Phosphate, dissolved	mg/L	<0.005
UA	G51D	C	2017/07/20	Potassium, total	mg/L	0.329
UA	G51D	C	2020/03/30	Potassium, total	mg/L	0.492
UA	G51D	C	2021/03/24	Potassium, total	mg/L	0.275
UA	G51D	C	2022/03/15	Potassium, total	mg/L	0.442
UA	G51D	C	2022/07/25	Potassium, total	mg/L	0.320
UA	G51D	C	2023/03/08	Potassium, total	mg/L	0.235
UA	G51D	C	2023/05/03	Potassium, total	mg/L	0.693
UA	G51D	C	2023/09/25	Potassium, total	mg/L	0.319
UA	G51D	C	2023/10/25	Potassium, total	mg/L	0.308
UA	G51D	C	2023/05/03	Silicon, dissolved	mg/L	19.9
UA	G51D	C	2023/09/25	Silicon, dissolved	mg/L	20.7
UA	G51D	C	2017/07/20	Sodium, total	mg/L	37.3
UA	G51D	C	2020/03/30	Sodium, total	mg/L	37.6
UA	G51D	C	2021/03/24	Sodium, total	mg/L	36.0
UA	G51D	C	2022/03/15	Sodium, total	mg/L	35.5
UA	G51D	C	2022/07/25	Sodium, total	mg/L	33.0
UA	G51D	C	2023/03/08	Sodium, total	mg/L	33.4
UA	G51D	C	2023/05/03	Sodium, total	mg/L	28.6
UA	G51D	C	2023/09/25	Sodium, total	mg/L	32.7
UA	G51D	C	2023/10/25	Sodium, total	mg/L	37.0
UA	G51D	C	2015/12/03	Sulfate, total	mg/L	117
UA	G51D	C	2016/03/15	Sulfate, total	mg/L	145
UA	G51D	C	2016/06/15	Sulfate, total	mg/L	139
UA	G51D	C	2016/09/14	Sulfate, total	mg/L	136
UA	G51D	C	2016/12/14	Sulfate, total	mg/L	101
UA	G51D	C	2017/03/08	Sulfate, total	mg/L	146
UA	G51D	C	2017/06/15	Sulfate, total	mg/L	149
UA	G51D	C	2017/07/20	Sulfate, total	mg/L	140
UA	G51D	C	2017/11/30	Sulfate, total	mg/L	138
UA	G51D	C	2018/06/19	Sulfate, total	mg/L	124
UA	G51D	C	2018/09/05	Sulfate, total	mg/L	134
UA	G51D	C	2019/03/27	Sulfate, total	mg/L	125
UA	G51D	C	2019/09/09	Sulfate, total	mg/L	109
UA	G51D	C	2020/03/30	Sulfate, total	mg/L	130
UA	G51D	C	2020/09/23	Sulfate, total	mg/L	121
UA	G51D	C	2021/03/24	Sulfate, total	mg/L	122
UA	G51D	C	2021/09/20	Sulfate, total	mg/L	131
UA	G51D	C	2022/03/15	Sulfate, total	mg/L	123
UA	G51D	C	2022/07/25	Sulfate, total	mg/L	116
UA	G51D	C	2022/09/20	Sulfate, total	mg/L	125
UA	G51D	C	2023/03/08	Sulfate, total	mg/L	131
UA	G51D	C	2023/05/03	Sulfate, total	mg/L	59.0
UA	G51D	C	2023/09/25	Sulfate, total	mg/L	127
UA	G51D	C	2023/10/25	Sulfate, total	mg/L	120
UA	G51D	C	2015/12/03	Temperature (Celsius)	degrees C	16.7
UA	G51D	C	2016/03/15	Temperature (Celsius)	degrees C	17.6
UA	G51D	C	2016/06/15	Temperature (Celsius)	degrees C	17.8
UA	G51D	C	2016/09/14	Temperature (Celsius)	degrees C	20.8
UA	G51D	C	2016/12/14	Temperature (Celsius)	degrees C	16.2
UA	G51D	C	2017/03/08	Temperature (Celsius)	degrees C	15.1
UA	G51D	C	2017/06/15	Temperature (Celsius)	degrees C	18.5
UA	G51D	C	2017/07/20	Temperature (Celsius)	degrees C	18.9

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G51D	C	2017/11/30	Temperature (Celsius)	degrees C	16.2
UA	G51D	C	2018/06/19	Temperature (Celsius)	degrees C	19.1
UA	G51D	C	2018/09/05	Temperature (Celsius)	degrees C	17.7
UA	G51D	C	2019/03/27	Temperature (Celsius)	degrees C	16.2
UA	G51D	C	2019/09/09	Temperature (Celsius)	degrees C	17.3
UA	G51D	C	2020/03/30	Temperature (Celsius)	degrees C	16.4
UA	G51D	C	2020/09/23	Temperature (Celsius)	degrees C	16.9
UA	G51D	C	2021/03/24	Temperature (Celsius)	degrees C	17.0
UA	G51D	C	2021/09/20	Temperature (Celsius)	degrees C	17.7
UA	G51D	C	2022/03/15	Temperature (Celsius)	degrees C	16.1
UA	G51D	C	2022/07/25	Temperature (Celsius)	degrees C	18.1
UA	G51D	C	2022/09/20	Temperature (Celsius)	degrees C	20.7
UA	G51D	C	2023/03/08	Temperature (Celsius)	degrees C	15.9
UA	G51D	C	2023/05/03	Temperature (Celsius)	degrees C	16.3
UA	G51D	C	2023/09/25	Temperature (Celsius)	degrees C	18.4
UA	G51D	C	2023/10/25	Temperature (Celsius)	degrees C	17.1
UA	G51D	C	2015/12/03	Total Dissolved Solids	mg/L	304
UA	G51D	C	2016/03/15	Total Dissolved Solids	mg/L	342
UA	G51D	C	2016/06/15	Total Dissolved Solids	mg/L	330
UA	G51D	C	2016/09/14	Total Dissolved Solids	mg/L	360
UA	G51D	C	2016/12/14	Total Dissolved Solids	mg/L	270
UA	G51D	C	2017/03/08	Total Dissolved Solids	mg/L	340
UA	G51D	C	2017/06/15	Total Dissolved Solids	mg/L	340
UA	G51D	C	2017/07/20	Total Dissolved Solids	mg/L	344
UA	G51D	C	2017/11/30	Total Dissolved Solids	mg/L	356
UA	G51D	C	2018/06/19	Total Dissolved Solids	mg/L	324
UA	G51D	C	2018/09/05	Total Dissolved Solids	mg/L	342
UA	G51D	C	2019/03/27	Total Dissolved Solids	mg/L	350
UA	G51D	C	2019/09/09	Total Dissolved Solids	mg/L	320
UA	G51D	C	2020/03/30	Total Dissolved Solids	mg/L	304
UA	G51D	C	2020/09/23	Total Dissolved Solids	mg/L	314
UA	G51D	C	2021/03/24	Total Dissolved Solids	mg/L	322
UA	G51D	C	2021/09/20	Total Dissolved Solids	mg/L	312
UA	G51D	C	2022/03/15	Total Dissolved Solids	mg/L	324
UA	G51D	C	2022/07/25	Total Dissolved Solids	mg/L	306
UA	G51D	C	2022/09/20	Total Dissolved Solids	mg/L	322
UA	G51D	C	2023/03/08	Total Dissolved Solids	mg/L	296
UA	G51D	C	2023/05/03	Total Dissolved Solids	mg/L	310
UA	G51D	C	2023/09/25	Total Dissolved Solids	mg/L	292
UA	G51D	C	2023/10/25	Total Dissolved Solids	mg/L	270
UA	G52D	C	2015/12/03	pH (field)	SU	6.5
UA	G52D	C	2016/03/15	pH (field)	SU	6.3
UA	G52D	C	2016/06/15	pH (field)	SU	6.6
UA	G52D	C	2016/09/14	pH (field)	SU	6.4
UA	G52D	C	2016/12/14	pH (field)	SU	6.7
UA	G52D	C	2017/03/07	pH (field)	SU	5.9
UA	G52D	C	2017/06/14	pH (field)	SU	6.2
UA	G52D	C	2017/07/19	pH (field)	SU	6.4
UA	G52D	C	2017/11/30	pH (field)	SU	6.0
UA	G52D	C	2018/06/19	pH (field)	SU	6.4
UA	G52D	C	2018/09/05	pH (field)	SU	6.3
UA	G52D	C	2019/03/27	pH (field)	SU	6.4
UA	G52D	C	2019/09/09	pH (field)	SU	6.0
UA	G52D	C	2020/03/30	pH (field)	SU	6.4
UA	G52D	C	2020/09/23	pH (field)	SU	6.5

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G52D	C	2021/03/25	pH (field)	SU	6.2
UA	G52D	C	2021/09/20	pH (field)	SU	6.3
UA	G52D	C	2022/03/15	pH (field)	SU	6.2
UA	G52D	C	2022/09/21	pH (field)	SU	6.3
UA	G52D	C	2023/03/10	pH (field)	SU	6.5
UA	G52D	C	2023/05/03	pH (field)	SU	6.3
UA	G52D	C	2023/09/26	pH (field)	SU	6.3
UA	G52D	C	2023/10/24	pH (field)	SU	6.3
UA	G52D	C	2015/12/03	Oxidation Reduction Potential	mV	-5.00
UA	G52D	C	2016/03/15	Oxidation Reduction Potential	mV	-81.0
UA	G52D	C	2016/06/15	Oxidation Reduction Potential	mV	-131
UA	G52D	C	2016/09/14	Oxidation Reduction Potential	mV	-76.0
UA	G52D	C	2016/12/14	Oxidation Reduction Potential	mV	104
UA	G52D	C	2017/03/07	Oxidation Reduction Potential	mV	26.0
UA	G52D	C	2017/06/14	Oxidation Reduction Potential	mV	61.0
UA	G52D	C	2017/07/19	Oxidation Reduction Potential	mV	-48.0
UA	G52D	C	2017/11/30	Oxidation Reduction Potential	mV	-59.0
UA	G52D	C	2018/06/19	Oxidation Reduction Potential	mV	-136
UA	G52D	C	2018/09/05	Oxidation Reduction Potential	mV	-49.0
UA	G52D	C	2019/03/27	Oxidation Reduction Potential	mV	-31.0
UA	G52D	C	2019/09/09	Oxidation Reduction Potential	mV	164
UA	G52D	C	2020/03/30	Oxidation Reduction Potential	mV	-12.0
UA	G52D	C	2020/09/23	Oxidation Reduction Potential	mV	-19.0
UA	G52D	C	2021/03/25	Oxidation Reduction Potential	mV	4.00
UA	G52D	C	2021/09/20	Oxidation Reduction Potential	mV	25.0
UA	G52D	C	2022/03/15	Oxidation Reduction Potential	mV	-48.0
UA	G52D	C	2022/09/21	Oxidation Reduction Potential	mV	122
UA	G52D	C	2023/03/10	Oxidation Reduction Potential	mV	26.7
UA	G52D	C	2023/05/03	Oxidation Reduction Potential	mV	68.0
UA	G52D	C	2023/09/26	Oxidation Reduction Potential	mV	55.0
UA	G52D	C	2023/10/24	Oxidation Reduction Potential	mV	<-300
UA	G52D	C	2015/12/03	Eh	V	0.19
UA	G52D	C	2016/03/15	Eh	V	0.11
UA	G52D	C	2016/06/15	Eh	V	0.061
UA	G52D	C	2016/09/14	Eh	V	0.12
UA	G52D	C	2016/12/14	Eh	V	0.30
UA	G52D	C	2017/03/07	Eh	V	0.22
UA	G52D	C	2017/06/14	Eh	V	0.25
UA	G52D	C	2017/07/19	Eh	V	0.14
UA	G52D	C	2017/11/30	Eh	V	0.14
UA	G52D	C	2018/06/19	Eh	V	0.058
UA	G52D	C	2018/09/05	Eh	V	0.15
UA	G52D	C	2019/03/27	Eh	V	0.16
UA	G52D	C	2019/09/09	Eh	V	0.36
UA	G52D	C	2020/03/30	Eh	V	0.18
UA	G52D	C	2020/09/23	Eh	V	0.18
UA	G52D	C	2021/03/25	Eh	V	0.20
UA	G52D	C	2021/09/20	Eh	V	0.22
UA	G52D	C	2022/03/15	Eh	V	0.15
UA	G52D	C	2022/09/21	Eh	V	0.32
UA	G52D	C	2023/03/10	Eh	V	0.22
UA	G52D	C	2023/05/03	Eh	V	0.26
UA	G52D	C	2023/09/26	Eh	V	0.25
UA	G52D	C	2023/10/24	Eh	V	-0.11
UA	G52D	C	2017/07/19	Alkalinity, bicarbonate	mg/L CaCO3	148

Attachment I. Site Groundwater Data
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Joppa East Ash Pond
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HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G52D	C	2020/03/30	Alkalinity, bicarbonate	mg/L CaCO3	152
UA	G52D	C	2021/03/25	Alkalinity, bicarbonate	mg/L CaCO3	149
UA	G52D	C	2021/09/20	Alkalinity, bicarbonate	mg/L CaCO3	147
UA	G52D	C	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	151
UA	G52D	C	2023/03/10	Alkalinity, bicarbonate	mg/L CaCO3	156
UA	G52D	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	53.0
UA	G52D	C	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G52D	C	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	152
UA	G52D	C	2015/12/03	Barium, total	mg/L	0.318
UA	G52D	C	2016/03/15	Barium, total	mg/L	0.345
UA	G52D	C	2016/06/15	Barium, total	mg/L	0.506
UA	G52D	C	2016/09/14	Barium, total	mg/L	0.362
UA	G52D	C	2016/12/14	Barium, total	mg/L	0.356
UA	G52D	C	2017/03/07	Barium, total	mg/L	0.358
UA	G52D	C	2017/06/14	Barium, total	mg/L	0.289
UA	G52D	C	2017/07/19	Barium, total	mg/L	0.293
UA	G52D	C	2018/06/19	Barium, total	mg/L	0.340
UA	G52D	C	2018/09/05	Barium, total	mg/L	0.275
UA	G52D	C	2019/03/27	Barium, total	mg/L	0.271
UA	G52D	C	2019/09/09	Barium, total	mg/L	0.254
UA	G52D	C	2020/03/30	Barium, total	mg/L	0.254
UA	G52D	C	2020/09/23	Barium, total	mg/L	0.278
UA	G52D	C	2021/03/25	Barium, total	mg/L	0.254
UA	G52D	C	2021/09/20	Barium, total	mg/L	0.232
UA	G52D	C	2022/03/15	Barium, total	mg/L	0.208
UA	G52D	C	2022/09/21	Barium, total	mg/L	0.225
UA	G52D	C	2023/03/10	Barium, total	mg/L	0.307
UA	G52D	C	2023/05/03	Barium, total	mg/L	0.0461
UA	G52D	C	2023/09/26	Barium, total	mg/L	0.250
UA	G52D	C	2023/10/24	Barium, total	mg/L	0.354
UA	G52D	C	2015/12/03	Boron, total	mg/L	<0.01
UA	G52D	C	2016/03/15	Boron, total	mg/L	<0.01
UA	G52D	C	2016/06/15	Boron, total	mg/L	<0.01
UA	G52D	C	2016/09/14	Boron, total	mg/L	<0.01
UA	G52D	C	2016/12/14	Boron, total	mg/L	<0.01
UA	G52D	C	2017/03/07	Boron, total	mg/L	<0.01
UA	G52D	C	2017/06/14	Boron, total	mg/L	<0.01
UA	G52D	C	2017/07/19	Boron, total	mg/L	<0.01
UA	G52D	C	2017/11/30	Boron, total	mg/L	<0.01
UA	G52D	C	2018/06/19	Boron, total	mg/L	<0.0092
UA	G52D	C	2018/09/05	Boron, total	mg/L	<0.0092
UA	G52D	C	2019/03/27	Boron, total	mg/L	<0.0092
UA	G52D	C	2019/09/09	Boron, total	mg/L	<0.0092
UA	G52D	C	2020/03/30	Boron, total	mg/L	<0.0092
UA	G52D	C	2020/09/23	Boron, total	mg/L	<0.0092
UA	G52D	C	2021/03/25	Boron, total	mg/L	<0.0092
UA	G52D	C	2021/09/20	Boron, total	mg/L	<0.0092
UA	G52D	C	2022/03/15	Boron, total	mg/L	<0.0092
UA	G52D	C	2022/09/21	Boron, total	mg/L	0.0110
UA	G52D	C	2023/03/10	Boron, total	mg/L	0.0319
UA	G52D	C	2023/05/03	Boron, total	mg/L	0.682
UA	G52D	C	2023/09/26	Boron, total	mg/L	<0.0092
UA	G52D	C	2023/10/24	Boron, total	mg/L	0.0210
UA	G52D	C	2015/12/03	Calcium, total	mg/L	46.6
UA	G52D	C	2016/03/15	Calcium, total	mg/L	49.1

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G52D	C	2016/06/15	Calcium, total	mg/L	69.2
UA	G52D	C	2016/09/14	Calcium, total	mg/L	47.6
UA	G52D	C	2016/12/14	Calcium, total	mg/L	53.4
UA	G52D	C	2017/03/07	Calcium, total	mg/L	55.0
UA	G52D	C	2017/06/14	Calcium, total	mg/L	51.0
UA	G52D	C	2017/07/19	Calcium, total	mg/L	50.7
UA	G52D	C	2017/11/30	Calcium, total	mg/L	54.7
UA	G52D	C	2018/06/19	Calcium, total	mg/L	50.1
UA	G52D	C	2018/09/05	Calcium, total	mg/L	49.8
UA	G52D	C	2019/03/27	Calcium, total	mg/L	59.8
UA	G52D	C	2019/09/09	Calcium, total	mg/L	52.2
UA	G52D	C	2020/03/30	Calcium, total	mg/L	48.8
UA	G52D	C	2020/09/23	Calcium, total	mg/L	59.0
UA	G52D	C	2021/03/25	Calcium, total	mg/L	48.6
UA	G52D	C	2021/09/20	Calcium, total	mg/L	47.8
UA	G52D	C	2022/03/15	Calcium, total	mg/L	48.3
UA	G52D	C	2022/09/21	Calcium, total	mg/L	45.6
UA	G52D	C	2023/03/10	Calcium, total	mg/L	49.3
UA	G52D	C	2023/05/03	Calcium, total	mg/L	28.8
UA	G52D	C	2023/09/26	Calcium, total	mg/L	44.8
UA	G52D	C	2023/10/24	Calcium, total	mg/L	47.9
UA	G52D	C	2015/12/03	Chloride, total	mg/L	22.0
UA	G52D	C	2016/03/15	Chloride, total	mg/L	22.0
UA	G52D	C	2016/06/15	Chloride, total	mg/L	21.0
UA	G52D	C	2016/09/14	Chloride, total	mg/L	20.0
UA	G52D	C	2016/12/14	Chloride, total	mg/L	20.0
UA	G52D	C	2017/03/07	Chloride, total	mg/L	18.0
UA	G52D	C	2017/06/14	Chloride, total	mg/L	17.0
UA	G52D	C	2017/07/19	Chloride, total	mg/L	15.0
UA	G52D	C	2017/11/30	Chloride, total	mg/L	15.0
UA	G52D	C	2018/06/19	Chloride, total	mg/L	15.0
UA	G52D	C	2018/09/05	Chloride, total	mg/L	14.0
UA	G52D	C	2019/03/27	Chloride, total	mg/L	13.0
UA	G52D	C	2019/09/09	Chloride, total	mg/L	14.0
UA	G52D	C	2020/03/30	Chloride, total	mg/L	14.0
UA	G52D	C	2020/09/23	Chloride, total	mg/L	15.0
UA	G52D	C	2021/03/25	Chloride, total	mg/L	14.0
UA	G52D	C	2021/09/20	Chloride, total	mg/L	13.0
UA	G52D	C	2022/03/15	Chloride, total	mg/L	12.0
UA	G52D	C	2022/09/21	Chloride, total	mg/L	12.0
UA	G52D	C	2023/03/10	Chloride, total	mg/L	12.0
UA	G52D	C	2023/05/03	Chloride, total	mg/L	5.00
UA	G52D	C	2023/09/26	Chloride, total	mg/L	11.0
UA	G52D	C	2023/10/24	Chloride, total	mg/L	12.0
UA	G52D	C	2015/12/03	Cobalt, total	mg/L	0.00560
UA	G52D	C	2016/03/15	Cobalt, total	mg/L	0.00640
UA	G52D	C	2016/06/15	Cobalt, total	mg/L	0.00930
UA	G52D	C	2016/09/14	Cobalt, total	mg/L	0.00630
UA	G52D	C	2016/12/14	Cobalt, total	mg/L	0.00300
UA	G52D	C	2017/03/07	Cobalt, total	mg/L	0.00720
UA	G52D	C	2017/06/14	Cobalt, total	mg/L	0.00620
UA	G52D	C	2017/07/19	Cobalt, total	mg/L	0.00130
UA	G52D	C	2018/06/19	Cobalt, total	mg/L	0.00450
UA	G52D	C	2018/09/05	Cobalt, total	mg/L	0.00190
UA	G52D	C	2019/03/27	Cobalt, total	mg/L	0.00690

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G52D	C	2019/09/09	Cobalt, total	mg/L	0.00220
UA	G52D	C	2020/03/30	Cobalt, total	mg/L	0.00330
UA	G52D	C	2020/09/23	Cobalt, total	mg/L	0.00150
UA	G52D	C	2021/03/25	Cobalt, total	mg/L	0.00160
UA	G52D	C	2021/09/20	Cobalt, total	mg/L	0.00110
UA	G52D	C	2022/03/15	Cobalt, total	mg/L	0.00630
UA	G52D	C	2022/09/21	Cobalt, total	mg/L	0.00440
UA	G52D	C	2023/03/10	Cobalt, total	mg/L	0.00220
UA	G52D	C	2023/05/03	Cobalt, total	mg/L	0.00240
UA	G52D	C	2023/09/26	Cobalt, total	mg/L	0.00420
UA	G52D	C	2023/10/24	Cobalt, total	mg/L	0.00340
UA	G52D	C	2023/05/03	Iron, dissolved	mg/L	<0.04
UA	G52D	C	2023/09/26	Iron, dissolved	mg/L	2.56
UA	G52D	C	2017/07/19	Magnesium, total	mg/L	17.0
UA	G52D	C	2020/03/30	Magnesium, total	mg/L	15.3
UA	G52D	C	2021/03/25	Magnesium, total	mg/L	14.6
UA	G52D	C	2022/03/15	Magnesium, total	mg/L	15.1
UA	G52D	C	2023/03/10	Magnesium, total	mg/L	15.3
UA	G52D	C	2023/05/03	Magnesium, total	mg/L	12.1
UA	G52D	C	2023/09/26	Magnesium, total	mg/L	14.3
UA	G52D	C	2023/10/24	Magnesium, total	mg/L	15.0
UA	G52D	C	2023/05/03	Manganese, dissolved	mg/L	0.0132
UA	G52D	C	2023/09/26	Manganese, dissolved	mg/L	0.193
UA	G52D	C	2023/05/03	Phosphate, dissolved	mg/L	0.0580
UA	G52D	C	2023/09/26	Phosphate, dissolved	mg/L	0.215
UA	G52D	C	2017/07/19	Potassium, total	mg/L	0.745
UA	G52D	C	2020/03/30	Potassium, total	mg/L	0.858
UA	G52D	C	2021/03/25	Potassium, total	mg/L	0.697
UA	G52D	C	2022/03/15	Potassium, total	mg/L	0.743
UA	G52D	C	2023/03/10	Potassium, total	mg/L	0.768
UA	G52D	C	2023/05/03	Potassium, total	mg/L	0.493
UA	G52D	C	2023/09/26	Potassium, total	mg/L	0.702
UA	G52D	C	2023/10/24	Potassium, total	mg/L	0.808
UA	G52D	C	2023/05/03	Silicon, dissolved	mg/L	21.0
UA	G52D	C	2023/09/26	Silicon, dissolved	mg/L	20.7
UA	G52D	C	2017/07/19	Sodium, total	mg/L	34.8
UA	G52D	C	2020/03/30	Sodium, total	mg/L	32.4
UA	G52D	C	2021/03/25	Sodium, total	mg/L	29.2
UA	G52D	C	2022/03/15	Sodium, total	mg/L	29.0
UA	G52D	C	2023/03/10	Sodium, total	mg/L	27.7
UA	G52D	C	2023/05/03	Sodium, total	mg/L	36.1
UA	G52D	C	2023/09/26	Sodium, total	mg/L	26.2
UA	G52D	C	2023/10/24	Sodium, total	mg/L	29.9
UA	G52D	C	2015/12/03	Sulfate, total	mg/L	65.0
UA	G52D	C	2016/03/15	Sulfate, total	mg/L	99.0
UA	G52D	C	2016/06/15	Sulfate, total	mg/L	88.0
UA	G52D	C	2016/09/14	Sulfate, total	mg/L	84.0
UA	G52D	C	2016/12/14	Sulfate, total	mg/L	82.0
UA	G52D	C	2017/03/07	Sulfate, total	mg/L	115
UA	G52D	C	2017/06/14	Sulfate, total	mg/L	112
UA	G52D	C	2017/07/19	Sulfate, total	mg/L	108
UA	G52D	C	2017/11/30	Sulfate, total	mg/L	97.0
UA	G52D	C	2018/06/19	Sulfate, total	mg/L	97.0
UA	G52D	C	2018/09/05	Sulfate, total	mg/L	101
UA	G52D	C	2019/03/27	Sulfate, total	mg/L	81.0

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G52D	C	2019/09/09	Sulfate, total	mg/L	78.0
UA	G52D	C	2020/03/30	Sulfate, total	mg/L	84.0
UA	G52D	C	2020/09/23	Sulfate, total	mg/L	84.0
UA	G52D	C	2021/03/25	Sulfate, total	mg/L	75.0
UA	G52D	C	2021/09/20	Sulfate, total	mg/L	83.0
UA	G52D	C	2022/03/15	Sulfate, total	mg/L	68.0
UA	G52D	C	2022/09/21	Sulfate, total	mg/L	72.0
UA	G52D	C	2023/03/10	Sulfate, total	mg/L	74.0
UA	G52D	C	2023/05/03	Sulfate, total	mg/L	129
UA	G52D	C	2023/09/26	Sulfate, total	mg/L	52.0
UA	G52D	C	2023/10/24	Sulfate, total	mg/L	52.0
UA	G52D	C	2015/12/03	Temperature (Celsius)	degrees C	15.4
UA	G52D	C	2016/03/15	Temperature (Celsius)	degrees C	17.9
UA	G52D	C	2016/06/15	Temperature (Celsius)	degrees C	19.6
UA	G52D	C	2016/09/14	Temperature (Celsius)	degrees C	19.0
UA	G52D	C	2016/12/14	Temperature (Celsius)	degrees C	16.1
UA	G52D	C	2017/03/07	Temperature (Celsius)	degrees C	14.1
UA	G52D	C	2017/06/14	Temperature (Celsius)	degrees C	24.1
UA	G52D	C	2017/07/19	Temperature (Celsius)	degrees C	23.8
UA	G52D	C	2017/11/30	Temperature (Celsius)	degrees C	14.8
UA	G52D	C	2018/06/19	Temperature (Celsius)	degrees C	17
UA	G52D	C	2018/09/05	Temperature (Celsius)	degrees C	17.1
UA	G52D	C	2019/03/27	Temperature (Celsius)	degrees C	14.8
UA	G52D	C	2019/09/09	Temperature (Celsius)	degrees C	17.3
UA	G52D	C	2020/03/30	Temperature (Celsius)	degrees C	15.2
UA	G52D	C	2020/09/23	Temperature (Celsius)	degrees C	15.7
UA	G52D	C	2021/03/25	Temperature (Celsius)	degrees C	15.3
UA	G52D	C	2021/09/20	Temperature (Celsius)	degrees C	18.2
UA	G52D	C	2022/03/15	Temperature (Celsius)	degrees C	14.7
UA	G52D	C	2022/09/21	Temperature (Celsius)	degrees C	17.4
UA	G52D	C	2023/03/10	Temperature (Celsius)	degrees C	14.8
UA	G52D	C	2023/05/03	Temperature (Celsius)	degrees C	16.7
UA	G52D	C	2023/09/26	Temperature (Celsius)	degrees C	15.9
UA	G52D	C	2023/10/24	Temperature (Celsius)	degrees C	16.6
UA	G52D	C	2015/12/03	Total Dissolved Solids	mg/L	332
UA	G52D	C	2016/03/15	Total Dissolved Solids	mg/L	310
UA	G52D	C	2016/06/15	Total Dissolved Solids	mg/L	360
UA	G52D	C	2016/09/14	Total Dissolved Solids	mg/L	376
UA	G52D	C	2016/12/14	Total Dissolved Solids	mg/L	356
UA	G52D	C	2017/03/07	Total Dissolved Solids	mg/L	410
UA	G52D	C	2017/06/14	Total Dissolved Solids	mg/L	372
UA	G52D	C	2017/07/19	Total Dissolved Solids	mg/L	412
UA	G52D	C	2017/11/30	Total Dissolved Solids	mg/L	392
UA	G52D	C	2018/06/19	Total Dissolved Solids	mg/L	388
UA	G52D	C	2018/09/05	Total Dissolved Solids	mg/L	384
UA	G52D	C	2019/03/27	Total Dissolved Solids	mg/L	376
UA	G52D	C	2019/09/09	Total Dissolved Solids	mg/L	370
UA	G52D	C	2020/03/30	Total Dissolved Solids	mg/L	362
UA	G52D	C	2020/09/23	Total Dissolved Solids	mg/L	336
UA	G52D	C	2021/03/25	Total Dissolved Solids	mg/L	332
UA	G52D	C	2021/09/20	Total Dissolved Solids	mg/L	318
UA	G52D	C	2022/03/15	Total Dissolved Solids	mg/L	350
UA	G52D	C	2022/09/21	Total Dissolved Solids	mg/L	334
UA	G52D	C	2023/03/10	Total Dissolved Solids	mg/L	292
UA	G52D	C	2023/05/03	Total Dissolved Solids	mg/L	296

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G52D	C	2023/09/26	Total Dissolved Solids	mg/L	282
UA	G52D	C	2023/10/24	Total Dissolved Solids	mg/L	296
UA	G53D	C	2015/12/03	pH (field)	SU	6.8
UA	G53D	C	2016/03/15	pH (field)	SU	6.7
UA	G53D	C	2016/06/15	pH (field)	SU	6.6
UA	G53D	C	2016/09/14	pH (field)	SU	6.5
UA	G53D	C	2016/12/14	pH (field)	SU	6.8
UA	G53D	C	2017/03/08	pH (field)	SU	7.2
UA	G53D	C	2017/06/15	pH (field)	SU	6.6
UA	G53D	C	2017/07/20	pH (field)	SU	6.8
UA	G53D	C	2017/11/30	pH (field)	SU	6.6
UA	G53D	C	2018/06/19	pH (field)	SU	6.6
UA	G53D	C	2018/09/05	pH (field)	SU	6.8
UA	G53D	C	2019/03/27	pH (field)	SU	6.6
UA	G53D	C	2019/09/09	pH (field)	SU	6.2
UA	G53D	C	2020/03/30	pH (field)	SU	6.7
UA	G53D	C	2020/09/23	pH (field)	SU	6.7
UA	G53D	C	2021/03/25	pH (field)	SU	6.5
UA	G53D	C	2021/09/20	pH (field)	SU	6.3
UA	G53D	C	2022/03/15	pH (field)	SU	6.5
UA	G53D	C	2022/07/25	pH (field)	SU	7.9
UA	G53D	C	2022/09/20	pH (field)	SU	6.5
UA	G53D	C	2023/03/09	pH (field)	SU	6.5
UA	G53D	C	2023/05/03	pH (field)	SU	6.5
UA	G53D	C	2023/09/27	pH (field)	SU	6.5
UA	G53D	C	2023/10/25	pH (field)	SU	6.5
UA	G53D	C	2015/12/03	Oxidation Reduction Potential	mV	45.0
UA	G53D	C	2016/03/15	Oxidation Reduction Potential	mV	64.0
UA	G53D	C	2016/06/15	Oxidation Reduction Potential	mV	112
UA	G53D	C	2016/09/14	Oxidation Reduction Potential	mV	189
UA	G53D	C	2016/12/14	Oxidation Reduction Potential	mV	70.0
UA	G53D	C	2017/03/08	Oxidation Reduction Potential	mV	251
UA	G53D	C	2017/06/15	Oxidation Reduction Potential	mV	200
UA	G53D	C	2017/07/20	Oxidation Reduction Potential	mV	100
UA	G53D	C	2017/11/30	Oxidation Reduction Potential	mV	85.0
UA	G53D	C	2018/06/19	Oxidation Reduction Potential	mV	151
UA	G53D	C	2018/09/05	Oxidation Reduction Potential	mV	37.0
UA	G53D	C	2019/03/27	Oxidation Reduction Potential	mV	172
UA	G53D	C	2019/09/09	Oxidation Reduction Potential	mV	171
UA	G53D	C	2020/03/30	Oxidation Reduction Potential	mV	141
UA	G53D	C	2020/09/23	Oxidation Reduction Potential	mV	101
UA	G53D	C	2021/03/25	Oxidation Reduction Potential	mV	138
UA	G53D	C	2021/09/20	Oxidation Reduction Potential	mV	66.0
UA	G53D	C	2022/03/15	Oxidation Reduction Potential	mV	5.00
UA	G53D	C	2022/07/25	Oxidation Reduction Potential	mV	-16.0
UA	G53D	C	2022/09/20	Oxidation Reduction Potential	mV	183
UA	G53D	C	2023/03/09	Oxidation Reduction Potential	mV	3.60
UA	G53D	C	2023/05/03	Oxidation Reduction Potential	mV	137
UA	G53D	C	2023/09/27	Oxidation Reduction Potential	mV	-23.0
UA	G53D	C	2023/10/25	Oxidation Reduction Potential	mV	49.0
UA	G53D	C	2015/12/03	Eh	V	0.24
UA	G53D	C	2016/03/15	Eh	V	0.26
UA	G53D	C	2016/06/15	Eh	V	0.31
UA	G53D	C	2016/09/14	Eh	V	0.38
UA	G53D	C	2016/12/14	Eh	V	0.26

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G53D	C	2017/03/08	Eh	V	0.45
UA	G53D	C	2017/06/15	Eh	V	0.39
UA	G53D	C	2017/07/20	Eh	V	0.29
UA	G53D	C	2017/11/30	Eh	V	0.28
UA	G53D	C	2018/06/19	Eh	V	0.34
UA	G53D	C	2018/09/05	Eh	V	0.23
UA	G53D	C	2019/03/27	Eh	V	0.37
UA	G53D	C	2019/09/09	Eh	V	0.36
UA	G53D	C	2020/03/30	Eh	V	0.34
UA	G53D	C	2020/09/23	Eh	V	0.30
UA	G53D	C	2021/03/25	Eh	V	0.33
UA	G53D	C	2021/09/20	Eh	V	0.26
UA	G53D	C	2022/03/15	Eh	V	0.20
UA	G53D	C	2022/07/25	Eh	V	0.18
UA	G53D	C	2022/09/20	Eh	V	0.38
UA	G53D	C	2023/03/09	Eh	V	0.20
UA	G53D	C	2023/05/03	Eh	V	0.33
UA	G53D	C	2023/09/27	Eh	V	0.17
UA	G53D	C	2023/10/25	Eh	V	0.24
UA	G53D	C	2017/07/20	Alkalinity, bicarbonate	mg/L CaCO3	194
UA	G53D	C	2020/03/30	Alkalinity, bicarbonate	mg/L CaCO3	160
UA	G53D	C	2021/03/25	Alkalinity, bicarbonate	mg/L CaCO3	166
UA	G53D	C	2021/09/20	Alkalinity, bicarbonate	mg/L CaCO3	171
UA	G53D	C	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	176
UA	G53D	C	2022/07/25	Alkalinity, bicarbonate	mg/L CaCO3	149
UA	G53D	C	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G53D	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	170
UA	G53D	C	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G53D	C	2023/10/25	Alkalinity, bicarbonate	mg/L CaCO3	170
UA	G53D	C	2015/12/03	Barium, total	mg/L	0.353
UA	G53D	C	2016/03/15	Barium, total	mg/L	0.279
UA	G53D	C	2016/06/15	Barium, total	mg/L	0.207
UA	G53D	C	2016/09/14	Barium, total	mg/L	0.191
UA	G53D	C	2016/12/14	Barium, total	mg/L	0.169
UA	G53D	C	2017/03/08	Barium, total	mg/L	0.109
UA	G53D	C	2017/06/15	Barium, total	mg/L	0.172
UA	G53D	C	2017/07/20	Barium, total	mg/L	0.165
UA	G53D	C	2018/06/19	Barium, total	mg/L	0.176
UA	G53D	C	2018/09/05	Barium, total	mg/L	0.133
UA	G53D	C	2019/03/27	Barium, total	mg/L	0.101
UA	G53D	C	2019/09/09	Barium, total	mg/L	0.128
UA	G53D	C	2020/03/30	Barium, total	mg/L	0.109
UA	G53D	C	2020/09/23	Barium, total	mg/L	0.122
UA	G53D	C	2021/03/25	Barium, total	mg/L	0.112
UA	G53D	C	2021/09/20	Barium, total	mg/L	0.103
UA	G53D	C	2022/03/15	Barium, total	mg/L	0.0922
UA	G53D	C	2022/07/25	Barium, total	mg/L	0.0913
UA	G53D	C	2022/09/20	Barium, total	mg/L	0.109
UA	G53D	C	2023/03/09	Barium, total	mg/L	0.101
UA	G53D	C	2023/05/03	Barium, total	mg/L	0.102
UA	G53D	C	2023/09/27	Barium, total	mg/L	0.0910
UA	G53D	C	2023/10/25	Barium, total	mg/L	0.107
UA	G53D	C	2015/12/03	Boron, total	mg/L	0.332
UA	G53D	C	2016/03/15	Boron, total	mg/L	0.334
UA	G53D	C	2016/06/15	Boron, total	mg/L	0.342

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G53D	C	2016/09/14	Boron, total	mg/L	0.368
UA	G53D	C	2016/12/14	Boron, total	mg/L	0.364
UA	G53D	C	2017/03/08	Boron, total	mg/L	0.138
UA	G53D	C	2017/06/15	Boron, total	mg/L	0.309
UA	G53D	C	2017/07/20	Boron, total	mg/L	0.366
UA	G53D	C	2017/11/30	Boron, total	mg/L	0.427
UA	G53D	C	2018/06/19	Boron, total	mg/L	0.361
UA	G53D	C	2018/09/05	Boron, total	mg/L	0.392
UA	G53D	C	2019/03/27	Boron, total	mg/L	0.269
UA	G53D	C	2019/09/09	Boron, total	mg/L	0.385
UA	G53D	C	2020/03/30	Boron, total	mg/L	0.334
UA	G53D	C	2020/09/23	Boron, total	mg/L	0.411
UA	G53D	C	2021/03/25	Boron, total	mg/L	0.355
UA	G53D	C	2021/09/20	Boron, total	mg/L	0.402
UA	G53D	C	2022/03/15	Boron, total	mg/L	0.332
UA	G53D	C	2022/07/25	Boron, total	mg/L	0.341
UA	G53D	C	2022/09/20	Boron, total	mg/L	0.431
UA	G53D	C	2023/03/09	Boron, total	mg/L	0.370
UA	G53D	C	2023/05/03	Boron, total	mg/L	0.367
UA	G53D	C	2023/09/27	Boron, total	mg/L	0.371
UA	G53D	C	2023/10/25	Boron, total	mg/L	0.349
UA	G53D	C	2015/12/03	Calcium, total	mg/L	62.6
UA	G53D	C	2016/03/15	Calcium, total	mg/L	50.5
UA	G53D	C	2016/06/15	Calcium, total	mg/L	47.2
UA	G53D	C	2016/09/14	Calcium, total	mg/L	44.4
UA	G53D	C	2016/12/14	Calcium, total	mg/L	44.5
UA	G53D	C	2017/03/08	Calcium, total	mg/L	23.6
UA	G53D	C	2017/06/15	Calcium, total	mg/L	38.9
UA	G53D	C	2017/07/20	Calcium, total	mg/L	40.8
UA	G53D	C	2017/11/30	Calcium, total	mg/L	44.6
UA	G53D	C	2018/06/19	Calcium, total	mg/L	37.8
UA	G53D	C	2018/09/05	Calcium, total	mg/L	40.3
UA	G53D	C	2019/03/27	Calcium, total	mg/L	30.5
UA	G53D	C	2019/09/09	Calcium, total	mg/L	42.2
UA	G53D	C	2020/03/30	Calcium, total	mg/L	34.8
UA	G53D	C	2020/09/23	Calcium, total	mg/L	44.4
UA	G53D	C	2021/03/25	Calcium, total	mg/L	38.6
UA	G53D	C	2021/09/20	Calcium, total	mg/L	38.5
UA	G53D	C	2022/03/15	Calcium, total	mg/L	38.1
UA	G53D	C	2022/07/25	Calcium, total	mg/L	39.7
UA	G53D	C	2022/09/20	Calcium, total	mg/L	35.9
UA	G53D	C	2023/03/09	Calcium, total	mg/L	38.3
UA	G53D	C	2023/05/03	Calcium, total	mg/L	34.3
UA	G53D	C	2023/09/27	Calcium, total	mg/L	35.9
UA	G53D	C	2023/10/25	Calcium, total	mg/L	38.6
UA	G53D	C	2015/12/03	Chloride, total	mg/L	22.0
UA	G53D	C	2016/03/15	Chloride, total	mg/L	20.0
UA	G53D	C	2016/06/15	Chloride, total	mg/L	17.0
UA	G53D	C	2016/09/14	Chloride, total	mg/L	20.0
UA	G53D	C	2016/12/14	Chloride, total	mg/L	20.0
UA	G53D	C	2017/03/08	Chloride, total	mg/L	6.00
UA	G53D	C	2017/06/15	Chloride, total	mg/L	18.0
UA	G53D	C	2017/07/20	Chloride, total	mg/L	18.0
UA	G53D	C	2017/11/30	Chloride, total	mg/L	20.0
UA	G53D	C	2018/06/19	Chloride, total	mg/L	18.0

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G53D	C	2018/09/05	Chloride, total	mg/L	20.0
UA	G53D	C	2019/03/27	Chloride, total	mg/L	12.0
UA	G53D	C	2019/09/09	Chloride, total	mg/L	18.0
UA	G53D	C	2020/03/30	Chloride, total	mg/L	17.0
UA	G53D	C	2020/09/23	Chloride, total	mg/L	20.0
UA	G53D	C	2021/03/25	Chloride, total	mg/L	19.0
UA	G53D	C	2021/09/20	Chloride, total	mg/L	19.0
UA	G53D	C	2022/03/15	Chloride, total	mg/L	18.0
UA	G53D	C	2022/07/25	Chloride, total	mg/L	19.0
UA	G53D	C	2022/09/20	Chloride, total	mg/L	18.0
UA	G53D	C	2023/03/09	Chloride, total	mg/L	17.0
UA	G53D	C	2023/05/03	Chloride, total	mg/L	18.0
UA	G53D	C	2023/09/27	Chloride, total	mg/L	17.0
UA	G53D	C	2023/10/25	Chloride, total	mg/L	18.0
UA	G53D	C	2015/12/03	Cobalt, total	mg/L	0.00870
UA	G53D	C	2016/03/15	Cobalt, total	mg/L	0.00870
UA	G53D	C	2016/06/15	Cobalt, total	mg/L	0.00590
UA	G53D	C	2016/09/14	Cobalt, total	mg/L	0.00200
UA	G53D	C	2016/12/14	Cobalt, total	mg/L	0.00290
UA	G53D	C	2017/03/08	Cobalt, total	mg/L	0.00270
UA	G53D	C	2017/06/15	Cobalt, total	mg/L	<0.0002
UA	G53D	C	2017/07/20	Cobalt, total	mg/L	0.00110
UA	G53D	C	2018/06/19	Cobalt, total	mg/L	<0.0001
UA	G53D	C	2018/09/05	Cobalt, total	mg/L	0.00160
UA	G53D	C	2019/03/27	Cobalt, total	mg/L	<0.0001
UA	G53D	C	2019/09/09	Cobalt, total	mg/L	0.00200
UA	G53D	C	2020/03/30	Cobalt, total	mg/L	<0.0001
UA	G53D	C	2020/09/23	Cobalt, total	mg/L	0.00240
UA	G53D	C	2021/03/25	Cobalt, total	mg/L	0.00260
UA	G53D	C	2021/09/20	Cobalt, total	mg/L	0.00210
UA	G53D	C	2022/03/15	Cobalt, total	mg/L	0.00220
UA	G53D	C	2022/07/25	Cobalt, total	mg/L	0.00210
UA	G53D	C	2022/09/20	Cobalt, total	mg/L	0.00170
UA	G53D	C	2023/03/09	Cobalt, total	mg/L	0.00220
UA	G53D	C	2023/05/03	Cobalt, total	mg/L	0.00180
UA	G53D	C	2023/09/27	Cobalt, total	mg/L	0.00130
UA	G53D	C	2023/10/25	Cobalt, total	mg/L	0.00120
UA	G53D	C	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G53D	C	2023/09/27	Iron, dissolved	mg/L	0.101
UA	G53D	C	2017/07/20	Magnesium, total	mg/L	19.2
UA	G53D	C	2020/03/30	Magnesium, total	mg/L	15.7
UA	G53D	C	2021/03/25	Magnesium, total	mg/L	15.7
UA	G53D	C	2022/03/15	Magnesium, total	mg/L	16.5
UA	G53D	C	2022/07/25	Magnesium, total	mg/L	17.0
UA	G53D	C	2023/03/09	Magnesium, total	mg/L	16.4
UA	G53D	C	2023/05/03	Magnesium, total	mg/L	15.3
UA	G53D	C	2023/09/27	Magnesium, total	mg/L	15.9
UA	G53D	C	2023/10/25	Magnesium, total	mg/L	16.9
UA	G53D	C	2023/05/03	Manganese, dissolved	mg/L	0.126
UA	G53D	C	2023/09/27	Manganese, dissolved	mg/L	0.172
UA	G53D	C	2023/05/03	Phosphate, dissolved	mg/L	0.0430
UA	G53D	C	2023/09/27	Phosphate, dissolved	mg/L	0.101
UA	G53D	C	2017/07/20	Potassium, total	mg/L	0.359
UA	G53D	C	2020/03/30	Potassium, total	mg/L	0.385
UA	G53D	C	2021/03/25	Potassium, total	mg/L	0.278

Attachment I. Site Groundwater Data
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Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G53D	C	2022/03/15	Potassium, total	mg/L	0.317
UA	G53D	C	2022/07/25	Potassium, total	mg/L	0.300
UA	G53D	C	2023/03/09	Potassium, total	mg/L	0.355
UA	G53D	C	2023/05/03	Potassium, total	mg/L	0.332
UA	G53D	C	2023/09/27	Potassium, total	mg/L	0.285
UA	G53D	C	2023/10/25	Potassium, total	mg/L	0.294
UA	G53D	C	2023/05/03	Silicon, dissolved	mg/L	18.0
UA	G53D	C	2023/09/27	Silicon, dissolved	mg/L	18.3
UA	G53D	C	2017/07/20	Sodium, total	mg/L	63.0
UA	G53D	C	2020/03/30	Sodium, total	mg/L	48.9
UA	G53D	C	2021/03/25	Sodium, total	mg/L	50.8
UA	G53D	C	2022/03/15	Sodium, total	mg/L	51.3
UA	G53D	C	2022/07/25	Sodium, total	mg/L	49.4
UA	G53D	C	2023/03/09	Sodium, total	mg/L	49.2
UA	G53D	C	2023/05/03	Sodium, total	mg/L	53.1
UA	G53D	C	2023/09/27	Sodium, total	mg/L	46.6
UA	G53D	C	2023/10/25	Sodium, total	mg/L	49.9
UA	G53D	C	2015/12/03	Sulfate, total	mg/L	103
UA	G53D	C	2016/03/15	Sulfate, total	mg/L	107
UA	G53D	C	2016/06/15	Sulfate, total	mg/L	107
UA	G53D	C	2016/09/14	Sulfate, total	mg/L	104
UA	G53D	C	2016/12/14	Sulfate, total	mg/L	106
UA	G53D	C	2017/03/08	Sulfate, total	mg/L	35.0
UA	G53D	C	2017/06/15	Sulfate, total	mg/L	79.0
UA	G53D	C	2017/07/20	Sulfate, total	mg/L	94.0
UA	G53D	C	2017/11/30	Sulfate, total	mg/L	98.0
UA	G53D	C	2018/06/19	Sulfate, total	mg/L	84.0
UA	G53D	C	2018/09/05	Sulfate, total	mg/L	81.0
UA	G53D	C	2019/03/27	Sulfate, total	mg/L	54.0
UA	G53D	C	2019/09/09	Sulfate, total	mg/L	80.0
UA	G53D	C	2020/03/30	Sulfate, total	mg/L	66.0
UA	G53D	C	2020/09/23	Sulfate, total	mg/L	79.0
UA	G53D	C	2021/03/25	Sulfate, total	mg/L	71.0
UA	G53D	C	2021/09/20	Sulfate, total	mg/L	78.0
UA	G53D	C	2022/03/15	Sulfate, total	mg/L	74.0
UA	G53D	C	2022/07/25	Sulfate, total	mg/L	77.0
UA	G53D	C	2022/09/20	Sulfate, total	mg/L	79.0
UA	G53D	C	2023/03/09	Sulfate, total	mg/L	72.0
UA	G53D	C	2023/05/03	Sulfate, total	mg/L	68.0
UA	G53D	C	2023/09/27	Sulfate, total	mg/L	73.0
UA	G53D	C	2023/10/25	Sulfate, total	mg/L	69.0
UA	G53D	C	2015/12/03	Temperature (Celsius)	degrees C	16.3
UA	G53D	C	2016/03/15	Temperature (Celsius)	degrees C	18.2
UA	G53D	C	2016/06/15	Temperature (Celsius)	degrees C	16.8
UA	G53D	C	2016/09/14	Temperature (Celsius)	degrees C	18.8
UA	G53D	C	2016/12/14	Temperature (Celsius)	degrees C	17.0
UA	G53D	C	2017/03/08	Temperature (Celsius)	degrees C	14.2
UA	G53D	C	2017/06/15	Temperature (Celsius)	degrees C	16.5
UA	G53D	C	2017/07/20	Temperature (Celsius)	degrees C	18.1
UA	G53D	C	2017/11/30	Temperature (Celsius)	degrees C	15.9
UA	G53D	C	2018/06/19	Temperature (Celsius)	degrees C	17.4
UA	G53D	C	2018/09/05	Temperature (Celsius)	degrees C	17.3
UA	G53D	C	2019/03/27	Temperature (Celsius)	degrees C	15.9
UA	G53D	C	2019/09/09	Temperature (Celsius)	degrees C	17.6
UA	G53D	C	2020/03/30	Temperature (Celsius)	degrees C	15.9

Attachment I. Site Groundwater Data
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Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G53D	C	2020/09/23	Temperature (Celsius)	degrees C	16.4
UA	G53D	C	2021/03/25	Temperature (Celsius)	degrees C	15.6
UA	G53D	C	2021/09/20	Temperature (Celsius)	degrees C	17.4
UA	G53D	C	2022/03/15	Temperature (Celsius)	degrees C	16.2
UA	G53D	C	2022/07/25	Temperature (Celsius)	degrees C	17.9
UA	G53D	C	2022/09/20	Temperature (Celsius)	degrees C	18.1
UA	G53D	C	2023/03/09	Temperature (Celsius)	degrees C	15.7
UA	G53D	C	2023/05/03	Temperature (Celsius)	degrees C	16.7
UA	G53D	C	2023/09/27	Temperature (Celsius)	degrees C	17.0
UA	G53D	C	2023/10/25	Temperature (Celsius)	degrees C	17.7
UA	G53D	C	2015/12/03	Total Dissolved Solids	mg/L	368
UA	G53D	C	2016/03/15	Total Dissolved Solids	mg/L	406
UA	G53D	C	2016/06/15	Total Dissolved Solids	mg/L	392
UA	G53D	C	2016/09/14	Total Dissolved Solids	mg/L	424
UA	G53D	C	2016/12/14	Total Dissolved Solids	mg/L	418
UA	G53D	C	2017/03/08	Total Dissolved Solids	mg/L	216
UA	G53D	C	2017/06/15	Total Dissolved Solids	mg/L	348
UA	G53D	C	2017/07/20	Total Dissolved Solids	mg/L	396
UA	G53D	C	2017/11/30	Total Dissolved Solids	mg/L	348
UA	G53D	C	2018/06/19	Total Dissolved Solids	mg/L	360
UA	G53D	C	2018/09/05	Total Dissolved Solids	mg/L	390
UA	G53D	C	2019/03/27	Total Dissolved Solids	mg/L	272
UA	G53D	C	2019/09/09	Total Dissolved Solids	mg/L	364
UA	G53D	C	2020/03/30	Total Dissolved Solids	mg/L	296
UA	G53D	C	2020/09/23	Total Dissolved Solids	mg/L	342
UA	G53D	C	2021/03/25	Total Dissolved Solids	mg/L	334
UA	G53D	C	2021/09/20	Total Dissolved Solids	mg/L	324
UA	G53D	C	2022/03/15	Total Dissolved Solids	mg/L	342
UA	G53D	C	2022/07/25	Total Dissolved Solids	mg/L	330
UA	G53D	C	2022/09/20	Total Dissolved Solids	mg/L	350
UA	G53D	C	2023/03/09	Total Dissolved Solids	mg/L	346
UA	G53D	C	2023/05/03	Total Dissolved Solids	mg/L	314
UA	G53D	C	2023/09/27	Total Dissolved Solids	mg/L	330
UA	G53D	C	2023/10/25	Total Dissolved Solids	mg/L	312
UA	G54D	C	2015/12/03	pH (field)	SU	7.0
UA	G54D	C	2016/03/15	pH (field)	SU	6.8
UA	G54D	C	2016/06/15	pH (field)	SU	6.6
UA	G54D	C	2016/09/14	pH (field)	SU	6.6
UA	G54D	C	2016/12/14	pH (field)	SU	6.7
UA	G54D	C	2017/03/08	pH (field)	SU	7.1
UA	G54D	C	2017/06/15	pH (field)	SU	6.8
UA	G54D	C	2017/07/20	pH (field)	SU	6.8
UA	G54D	C	2017/11/30	pH (field)	SU	6.7
UA	G54D	C	2018/06/19	pH (field)	SU	6.7
UA	G54D	C	2018/09/05	pH (field)	SU	6.5
UA	G54D	C	2019/03/27	pH (field)	SU	6.8
UA	G54D	C	2019/09/09	pH (field)	SU	6.4
UA	G54D	C	2020/03/30	pH (field)	SU	6.8
UA	G54D	C	2020/09/23	pH (field)	SU	6.7
UA	G54D	C	2021/03/24	pH (field)	SU	6.6
UA	G54D	C	2021/09/20	pH (field)	SU	6.5
UA	G54D	C	2022/03/15	pH (field)	SU	6.6
UA	G54D	C	2022/07/26	pH (field)	SU	7.1
UA	G54D	C	2022/09/20	pH (field)	SU	6.5
UA	G54D	C	2023/03/09	pH (field)	SU	6.5

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HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G54D	C	2023/05/03	pH (field)	SU	6.8
UA	G54D	C	2023/09/26	pH (field)	SU	6.6
UA	G54D	C	2023/10/25	pH (field)	SU	6.6
UA	G54D	C	2015/12/03	Oxidation Reduction Potential	mV	3.00
UA	G54D	C	2016/03/15	Oxidation Reduction Potential	mV	-73.0
UA	G54D	C	2016/06/15	Oxidation Reduction Potential	mV	-118
UA	G54D	C	2016/09/14	Oxidation Reduction Potential	mV	7.00
UA	G54D	C	2016/12/14	Oxidation Reduction Potential	mV	142
UA	G54D	C	2017/03/08	Oxidation Reduction Potential	mV	92.0
UA	G54D	C	2017/06/15	Oxidation Reduction Potential	mV	100
UA	G54D	C	2017/07/20	Oxidation Reduction Potential	mV	37.0
UA	G54D	C	2017/11/30	Oxidation Reduction Potential	mV	39.0
UA	G54D	C	2018/06/19	Oxidation Reduction Potential	mV	25.0
UA	G54D	C	2018/09/05	Oxidation Reduction Potential	mV	-13.0
UA	G54D	C	2019/03/27	Oxidation Reduction Potential	mV	43.0
UA	G54D	C	2019/09/09	Oxidation Reduction Potential	mV	121
UA	G54D	C	2020/03/30	Oxidation Reduction Potential	mV	-1.00
UA	G54D	C	2020/09/23	Oxidation Reduction Potential	mV	62.0
UA	G54D	C	2021/03/24	Oxidation Reduction Potential	mV	92.0
UA	G54D	C	2021/09/20	Oxidation Reduction Potential	mV	27.0
UA	G54D	C	2022/03/15	Oxidation Reduction Potential	mV	-2.00
UA	G54D	C	2022/07/26	Oxidation Reduction Potential	mV	-67.9
UA	G54D	C	2022/09/20	Oxidation Reduction Potential	mV	184
UA	G54D	C	2023/03/09	Oxidation Reduction Potential	mV	1.50
UA	G54D	C	2023/05/03	Oxidation Reduction Potential	mV	42.0
UA	G54D	C	2023/09/26	Oxidation Reduction Potential	mV	38.0
UA	G54D	C	2023/10/25	Oxidation Reduction Potential	mV	-32.0
UA	G54D	C	2015/12/03	Eh	V	0.20
UA	G54D	C	2016/03/15	Eh	V	0.12
UA	G54D	C	2016/06/15	Eh	V	0.076
UA	G54D	C	2016/09/14	Eh	V	0.20
UA	G54D	C	2016/12/14	Eh	V	0.34
UA	G54D	C	2017/03/08	Eh	V	0.29
UA	G54D	C	2017/06/15	Eh	V	0.29
UA	G54D	C	2017/07/20	Eh	V	0.23
UA	G54D	C	2017/11/30	Eh	V	0.23
UA	G54D	C	2018/06/19	Eh	V	0.22
UA	G54D	C	2018/09/05	Eh	V	0.18
UA	G54D	C	2019/03/27	Eh	V	0.24
UA	G54D	C	2019/09/09	Eh	V	0.31
UA	G54D	C	2020/03/30	Eh	V	0.19
UA	G54D	C	2020/09/23	Eh	V	0.26
UA	G54D	C	2021/03/24	Eh	V	0.29
UA	G54D	C	2021/09/20	Eh	V	0.22
UA	G54D	C	2022/03/15	Eh	V	0.19
UA	G54D	C	2022/07/26	Eh	V	0.12
UA	G54D	C	2022/09/20	Eh	V	0.38
UA	G54D	C	2023/03/09	Eh	V	0.20
UA	G54D	C	2023/05/03	Eh	V	0.24
UA	G54D	C	2023/09/26	Eh	V	0.23
UA	G54D	C	2023/10/25	Eh	V	0.16
UA	G54D	C	2017/07/20	Alkalinity, bicarbonate	mg/L CaCO3	210
UA	G54D	C	2020/03/30	Alkalinity, bicarbonate	mg/L CaCO3	220
UA	G54D	C	2021/03/24	Alkalinity, bicarbonate	mg/L CaCO3	214
UA	G54D	C	2021/09/20	Alkalinity, bicarbonate	mg/L CaCO3	207

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HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G54D	C	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	208
UA	G54D	C	2022/07/26	Alkalinity, bicarbonate	mg/L CaCO3	208
UA	G54D	C	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	210
UA	G54D	C	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	206
UA	G54D	C	2023/09/26	Alkalinity, bicarbonate	mg/L CaCO3	214
UA	G54D	C	2023/10/25	Alkalinity, bicarbonate	mg/L CaCO3	201
UA	G54D	C	2015/12/03	Barium, total	mg/L	0.115
UA	G54D	C	2016/03/15	Barium, total	mg/L	0.106
UA	G54D	C	2016/06/15	Barium, total	mg/L	0.114
UA	G54D	C	2016/09/14	Barium, total	mg/L	0.134
UA	G54D	C	2016/12/14	Barium, total	mg/L	0.138
UA	G54D	C	2017/03/08	Barium, total	mg/L	0.132
UA	G54D	C	2017/06/15	Barium, total	mg/L	0.105
UA	G54D	C	2017/07/20	Barium, total	mg/L	0.127
UA	G54D	C	2018/06/19	Barium, total	mg/L	0.196
UA	G54D	C	2018/09/05	Barium, total	mg/L	0.131
UA	G54D	C	2019/03/27	Barium, total	mg/L	0.120
UA	G54D	C	2019/09/09	Barium, total	mg/L	0.128
UA	G54D	C	2020/03/30	Barium, total	mg/L	0.105
UA	G54D	C	2020/09/23	Barium, total	mg/L	0.160
UA	G54D	C	2021/03/24	Barium, total	mg/L	0.0941
UA	G54D	C	2021/09/20	Barium, total	mg/L	0.0879
UA	G54D	C	2022/03/15	Barium, total	mg/L	0.0640
UA	G54D	C	2022/07/26	Barium, total	mg/L	0.0866
UA	G54D	C	2022/09/20	Barium, total	mg/L	0.0768
UA	G54D	C	2023/03/09	Barium, total	mg/L	0.0724
UA	G54D	C	2023/05/03	Barium, total	mg/L	0.0794
UA	G54D	C	2023/09/26	Barium, total	mg/L	0.0739
UA	G54D	C	2023/10/25	Barium, total	mg/L	0.121
UA	G54D	C	2015/12/03	Boron, total	mg/L	0.663
UA	G54D	C	2016/03/15	Boron, total	mg/L	0.513
UA	G54D	C	2016/06/15	Boron, total	mg/L	0.508
UA	G54D	C	2016/09/14	Boron, total	mg/L	0.557
UA	G54D	C	2016/12/14	Boron, total	mg/L	0.564
UA	G54D	C	2017/03/08	Boron, total	mg/L	0.499
UA	G54D	C	2017/06/15	Boron, total	mg/L	0.685
UA	G54D	C	2017/07/20	Boron, total	mg/L	0.580
UA	G54D	C	2017/11/30	Boron, total	mg/L	0.646
UA	G54D	C	2018/06/19	Boron, total	mg/L	0.631
UA	G54D	C	2018/09/05	Boron, total	mg/L	0.660
UA	G54D	C	2019/03/27	Boron, total	mg/L	1.03
UA	G54D	C	2019/09/09	Boron, total	mg/L	0.614
UA	G54D	C	2020/03/30	Boron, total	mg/L	0.766
UA	G54D	C	2020/09/23	Boron, total	mg/L	0.819
UA	G54D	C	2021/03/24	Boron, total	mg/L	0.404
UA	G54D	C	2021/09/20	Boron, total	mg/L	0.350
UA	G54D	C	2022/03/15	Boron, total	mg/L	0.451
UA	G54D	C	2022/07/26	Boron, total	mg/L	0.178
UA	G54D	C	2022/09/20	Boron, total	mg/L	0.252
UA	G54D	C	2023/03/09	Boron, total	mg/L	0.555
UA	G54D	C	2023/05/03	Boron, total	mg/L	0.555
UA	G54D	C	2023/09/26	Boron, total	mg/L	0.404
UA	G54D	C	2023/10/25	Boron, total	mg/L	0.396
UA	G54D	C	2015/12/03	Calcium, total	mg/L	103
UA	G54D	C	2016/03/15	Calcium, total	mg/L	75.2

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Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G54D	C	2016/06/15	Calcium, total	mg/L	72.8
UA	G54D	C	2016/09/14	Calcium, total	mg/L	70.4
UA	G54D	C	2016/12/14	Calcium, total	mg/L	74.3
UA	G54D	C	2017/03/08	Calcium, total	mg/L	74.1
UA	G54D	C	2017/06/15	Calcium, total	mg/L	80.5
UA	G54D	C	2017/07/20	Calcium, total	mg/L	75.7
UA	G54D	C	2017/11/30	Calcium, total	mg/L	76.2
UA	G54D	C	2018/06/19	Calcium, total	mg/L	72.7
UA	G54D	C	2018/09/05	Calcium, total	mg/L	73.6
UA	G54D	C	2019/03/27	Calcium, total	mg/L	115
UA	G54D	C	2019/09/09	Calcium, total	mg/L	79.9
UA	G54D	C	2020/03/30	Calcium, total	mg/L	84.9
UA	G54D	C	2020/09/23	Calcium, total	mg/L	122
UA	G54D	C	2021/03/24	Calcium, total	mg/L	78.1
UA	G54D	C	2021/09/20	Calcium, total	mg/L	72.8
UA	G54D	C	2022/03/15	Calcium, total	mg/L	83.4
UA	G54D	C	2022/07/26	Calcium, total	mg/L	68.9
UA	G54D	C	2022/09/20	Calcium, total	mg/L	69.7
UA	G54D	C	2023/03/09	Calcium, total	mg/L	86.9
UA	G54D	C	2023/05/03	Calcium, total	mg/L	81.5
UA	G54D	C	2023/09/26	Calcium, total	mg/L	81.2
UA	G54D	C	2023/10/25	Calcium, total	mg/L	87.5
UA	G54D	C	2015/12/03	Chloride, total	mg/L	33.0
UA	G54D	C	2016/03/15	Chloride, total	mg/L	32.0
UA	G54D	C	2016/06/15	Chloride, total	mg/L	28.0
UA	G54D	C	2016/09/14	Chloride, total	mg/L	28.0
UA	G54D	C	2016/12/14	Chloride, total	mg/L	26.0
UA	G54D	C	2017/03/08	Chloride, total	mg/L	26.0
UA	G54D	C	2017/06/15	Chloride, total	mg/L	24.0
UA	G54D	C	2017/07/20	Chloride, total	mg/L	24.0
UA	G54D	C	2017/11/30	Chloride, total	mg/L	26.0
UA	G54D	C	2018/06/19	Chloride, total	mg/L	26.0
UA	G54D	C	2018/09/05	Chloride, total	mg/L	25.0
UA	G54D	C	2019/03/27	Chloride, total	mg/L	22.0
UA	G54D	C	2019/09/09	Chloride, total	mg/L	<2
UA	G54D	C	2020/03/30	Chloride, total	mg/L	22.0
UA	G54D	C	2020/09/23	Chloride, total	mg/L	25.0
UA	G54D	C	2021/03/24	Chloride, total	mg/L	23.0
UA	G54D	C	2021/09/20	Chloride, total	mg/L	24.0
UA	G54D	C	2022/03/15	Chloride, total	mg/L	21.0
UA	G54D	C	2022/07/26	Chloride, total	mg/L	23.0
UA	G54D	C	2022/09/20	Chloride, total	mg/L	22.0
UA	G54D	C	2023/03/09	Chloride, total	mg/L	22.0
UA	G54D	C	2023/05/03	Chloride, total	mg/L	22.0
UA	G54D	C	2023/09/26	Chloride, total	mg/L	20.0
UA	G54D	C	2023/10/25	Chloride, total	mg/L	23.0
UA	G54D	C	2015/12/03	Cobalt, total	mg/L	0.0268
UA	G54D	C	2016/03/15	Cobalt, total	mg/L	0.0183
UA	G54D	C	2016/06/15	Cobalt, total	mg/L	0.0158
UA	G54D	C	2016/09/14	Cobalt, total	mg/L	0.0167
UA	G54D	C	2016/12/14	Cobalt, total	mg/L	0.0178
UA	G54D	C	2017/03/08	Cobalt, total	mg/L	0.0170
UA	G54D	C	2017/06/15	Cobalt, total	mg/L	0.0160
UA	G54D	C	2017/07/20	Cobalt, total	mg/L	0.0139
UA	G54D	C	2018/06/19	Cobalt, total	mg/L	0.0134

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G54D	C	2018/09/05	Cobalt, total	mg/L	0.0109
UA	G54D	C	2019/03/27	Cobalt, total	mg/L	0.0138
UA	G54D	C	2019/09/09	Cobalt, total	mg/L	0.0117
UA	G54D	C	2020/03/30	Cobalt, total	mg/L	0.0130
UA	G54D	C	2020/09/23	Cobalt, total	mg/L	0.0163
UA	G54D	C	2021/03/24	Cobalt, total	mg/L	0.00450
UA	G54D	C	2021/09/20	Cobalt, total	mg/L	0.00830
UA	G54D	C	2022/03/15	Cobalt, total	mg/L	0.0110
UA	G54D	C	2022/07/26	Cobalt, total	mg/L	0.00540
UA	G54D	C	2022/09/20	Cobalt, total	mg/L	0.00480
UA	G54D	C	2023/03/09	Cobalt, total	mg/L	0.0113
UA	G54D	C	2023/05/03	Cobalt, total	mg/L	0.0106
UA	G54D	C	2023/09/26	Cobalt, total	mg/L	0.0102
UA	G54D	C	2023/10/25	Cobalt, total	mg/L	0.00880
UA	G54D	C	2023/05/03	Iron, dissolved	mg/L	0.716
UA	G54D	C	2023/09/26	Iron, dissolved	mg/L	0.669
UA	G54D	C	2017/07/20	Magnesium, total	mg/L	25.2
UA	G54D	C	2020/03/30	Magnesium, total	mg/L	27.1
UA	G54D	C	2021/03/24	Magnesium, total	mg/L	24.2
UA	G54D	C	2022/03/15	Magnesium, total	mg/L	25.8
UA	G54D	C	2022/07/26	Magnesium, total	mg/L	22.3
UA	G54D	C	2023/03/09	Magnesium, total	mg/L	26.4
UA	G54D	C	2023/05/03	Magnesium, total	mg/L	26.4
UA	G54D	C	2023/09/26	Magnesium, total	mg/L	25.7
UA	G54D	C	2023/10/25	Magnesium, total	mg/L	27.6
UA	G54D	C	2023/05/03	Manganese, dissolved	mg/L	1.04
UA	G54D	C	2023/09/26	Manganese, dissolved	mg/L	0.960
UA	G54D	C	2023/05/03	Phosphate, dissolved	mg/L	<0.034
UA	G54D	C	2023/09/26	Phosphate, dissolved	mg/L	<0.005
UA	G54D	C	2017/07/20	Potassium, total	mg/L	1.16
UA	G54D	C	2020/03/30	Potassium, total	mg/L	1.36
UA	G54D	C	2021/03/24	Potassium, total	mg/L	1.12
UA	G54D	C	2022/03/15	Potassium, total	mg/L	1.21
UA	G54D	C	2022/07/26	Potassium, total	mg/L	1.12
UA	G54D	C	2023/03/09	Potassium, total	mg/L	1.28
UA	G54D	C	2023/05/03	Potassium, total	mg/L	1.21
UA	G54D	C	2023/09/26	Potassium, total	mg/L	1.18
UA	G54D	C	2023/10/25	Potassium, total	mg/L	1.59
UA	G54D	C	2023/05/03	Silicon, dissolved	mg/L	12.8
UA	G54D	C	2023/09/26	Silicon, dissolved	mg/L	11.6
UA	G54D	C	2017/07/20	Sodium, total	mg/L	41.1
UA	G54D	C	2020/03/30	Sodium, total	mg/L	47.8
UA	G54D	C	2021/03/24	Sodium, total	mg/L	62.4
UA	G54D	C	2022/03/15	Sodium, total	mg/L	54.2
UA	G54D	C	2022/07/26	Sodium, total	mg/L	56.8
UA	G54D	C	2023/03/09	Sodium, total	mg/L	55.7
UA	G54D	C	2023/05/03	Sodium, total	mg/L	57.0
UA	G54D	C	2023/09/26	Sodium, total	mg/L	48.3
UA	G54D	C	2023/10/25	Sodium, total	mg/L	57.4
UA	G54D	C	2015/12/03	Sulfate, total	mg/L	191
UA	G54D	C	2016/03/15	Sulfate, total	mg/L	176
UA	G54D	C	2016/06/15	Sulfate, total	mg/L	160
UA	G54D	C	2016/09/14	Sulfate, total	mg/L	149
UA	G54D	C	2016/12/14	Sulfate, total	mg/L	144
UA	G54D	C	2017/03/08	Sulfate, total	mg/L	131

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G54D	C	2017/06/15	Sulfate, total	mg/L	170
UA	G54D	C	2017/07/20	Sulfate, total	mg/L	151
UA	G54D	C	2017/11/30	Sulfate, total	mg/L	136
UA	G54D	C	2018/06/19	Sulfate, total	mg/L	146
UA	G54D	C	2018/09/05	Sulfate, total	mg/L	152
UA	G54D	C	2019/03/27	Sulfate, total	mg/L	142
UA	G54D	C	2019/09/09	Sulfate, total	mg/L	136
UA	G54D	C	2020/03/30	Sulfate, total	mg/L	184
UA	G54D	C	2020/09/23	Sulfate, total	mg/L	173
UA	G54D	C	2021/03/24	Sulfate, total	mg/L	186
UA	G54D	C	2021/09/20	Sulfate, total	mg/L	175
UA	G54D	C	2022/03/15	Sulfate, total	mg/L	213
UA	G54D	C	2022/07/26	Sulfate, total	mg/L	188
UA	G54D	C	2022/09/20	Sulfate, total	mg/L	218
UA	G54D	C	2023/03/09	Sulfate, total	mg/L	231
UA	G54D	C	2023/05/03	Sulfate, total	mg/L	194
UA	G54D	C	2023/09/26	Sulfate, total	mg/L	180
UA	G54D	C	2023/10/25	Sulfate, total	mg/L	192
UA	G54D	C	2015/12/03	Temperature (Celsius)	degrees C	15.8
UA	G54D	C	2016/03/15	Temperature (Celsius)	degrees C	17.8
UA	G54D	C	2016/06/15	Temperature (Celsius)	degrees C	17.1
UA	G54D	C	2016/09/14	Temperature (Celsius)	degrees C	18.3
UA	G54D	C	2016/12/14	Temperature (Celsius)	degrees C	16.3
UA	G54D	C	2017/03/08	Temperature (Celsius)	degrees C	14.3
UA	G54D	C	2017/06/15	Temperature (Celsius)	degrees C	17.2
UA	G54D	C	2017/07/20	Temperature (Celsius)	degrees C	17.6
UA	G54D	C	2017/11/30	Temperature (Celsius)	degrees C	15.5
UA	G54D	C	2018/06/19	Temperature (Celsius)	degrees C	17.3
UA	G54D	C	2018/09/05	Temperature (Celsius)	degrees C	16.8
UA	G54D	C	2019/03/27	Temperature (Celsius)	degrees C	15.3
UA	G54D	C	2019/09/09	Temperature (Celsius)	degrees C	17.4
UA	G54D	C	2020/03/30	Temperature (Celsius)	degrees C	15.6
UA	G54D	C	2020/09/23	Temperature (Celsius)	degrees C	15.8
UA	G54D	C	2021/03/24	Temperature (Celsius)	degrees C	16.0
UA	G54D	C	2021/09/20	Temperature (Celsius)	degrees C	16.9
UA	G54D	C	2022/03/15	Temperature (Celsius)	degrees C	15.9
UA	G54D	C	2022/07/26	Temperature (Celsius)	degrees C	23.9
UA	G54D	C	2022/09/20	Temperature (Celsius)	degrees C	18.4
UA	G54D	C	2023/03/09	Temperature (Celsius)	degrees C	15.2
UA	G54D	C	2023/05/03	Temperature (Celsius)	degrees C	16.4
UA	G54D	C	2023/09/26	Temperature (Celsius)	degrees C	17.2
UA	G54D	C	2023/10/25	Temperature (Celsius)	degrees C	17.2
UA	G54D	C	2015/12/03	Total Dissolved Solids	mg/L	556
UA	G54D	C	2016/03/15	Total Dissolved Solids	mg/L	554
UA	G54D	C	2016/06/15	Total Dissolved Solids	mg/L	476
UA	G54D	C	2016/09/14	Total Dissolved Solids	mg/L	502
UA	G54D	C	2016/12/14	Total Dissolved Solids	mg/L	456
UA	G54D	C	2017/03/08	Total Dissolved Solids	mg/L	482
UA	G54D	C	2017/06/15	Total Dissolved Solids	mg/L	506
UA	G54D	C	2017/07/20	Total Dissolved Solids	mg/L	512
UA	G54D	C	2017/11/30	Total Dissolved Solids	mg/L	472
UA	G54D	C	2018/06/19	Total Dissolved Solids	mg/L	486
UA	G54D	C	2018/09/05	Total Dissolved Solids	mg/L	480
UA	G54D	C	2019/03/27	Total Dissolved Solids	mg/L	510
UA	G54D	C	2019/09/09	Total Dissolved Solids	mg/L	482

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G54D	C	2020/03/30	Total Dissolved Solids	mg/L	508
UA	G54D	C	2020/09/23	Total Dissolved Solids	mg/L	508
UA	G54D	C	2021/03/24	Total Dissolved Solids	mg/L	532
UA	G54D	C	2021/09/20	Total Dissolved Solids	mg/L	474
UA	G54D	C	2022/03/15	Total Dissolved Solids	mg/L	524
UA	G54D	C	2022/07/26	Total Dissolved Solids	mg/L	492
UA	G54D	C	2022/09/20	Total Dissolved Solids	mg/L	518
UA	G54D	C	2023/03/09	Total Dissolved Solids	mg/L	562
UA	G54D	C	2023/05/03	Total Dissolved Solids	mg/L	544
UA	G54D	C	2023/09/26	Total Dissolved Solids	mg/L	508
UA	G54D	C	2023/10/25	Total Dissolved Solids	mg/L	502
UA	G12S	Delin	2022/01/20	pH (field)	SU	6.3
UA	G12S	Delin	2022/02/10	pH (field)	SU	6.6
UA	G12S	Delin	2022/03/16	pH (field)	SU	6.5
UA	G12S	Delin	2022/07/23	pH (field)	SU	7.1
UA	G12S	Delin	2022/09/13	pH (field)	SU	6.3
UA	G12S	Delin	2022/11/01	pH (field)	SU	6.4
UA	G12S	Delin	2023/01/26	pH (field)	SU	6.9
UA	G12S	Delin	2023/03/09	pH (field)	SU	6.6
UA	G12S	Delin	2023/05/02	pH (field)	SU	6.1
UA	G12S	Delin	2023/09/28	pH (field)	SU	6.6
UA	G12S	Delin	2023/10/24	pH (field)	SU	6.5
UA	G12S	Delin	2022/01/20	Oxidation Reduction Potential	mV	62.0
UA	G12S	Delin	2022/02/10	Oxidation Reduction Potential	mV	-4.00
UA	G12S	Delin	2022/03/16	Oxidation Reduction Potential	mV	97.0
UA	G12S	Delin	2022/07/23	Oxidation Reduction Potential	mV	51.6
UA	G12S	Delin	2022/09/13	Oxidation Reduction Potential	mV	141
UA	G12S	Delin	2022/11/01	Oxidation Reduction Potential	mV	124
UA	G12S	Delin	2023/01/26	Oxidation Reduction Potential	mV	23.7
UA	G12S	Delin	2023/03/09	Oxidation Reduction Potential	mV	107
UA	G12S	Delin	2023/05/02	Oxidation Reduction Potential	mV	101
UA	G12S	Delin	2023/09/28	Oxidation Reduction Potential	mV	108
UA	G12S	Delin	2023/10/24	Oxidation Reduction Potential	mV	116
UA	G12S	Delin	2022/01/20	Eh	V	0.26
UA	G12S	Delin	2022/02/10	Eh	V	0.19
UA	G12S	Delin	2022/03/16	Eh	V	0.29
UA	G12S	Delin	2022/07/23	Eh	V	0.25
UA	G12S	Delin	2022/09/13	Eh	V	0.34
UA	G12S	Delin	2022/11/01	Eh	V	0.32
UA	G12S	Delin	2023/01/26	Eh	V	0.22
UA	G12S	Delin	2023/03/09	Eh	V	0.30
UA	G12S	Delin	2023/05/02	Eh	V	0.30
UA	G12S	Delin	2023/09/28	Eh	V	0.30
UA	G12S	Delin	2023/10/24	Eh	V	0.31
UA	G12S	Delin	2022/01/20	Alkalinity, bicarbonate	mg/L CaCO3	139
UA	G12S	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	134
UA	G12S	Delin	2022/03/16	Alkalinity, bicarbonate	mg/L CaCO3	138
UA	G12S	Delin	2022/07/23	Alkalinity, bicarbonate	mg/L CaCO3	139
UA	G12S	Delin	2022/09/13	Alkalinity, bicarbonate	mg/L CaCO3	132
UA	G12S	Delin	2022/11/01	Alkalinity, bicarbonate	mg/L CaCO3	134
UA	G12S	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	139
UA	G12S	Delin	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	140
UA	G12S	Delin	2023/05/02	Alkalinity, bicarbonate	mg/L CaCO3	135
UA	G12S	Delin	2023/09/28	Alkalinity, bicarbonate	mg/L CaCO3	142
UA	G12S	Delin	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	136

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G12S	Delin	2022/01/20	Barium, total	mg/L	0.0367
UA	G12S	Delin	2022/02/10	Barium, total	mg/L	0.0343
UA	G12S	Delin	2022/03/16	Barium, total	mg/L	0.0287
UA	G12S	Delin	2022/07/23	Barium, total	mg/L	0.0291
UA	G12S	Delin	2022/09/13	Barium, total	mg/L	0.0270
UA	G12S	Delin	2022/11/01	Barium, total	mg/L	0.0311
UA	G12S	Delin	2023/01/26	Barium, total	mg/L	0.0303
UA	G12S	Delin	2023/03/09	Barium, total	mg/L	0.0315
UA	G12S	Delin	2023/05/02	Barium, total	mg/L	0.0372
UA	G12S	Delin	2023/09/28	Barium, total	mg/L	0.0267
UA	G12S	Delin	2023/10/24	Barium, total	mg/L	0.0361
UA	G12S	Delin	2022/01/20	Boron, total	mg/L	5.91
UA	G12S	Delin	2022/02/10	Boron, total	mg/L	5.89
UA	G12S	Delin	2022/03/16	Boron, total	mg/L	5.83
UA	G12S	Delin	2022/07/23	Boron, total	mg/L	6.15
UA	G12S	Delin	2022/09/13	Boron, total	mg/L	5.24
UA	G12S	Delin	2022/11/01	Boron, total	mg/L	5.71
UA	G12S	Delin	2023/01/26	Boron, total	mg/L	6.40
UA	G12S	Delin	2023/03/09	Boron, total	mg/L	6.23
UA	G12S	Delin	2023/05/02	Boron, total	mg/L	6.49
UA	G12S	Delin	2023/09/28	Boron, total	mg/L	8.16
UA	G12S	Delin	2023/10/24	Boron, total	mg/L	6.80
UA	G12S	Delin	2022/01/20	Calcium, total	mg/L	83.7
UA	G12S	Delin	2022/02/10	Calcium, total	mg/L	78.8
UA	G12S	Delin	2022/03/16	Calcium, total	mg/L	80.8
UA	G12S	Delin	2022/07/23	Calcium, total	mg/L	79.7
UA	G12S	Delin	2022/09/13	Calcium, total	mg/L	73.3
UA	G12S	Delin	2022/11/01	Calcium, total	mg/L	78.2
UA	G12S	Delin	2023/01/26	Calcium, total	mg/L	87.6
UA	G12S	Delin	2023/03/09	Calcium, total	mg/L	79.6
UA	G12S	Delin	2023/05/02	Calcium, total	mg/L	77.5
UA	G12S	Delin	2023/09/28	Calcium, total	mg/L	82.0
UA	G12S	Delin	2023/10/24	Calcium, total	mg/L	77.9
UA	G12S	Delin	2022/01/20	Chloride, total	mg/L	19.0
UA	G12S	Delin	2022/02/10	Chloride, total	mg/L	19.0
UA	G12S	Delin	2022/03/16	Chloride, total	mg/L	19.0
UA	G12S	Delin	2022/07/23	Chloride, total	mg/L	21.0
UA	G12S	Delin	2022/09/13	Chloride, total	mg/L	21.0
UA	G12S	Delin	2022/11/01	Chloride, total	mg/L	21.0
UA	G12S	Delin	2023/01/26	Chloride, total	mg/L	22.0
UA	G12S	Delin	2023/03/09	Chloride, total	mg/L	21.0
UA	G12S	Delin	2023/05/02	Chloride, total	mg/L	24.0
UA	G12S	Delin	2023/09/28	Chloride, total	mg/L	22.0
UA	G12S	Delin	2023/10/24	Chloride, total	mg/L	24.0
UA	G12S	Delin	2022/01/20	Cobalt, total	mg/L	<0.0001
UA	G12S	Delin	2022/02/10	Cobalt, total	mg/L	<0.0001
UA	G12S	Delin	2022/03/16	Cobalt, total	mg/L	<0.0001
UA	G12S	Delin	2022/07/23	Cobalt, total	mg/L	0.000200
UA	G12S	Delin	2022/09/13	Cobalt, total	mg/L	0.000300
UA	G12S	Delin	2022/11/01	Cobalt, total	mg/L	<0.0001
UA	G12S	Delin	2023/01/26	Cobalt, total	mg/L	0.000200
UA	G12S	Delin	2023/03/09	Cobalt, total	mg/L	0.000200
UA	G12S	Delin	2023/05/02	Cobalt, total	mg/L	0.000900
UA	G12S	Delin	2023/09/28	Cobalt, total	mg/L	<0.0001
UA	G12S	Delin	2023/10/24	Cobalt, total	mg/L	<0.0001

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G12S	Delin	2023/05/02	Iron, dissolved	mg/L	<0.02
UA	G12S	Delin	2023/09/28	Iron, dissolved	mg/L	<0.0115
UA	G12S	Delin	2022/01/20	Magnesium, total	mg/L	24.1
UA	G12S	Delin	2022/02/10	Magnesium, total	mg/L	23.9
UA	G12S	Delin	2022/03/16	Magnesium, total	mg/L	23.4
UA	G12S	Delin	2022/07/23	Magnesium, total	mg/L	23.2
UA	G12S	Delin	2022/09/13	Magnesium, total	mg/L	21.6
UA	G12S	Delin	2022/11/01	Magnesium, total	mg/L	23.5
UA	G12S	Delin	2023/01/26	Magnesium, total	mg/L	25.9
UA	G12S	Delin	2023/03/09	Magnesium, total	mg/L	23.2
UA	G12S	Delin	2023/05/02	Magnesium, total	mg/L	24.0
UA	G12S	Delin	2023/09/28	Magnesium, total	mg/L	24.4
UA	G12S	Delin	2023/10/24	Magnesium, total	mg/L	23.2
UA	G12S	Delin	2023/05/02	Manganese, dissolved	mg/L	0.00640
UA	G12S	Delin	2023/09/28	Manganese, dissolved	mg/L	0.00820
UA	G12S	Delin	2023/05/02	Phosphate, dissolved	mg/L	0.0520
UA	G12S	Delin	2023/09/28	Phosphate, dissolved	mg/L	0.0400
UA	G12S	Delin	2022/01/20	Potassium, total	mg/L	1.56
UA	G12S	Delin	2022/02/10	Potassium, total	mg/L	1.65
UA	G12S	Delin	2022/03/16	Potassium, total	mg/L	1.54
UA	G12S	Delin	2022/07/23	Potassium, total	mg/L	1.53
UA	G12S	Delin	2022/09/13	Potassium, total	mg/L	1.46
UA	G12S	Delin	2022/11/01	Potassium, total	mg/L	1.56
UA	G12S	Delin	2023/01/26	Potassium, total	mg/L	1.52
UA	G12S	Delin	2023/03/09	Potassium, total	mg/L	1.56
UA	G12S	Delin	2023/05/02	Potassium, total	mg/L	1.59
UA	G12S	Delin	2023/09/28	Potassium, total	mg/L	1.60
UA	G12S	Delin	2023/10/24	Potassium, total	mg/L	1.55
UA	G12S	Delin	2023/05/02	Silicon, dissolved	mg/L	6.74
UA	G12S	Delin	2023/09/28	Silicon, dissolved	mg/L	6.68
UA	G12S	Delin	2022/01/20	Sodium, total	mg/L	31.6
UA	G12S	Delin	2022/02/10	Sodium, total	mg/L	30.0
UA	G12S	Delin	2022/03/16	Sodium, total	mg/L	30.7
UA	G12S	Delin	2022/07/23	Sodium, total	mg/L	29.3
UA	G12S	Delin	2022/09/13	Sodium, total	mg/L	28.4
UA	G12S	Delin	2022/11/01	Sodium, total	mg/L	29.2
UA	G12S	Delin	2023/01/26	Sodium, total	mg/L	28.4
UA	G12S	Delin	2023/03/09	Sodium, total	mg/L	28.5
UA	G12S	Delin	2023/05/02	Sodium, total	mg/L	31.9
UA	G12S	Delin	2023/09/28	Sodium, total	mg/L	29.5
UA	G12S	Delin	2023/10/24	Sodium, total	mg/L	28.9
UA	G12S	Delin	2022/01/20	Sulfate, total	mg/L	175
UA	G12S	Delin	2022/02/10	Sulfate, total	mg/L	211
UA	G12S	Delin	2022/03/16	Sulfate, total	mg/L	209
UA	G12S	Delin	2022/07/23	Sulfate, total	mg/L	197
UA	G12S	Delin	2022/09/13	Sulfate, total	mg/L	192
UA	G12S	Delin	2022/11/01	Sulfate, total	mg/L	175
UA	G12S	Delin	2023/01/26	Sulfate, total	mg/L	196
UA	G12S	Delin	2023/03/09	Sulfate, total	mg/L	192
UA	G12S	Delin	2023/05/02	Sulfate, total	mg/L	191
UA	G12S	Delin	2023/09/28	Sulfate, total	mg/L	179
UA	G12S	Delin	2023/10/24	Sulfate, total	mg/L	194
UA	G12S	Delin	2022/01/20	Temperature (Celsius)	degrees C	14.5
UA	G12S	Delin	2022/02/10	Temperature (Celsius)	degrees C	14.6
UA	G12S	Delin	2022/03/16	Temperature (Celsius)	degrees C	14.7

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G12S	Delin	2022/07/23	Temperature (Celsius)	degrees C	15.3
UA	G12S	Delin	2022/09/13	Temperature (Celsius)	degrees C	17.0
UA	G12S	Delin	2022/11/01	Temperature (Celsius)	degrees C	15.6
UA	G12S	Delin	2023/01/26	Temperature (Celsius)	degrees C	13.1
UA	G12S	Delin	2023/03/09	Temperature (Celsius)	degrees C	14.6
UA	G12S	Delin	2023/05/02	Temperature (Celsius)	degrees C	15.0
UA	G12S	Delin	2023/09/28	Temperature (Celsius)	degrees C	15.3
UA	G12S	Delin	2023/10/24	Temperature (Celsius)	degrees C	15.4
UA	G12S	Delin	2022/01/20	Total Dissolved Solids	mg/L	470
UA	G12S	Delin	2022/02/10	Total Dissolved Solids	mg/L	432
UA	G12S	Delin	2022/03/16	Total Dissolved Solids	mg/L	456
UA	G12S	Delin	2022/07/23	Total Dissolved Solids	mg/L	466
UA	G12S	Delin	2022/09/13	Total Dissolved Solids	mg/L	438
UA	G12S	Delin	2022/11/01	Total Dissolved Solids	mg/L	460
UA	G12S	Delin	2023/01/26	Total Dissolved Solids	mg/L	468
UA	G12S	Delin	2023/03/09	Total Dissolved Solids	mg/L	470
UA	G12S	Delin	2023/05/02	Total Dissolved Solids	mg/L	444
UA	G12S	Delin	2023/09/28	Total Dissolved Solids	mg/L	484
UA	G12S	Delin	2023/10/24	Total Dissolved Solids	mg/L	444
UA	G12D	Delin	2022/01/20	pH (field)	SU	6.5
UA	G12D	Delin	2022/02/10	pH (field)	SU	6.7
UA	G12D	Delin	2022/03/16	pH (field)	SU	6.6
UA	G12D	Delin	2022/07/23	pH (field)	SU	7.3
UA	G12D	Delin	2022/09/13	pH (field)	SU	6.6
UA	G12D	Delin	2022/11/01	pH (field)	SU	6.7
UA	G12D	Delin	2023/01/26	pH (field)	SU	6.9
UA	G12D	Delin	2023/03/09	pH (field)	SU	6.6
UA	G12D	Delin	2023/05/02	pH (field)	SU	6.9
UA	G12D	Delin	2023/09/28	pH (field)	SU	6.6
UA	G12D	Delin	2023/10/24	pH (field)	SU	6.6
UA	G12D	Delin	2022/01/20	Oxidation Reduction Potential	mV	40.0
UA	G12D	Delin	2022/02/10	Oxidation Reduction Potential	mV	10.0
UA	G12D	Delin	2022/03/16	Oxidation Reduction Potential	mV	69.0
UA	G12D	Delin	2022/07/23	Oxidation Reduction Potential	mV	43.5
UA	G12D	Delin	2022/09/13	Oxidation Reduction Potential	mV	134
UA	G12D	Delin	2022/11/01	Oxidation Reduction Potential	mV	109
UA	G12D	Delin	2023/01/26	Oxidation Reduction Potential	mV	33.7
UA	G12D	Delin	2023/03/09	Oxidation Reduction Potential	mV	108
UA	G12D	Delin	2023/05/02	Oxidation Reduction Potential	mV	94.0
UA	G12D	Delin	2023/09/28	Oxidation Reduction Potential	mV	112
UA	G12D	Delin	2023/10/24	Oxidation Reduction Potential	mV	116
UA	G12D	Delin	2022/01/20	Eh	V	0.24
UA	G12D	Delin	2022/02/10	Eh	V	0.21
UA	G12D	Delin	2022/03/16	Eh	V	0.26
UA	G12D	Delin	2022/07/23	Eh	V	0.24
UA	G12D	Delin	2022/09/13	Eh	V	0.33
UA	G12D	Delin	2022/11/01	Eh	V	0.30
UA	G12D	Delin	2023/01/26	Eh	V	0.23
UA	G12D	Delin	2023/03/09	Eh	V	0.30
UA	G12D	Delin	2023/05/02	Eh	V	0.29
UA	G12D	Delin	2023/09/28	Eh	V	0.31
UA	G12D	Delin	2023/10/24	Eh	V	0.31
UA	G12D	Delin	2022/01/20	Alkalinity, bicarbonate	mg/L CaCO3	140
UA	G12D	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	141
UA	G12D	Delin	2022/03/16	Alkalinity, bicarbonate	mg/L CaCO3	146

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G12D	Delin	2022/07/23	Alkalinity, bicarbonate	mg/L CaCO3	142
UA	G12D	Delin	2022/09/13	Alkalinity, bicarbonate	mg/L CaCO3	139
UA	G12D	Delin	2022/11/01	Alkalinity, bicarbonate	mg/L CaCO3	145
UA	G12D	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	141
UA	G12D	Delin	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	146
UA	G12D	Delin	2023/05/02	Alkalinity, bicarbonate	mg/L CaCO3	142
UA	G12D	Delin	2023/09/28	Alkalinity, bicarbonate	mg/L CaCO3	152
UA	G12D	Delin	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	142
UA	G12D	Delin	2022/01/20	Barium, total	mg/L	0.0449
UA	G12D	Delin	2022/02/10	Barium, total	mg/L	0.0361
UA	G12D	Delin	2022/03/16	Barium, total	mg/L	0.0282
UA	G12D	Delin	2022/07/23	Barium, total	mg/L	0.0322
UA	G12D	Delin	2022/09/13	Barium, total	mg/L	0.0456
UA	G12D	Delin	2022/11/01	Barium, total	mg/L	0.0311
UA	G12D	Delin	2023/01/26	Barium, total	mg/L	0.0326
UA	G12D	Delin	2023/03/09	Barium, total	mg/L	0.0314
UA	G12D	Delin	2023/05/02	Barium, total	mg/L	0.0313
UA	G12D	Delin	2023/09/28	Barium, total	mg/L	0.0282
UA	G12D	Delin	2023/10/24	Barium, total	mg/L	0.0423
UA	G12D	Delin	2022/01/20	Boron, total	mg/L	6.94
UA	G12D	Delin	2022/02/10	Boron, total	mg/L	6.38
UA	G12D	Delin	2022/03/16	Boron, total	mg/L	6.79
UA	G12D	Delin	2022/07/23	Boron, total	mg/L	6.59
UA	G12D	Delin	2022/09/13	Boron, total	mg/L	5.31
UA	G12D	Delin	2022/11/01	Boron, total	mg/L	5.79
UA	G12D	Delin	2023/01/26	Boron, total	mg/L	7.92
UA	G12D	Delin	2023/03/09	Boron, total	mg/L	6.32
UA	G12D	Delin	2023/05/02	Boron, total	mg/L	6.48
UA	G12D	Delin	2023/09/28	Boron, total	mg/L	6.58
UA	G12D	Delin	2023/10/24	Boron, total	mg/L	8.01
UA	G12D	Delin	2022/01/20	Calcium, total	mg/L	88.4
UA	G12D	Delin	2022/02/10	Calcium, total	mg/L	85.8
UA	G12D	Delin	2022/03/16	Calcium, total	mg/L	88.1
UA	G12D	Delin	2022/07/23	Calcium, total	mg/L	87.2
UA	G12D	Delin	2022/09/13	Calcium, total	mg/L	79.9
UA	G12D	Delin	2022/11/01	Calcium, total	mg/L	85.3
UA	G12D	Delin	2023/01/26	Calcium, total	mg/L	90.3
UA	G12D	Delin	2023/03/09	Calcium, total	mg/L	85.6
UA	G12D	Delin	2023/05/02	Calcium, total	mg/L	80.9
UA	G12D	Delin	2023/09/28	Calcium, total	mg/L	84.8
UA	G12D	Delin	2023/10/24	Calcium, total	mg/L	82.7
UA	G12D	Delin	2022/01/20	Chloride, total	mg/L	18.0
UA	G12D	Delin	2022/02/10	Chloride, total	mg/L	19.0
UA	G12D	Delin	2022/03/16	Chloride, total	mg/L	19.0
UA	G12D	Delin	2022/07/23	Chloride, total	mg/L	20.0
UA	G12D	Delin	2022/09/13	Chloride, total	mg/L	19.0
UA	G12D	Delin	2022/11/01	Chloride, total	mg/L	20.0
UA	G12D	Delin	2023/01/26	Chloride, total	mg/L	20.0
UA	G12D	Delin	2023/03/09	Chloride, total	mg/L	19.0
UA	G12D	Delin	2023/05/02	Chloride, total	mg/L	20.0
UA	G12D	Delin	2023/09/28	Chloride, total	mg/L	20.0
UA	G12D	Delin	2023/10/24	Chloride, total	mg/L	21.0
UA	G12D	Delin	2022/01/20	Cobalt, total	mg/L	0.00140
UA	G12D	Delin	2022/02/10	Cobalt, total	mg/L	<0.0001
UA	G12D	Delin	2022/03/16	Cobalt, total	mg/L	<0.0001

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G12D	Delin	2022/07/23	Cobalt, total	mg/L	0.000600
UA	G12D	Delin	2022/09/13	Cobalt, total	mg/L	0.000300
UA	G12D	Delin	2022/11/01	Cobalt, total	mg/L	0.000200
UA	G12D	Delin	2023/01/26	Cobalt, total	mg/L	0.000100
UA	G12D	Delin	2023/03/09	Cobalt, total	mg/L	0.000400
UA	G12D	Delin	2023/05/02	Cobalt, total	mg/L	0.000200
UA	G12D	Delin	2023/09/28	Cobalt, total	mg/L	<0.0001
UA	G12D	Delin	2023/10/24	Cobalt, total	mg/L	<0.0001
UA	G12D	Delin	2023/05/02	Iron, dissolved	mg/L	<0.02
UA	G12D	Delin	2023/09/28	Iron, dissolved	mg/L	0.0599
UA	G12D	Delin	2022/01/20	Magnesium, total	mg/L	24.6
UA	G12D	Delin	2022/02/10	Magnesium, total	mg/L	25.3
UA	G12D	Delin	2022/03/16	Magnesium, total	mg/L	24.9
UA	G12D	Delin	2022/07/23	Magnesium, total	mg/L	24.8
UA	G12D	Delin	2022/09/13	Magnesium, total	mg/L	22.8
UA	G12D	Delin	2022/11/01	Magnesium, total	mg/L	24.8
UA	G12D	Delin	2023/01/26	Magnesium, total	mg/L	26.3
UA	G12D	Delin	2023/03/09	Magnesium, total	mg/L	24.3
UA	G12D	Delin	2023/05/02	Magnesium, total	mg/L	24.6
UA	G12D	Delin	2023/09/28	Magnesium, total	mg/L	25.0
UA	G12D	Delin	2023/10/24	Magnesium, total	mg/L	24.2
UA	G12D	Delin	2023/05/02	Manganese, dissolved	mg/L	0.00500
UA	G12D	Delin	2023/09/28	Manganese, dissolved	mg/L	0.00510
UA	G12D	Delin	2023/05/02	Phosphate, dissolved	mg/L	0.0520
UA	G12D	Delin	2023/09/28	Phosphate, dissolved	mg/L	0.0520
UA	G12D	Delin	2022/01/20	Potassium, total	mg/L	1.47
UA	G12D	Delin	2022/02/10	Potassium, total	mg/L	1.64
UA	G12D	Delin	2022/03/16	Potassium, total	mg/L	1.53
UA	G12D	Delin	2022/07/23	Potassium, total	mg/L	1.56
UA	G12D	Delin	2022/09/13	Potassium, total	mg/L	1.47
UA	G12D	Delin	2022/11/01	Potassium, total	mg/L	1.55
UA	G12D	Delin	2023/01/26	Potassium, total	mg/L	1.52
UA	G12D	Delin	2023/03/09	Potassium, total	mg/L	1.55
UA	G12D	Delin	2023/05/02	Potassium, total	mg/L	1.54
UA	G12D	Delin	2023/09/28	Potassium, total	mg/L	1.68
UA	G12D	Delin	2023/10/24	Potassium, total	mg/L	1.53
UA	G12D	Delin	2023/05/02	Silicon, dissolved	mg/L	6.42
UA	G12D	Delin	2023/09/28	Silicon, dissolved	mg/L	6.51
UA	G12D	Delin	2022/01/20	Sodium, total	mg/L	29.7
UA	G12D	Delin	2022/02/10	Sodium, total	mg/L	29.5
UA	G12D	Delin	2022/03/16	Sodium, total	mg/L	29.7
UA	G12D	Delin	2022/07/23	Sodium, total	mg/L	29.3
UA	G12D	Delin	2022/09/13	Sodium, total	mg/L	28.0
UA	G12D	Delin	2022/11/01	Sodium, total	mg/L	27.7
UA	G12D	Delin	2023/01/26	Sodium, total	mg/L	27.5
UA	G12D	Delin	2023/03/09	Sodium, total	mg/L	27.4
UA	G12D	Delin	2023/05/02	Sodium, total	mg/L	30.3
UA	G12D	Delin	2023/09/28	Sodium, total	mg/L	28.8
UA	G12D	Delin	2023/10/24	Sodium, total	mg/L	27.6
UA	G12D	Delin	2022/01/20	Sulfate, total	mg/L	195
UA	G12D	Delin	2022/02/10	Sulfate, total	mg/L	191
UA	G12D	Delin	2022/03/16	Sulfate, total	mg/L	225
UA	G12D	Delin	2022/07/23	Sulfate, total	mg/L	196
UA	G12D	Delin	2022/09/13	Sulfate, total	mg/L	231
UA	G12D	Delin	2022/11/01	Sulfate, total	mg/L	185

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G12D	Delin	2023/01/26	Sulfate, total	mg/L	201
UA	G12D	Delin	2023/03/09	Sulfate, total	mg/L	198
UA	G12D	Delin	2023/05/02	Sulfate, total	mg/L	195
UA	G12D	Delin	2023/09/28	Sulfate, total	mg/L	180
UA	G12D	Delin	2023/10/24	Sulfate, total	mg/L	195
UA	G12D	Delin	2022/01/20	Temperature (Celsius)	degrees C	14.4
UA	G12D	Delin	2022/02/10	Temperature (Celsius)	degrees C	14.6
UA	G12D	Delin	2022/03/16	Temperature (Celsius)	degrees C	14.8
UA	G12D	Delin	2022/07/23	Temperature (Celsius)	degrees C	17.2
UA	G12D	Delin	2022/09/13	Temperature (Celsius)	degrees C	18.4
UA	G12D	Delin	2022/11/01	Temperature (Celsius)	degrees C	16.3
UA	G12D	Delin	2023/01/26	Temperature (Celsius)	degrees C	13.3
UA	G12D	Delin	2023/03/09	Temperature (Celsius)	degrees C	14.6
UA	G12D	Delin	2023/05/02	Temperature (Celsius)	degrees C	15.1
UA	G12D	Delin	2023/09/28	Temperature (Celsius)	degrees C	15.5
UA	G12D	Delin	2023/10/24	Temperature (Celsius)	degrees C	15.6
UA	G12D	Delin	2022/01/20	Total Dissolved Solids	mg/L	492
UA	G12D	Delin	2022/02/10	Total Dissolved Solids	mg/L	458
UA	G12D	Delin	2022/03/16	Total Dissolved Solids	mg/L	482
UA	G12D	Delin	2022/07/23	Total Dissolved Solids	mg/L	512
UA	G12D	Delin	2022/09/13	Total Dissolved Solids	mg/L	444
UA	G12D	Delin	2022/11/01	Total Dissolved Solids	mg/L	480
UA	G12D	Delin	2023/01/26	Total Dissolved Solids	mg/L	448
UA	G12D	Delin	2023/03/09	Total Dissolved Solids	mg/L	472
UA	G12D	Delin	2023/05/02	Total Dissolved Solids	mg/L	466
UA	G12D	Delin	2023/09/28	Total Dissolved Solids	mg/L	484
UA	G12D	Delin	2023/10/24	Total Dissolved Solids	mg/L	442
UA	G13S	Delin	2022/01/20	pH (field)	SU	6.5
UA	G13S	Delin	2022/02/10	pH (field)	SU	6.5
UA	G13S	Delin	2022/03/16	pH (field)	SU	6.3
UA	G13S	Delin	2022/07/23	pH (field)	SU	7.3
UA	G13S	Delin	2022/09/13	pH (field)	SU	6.0
UA	G13S	Delin	2022/11/01	pH (field)	SU	6.4
UA	G13S	Delin	2023/01/26	pH (field)	SU	6.9
UA	G13S	Delin	2023/03/09	pH (field)	SU	6.6
UA	G13S	Delin	2023/05/02	pH (field)	SU	7.1
UA	G13S	Delin	2023/09/27	pH (field)	SU	6.7
UA	G13S	Delin	2023/10/24	pH (field)	SU	6.5
UA	G13S	Delin	2022/01/20	Oxidation Reduction Potential	mV	67.0
UA	G13S	Delin	2022/02/10	Oxidation Reduction Potential	mV	19.0
UA	G13S	Delin	2022/03/16	Oxidation Reduction Potential	mV	112
UA	G13S	Delin	2022/07/23	Oxidation Reduction Potential	mV	0.800
UA	G13S	Delin	2022/09/13	Oxidation Reduction Potential	mV	142
UA	G13S	Delin	2022/11/01	Oxidation Reduction Potential	mV	187
UA	G13S	Delin	2023/01/26	Oxidation Reduction Potential	mV	24.1
UA	G13S	Delin	2023/03/09	Oxidation Reduction Potential	mV	113
UA	G13S	Delin	2023/05/02	Oxidation Reduction Potential	mV	87.0
UA	G13S	Delin	2023/09/27	Oxidation Reduction Potential	mV	7.00
UA	G13S	Delin	2023/10/24	Oxidation Reduction Potential	mV	107
UA	G13S	Delin	2022/01/20	Eh	V	0.26
UA	G13S	Delin	2022/02/10	Eh	V	0.21
UA	G13S	Delin	2022/03/16	Eh	V	0.31
UA	G13S	Delin	2022/07/23	Eh	V	0.20
UA	G13S	Delin	2022/09/13	Eh	V	0.34
UA	G13S	Delin	2022/11/01	Eh	V	0.38

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G13S	Delin	2023/01/26	Eh	V	0.22
UA	G13S	Delin	2023/03/09	Eh	V	0.31
UA	G13S	Delin	2023/05/02	Eh	V	0.28
UA	G13S	Delin	2023/09/27	Eh	V	0.20
UA	G13S	Delin	2023/10/24	Eh	V	0.30
UA	G13S	Delin	2022/01/20	Alkalinity, bicarbonate	mg/L CaCO3	146
UA	G13S	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	143
UA	G13S	Delin	2022/03/16	Alkalinity, bicarbonate	mg/L CaCO3	147
UA	G13S	Delin	2022/07/23	Alkalinity, bicarbonate	mg/L CaCO3	147
UA	G13S	Delin	2022/09/13	Alkalinity, bicarbonate	mg/L CaCO3	140
UA	G13S	Delin	2022/11/01	Alkalinity, bicarbonate	mg/L CaCO3	149
UA	G13S	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	104
UA	G13S	Delin	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	150
UA	G13S	Delin	2023/05/02	Alkalinity, bicarbonate	mg/L CaCO3	155
UA	G13S	Delin	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	157
UA	G13S	Delin	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	149
UA	G13S	Delin	2022/01/20	Barium, total	mg/L	0.0341
UA	G13S	Delin	2022/02/10	Barium, total	mg/L	0.0297
UA	G13S	Delin	2022/03/16	Barium, total	mg/L	0.0259
UA	G13S	Delin	2022/07/23	Barium, total	mg/L	0.0299
UA	G13S	Delin	2022/09/13	Barium, total	mg/L	0.0399
UA	G13S	Delin	2022/11/01	Barium, total	mg/L	0.0310
UA	G13S	Delin	2023/01/26	Barium, total	mg/L	0.0326
UA	G13S	Delin	2023/03/09	Barium, total	mg/L	0.0351
UA	G13S	Delin	2023/05/02	Barium, total	mg/L	0.0307
UA	G13S	Delin	2023/09/27	Barium, total	mg/L	0.0261
UA	G13S	Delin	2023/10/24	Barium, total	mg/L	0.0408
UA	G13S	Delin	2022/01/20	Boron, total	mg/L	5.22
UA	G13S	Delin	2022/02/10	Boron, total	mg/L	4.74
UA	G13S	Delin	2022/03/16	Boron, total	mg/L	4.99
UA	G13S	Delin	2022/07/23	Boron, total	mg/L	5.49
UA	G13S	Delin	2022/09/13	Boron, total	mg/L	4.34
UA	G13S	Delin	2022/11/01	Boron, total	mg/L	4.78
UA	G13S	Delin	2023/01/26	Boron, total	mg/L	7.31
UA	G13S	Delin	2023/03/09	Boron, total	mg/L	5.47
UA	G13S	Delin	2023/05/02	Boron, total	mg/L	4.75
UA	G13S	Delin	2023/09/27	Boron, total	mg/L	6.78
UA	G13S	Delin	2023/10/24	Boron, total	mg/L	5.82
UA	G13S	Delin	2022/01/20	Calcium, total	mg/L	82.2
UA	G13S	Delin	2022/02/10	Calcium, total	mg/L	79.5
UA	G13S	Delin	2022/03/16	Calcium, total	mg/L	80.4
UA	G13S	Delin	2022/07/23	Calcium, total	mg/L	82.3
UA	G13S	Delin	2022/09/13	Calcium, total	mg/L	74.2
UA	G13S	Delin	2022/11/01	Calcium, total	mg/L	78.4
UA	G13S	Delin	2023/01/26	Calcium, total	mg/L	84.6
UA	G13S	Delin	2023/03/09	Calcium, total	mg/L	79.2
UA	G13S	Delin	2023/05/02	Calcium, total	mg/L	76.8
UA	G13S	Delin	2023/09/27	Calcium, total	mg/L	80.8
UA	G13S	Delin	2023/10/24	Calcium, total	mg/L	77.8
UA	G13S	Delin	2022/01/20	Chloride, total	mg/L	19.0
UA	G13S	Delin	2022/02/10	Chloride, total	mg/L	19.0
UA	G13S	Delin	2022/03/16	Chloride, total	mg/L	20.0
UA	G13S	Delin	2022/07/23	Chloride, total	mg/L	21.0
UA	G13S	Delin	2022/09/13	Chloride, total	mg/L	20.0
UA	G13S	Delin	2022/11/01	Chloride, total	mg/L	21.0

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G13S	Delin	2023/01/26	Chloride, total	mg/L	20.0
UA	G13S	Delin	2023/03/09	Chloride, total	mg/L	20.0
UA	G13S	Delin	2023/05/02	Chloride, total	mg/L	21.0
UA	G13S	Delin	2023/09/27	Chloride, total	mg/L	20.0
UA	G13S	Delin	2023/10/24	Chloride, total	mg/L	21.0
UA	G13S	Delin	2022/01/20	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2022/02/10	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2022/03/16	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2022/07/23	Cobalt, total	mg/L	<0.0006
UA	G13S	Delin	2022/09/13	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2022/11/01	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2023/01/26	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2023/03/09	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2023/05/02	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2023/09/27	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2023/10/24	Cobalt, total	mg/L	<0.0001
UA	G13S	Delin	2023/05/02	Iron, dissolved	mg/L	<0.02
UA	G13S	Delin	2023/09/27	Iron, dissolved	mg/L	0.0350
UA	G13S	Delin	2022/01/20	Magnesium, total	mg/L	22.6
UA	G13S	Delin	2022/02/10	Magnesium, total	mg/L	22.9
UA	G13S	Delin	2022/03/16	Magnesium, total	mg/L	22.6
UA	G13S	Delin	2022/07/23	Magnesium, total	mg/L	23.0
UA	G13S	Delin	2022/09/13	Magnesium, total	mg/L	20.8
UA	G13S	Delin	2022/11/01	Magnesium, total	mg/L	22.5
UA	G13S	Delin	2023/01/26	Magnesium, total	mg/L	23.9
UA	G13S	Delin	2023/03/09	Magnesium, total	mg/L	22.0
UA	G13S	Delin	2023/05/02	Magnesium, total	mg/L	23.3
UA	G13S	Delin	2023/09/27	Magnesium, total	mg/L	22.9
UA	G13S	Delin	2023/10/24	Magnesium, total	mg/L	21.9
UA	G13S	Delin	2023/05/02	Manganese, dissolved	mg/L	<0.0025
UA	G13S	Delin	2023/09/27	Manganese, dissolved	mg/L	<0.0008
UA	G13S	Delin	2023/05/02	Phosphate, dissolved	mg/L	0.160
UA	G13S	Delin	2023/09/27	Phosphate, dissolved	mg/L	0.0580
UA	G13S	Delin	2022/01/20	Potassium, total	mg/L	1.46
UA	G13S	Delin	2022/02/10	Potassium, total	mg/L	1.64
UA	G13S	Delin	2022/03/16	Potassium, total	mg/L	1.55
UA	G13S	Delin	2022/07/23	Potassium, total	mg/L	1.56
UA	G13S	Delin	2022/09/13	Potassium, total	mg/L	1.44
UA	G13S	Delin	2022/11/01	Potassium, total	mg/L	1.55
UA	G13S	Delin	2023/01/26	Potassium, total	mg/L	1.62
UA	G13S	Delin	2023/03/09	Potassium, total	mg/L	1.59
UA	G13S	Delin	2023/05/02	Potassium, total	mg/L	1.63
UA	G13S	Delin	2023/09/27	Potassium, total	mg/L	1.64
UA	G13S	Delin	2023/10/24	Potassium, total	mg/L	1.57
UA	G13S	Delin	2023/05/02	Silicon, dissolved	mg/L	6.96
UA	G13S	Delin	2023/09/27	Silicon, dissolved	mg/L	7.06
UA	G13S	Delin	2022/01/20	Sodium, total	mg/L	30.2
UA	G13S	Delin	2022/02/10	Sodium, total	mg/L	30.0
UA	G13S	Delin	2022/03/16	Sodium, total	mg/L	30.8
UA	G13S	Delin	2022/07/23	Sodium, total	mg/L	30.0
UA	G13S	Delin	2022/09/13	Sodium, total	mg/L	28.2
UA	G13S	Delin	2022/11/01	Sodium, total	mg/L	29.1
UA	G13S	Delin	2023/01/26	Sodium, total	mg/L	28.8
UA	G13S	Delin	2023/03/09	Sodium, total	mg/L	29.1
UA	G13S	Delin	2023/05/02	Sodium, total	mg/L	33.5

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G13S	Delin	2023/09/27	Sodium, total	mg/L	30.1
UA	G13S	Delin	2023/10/24	Sodium, total	mg/L	29.3
UA	G13S	Delin	2022/01/20	Sulfate, total	mg/L	155
UA	G13S	Delin	2022/02/10	Sulfate, total	mg/L	151
UA	G13S	Delin	2022/03/16	Sulfate, total	mg/L	159
UA	G13S	Delin	2022/07/23	Sulfate, total	mg/L	168
UA	G13S	Delin	2022/09/13	Sulfate, total	mg/L	179
UA	G13S	Delin	2022/11/01	Sulfate, total	mg/L	182
UA	G13S	Delin	2023/01/26	Sulfate, total	mg/L	180
UA	G13S	Delin	2023/03/09	Sulfate, total	mg/L	168
UA	G13S	Delin	2023/05/02	Sulfate, total	mg/L	170
UA	G13S	Delin	2023/09/27	Sulfate, total	mg/L	185
UA	G13S	Delin	2023/10/24	Sulfate, total	mg/L	176
UA	G13S	Delin	2022/01/20	Temperature (Celsius)	degrees C	14.2
UA	G13S	Delin	2022/02/10	Temperature (Celsius)	degrees C	14.3
UA	G13S	Delin	2022/03/16	Temperature (Celsius)	degrees C	14.3
UA	G13S	Delin	2022/07/23	Temperature (Celsius)	degrees C	16.8
UA	G13S	Delin	2022/09/13	Temperature (Celsius)	degrees C	16.7
UA	G13S	Delin	2022/11/01	Temperature (Celsius)	degrees C	16.2
UA	G13S	Delin	2023/01/26	Temperature (Celsius)	degrees C	13.6
UA	G13S	Delin	2023/03/09	Temperature (Celsius)	degrees C	14.3
UA	G13S	Delin	2023/05/02	Temperature (Celsius)	degrees C	18.2
UA	G13S	Delin	2023/09/27	Temperature (Celsius)	degrees C	15.6
UA	G13S	Delin	2023/10/24	Temperature (Celsius)	degrees C	15.2
UA	G13S	Delin	2022/01/20	Total Dissolved Solids	mg/L	456
UA	G13S	Delin	2022/02/10	Total Dissolved Solids	mg/L	428
UA	G13S	Delin	2022/03/16	Total Dissolved Solids	mg/L	440
UA	G13S	Delin	2022/07/23	Total Dissolved Solids	mg/L	458
UA	G13S	Delin	2022/09/13	Total Dissolved Solids	mg/L	392
UA	G13S	Delin	2022/11/01	Total Dissolved Solids	mg/L	436
UA	G13S	Delin	2023/01/26	Total Dissolved Solids	mg/L	434
UA	G13S	Delin	2023/03/09	Total Dissolved Solids	mg/L	444
UA	G13S	Delin	2023/05/02	Total Dissolved Solids	mg/L	446
UA	G13S	Delin	2023/09/27	Total Dissolved Solids	mg/L	442
UA	G13S	Delin	2023/10/24	Total Dissolved Solids	mg/L	442
UA	G13D	Delin	2022/01/20	pH (field)	SU	6.6
UA	G13D	Delin	2022/02/10	pH (field)	SU	6.5
UA	G13D	Delin	2022/03/16	pH (field)	SU	6.4
UA	G13D	Delin	2022/07/23	pH (field)	SU	7.3
UA	G13D	Delin	2022/09/13	pH (field)	SU	5.9
UA	G13D	Delin	2022/11/01	pH (field)	SU	6.4
UA	G13D	Delin	2023/01/26	pH (field)	SU	7.0
UA	G13D	Delin	2023/03/09	pH (field)	SU	6.6
UA	G13D	Delin	2023/05/02	pH (field)	SU	7.0
UA	G13D	Delin	2023/09/27	pH (field)	SU	6.7
UA	G13D	Delin	2023/10/24	pH (field)	SU	6.6
UA	G13D	Delin	2022/01/20	Oxidation Reduction Potential	mV	57.0
UA	G13D	Delin	2022/02/10	Oxidation Reduction Potential	mV	28.0
UA	G13D	Delin	2022/03/16	Oxidation Reduction Potential	mV	97.0
UA	G13D	Delin	2022/07/23	Oxidation Reduction Potential	mV	13.0
UA	G13D	Delin	2022/09/13	Oxidation Reduction Potential	mV	144
UA	G13D	Delin	2022/11/01	Oxidation Reduction Potential	mV	147
UA	G13D	Delin	2023/01/26	Oxidation Reduction Potential	mV	-7.90
UA	G13D	Delin	2023/03/09	Oxidation Reduction Potential	mV	115
UA	G13D	Delin	2023/05/02	Oxidation Reduction Potential	mV	80.0

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G13D	Delin	2023/09/27	Oxidation Reduction Potential	mV	10.0
UA	G13D	Delin	2023/10/24	Oxidation Reduction Potential	mV	111
UA	G13D	Delin	2022/01/20	Eh	V	0.25
UA	G13D	Delin	2022/02/10	Eh	V	0.22
UA	G13D	Delin	2022/03/16	Eh	V	0.29
UA	G13D	Delin	2022/07/23	Eh	V	0.21
UA	G13D	Delin	2022/09/13	Eh	V	0.34
UA	G13D	Delin	2022/11/01	Eh	V	0.34
UA	G13D	Delin	2023/01/26	Eh	V	0.19
UA	G13D	Delin	2023/03/09	Eh	V	0.31
UA	G13D	Delin	2023/05/02	Eh	V	0.28
UA	G13D	Delin	2023/09/27	Eh	V	0.20
UA	G13D	Delin	2023/10/24	Eh	V	0.31
UA	G13D	Delin	2022/01/20	Alkalinity, bicarbonate	mg/L CaCO3	148
UA	G13D	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	153
UA	G13D	Delin	2022/03/16	Alkalinity, bicarbonate	mg/L CaCO3	163
UA	G13D	Delin	2022/07/23	Alkalinity, bicarbonate	mg/L CaCO3	154
UA	G13D	Delin	2022/09/13	Alkalinity, bicarbonate	mg/L CaCO3	152
UA	G13D	Delin	2022/11/01	Alkalinity, bicarbonate	mg/L CaCO3	156
UA	G13D	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	160
UA	G13D	Delin	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	158
UA	G13D	Delin	2023/05/02	Alkalinity, bicarbonate	mg/L CaCO3	154
UA	G13D	Delin	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	169
UA	G13D	Delin	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	164
UA	G13D	Delin	2022/01/20	Barium, total	mg/L	0.0376
UA	G13D	Delin	2022/02/10	Barium, total	mg/L	0.0346
UA	G13D	Delin	2022/03/16	Barium, total	mg/L	0.0302
UA	G13D	Delin	2022/07/23	Barium, total	mg/L	0.0527
UA	G13D	Delin	2022/09/13	Barium, total	mg/L	0.0433
UA	G13D	Delin	2022/11/01	Barium, total	mg/L	0.0328
UA	G13D	Delin	2023/01/26	Barium, total	mg/L	0.0336
UA	G13D	Delin	2023/03/09	Barium, total	mg/L	0.0450
UA	G13D	Delin	2023/05/02	Barium, total	mg/L	0.0545
UA	G13D	Delin	2023/09/27	Barium, total	mg/L	0.0284
UA	G13D	Delin	2023/10/24	Barium, total	mg/L	0.0284
UA	G13D	Delin	2022/01/20	Boron, total	mg/L	4.62
UA	G13D	Delin	2022/02/10	Boron, total	mg/L	4.55
UA	G13D	Delin	2022/03/16	Boron, total	mg/L	4.82
UA	G13D	Delin	2022/07/23	Boron, total	mg/L	6.81
UA	G13D	Delin	2022/09/13	Boron, total	mg/L	3.66
UA	G13D	Delin	2022/11/01	Boron, total	mg/L	4.84
UA	G13D	Delin	2023/01/26	Boron, total	mg/L	5.69
UA	G13D	Delin	2023/03/09	Boron, total	mg/L	5.63
UA	G13D	Delin	2023/05/02	Boron, total	mg/L	6.44
UA	G13D	Delin	2023/09/27	Boron, total	mg/L	5.16
UA	G13D	Delin	2023/10/24	Boron, total	mg/L	3.64
UA	G13D	Delin	2022/01/20	Calcium, total	mg/L	84.5
UA	G13D	Delin	2022/02/10	Calcium, total	mg/L	83.0
UA	G13D	Delin	2022/03/16	Calcium, total	mg/L	81.5
UA	G13D	Delin	2022/07/23	Calcium, total	mg/L	83.3
UA	G13D	Delin	2022/09/13	Calcium, total	mg/L	77.0
UA	G13D	Delin	2022/11/01	Calcium, total	mg/L	84.2
UA	G13D	Delin	2023/01/26	Calcium, total	mg/L	85.4
UA	G13D	Delin	2023/03/09	Calcium, total	mg/L	81.6
UA	G13D	Delin	2023/05/02	Calcium, total	mg/L	124

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G13D	Delin	2023/09/27	Calcium, total	mg/L	80.2
UA	G13D	Delin	2023/10/24	Calcium, total	mg/L	78.1
UA	G13D	Delin	2022/01/20	Chloride, total	mg/L	19.0
UA	G13D	Delin	2022/02/10	Chloride, total	mg/L	19.0
UA	G13D	Delin	2022/03/16	Chloride, total	mg/L	19.0
UA	G13D	Delin	2022/07/23	Chloride, total	mg/L	20.0
UA	G13D	Delin	2022/09/13	Chloride, total	mg/L	19.0
UA	G13D	Delin	2022/11/01	Chloride, total	mg/L	20.0
UA	G13D	Delin	2023/01/26	Chloride, total	mg/L	20.0
UA	G13D	Delin	2023/03/09	Chloride, total	mg/L	19.0
UA	G13D	Delin	2023/05/02	Chloride, total	mg/L	20.0
UA	G13D	Delin	2023/09/27	Chloride, total	mg/L	19.0
UA	G13D	Delin	2023/10/24	Chloride, total	mg/L	20.0
UA	G13D	Delin	2022/01/20	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2022/02/10	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2022/03/16	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2022/07/23	Cobalt, total	mg/L	0.00120
UA	G13D	Delin	2022/09/13	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2022/11/01	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2023/01/26	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2023/03/09	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2023/05/02	Cobalt, total	mg/L	0.000200
UA	G13D	Delin	2023/09/27	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2023/10/24	Cobalt, total	mg/L	<0.0001
UA	G13D	Delin	2023/05/02	Iron, dissolved	mg/L	<0.02
UA	G13D	Delin	2023/09/27	Iron, dissolved	mg/L	0.0374
UA	G13D	Delin	2022/01/20	Magnesium, total	mg/L	22.7
UA	G13D	Delin	2022/02/10	Magnesium, total	mg/L	23.2
UA	G13D	Delin	2022/03/16	Magnesium, total	mg/L	21.7
UA	G13D	Delin	2022/07/23	Magnesium, total	mg/L	22.6
UA	G13D	Delin	2022/09/13	Magnesium, total	mg/L	21.0
UA	G13D	Delin	2022/11/01	Magnesium, total	mg/L	22.5
UA	G13D	Delin	2023/01/26	Magnesium, total	mg/L	23.7
UA	G13D	Delin	2023/03/09	Magnesium, total	mg/L	22.1
UA	G13D	Delin	2023/05/02	Magnesium, total	mg/L	33.9
UA	G13D	Delin	2023/09/27	Magnesium, total	mg/L	22.3
UA	G13D	Delin	2023/10/24	Magnesium, total	mg/L	21.6
UA	G13D	Delin	2023/05/02	Manganese, dissolved	mg/L	<0.0025
UA	G13D	Delin	2023/09/27	Manganese, dissolved	mg/L	<0.0008
UA	G13D	Delin	2023/05/02	Phosphate, dissolved	mg/L	0.0860
UA	G13D	Delin	2023/09/27	Phosphate, dissolved	mg/L	0.0430
UA	G13D	Delin	2022/01/20	Potassium, total	mg/L	1.59
UA	G13D	Delin	2022/02/10	Potassium, total	mg/L	1.78
UA	G13D	Delin	2022/03/16	Potassium, total	mg/L	1.64
UA	G13D	Delin	2022/07/23	Potassium, total	mg/L	1.66
UA	G13D	Delin	2022/09/13	Potassium, total	mg/L	1.60
UA	G13D	Delin	2022/11/01	Potassium, total	mg/L	1.69
UA	G13D	Delin	2023/01/26	Potassium, total	mg/L	1.63
UA	G13D	Delin	2023/03/09	Potassium, total	mg/L	1.74
UA	G13D	Delin	2023/05/02	Potassium, total	mg/L	2.60
UA	G13D	Delin	2023/09/27	Potassium, total	mg/L	1.77
UA	G13D	Delin	2023/10/24	Potassium, total	mg/L	1.70
UA	G13D	Delin	2023/05/02	Silicon, dissolved	mg/L	6.23
UA	G13D	Delin	2023/09/27	Silicon, dissolved	mg/L	6.29
UA	G13D	Delin	2022/01/20	Sodium, total	mg/L	30.7

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G13D	Delin	2022/02/10	Sodium, total	mg/L	30.6
UA	G13D	Delin	2022/03/16	Sodium, total	mg/L	30.7
UA	G13D	Delin	2022/07/23	Sodium, total	mg/L	30.8
UA	G13D	Delin	2022/09/13	Sodium, total	mg/L	30.0
UA	G13D	Delin	2022/11/01	Sodium, total	mg/L	31.5
UA	G13D	Delin	2023/01/26	Sodium, total	mg/L	28.6
UA	G13D	Delin	2023/03/09	Sodium, total	mg/L	30.1
UA	G13D	Delin	2023/05/02	Sodium, total	mg/L	50.5
UA	G13D	Delin	2023/09/27	Sodium, total	mg/L	30.8
UA	G13D	Delin	2023/10/24	Sodium, total	mg/L	30.2
UA	G13D	Delin	2022/01/20	Sulfate, total	mg/L	157
UA	G13D	Delin	2022/02/10	Sulfate, total	mg/L	185
UA	G13D	Delin	2022/03/16	Sulfate, total	mg/L	162
UA	G13D	Delin	2022/07/23	Sulfate, total	mg/L	164
UA	G13D	Delin	2022/09/13	Sulfate, total	mg/L	181
UA	G13D	Delin	2022/11/01	Sulfate, total	mg/L	158
UA	G13D	Delin	2023/01/26	Sulfate, total	mg/L	171
UA	G13D	Delin	2023/03/09	Sulfate, total	mg/L	155
UA	G13D	Delin	2023/05/02	Sulfate, total	mg/L	168
UA	G13D	Delin	2023/09/27	Sulfate, total	mg/L	147
UA	G13D	Delin	2023/10/24	Sulfate, total	mg/L	162
UA	G13D	Delin	2022/01/20	Temperature (Celsius)	degrees C	14.1
UA	G13D	Delin	2022/02/10	Temperature (Celsius)	degrees C	14.3
UA	G13D	Delin	2022/03/16	Temperature (Celsius)	degrees C	14.4
UA	G13D	Delin	2022/07/23	Temperature (Celsius)	degrees C	15.9
UA	G13D	Delin	2022/09/13	Temperature (Celsius)	degrees C	17.9
UA	G13D	Delin	2022/11/01	Temperature (Celsius)	degrees C	15.4
UA	G13D	Delin	2023/01/26	Temperature (Celsius)	degrees C	12.7
UA	G13D	Delin	2023/03/09	Temperature (Celsius)	degrees C	14.3
UA	G13D	Delin	2023/05/02	Temperature (Celsius)	degrees C	15.1
UA	G13D	Delin	2023/09/27	Temperature (Celsius)	degrees C	17.2
UA	G13D	Delin	2023/10/24	Temperature (Celsius)	degrees C	15.2
UA	G13D	Delin	2022/01/20	Total Dissolved Solids	mg/L	444
UA	G13D	Delin	2022/02/10	Total Dissolved Solids	mg/L	398
UA	G13D	Delin	2022/03/16	Total Dissolved Solids	mg/L	436
UA	G13D	Delin	2022/07/23	Total Dissolved Solids	mg/L	442
UA	G13D	Delin	2022/09/13	Total Dissolved Solids	mg/L	418
UA	G13D	Delin	2022/11/01	Total Dissolved Solids	mg/L	438
UA	G13D	Delin	2023/01/26	Total Dissolved Solids	mg/L	420
UA	G13D	Delin	2023/03/09	Total Dissolved Solids	mg/L	430
UA	G13D	Delin	2023/05/02	Total Dissolved Solids	mg/L	420
UA	G13D	Delin	2023/09/27	Total Dissolved Solids	mg/L	426
UA	G13D	Delin	2023/10/24	Total Dissolved Solids	mg/L	418
UA	G14S	Delin	2022/01/19	pH (field)	SU	6.6
UA	G14S	Delin	2022/02/10	pH (field)	SU	6.5
UA	G14S	Delin	2022/03/15	pH (field)	SU	6.5
UA	G14S	Delin	2022/07/24	pH (field)	SU	7.6
UA	G14S	Delin	2022/09/14	pH (field)	SU	6.4
UA	G14S	Delin	2022/11/03	pH (field)	SU	6.6
UA	G14S	Delin	2023/01/25	pH (field)	SU	7.2
UA	G14S	Delin	2023/03/10	pH (field)	SU	6.6
UA	G14S	Delin	2022/01/19	Oxidation Reduction Potential	mV	12.0
UA	G14S	Delin	2022/02/10	Oxidation Reduction Potential	mV	32.0
UA	G14S	Delin	2022/03/15	Oxidation Reduction Potential	mV	63.0
UA	G14S	Delin	2022/07/24	Oxidation Reduction Potential	mV	-21.5

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G14S	Delin	2022/09/14	Oxidation Reduction Potential	mV	215
UA	G14S	Delin	2022/11/03	Oxidation Reduction Potential	mV	68.3
UA	G14S	Delin	2023/01/25	Oxidation Reduction Potential	mV	34.7
UA	G14S	Delin	2023/03/10	Oxidation Reduction Potential	mV	59.7
UA	G14S	Delin	2022/01/19	Eh	V	0.21
UA	G14S	Delin	2022/02/10	Eh	V	0.23
UA	G14S	Delin	2022/03/15	Eh	V	0.26
UA	G14S	Delin	2022/07/24	Eh	V	0.17
UA	G14S	Delin	2022/09/14	Eh	V	0.41
UA	G14S	Delin	2022/11/03	Eh	V	0.26
UA	G14S	Delin	2023/01/25	Eh	V	0.23
UA	G14S	Delin	2023/03/10	Eh	V	0.26
UA	G14S	Delin	2022/01/19	Alkalinity, bicarbonate	mg/L CaCO3	161
UA	G14S	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	160
UA	G14S	Delin	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	166
UA	G14S	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	164
UA	G14S	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	154
UA	G14S	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	168
UA	G14S	Delin	2023/01/25	Alkalinity, bicarbonate	mg/L CaCO3	166
UA	G14S	Delin	2023/03/10	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G14S	Delin	2022/01/19	Barium, total	mg/L	0.0381
UA	G14S	Delin	2022/02/10	Barium, total	mg/L	0.0348
UA	G14S	Delin	2022/03/15	Barium, total	mg/L	0.0314
UA	G14S	Delin	2022/07/24	Barium, total	mg/L	0.0356
UA	G14S	Delin	2022/09/14	Barium, total	mg/L	0.0427
UA	G14S	Delin	2022/11/03	Barium, total	mg/L	0.0317
UA	G14S	Delin	2023/01/25	Barium, total	mg/L	0.0337
UA	G14S	Delin	2023/03/10	Barium, total	mg/L	0.0415
UA	G14S	Delin	2022/01/19	Boron, total	mg/L	3.40
UA	G14S	Delin	2022/02/10	Boron, total	mg/L	3.60
UA	G14S	Delin	2022/03/15	Boron, total	mg/L	4.02
UA	G14S	Delin	2022/07/24	Boron, total	mg/L	3.75
UA	G14S	Delin	2022/09/14	Boron, total	mg/L	3.09
UA	G14S	Delin	2022/11/03	Boron, total	mg/L	3.22
UA	G14S	Delin	2023/01/25	Boron, total	mg/L	3.77
UA	G14S	Delin	2023/03/10	Boron, total	mg/L	4.34
UA	G14S	Delin	2022/01/19	Calcium, total	mg/L	88.0
UA	G14S	Delin	2022/02/10	Calcium, total	mg/L	85.0
UA	G14S	Delin	2022/03/15	Calcium, total	mg/L	85.8
UA	G14S	Delin	2022/07/24	Calcium, total	mg/L	84.1
UA	G14S	Delin	2022/09/14	Calcium, total	mg/L	77.8
UA	G14S	Delin	2022/11/03	Calcium, total	mg/L	86.4
UA	G14S	Delin	2023/01/25	Calcium, total	mg/L	85.0
UA	G14S	Delin	2023/03/10	Calcium, total	mg/L	83.9
UA	G14S	Delin	2022/01/19	Chloride, total	mg/L	21.0
UA	G14S	Delin	2022/02/10	Chloride, total	mg/L	20.0
UA	G14S	Delin	2022/03/15	Chloride, total	mg/L	20.0
UA	G14S	Delin	2022/07/24	Chloride, total	mg/L	22.0
UA	G14S	Delin	2022/09/14	Chloride, total	mg/L	20.0
UA	G14S	Delin	2022/11/03	Chloride, total	mg/L	20.0
UA	G14S	Delin	2023/01/25	Chloride, total	mg/L	20.0
UA	G14S	Delin	2023/03/10	Chloride, total	mg/L	19.0
UA	G14S	Delin	2022/01/19	Cobalt, total	mg/L	<0.0001
UA	G14S	Delin	2022/02/10	Cobalt, total	mg/L	<0.0001
UA	G14S	Delin	2022/03/15	Cobalt, total	mg/L	<0.0001

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G14S	Delin	2022/07/24	Cobalt, total	mg/L	0.000300
UA	G14S	Delin	2022/09/14	Cobalt, total	mg/L	<0.0001
UA	G14S	Delin	2022/11/03	Cobalt, total	mg/L	<0.0001
UA	G14S	Delin	2023/01/25	Cobalt, total	mg/L	0.000200
UA	G14S	Delin	2023/03/10	Cobalt, total	mg/L	<0.0001
UA	G14S	Delin	2022/01/19	Magnesium, total	mg/L	22.7
UA	G14S	Delin	2022/02/10	Magnesium, total	mg/L	22.6
UA	G14S	Delin	2022/03/15	Magnesium, total	mg/L	21.8
UA	G14S	Delin	2022/07/24	Magnesium, total	mg/L	21.4
UA	G14S	Delin	2022/09/14	Magnesium, total	mg/L	20.4
UA	G14S	Delin	2022/11/03	Magnesium, total	mg/L	22.3
UA	G14S	Delin	2023/01/25	Magnesium, total	mg/L	22.3
UA	G14S	Delin	2023/03/10	Magnesium, total	mg/L	21.4
UA	G14S	Delin	2022/01/19	Potassium, total	mg/L	1.66
UA	G14S	Delin	2022/02/10	Potassium, total	mg/L	1.81
UA	G14S	Delin	2022/03/15	Potassium, total	mg/L	1.72
UA	G14S	Delin	2022/07/24	Potassium, total	mg/L	1.72
UA	G14S	Delin	2022/09/14	Potassium, total	mg/L	1.61
UA	G14S	Delin	2022/11/03	Potassium, total	mg/L	1.79
UA	G14S	Delin	2023/01/25	Potassium, total	mg/L	1.84
UA	G14S	Delin	2023/03/10	Potassium, total	mg/L	1.82
UA	G14S	Delin	2022/01/19	Sodium, total	mg/L	41.4
UA	G14S	Delin	2022/02/10	Sodium, total	mg/L	39.3
UA	G14S	Delin	2022/03/15	Sodium, total	mg/L	41.4
UA	G14S	Delin	2022/07/24	Sodium, total	mg/L	38.4
UA	G14S	Delin	2022/09/14	Sodium, total	mg/L	38.2
UA	G14S	Delin	2022/11/03	Sodium, total	mg/L	40.2
UA	G14S	Delin	2023/01/25	Sodium, total	mg/L	33.8
UA	G14S	Delin	2023/03/10	Sodium, total	mg/L	36.8
UA	G14S	Delin	2022/01/19	Sulfate, total	mg/L	180
UA	G14S	Delin	2022/02/10	Sulfate, total	mg/L	190
UA	G14S	Delin	2022/03/15	Sulfate, total	mg/L	197
UA	G14S	Delin	2022/07/24	Sulfate, total	mg/L	180
UA	G14S	Delin	2022/09/14	Sulfate, total	mg/L	162
UA	G14S	Delin	2022/11/03	Sulfate, total	mg/L	165
UA	G14S	Delin	2023/01/25	Sulfate, total	mg/L	158
UA	G14S	Delin	2023/03/10	Sulfate, total	mg/L	166
UA	G14S	Delin	2022/01/19	Temperature (Celsius)	degrees C	14.0
UA	G14S	Delin	2022/02/10	Temperature (Celsius)	degrees C	13.9
UA	G14S	Delin	2022/03/15	Temperature (Celsius)	degrees C	14.1
UA	G14S	Delin	2022/07/24	Temperature (Celsius)	degrees C	14.7
UA	G14S	Delin	2022/09/14	Temperature (Celsius)	degrees C	15.6
UA	G14S	Delin	2022/11/03	Temperature (Celsius)	degrees C	15
UA	G14S	Delin	2023/01/25	Temperature (Celsius)	degrees C	13
UA	G14S	Delin	2023/03/10	Temperature (Celsius)	degrees C	13.8
UA	G14S	Delin	2022/01/19	Total Dissolved Solids	mg/L	498
UA	G14S	Delin	2022/02/10	Total Dissolved Solids	mg/L	456
UA	G14S	Delin	2022/03/15	Total Dissolved Solids	mg/L	472
UA	G14S	Delin	2022/07/24	Total Dissolved Solids	mg/L	474
UA	G14S	Delin	2022/09/14	Total Dissolved Solids	mg/L	464
UA	G14S	Delin	2022/11/03	Total Dissolved Solids	mg/L	454
UA	G14S	Delin	2023/01/25	Total Dissolved Solids	mg/L	438
UA	G14S	Delin	2023/03/10	Total Dissolved Solids	mg/L	440
UA	G14D	Delin	2022/01/19	pH (field)	SU	7.0
UA	G14D	Delin	2022/02/10	pH (field)	SU	7.1

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G14D	Delin	2022/03/15	pH (field)	SU	7.1
UA	G14D	Delin	2022/07/24	pH (field)	SU	7.9
UA	G14D	Delin	2022/09/15	pH (field)	SU	7.1
UA	G14D	Delin	2022/11/03	pH (field)	SU	7.1
UA	G14D	Delin	2023/01/26	pH (field)	SU	7.5
UA	G14D	Delin	2023/03/10	pH (field)	SU	6.9
UA	G14D	Delin	2022/01/19	Oxidation Reduction Potential	mV	-63.0
UA	G14D	Delin	2022/02/10	Oxidation Reduction Potential	mV	-36.0
UA	G14D	Delin	2022/03/15	Oxidation Reduction Potential	mV	-92.0
UA	G14D	Delin	2022/07/24	Oxidation Reduction Potential	mV	-197
UA	G14D	Delin	2022/09/15	Oxidation Reduction Potential	mV	219
UA	G14D	Delin	2022/11/03	Oxidation Reduction Potential	mV	67.7
UA	G14D	Delin	2023/01/26	Oxidation Reduction Potential	mV	156
UA	G14D	Delin	2023/03/10	Oxidation Reduction Potential	mV	75.3
UA	G14D	Delin	2022/01/19	Eh	V	0.13
UA	G14D	Delin	2022/02/10	Eh	V	0.16
UA	G14D	Delin	2022/03/15	Eh	V	0.10
UA	G14D	Delin	2022/07/24	Eh	V	-0.0014
UA	G14D	Delin	2022/09/15	Eh	V	0.41
UA	G14D	Delin	2022/11/03	Eh	V	0.26
UA	G14D	Delin	2023/01/26	Eh	V	0.36
UA	G14D	Delin	2023/03/10	Eh	V	0.27
UA	G14D	Delin	2022/01/19	Alkalinity, bicarbonate	mg/L CaCO3	253
UA	G14D	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	252
UA	G14D	Delin	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	254
UA	G14D	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	249
UA	G14D	Delin	2022/09/15	Alkalinity, bicarbonate	mg/L CaCO3	254
UA	G14D	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	256
UA	G14D	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	157
UA	G14D	Delin	2023/03/10	Alkalinity, bicarbonate	mg/L CaCO3	90.0
UA	G14D	Delin	2022/01/19	Barium, total	mg/L	0.106
UA	G14D	Delin	2022/02/10	Barium, total	mg/L	0.0992
UA	G14D	Delin	2022/03/15	Barium, total	mg/L	0.103
UA	G14D	Delin	2022/07/24	Barium, total	mg/L	0.0896
UA	G14D	Delin	2022/09/15	Barium, total	mg/L	0.0916
UA	G14D	Delin	2022/11/03	Barium, total	mg/L	0.104
UA	G14D	Delin	2023/01/26	Barium, total	mg/L	0.0553
UA	G14D	Delin	2023/03/10	Barium, total	mg/L	0.0340
UA	G14D	Delin	2022/01/19	Boron, total	mg/L	0.0540
UA	G14D	Delin	2022/02/10	Boron, total	mg/L	<0.0092
UA	G14D	Delin	2022/03/15	Boron, total	mg/L	<0.0092
UA	G14D	Delin	2022/07/24	Boron, total	mg/L	0.0252
UA	G14D	Delin	2022/09/15	Boron, total	mg/L	0.0200
UA	G14D	Delin	2022/11/03	Boron, total	mg/L	0.0180
UA	G14D	Delin	2023/01/26	Boron, total	mg/L	0.0781
UA	G14D	Delin	2023/03/10	Boron, total	mg/L	0.101
UA	G14D	Delin	2022/01/19	Calcium, total	mg/L	75.9
UA	G14D	Delin	2022/02/10	Calcium, total	mg/L	77.7
UA	G14D	Delin	2022/03/15	Calcium, total	mg/L	72.1
UA	G14D	Delin	2022/07/24	Calcium, total	mg/L	82.9
UA	G14D	Delin	2022/09/15	Calcium, total	mg/L	72.9
UA	G14D	Delin	2022/11/03	Calcium, total	mg/L	82.9
UA	G14D	Delin	2023/01/26	Calcium, total	mg/L	48.4
UA	G14D	Delin	2023/03/10	Calcium, total	mg/L	24.4
UA	G14D	Delin	2022/01/19	Chloride, total	mg/L	4.00

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G14D	Delin	2022/02/10	Chloride, total	mg/L	3.00
UA	G14D	Delin	2022/03/15	Chloride, total	mg/L	<1
UA	G14D	Delin	2022/07/24	Chloride, total	mg/L	4.00
UA	G14D	Delin	2022/09/15	Chloride, total	mg/L	4.00
UA	G14D	Delin	2022/11/03	Chloride, total	mg/L	4.00
UA	G14D	Delin	2023/01/26	Chloride, total	mg/L	2.00
UA	G14D	Delin	2023/03/10	Chloride, total	mg/L	1.00
UA	G14D	Delin	2022/01/19	Cobalt, total	mg/L	<0.0001
UA	G14D	Delin	2022/02/10	Cobalt, total	mg/L	<0.0001
UA	G14D	Delin	2022/03/15	Cobalt, total	mg/L	<0.0001
UA	G14D	Delin	2022/07/24	Cobalt, total	mg/L	0.000400
UA	G14D	Delin	2022/09/15	Cobalt, total	mg/L	0.000100
UA	G14D	Delin	2022/11/03	Cobalt, total	mg/L	<0.0001
UA	G14D	Delin	2023/01/26	Cobalt, total	mg/L	0.000400
UA	G14D	Delin	2023/03/10	Cobalt, total	mg/L	0.000500
UA	G14D	Delin	2022/01/19	Magnesium, total	mg/L	14.8
UA	G14D	Delin	2022/02/10	Magnesium, total	mg/L	15.5
UA	G14D	Delin	2022/03/15	Magnesium, total	mg/L	14.9
UA	G14D	Delin	2022/07/24	Magnesium, total	mg/L	15.5
UA	G14D	Delin	2022/09/15	Magnesium, total	mg/L	13.7
UA	G14D	Delin	2022/11/03	Magnesium, total	mg/L	16.0
UA	G14D	Delin	2023/01/26	Magnesium, total	mg/L	11.7
UA	G14D	Delin	2023/03/10	Magnesium, total	mg/L	5.13
UA	G14D	Delin	2022/01/19	Potassium, total	mg/L	1.39
UA	G14D	Delin	2022/02/10	Potassium, total	mg/L	1.51
UA	G14D	Delin	2022/03/15	Potassium, total	mg/L	1.52
UA	G14D	Delin	2022/07/24	Potassium, total	mg/L	1.57
UA	G14D	Delin	2022/09/15	Potassium, total	mg/L	1.58
UA	G14D	Delin	2022/11/03	Potassium, total	mg/L	1.64
UA	G14D	Delin	2023/01/26	Potassium, total	mg/L	12.5
UA	G14D	Delin	2023/03/10	Potassium, total	mg/L	5.61
UA	G14D	Delin	2022/01/19	Sodium, total	mg/L	8.21
UA	G14D	Delin	2022/02/10	Sodium, total	mg/L	8.40
UA	G14D	Delin	2022/03/15	Sodium, total	mg/L	8.51
UA	G14D	Delin	2022/07/24	Sodium, total	mg/L	8.55
UA	G14D	Delin	2022/09/15	Sodium, total	mg/L	8.12
UA	G14D	Delin	2022/11/03	Sodium, total	mg/L	9.20
UA	G14D	Delin	2023/01/26	Sodium, total	mg/L	3.59
UA	G14D	Delin	2023/03/10	Sodium, total	mg/L	1.14
UA	G14D	Delin	2022/01/19	Sulfate, total	mg/L	<6
UA	G14D	Delin	2022/02/10	Sulfate, total	mg/L	<6
UA	G14D	Delin	2022/03/15	Sulfate, total	mg/L	<6
UA	G14D	Delin	2022/07/24	Sulfate, total	mg/L	<6
UA	G14D	Delin	2022/09/15	Sulfate, total	mg/L	<6
UA	G14D	Delin	2022/11/03	Sulfate, total	mg/L	<6
UA	G14D	Delin	2023/01/26	Sulfate, total	mg/L	25.0
UA	G14D	Delin	2023/03/10	Sulfate, total	mg/L	11.0
UA	G14D	Delin	2022/01/19	Temperature (Celsius)	degrees C	13.9
UA	G14D	Delin	2022/02/10	Temperature (Celsius)	degrees C	13.7
UA	G14D	Delin	2022/03/15	Temperature (Celsius)	degrees C	14.2
UA	G14D	Delin	2022/07/24	Temperature (Celsius)	degrees C	15.2
UA	G14D	Delin	2022/09/15	Temperature (Celsius)	degrees C	16.2
UA	G14D	Delin	2022/11/03	Temperature (Celsius)	degrees C	15
UA	G14D	Delin	2023/01/26	Temperature (Celsius)	degrees C	9.60
UA	G14D	Delin	2023/03/10	Temperature (Celsius)	degrees C	12.8

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G14D	Delin	2022/01/19	Total Dissolved Solids	mg/L	278
UA	G14D	Delin	2022/02/10	Total Dissolved Solids	mg/L	244
UA	G14D	Delin	2022/03/15	Total Dissolved Solids	mg/L	278
UA	G14D	Delin	2022/07/24	Total Dissolved Solids	mg/L	250
UA	G14D	Delin	2022/09/15	Total Dissolved Solids	mg/L	180
UA	G14D	Delin	2022/11/03	Total Dissolved Solids	mg/L	280
UA	G14D	Delin	2023/01/26	Total Dissolved Solids	mg/L	230
UA	G14D	Delin	2023/03/10	Total Dissolved Solids	mg/L	144
UA	G15S	Delin	2022/01/19	pH (field)	SU	6.2
UA	G15S	Delin	2022/02/10	pH (field)	SU	6.2
UA	G15S	Delin	2022/03/15	pH (field)	SU	6.2
UA	G15S	Delin	2022/07/24	pH (field)	SU	7.1
UA	G15S	Delin	2022/09/13	pH (field)	SU	5.9
UA	G15S	Delin	2022/11/03	pH (field)	SU	6.4
UA	G15S	Delin	2023/01/25	pH (field)	SU	6.8
UA	G15S	Delin	2023/03/09	pH (field)	SU	6.2
UA	G15S	Delin	2022/01/19	Oxidation Reduction Potential	mV	68.0
UA	G15S	Delin	2022/02/10	Oxidation Reduction Potential	mV	82.0
UA	G15S	Delin	2022/03/15	Oxidation Reduction Potential	mV	99.0
UA	G15S	Delin	2022/07/24	Oxidation Reduction Potential	mV	-28.5
UA	G15S	Delin	2022/09/13	Oxidation Reduction Potential	mV	137
UA	G15S	Delin	2022/11/03	Oxidation Reduction Potential	mV	82.8
UA	G15S	Delin	2023/01/25	Oxidation Reduction Potential	mV	41.6
UA	G15S	Delin	2023/03/09	Oxidation Reduction Potential	mV	127
UA	G15S	Delin	2022/01/19	Eh	V	0.26
UA	G15S	Delin	2022/02/10	Eh	V	0.28
UA	G15S	Delin	2022/03/15	Eh	V	0.29
UA	G15S	Delin	2022/07/24	Eh	V	0.17
UA	G15S	Delin	2022/09/13	Eh	V	0.33
UA	G15S	Delin	2022/11/03	Eh	V	0.28
UA	G15S	Delin	2023/01/25	Eh	V	0.24
UA	G15S	Delin	2023/03/09	Eh	V	0.32
UA	G15S	Delin	2022/01/19	Alkalinity, bicarbonate	mg/L CaCO3	135
UA	G15S	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	139
UA	G15S	Delin	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	130
UA	G15S	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	101
UA	G15S	Delin	2022/09/13	Alkalinity, bicarbonate	mg/L CaCO3	118
UA	G15S	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	112
UA	G15S	Delin	2023/01/25	Alkalinity, bicarbonate	mg/L CaCO3	127
UA	G15S	Delin	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	135
UA	G15S	Delin	2022/01/19	Barium, total	mg/L	0.0914
UA	G15S	Delin	2022/02/10	Barium, total	mg/L	0.101
UA	G15S	Delin	2022/03/15	Barium, total	mg/L	0.0895
UA	G15S	Delin	2022/07/24	Barium, total	mg/L	0.106
UA	G15S	Delin	2022/09/13	Barium, total	mg/L	0.162
UA	G15S	Delin	2022/11/03	Barium, total	mg/L	0.130
UA	G15S	Delin	2023/01/25	Barium, total	mg/L	0.0970
UA	G15S	Delin	2023/03/09	Barium, total	mg/L	0.0999
UA	G15S	Delin	2022/01/19	Boron, total	mg/L	1.14
UA	G15S	Delin	2022/02/10	Boron, total	mg/L	1.05
UA	G15S	Delin	2022/03/15	Boron, total	mg/L	0.740
UA	G15S	Delin	2022/07/24	Boron, total	mg/L	1.26
UA	G15S	Delin	2022/09/13	Boron, total	mg/L	0.980
UA	G15S	Delin	2022/11/03	Boron, total	mg/L	1.32
UA	G15S	Delin	2023/01/25	Boron, total	mg/L	0.963

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G15S	Delin	2023/03/09	Boron, total	mg/L	1.33
UA	G15S	Delin	2022/01/19	Calcium, total	mg/L	55.7
UA	G15S	Delin	2022/02/10	Calcium, total	mg/L	56.6
UA	G15S	Delin	2022/03/15	Calcium, total	mg/L	45.5
UA	G15S	Delin	2022/07/24	Calcium, total	mg/L	49.7
UA	G15S	Delin	2022/09/13	Calcium, total	mg/L	49.7
UA	G15S	Delin	2022/11/03	Calcium, total	mg/L	55.3
UA	G15S	Delin	2023/01/25	Calcium, total	mg/L	52.9
UA	G15S	Delin	2023/03/09	Calcium, total	mg/L	52.0
UA	G15S	Delin	2022/01/19	Chloride, total	mg/L	6.00
UA	G15S	Delin	2022/02/10	Chloride, total	mg/L	7.00
UA	G15S	Delin	2022/03/15	Chloride, total	mg/L	3.00
UA	G15S	Delin	2022/07/24	Chloride, total	mg/L	6.00
UA	G15S	Delin	2022/09/13	Chloride, total	mg/L	7.00
UA	G15S	Delin	2022/11/03	Chloride, total	mg/L	7.00
UA	G15S	Delin	2023/01/25	Chloride, total	mg/L	5.00
UA	G15S	Delin	2023/03/09	Chloride, total	mg/L	5.00
UA	G15S	Delin	2022/01/19	Cobalt, total	mg/L	0.00690
UA	G15S	Delin	2022/02/10	Cobalt, total	mg/L	0.00420
UA	G15S	Delin	2022/03/15	Cobalt, total	mg/L	0.00260
UA	G15S	Delin	2022/07/24	Cobalt, total	mg/L	0.00370
UA	G15S	Delin	2022/09/13	Cobalt, total	mg/L	0.00220
UA	G15S	Delin	2022/11/03	Cobalt, total	mg/L	0.000500
UA	G15S	Delin	2023/01/25	Cobalt, total	mg/L	0.000400
UA	G15S	Delin	2023/03/09	Cobalt, total	mg/L	0.00130
UA	G15S	Delin	2022/01/19	Magnesium, total	mg/L	18.2
UA	G15S	Delin	2022/02/10	Magnesium, total	mg/L	19.2
UA	G15S	Delin	2022/03/15	Magnesium, total	mg/L	14.7
UA	G15S	Delin	2022/07/24	Magnesium, total	mg/L	18.0
UA	G15S	Delin	2022/09/13	Magnesium, total	mg/L	18.0
UA	G15S	Delin	2022/11/03	Magnesium, total	mg/L	19.9
UA	G15S	Delin	2023/01/25	Magnesium, total	mg/L	19.4
UA	G15S	Delin	2023/03/09	Magnesium, total	mg/L	18.1
UA	G15S	Delin	2022/01/19	Potassium, total	mg/L	0.733
UA	G15S	Delin	2022/02/10	Potassium, total	mg/L	0.758
UA	G15S	Delin	2022/03/15	Potassium, total	mg/L	0.608
UA	G15S	Delin	2022/07/24	Potassium, total	mg/L	0.548
UA	G15S	Delin	2022/09/13	Potassium, total	mg/L	0.591
UA	G15S	Delin	2022/11/03	Potassium, total	mg/L	0.569
UA	G15S	Delin	2023/01/25	Potassium, total	mg/L	0.524
UA	G15S	Delin	2023/03/09	Potassium, total	mg/L	0.778
UA	G15S	Delin	2022/01/19	Sodium, total	mg/L	21.1
UA	G15S	Delin	2022/02/10	Sodium, total	mg/L	21.0
UA	G15S	Delin	2022/03/15	Sodium, total	mg/L	13.9
UA	G15S	Delin	2022/07/24	Sodium, total	mg/L	17.9
UA	G15S	Delin	2022/09/13	Sodium, total	mg/L	19.4
UA	G15S	Delin	2022/11/03	Sodium, total	mg/L	22.6
UA	G15S	Delin	2023/01/25	Sodium, total	mg/L	17.5
UA	G15S	Delin	2023/03/09	Sodium, total	mg/L	20.5
UA	G15S	Delin	2022/01/19	Sulfate, total	mg/L	101
UA	G15S	Delin	2022/02/10	Sulfate, total	mg/L	104
UA	G15S	Delin	2022/03/15	Sulfate, total	mg/L	53.0
UA	G15S	Delin	2022/07/24	Sulfate, total	mg/L	108
UA	G15S	Delin	2022/09/13	Sulfate, total	mg/L	148
UA	G15S	Delin	2022/11/03	Sulfate, total	mg/L	123

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G15S	Delin	2023/01/25	Sulfate, total	mg/L	88.0
UA	G15S	Delin	2023/03/09	Sulfate, total	mg/L	89.0
UA	G15S	Delin	2022/01/19	Temperature (Celsius)	degrees C	14.1
UA	G15S	Delin	2022/02/10	Temperature (Celsius)	degrees C	14.2
UA	G15S	Delin	2022/03/15	Temperature (Celsius)	degrees C	14.3
UA	G15S	Delin	2022/07/24	Temperature (Celsius)	degrees C	15.1
UA	G15S	Delin	2022/09/13	Temperature (Celsius)	degrees C	15.8
UA	G15S	Delin	2022/11/03	Temperature (Celsius)	degrees C	15.3
UA	G15S	Delin	2023/01/25	Temperature (Celsius)	degrees C	13.5
UA	G15S	Delin	2023/03/09	Temperature (Celsius)	degrees C	14.2
UA	G15S	Delin	2022/01/19	Total Dissolved Solids	mg/L	320
UA	G15S	Delin	2022/02/10	Total Dissolved Solids	mg/L	290
UA	G15S	Delin	2022/03/15	Total Dissolved Solids	mg/L	230
UA	G15S	Delin	2022/07/24	Total Dissolved Solids	mg/L	302
UA	G15S	Delin	2022/09/13	Total Dissolved Solids	mg/L	306
UA	G15S	Delin	2022/11/03	Total Dissolved Solids	mg/L	336
UA	G15S	Delin	2023/01/25	Total Dissolved Solids	mg/L	282
UA	G15S	Delin	2023/03/09	Total Dissolved Solids	mg/L	310
UA	G15D	Delin	2022/01/19	pH (field)	SU	6.8
UA	G15D	Delin	2022/02/11	pH (field)	SU	6.7
UA	G15D	Delin	2022/03/15	pH (field)	SU	6.8
UA	G15D	Delin	2022/07/24	pH (field)	SU	8.2
UA	G15D	Delin	2022/09/13	pH (field)	SU	6.8
UA	G15D	Delin	2022/11/03	pH (field)	SU	7.1
UA	G15D	Delin	2023/01/25	pH (field)	SU	7.3
UA	G15D	Delin	2023/03/09	pH (field)	SU	6.7
UA	G15D	Delin	2022/01/19	Oxidation Reduction Potential	mV	-58.0
UA	G15D	Delin	2022/02/11	Oxidation Reduction Potential	mV	-73.0
UA	G15D	Delin	2022/03/15	Oxidation Reduction Potential	mV	-78.0
UA	G15D	Delin	2022/07/24	Oxidation Reduction Potential	mV	-220
UA	G15D	Delin	2022/09/13	Oxidation Reduction Potential	mV	101
UA	G15D	Delin	2022/11/03	Oxidation Reduction Potential	mV	-6.10
UA	G15D	Delin	2023/01/25	Oxidation Reduction Potential	mV	-95.5
UA	G15D	Delin	2023/03/09	Oxidation Reduction Potential	mV	-28.4
UA	G15D	Delin	2022/01/19	Eh	V	0.14
UA	G15D	Delin	2022/02/11	Eh	V	0.12
UA	G15D	Delin	2022/03/15	Eh	V	0.12
UA	G15D	Delin	2022/07/24	Eh	V	-0.025
UA	G15D	Delin	2022/09/13	Eh	V	0.30
UA	G15D	Delin	2022/11/03	Eh	V	0.19
UA	G15D	Delin	2023/01/25	Eh	V	0.10
UA	G15D	Delin	2023/03/09	Eh	V	0.17
UA	G15D	Delin	2022/01/19	Alkalinity, bicarbonate	mg/L CaCO3	169
UA	G15D	Delin	2022/02/11	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G15D	Delin	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	172
UA	G15D	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	169
UA	G15D	Delin	2022/09/13	Alkalinity, bicarbonate	mg/L CaCO3	169
UA	G15D	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	163
UA	G15D	Delin	2023/01/25	Alkalinity, bicarbonate	mg/L CaCO3	88.0
UA	G15D	Delin	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G15D	Delin	2022/01/19	Barium, total	mg/L	0.0506
UA	G15D	Delin	2022/02/11	Barium, total	mg/L	0.0444
UA	G15D	Delin	2022/03/15	Barium, total	mg/L	0.0365
UA	G15D	Delin	2022/07/24	Barium, total	mg/L	0.0411
UA	G15D	Delin	2022/09/13	Barium, total	mg/L	0.0364

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G15D	Delin	2022/11/03	Barium, total	mg/L	0.0436
UA	G15D	Delin	2023/01/25	Barium, total	mg/L	0.0327
UA	G15D	Delin	2023/03/09	Barium, total	mg/L	0.0441
UA	G15D	Delin	2022/01/19	Boron, total	mg/L	6.69
UA	G15D	Delin	2022/02/11	Boron, total	mg/L	6.10
UA	G15D	Delin	2022/03/15	Boron, total	mg/L	7.88
UA	G15D	Delin	2022/07/24	Boron, total	mg/L	6.22
UA	G15D	Delin	2022/09/13	Boron, total	mg/L	4.17
UA	G15D	Delin	2022/11/03	Boron, total	mg/L	4.26
UA	G15D	Delin	2023/01/25	Boron, total	mg/L	6.17
UA	G15D	Delin	2023/03/09	Boron, total	mg/L	7.22
UA	G15D	Delin	2022/01/19	Calcium, total	mg/L	134
UA	G15D	Delin	2022/02/11	Calcium, total	mg/L	126
UA	G15D	Delin	2022/03/15	Calcium, total	mg/L	134
UA	G15D	Delin	2022/07/24	Calcium, total	mg/L	133
UA	G15D	Delin	2022/09/13	Calcium, total	mg/L	115
UA	G15D	Delin	2022/11/03	Calcium, total	mg/L	123
UA	G15D	Delin	2023/01/25	Calcium, total	mg/L	132
UA	G15D	Delin	2023/03/09	Calcium, total	mg/L	132
UA	G15D	Delin	2022/01/19	Chloride, total	mg/L	19.0
UA	G15D	Delin	2022/02/11	Chloride, total	mg/L	19.0
UA	G15D	Delin	2022/03/15	Chloride, total	mg/L	20.0
UA	G15D	Delin	2022/07/24	Chloride, total	mg/L	19.0
UA	G15D	Delin	2022/09/13	Chloride, total	mg/L	17.0
UA	G15D	Delin	2022/11/03	Chloride, total	mg/L	19.0
UA	G15D	Delin	2023/01/25	Chloride, total	mg/L	18.0
UA	G15D	Delin	2023/03/09	Chloride, total	mg/L	18.0
UA	G15D	Delin	2022/01/19	Cobalt, total	mg/L	0.0238
UA	G15D	Delin	2022/02/11	Cobalt, total	mg/L	0.0178
UA	G15D	Delin	2022/03/15	Cobalt, total	mg/L	0.0217
UA	G15D	Delin	2022/07/24	Cobalt, total	mg/L	0.00980
UA	G15D	Delin	2022/09/13	Cobalt, total	mg/L	0.00400
UA	G15D	Delin	2022/11/03	Cobalt, total	mg/L	0.00500
UA	G15D	Delin	2023/01/25	Cobalt, total	mg/L	0.00720
UA	G15D	Delin	2023/03/09	Cobalt, total	mg/L	0.00920
UA	G15D	Delin	2022/01/19	Magnesium, total	mg/L	30.6
UA	G15D	Delin	2022/02/11	Magnesium, total	mg/L	30.5
UA	G15D	Delin	2022/03/15	Magnesium, total	mg/L	30.7
UA	G15D	Delin	2022/07/24	Magnesium, total	mg/L	31.0
UA	G15D	Delin	2022/09/13	Magnesium, total	mg/L	26.8
UA	G15D	Delin	2022/11/03	Magnesium, total	mg/L	29.1
UA	G15D	Delin	2023/01/25	Magnesium, total	mg/L	30.8
UA	G15D	Delin	2023/03/09	Magnesium, total	mg/L	30.2
UA	G15D	Delin	2022/01/19	Potassium, total	mg/L	2.64
UA	G15D	Delin	2022/02/11	Potassium, total	mg/L	2.95
UA	G15D	Delin	2022/03/15	Potassium, total	mg/L	2.84
UA	G15D	Delin	2022/07/24	Potassium, total	mg/L	2.12
UA	G15D	Delin	2022/09/13	Potassium, total	mg/L	1.82
UA	G15D	Delin	2022/11/03	Potassium, total	mg/L	1.91
UA	G15D	Delin	2023/01/25	Potassium, total	mg/L	2.78
UA	G15D	Delin	2023/03/09	Potassium, total	mg/L	2.88
UA	G15D	Delin	2022/01/19	Sodium, total	mg/L	61.3
UA	G15D	Delin	2022/02/11	Sodium, total	mg/L	58.9
UA	G15D	Delin	2022/03/15	Sodium, total	mg/L	63.3
UA	G15D	Delin	2022/07/24	Sodium, total	mg/L	46.1

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G15D	Delin	2022/09/13	Sodium, total	mg/L	42.6
UA	G15D	Delin	2022/11/03	Sodium, total	mg/L	43.4
UA	G15D	Delin	2023/01/25	Sodium, total	mg/L	56.8
UA	G15D	Delin	2023/03/09	Sodium, total	mg/L	58.7
UA	G15D	Delin	2022/01/19	Sulfate, total	mg/L	362
UA	G15D	Delin	2022/02/11	Sulfate, total	mg/L	389
UA	G15D	Delin	2022/03/15	Sulfate, total	mg/L	375
UA	G15D	Delin	2022/07/24	Sulfate, total	mg/L	300
UA	G15D	Delin	2022/09/13	Sulfate, total	mg/L	310
UA	G15D	Delin	2022/11/03	Sulfate, total	mg/L	320
UA	G15D	Delin	2023/01/25	Sulfate, total	mg/L	377
UA	G15D	Delin	2023/03/09	Sulfate, total	mg/L	382
UA	G15D	Delin	2022/01/19	Temperature (Celsius)	degrees C	13.8
UA	G15D	Delin	2022/02/11	Temperature (Celsius)	degrees C	13.9
UA	G15D	Delin	2022/03/15	Temperature (Celsius)	degrees C	14.7
UA	G15D	Delin	2022/07/24	Temperature (Celsius)	degrees C	16.6
UA	G15D	Delin	2022/09/13	Temperature (Celsius)	degrees C	15.7
UA	G15D	Delin	2022/11/03	Temperature (Celsius)	degrees C	16.7
UA	G15D	Delin	2023/01/25	Temperature (Celsius)	degrees C	13.5
UA	G15D	Delin	2023/03/09	Temperature (Celsius)	degrees C	14.2
UA	G15D	Delin	2022/01/19	Total Dissolved Solids	mg/L	762
UA	G15D	Delin	2022/02/11	Total Dissolved Solids	mg/L	726
UA	G15D	Delin	2022/03/15	Total Dissolved Solids	mg/L	770
UA	G15D	Delin	2022/07/24	Total Dissolved Solids	mg/L	658
UA	G15D	Delin	2022/09/13	Total Dissolved Solids	mg/L	542
UA	G15D	Delin	2022/11/03	Total Dissolved Solids	mg/L	655
UA	G15D	Delin	2023/01/25	Total Dissolved Solids	mg/L	676
UA	G15D	Delin	2023/03/09	Total Dissolved Solids	mg/L	790
UA	G16S	Delin	2022/01/19	pH (field)	SU	6.7
UA	G16S	Delin	2022/02/10	pH (field)	SU	6.7
UA	G16S	Delin	2022/03/15	pH (field)	SU	6.7
UA	G16S	Delin	2022/07/24	pH (field)	SU	8.0
UA	G16S	Delin	2022/09/14	pH (field)	SU	6.7
UA	G16S	Delin	2022/11/03	pH (field)	SU	6.9
UA	G16S	Delin	2023/01/25	pH (field)	SU	7.3
UA	G16S	Delin	2023/03/09	pH (field)	SU	6.7
UA	G16S	Delin	2023/05/02	pH (field)	SU	7.0
UA	G16S	Delin	2023/09/27	pH (field)	SU	6.7
UA	G16S	Delin	2023/10/24	pH (field)	SU	6.5
UA	G16S	Delin	2022/01/19	Oxidation Reduction Potential	mV	-16.0
UA	G16S	Delin	2022/02/10	Oxidation Reduction Potential	mV	8.00
UA	G16S	Delin	2022/03/15	Oxidation Reduction Potential	mV	-1.00
UA	G16S	Delin	2022/07/24	Oxidation Reduction Potential	mV	-113
UA	G16S	Delin	2022/09/14	Oxidation Reduction Potential	mV	214
UA	G16S	Delin	2022/11/03	Oxidation Reduction Potential	mV	53.6
UA	G16S	Delin	2023/01/25	Oxidation Reduction Potential	mV	-6.60
UA	G16S	Delin	2023/03/09	Oxidation Reduction Potential	mV	116
UA	G16S	Delin	2023/05/02	Oxidation Reduction Potential	mV	-28.0
UA	G16S	Delin	2023/09/27	Oxidation Reduction Potential	mV	113
UA	G16S	Delin	2023/10/24	Oxidation Reduction Potential	mV	124
UA	G16S	Delin	2022/01/19	Eh	V	0.18
UA	G16S	Delin	2022/02/10	Eh	V	0.20
UA	G16S	Delin	2022/03/15	Eh	V	0.19
UA	G16S	Delin	2022/07/24	Eh	V	0.082
UA	G16S	Delin	2022/09/14	Eh	V	0.41

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G16S	Delin	2022/11/03	Eh	V	0.25
UA	G16S	Delin	2023/01/25	Eh	V	0.19
UA	G16S	Delin	2023/03/09	Eh	V	0.31
UA	G16S	Delin	2023/05/02	Eh	V	0.17
UA	G16S	Delin	2023/09/27	Eh	V	0.31
UA	G16S	Delin	2023/10/24	Eh	V	0.32
UA	G16S	Delin	2022/01/19	Alkalinity, bicarbonate	mg/L CaCO3	242
UA	G16S	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	243
UA	G16S	Delin	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G16S	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	261
UA	G16S	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	262
UA	G16S	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	262
UA	G16S	Delin	2023/01/25	Alkalinity, bicarbonate	mg/L CaCO3	253
UA	G16S	Delin	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	243
UA	G16S	Delin	2023/05/02	Alkalinity, bicarbonate	mg/L CaCO3	265
UA	G16S	Delin	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	276
UA	G16S	Delin	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	259
UA	G16S	Delin	2022/01/19	Barium, total	mg/L	0.0421
UA	G16S	Delin	2022/02/10	Barium, total	mg/L	0.0407
UA	G16S	Delin	2022/03/15	Barium, total	mg/L	0.0372
UA	G16S	Delin	2022/07/24	Barium, total	mg/L	0.0367
UA	G16S	Delin	2022/09/14	Barium, total	mg/L	0.0351
UA	G16S	Delin	2022/11/03	Barium, total	mg/L	0.0450
UA	G16S	Delin	2023/01/25	Barium, total	mg/L	0.0359
UA	G16S	Delin	2023/03/09	Barium, total	mg/L	0.0479
UA	G16S	Delin	2023/05/02	Barium, total	mg/L	0.0353
UA	G16S	Delin	2023/09/27	Barium, total	mg/L	0.0281
UA	G16S	Delin	2023/10/24	Barium, total	mg/L	0.0425
UA	G16S	Delin	2022/01/19	Boron, total	mg/L	7.24
UA	G16S	Delin	2022/02/10	Boron, total	mg/L	7.63
UA	G16S	Delin	2022/03/15	Boron, total	mg/L	6.74
UA	G16S	Delin	2022/07/24	Boron, total	mg/L	6.79
UA	G16S	Delin	2022/09/14	Boron, total	mg/L	5.96
UA	G16S	Delin	2022/11/03	Boron, total	mg/L	7.24
UA	G16S	Delin	2023/01/25	Boron, total	mg/L	7.18
UA	G16S	Delin	2023/03/09	Boron, total	mg/L	10.6
UA	G16S	Delin	2023/05/02	Boron, total	mg/L	6.72
UA	G16S	Delin	2023/09/27	Boron, total	mg/L	8.29
UA	G16S	Delin	2023/10/24	Boron, total	mg/L	5.85
UA	G16S	Delin	2022/01/19	Calcium, total	mg/L	147
UA	G16S	Delin	2022/02/10	Calcium, total	mg/L	142
UA	G16S	Delin	2022/03/15	Calcium, total	mg/L	128
UA	G16S	Delin	2022/07/24	Calcium, total	mg/L	153
UA	G16S	Delin	2022/09/14	Calcium, total	mg/L	137
UA	G16S	Delin	2022/11/03	Calcium, total	mg/L	148
UA	G16S	Delin	2023/01/25	Calcium, total	mg/L	133
UA	G16S	Delin	2023/03/09	Calcium, total	mg/L	137
UA	G16S	Delin	2023/05/02	Calcium, total	mg/L	141
UA	G16S	Delin	2023/09/27	Calcium, total	mg/L	143
UA	G16S	Delin	2023/10/24	Calcium, total	mg/L	157
UA	G16S	Delin	2022/01/19	Chloride, total	mg/L	17.0
UA	G16S	Delin	2022/02/10	Chloride, total	mg/L	17.0
UA	G16S	Delin	2022/03/15	Chloride, total	mg/L	17.0
UA	G16S	Delin	2022/07/24	Chloride, total	mg/L	17.0
UA	G16S	Delin	2022/09/14	Chloride, total	mg/L	16.0

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G16S	Delin	2022/11/03	Chloride, total	mg/L	16.0
UA	G16S	Delin	2023/01/25	Chloride, total	mg/L	17.0
UA	G16S	Delin	2023/03/09	Chloride, total	mg/L	18.0
UA	G16S	Delin	2023/05/02	Chloride, total	mg/L	17.0
UA	G16S	Delin	2023/09/27	Chloride, total	mg/L	17.0
UA	G16S	Delin	2023/10/24	Chloride, total	mg/L	16.0
UA	G16S	Delin	2022/01/19	Cobalt, total	mg/L	0.00540
UA	G16S	Delin	2022/02/10	Cobalt, total	mg/L	0.00490
UA	G16S	Delin	2022/03/15	Cobalt, total	mg/L	0.00450
UA	G16S	Delin	2022/07/24	Cobalt, total	mg/L	0.00710
UA	G16S	Delin	2022/09/14	Cobalt, total	mg/L	0.00400
UA	G16S	Delin	2022/11/03	Cobalt, total	mg/L	0.00530
UA	G16S	Delin	2023/01/25	Cobalt, total	mg/L	0.00460
UA	G16S	Delin	2023/03/09	Cobalt, total	mg/L	0.00380
UA	G16S	Delin	2023/05/02	Cobalt, total	mg/L	0.00410
UA	G16S	Delin	2023/09/27	Cobalt, total	mg/L	0.00460
UA	G16S	Delin	2023/10/24	Cobalt, total	mg/L	0.00360
UA	G16S	Delin	2023/05/02	Iron, dissolved	mg/L	<0.02
UA	G16S	Delin	2023/09/27	Iron, dissolved	mg/L	0.0804
UA	G16S	Delin	2022/01/19	Magnesium, total	mg/L	25.5
UA	G16S	Delin	2022/02/10	Magnesium, total	mg/L	25.3
UA	G16S	Delin	2022/03/15	Magnesium, total	mg/L	23.6
UA	G16S	Delin	2022/07/24	Magnesium, total	mg/L	25.5
UA	G16S	Delin	2022/09/14	Magnesium, total	mg/L	23.1
UA	G16S	Delin	2022/11/03	Magnesium, total	mg/L	24.0
UA	G16S	Delin	2023/01/25	Magnesium, total	mg/L	23.2
UA	G16S	Delin	2023/03/09	Magnesium, total	mg/L	24.5
UA	G16S	Delin	2023/05/02	Magnesium, total	mg/L	24.6
UA	G16S	Delin	2023/09/27	Magnesium, total	mg/L	24.7
UA	G16S	Delin	2023/10/24	Magnesium, total	mg/L	27.1
UA	G16S	Delin	2023/05/02	Manganese, dissolved	mg/L	10.2
UA	G16S	Delin	2023/09/27	Manganese, dissolved	mg/L	8.75
UA	G16S	Delin	2023/05/02	Phosphate, dissolved	mg/L	0.104
UA	G16S	Delin	2023/09/27	Phosphate, dissolved	mg/L	0.0370
UA	G16S	Delin	2022/01/19	Potassium, total	mg/L	3.60
UA	G16S	Delin	2022/02/10	Potassium, total	mg/L	3.81
UA	G16S	Delin	2022/03/15	Potassium, total	mg/L	3.64
UA	G16S	Delin	2022/07/24	Potassium, total	mg/L	3.70
UA	G16S	Delin	2022/09/14	Potassium, total	mg/L	3.38
UA	G16S	Delin	2022/11/03	Potassium, total	mg/L	3.69
UA	G16S	Delin	2023/01/25	Potassium, total	mg/L	3.42
UA	G16S	Delin	2023/03/09	Potassium, total	mg/L	3.67
UA	G16S	Delin	2023/05/02	Potassium, total	mg/L	3.56
UA	G16S	Delin	2023/09/27	Potassium, total	mg/L	3.61
UA	G16S	Delin	2023/10/24	Potassium, total	mg/L	3.84
UA	G16S	Delin	2023/05/02	Silicon, dissolved	mg/L	6.78
UA	G16S	Delin	2023/09/27	Silicon, dissolved	mg/L	6.83
UA	G16S	Delin	2022/01/19	Sodium, total	mg/L	41.3
UA	G16S	Delin	2022/02/10	Sodium, total	mg/L	40.8
UA	G16S	Delin	2022/03/15	Sodium, total	mg/L	39.7
UA	G16S	Delin	2022/07/24	Sodium, total	mg/L	36.4
UA	G16S	Delin	2022/09/14	Sodium, total	mg/L	34.5
UA	G16S	Delin	2022/11/03	Sodium, total	mg/L	36.0
UA	G16S	Delin	2023/01/25	Sodium, total	mg/L	34.0
UA	G16S	Delin	2023/03/09	Sodium, total	mg/L	39.8

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G16S	Delin	2023/05/02	Sodium, total	mg/L	37.8
UA	G16S	Delin	2023/09/27	Sodium, total	mg/L	35.2
UA	G16S	Delin	2023/10/24	Sodium, total	mg/L	39.8
UA	G16S	Delin	2022/01/19	Sulfate, total	mg/L	279
UA	G16S	Delin	2022/02/10	Sulfate, total	mg/L	271
UA	G16S	Delin	2022/03/15	Sulfate, total	mg/L	300
UA	G16S	Delin	2022/07/24	Sulfate, total	mg/L	249
UA	G16S	Delin	2022/09/14	Sulfate, total	mg/L	262
UA	G16S	Delin	2022/11/03	Sulfate, total	mg/L	272
UA	G16S	Delin	2023/01/25	Sulfate, total	mg/L	255
UA	G16S	Delin	2023/03/09	Sulfate, total	mg/L	299
UA	G16S	Delin	2023/05/02	Sulfate, total	mg/L	256
UA	G16S	Delin	2023/09/27	Sulfate, total	mg/L	229
UA	G16S	Delin	2023/10/24	Sulfate, total	mg/L	256
UA	G16S	Delin	2022/01/19	Temperature (Celsius)	degrees C	14.2
UA	G16S	Delin	2022/02/10	Temperature (Celsius)	degrees C	14.2
UA	G16S	Delin	2022/03/15	Temperature (Celsius)	degrees C	14.3
UA	G16S	Delin	2022/07/24	Temperature (Celsius)	degrees C	15.6
UA	G16S	Delin	2022/09/14	Temperature (Celsius)	degrees C	15.6
UA	G16S	Delin	2022/11/03	Temperature (Celsius)	degrees C	14.7
UA	G16S	Delin	2023/01/25	Temperature (Celsius)	degrees C	13.7
UA	G16S	Delin	2023/03/09	Temperature (Celsius)	degrees C	14.3
UA	G16S	Delin	2023/05/02	Temperature (Celsius)	degrees C	14.6
UA	G16S	Delin	2023/09/27	Temperature (Celsius)	degrees C	14.9
UA	G16S	Delin	2023/10/24	Temperature (Celsius)	degrees C	14.6
UA	G16S	Delin	2022/01/19	Total Dissolved Solids	mg/L	720
UA	G16S	Delin	2022/02/10	Total Dissolved Solids	mg/L	684
UA	G16S	Delin	2022/03/15	Total Dissolved Solids	mg/L	742
UA	G16S	Delin	2022/07/24	Total Dissolved Solids	mg/L	710
UA	G16S	Delin	2022/09/14	Total Dissolved Solids	mg/L	338
UA	G16S	Delin	2022/11/03	Total Dissolved Solids	mg/L	655
UA	G16S	Delin	2023/01/25	Total Dissolved Solids	mg/L	670
UA	G16S	Delin	2023/03/09	Total Dissolved Solids	mg/L	694
UA	G16S	Delin	2023/05/02	Total Dissolved Solids	mg/L	672
UA	G16S	Delin	2023/09/27	Total Dissolved Solids	mg/L	686
UA	G16S	Delin	2023/10/24	Total Dissolved Solids	mg/L	674
UA	G16D	Delin	2022/01/19	pH (field)	SU	7.1
UA	G16D	Delin	2022/02/10	pH (field)	SU	6.8
UA	G16D	Delin	2022/03/15	pH (field)	SU	7.0
UA	G16D	Delin	2022/07/24	pH (field)	SU	8.0
UA	G16D	Delin	2022/09/14	pH (field)	SU	6.8
UA	G16D	Delin	2022/11/03	pH (field)	SU	6.9
UA	G16D	Delin	2023/01/25	pH (field)	SU	7.3
UA	G16D	Delin	2023/03/09	pH (field)	SU	6.8
UA	G16D	Delin	2022/01/19	Oxidation Reduction Potential	mV	-101
UA	G16D	Delin	2022/02/10	Oxidation Reduction Potential	mV	-74.0
UA	G16D	Delin	2022/03/15	Oxidation Reduction Potential	mV	-132
UA	G16D	Delin	2022/07/24	Oxidation Reduction Potential	mV	-234
UA	G16D	Delin	2022/09/14	Oxidation Reduction Potential	mV	191
UA	G16D	Delin	2022/11/03	Oxidation Reduction Potential	mV	-25.3
UA	G16D	Delin	2023/01/25	Oxidation Reduction Potential	mV	-122
UA	G16D	Delin	2023/03/09	Oxidation Reduction Potential	mV	-72.8
UA	G16D	Delin	2022/01/19	Eh	V	0.095
UA	G16D	Delin	2022/02/10	Eh	V	0.12
UA	G16D	Delin	2022/03/15	Eh	V	0.064

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G16D	Delin	2022/07/24	Eh	V	-0.039
UA	G16D	Delin	2022/09/14	Eh	V	0.39
UA	G16D	Delin	2022/11/03	Eh	V	0.17
UA	G16D	Delin	2023/01/25	Eh	V	0.074
UA	G16D	Delin	2023/03/09	Eh	V	0.12
UA	G16D	Delin	2022/01/19	Alkalinity, bicarbonate	mg/L CaCO3	228
UA	G16D	Delin	2022/02/10	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G16D	Delin	2022/03/15	Alkalinity, bicarbonate	mg/L CaCO3	217
UA	G16D	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G16D	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	176
UA	G16D	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	181
UA	G16D	Delin	2023/01/25	Alkalinity, bicarbonate	mg/L CaCO3	174
UA	G16D	Delin	2023/03/09	Alkalinity, bicarbonate	mg/L CaCO3	193
UA	G16D	Delin	2022/01/19	Barium, total	mg/L	0.0908
UA	G16D	Delin	2022/02/10	Barium, total	mg/L	0.0582
UA	G16D	Delin	2022/03/15	Barium, total	mg/L	0.0607
UA	G16D	Delin	2022/07/24	Barium, total	mg/L	0.0399
UA	G16D	Delin	2022/09/14	Barium, total	mg/L	0.0365
UA	G16D	Delin	2022/11/03	Barium, total	mg/L	0.0389
UA	G16D	Delin	2023/01/25	Barium, total	mg/L	0.0405
UA	G16D	Delin	2023/03/09	Barium, total	mg/L	0.0463
UA	G16D	Delin	2022/01/19	Boron, total	mg/L	2.89
UA	G16D	Delin	2022/02/10	Boron, total	mg/L	7.79
UA	G16D	Delin	2022/03/15	Boron, total	mg/L	4.16
UA	G16D	Delin	2022/07/24	Boron, total	mg/L	7.15
UA	G16D	Delin	2022/09/14	Boron, total	mg/L	6.51
UA	G16D	Delin	2022/11/03	Boron, total	mg/L	6.22
UA	G16D	Delin	2023/01/25	Boron, total	mg/L	7.53
UA	G16D	Delin	2023/03/09	Boron, total	mg/L	7.38
UA	G16D	Delin	2022/01/19	Calcium, total	mg/L	81.8
UA	G16D	Delin	2022/02/10	Calcium, total	mg/L	104
UA	G16D	Delin	2022/03/15	Calcium, total	mg/L	92.3
UA	G16D	Delin	2022/07/24	Calcium, total	mg/L	105
UA	G16D	Delin	2022/09/14	Calcium, total	mg/L	95.4
UA	G16D	Delin	2022/11/03	Calcium, total	mg/L	104
UA	G16D	Delin	2023/01/25	Calcium, total	mg/L	112
UA	G16D	Delin	2023/03/09	Calcium, total	mg/L	101
UA	G16D	Delin	2022/01/19	Chloride, total	mg/L	12.0
UA	G16D	Delin	2022/02/10	Chloride, total	mg/L	18.0
UA	G16D	Delin	2022/03/15	Chloride, total	mg/L	15.0
UA	G16D	Delin	2022/07/24	Chloride, total	mg/L	18.0
UA	G16D	Delin	2022/09/14	Chloride, total	mg/L	17.0
UA	G16D	Delin	2022/11/03	Chloride, total	mg/L	17.0
UA	G16D	Delin	2023/01/25	Chloride, total	mg/L	17.0
UA	G16D	Delin	2023/03/09	Chloride, total	mg/L	16.0
UA	G16D	Delin	2022/01/19	Cobalt, total	mg/L	<0.0001
UA	G16D	Delin	2022/02/10	Cobalt, total	mg/L	<0.0001
UA	G16D	Delin	2022/03/15	Cobalt, total	mg/L	<0.0001
UA	G16D	Delin	2022/07/24	Cobalt, total	mg/L	0.000500
UA	G16D	Delin	2022/09/14	Cobalt, total	mg/L	0.000500
UA	G16D	Delin	2022/11/03	Cobalt, total	mg/L	0.000300
UA	G16D	Delin	2023/01/25	Cobalt, total	mg/L	0.000400
UA	G16D	Delin	2023/03/09	Cobalt, total	mg/L	0.000300
UA	G16D	Delin	2022/01/19	Magnesium, total	mg/L	21.2
UA	G16D	Delin	2022/02/10	Magnesium, total	mg/L	28.8

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G16D	Delin	2022/03/15	Magnesium, total	mg/L	24.3
UA	G16D	Delin	2022/07/24	Magnesium, total	mg/L	27.8
UA	G16D	Delin	2022/09/14	Magnesium, total	mg/L	25.2
UA	G16D	Delin	2022/11/03	Magnesium, total	mg/L	26.3
UA	G16D	Delin	2023/01/25	Magnesium, total	mg/L	30.3
UA	G16D	Delin	2023/03/09	Magnesium, total	mg/L	26.5
UA	G16D	Delin	2022/01/19	Potassium, total	mg/L	1.50
UA	G16D	Delin	2022/02/10	Potassium, total	mg/L	1.88
UA	G16D	Delin	2022/03/15	Potassium, total	mg/L	1.57
UA	G16D	Delin	2022/07/24	Potassium, total	mg/L	1.72
UA	G16D	Delin	2022/09/14	Potassium, total	mg/L	1.57
UA	G16D	Delin	2022/11/03	Potassium, total	mg/L	1.68
UA	G16D	Delin	2023/01/25	Potassium, total	mg/L	1.77
UA	G16D	Delin	2023/03/09	Potassium, total	mg/L	1.72
UA	G16D	Delin	2022/01/19	Sodium, total	mg/L	26.3
UA	G16D	Delin	2022/02/10	Sodium, total	mg/L	24.8
UA	G16D	Delin	2022/03/15	Sodium, total	mg/L	19.8
UA	G16D	Delin	2022/07/24	Sodium, total	mg/L	23.3
UA	G16D	Delin	2022/09/14	Sodium, total	mg/L	21.7
UA	G16D	Delin	2022/11/03	Sodium, total	mg/L	23.2
UA	G16D	Delin	2023/01/25	Sodium, total	mg/L	23.8
UA	G16D	Delin	2023/03/09	Sodium, total	mg/L	22.2
UA	G16D	Delin	2022/01/19	Sulfate, total	mg/L	79.0
UA	G16D	Delin	2022/02/10	Sulfate, total	mg/L	198
UA	G16D	Delin	2022/03/15	Sulfate, total	mg/L	117
UA	G16D	Delin	2022/07/24	Sulfate, total	mg/L	198
UA	G16D	Delin	2022/09/14	Sulfate, total	mg/L	187
UA	G16D	Delin	2022/11/03	Sulfate, total	mg/L	203
UA	G16D	Delin	2023/01/25	Sulfate, total	mg/L	201
UA	G16D	Delin	2023/03/09	Sulfate, total	mg/L	183
UA	G16D	Delin	2022/01/19	Temperature (Celsius)	degrees C	14.1
UA	G16D	Delin	2022/02/10	Temperature (Celsius)	degrees C	14.3
UA	G16D	Delin	2022/03/15	Temperature (Celsius)	degrees C	14.5
UA	G16D	Delin	2022/07/24	Temperature (Celsius)	degrees C	15.7
UA	G16D	Delin	2022/09/14	Temperature (Celsius)	degrees C	17.0
UA	G16D	Delin	2022/11/03	Temperature (Celsius)	degrees C	14.9
UA	G16D	Delin	2023/01/25	Temperature (Celsius)	degrees C	13.1
UA	G16D	Delin	2023/03/09	Temperature (Celsius)	degrees C	14.3
UA	G16D	Delin	2022/01/19	Total Dissolved Solids	mg/L	400
UA	G16D	Delin	2022/02/10	Total Dissolved Solids	mg/L	488
UA	G16D	Delin	2022/03/15	Total Dissolved Solids	mg/L	430
UA	G16D	Delin	2022/07/24	Total Dissolved Solids	mg/L	552
UA	G16D	Delin	2022/09/14	Total Dissolved Solids	mg/L	380
UA	G16D	Delin	2022/11/03	Total Dissolved Solids	mg/L	470
UA	G16D	Delin	2023/01/25	Total Dissolved Solids	mg/L	510
UA	G16D	Delin	2023/03/09	Total Dissolved Solids	mg/L	496
UA	G17S	Delin	2022/07/24	pH (field)	SU	7.5
UA	G17S	Delin	2022/09/14	pH (field)	SU	6.6
UA	G17S	Delin	2022/11/02	pH (field)	SU	6.8
UA	G17S	Delin	2023/01/24	pH (field)	SU	6.7
UA	G17S	Delin	2022/07/24	Oxidation Reduction Potential	mV	-39.5
UA	G17S	Delin	2022/09/14	Oxidation Reduction Potential	mV	210
UA	G17S	Delin	2022/11/02	Oxidation Reduction Potential	mV	150
UA	G17S	Delin	2023/01/24	Oxidation Reduction Potential	mV	58.4
UA	G17S	Delin	2022/07/24	Eh	V	0.15

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G17S	Delin	2022/09/14	Eh	V	0.40
UA	G17S	Delin	2022/11/02	Eh	V	0.34
UA	G17S	Delin	2023/01/24	Eh	V	0.25
UA	G17S	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	150
UA	G17S	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	149
UA	G17S	Delin	2022/11/02	Alkalinity, bicarbonate	mg/L CaCO3	155
UA	G17S	Delin	2023/01/24	Alkalinity, bicarbonate	mg/L CaCO3	148
UA	G17S	Delin	2022/07/24	Barium, total	mg/L	0.0547
UA	G17S	Delin	2022/09/14	Barium, total	mg/L	0.0554
UA	G17S	Delin	2022/11/02	Barium, total	mg/L	0.0427
UA	G17S	Delin	2023/01/24	Barium, total	mg/L	0.0414
UA	G17S	Delin	2022/07/24	Boron, total	mg/L	2.76
UA	G17S	Delin	2022/09/14	Boron, total	mg/L	2.43
UA	G17S	Delin	2022/11/02	Boron, total	mg/L	2.59
UA	G17S	Delin	2023/01/24	Boron, total	mg/L	2.71
UA	G17S	Delin	2022/07/24	Calcium, total	mg/L	60.1
UA	G17S	Delin	2022/09/14	Calcium, total	mg/L	59.5
UA	G17S	Delin	2022/11/02	Calcium, total	mg/L	62.7
UA	G17S	Delin	2023/01/24	Calcium, total	mg/L	58.1
UA	G17S	Delin	2022/07/24	Chloride, total	mg/L	17.0
UA	G17S	Delin	2022/09/14	Chloride, total	mg/L	18.0
UA	G17S	Delin	2022/11/02	Chloride, total	mg/L	16.0
UA	G17S	Delin	2023/01/24	Chloride, total	mg/L	14.0
UA	G17S	Delin	2022/07/24	Cobalt, total	mg/L	0.00160
UA	G17S	Delin	2022/09/14	Cobalt, total	mg/L	0.000400
UA	G17S	Delin	2022/11/02	Cobalt, total	mg/L	0.000300
UA	G17S	Delin	2023/01/24	Cobalt, total	mg/L	0.000300
UA	G17S	Delin	2022/07/24	Magnesium, total	mg/L	16.7
UA	G17S	Delin	2022/09/14	Magnesium, total	mg/L	16.5
UA	G17S	Delin	2022/11/02	Magnesium, total	mg/L	17.6
UA	G17S	Delin	2023/01/24	Magnesium, total	mg/L	16.3
UA	G17S	Delin	2022/07/24	Potassium, total	mg/L	1.41
UA	G17S	Delin	2022/09/14	Potassium, total	mg/L	1.34
UA	G17S	Delin	2022/11/02	Potassium, total	mg/L	1.37
UA	G17S	Delin	2023/01/24	Potassium, total	mg/L	1.27
UA	G17S	Delin	2022/07/24	Sodium, total	mg/L	28.1
UA	G17S	Delin	2022/09/14	Sodium, total	mg/L	26.4
UA	G17S	Delin	2022/11/02	Sodium, total	mg/L	27.1
UA	G17S	Delin	2023/01/24	Sodium, total	mg/L	25.9
UA	G17S	Delin	2022/07/24	Sulfate, total	mg/L	97.0
UA	G17S	Delin	2022/09/14	Sulfate, total	mg/L	112
UA	G17S	Delin	2022/11/02	Sulfate, total	mg/L	99.0
UA	G17S	Delin	2023/01/24	Sulfate, total	mg/L	99.0
UA	G17S	Delin	2022/07/24	Temperature (Celsius)	degrees C	17.5
UA	G17S	Delin	2022/09/14	Temperature (Celsius)	degrees C	17.8
UA	G17S	Delin	2022/11/02	Temperature (Celsius)	degrees C	17.0
UA	G17S	Delin	2023/01/24	Temperature (Celsius)	degrees C	15.9
UA	G17S	Delin	2022/07/24	Total Dissolved Solids	mg/L	352
UA	G17S	Delin	2022/09/14	Total Dissolved Solids	mg/L	352
UA	G17S	Delin	2022/11/02	Total Dissolved Solids	mg/L	372
UA	G17S	Delin	2023/01/24	Total Dissolved Solids	mg/L	342
UA	G17D	Delin	2022/07/24	pH (field)	SU	7.7
UA	G17D	Delin	2022/09/14	pH (field)	SU	6.5
UA	G17D	Delin	2022/11/02	pH (field)	SU	6.9
UA	G17D	Delin	2023/01/24	pH (field)	SU	6.8

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G17D	Delin	2022/07/24	Oxidation Reduction Potential	mV	-193
UA	G17D	Delin	2022/09/14	Oxidation Reduction Potential	mV	205
UA	G17D	Delin	2022/11/02	Oxidation Reduction Potential	mV	85.6
UA	G17D	Delin	2023/01/24	Oxidation Reduction Potential	mV	-52.5
UA	G17D	Delin	2022/07/24	Eh	V	0.00053
UA	G17D	Delin	2022/09/14	Eh	V	0.40
UA	G17D	Delin	2022/11/02	Eh	V	0.28
UA	G17D	Delin	2023/01/24	Eh	V	0.14
UA	G17D	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	172
UA	G17D	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G17D	Delin	2022/11/02	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G17D	Delin	2023/01/24	Alkalinity, bicarbonate	mg/L CaCO3	168
UA	G17D	Delin	2022/07/24	Barium, total	mg/L	0.0468
UA	G17D	Delin	2022/09/14	Barium, total	mg/L	0.0353
UA	G17D	Delin	2022/11/02	Barium, total	mg/L	0.0371
UA	G17D	Delin	2023/01/24	Barium, total	mg/L	0.0384
UA	G17D	Delin	2022/07/24	Boron, total	mg/L	4.15
UA	G17D	Delin	2022/09/14	Boron, total	mg/L	3.81
UA	G17D	Delin	2022/11/02	Boron, total	mg/L	4.01
UA	G17D	Delin	2023/01/24	Boron, total	mg/L	4.13
UA	G17D	Delin	2022/07/24	Calcium, total	mg/L	80.3
UA	G17D	Delin	2022/09/14	Calcium, total	mg/L	77.0
UA	G17D	Delin	2022/11/02	Calcium, total	mg/L	77.5
UA	G17D	Delin	2023/01/24	Calcium, total	mg/L	73.3
UA	G17D	Delin	2022/07/24	Chloride, total	mg/L	17.0
UA	G17D	Delin	2022/09/14	Chloride, total	mg/L	16.0
UA	G17D	Delin	2022/11/02	Chloride, total	mg/L	17.0
UA	G17D	Delin	2023/01/24	Chloride, total	mg/L	16.0
UA	G17D	Delin	2022/07/24	Cobalt, total	mg/L	0.00220
UA	G17D	Delin	2022/09/14	Cobalt, total	mg/L	0.000500
UA	G17D	Delin	2022/11/02	Cobalt, total	mg/L	0.000400
UA	G17D	Delin	2023/01/24	Cobalt, total	mg/L	0.000600
UA	G17D	Delin	2022/07/24	Magnesium, total	mg/L	21.5
UA	G17D	Delin	2022/09/14	Magnesium, total	mg/L	20.2
UA	G17D	Delin	2022/11/02	Magnesium, total	mg/L	21.1
UA	G17D	Delin	2023/01/24	Magnesium, total	mg/L	19.9
UA	G17D	Delin	2022/07/24	Potassium, total	mg/L	1.44
UA	G17D	Delin	2022/09/14	Potassium, total	mg/L	1.32
UA	G17D	Delin	2022/11/02	Potassium, total	mg/L	1.31
UA	G17D	Delin	2023/01/24	Potassium, total	mg/L	1.28
UA	G17D	Delin	2022/07/24	Sodium, total	mg/L	28.9
UA	G17D	Delin	2022/09/14	Sodium, total	mg/L	27.1
UA	G17D	Delin	2022/11/02	Sodium, total	mg/L	28.1
UA	G17D	Delin	2023/01/24	Sodium, total	mg/L	26.0
UA	G17D	Delin	2022/07/24	Sulfate, total	mg/L	143
UA	G17D	Delin	2022/09/14	Sulfate, total	mg/L	144
UA	G17D	Delin	2022/11/02	Sulfate, total	mg/L	155
UA	G17D	Delin	2023/01/24	Sulfate, total	mg/L	146
UA	G17D	Delin	2022/07/24	Temperature (Celsius)	degrees C	17.2
UA	G17D	Delin	2022/09/14	Temperature (Celsius)	degrees C	18.3
UA	G17D	Delin	2022/11/02	Temperature (Celsius)	degrees C	16.9
UA	G17D	Delin	2023/01/24	Temperature (Celsius)	degrees C	15.6
UA	G17D	Delin	2022/07/24	Total Dissolved Solids	mg/L	414
UA	G17D	Delin	2022/09/14	Total Dissolved Solids	mg/L	292
UA	G17D	Delin	2022/11/02	Total Dissolved Solids	mg/L	440

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G17D	Delin	2023/01/24	Total Dissolved Solids	mg/L	408
UA	G19S	Delin	2022/07/27	pH (field)	SU	7.4
UA	G19S	Delin	2022/09/14	pH (field)	SU	6.2
UA	G19S	Delin	2022/11/02	pH (field)	SU	6.4
UA	G19S	Delin	2023/01/24	pH (field)	SU	7.8
UA	G19S	Delin	2023/05/03	pH (field)	SU	6.8
UA	G19S	Delin	2023/09/28	pH (field)	SU	6.4
UA	G19S	Delin	2023/10/23	pH (field)	SU	6.4
UA	G19S	Delin	2022/07/27	Oxidation Reduction Potential	mV	36.1
UA	G19S	Delin	2022/09/14	Oxidation Reduction Potential	mV	225
UA	G19S	Delin	2022/11/02	Oxidation Reduction Potential	mV	50.2
UA	G19S	Delin	2023/01/24	Oxidation Reduction Potential	mV	26.1
UA	G19S	Delin	2023/05/03	Oxidation Reduction Potential	mV	111
UA	G19S	Delin	2023/09/28	Oxidation Reduction Potential	mV	127
UA	G19S	Delin	2023/10/23	Oxidation Reduction Potential	mV	151
UA	G19S	Delin	2022/07/27	Eh	V	0.23
UA	G19S	Delin	2022/09/14	Eh	V	0.42
UA	G19S	Delin	2022/11/02	Eh	V	0.24
UA	G19S	Delin	2023/01/24	Eh	V	0.22
UA	G19S	Delin	2023/05/03	Eh	V	0.31
UA	G19S	Delin	2023/09/28	Eh	V	0.32
UA	G19S	Delin	2023/10/23	Eh	V	0.35
UA	G19S	Delin	2022/07/27	Alkalinity, bicarbonate	mg/L CaCO3	184
UA	G19S	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	185
UA	G19S	Delin	2022/11/02	Alkalinity, bicarbonate	mg/L CaCO3	191
UA	G19S	Delin	2023/01/24	Alkalinity, bicarbonate	mg/L CaCO3	184
UA	G19S	Delin	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	183
UA	G19S	Delin	2023/09/28	Alkalinity, bicarbonate	mg/L CaCO3	192
UA	G19S	Delin	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	181
UA	G19S	Delin	2022/07/27	Barium, total	mg/L	0.120
UA	G19S	Delin	2022/09/14	Barium, total	mg/L	0.128
UA	G19S	Delin	2022/11/02	Barium, total	mg/L	0.0868
UA	G19S	Delin	2023/01/24	Barium, total	mg/L	0.0864
UA	G19S	Delin	2023/05/03	Barium, total	mg/L	0.0893
UA	G19S	Delin	2023/09/28	Barium, total	mg/L	0.0741
UA	G19S	Delin	2023/10/23	Barium, total	mg/L	0.101
UA	G19S	Delin	2022/07/27	Boron, total	mg/L	0.712
UA	G19S	Delin	2022/09/14	Boron, total	mg/L	0.515
UA	G19S	Delin	2022/11/02	Boron, total	mg/L	0.449
UA	G19S	Delin	2023/01/24	Boron, total	mg/L	0.573
UA	G19S	Delin	2023/05/03	Boron, total	mg/L	0.655
UA	G19S	Delin	2023/09/28	Boron, total	mg/L	0.668
UA	G19S	Delin	2023/10/23	Boron, total	mg/L	0.743
UA	G19S	Delin	2022/07/27	Calcium, total	mg/L	67.5
UA	G19S	Delin	2022/09/14	Calcium, total	mg/L	62.3
UA	G19S	Delin	2022/11/02	Calcium, total	mg/L	65.9
UA	G19S	Delin	2023/01/24	Calcium, total	mg/L	61.8
UA	G19S	Delin	2023/05/03	Calcium, total	mg/L	63.7
UA	G19S	Delin	2023/09/28	Calcium, total	mg/L	62.5
UA	G19S	Delin	2023/10/23	Calcium, total	mg/L	70.1
UA	G19S	Delin	2022/07/27	Chloride, total	mg/L	54.0
UA	G19S	Delin	2022/09/14	Chloride, total	mg/L	69.0
UA	G19S	Delin	2022/11/02	Chloride, total	mg/L	72.0
UA	G19S	Delin	2023/01/24	Chloride, total	mg/L	69.0
UA	G19S	Delin	2023/05/03	Chloride, total	mg/L	53.0

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G19S	Delin	2023/09/28	Chloride, total	mg/L	62.0
UA	G19S	Delin	2023/10/23	Chloride, total	mg/L	60.0
UA	G19S	Delin	2022/07/27	Cobalt, total	mg/L	0.00160
UA	G19S	Delin	2022/09/14	Cobalt, total	mg/L	0.000800
UA	G19S	Delin	2022/11/02	Cobalt, total	mg/L	0.000500
UA	G19S	Delin	2023/01/24	Cobalt, total	mg/L	0.000700
UA	G19S	Delin	2023/05/03	Cobalt, total	mg/L	0.000400
UA	G19S	Delin	2023/09/28	Cobalt, total	mg/L	0.000200
UA	G19S	Delin	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G19S	Delin	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G19S	Delin	2023/09/28	Iron, dissolved	mg/L	0.487
UA	G19S	Delin	2022/07/27	Magnesium, total	mg/L	20.9
UA	G19S	Delin	2022/09/14	Magnesium, total	mg/L	19.5
UA	G19S	Delin	2022/11/02	Magnesium, total	mg/L	21.2
UA	G19S	Delin	2023/01/24	Magnesium, total	mg/L	20.3
UA	G19S	Delin	2023/05/03	Magnesium, total	mg/L	20.6
UA	G19S	Delin	2023/09/28	Magnesium, total	mg/L	19.3
UA	G19S	Delin	2023/10/23	Magnesium, total	mg/L	21.7
UA	G19S	Delin	2023/05/03	Manganese, dissolved	mg/L	0.0225
UA	G19S	Delin	2023/09/28	Manganese, dissolved	mg/L	0.0105
UA	G19S	Delin	2023/05/03	Phosphate, dissolved	mg/L	<0.005
UA	G19S	Delin	2023/09/28	Phosphate, dissolved	mg/L	0.0520
UA	G19S	Delin	2022/07/27	Potassium, total	mg/L	1.25
UA	G19S	Delin	2022/09/14	Potassium, total	mg/L	1.20
UA	G19S	Delin	2022/11/02	Potassium, total	mg/L	1.21
UA	G19S	Delin	2023/01/24	Potassium, total	mg/L	1.17
UA	G19S	Delin	2023/05/03	Potassium, total	mg/L	1.26
UA	G19S	Delin	2023/09/28	Potassium, total	mg/L	1.24
UA	G19S	Delin	2023/10/23	Potassium, total	mg/L	1.37
UA	G19S	Delin	2023/05/03	Silicon, dissolved	mg/L	6.50
UA	G19S	Delin	2023/09/28	Silicon, dissolved	mg/L	6.50
UA	G19S	Delin	2022/07/27	Sodium, total	mg/L	37.4
UA	G19S	Delin	2022/09/14	Sodium, total	mg/L	35.6
UA	G19S	Delin	2022/11/02	Sodium, total	mg/L	37.8
UA	G19S	Delin	2023/01/24	Sodium, total	mg/L	33.9
UA	G19S	Delin	2023/05/03	Sodium, total	mg/L	38.3
UA	G19S	Delin	2023/09/28	Sodium, total	mg/L	35.7
UA	G19S	Delin	2023/10/23	Sodium, total	mg/L	39.6
UA	G19S	Delin	2022/07/27	Sulfate, total	mg/L	45.0
UA	G19S	Delin	2022/09/14	Sulfate, total	mg/L	46.0
UA	G19S	Delin	2022/11/02	Sulfate, total	mg/L	38.0
UA	G19S	Delin	2023/01/24	Sulfate, total	mg/L	36.0
UA	G19S	Delin	2023/05/03	Sulfate, total	mg/L	40.0
UA	G19S	Delin	2023/09/28	Sulfate, total	mg/L	34.0
UA	G19S	Delin	2023/10/23	Sulfate, total	mg/L	43.0
UA	G19S	Delin	2022/07/27	Temperature (Celsius)	degrees C	19.4
UA	G19S	Delin	2022/09/14	Temperature (Celsius)	degrees C	17.1
UA	G19S	Delin	2022/11/02	Temperature (Celsius)	degrees C	17.1
UA	G19S	Delin	2023/01/24	Temperature (Celsius)	degrees C	14.7
UA	G19S	Delin	2023/05/03	Temperature (Celsius)	degrees C	16.0
UA	G19S	Delin	2023/09/28	Temperature (Celsius)	degrees C	15.4
UA	G19S	Delin	2023/10/23	Temperature (Celsius)	degrees C	16.3
UA	G19S	Delin	2022/07/27	Total Dissolved Solids	mg/L	390
UA	G19S	Delin	2022/09/14	Total Dissolved Solids	mg/L	332
UA	G19S	Delin	2022/11/02	Total Dissolved Solids	mg/L	398

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G19S	Delin	2023/01/24	Total Dissolved Solids	mg/L	366
UA	G19S	Delin	2023/05/03	Total Dissolved Solids	mg/L	334
UA	G19S	Delin	2023/09/28	Total Dissolved Solids	mg/L	390
UA	G19S	Delin	2023/10/23	Total Dissolved Solids	mg/L	350
UA	G19D	Delin	2022/07/27	pH (field)	SU	7.5
UA	G19D	Delin	2022/09/14	pH (field)	SU	6.2
UA	G19D	Delin	2022/11/02	pH (field)	SU	6.7
UA	G19D	Delin	2023/01/24	pH (field)	SU	6.7
UA	G19D	Delin	2023/05/03	pH (field)	SU	7.0
UA	G19D	Delin	2023/09/28	pH (field)	SU	6.4
UA	G19D	Delin	2023/10/23	pH (field)	SU	6.6
UA	G19D	Delin	2022/07/27	Oxidation Reduction Potential	mV	39.8
UA	G19D	Delin	2022/09/14	Oxidation Reduction Potential	mV	223
UA	G19D	Delin	2022/11/02	Oxidation Reduction Potential	mV	50.8
UA	G19D	Delin	2023/01/24	Oxidation Reduction Potential	mV	50.3
UA	G19D	Delin	2023/05/03	Oxidation Reduction Potential	mV	91.0
UA	G19D	Delin	2023/09/28	Oxidation Reduction Potential	mV	125
UA	G19D	Delin	2023/10/23	Oxidation Reduction Potential	mV	146
UA	G19D	Delin	2022/07/27	Eh	V	0.23
UA	G19D	Delin	2022/09/14	Eh	V	0.42
UA	G19D	Delin	2022/11/02	Eh	V	0.24
UA	G19D	Delin	2023/01/24	Eh	V	0.25
UA	G19D	Delin	2023/05/03	Eh	V	0.29
UA	G19D	Delin	2023/09/28	Eh	V	0.32
UA	G19D	Delin	2023/10/23	Eh	V	0.34
UA	G19D	Delin	2022/07/27	Alkalinity, bicarbonate	mg/L CaCO3	166
UA	G19D	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	158
UA	G19D	Delin	2022/11/02	Alkalinity, bicarbonate	mg/L CaCO3	171
UA	G19D	Delin	2023/01/24	Alkalinity, bicarbonate	mg/L CaCO3	144
UA	G19D	Delin	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G19D	Delin	2023/09/28	Alkalinity, bicarbonate	mg/L CaCO3	181
UA	G19D	Delin	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	168
UA	G19D	Delin	2022/07/27	Barium, total	mg/L	0.110
UA	G19D	Delin	2022/09/14	Barium, total	mg/L	0.160
UA	G19D	Delin	2022/11/02	Barium, total	mg/L	0.104
UA	G19D	Delin	2023/01/24	Barium, total	mg/L	0.0999
UA	G19D	Delin	2023/05/03	Barium, total	mg/L	0.103
UA	G19D	Delin	2023/09/28	Barium, total	mg/L	0.0986
UA	G19D	Delin	2023/10/23	Barium, total	mg/L	0.135
UA	G19D	Delin	2022/07/27	Boron, total	mg/L	0.615
UA	G19D	Delin	2022/09/14	Boron, total	mg/L	0.496
UA	G19D	Delin	2022/11/02	Boron, total	mg/L	0.637
UA	G19D	Delin	2023/01/24	Boron, total	mg/L	0.655
UA	G19D	Delin	2023/05/03	Boron, total	mg/L	0.772
UA	G19D	Delin	2023/09/28	Boron, total	mg/L	0.621
UA	G19D	Delin	2023/10/23	Boron, total	mg/L	0.809
UA	G19D	Delin	2022/07/27	Calcium, total	mg/L	54.9
UA	G19D	Delin	2022/09/14	Calcium, total	mg/L	51.1
UA	G19D	Delin	2022/11/02	Calcium, total	mg/L	55.6
UA	G19D	Delin	2023/01/24	Calcium, total	mg/L	49.8
UA	G19D	Delin	2023/05/03	Calcium, total	mg/L	53.2
UA	G19D	Delin	2023/09/28	Calcium, total	mg/L	51.8
UA	G19D	Delin	2023/10/23	Calcium, total	mg/L	57.3
UA	G19D	Delin	2022/07/27	Chloride, total	mg/L	28.0
UA	G19D	Delin	2022/09/14	Chloride, total	mg/L	26.0

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G19D	Delin	2022/11/02	Chloride, total	mg/L	27.0
UA	G19D	Delin	2023/01/24	Chloride, total	mg/L	25.0
UA	G19D	Delin	2023/05/03	Chloride, total	mg/L	26.0
UA	G19D	Delin	2023/09/28	Chloride, total	mg/L	25.0
UA	G19D	Delin	2023/10/23	Chloride, total	mg/L	27.0
UA	G19D	Delin	2022/07/27	Cobalt, total	mg/L	0.000100
UA	G19D	Delin	2022/09/14	Cobalt, total	mg/L	<0.0001
UA	G19D	Delin	2022/11/02	Cobalt, total	mg/L	<0.0001
UA	G19D	Delin	2023/01/24	Cobalt, total	mg/L	<0.0001
UA	G19D	Delin	2023/05/03	Cobalt, total	mg/L	0.000400
UA	G19D	Delin	2023/09/28	Cobalt, total	mg/L	0.00120
UA	G19D	Delin	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G19D	Delin	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G19D	Delin	2023/09/28	Iron, dissolved	mg/L	<0.0115
UA	G19D	Delin	2022/07/27	Magnesium, total	mg/L	15.6
UA	G19D	Delin	2022/09/14	Magnesium, total	mg/L	14.9
UA	G19D	Delin	2022/11/02	Magnesium, total	mg/L	16.6
UA	G19D	Delin	2023/01/24	Magnesium, total	mg/L	15.1
UA	G19D	Delin	2023/05/03	Magnesium, total	mg/L	15.7
UA	G19D	Delin	2023/09/28	Magnesium, total	mg/L	15.0
UA	G19D	Delin	2023/10/23	Magnesium, total	mg/L	16.5
UA	G19D	Delin	2023/05/03	Manganese, dissolved	mg/L	0.00360
UA	G19D	Delin	2023/09/28	Manganese, dissolved	mg/L	0.00140
UA	G19D	Delin	2023/05/03	Phosphate, dissolved	mg/L	0.0150
UA	G19D	Delin	2023/09/28	Phosphate, dissolved	mg/L	0.0520
UA	G19D	Delin	2022/07/27	Potassium, total	mg/L	1.29
UA	G19D	Delin	2022/09/14	Potassium, total	mg/L	1.24
UA	G19D	Delin	2022/11/02	Potassium, total	mg/L	1.30
UA	G19D	Delin	2023/01/24	Potassium, total	mg/L	1.21
UA	G19D	Delin	2023/05/03	Potassium, total	mg/L	1.31
UA	G19D	Delin	2023/09/28	Potassium, total	mg/L	1.27
UA	G19D	Delin	2023/10/23	Potassium, total	mg/L	1.43
UA	G19D	Delin	2023/05/03	Silicon, dissolved	mg/L	5.98
UA	G19D	Delin	2023/09/28	Silicon, dissolved	mg/L	6.01
UA	G19D	Delin	2022/07/27	Sodium, total	mg/L	29.0
UA	G19D	Delin	2022/09/14	Sodium, total	mg/L	27.9
UA	G19D	Delin	2022/11/02	Sodium, total	mg/L	29.4
UA	G19D	Delin	2023/01/24	Sodium, total	mg/L	26.5
UA	G19D	Delin	2023/05/03	Sodium, total	mg/L	30.7
UA	G19D	Delin	2023/09/28	Sodium, total	mg/L	27.2
UA	G19D	Delin	2023/10/23	Sodium, total	mg/L	31.4
UA	G19D	Delin	2022/07/27	Sulfate, total	mg/L	41.0
UA	G19D	Delin	2022/09/14	Sulfate, total	mg/L	44.0
UA	G19D	Delin	2022/11/02	Sulfate, total	mg/L	41.0
UA	G19D	Delin	2023/01/24	Sulfate, total	mg/L	41.0
UA	G19D	Delin	2023/05/03	Sulfate, total	mg/L	46.0
UA	G19D	Delin	2023/09/28	Sulfate, total	mg/L	35.0
UA	G19D	Delin	2023/10/23	Sulfate, total	mg/L	43.0
UA	G19D	Delin	2022/07/27	Temperature (Celsius)	degrees C	18.6
UA	G19D	Delin	2022/09/14	Temperature (Celsius)	degrees C	18.6
UA	G19D	Delin	2022/11/02	Temperature (Celsius)	degrees C	17.8
UA	G19D	Delin	2023/01/24	Temperature (Celsius)	degrees C	14.9
UA	G19D	Delin	2023/05/03	Temperature (Celsius)	degrees C	15.8
UA	G19D	Delin	2023/09/28	Temperature (Celsius)	degrees C	15.5
UA	G19D	Delin	2023/10/23	Temperature (Celsius)	degrees C	17.6

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G19D	Delin	2022/07/27	Total Dissolved Solids	mg/L	310
UA	G19D	Delin	2022/09/14	Total Dissolved Solids	mg/L	310
UA	G19D	Delin	2022/11/02	Total Dissolved Solids	mg/L	314
UA	G19D	Delin	2023/01/24	Total Dissolved Solids	mg/L	302
UA	G19D	Delin	2023/05/03	Total Dissolved Solids	mg/L	282
UA	G19D	Delin	2023/09/28	Total Dissolved Solids	mg/L	290
UA	G19D	Delin	2023/10/23	Total Dissolved Solids	mg/L	278
UA	G20S	Delin	2022/07/24	pH (field)	SU	7.9
UA	G20S	Delin	2022/09/15	pH (field)	SU	6.4
UA	G20S	Delin	2022/11/03	pH (field)	SU	6.7
UA	G20S	Delin	2023/01/26	pH (field)	SU	7.0
UA	G20S	Delin	2023/05/03	pH (field)	SU	6.9
UA	G20S	Delin	2023/09/27	pH (field)	SU	6.6
UA	G20S	Delin	2023/10/24	pH (field)	SU	6.3
UA	G20S	Delin	2022/07/24	Oxidation Reduction Potential	mV	-18.6
UA	G20S	Delin	2022/09/15	Oxidation Reduction Potential	mV	145
UA	G20S	Delin	2022/11/03	Oxidation Reduction Potential	mV	69.9
UA	G20S	Delin	2023/01/26	Oxidation Reduction Potential	mV	-0.800
UA	G20S	Delin	2023/05/03	Oxidation Reduction Potential	mV	71.0
UA	G20S	Delin	2023/09/27	Oxidation Reduction Potential	mV	99.0
UA	G20S	Delin	2023/10/24	Oxidation Reduction Potential	mV	113
UA	G20S	Delin	2022/07/24	Eh	V	0.18
UA	G20S	Delin	2022/09/15	Eh	V	0.34
UA	G20S	Delin	2022/11/03	Eh	V	0.26
UA	G20S	Delin	2023/01/26	Eh	V	0.20
UA	G20S	Delin	2023/05/03	Eh	V	0.27
UA	G20S	Delin	2023/09/27	Eh	V	0.29
UA	G20S	Delin	2023/10/24	Eh	V	0.31
UA	G20S	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	149
UA	G20S	Delin	2022/09/15	Alkalinity, bicarbonate	mg/L CaCO3	141
UA	G20S	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	142
UA	G20S	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	149
UA	G20S	Delin	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	141
UA	G20S	Delin	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	164
UA	G20S	Delin	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	147
UA	G20S	Delin	2022/07/24	Barium, total	mg/L	0.0586
UA	G20S	Delin	2022/09/15	Barium, total	mg/L	0.0459
UA	G20S	Delin	2022/11/03	Barium, total	mg/L	0.0562
UA	G20S	Delin	2023/01/26	Barium, total	mg/L	0.0313
UA	G20S	Delin	2023/05/03	Barium, total	mg/L	0.0472
UA	G20S	Delin	2023/09/27	Barium, total	mg/L	0.0430
UA	G20S	Delin	2023/10/24	Barium, total	mg/L	0.0573
UA	G20S	Delin	2022/07/24	Boron, total	mg/L	4.84
UA	G20S	Delin	2022/09/15	Boron, total	mg/L	3.24
UA	G20S	Delin	2022/11/03	Boron, total	mg/L	4.49
UA	G20S	Delin	2023/01/26	Boron, total	mg/L	3.77
UA	G20S	Delin	2023/05/03	Boron, total	mg/L	3.69
UA	G20S	Delin	2023/09/27	Boron, total	mg/L	3.58
UA	G20S	Delin	2023/10/24	Boron, total	mg/L	4.45
UA	G20S	Delin	2022/07/24	Calcium, total	mg/L	72.1
UA	G20S	Delin	2022/09/15	Calcium, total	mg/L	63.5
UA	G20S	Delin	2022/11/03	Calcium, total	mg/L	72.5
UA	G20S	Delin	2023/01/26	Calcium, total	mg/L	75.2
UA	G20S	Delin	2023/05/03	Calcium, total	mg/L	66.7
UA	G20S	Delin	2023/09/27	Calcium, total	mg/L	67.0

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G20S	Delin	2023/10/24	Calcium, total	mg/L	74.2
UA	G20S	Delin	2022/07/24	Chloride, total	mg/L	19.0
UA	G20S	Delin	2022/09/15	Chloride, total	mg/L	17.0
UA	G20S	Delin	2022/11/03	Chloride, total	mg/L	16.0
UA	G20S	Delin	2023/01/26	Chloride, total	mg/L	14.0
UA	G20S	Delin	2023/05/03	Chloride, total	mg/L	19.0
UA	G20S	Delin	2023/09/27	Chloride, total	mg/L	16.0
UA	G20S	Delin	2023/10/24	Chloride, total	mg/L	18.0
UA	G20S	Delin	2022/07/24	Cobalt, total	mg/L	0.000200
UA	G20S	Delin	2022/09/15	Cobalt, total	mg/L	<0.0001
UA	G20S	Delin	2022/11/03	Cobalt, total	mg/L	<0.0001
UA	G20S	Delin	2023/01/26	Cobalt, total	mg/L	<0.0001
UA	G20S	Delin	2023/05/03	Cobalt, total	mg/L	<0.0001
UA	G20S	Delin	2023/09/27	Cobalt, total	mg/L	<0.0001
UA	G20S	Delin	2023/10/24	Cobalt, total	mg/L	<0.0001
UA	G20S	Delin	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G20S	Delin	2023/09/27	Iron, dissolved	mg/L	0.0501
UA	G20S	Delin	2022/07/24	Magnesium, total	mg/L	19.3
UA	G20S	Delin	2022/09/15	Magnesium, total	mg/L	17.4
UA	G20S	Delin	2022/11/03	Magnesium, total	mg/L	19.4
UA	G20S	Delin	2023/01/26	Magnesium, total	mg/L	20.1
UA	G20S	Delin	2023/05/03	Magnesium, total	mg/L	19.1
UA	G20S	Delin	2023/09/27	Magnesium, total	mg/L	18.9
UA	G20S	Delin	2023/10/24	Magnesium, total	mg/L	20.1
UA	G20S	Delin	2023/05/03	Manganese, dissolved	mg/L	0.00310
UA	G20S	Delin	2023/09/27	Manganese, dissolved	mg/L	<0.0012
UA	G20S	Delin	2023/05/03	Phosphate, dissolved	mg/L	0.0340
UA	G20S	Delin	2023/09/27	Phosphate, dissolved	mg/L	0.0580
UA	G20S	Delin	2022/07/24	Potassium, total	mg/L	1.23
UA	G20S	Delin	2022/09/15	Potassium, total	mg/L	1.19
UA	G20S	Delin	2022/11/03	Potassium, total	mg/L	1.35
UA	G20S	Delin	2023/01/26	Potassium, total	mg/L	1.39
UA	G20S	Delin	2023/05/03	Potassium, total	mg/L	1.25
UA	G20S	Delin	2023/09/27	Potassium, total	mg/L	1.31
UA	G20S	Delin	2023/10/24	Potassium, total	mg/L	1.39
UA	G20S	Delin	2023/05/03	Silicon, dissolved	mg/L	6.30
UA	G20S	Delin	2023/09/27	Silicon, dissolved	mg/L	6.49
UA	G20S	Delin	2022/07/24	Sodium, total	mg/L	35.8
UA	G20S	Delin	2022/09/15	Sodium, total	mg/L	33.9
UA	G20S	Delin	2022/11/03	Sodium, total	mg/L	35.4
UA	G20S	Delin	2023/01/26	Sodium, total	mg/L	29.6
UA	G20S	Delin	2023/05/03	Sodium, total	mg/L	39.0
UA	G20S	Delin	2023/09/27	Sodium, total	mg/L	34.0
UA	G20S	Delin	2023/10/24	Sodium, total	mg/L	37.8
UA	G20S	Delin	2022/07/24	Sulfate, total	mg/L	143
UA	G20S	Delin	2022/09/15	Sulfate, total	mg/L	143
UA	G20S	Delin	2022/11/03	Sulfate, total	mg/L	143
UA	G20S	Delin	2023/01/26	Sulfate, total	mg/L	148
UA	G20S	Delin	2023/05/03	Sulfate, total	mg/L	145
UA	G20S	Delin	2023/09/27	Sulfate, total	mg/L	138
UA	G20S	Delin	2023/10/24	Sulfate, total	mg/L	145
UA	G20S	Delin	2022/07/24	Temperature (Celsius)	degrees C	16
UA	G20S	Delin	2022/09/15	Temperature (Celsius)	degrees C	16.1
UA	G20S	Delin	2022/11/03	Temperature (Celsius)	degrees C	15.6
UA	G20S	Delin	2023/01/26	Temperature (Celsius)	degrees C	13.7

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G20S	Delin	2023/05/03	Temperature (Celsius)	degrees C	15.1
UA	G20S	Delin	2023/09/27	Temperature (Celsius)	degrees C	15.5
UA	G20S	Delin	2023/10/24	Temperature (Celsius)	degrees C	15.1
UA	G20S	Delin	2022/07/24	Total Dissolved Solids	mg/L	400
UA	G20S	Delin	2022/09/15	Total Dissolved Solids	mg/L	380
UA	G20S	Delin	2022/11/03	Total Dissolved Solids	mg/L	392
UA	G20S	Delin	2023/01/26	Total Dissolved Solids	mg/L	380
UA	G20S	Delin	2023/05/03	Total Dissolved Solids	mg/L	372
UA	G20S	Delin	2023/09/27	Total Dissolved Solids	mg/L	400
UA	G20S	Delin	2023/10/24	Total Dissolved Solids	mg/L	384
UA	G20D	Delin	2022/07/24	pH (field)	SU	8.1
UA	G20D	Delin	2022/09/15	pH (field)	SU	7.3
UA	G20D	Delin	2022/11/03	pH (field)	SU	7.0
UA	G20D	Delin	2023/01/26	pH (field)	SU	7.2
UA	G20D	Delin	2023/05/03	pH (field)	SU	7.0
UA	G20D	Delin	2023/09/27	pH (field)	SU	6.9
UA	G20D	Delin	2023/10/24	pH (field)	SU	6.7
UA	G20D	Delin	2022/07/24	Oxidation Reduction Potential	mV	-212
UA	G20D	Delin	2022/09/15	Oxidation Reduction Potential	mV	143
UA	G20D	Delin	2022/11/03	Oxidation Reduction Potential	mV	23.3
UA	G20D	Delin	2023/01/26	Oxidation Reduction Potential	mV	-64.1
UA	G20D	Delin	2023/05/03	Oxidation Reduction Potential	mV	49.0
UA	G20D	Delin	2023/09/27	Oxidation Reduction Potential	mV	88.0
UA	G20D	Delin	2023/10/24	Oxidation Reduction Potential	mV	109
UA	G20D	Delin	2022/07/24	Eh	V	-0.017
UA	G20D	Delin	2022/09/15	Eh	V	0.33
UA	G20D	Delin	2022/11/03	Eh	V	0.22
UA	G20D	Delin	2023/01/26	Eh	V	0.13
UA	G20D	Delin	2023/05/03	Eh	V	0.24
UA	G20D	Delin	2023/09/27	Eh	V	0.28
UA	G20D	Delin	2023/10/24	Eh	V	0.30
UA	G20D	Delin	2022/07/24	Alkalinity, bicarbonate	mg/L CaCO3	172
UA	G20D	Delin	2022/09/15	Alkalinity, bicarbonate	mg/L CaCO3	155
UA	G20D	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	168
UA	G20D	Delin	2023/01/26	Alkalinity, bicarbonate	mg/L CaCO3	169
UA	G20D	Delin	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	171
UA	G20D	Delin	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	184
UA	G20D	Delin	2023/10/24	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G20D	Delin	2022/07/24	Barium, total	mg/L	0.0892
UA	G20D	Delin	2022/09/15	Barium, total	mg/L	0.0922
UA	G20D	Delin	2022/11/03	Barium, total	mg/L	0.0877
UA	G20D	Delin	2023/01/26	Barium, total	mg/L	0.104
UA	G20D	Delin	2023/05/03	Barium, total	mg/L	0.0852
UA	G20D	Delin	2023/09/27	Barium, total	mg/L	0.0865
UA	G20D	Delin	2023/10/24	Barium, total	mg/L	0.0799
UA	G20D	Delin	2022/07/24	Boron, total	mg/L	2.93
UA	G20D	Delin	2022/09/15	Boron, total	mg/L	2.52
UA	G20D	Delin	2022/11/03	Boron, total	mg/L	2.42
UA	G20D	Delin	2023/01/26	Boron, total	mg/L	2.88
UA	G20D	Delin	2023/05/03	Boron, total	mg/L	2.50
UA	G20D	Delin	2023/09/27	Boron, total	mg/L	2.64
UA	G20D	Delin	2023/10/24	Boron, total	mg/L	2.16
UA	G20D	Delin	2022/07/24	Calcium, total	mg/L	90.5
UA	G20D	Delin	2022/09/15	Calcium, total	mg/L	77.1
UA	G20D	Delin	2022/11/03	Calcium, total	mg/L	85.7

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G20D	Delin	2023/01/26	Calcium, total	mg/L	88.1
UA	G20D	Delin	2023/05/03	Calcium, total	mg/L	77.7
UA	G20D	Delin	2023/09/27	Calcium, total	mg/L	81.1
UA	G20D	Delin	2023/10/24	Calcium, total	mg/L	87.6
UA	G20D	Delin	2022/07/24	Chloride, total	mg/L	15.0
UA	G20D	Delin	2022/09/15	Chloride, total	mg/L	14.0
UA	G20D	Delin	2022/11/03	Chloride, total	mg/L	14.0
UA	G20D	Delin	2023/01/26	Chloride, total	mg/L	15.0
UA	G20D	Delin	2023/05/03	Chloride, total	mg/L	14.0
UA	G20D	Delin	2023/09/27	Chloride, total	mg/L	14.0
UA	G20D	Delin	2023/10/24	Chloride, total	mg/L	14.0
UA	G20D	Delin	2022/07/24	Cobalt, total	mg/L	0.000600
UA	G20D	Delin	2022/09/15	Cobalt, total	mg/L	0.000400
UA	G20D	Delin	2022/11/03	Cobalt, total	mg/L	0.000200
UA	G20D	Delin	2023/01/26	Cobalt, total	mg/L	0.000800
UA	G20D	Delin	2023/05/03	Cobalt, total	mg/L	<0.0001
UA	G20D	Delin	2023/09/27	Cobalt, total	mg/L	<0.0001
UA	G20D	Delin	2023/10/24	Cobalt, total	mg/L	<0.0001
UA	G20D	Delin	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G20D	Delin	2023/09/27	Iron, dissolved	mg/L	<0.0115
UA	G20D	Delin	2022/07/24	Magnesium, total	mg/L	22.6
UA	G20D	Delin	2022/09/15	Magnesium, total	mg/L	19.4
UA	G20D	Delin	2022/11/03	Magnesium, total	mg/L	21.6
UA	G20D	Delin	2023/01/26	Magnesium, total	mg/L	22.2
UA	G20D	Delin	2023/05/03	Magnesium, total	mg/L	21.0
UA	G20D	Delin	2023/09/27	Magnesium, total	mg/L	21.2
UA	G20D	Delin	2023/10/24	Magnesium, total	mg/L	22.1
UA	G20D	Delin	2023/05/03	Manganese, dissolved	mg/L	0.0138
UA	G20D	Delin	2023/09/27	Manganese, dissolved	mg/L	<0.0012
UA	G20D	Delin	2023/05/03	Phosphate, dissolved	mg/L	0.0150
UA	G20D	Delin	2023/09/27	Phosphate, dissolved	mg/L	0.0250
UA	G20D	Delin	2022/07/24	Potassium, total	mg/L	1.40
UA	G20D	Delin	2022/09/15	Potassium, total	mg/L	1.25
UA	G20D	Delin	2022/11/03	Potassium, total	mg/L	1.31
UA	G20D	Delin	2023/01/26	Potassium, total	mg/L	1.69
UA	G20D	Delin	2023/05/03	Potassium, total	mg/L	1.81
UA	G20D	Delin	2023/09/27	Potassium, total	mg/L	1.29
UA	G20D	Delin	2023/10/24	Potassium, total	mg/L	1.42
UA	G20D	Delin	2023/05/03	Silicon, dissolved	mg/L	6.46
UA	G20D	Delin	2023/09/27	Silicon, dissolved	mg/L	5.68
UA	G20D	Delin	2022/07/24	Sodium, total	mg/L	21.9
UA	G20D	Delin	2022/09/15	Sodium, total	mg/L	20.0
UA	G20D	Delin	2022/11/03	Sodium, total	mg/L	21.7
UA	G20D	Delin	2023/01/26	Sodium, total	mg/L	21.6
UA	G20D	Delin	2023/05/03	Sodium, total	mg/L	23.6
UA	G20D	Delin	2023/09/27	Sodium, total	mg/L	20.2
UA	G20D	Delin	2023/10/24	Sodium, total	mg/L	22.5
UA	G20D	Delin	2022/07/24	Sulfate, total	mg/L	141
UA	G20D	Delin	2022/09/15	Sulfate, total	mg/L	141
UA	G20D	Delin	2022/11/03	Sulfate, total	mg/L	149
UA	G20D	Delin	2023/01/26	Sulfate, total	mg/L	133
UA	G20D	Delin	2023/05/03	Sulfate, total	mg/L	140
UA	G20D	Delin	2023/09/27	Sulfate, total	mg/L	129
UA	G20D	Delin	2023/10/24	Sulfate, total	mg/L	143
UA	G20D	Delin	2022/07/24	Temperature (Celsius)	degrees C	15.7

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G20D	Delin	2022/09/15	Temperature (Celsius)	degrees C	21.4
UA	G20D	Delin	2022/11/03	Temperature (Celsius)	degrees C	18.1
UA	G20D	Delin	2023/01/26	Temperature (Celsius)	degrees C	13.3
UA	G20D	Delin	2023/05/03	Temperature (Celsius)	degrees C	15.4
UA	G20D	Delin	2023/09/27	Temperature (Celsius)	degrees C	15.4
UA	G20D	Delin	2023/10/24	Temperature (Celsius)	degrees C	15.2
UA	G20D	Delin	2022/07/24	Total Dissolved Solids	mg/L	404
UA	G20D	Delin	2022/09/15	Total Dissolved Solids	mg/L	376
UA	G20D	Delin	2022/11/03	Total Dissolved Solids	mg/L	398
UA	G20D	Delin	2023/01/26	Total Dissolved Solids	mg/L	396
UA	G20D	Delin	2023/05/03	Total Dissolved Solids	mg/L	390
UA	G20D	Delin	2023/09/27	Total Dissolved Solids	mg/L	394
UA	G20D	Delin	2023/10/24	Total Dissolved Solids	mg/L	384
UA	G21S	Delin	2022/07/28	pH (field)	SU	7.3
UA	G21S	Delin	2022/09/15	pH (field)	SU	6.6
UA	G21S	Delin	2022/11/03	pH (field)	SU	6.8
UA	G21S	Delin	2023/01/25	pH (field)	SU	7.2
UA	G21S	Delin	2023/05/03	pH (field)	SU	6.8
UA	G21S	Delin	2023/09/27	pH (field)	SU	6.6
UA	G21S	Delin	2023/10/23	pH (field)	SU	6.6
UA	G21S	Delin	2022/07/28	Oxidation Reduction Potential	mV	99.5
UA	G21S	Delin	2022/09/15	Oxidation Reduction Potential	mV	210
UA	G21S	Delin	2022/11/03	Oxidation Reduction Potential	mV	189
UA	G21S	Delin	2023/01/25	Oxidation Reduction Potential	mV	5.20
UA	G21S	Delin	2023/05/03	Oxidation Reduction Potential	mV	86.0
UA	G21S	Delin	2023/09/27	Oxidation Reduction Potential	mV	35.0
UA	G21S	Delin	2023/10/23	Oxidation Reduction Potential	mV	156
UA	G21S	Delin	2022/07/28	Eh	V	0.29
UA	G21S	Delin	2022/09/15	Eh	V	0.41
UA	G21S	Delin	2022/11/03	Eh	V	0.38
UA	G21S	Delin	2023/01/25	Eh	V	0.20
UA	G21S	Delin	2023/05/03	Eh	V	0.28
UA	G21S	Delin	2023/09/27	Eh	V	0.23
UA	G21S	Delin	2023/10/23	Eh	V	0.35
UA	G21S	Delin	2022/07/28	Alkalinity, bicarbonate	mg/L CaCO3	152
UA	G21S	Delin	2022/09/15	Alkalinity, bicarbonate	mg/L CaCO3	140
UA	G21S	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	151
UA	G21S	Delin	2023/01/25	Alkalinity, bicarbonate	mg/L CaCO3	143
UA	G21S	Delin	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	150
UA	G21S	Delin	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	161
UA	G21S	Delin	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	150
UA	G21S	Delin	2022/07/28	Barium, total	mg/L	0.0314
UA	G21S	Delin	2022/09/15	Barium, total	mg/L	0.0286
UA	G21S	Delin	2022/11/03	Barium, total	mg/L	0.0405
UA	G21S	Delin	2023/01/25	Barium, total	mg/L	0.0299
UA	G21S	Delin	2023/05/03	Barium, total	mg/L	0.0320
UA	G21S	Delin	2023/09/27	Barium, total	mg/L	0.0299
UA	G21S	Delin	2023/10/23	Barium, total	mg/L	0.0509
UA	G21S	Delin	2022/07/28	Boron, total	mg/L	3.87
UA	G21S	Delin	2022/09/15	Boron, total	mg/L	4.12
UA	G21S	Delin	2022/11/03	Boron, total	mg/L	5.00
UA	G21S	Delin	2023/01/25	Boron, total	mg/L	4.34
UA	G21S	Delin	2023/05/03	Boron, total	mg/L	4.34
UA	G21S	Delin	2023/09/27	Boron, total	mg/L	4.30
UA	G21S	Delin	2023/10/23	Boron, total	mg/L	3.39

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G21S	Delin	2022/07/28	Calcium, total	mg/L	106
UA	G21S	Delin	2022/09/15	Calcium, total	mg/L	101
UA	G21S	Delin	2022/11/03	Calcium, total	mg/L	111
UA	G21S	Delin	2023/01/25	Calcium, total	mg/L	103
UA	G21S	Delin	2023/05/03	Calcium, total	mg/L	107
UA	G21S	Delin	2023/09/27	Calcium, total	mg/L	105
UA	G21S	Delin	2023/10/23	Calcium, total	mg/L	116
UA	G21S	Delin	2022/07/28	Chloride, total	mg/L	21.0
UA	G21S	Delin	2022/09/15	Chloride, total	mg/L	19.0
UA	G21S	Delin	2022/11/03	Chloride, total	mg/L	18.0
UA	G21S	Delin	2023/01/25	Chloride, total	mg/L	20.0
UA	G21S	Delin	2023/05/03	Chloride, total	mg/L	20.0
UA	G21S	Delin	2023/09/27	Chloride, total	mg/L	19.0
UA	G21S	Delin	2023/10/23	Chloride, total	mg/L	20.0
UA	G21S	Delin	2022/07/28	Cobalt, total	mg/L	0.000900
UA	G21S	Delin	2022/09/15	Cobalt, total	mg/L	0.000600
UA	G21S	Delin	2022/11/03	Cobalt, total	mg/L	0.000400
UA	G21S	Delin	2023/01/25	Cobalt, total	mg/L	0.000400
UA	G21S	Delin	2023/05/03	Cobalt, total	mg/L	0.000500
UA	G21S	Delin	2023/09/27	Cobalt, total	mg/L	0.000300
UA	G21S	Delin	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G21S	Delin	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G21S	Delin	2023/09/27	Iron, dissolved	mg/L	<0.0115
UA	G21S	Delin	2022/07/28	Magnesium, total	mg/L	25.8
UA	G21S	Delin	2022/09/15	Magnesium, total	mg/L	23.9
UA	G21S	Delin	2022/11/03	Magnesium, total	mg/L	26.0
UA	G21S	Delin	2023/01/25	Magnesium, total	mg/L	25.2
UA	G21S	Delin	2023/05/03	Magnesium, total	mg/L	26.0
UA	G21S	Delin	2023/09/27	Magnesium, total	mg/L	25.9
UA	G21S	Delin	2023/10/23	Magnesium, total	mg/L	27.9
UA	G21S	Delin	2023/05/03	Manganese, dissolved	mg/L	<0.0025
UA	G21S	Delin	2023/09/27	Manganese, dissolved	mg/L	<0.0012
UA	G21S	Delin	2023/05/03	Phosphate, dissolved	mg/L	0.0370
UA	G21S	Delin	2023/09/27	Phosphate, dissolved	mg/L	0.0180
UA	G21S	Delin	2022/07/28	Potassium, total	mg/L	2.23
UA	G21S	Delin	2022/09/15	Potassium, total	mg/L	2.27
UA	G21S	Delin	2022/11/03	Potassium, total	mg/L	2.27
UA	G21S	Delin	2023/01/25	Potassium, total	mg/L	2.29
UA	G21S	Delin	2023/05/03	Potassium, total	mg/L	2.29
UA	G21S	Delin	2023/09/27	Potassium, total	mg/L	2.41
UA	G21S	Delin	2023/10/23	Potassium, total	mg/L	2.40
UA	G21S	Delin	2023/05/03	Silicon, dissolved	mg/L	6.53
UA	G21S	Delin	2023/09/27	Silicon, dissolved	mg/L	6.75
UA	G21S	Delin	2022/07/28	Sodium, total	mg/L	52.0
UA	G21S	Delin	2022/09/15	Sodium, total	mg/L	53.7
UA	G21S	Delin	2022/11/03	Sodium, total	mg/L	57.0
UA	G21S	Delin	2023/01/25	Sodium, total	mg/L	52.3
UA	G21S	Delin	2023/05/03	Sodium, total	mg/L	59.3
UA	G21S	Delin	2023/09/27	Sodium, total	mg/L	54.9
UA	G21S	Delin	2023/10/23	Sodium, total	mg/L	60.8
UA	G21S	Delin	2022/07/28	Sulfate, total	mg/L	326
UA	G21S	Delin	2022/09/15	Sulfate, total	mg/L	324
UA	G21S	Delin	2022/11/03	Sulfate, total	mg/L	287
UA	G21S	Delin	2023/01/25	Sulfate, total	mg/L	294
UA	G21S	Delin	2023/05/03	Sulfate, total	mg/L	287

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G21S	Delin	2023/09/27	Sulfate, total	mg/L	281
UA	G21S	Delin	2023/10/23	Sulfate, total	mg/L	309
UA	G21S	Delin	2022/07/28	Temperature (Celsius)	degrees C	19.8
UA	G21S	Delin	2022/09/15	Temperature (Celsius)	degrees C	15.1
UA	G21S	Delin	2022/11/03	Temperature (Celsius)	degrees C	14.4
UA	G21S	Delin	2023/01/25	Temperature (Celsius)	degrees C	12.6
UA	G21S	Delin	2023/05/03	Temperature (Celsius)	degrees C	14.6
UA	G21S	Delin	2023/09/27	Temperature (Celsius)	degrees C	15.0
UA	G21S	Delin	2023/10/23	Temperature (Celsius)	degrees C	15.8
UA	G21S	Delin	2022/07/28	Total Dissolved Solids	mg/L	616
UA	G21S	Delin	2022/09/15	Total Dissolved Solids	mg/L	590
UA	G21S	Delin	2022/11/03	Total Dissolved Solids	mg/L	632
UA	G21S	Delin	2023/01/25	Total Dissolved Solids	mg/L	626
UA	G21S	Delin	2023/05/03	Total Dissolved Solids	mg/L	614
UA	G21S	Delin	2023/09/27	Total Dissolved Solids	mg/L	640
UA	G21S	Delin	2023/10/23	Total Dissolved Solids	mg/L	620
UA	G21D	Delin	2022/07/28	pH (field)	SU	7.7
UA	G21D	Delin	2022/09/15	pH (field)	SU	6.9
UA	G21D	Delin	2022/11/03	pH (field)	SU	7.1
UA	G21D	Delin	2023/01/25	pH (field)	SU	7.5
UA	G21D	Delin	2023/05/03	pH (field)	SU	7.2
UA	G21D	Delin	2023/09/27	pH (field)	SU	6.8
UA	G21D	Delin	2023/10/23	pH (field)	SU	7.0
UA	G21D	Delin	2022/07/28	Oxidation Reduction Potential	mV	-222
UA	G21D	Delin	2022/09/15	Oxidation Reduction Potential	mV	194
UA	G21D	Delin	2022/11/03	Oxidation Reduction Potential	mV	-55.4
UA	G21D	Delin	2023/01/25	Oxidation Reduction Potential	mV	-156
UA	G21D	Delin	2023/05/03	Oxidation Reduction Potential	mV	478
UA	G21D	Delin	2023/09/27	Oxidation Reduction Potential	mV	-52.0
UA	G21D	Delin	2023/10/23	Oxidation Reduction Potential	mV	86.0
UA	G21D	Delin	2022/07/28	Eh	V	-0.027
UA	G21D	Delin	2022/09/15	Eh	V	0.39
UA	G21D	Delin	2022/11/03	Eh	V	0.14
UA	G21D	Delin	2023/01/25	Eh	V	0.041
UA	G21D	Delin	2023/05/03	Eh	V	0.67
UA	G21D	Delin	2023/09/27	Eh	V	0.14
UA	G21D	Delin	2023/10/23	Eh	V	0.28
UA	G21D	Delin	2022/07/28	Alkalinity, bicarbonate	mg/L CaCO3	183
UA	G21D	Delin	2022/09/15	Alkalinity, bicarbonate	mg/L CaCO3	174
UA	G21D	Delin	2022/11/03	Alkalinity, bicarbonate	mg/L CaCO3	176
UA	G21D	Delin	2023/01/25	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G21D	Delin	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	172
UA	G21D	Delin	2023/09/27	Alkalinity, bicarbonate	mg/L CaCO3	178
UA	G21D	Delin	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	174
UA	G21D	Delin	2022/07/28	Barium, total	mg/L	0.0583
UA	G21D	Delin	2022/09/15	Barium, total	mg/L	0.0540
UA	G21D	Delin	2022/11/03	Barium, total	mg/L	0.0481
UA	G21D	Delin	2023/01/25	Barium, total	mg/L	0.0451
UA	G21D	Delin	2023/05/03	Barium, total	mg/L	0.0449
UA	G21D	Delin	2023/09/27	Barium, total	mg/L	0.0541
UA	G21D	Delin	2023/10/23	Barium, total	mg/L	0.0518
UA	G21D	Delin	2022/07/28	Boron, total	mg/L	2.99
UA	G21D	Delin	2022/09/15	Boron, total	mg/L	2.81
UA	G21D	Delin	2022/11/03	Boron, total	mg/L	2.88
UA	G21D	Delin	2023/01/25	Boron, total	mg/L	3.16

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G21D	Delin	2023/05/03	Boron, total	mg/L	3.11
UA	G21D	Delin	2023/09/27	Boron, total	mg/L	3.91
UA	G21D	Delin	2023/10/23	Boron, total	mg/L	2.63
UA	G21D	Delin	2022/07/28	Calcium, total	mg/L	103
UA	G21D	Delin	2022/09/15	Calcium, total	mg/L	96.7
UA	G21D	Delin	2022/11/03	Calcium, total	mg/L	104
UA	G21D	Delin	2023/01/25	Calcium, total	mg/L	95.6
UA	G21D	Delin	2023/05/03	Calcium, total	mg/L	101
UA	G21D	Delin	2023/09/27	Calcium, total	mg/L	99.8
UA	G21D	Delin	2023/10/23	Calcium, total	mg/L	108
UA	G21D	Delin	2022/07/28	Chloride, total	mg/L	19.0
UA	G21D	Delin	2022/09/15	Chloride, total	mg/L	18.0
UA	G21D	Delin	2022/11/03	Chloride, total	mg/L	18.0
UA	G21D	Delin	2023/01/25	Chloride, total	mg/L	17.0
UA	G21D	Delin	2023/05/03	Chloride, total	mg/L	18.0
UA	G21D	Delin	2023/09/27	Chloride, total	mg/L	17.0
UA	G21D	Delin	2023/10/23	Chloride, total	mg/L	17.0
UA	G21D	Delin	2022/07/28	Cobalt, total	mg/L	0.00280
UA	G21D	Delin	2022/09/15	Cobalt, total	mg/L	0.00250
UA	G21D	Delin	2022/11/03	Cobalt, total	mg/L	0.00190
UA	G21D	Delin	2023/01/25	Cobalt, total	mg/L	0.00210
UA	G21D	Delin	2023/05/03	Cobalt, total	mg/L	0.00250
UA	G21D	Delin	2023/09/27	Cobalt, total	mg/L	0.00150
UA	G21D	Delin	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G21D	Delin	2023/05/03	Iron, dissolved	mg/L	1.36
UA	G21D	Delin	2023/09/27	Iron, dissolved	mg/L	0.985
UA	G21D	Delin	2022/07/28	Magnesium, total	mg/L	24.4
UA	G21D	Delin	2022/09/15	Magnesium, total	mg/L	23.1
UA	G21D	Delin	2022/11/03	Magnesium, total	mg/L	23.8
UA	G21D	Delin	2023/01/25	Magnesium, total	mg/L	24.4
UA	G21D	Delin	2023/05/03	Magnesium, total	mg/L	25.0
UA	G21D	Delin	2023/09/27	Magnesium, total	mg/L	24.7
UA	G21D	Delin	2023/10/23	Magnesium, total	mg/L	25.7
UA	G21D	Delin	2023/05/03	Manganese, dissolved	mg/L	0.197
UA	G21D	Delin	2023/09/27	Manganese, dissolved	mg/L	0.140
UA	G21D	Delin	2023/05/03	Phosphate, dissolved	mg/L	0.0340
UA	G21D	Delin	2023/09/27	Phosphate, dissolved	mg/L	0.0250
UA	G21D	Delin	2022/07/28	Potassium, total	mg/L	1.57
UA	G21D	Delin	2022/09/15	Potassium, total	mg/L	1.45
UA	G21D	Delin	2022/11/03	Potassium, total	mg/L	1.47
UA	G21D	Delin	2023/01/25	Potassium, total	mg/L	1.46
UA	G21D	Delin	2023/05/03	Potassium, total	mg/L	1.59
UA	G21D	Delin	2023/09/27	Potassium, total	mg/L	1.50
UA	G21D	Delin	2023/10/23	Potassium, total	mg/L	1.65
UA	G21D	Delin	2023/05/03	Silicon, dissolved	mg/L	5.90
UA	G21D	Delin	2023/09/27	Silicon, dissolved	mg/L	5.92
UA	G21D	Delin	2022/07/28	Sodium, total	mg/L	32.4
UA	G21D	Delin	2022/09/15	Sodium, total	mg/L	32.8
UA	G21D	Delin	2022/11/03	Sodium, total	mg/L	34.4
UA	G21D	Delin	2023/01/25	Sodium, total	mg/L	31.2
UA	G21D	Delin	2023/05/03	Sodium, total	mg/L	36.0
UA	G21D	Delin	2023/09/27	Sodium, total	mg/L	32.3
UA	G21D	Delin	2023/10/23	Sodium, total	mg/L	35.6
UA	G21D	Delin	2022/07/28	Sulfate, total	mg/L	208
UA	G21D	Delin	2022/09/15	Sulfate, total	mg/L	224

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G21D	Delin	2022/11/03	Sulfate, total	mg/L	233
UA	G21D	Delin	2023/01/25	Sulfate, total	mg/L	213
UA	G21D	Delin	2023/05/03	Sulfate, total	mg/L	219
UA	G21D	Delin	2023/09/27	Sulfate, total	mg/L	230
UA	G21D	Delin	2023/10/23	Sulfate, total	mg/L	229
UA	G21D	Delin	2022/07/28	Temperature (Celsius)	degrees C	15.9
UA	G21D	Delin	2022/09/15	Temperature (Celsius)	degrees C	15.1
UA	G21D	Delin	2022/11/03	Temperature (Celsius)	degrees C	14.4
UA	G21D	Delin	2023/01/25	Temperature (Celsius)	degrees C	13.5
UA	G21D	Delin	2023/05/03	Temperature (Celsius)	degrees C	14.5
UA	G21D	Delin	2023/09/27	Temperature (Celsius)	degrees C	15.4
UA	G21D	Delin	2023/10/23	Temperature (Celsius)	degrees C	15.9
UA	G21D	Delin	2022/07/28	Total Dissolved Solids	mg/L	518
UA	G21D	Delin	2022/09/15	Total Dissolved Solids	mg/L	462
UA	G21D	Delin	2022/11/03	Total Dissolved Solids	mg/L	515
UA	G21D	Delin	2023/01/25	Total Dissolved Solids	mg/L	516
UA	G21D	Delin	2023/05/03	Total Dissolved Solids	mg/L	522
UA	G21D	Delin	2023/09/27	Total Dissolved Solids	mg/L	542
UA	G21D	Delin	2023/10/23	Total Dissolved Solids	mg/L	500
UA	G22S	Delin	2022/07/25	pH (field)	SU	7.6
UA	G22S	Delin	2022/07/27	pH (field)	SU	7.5
UA	G22S	Delin	2022/09/14	pH (field)	SU	5.7
UA	G22S	Delin	2022/11/02	pH (field)	SU	6.7
UA	G22S	Delin	2023/01/24	pH (field)	SU	6.7
UA	G22S	Delin	2023/05/03	pH (field)	SU	6.9
UA	G22S	Delin	2023/09/28	pH (field)	SU	6.5
UA	G22S	Delin	2023/10/23	pH (field)	SU	6.6
UA	G22S	Delin	2022/07/25	Oxidation Reduction Potential	mV	95.7
UA	G22S	Delin	2022/07/27	Oxidation Reduction Potential	mV	64.7
UA	G22S	Delin	2022/09/14	Oxidation Reduction Potential	mV	232
UA	G22S	Delin	2022/11/02	Oxidation Reduction Potential	mV	64.1
UA	G22S	Delin	2023/01/24	Oxidation Reduction Potential	mV	-4.00
UA	G22S	Delin	2023/05/03	Oxidation Reduction Potential	mV	95.0
UA	G22S	Delin	2023/09/28	Oxidation Reduction Potential	mV	112
UA	G22S	Delin	2023/10/23	Oxidation Reduction Potential	mV	153
UA	G22S	Delin	2022/07/25	Eh	V	0.29
UA	G22S	Delin	2022/07/27	Eh	V	0.25
UA	G22S	Delin	2022/09/14	Eh	V	0.42
UA	G22S	Delin	2022/11/02	Eh	V	0.26
UA	G22S	Delin	2023/01/24	Eh	V	0.19
UA	G22S	Delin	2023/05/03	Eh	V	0.29
UA	G22S	Delin	2023/09/28	Eh	V	0.31
UA	G22S	Delin	2023/10/23	Eh	V	0.35
UA	G22S	Delin	2022/07/25	Alkalinity, bicarbonate	mg/L CaCO3	159
UA	G22S	Delin	2022/07/27	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G22S	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	163
UA	G22S	Delin	2022/11/02	Alkalinity, bicarbonate	mg/L CaCO3	162
UA	G22S	Delin	2023/01/24	Alkalinity, bicarbonate	mg/L CaCO3	156
UA	G22S	Delin	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	161
UA	G22S	Delin	2023/09/28	Alkalinity, bicarbonate	mg/L CaCO3	169
UA	G22S	Delin	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	165
UA	G22S	Delin	2022/07/25	Barium, total	mg/L	0.0820
UA	G22S	Delin	2022/07/27	Barium, total	mg/L	0.0785
UA	G22S	Delin	2022/09/14	Barium, total	mg/L	0.105
UA	G22S	Delin	2022/11/02	Barium, total	mg/L	0.0784

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G22S	Delin	2023/01/24	Barium, total	mg/L	0.0799
UA	G22S	Delin	2023/05/03	Barium, total	mg/L	0.0830
UA	G22S	Delin	2023/09/28	Barium, total	mg/L	0.0795
UA	G22S	Delin	2023/10/23	Barium, total	mg/L	0.0765
UA	G22S	Delin	2022/07/25	Boron, total	mg/L	1.39
UA	G22S	Delin	2022/07/27	Boron, total	mg/L	1.35
UA	G22S	Delin	2022/09/14	Boron, total	mg/L	1.10
UA	G22S	Delin	2022/11/02	Boron, total	mg/L	1.16
UA	G22S	Delin	2023/01/24	Boron, total	mg/L	1.27
UA	G22S	Delin	2023/05/03	Boron, total	mg/L	1.36
UA	G22S	Delin	2023/09/28	Boron, total	mg/L	1.29
UA	G22S	Delin	2023/10/23	Boron, total	mg/L	1.17
UA	G22S	Delin	2022/07/25	Calcium, total	mg/L	60.3
UA	G22S	Delin	2022/07/27	Calcium, total	mg/L	56.5
UA	G22S	Delin	2022/09/14	Calcium, total	mg/L	55.2
UA	G22S	Delin	2022/11/02	Calcium, total	mg/L	56.5
UA	G22S	Delin	2023/01/24	Calcium, total	mg/L	50.8
UA	G22S	Delin	2023/05/03	Calcium, total	mg/L	55.4
UA	G22S	Delin	2023/09/28	Calcium, total	mg/L	55.0
UA	G22S	Delin	2023/10/23	Calcium, total	mg/L	60.3
UA	G22S	Delin	2022/07/25	Chloride, total	mg/L	23.0
UA	G22S	Delin	2022/07/27	Chloride, total	mg/L	23.0
UA	G22S	Delin	2022/09/14	Chloride, total	mg/L	22.0
UA	G22S	Delin	2022/11/02	Chloride, total	mg/L	23.0
UA	G22S	Delin	2023/01/24	Chloride, total	mg/L	22.0
UA	G22S	Delin	2023/05/03	Chloride, total	mg/L	22.0
UA	G22S	Delin	2023/09/28	Chloride, total	mg/L	21.0
UA	G22S	Delin	2023/10/23	Chloride, total	mg/L	22.0
UA	G22S	Delin	2022/07/25	Cobalt, total	mg/L	0.000100
UA	G22S	Delin	2022/07/27	Cobalt, total	mg/L	<0.0001
UA	G22S	Delin	2022/09/14	Cobalt, total	mg/L	<0.0001
UA	G22S	Delin	2022/11/02	Cobalt, total	mg/L	<0.0001
UA	G22S	Delin	2023/01/24	Cobalt, total	mg/L	<0.0001
UA	G22S	Delin	2023/05/03	Cobalt, total	mg/L	<0.0001
UA	G22S	Delin	2023/09/28	Cobalt, total	mg/L	<0.0001
UA	G22S	Delin	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G22S	Delin	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G22S	Delin	2023/09/28	Iron, dissolved	mg/L	<0.0115
UA	G22S	Delin	2022/07/25	Magnesium, total	mg/L	17.1
UA	G22S	Delin	2022/07/27	Magnesium, total	mg/L	15.9
UA	G22S	Delin	2022/09/14	Magnesium, total	mg/L	15.6
UA	G22S	Delin	2022/11/02	Magnesium, total	mg/L	15.6
UA	G22S	Delin	2023/01/24	Magnesium, total	mg/L	15.8
UA	G22S	Delin	2023/05/03	Magnesium, total	mg/L	16.4
UA	G22S	Delin	2023/09/28	Magnesium, total	mg/L	16.3
UA	G22S	Delin	2023/10/23	Magnesium, total	mg/L	17.2
UA	G22S	Delin	2023/05/03	Manganese, dissolved	mg/L	<0.0025
UA	G22S	Delin	2023/09/28	Manganese, dissolved	mg/L	<0.0012
UA	G22S	Delin	2023/05/03	Phosphate, dissolved	mg/L	0.0520
UA	G22S	Delin	2023/09/28	Phosphate, dissolved	mg/L	0.0950
UA	G22S	Delin	2022/07/25	Potassium, total	mg/L	1.18
UA	G22S	Delin	2022/07/27	Potassium, total	mg/L	1.18
UA	G22S	Delin	2022/09/14	Potassium, total	mg/L	1.18
UA	G22S	Delin	2022/11/02	Potassium, total	mg/L	1.19
UA	G22S	Delin	2023/01/24	Potassium, total	mg/L	1.09

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G22S	Delin	2023/05/03	Potassium, total	mg/L	1.22
UA	G22S	Delin	2023/09/28	Potassium, total	mg/L	1.19
UA	G22S	Delin	2023/10/23	Potassium, total	mg/L	1.35
UA	G22S	Delin	2023/05/03	Silicon, dissolved	mg/L	6.40
UA	G22S	Delin	2023/09/28	Silicon, dissolved	mg/L	6.50
UA	G22S	Delin	2022/07/25	Sodium, total	mg/L	29.1
UA	G22S	Delin	2022/07/27	Sodium, total	mg/L	28.6
UA	G22S	Delin	2022/09/14	Sodium, total	mg/L	29.1
UA	G22S	Delin	2022/11/02	Sodium, total	mg/L	29.1
UA	G22S	Delin	2023/01/24	Sodium, total	mg/L	26.1
UA	G22S	Delin	2023/05/03	Sodium, total	mg/L	31.3
UA	G22S	Delin	2023/09/28	Sodium, total	mg/L	27.9
UA	G22S	Delin	2023/10/23	Sodium, total	mg/L	31.8
UA	G22S	Delin	2022/07/25	Sulfate, total	mg/L	74.0
UA	G22S	Delin	2022/07/27	Sulfate, total	mg/L	65.0
UA	G22S	Delin	2022/09/14	Sulfate, total	mg/L	70.0
UA	G22S	Delin	2022/11/02	Sulfate, total	mg/L	63.0
UA	G22S	Delin	2023/01/24	Sulfate, total	mg/L	61.0
UA	G22S	Delin	2023/05/03	Sulfate, total	mg/L	63.0
UA	G22S	Delin	2023/09/28	Sulfate, total	mg/L	66.0
UA	G22S	Delin	2023/10/23	Sulfate, total	mg/L	64.0
UA	G22S	Delin	2022/07/25	Temperature (Celsius)	degrees C	16.4
UA	G22S	Delin	2022/07/27	Temperature (Celsius)	degrees C	29.5
UA	G22S	Delin	2022/09/14	Temperature (Celsius)	degrees C	19.6
UA	G22S	Delin	2022/11/02	Temperature (Celsius)	degrees C	18.2
UA	G22S	Delin	2023/01/24	Temperature (Celsius)	degrees C	15.0
UA	G22S	Delin	2023/05/03	Temperature (Celsius)	degrees C	17.0
UA	G22S	Delin	2023/09/28	Temperature (Celsius)	degrees C	15.7
UA	G22S	Delin	2023/10/23	Temperature (Celsius)	degrees C	17.1
UA	G22S	Delin	2022/07/25	Total Dissolved Solids	mg/L	318
UA	G22S	Delin	2022/07/27	Total Dissolved Solids	mg/L	306
UA	G22S	Delin	2022/09/14	Total Dissolved Solids	mg/L	214
UA	G22S	Delin	2022/11/02	Total Dissolved Solids	mg/L	328
UA	G22S	Delin	2023/01/24	Total Dissolved Solids	mg/L	316
UA	G22S	Delin	2023/05/03	Total Dissolved Solids	mg/L	302
UA	G22S	Delin	2023/09/28	Total Dissolved Solids	mg/L	324
UA	G22S	Delin	2023/10/23	Total Dissolved Solids	mg/L	286
UA	G22D	Delin	2022/07/27	pH (field)	SU	7.8
UA	G22D	Delin	2022/09/14	pH (field)	SU	6.8
UA	G22D	Delin	2022/11/02	pH (field)	SU	6.5
UA	G22D	Delin	2023/01/24	pH (field)	SU	6.8
UA	G22D	Delin	2023/05/03	pH (field)	SU	7.0
UA	G22D	Delin	2023/09/28	pH (field)	SU	6.5
UA	G22D	Delin	2023/10/23	pH (field)	SU	6.7
UA	G22D	Delin	2022/07/27	Oxidation Reduction Potential	mV	-171
UA	G22D	Delin	2022/09/14	Oxidation Reduction Potential	mV	219
UA	G22D	Delin	2022/11/02	Oxidation Reduction Potential	mV	82.6
UA	G22D	Delin	2023/01/24	Oxidation Reduction Potential	mV	15.5
UA	G22D	Delin	2023/05/03	Oxidation Reduction Potential	mV	10.0
UA	G22D	Delin	2023/09/28	Oxidation Reduction Potential	mV	22.0
UA	G22D	Delin	2023/10/23	Oxidation Reduction Potential	mV	151
UA	G22D	Delin	2022/07/27	Eh	V	0.022
UA	G22D	Delin	2022/09/14	Eh	V	0.40
UA	G22D	Delin	2022/11/02	Eh	V	0.28
UA	G22D	Delin	2023/01/24	Eh	V	0.21

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G22D	Delin	2023/05/03	Eh	V	0.20
UA	G22D	Delin	2023/09/28	Eh	V	0.22
UA	G22D	Delin	2023/10/23	Eh	V	0.35
UA	G22D	Delin	2022/07/27	Alkalinity, bicarbonate	mg/L CaCO3	187
UA	G22D	Delin	2022/09/14	Alkalinity, bicarbonate	mg/L CaCO3	180
UA	G22D	Delin	2022/11/02	Alkalinity, bicarbonate	mg/L CaCO3	177
UA	G22D	Delin	2023/01/24	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G22D	Delin	2023/05/03	Alkalinity, bicarbonate	mg/L CaCO3	173
UA	G22D	Delin	2023/09/28	Alkalinity, bicarbonate	mg/L CaCO3	182
UA	G22D	Delin	2023/10/23	Alkalinity, bicarbonate	mg/L CaCO3	174
UA	G22D	Delin	2022/07/27	Barium, total	mg/L	0.141
UA	G22D	Delin	2022/09/14	Barium, total	mg/L	0.130
UA	G22D	Delin	2022/11/02	Barium, total	mg/L	0.0892
UA	G22D	Delin	2023/01/24	Barium, total	mg/L	0.0920
UA	G22D	Delin	2023/05/03	Barium, total	mg/L	0.0995
UA	G22D	Delin	2023/09/28	Barium, total	mg/L	0.118
UA	G22D	Delin	2023/10/23	Barium, total	mg/L	0.120
UA	G22D	Delin	2022/07/27	Boron, total	mg/L	0.635
UA	G22D	Delin	2022/09/14	Boron, total	mg/L	0.562
UA	G22D	Delin	2022/11/02	Boron, total	mg/L	0.579
UA	G22D	Delin	2023/01/24	Boron, total	mg/L	0.717
UA	G22D	Delin	2023/05/03	Boron, total	mg/L	0.683
UA	G22D	Delin	2023/09/28	Boron, total	mg/L	0.896
UA	G22D	Delin	2023/10/23	Boron, total	mg/L	0.847
UA	G22D	Delin	2022/07/27	Calcium, total	mg/L	59.8
UA	G22D	Delin	2022/09/14	Calcium, total	mg/L	55.9
UA	G22D	Delin	2022/11/02	Calcium, total	mg/L	58.9
UA	G22D	Delin	2023/01/24	Calcium, total	mg/L	53.4
UA	G22D	Delin	2023/05/03	Calcium, total	mg/L	54.8
UA	G22D	Delin	2023/09/28	Calcium, total	mg/L	55.1
UA	G22D	Delin	2023/10/23	Calcium, total	mg/L	60.8
UA	G22D	Delin	2022/07/27	Chloride, total	mg/L	21.0
UA	G22D	Delin	2022/09/14	Chloride, total	mg/L	20.0
UA	G22D	Delin	2022/11/02	Chloride, total	mg/L	20.0
UA	G22D	Delin	2023/01/24	Chloride, total	mg/L	21.0
UA	G22D	Delin	2023/05/03	Chloride, total	mg/L	21.0
UA	G22D	Delin	2023/09/28	Chloride, total	mg/L	20.0
UA	G22D	Delin	2023/10/23	Chloride, total	mg/L	21.0
UA	G22D	Delin	2022/07/27	Cobalt, total	mg/L	0.000700
UA	G22D	Delin	2022/09/14	Cobalt, total	mg/L	0.000300
UA	G22D	Delin	2022/11/02	Cobalt, total	mg/L	0.000200
UA	G22D	Delin	2023/01/24	Cobalt, total	mg/L	0.000200
UA	G22D	Delin	2023/05/03	Cobalt, total	mg/L	0.000300
UA	G22D	Delin	2023/09/28	Cobalt, total	mg/L	0.000500
UA	G22D	Delin	2023/10/23	Cobalt, total	mg/L	<0.0001
UA	G22D	Delin	2023/05/03	Iron, dissolved	mg/L	<0.02
UA	G22D	Delin	2023/09/28	Iron, dissolved	mg/L	0.183
UA	G22D	Delin	2022/07/27	Magnesium, total	mg/L	16.0
UA	G22D	Delin	2022/09/14	Magnesium, total	mg/L	15.4
UA	G22D	Delin	2022/11/02	Magnesium, total	mg/L	15.7
UA	G22D	Delin	2023/01/24	Magnesium, total	mg/L	16.0
UA	G22D	Delin	2023/05/03	Magnesium, total	mg/L	15.6
UA	G22D	Delin	2023/09/28	Magnesium, total	mg/L	16.0
UA	G22D	Delin	2023/10/23	Magnesium, total	mg/L	17.1
UA	G22D	Delin	2023/05/03	Manganese, dissolved	mg/L	0.0417

Attachment I. Site Groundwater Data
Geochemical Conceptual Site Model
Joppa East Ash Pond
Joppa Power Plant
Joppa, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
UA	G22D	Delin	2023/09/28	Manganese, dissolved	mg/L	0.0532
UA	G22D	Delin	2023/05/03	Phosphate, dissolved	mg/L	<0.005
UA	G22D	Delin	2023/09/28	Phosphate, dissolved	mg/L	0.126
UA	G22D	Delin	2022/07/27	Potassium, total	mg/L	1.16
UA	G22D	Delin	2022/09/14	Potassium, total	mg/L	1.10
UA	G22D	Delin	2022/11/02	Potassium, total	mg/L	1.08
UA	G22D	Delin	2023/01/24	Potassium, total	mg/L	0.986
UA	G22D	Delin	2023/05/03	Potassium, total	mg/L	1.39
UA	G22D	Delin	2023/09/28	Potassium, total	mg/L	1.35
UA	G22D	Delin	2023/10/23	Potassium, total	mg/L	1.25
UA	G22D	Delin	2023/05/03	Silicon, dissolved	mg/L	5.67
UA	G22D	Delin	2023/09/28	Silicon, dissolved	mg/L	5.60
UA	G22D	Delin	2022/07/27	Sodium, total	mg/L	19.1
UA	G22D	Delin	2022/09/14	Sodium, total	mg/L	18.9
UA	G22D	Delin	2022/11/02	Sodium, total	mg/L	19.2
UA	G22D	Delin	2023/01/24	Sodium, total	mg/L	18.3
UA	G22D	Delin	2023/05/03	Sodium, total	mg/L	20.1
UA	G22D	Delin	2023/09/28	Sodium, total	mg/L	19.2
UA	G22D	Delin	2023/10/23	Sodium, total	mg/L	21.3
UA	G22D	Delin	2022/07/27	Sulfate, total	mg/L	33.0
UA	G22D	Delin	2022/09/14	Sulfate, total	mg/L	40.0
UA	G22D	Delin	2022/11/02	Sulfate, total	mg/L	38.0
UA	G22D	Delin	2023/01/24	Sulfate, total	mg/L	36.0
UA	G22D	Delin	2023/05/03	Sulfate, total	mg/L	37.0
UA	G22D	Delin	2023/09/28	Sulfate, total	mg/L	37.0
UA	G22D	Delin	2023/10/23	Sulfate, total	mg/L	40.0
UA	G22D	Delin	2022/07/27	Temperature (Celsius)	degrees C	18.4
UA	G22D	Delin	2022/09/14	Temperature (Celsius)	degrees C	30.4
UA	G22D	Delin	2022/11/02	Temperature (Celsius)	degrees C	16.9
UA	G22D	Delin	2023/01/24	Temperature (Celsius)	degrees C	15.1
UA	G22D	Delin	2023/05/03	Temperature (Celsius)	degrees C	17.2
UA	G22D	Delin	2023/09/28	Temperature (Celsius)	degrees C	16.6
UA	G22D	Delin	2023/10/23	Temperature (Celsius)	degrees C	16.7
UA	G22D	Delin	2022/07/27	Total Dissolved Solids	mg/L	272
UA	G22D	Delin	2022/09/14	Total Dissolved Solids	mg/L	150
UA	G22D	Delin	2022/11/02	Total Dissolved Solids	mg/L	294
UA	G22D	Delin	2023/01/24	Total Dissolved Solids	mg/L	278
UA	G22D	Delin	2023/05/03	Total Dissolved Solids	mg/L	264
UA	G22D	Delin	2023/09/28	Total Dissolved Solids	mg/L	296
UA	G22D	Delin	2023/10/23	Total Dissolved Solids	mg/L	252

Notes:
< = results is less than detection limit
B = Background
C = Compliance
Delin = Delination
HSU = Hydrostratigraphic Unit
CCR = Coal Combustion Residuals
LAU = Lower Aquifer Unit
UA = Uppermost Aquifer
mg/L = milligrams per liter
SU = standard units
V = volts

ATTACHMENT J

Memorandum – Draft Evaluation of Partition Coefficients – Joppa East Ash Pond

Geosyntec consultants

1 McBride and Son Center Drive, Suite 202
Chesterfield, MO 63005
www.geosyntec.com

Memorandum

Date:	May 24, 2022
To:	David Mitchell, Stu Cravens, Vic Modeer Electric Energy Inc.
Copies to:	Brian Hennings - Ramboll
From:	Allison Kreinberg, Ryan Fimmen – Geosyntec Consultants, Inc.
Subject:	Draft Evaluation of Partition Coefficient Results – Joppa East Ash Pond CCR Unit 401, Joppa Power Plant, Joppa, Illinois

INTRODUCTION

Electric Energy, Inc. currently operates the Joppa Power Plant (JPP) and its associated ash ponds located in Joppa, Illinois. The East Ash Pond (EAP) (Vistra identification [ID] No. 401; Illinois Environmental Protection Agency [IEPA] ID No. W1270100004-02; National Inventory of Dams [NID] No. IL50714) is an active 111-acre unlined surface impoundment used to manage CCR and non-CCR waste streams at the JPP. Geosyntec Consultants (Geosyntec) is assisting Electric Energy, Inc. with Part 845 compliance at the Site.

Electric Energy, Inc. is currently preparing a Construction Permit application for the EAP as required under Section 845.220. As part of the Construction Permit application, groundwater modeling is being completed for known potential exceedances of groundwater protection standards (GWPS) identified in the Operating Permit (Burns & McDonnell, 2021). In the Operating Permit (October 2021), Burns & McDonnell identified potential GWPS exceedances for several constituents potentially associated with the EAP, including boron, pH (field), and sulfate. An evaluation of potential exceedances of applicable GWPS found that the pH potential exceedances are not related to the EAP (Ramboll, 2022). Batch adsorption testing was conducted for boron to generate site-specific partition coefficients. This technical memorandum summarizes the results of the batch adsorption testing and calculation of partition coefficients.

BATCH ATTENUATION TESTING

In 2021, Geosyntec conducted a field investigation at the EAP which included completion of three (3) soil/rock borings ranging in depth from 50 to 80 feet below ground surface. As part of that investigation, soil and groundwater samples were submitted to SiREM Laboratories (Guelph, ON) for batch solid/liquid partitioning testing.

One groundwater sample (G07) and one soil sample (SB-03) were used for batch attenuation testing at five (5) soil:solution ratios (**Table 1**), each ran in duplicate. For each treatment, 0.1 L of groundwater was brought into contact with varying amounts of soil (0.004 to 0.2 kg) and equilibrated over a seven-day period. Each microcosm was amended (i.e., spiked) with boric acid (H_3BO_3) to achieve the desired initial concentration (5 mg/L) of boron (**Table 2**).

An initial sample of the stock solution for each experimental design was collected on Day 0, and a control sample (i.e., only amended G07 groundwater with no aquifer solids) was collected on Day 7 after tumbling in polypropylene bottleware to evaluate any loss due to interactions with the bottleware or changes in ambient conditions. Duplicates were constructed for each microcosm, including the control samples. After seven days of contact time, an aliquot of the free liquid was collected and filtered through a 0.45-micron (µm) filter prior to analysis for dissolved concentrations of boron. The oxidation/reduction potential (redox) and pH were measured for each batch test at the beginning and end of the contact period and in the control samples.

Data obtained from the test (**Table 3**) were used to construct isotherms for boron; 5-point isotherms were constructed by averaging duplicate results for each soil:solution ratio. Mathematical fitting was used to calculate the attenuation distribution coefficients (K_d), assuming linear adsorption. The linear adsorption equation was used:

$$q_e = K_d \times C_e \qquad \text{Eq. 1}$$

where q_e is the mass of constituent adsorbed to the solid phase at equilibrium, C_e is the remaining aqueous constituent concentration at equilibrium, and K_d is the linear sorption coefficient (reported in liters per kilogram [L/kg]). The data showed a deviation from a linear trend, and so were also fitted using non-linear isotherms. The non-linear Langmuir isotherm was used:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \qquad \text{Eq. 2}$$

where q_m is the inverse of the slope and K_L is the Langmuir distribution coefficient. The adsorption data were linearized according to:

$$\frac{C_e}{q_e} = \frac{1}{(K_L \times q_m)} + \frac{C_e}{q_m} \qquad \text{Eq. 3}$$

A common non-linear Freundlich equation was also used:

$$q_e = K_F(C_e)^{1/n} \qquad \text{Eq. 4}$$

where q_e is the mass of constituent adsorbed to the solid phase at equilibrium, C_e is the remaining aqueous constituent concentration at equilibrium, K_F is the Freundlich distribution coefficient, and $1/n$ is a non-linearity constant. The adsorption data were plotted as log-transformed values to perform the non-linear isotherm fitting using the linearized Freundlich equation:

$$log(q_e) = \log(K_F) + (1/n)\log(C_e) \qquad \text{Eq. 5}$$

The calculated linear, Langmuir, and Freundlich distribution coefficients (K_d, K_L, and K_F, respectively) and 1/*n* values are shown in **Table 4**.

SUMMARY OF RESULTS

The partition coefficient values for G07 are presented in **Table 4**. A figure which shows the linear, Langmuir, and Freundlich isotherms for boron is provided in **Appendix A**.

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

REFERENCES

Burns & McDonnell. 2021. Initial Operating Permit Joppa East Ash Pond. October

EPRI, 2005. *Chemical Constituents In Coal Combustion Product Leachate: Boron. Final Report 1005258.*

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2022. *Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond, CCR Unit 401, May 2022.*

Strenge, D. and Peterson, S. 1989. Chemical Data Bases for the Multimedia Environmental Pollutant Assessment System (MEPAS) (No. PNL-7145). Pacific Northwest National Laboratory, Richland, WA (USA).

TABLES

Table 1 - Batch Attenuation Testing Data Summary
Joppa EAP

Groundwater Sample ID	Soil Sample ID	Soil: Water Ratio
G07	SB-03 (57.5-62.5, 63.5-70.0 ft bgs)	2:1.3
		1:1.2
		1:5.6
		1:11.0
		1:27.3

Notes:

ft bgs = feet below ground surface

Table 2 - Microcosm Amendment and Target Concentration
Joppa EAP

Groundwater Sample ID	Soil Sample ID	Compound	Amendment	Target Concentration (mg/L)
G07	SB-03 (57.5-62, 63.5-70.0 ft bgs)	Boron	7.89 mL of a 2 g/L H_3BO_3	5

Notes:

ft bgs - feet below ground surface

mg/L - milligrams per liter

mL - milliliters

H_3BO_3 - boric acid

Table 3 - Batch Attenuation Testing Results, G07
Joppa EAP

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	pH	ORP
						mg/L	SU	mV
G07	--	Water Control Only	23-Dec-21	0	G07-1a	5.8	7.23	81
					G07-2a	5.4	7.3	73
					Average Concentration (mg/L)	**5.6**	**7.3**	**77**
			30-Dec-21	7	G07-1	4.1	7.14	193
					G07-2	4.3	7.09	168
					Average Concentration (mg/L)	**4.2**	**7.1**	**181**
	SB-03	2:1.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 2:1-1	2.5	6.85	148
					SB-03: G07 2:1-2	3.1	6.75	132
					Average Concentration (mg/L)	**2.8**	**6.8**	**140**
		1:1.2 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:1-1	3.1	6.84	146
					SB-03: G07 1:1-2	3.1	6.95	142
					Average Concentration (mg/L)	**3.1**	**6.9**	**144**
		1:5.6 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:5-1	3.8	6.96	134
					SB-03: G07 1:5-2	4.3	6.91	135
					Average Concentration (mg/L)	**4.1**	**6.9**	**135**
		1:11 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:10-1	4.4	6.98	136
					SB-03: G07 1:10-2	4.4	6.89	131
					Average Concentration (mg/L)	**4.4**	**6.9**	**134**
		1:27.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:20-1	4.5	7.08	146
					SB-03: G07 1:20-2	4.4	6.92	150
					Average Concentration (mg/L)	**4.5**	**7.0**	**148**

Notes:

mg/L - milligrams per liter
mV - millivolts
SU - Standard Units
ORP - oxidation/reduction potential

Table 4 - Partition Coefficient Results, G07
Joppa EAP

Materials	Analyte	Isotherm	Variable	Value
G07/SB-03	**Boron**	**Linear**	**R^2**	0.998
			K_D (L/kg)	2.40
		Langmuir	**R^2**	0.982
			q_m (mg/g)	0.06
			K_L (L/kg)	5.66E+04
		Freundlich	**R^2**	0.999
			1/n	0.83
			K_F (L/kg)	86.4

Notes:

K_D - linear partition coefficient

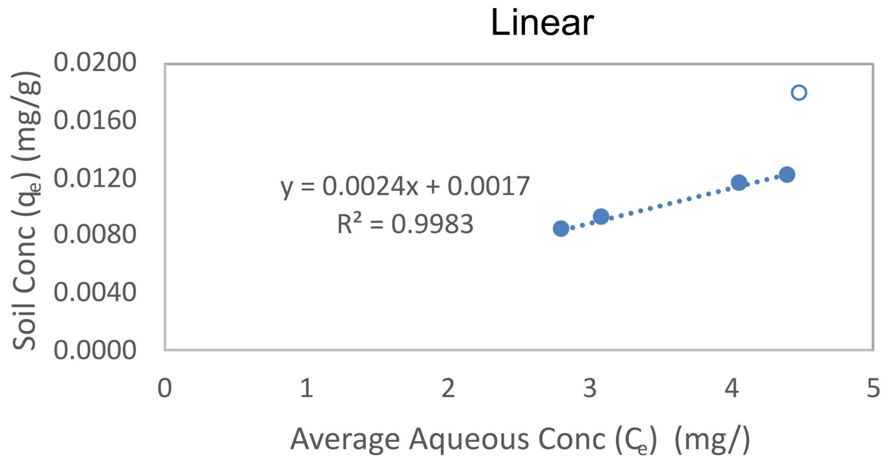
K_L - Langmuir partition coefficient

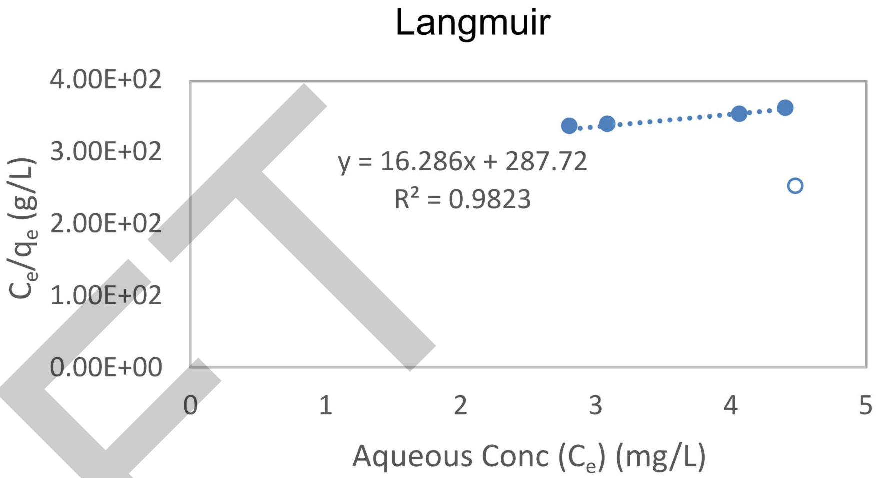
K_F - Freundlich partition coefficient

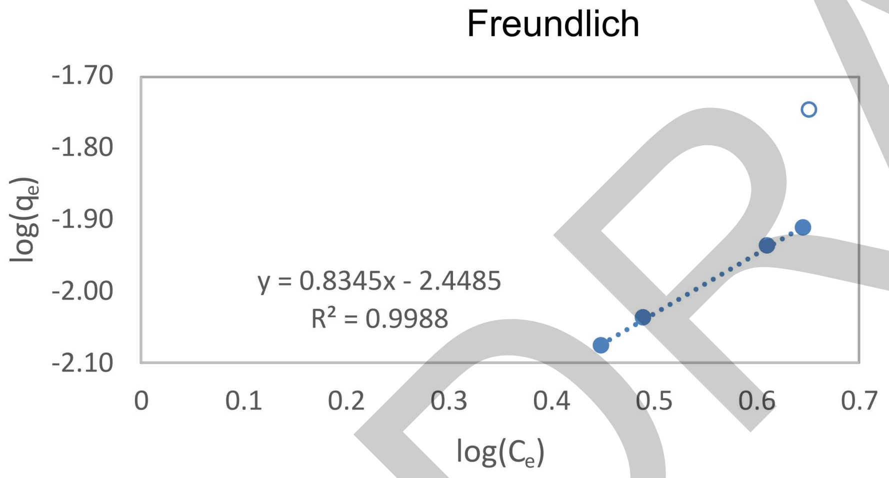
q_m - inverse of the slope of the linearized Langmuir isotherm

n - non-linearity constant of the Freundlich isotherm

APPENDIX A
BATCH TESTING ISOTHERM PLOTS







Notes:

q_e - mass of constituent adsorbed to the solid phase
C_e - remaining aqueous constituent concentration
mg/L - milligrams per liter
mg/g - milligrams per gram
g/L - grams per liter

The results from the 1:27.3 soil:solution ratio, shown as hollow symbols, were not used to calculate the partition coefficients.

G07 Boron Partitioning Coefficients
Joppa Power Plant EAP
Joppa, Illinois

Geosyntec
consultants

Columbus, OH

May 2022

Figure
1

Appendix E

Groundwater Polishing Report

Geosyntec consultants

engineers | scientists | innovators

Groundwater Polishing Evaluation Report

Joppa Power Plant – East Ash Pond Unit

(IEPA ID No. 401)

Prepared for

Electric Energy Inc
2100 Portland Road
Joppa, Illinois 62953

Prepared by

Geosyntec Consultants, Inc.
500 W. Wilson Bridge Road, Suite 250
Worthington, Ohio 43085

Project Number: GLP8030C

February 17, 2025

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ACRONYMS AND ABBREVIATIONS

35 I.A.C.	Title 35 of the Illinois Administrative Code
CAAA	Corrective Actions Alternative Analysis
CCR	Coal combustion residuals
COC	Constituent of concern
EAP	East Ash Pond
GCSM	Geochemical conceptual site model
GWPS	Groundwater protection standard
LAU	Lower aquifer unit
LCU	Lower confining unit
mg/kg	milligrams per kilogram
PMP	Potential migration pathway
redox	oxidation-reduction
SEP	Sequential extraction procedure
UA	Uppermost aquifer
UCU	Upper confining unit
USEPA	United States Environmental Protection Agency
XRD	X-ray diffraction

EXECUTIVE SUMMARY

This document has been prepared as an attachment to the Corrective Actions Alternative Analysis (CAAA) prepared by Gradient for Joppa Power Plant East Ash Pond (EAP) Unit. The constituent of concern (COC) addressed in the CAAA and in this document is boron, which has been identified as having exceedances of the site-specific groundwater protection standards (GWPS). Natural geochemical processes may be appropriate as a "polishing step" for residual plume management after effective source control implementation if there are no risks to receptors and/or the contaminant plume is not expanding (United States Environmental Protection Agency [USEPA] 1999; USEPA 2015). Source control is a major component of every corrective action considered in the CAAA, and there are no risks to human health or the environment at Joppa EAP.

Natural groundwater polishing processes, which include both physical and chemical mechanisms, reduce the concentration of COCs in the groundwater. After source control is implemented, a geochemical trailing gradient may form in the subsurface as conditions undergo a return to background water quality which could affect chemical groundwater polishing mechanisms (Savannah River National Laboratory, 2011). This report supports groundwater polishing as a component of the proposed corrective action by evaluating the contribution of chemical mechanisms to groundwater polishing under current conditions and after source control implementation. The groundwater flow and transport model estimated the time to reach the GWPS based on hydraulic properties of the aquifer. The results of this groundwater polishing evaluation contextualize these estimates by evaluating the potential for attenuation of boron and for previously attenuated boron to be remobilized to groundwater as groundwater quality returns to background conditions.

Groundwater polishing mechanisms were assessed using speciation and reaction geochemical models: speciation models assess the distribution of constituents between solid and aqueous phases, and reaction models evaluate how that distribution may change with changing site conditions (USEPA 2015). Inputs to the model include geochemically reactive solid mineral phases, compliance well groundwater composition, and background groundwater composition based on site-specific data.

The results of the groundwater polishing evaluation indicate that some chemical attenuation of boron is feasible under current conditions through sorption to iron and aluminum oxide solids. Modeling indicates that boron attenuation via sorption onto mineral surfaces should remain stable under post-source control conditions, as iron and aluminum oxide mineral phases are predicted to experience minor (if any) dissolution with background groundwater interaction. Aqueous boron concentrations should decrease below the GWPS at all wells in the compliance monitoring network following post-closure migration of background groundwater. Remobilization of boron is unlikely to affect the estimated time to reach the GWPS based on modeling results. These results will inform corrective action groundwater monitoring and adaptive site management, critical components of every corrective action considered in the CAAA.

1. INTRODUCTION

This document has been prepared as an attachment to the Corrective Actions Alternatives Analysis (CAAA) prepared by Gradient for Joppa Power Plant East Ash Pond (EAP) unit. The purpose of the CAAA is to holistically evaluate potentially viable corrective actions to remediate groundwater and achieve compliance with site-specific groundwater protection standards (GWPS) for all monitored parameters under Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845.600. The constituent of concern (COC) addressed in this document is boron, which has been identified as having exceedances[1] of the site-specific GWPS. In the CAAA, all corrective actions considered consisted of source control and residual plume management. Natural geochemical processes may be appropriate as a "polishing step" for residual plume management after effective source control implementation, if there are no risks to receptors and/or the contaminant plume is not expanding (United States Environmental Protection Agency [USEPA] 1999; USEPA 2015). Source control is a major component of every corrective action considered in the CAAA, and there are no risks to human health or the environment at Joppa EAP.[2]

Groundwater polishing processes include both physical and chemical mechanisms within the subsurface which reduce the concentration of COCs in the groundwater. Physical components of groundwater polishing, including advection, dilution, and dispersion, are assessed by groundwater flow and transport modeling (Groundwater Modeling Technical Memorandum[3]). Chemical mechanisms of groundwater polishing include sorption and mineral precipitation. After source control is implemented, a geochemical trailing gradient may form in the subsurface as conditions undergo a return to background water quality which could affect chemical groundwater polishing mechanisms (Savannah River National Laboratory [SRNL], 2011). The chemical mechanisms of groundwater polishing at Joppa EAP are evaluated herein using a geochemical modeling-based approach informed by site-specific data. This report uses geochemical modeling to evaluate the influence of chemical mechanisms on groundwater polishing under current conditions and after source control implementation.

The groundwater flow and transport model (Groundwater Modeling Technical Memorandum[4]) estimated the time for boron (as a conservative surrogate) to reach the GWPS under different potential corrective actions based on physical components of groundwater polishing and did not

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[1] Throughout this document, "exceedance" or "exceedances" is intended to refer only to potential exceedances of proposed applicable background statistics or groundwater protection standards (GWPSs) as described in the proposed groundwater monitoring program which was submitted to the IEPA on October 25, 2021 as part of Electric Energy, Inc.'s operating permit application for the East Ash Pond. That operating permit application, including the proposed groundwater monitoring program, remains under review by the IEPA and therefore Electric Energy, Inc. has not identified any actual exceedances.

[2] The Human Health and Ecological Risk Assessment serves as Appendix A of the CAAA to which this report is attached.

[3] The Groundwater Modeling Technical Memorandum serves as Appendix B of the Corrective Action Supporting Information Report; the Corrective Action Supporting Information Report serves as Appendix B.1 of the CAAA to which this report is attached.

[4] Ibid.

incorporate any potential chemical controls on parameter distribution. This geochemical modeling effort supports the assessment of groundwater polishing as a component of the proposed corrective action by evaluating the potential for chemical attenuation of boron before and after source control as a means of contextualizing the times estimated in the flow and transport model. This analysis also provides an initial foundation for understanding groundwater chemistry to inform adaptive site management as a key component of the Corrective Action Groundwater Monitoring Plan[5].

---

[5] The Corrective Action Groundwater Monitoring Plan serves as Appendix B.1 to the Construction Permit Application.

2. SITE BACKGROUND

2.1 Site Overview

A thorough overview of general site characteristics is presented in Section 1 of the CAAA to which this document is attached and summarized here. The Joppa Power Plant is owned by Electric Energy Inc. The facility is located in the Village of Joppa, Illinois, along one bank of the Ohio River and operated as an electrical generation plant from 1953 to 2022. The EAP is an unlined, 128-acre surface impoundment used for the management of bottom ash, fly ash, and other non-coal combustion residuals (CCR) waste generated by the facility. Since electricity generation at the Joppa Power Plant ceased in 2022, the EAP no longer receives bottom ash or fly ash.

A groundwater monitoring network was proposed in accordance with 35 I.A.C. § 845.630 to monitor groundwater quality which passes the waste boundary as part of the Operating Permit Application to Illinois Environmental Protection Agency (IEPA) for the EAP unit. The proposed groundwater monitoring network is shown in **Attachment A**. The proposed monitoring network consists of twelve compliance monitoring wells (G03, G05, G06, G07, G08, G09, G10, G11, G51D, G52D, G53D, and G54D) and two background wells (G01D and G02D).

The geology underlying the Site in the vicinity of the EAP consists of four distinct 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 clay sand 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 JPP. The LAU is considered a potential migration pathway (PMP) at the Site.

Groundwater migrates downward through the UCU into the UA in the vicinity of the EAP. Further downward migration is limited by the LCU. Within the UA, groundwater flows generally to the south and southeast toward the Ohio River as well as towards the Village of Joppa. The primary receiving body of water in the vicinity of the Site is the Ohio River. 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. A map showing representative UA groundwater flow direction at the site is shown in **Attachment A**.

2.2 Identified Exceedances of the GWPS

The following GWPS exceedances at compliance groundwater monitoring wells likely attributable to the Joppa EAP were observed from 2023 Q2 through 2023 Q4 (Ramboll 2024):

- Boron – Observed at monitoring wells G06, G07, G08, G09, and G10.

The data set for geochemical modeling was finalized after the 2023 Q4 sampling event. Groundwater at these compliance wells is representative of groundwater conditions downgradient of the unit, and samples may be referred to as downgradient groundwater.

GWPS exceedances within the EAP network are limited to the UA. Boron is widely distributed throughout UA monitoring locations downgradient of the EAP. Multiple downgradient wells contain boron exceedances, including compliance wells and downgradient delineation wells installed past the property boundary. All wells containing boron GWPS exceedances are located generally south-southeast of the EAP unit[6].

Modeling parameters with observed exceedances is appropriate to the scope of the CAAA. Additionally, the selected remedy will meet the performance standards of 35 I.A.C. § 845.670(d) and the Corrective Action Plan will be submitted to the Agency on or before April 18, 2025. Once implemented and completed, the selected remedy will attain the GWPSs.

2.3 Geochemical Conceptual Site Model

A Geochemical Conceptual Site Model (GCSM)[7] was developed for Joppa EAP to describe the geochemical processes that contribute to mobilization and attenuation of constituents in the environment under current conditions, including evaluating whether chemical interactions of COCs with aquifer solids contribute to the attenuation of aqueous concentrations at compliance monitoring wells (Geosyntec 2024). This discussion relies on laboratory reports and raw data previously presented in the Nature and Extent Report submitted to IEPA on April 18, 2024 (Ramboll 2024) in accordance with 35 I.A.C. § 845.650(d)(1) and provided again in full as Appendix D of the CAAA to which this report is attached.

The primary source of boron to groundwaters of the UA within the monitoring network is the EAP CCR porewater, based on COC concentrations within the source and relationships to hydrogeological patterns at the site.

Limited variability in pH or oxidation-reduction (redox) conditions is observed between upgradient (background) and downgradient locations, with pH values observed to be generally stable and circumneutral to slightly acidic, and redox conditions being generally oxidizing with a slight redox gradient observed moving from oxidizing upgradient groundwater to mixed oxidizing-reducing downgradient groundwater.

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[6] The Nature and Extent Report was previously submitted to IEPA (Ramboll 2024) and is provided as Appendix D of the CAAA to which this report is attached.
[7] The GCSM is a component of the Nature and Extent Report previously submitted to IEPA (Ramboll 2024) and is provided as Appendix D of the CAAA to which this report is attached.

Boron in the groundwater system may be attenuated via adsorption and surface complexation reactions within portions of the UA. Boron sorption to iron oxyhydroxide phases in particular is well-studied and is likely occurring within the subsurface near the EAP due to the ubiquitous nature of these materials. Groundwater conditions from the UA are typically predicted to favor amorphous iron oxide stability at most locations. The detected presence of iron oxides in some site solids supports the potential for occurrence of this mechanism. Crystalline iron oxides, including hematite and goethite, were identified in analyzed aquifer solids samples at notable abundances ranging from 0.1 to 8.2%. The presence of clay minerals (e.g., kaolinite) in the UA solids material indicates that adsorption to clays may be another potential attenuation mechanism for boron at locations near the EAP. Additionally, boron sorption to aluminum oxide phases is also common in natural systems with low to neutral pH conditions. Crystalline aluminum oxide mineral phases were not detected in mineralogical analyses of aquifer solids samples, although amorphous aluminum oxide solid phases are widespread in natural environments and likely constitute another boron attenuation mechanism near the EAP.

Batch attenuation testing was conducted for boron to evaluate sorption and to generate site-specific distribution coefficients between solid and aqueous phase. A linear partition coefficient (K_d) value of 2.4 liters per kilogram was established to represent boron attenuation within the UA of the EAP based on the goodness-of-fit and comparability of the value to academic studies. This K_d value provides additional evidence of boron sorption to UA solids.

The GCSM findings suggest the potential for chemical attenuation of boron based on detected abundances of iron oxide and clay minerals, groundwater redox conditions favorable for the stability of these potential sorbing surfaces, and batch testing results which yielded a partition coefficient with a high goodness-of-fit.

3. GROUNDWATER POLISHING REMEDY EVALUATION

This groundwater polishing evaluation uses geochemical modeling to evaluate chemical attenuation of COCs under current conditions and to predict changes in attenuation at exceedance locations following source control. This evaluation will therefore further assess if chemical mechanisms of groundwater polishing will contribute to the remedy achieving the GWPS in a reasonable amount of time. Speciation and reaction models are geochemical models that can be used to evaluate the potential for chemical attenuation in groundwater. Speciation models assess the distribution of constituents between solid and aqueous phases, and reaction models evaluate how that distribution may change with changing site conditions (USEPA 2015). The results of the geochemical modeling provide insight into groundwater polishing mechanisms and additional context for the time estimated to reach the GWPS determined by the groundwater flow and transport model[8], which is based on hydraulic properties of the aquifer and does not take into account chemical interactions occurring within the hydrologic unit.

3.1 Methods

Geochemical modeling was done in PHREEQC Version 3 (USGS 2021) using a modified MINTEQ v4 thermodynamic database (as described in relevant sections below). The geochemical modeling of current conditions and conditions after source control is completed includes speciation and reaction modeling (USEPA 2015):

1. Speciation: To understand groundwater polishing mechanisms under current conditions, a solid phase representative of site conditions is equilibrated with current downgradient groundwater. The results of speciation modeling represent the association of boron with the solid phase under current conditions through mechanisms such as sorption or precipitation.
2. Reaction: In the reaction modeling, the solid phase generated during the speciation modeling phase is reacted iteratively with background groundwater. These results represent the geochemical conditions expected after the source is controlled during which a trailing geochemical gradient may be created (SRNL 2011). The reactions with background groundwater assess the potential for a trailing geochemical gradient to drive changes in groundwater chemistry. Persistence of elevated groundwater COC concentrations over several reaction iterations suggests a trailing geochemical gradient may affect the time to reach the GWPS.

The equilibrium thermodynamic modeling approach used herein allows that the solid and aqueous phases reach equilibrium during each step. The primary goal of this model is to inform the assessment of whether groundwater polishing is an appropriate remedy for the site by evaluating dominant geochemical reactions that may occur at time scales relevant to groundwater flow, including adsorption and certain mineral dissolution/precipitation (i.e., iron and aluminum (hydr)oxides, carbonates, and some sulfates) as identified in the GCSM[9]. The model therefore

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[8] See Footnote 2.

[9] See Footnote 6.

includes those parameters that are expected to contribute to those reactions (as discussed below) and does not include every constituent of the solid phase and groundwater in order to capture "the salient aspects of the system's behavior without introducing unnecessary complexity" (USEPA 2015). This model is therefore a semi-quantitative estimation of chemical behavior in the subsurface rather than a prediction of groundwater quality, consistent with USEPA guidance that geochemical modeling "is often most helpful for identifying relative changes in contaminant speciation and distribution" (USEPA 2015).

3.1.1 Model Set-Up

Inputs to the model include solid phase composition, downgradient groundwater composition for wells with boron GWPS exceedances, and background groundwater composition. The PHREEQC input files and modified MINTEQ v4 database are provided in **Attachment B**. The data included for model parameterization is summarized in **Table 1** and discussed in greater detail in **Attachment C**. All data used in the model and discussed below are documented in the Nature and Extent Report[10].

3.1.1.1 Solid Phase Inputs

Iron hydroxide (ferrihydrite, [$Fe(OH)_3$]) and aluminum hydroxide (gibbsite [$Al(OH)_3$]) are widespread in the environment and known to act as sorbing phases for many groundwater constituents, including boron (Dzombak and Morel 1990; Karamalidis and Dzombak 2010). Model input concentrations for ferrihydrite and gibbsite are ideally derived from sequential extraction procedure (SEP) analyses of iron and aluminum respectively. Because SEP analyses for iron and aluminum were not completed for Joppa EAP samples, model input concentrations for ferrihydrite for Joppa EAP were derived using site-specific total metals and mineralogy (X-ray diffraction [XRD]) datasets which were refined using an analogous compiled SEP dataset, as described in greater detail in **Attachment C**. Gibbsite input concentrations for Joppa EAP were taken directly from the analogous compiled SEP dataset.

Metal oxide concentrations representing the 25th percentile, median, and 75th percentile of the observed data were used to test the sensitivity of the model to the amount of sorbing phases present. Both ferrihydrite and gibbsite were allowed to dissolve or precipitate in the reaction phase of the model.

Calcite and dolomite would typically be included as mineral phases in the speciation model solids input because carbonate mineral formation and dissolution are often major controls on groundwater pH (Stumm and Morgan 1996; Stackelberg et al. 2020). However, neither mineral was detected in XRD analyses of EAP solids samples, so neither mineral was included in the modeling effort. Both calcite and dolomite were allowed to precipitate in the reaction phase of the model.

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[10] The Nature and Extent Report was previously submitted to IEPA (Ramboll 2024) and is provided as Appendix D of the CAAA to which this report is attached. The Nature and Extent report contains laboratory reports and tabulated results from solid phase analysis and tabulated results from groundwater analyses. Laboratory reports for groundwater data are provided quarterly to IEPA and posted to the facility's operating record in accordance with 35 I.A.C. § 845.800(d)(15).

3.1.1.2 Aqueous Inputs

In addition to boron, the following parameters are included to capture the expected attenuation and mobilization mechanisms (see **Section 2.3**):

- Temperature, pH, and pe (calculated from field-measured oxidation-reduction potential based on groundwater temperature).
- Major ions: Alkalinity, sulfate, chloride, fluoride, calcium, magnesium, potassium, and sodium.
- Oxyanions: Silicon and phosphate.
- Redox-active metals: Aluminum, iron, and manganese.
- Remaining constituents regulated under 35 I.A.C. § 845.600[11].

This full suite of geochemical parameters for the modeling effort was measured in Quarter 2 and Quarter 3, 2023. The medians of these results were used in the model to represent average groundwater interacting with the solid phase. For downgradient wells with boron exceedances (**Section 2.3**), the median for each parameter was calculated for each location individually. For background wells, a single median for each parameter was calculated using data from both background locations (see **Section 2.1**).

3.2 Results and Discussion

3.2.1 Model Results

Geochemical modeling results are shown on **Figures 1 through 3** below. Current geochemical conditions are represented in model output figures as 'Speciation Model' and subsequent reaction calculation results are represented with 'First Reaction' and 'Second Reaction'. Full modeling results are provided in **Attachment D**.

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[11] Mercury, thallium, total dissolved solids, and radium were not included in the model. Mercury reactions within the environment are highly complex and would require a separate modeling effort, and the high frequency of non-detect concentrations in the groundwater indicate it would not contribute to model outcomes. Thallium forms a non-reactive monovalent cation and is rarely detected in the groundwater and is therefore not expected to contribute to model outcomes. Total dissolved solids are not a chemical parameter, but rather the result of other chemical abundances taken together. Radium is not included in most thermodynamic databases.

Figure 1: Percentage of Sorbed Boron

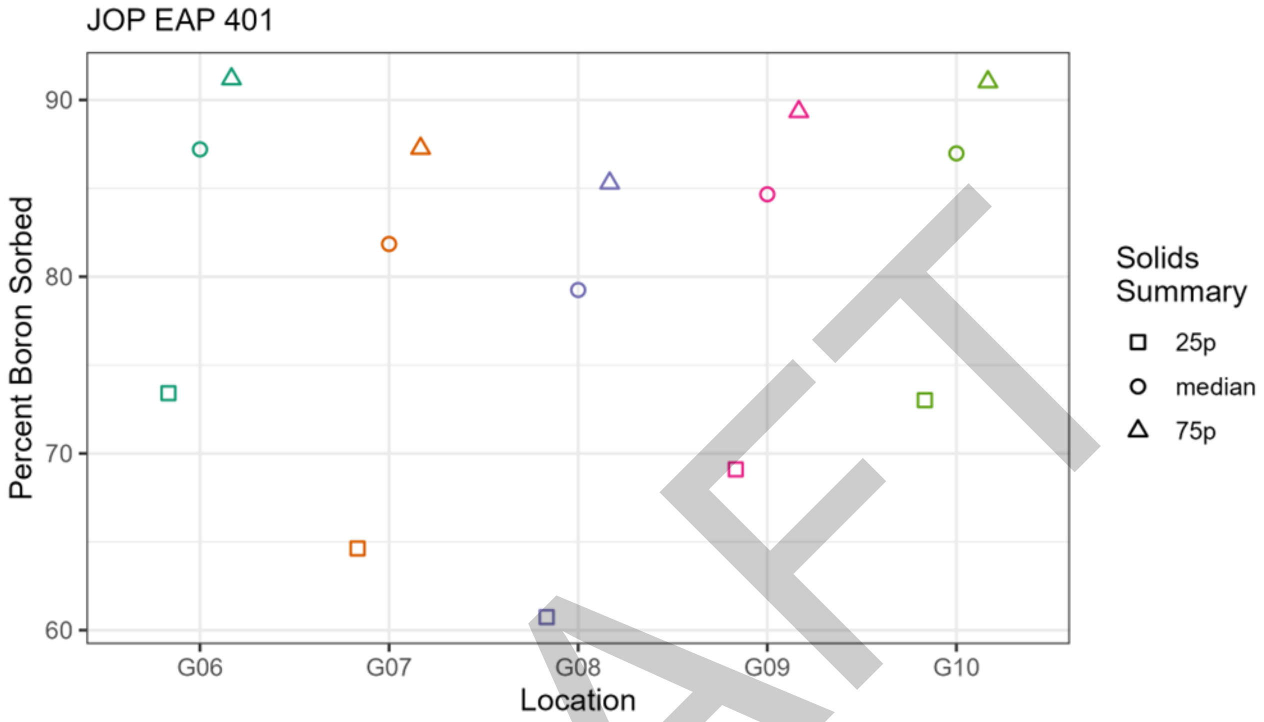


Figure 2: Modeled Boron Behavior

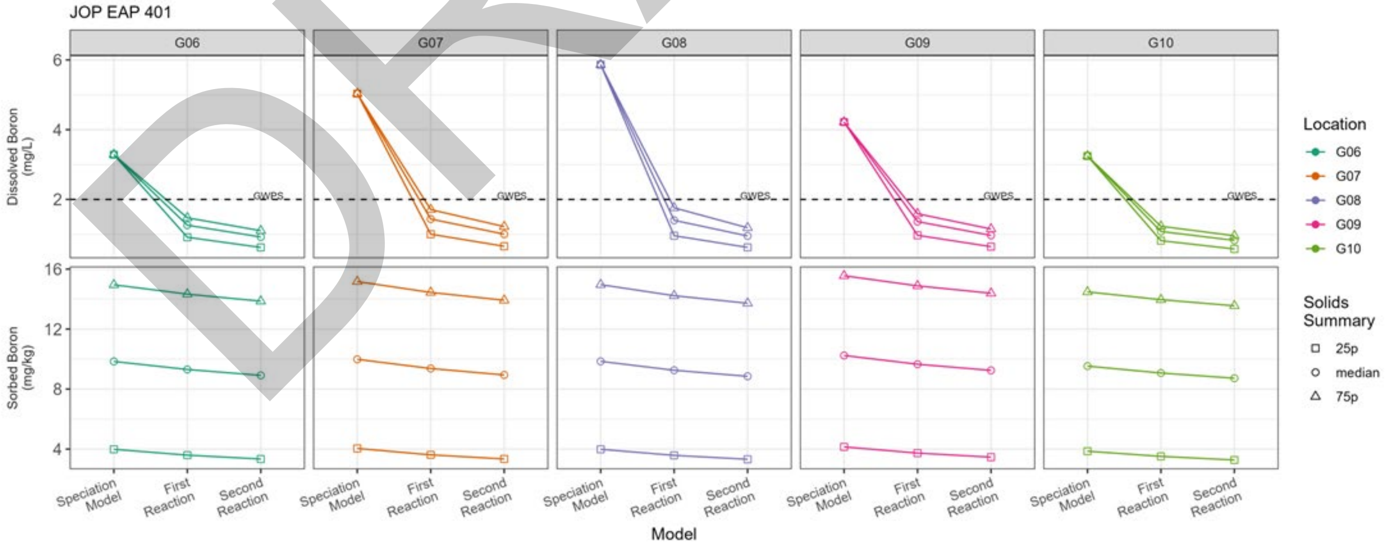
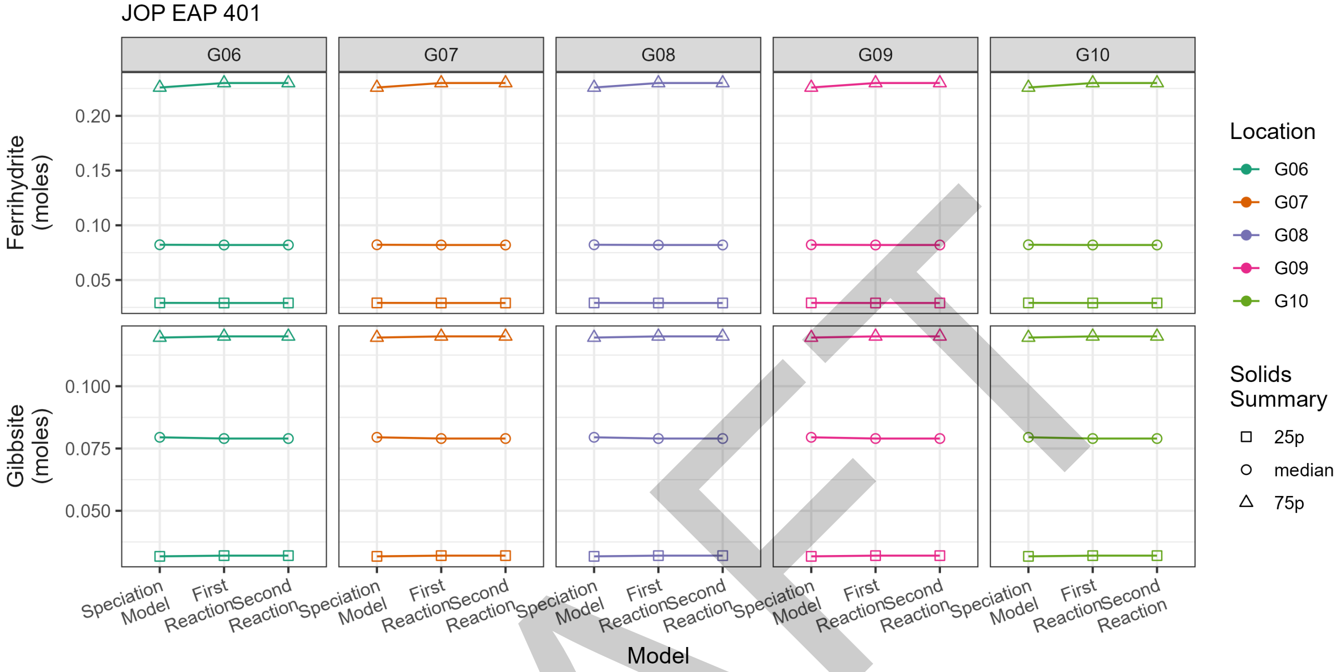


Figure 3: Modeled Sorbing Phase Behavior



3.2.2 Speciation Modeling

Results of speciation modeling support the determination of the GCSM that chemical attenuation of boron is likely to occur. Speciation calculations indicate that between 60 to 91% of boron present in (modeled) downgradient compliance well groundwater will sorb to mineral surfaces (**Figure 1**), with most of the predicted sorption associated with the aluminum oxide (gibbsite) phase (**Attachment D**). Sensitivity assessments demonstrate the influence of variable sorbing mineral mass inputs on boron sorption, with the 25th percentile and 75th percentile values for mineral mass accounting for differences of up to 25% of aqueous boron sorbed under current conditions. These predicted proportions of sorbed aqueous boron correspond to total sorbed boron masses ranging from approximately 4.0 to 15.5 mg/kg. Model results using the median solid-phase inputs yield total sorbed boron masses of approximately 10 mg/kg for all wells with boron exceedances (**Figure 2**). These results suggest that boron sorption under current geochemical conditions is favorable and relatively uniform across wells with GWPS exceedances, although the absolute amount of sorbed boron is sensitive to the amount of sorbent.

3.2.3 Reaction Modeling

Reaction modeling of conditions following source control demonstrates that aqueous boron concentrations change with background groundwater interaction. Aqueous boron concentrations are predicted to decrease at all wells with current exceedances with each iterative reaction (**Figure 2**).

Boron is predicted to sorb to ferrihydrite and gibbsite, both of which are expected to remain stable and exhibit minor (less than 0.01%, **Table 2**) predicted dissolution under post-source control conditions (**Figure 3**). The predicted stability of sorbing mineral phases under post-source control conditions demonstrates the continued feasibility of boron chemical attenuation mechanisms in the EAP. While a minor (< 2 mg/kg over two iterative reactions) component of boron desorption from solids is predicted, the impact of desorption under post-source control conditions is expected to be outpaced by the influence of lower boron concentration background groundwater. Based on reaction modeling sensitivity results, boron attenuation is not particularly sensitive to the amount of sorbent, providing assurance that boron attenuation feasibility within this system is not highly dependent on sorbent model input assumptions. The modeled scenario is predicted to result in net decreases to aqueous boron concentrations at compliance wells. Every modeled well is predicted to achieve the boron GWPS within one iterative reaction.

These results suggest that chemical attenuation of boron should remain feasible following source control efforts. The primary chemical attenuation mechanisms for boron are anticipated to be sorption to iron and aluminum oxide mineral phases which are predicted to be stable in post-source control conditions. Results suggest that the flow and transport model conclusions are approximately correct for boron, and that the time to reach the GWPS is not anticipated to be affected by desorption of boron from the solid phase. All wells within the compliance network should achieve the GWPS for boron through natural processes.

4. CONCLUSIONS

This report evaluated the contribution of chemical mechanisms to groundwater polishing via geochemical modeling. The results of the groundwater polishing evaluation also contextualize estimates of the modeled time to reach the GWPS by evaluating potential changes in boron attenuation as groundwater quality returns to background conditions.

Geochemical modeling of current EAP conditions demonstrates chemical attenuation of boron via sorption to aquifer solids, particularly iron and aluminum oxides. Modeling of anticipated post-source control conditions predicts a minor component of boron desorption from these solids that will be offset by interaction with background groundwater containing low aqueous boron concentrations, resulting in net aqueous boron concentration decreases at wells with exceedances. Modeling also predicts that iron and aluminum oxide sorbing minerals phases will remain stable in post-source control conditions, and as a result the anticipated primary boron chemical attenuation mechanism will remain viable.

Results of the geochemical modeling suggest that the time to reach the boron GWPS determined by the groundwater flow and transport model is not anticipated to be impacted by desorption of boron from aquifer solids under post-source control conditions. These results will inform corrective action groundwater monitoring and adaptive site management, critical components of every corrective action considered in the CAAA.

5. REFERENCES

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TABLES

Table 1. Summary of Geochemical Model Inputs
Groundwater Polishing Evaluation Report
Joppa Power Plant - East Ash Pond Unit

Model Component	Parameters	Data source(s)
Solid Phase	Iron (hydr)oxides, aluminum (hydr)oxides	Site-specific total metals and X-ray diffraction results from solid samples which were refined using representative results from sequential extraction data
	Calcite and dolomite	X-ray diffraction results
Downgradient groundwater (COC exceedance locations)	Boron, iron, manganese, major ions[1], 845 constituents[1]	Median concentrations per well from data collected in Q2 and Q3 2023
Background groundwater		Median concentrations from all network background wells using data collected in Q2 and Q3 2023

[1] See Section 3.1.1.2 for details.

Table 2: Geochemical Modeling Response of Sorbing Phases
Groundwater Polishing Evaluation
Joppa Power Plant - East Ash Pond Unit

Parameter	Hydrostratigraphic Unit	Location	Summary Type	First Reaction Change		Second Reaction Change	
				mg/kg	%	mg/kg	%
Ferrihydrite	UA	G06	25p	0.024	<0.01	0.024	<0.01
			median	0.024	<0.01	0.024	<0.01
			75p	0.024	<0.01	0.024	<0.01
		G07	25p	0.023	<0.01	0.023	<0.01
			median	0.022	<0.01	0.023	<0.01
			75p	0.022	<0.01	0.022	<0.01
		G08	25p	0.024	<0.01	0.024	<0.01
			median	0.025	<0.01	0.024	<0.01
			75p	0.028	<0.01	0.023	<0.01
		G09	25p	0.023	<0.01	0.024	<0.01
			median	0.023	<0.01	0.023	<0.01
			75p	0.022	<0.01	0.022	<0.01
		G10	25p	0.024	<0.01	0.024	<0.01
			median	0.023	<0.01	0.024	<0.01
			75p	0.023	<0.01	0.023	<0.01
Gibbsite		G06	25p	0.009	<0.01	0.009	<0.01
			median	0.009	<0.01	0.009	<0.01
			75p	0.008	<0.01	0.008	<0.01
		G07	25p	0.007	<0.01	0.008	<0.01
			median	0.006	<0.01	0.007	<0.01
			75p	0.005	<0.01	0.005	<0.01
		G08	25p	0.009	<0.01	0.009	<0.01
			median	0.009	<0.01	0.009	<0.01
			75p	0.009	<0.01	0.009	<0.01
		G09	25p	0.008	<0.01	0.009	<0.01
			median	0.007	<0.01	0.008	<0.01
			75p	0.004	<0.01	0.006	<0.01
		G10	25p	0.008	<0.01	0.009	<0.01
			median	0.008	<0.01	0.008	<0.01
			75p	0.008	<0.01	0.008	<0.01

Notes:
% = percent
25p = 25th percentile
75p = 75th percentile
mg/kg = milligram/kilogram
UA = Uppermost Aquifer

ATTACHMENT A

Operating Permit Network Map and Potentiometric Surface (September 2023)

▣ COMPLIANCE MONITORING WELL
▣ BACKGROUND MONITORING WELL
▣ PORE WATER WELL
▣ MONITORING WELL
◓ STAFF GAGE, RIVER
◓ STAFF GAGE, CCR UNIT
— GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- - INFERRED GROUNDWATER ELEVATION CONTOUR
→ GROUNDWATER FLOW DIRECTION
▭ REGULATED UNIT (SUBJECT UNIT)
▭ PROPERTY BOUNDARY

0 275 550 Feet

NOTES
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)
*GAGING DATA FROM USGS 03612600 OHIO RIVER AT OLMSTED, IL LOCATED APPROXIMATELY 12 MILES DOWNSTREAM OF JOPPA POWER PLANT.

POTENTIOMETRIC SURFACE MAP
SEPTEMBER 25, 2023

2023 ANNUAL GROUNDWATER MONITORING
AND CORRECTIVE ACTION REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

ATTACHMENT B

PHREEQC Input Files and Thermodynamic Database

25th Percentile Metal Oxides/No Charge Balance

```
SELECTED_OUTPUT 1
-file JOP_845_401_25p_cb-false_out.csv
-charge_balance true
-percent_error true
-totals S(6) B Li As C(4) Cl F Ca Mg Na K Ba Si P Mn Fe Al Sb Be Cd Cr Co Pb Mo Se Hfo_s Hfo_w
Hao_
-molalities Hfo_wOBa+ Hfo_wOCa+ Hfo_wOMg+ Hfo_wOH
Hfo_wOH2+ Hfo_wOHSO4-2 Hfo_wSO4- Hfo_wOSi(OH)3
Hfo_wOSiO(OH)2- Hfo_wHCO3 Hfo_wCO3- Hfo_wPO4-2
Hfo_wHPO4- Hfo_wH2PO4 Hfo_sCO3- Hfo_sHCO3
Hfo_sHPO4- Hfo_sH2BO3 Hfo_sH2PO4 Hfo_sOSi(OH)3
Hfo_sOSiO(OH)2- Hfo_sOHSO4-2 Hfo_sSO4-
Hao_SO4- Hao_OHSO4-2 Hao_H2BO3 Hao_H3BO4-
-equilibrium_phases Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite

SOLUTION 1 #G06 (C - UA)
redox pe
units mg/l
density 1
pH 6.595
pe 5.055
temp 15.95
S(6) 197.5 as SO4
B 3.285
Li 0.004125
As 0.002675
C(4) 101.75 as CO3
Cl 21.5
F 0.265
Ca 88.7
Mg 24.3
Na 47.65
K 2.46
Ba 0.03525
Si 6.36
P 0.0195
Mn 0.0141
Fe 0.022605
Al 0.008175
Sb 0.00085
Be 0.0002
Cd 0.000175
Cr 0.0056
Co 0.0024
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 2 #G07 (C - UA)
redox pe
units mg/l
```

```
density 1
pH 6.405
pe 5.38
temp 15.8
S(6) 264 as SO4
B 5.035
Li 0.006
As 0.002525
C(4) 104 as CO3
Cl 21.5
F 0.415
Ca 97.2
Mg 24.1
Na 69.45
K 4.23
Ba 0.1258
Si 8.79
P 0.0145
Mn 2.475
Fe 0.088505
Al 0.008175
Sb 0.0004
Be 0.00075
Cd 0.000175
Cr 0.0196
Co 0.00445
Pb 0.00315
Mo 0.001275
Se 0.0003
end

SOLUTION 3 #G08 (C - UA)
redox pe
units mg/l
density 1
pH 6.945
pe 4
temp 17.3
S(6) 341.5 as SO4
B 5.865
Li 0.0058
As 0.0099
C(4) 99.65 as CO3
Cl 15
F 0.3
Ca 136
Mg 32.55
Na 40.05
K 1.645
Ba 0.06535
Si 6.1
P 0.0195
Mn 2.045
Fe 0.9105
```

```
Al 0.008175
Sb 0.0002
Be 0.0003
Cd 0.000175
Cr 0.00565
Co 0.0075
Pb 0.00115
Mo 0.002075
Se 0.0003
end

SOLUTION 4 #G09 (C - UA)
redox pe
units mg/l
density 1
pH 6.305
pe 4.07
temp 17.3
S(6) 235 as SO4
B 4.22
Li 0.00635
As 0.0067
C(4) 68.6 as CO3
Cl 18.5
F 0.325
Ca 66
Mg 25.4
Na 62.7
K 0.9565
Ba 0.04155
Si 15.4
P 0.0265
Mn 1.01
Fe 2.015
Al 0.008175
Sb 0.00195
Be 0.00055
Cd 0.000175
Cr 0.00525
Co 0.00605
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 5 #G10 (C - UA)
redox pe
units mg/l
density 1
pH 6.625
pe 5.405
temp 17.3
S(6) 360.5 as SO4
B 3.245
Li 0.0068
```

```
As 0.004025
C(4) 117.45 as CO3
Cl 25.5
F 0.335
Ca 122
Mg 38
Na 82.2
K 7.705
Ba 0.048
Si 11.75
P 0.0215
Mn 0.1525
Fe 0.4295
Al 0.008175
Sb 0.0002
Be 0.0004
Cd 0.000175
Cr 0.0084
Co 0.00395
Pb 0.00115
Mo 0.001725
Se 0.0003
end

EQUILIBRIUM_PHASES 1 #G06 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 1
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 1
save surface 1
end

EQUILIBRIUM_PHASES 2 #G07 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 2
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 2
save surface 2
end

EQUILIBRIUM_PHASES 3 #G08 (C - UA) - 25p
```

```
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 3
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 3
save surface 3
end

EQUILIBRIUM_PHASES 4 #G09 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 4
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 4
save surface 4
end

EQUILIBRIUM_PHASES 5 #G10 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 5
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 5
save surface 5
end

SOLUTION 6 #average background
redox pe
units mg/l
density 1
pH 6.43
pe 5.57
temp 15.8
S(6) 20.5
B 0.03055
Li 0.005125
```

```
As 0.002525
C(4) 117.55
Cl 16 charge
F 0.215
Ca 32.4
Mg 9.49
Na 58.1
K 1.19
Ba 0.2115
Si 6.54
P 0.00875
Mn 0.01815
Fe 0.0415
Al 0.008175
Sb 0.0002
Be 0.0001
Cd 0.000175
Cr 0.0026
Co 0.0006
Pb 0.00195
Mo 0.001275
Se 0.00155

SAVE solution 6

end

#FIRST FLUSH

#G06 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium__phases 1
SAVE surface 1
end

#G06 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium__phases 1
SAVE surface 1
end

#G07 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium__phases 2
SAVE surface 2
end

#G07 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium__phases 2
```

```
SAVE surface 2
end

#G08 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G08 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G09 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G09 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G10 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G10 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end
```

25th Percentile Metal Oxides/Charge Balance on Chloride

```
SELECTED_OUTPUT 1
-file JOP_845_401_25p_cb-true_out.csv
-charge_balance true
-percent_error true
-totals S(6) B Li As C(4) Cl F Ca Mg Na K Ba Si P Mn Fe Al Sb Be Cd Cr Co Pb Mo Se Hfo_s Hfo_w Hao_
-molalities Hfo_wOBa+ Hfo_wOCa+ Hfo_wOMg+ Hfo_wOH
Hfo_wOH2+ Hfo_wOHSO4-2 Hfo_wSO4- Hfo_wOSi(OH)3
Hfo_wOSiO(OH)2- Hfo_wHCO3 Hfo_wCO3- Hfo_wPO4-2
Hfo_wHPO4- Hfo_wH2PO4 Hfo_sCO3- Hfo_sHCO3
Hfo_sHPO4- Hfo_sH2BO3 Hfo_sH2PO4 Hfo_sOSi(OH)3
Hfo_sOSiO(OH)2- Hfo_sOHSO4-2 Hfo_sSO4-
Hao_SO4- Hao_OHSO4-2 Hao_H2BO3 Hao_H3BO4-
-equilibrium_phases Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite

SOLUTION 1 #G06 (C - UA)
redox pe
units mg/l
density 1
pH 6.595
pe 5.055
temp 15.95
S(6) 197.5 as SO4
B 3.285
Li 0.004125
As 0.002675
C(4) 101.75 as CO3
Cl 21.5 charge
F 0.265
Ca 88.7
Mg 24.3
Na 47.65
K 2.46
Ba 0.03525
Si 6.36
P 0.0195
Mn 0.0141
Fe 0.022605
Al 0.008175
Sb 0.00085
Be 0.0002
Cd 0.000175
Cr 0.0056
Co 0.0024
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 2 #G07 (C - UA)
redox pe
units mg/l
```

```
density 1
pH 6.405
pe 5.38
temp 15.8
S(6) 264 as SO4
B 5.035
Li 0.006
As 0.002525
C(4) 104 as CO3
Cl 21.5 charge
F 0.415
Ca 97.2
Mg 24.1
Na 69.45
K 4.23
Ba 0.1258
Si 8.79
P 0.0145
Mn 2.475
Fe 0.088505
Al 0.008175
Sb 0.0004
Be 0.00075
Cd 0.000175
Cr 0.0196
Co 0.00445
Pb 0.00315
Mo 0.001275
Se 0.0003
end

SOLUTION 3 #G08 (C - UA)
redox pe
units mg/l
density 1
pH 6.945
pe 4
temp 17.3
S(6) 341.5 as SO4
B 5.865
Li 0.0058
As 0.0099
C(4) 99.65 as CO3
Cl 15 charge
F 0.3
Ca 136
Mg 32.55
Na 40.05
K 1.645
Ba 0.06535
Si 6.1
P 0.0195
Mn 2.045
Fe 0.9105
```

```
Al 0.008175
Sb 0.0002
Be 0.0003
Cd 0.000175
Cr 0.00565
Co 0.0075
Pb 0.00115
Mo 0.002075
Se 0.0003
end

SOLUTION 4 #G09 (C - UA)
redox pe
units mg/l
density 1
pH 6.305
pe 4.07
temp 17.3
S(6) 235 as SO4
B 4.22
Li 0.00635
As 0.0067
C(4) 68.6 as CO3
Cl 18.5 charge
F 0.325
Ca 66
Mg 25.4
Na 62.7
K 0.9565
Ba 0.04155
Si 15.4
P 0.0265
Mn 1.01
Fe 2.015
Al 0.008175
Sb 0.00195
Be 0.00055
Cd 0.000175
Cr 0.00525
Co 0.00605
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 5 #G10 (C - UA)
redox pe
units mg/l
density 1
pH 6.625
pe 5.405
temp 17.3
S(6) 360.5 as SO4
B 3.245
Li 0.0068
```

```
As 0.004025
C(4) 117.45 as CO3
Cl 25.5 charge
F 0.335
Ca 122
Mg 38
Na 82.2
K 7.705
Ba 0.048
Si 11.75
P 0.0215
Mn 0.1525
Fe 0.4295
Al 0.008175
Sb 0.0002
Be 0.0004
Cd 0.000175
Cr 0.0084
Co 0.00395
Pb 0.00115
Mo 0.001725
Se 0.0003
end

EQUILIBRIUM_PHASES 1 #G06 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 1
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 1
save surface 1
end

EQUILIBRIUM_PHASES 2 #G07 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 2
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 2
save surface 2
end

EQUILIBRIUM_PHASES 3 #G08 (C - UA) - 25p
```

```
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 3
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 3
save surface 3
end

EQUILIBRIUM_PHASES 4 #G09 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 4
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 4
save surface 4
end

EQUILIBRIUM_PHASES 5 #G10 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.032
Ferrihydrite 0 0.029
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 5
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 5
save surface 5
end

SOLUTION 6 #average background
redox pe
units mg/l
density 1
pH 6.43
pe 5.57
temp 15.8
S(6) 20.5
B 0.03055
Li 0.005125
```

```
As 0.002525
C(4) 117.55
Cl 16 charge
F 0.215
Ca 32.4
Mg 9.49
Na 58.1
K 1.19
Ba 0.2115
Si 6.54
P 0.00875
Mn 0.01815
Fe 0.0415
Al 0.008175
Sb 0.0002
Be 0.0001
Cd 0.000175
Cr 0.0026
Co 0.0006
Pb 0.00195
Mo 0.001275
Se 0.00155

SAVE solution 6

end

#FIRST FLUSH

#G06 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G06 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G07 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G07 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G08 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G08 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G09 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G09 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G10 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G10 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end
```

75th Percentile Metal Oxides/No Charge Balance

```
SELECTED_OUTPUT 1
-file JOP_845_401_75p_cb-false_out.csv
-charge_balance true
-percent_error true
-totals S(6) B Li As C(4) Cl F Ca Mg Na K Ba Si P Mn Fe Al Sb Be Cd Cr Co Pb Mo Se Hfo_s Hfo_w
Hao_
-molalities Hfo_wOBa+ Hfo_wOCa+ Hfo_wOMg+ Hfo_wOH
Hfo_wOH2+ Hfo_wOHSO4-2 Hfo_wSO4- Hfo_wOSi(OH)3
Hfo_wOSiO(OH)2- Hfo_wHCO3 Hfo_wCO3- Hfo_wPO4-2
Hfo_wHPO4- Hfo_wH2PO4 Hfo_sCO3- Hfo_sHCO3
Hfo_sHPO4- Hfo_sH2BO3 Hfo_sH2PO4 Hfo_sOSi(OH)3
Hfo_sOSiO(OH)2- Hfo_sOHSO4-2 Hfo_sSO4-
Hao_SO4- Hao_OHSO4-2 Hao_H2BO3 Hao_H3BO4-
-equilibrium_phases Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite

SOLUTION 1 #G06 (C - UA)
redox pe
units mg/l
density 1
pH 6.595
pe 5.055
temp 15.95
S(6) 197.5 as SO4
B 3.285
Li 0.004125
As 0.002675
C(4) 101.75 as CO3
Cl 21.5
F 0.265
Ca 88.7
Mg 24.3
Na 47.65
K 2.46
Ba 0.03525
Si 6.36
P 0.0195
Mn 0.0141
Fe 0.022605
Al 0.008175
Sb 0.00085
Be 0.0002
Cd 0.000175
Cr 0.0056
Co 0.0024
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 2 #G07 (C - UA)
redox pe
units mg/l
```

```
density 1
pH 6.405
pe 5.38
temp 15.8
S(6) 264 as SO4
B 5.035
Li 0.006
As 0.002525
C(4) 104 as CO3
Cl 21.5
F 0.415
Ca 97.2
Mg 24.1
Na 69.45
K 4.23
Ba 0.1258
Si 8.79
P 0.0145
Mn 2.475
Fe 0.088505
Al 0.008175
Sb 0.0004
Be 0.00075
Cd 0.000175
Cr 0.0196
Co 0.00445
Pb 0.00315
Mo 0.001275
Se 0.0003
end

SOLUTION 3 #G08 (C - UA)
redox pe
units mg/l
density 1
pH 6.945
pe 4
temp 17.3
S(6) 341.5 as SO4
B 5.865
Li 0.0058
As 0.0099
C(4) 99.65 as CO3
Cl 15
F 0.3
Ca 136
Mg 32.55
Na 40.05
K 1.645
Ba 0.06535
Si 6.1
P 0.0195
Mn 2.045
Fe 0.9105
```

```
Al 0.008175
Sb 0.0002
Be 0.0003
Cd 0.000175
Cr 0.00565
Co 0.0075
Pb 0.00115
Mo 0.002075
Se 0.0003
end

SOLUTION 4 #G09 (C - UA)
redox pe
units mg/l
density 1
pH 6.305
pe 4.07
temp 17.3
S(6) 235 as SO4
B 4.22
Li 0.00635
As 0.0067
C(4) 68.6 as CO3
Cl 18.5
F 0.325
Ca 66
Mg 25.4
Na 62.7
K 0.9565
Ba 0.04155
Si 15.4
P 0.0265
Mn 1.01
Fe 2.015
Al 0.008175
Sb 0.00195
Be 0.00055
Cd 0.000175
Cr 0.00525
Co 0.00605
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 5 #G10 (C - UA)
redox pe
units mg/l
density 1
pH 6.625
pe 5.405
temp 17.3
S(6) 360.5 as SO4
B 3.245
Li 0.0068
```

```
As 0.004025
C(4) 117.45 as CO3
Cl 25.5
F 0.335
Ca 122
Mg 38
Na 82.2
K 7.705
Ba 0.048
Si 11.75
P 0.0215
Mn 0.1525
Fe 0.4295
Al 0.008175
Sb 0.0002
Be 0.0004
Cd 0.000175
Cr 0.0084
Co 0.00395
Pb 0.00115
Mo 0.001725
Se 0.0003
end

EQUILIBRIUM_PHASES 1 #G06 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 1
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 1
save surface 1
end

EQUILIBRIUM_PHASES 2 #G07 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 2
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 2
save surface 2
end

EQUILIBRIUM_PHASES 3 #G08 (C - UA) - 75p
```

```
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 3
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 3
save surface 3
end

EQUILIBRIUM_PHASES 4 #G09 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 4
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 4
save surface 4
end

EQUILIBRIUM_PHASES 5 #G10 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 5
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 5
save surface 5
end

SOLUTION 6 #average background
redox pe
units mg/l
density 1
pH 6.43
pe 5.57
temp 15.8
S(6) 20.5
B 0.03055
Li 0.005125
```

```
As 0.002525
C(4) 117.55
Cl 16 charge
F 0.215
Ca 32.4
Mg 9.49
Na 58.1
K 1.19
Ba 0.2115
Si 6.54
P 0.00875
Mn 0.01815
Fe 0.0415
Al 0.008175
Sb 0.0002
Be 0.0001
Cd 0.000175
Cr 0.0026
Co 0.0006
Pb 0.00195
Mo 0.001275
Se 0.00155

SAVE solution 6

end

#FIRST FLUSH

#G06 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium__phases 1
SAVE surface 1
end

#G06 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium__phases 1
SAVE surface 1
end

#G07 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium__phases 2
SAVE surface 2
end

#G07 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium__phases 2
```

```
SAVE surface 2
end

#G08 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G08 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G09 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G09 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G10 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G10 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end
```

75th Percentile Metal Oxides/Charge Balance on Chloride

```
SELECTED_OUTPUT 1
-file JOP_845_401_75p_cb-true_out.csv
-charge_balance true
-percent_error true
-totals S(6) B Li As C(4) Cl F Ca Mg Na K Ba Si P Mn Fe Al Sb Be Cd Cr Co Pb Mo Se Hfo_s Hfo_w Hao_
-molalities Hfo_wOBa+ Hfo_wOCa+ Hfo_wOMg+ Hfo_wOH
Hfo_wOH2+ Hfo_wOHSO4-2 Hfo_wSO4- Hfo_wOSi(OH)3
Hfo_wOSiO(OH)2- Hfo_wHCO3 Hfo_wCO3- Hfo_wPO4-2
Hfo_wHPO4- Hfo_wH2PO4 Hfo_sCO3- Hfo_sHCO3
Hfo_sHPO4- Hfo_sH2BO3 Hfo_sH2PO4 Hfo_sOSi(OH)3
Hfo_sOSiO(OH)2- Hfo_sOHSO4-2 Hfo_sSO4-
Hao_SO4- Hao_OHSO4-2 Hao_H2BO3 Hao_H3BO4-
-equilibrium_phases Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite

SOLUTION 1 #G06 (C - UA)
redox pe
units mg/l
density 1
pH 6.595
pe 5.055
temp 15.95
S(6) 197.5 as SO4
B 3.285
Li 0.004125
As 0.002675
C(4) 101.75 as CO3
Cl 21.5 charge
F 0.265
Ca 88.7
Mg 24.3
Na 47.65
K 2.46
Ba 0.03525
Si 6.36
P 0.0195
Mn 0.0141
Fe 0.022605
Al 0.008175
Sb 0.00085
Be 0.0002
Cd 0.000175
Cr 0.0056
Co 0.0024
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 2 #G07 (C - UA)
redox pe
units mg/l
```

```
density 1
pH 6.405
pe 5.38
temp 15.8
S(6) 264 as SO4
B 5.035
Li 0.006
As 0.002525
C(4) 104 as CO3
Cl 21.5 charge
F 0.415
Ca 97.2
Mg 24.1
Na 69.45
K 4.23
Ba 0.1258
Si 8.79
P 0.0145
Mn 2.475
Fe 0.088505
Al 0.008175
Sb 0.0004
Be 0.00075
Cd 0.000175
Cr 0.0196
Co 0.00445
Pb 0.00315
Mo 0.001275
Se 0.0003
end

SOLUTION 3 #G08 (C - UA)
redox pe
units mg/l
density 1
pH 6.945
pe 4
temp 17.3
S(6) 341.5 as SO4
B 5.865
Li 0.0058
As 0.0099
C(4) 99.65 as CO3
Cl 15 charge
F 0.3
Ca 136
Mg 32.55
Na 40.05
K 1.645
Ba 0.06535
Si 6.1
P 0.0195
Mn 2.045
Fe 0.9105
```

```
Al 0.008175
Sb 0.0002
Be 0.0003
Cd 0.000175
Cr 0.00565
Co 0.0075
Pb 0.00115
Mo 0.002075
Se 0.0003
end

SOLUTION 4 #G09 (C - UA)
redox pe
units mg/l
density 1
pH 6.305
pe 4.07
temp 17.3
S(6) 235 as SO4
B 4.22
Li 0.00635
As 0.0067
C(4) 68.6 as CO3
Cl 18.5 charge
F 0.325
Ca 66
Mg 25.4
Na 62.7
K 0.9565
Ba 0.04155
Si 15.4
P 0.0265
Mn 1.01
Fe 2.015
Al 0.008175
Sb 0.00195
Be 0.00055
Cd 0.000175
Cr 0.00525
Co 0.00605
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 5 #G10 (C - UA)
redox pe
units mg/l
density 1
pH 6.625
pe 5.405
temp 17.3
S(6) 360.5 as SO4
B 3.245
Li 0.0068
```

```
As 0.004025
C(4) 117.45 as CO3
Cl 25.5 charge
F 0.335
Ca 122
Mg 38
Na 82.2
K 7.705
Ba 0.048
Si 11.75
P 0.0215
Mn 0.1525
Fe 0.4295
Al 0.008175
Sb 0.0002
Be 0.0004
Cd 0.000175
Cr 0.0084
Co 0.00395
Pb 0.00115
Mo 0.001725
Se 0.0003
end

EQUILIBRIUM_PHASES 1 #G06 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 1
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 1
save surface 1
end

EQUILIBRIUM_PHASES 2 #G07 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 2
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 2
save surface 2
end

EQUILIBRIUM_PHASES 3 #G08 (C - UA) - 75p
```

```
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 3
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 3
save surface 3
end

EQUILIBRIUM_PHASES 4 #G09 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 4
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 4
save surface 4
end

EQUILIBRIUM_PHASES 5 #G10 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.23
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 5
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 5
save surface 5
end

SOLUTION 6 #average background
redox pe
units mg/l
density 1
pH 6.43
pe 5.57
temp 15.8
S(6) 20.5
B 0.03055
Li 0.005125
```

```
As 0.002525
C(4) 117.55
Cl 16 charge
F 0.215
Ca 32.4
Mg 9.49
Na 58.1
K 1.19
Ba 0.2115
Si 6.54
P 0.00875
Mn 0.01815
Fe 0.0415
Al 0.008175
Sb 0.0002
Be 0.0001
Cd 0.000175
Cr 0.0026
Co 0.0006
Pb 0.00195
Mo 0.001275
Se 0.00155

SAVE solution 6

end

#FIRST FLUSH

#G06 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G06 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G07 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G07 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G08 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G08 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G09 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G09 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G10 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G10 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end
```

Median Metal Oxides/No Charge Balance

```
SELECTED_OUTPUT 1
-file JOP_845_401_median_cb-false_out.csv
-charge_balance true
-percent_error true
-totals S(6) B Li As C(4) Cl F Ca Mg Na K Ba Si P Mn Fe Al Sb Be Cd Cr Co Pb Mo Se Hfo_s Hfo_w Hao_
-molalities Hfo_wOBa+ Hfo_wOCa+ Hfo_wOMg+ Hfo_wOH
Hfo_wOH2+ Hfo_wOHSO4-2 Hfo_wSO4- Hfo_wOSi(OH)3
Hfo_wOSiO(OH)2- Hfo_wHCO3 Hfo_wCO3- Hfo_wPO4-2
Hfo_wHPO4- Hfo_wH2PO4 Hfo_sCO3- Hfo_sHCO3
Hfo_sHPO4- Hfo_sH2BO3 Hfo_sH2PO4 Hfo_sOSi(OH)3
Hfo_sOSiO(OH)2- Hfo_sOHSO4-2 Hfo_sSO4-
Hao_SO4- Hao_OHSO4-2 Hao_H2BO3 Hao_H3BO4-
-equilibrium_phases Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite

SOLUTION 1 #G06 (C - UA)
redox pe
units mg/l
density 1
pH 6.595
pe 5.055
temp 15.95
S(6) 197.5 as SO4
B 3.285
Li 0.004125
As 0.002675
C(4) 101.75 as CO3
Cl 21.5
F 0.265
Ca 88.7
Mg 24.3
Na 47.65
K 2.46
Ba 0.03525
Si 6.36
P 0.0195
Mn 0.0141
Fe 0.022605
Al 0.008175
Sb 0.00085
Be 0.0002
Cd 0.000175
Cr 0.0056
Co 0.0024
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 2 #G07 (C - UA)
redox pe
units mg/l
```

```
density 1
pH 6.405
pe 5.38
temp 15.8
S(6) 264 as SO4
B 5.035
Li 0.006
As 0.002525
C(4) 104 as CO3
Cl 21.5
F 0.415
Ca 97.2
Mg 24.1
Na 69.45
K 4.23
Ba 0.1258
Si 8.79
P 0.0145
Mn 2.475
Fe 0.088505
Al 0.008175
Sb 0.0004
Be 0.00075
Cd 0.000175
Cr 0.0196
Co 0.00445
Pb 0.00315
Mo 0.001275
Se 0.0003
end

SOLUTION 3 #G08 (C - UA)
redox pe
units mg/l
density 1
pH 6.945
pe 4
temp 17.3
S(6) 341.5 as SO4
B 5.865
Li 0.0058
As 0.0099
C(4) 99.65 as CO3
Cl 15
F 0.3
Ca 136
Mg 32.55
Na 40.05
K 1.645
Ba 0.06535
Si 6.1
P 0.0195
Mn 2.045
Fe 0.9105
```

```
Al 0.008175
Sb 0.0002
Be 0.0003
Cd 0.000175
Cr 0.00565
Co 0.0075
Pb 0.00115
Mo 0.002075
Se 0.0003
end

SOLUTION 4 #G09 (C - UA)
redox pe
units mg/l
density 1
pH 6.305
pe 4.07
temp 17.3
S(6) 235 as SO4
B 4.22
Li 0.00635
As 0.0067
C(4) 68.6 as CO3
Cl 18.5
F 0.325
Ca 66
Mg 25.4
Na 62.7
K 0.9565
Ba 0.04155
Si 15.4
P 0.0265
Mn 1.01
Fe 2.015
Al 0.008175
Sb 0.00195
Be 0.00055
Cd 0.000175
Cr 0.00525
Co 0.00605
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 5 #G10 (C - UA)
redox pe
units mg/l
density 1
pH 6.625
pe 5.405
temp 17.3
S(6) 360.5 as SO4
B 3.245
Li 0.0068
```

```
As 0.004025
C(4) 117.45 as CO3
Cl 25.5
F 0.335
Ca 122
Mg 38
Na 82.2
K 7.705
Ba 0.048
Si 11.75
P 0.0215
Mn 0.1525
Fe 0.4295
Al 0.008175
Sb 0.0002
Be 0.0004
Cd 0.000175
Cr 0.0084
Co 0.00395
Pb 0.00115
Mo 0.001725
Se 0.0003
end

EQUILIBRIUM_PHASES 1 #G06 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 1
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 1
save surface 1
end

EQUILIBRIUM_PHASES 2 #G07 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 2
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 2
save surface 2
end

EQUILIBRIUM_PHASES 3 #G08 (C - UA) - median
```

```
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 3
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 3
save surface 3
end

EQUILIBRIUM_PHASES 4 #G09 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 4
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 4
save surface 4
end

EQUILIBRIUM_PHASES 5 #G10 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 5
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 5
save surface 5
end

SOLUTION 6 #average background
redox pe
units mg/l
density 1
pH 6.43
pe 5.57
temp 15.8
S(6) 20.5
B 0.03055
Li 0.005125
```

```
As 0.002525
C(4) 117.55
Cl 16 charge
F 0.215
Ca 32.4
Mg 9.49
Na 58.1
K 1.19
Ba 0.2115
Si 6.54
P 0.00875
Mn 0.01815
Fe 0.0415
Al 0.008175
Sb 0.0002
Be 0.0001
Cd 0.000175
Cr 0.0026
Co 0.0006
Pb 0.00195
Mo 0.001275
Se 0.00155

SAVE solution 6

end

#FIRST FLUSH

#G06 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G06 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G07 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G07 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G08 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G08 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G09 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G09 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G10 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G10 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end
```

Median Metal Oxides/Charge Balance on Chloride

```
SELECTED_OUTPUT 1
-file JOP_845_401_median_cb-true_out.csv
-charge_balance true
-percent_error true
-totals S(6) B Li As C(4) Cl F Ca Mg Na K Ba Si P Mn Fe Al Sb Be Cd Cr Co Pb Mo Se Hfo_s Hfo_w
Hao_
-molalities Hfo_wOBa+ Hfo_wOCa+ Hfo_wOMg+ Hfo_wOH
Hfo_wOH2+ Hfo_wOHSO4-2 Hfo_wSO4- Hfo_wOSi(OH)3
Hfo_wOSiO(OH)2- Hfo_wHCO3 Hfo_wCO3- Hfo_wPO4-2
Hfo_wHPO4- Hfo_wH2PO4 Hfo_sCO3- Hfo_sHCO3
Hfo_sHPO4- Hfo_sH2BO3 Hfo_sH2PO4 Hfo_sOSi(OH)3
Hfo_sOSiO(OH)2- Hfo_sOHSO4-2 Hfo_sSO4-
Hao_SO4- Hao_OHSO4-2 Hao_H2BO3 Hao_H3BO4-
-equilibrium_phases Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum Kaolinite

SOLUTION 1 #G06 (C - UA)
redox pe
units mg/l
density 1
pH 6.595
pe 5.055
temp 15.95
S(6) 197.5 as SO4
B 3.285
Li 0.004125
As 0.002675
C(4) 101.75 as CO3
Cl 21.5 charge
F 0.265
Ca 88.7
Mg 24.3
Na 47.65
K 2.46
Ba 0.03525
Si 6.36
P 0.0195
Mn 0.0141
Fe 0.022605
Al 0.008175
Sb 0.00085
Be 0.0002
Cd 0.000175
Cr 0.0056
Co 0.0024
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 2 #G07 (C - UA)
redox pe
units mg/l
```

```
density 1
pH 6.405
pe 5.38
temp 15.8
S(6) 264 as SO4
B 5.035
Li 0.006
As 0.002525
C(4) 104 as CO3
Cl 21.5 charge
F 0.415
Ca 97.2
Mg 24.1
Na 69.45
K 4.23
Ba 0.1258
Si 8.79
P 0.0145
Mn 2.475
Fe 0.088505
Al 0.008175
Sb 0.0004
Be 0.00075
Cd 0.000175
Cr 0.0196
Co 0.00445
Pb 0.00315
Mo 0.001275
Se 0.0003
end

SOLUTION 3 #G08 (C - UA)
redox pe
units mg/l
density 1
pH 6.945
pe 4
temp 17.3
S(6) 341.5 as SO4
B 5.865
Li 0.0058
As 0.0099
C(4) 99.65 as CO3
Cl 15 charge
F 0.3
Ca 136
Mg 32.55
Na 40.05
K 1.645
Ba 0.06535
Si 6.1
P 0.0195
Mn 2.045
Fe 0.9105
```

```
Al 0.008175
Sb 0.0002
Be 0.0003
Cd 0.000175
Cr 0.00565
Co 0.0075
Pb 0.00115
Mo 0.002075
Se 0.0003
end

SOLUTION 4 #G09 (C - UA)
redox pe
units mg/l
density 1
pH 6.305
pe 4.07
temp 17.3
S(6) 235 as SO4
B 4.22
Li 0.00635
As 0.0067
C(4) 68.6 as CO3
Cl 18.5 charge
F 0.325
Ca 66
Mg 25.4
Na 62.7
K 0.9565
Ba 0.04155
Si 15.4
P 0.0265
Mn 1.01
Fe 2.015
Al 0.008175
Sb 0.00195
Be 0.00055
Cd 0.000175
Cr 0.00525
Co 0.00605
Pb 0.00115
Mo 0.001075
Se 0.0003
end

SOLUTION 5 #G10 (C - UA)
redox pe
units mg/l
density 1
pH 6.625
pe 5.405
temp 17.3
S(6) 360.5 as SO4
B 3.245
Li 0.0068
```

```
As 0.004025
C(4) 117.45 as CO3
Cl 25.5 charge
F 0.335
Ca 122
Mg 38
Na 82.2
K 7.705
Ba 0.048
Si 11.75
P 0.0215
Mn 0.1525
Fe 0.4295
Al 0.008175
Sb 0.0002
Be 0.0004
Cd 0.000175
Cr 0.0084
Co 0.00395
Pb 0.00115
Mo 0.001725
Se 0.0003
end

EQUILIBRIUM_PHASES 1 #G06 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 1
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 1
save surface 1
end

EQUILIBRIUM_PHASES 2 #G07 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 2
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 2
save surface 2
end

EQUILIBRIUM_PHASES 3 #G08 (C - UA) - median
```

```
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 3
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 3
save surface 3
end

EQUILIBRIUM_PHASES 4 #G09 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 4
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 4
save surface 4
end

EQUILIBRIUM_PHASES 5 #G10 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.079
Ferrihydrite 0 0.082
Calcite 0 0
Dolomite(ordered) 0 0

SURFACE 5
Hfo_wOH Ferrihydrite equilibrium_phase 0.2 53400
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 53400
Hao_OH Gibbsite equilibrium_phase 0.033 2496
-equil 5
save surface 5
end

SOLUTION 6 #average background
redox pe
units mg/l
density 1
pH 6.43
pe 5.57
temp 15.8
S(6) 20.5
B 0.03055
Li 0.005125
```

```
As 0.002525
C(4) 117.55
Cl 16 charge
F 0.215
Ca 32.4
Mg 9.49
Na 58.1
K 1.19
Ba 0.2115
Si 6.54
P 0.00875
Mn 0.01815
Fe 0.0415
Al 0.008175
Sb 0.0002
Be 0.0001
Cd 0.000175
Cr 0.0026
Co 0.0006
Pb 0.00195
Mo 0.001275
Se 0.00155

SAVE solution 6

end

#FIRST FLUSH

#G06 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G06 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G07 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G07 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G08 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G08 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G09 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G09 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G10 (C - UA) - First Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G10 (C - UA) - Second Flush
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end
```

Database

```
#$Id: minteq.v4.dat 12387 2017-02-09 16:41:47Z dlpark $
SOLUTION_MASTER_SPECIES
Alkalinity CO3-2 2.0 HCO3 61.0173
E e- 0 0 0
O H2O 0 O 16.00
O(-2) H2O 0 O
O(0) O2 0 O
Ag Ag+ 0.0 Ag 107.868
Al Al+3 0.0 Al 26.9815
As H3AsO4 -1.0 As 74.9216
As(3) H3AsO3 0.0 As
As(5) H3AsO4 -1.0 As
B H3BO3 0.0 B 10.81
Ba Ba+2 0.0 Ba 137.33
Be Be+2 0.0 Be 9.0122
Br Br- 0.0 Br 79.904
C CO3-2 2.0 CO3 12.0111
C(4) CO3-2 2.0 CO3 12.0111
Cyanide Cyanide- 1.0 Cyanide 26.0177
Dom_a Dom_a 0.0 C 12.0111
Dom_b Dom_b 0.0 C 12.0111
Dom_c Dom_c 0.0 C 12.0111
Ca Ca+2 0.0 Ca 40.078
Cd Cd+2 0.0 Cd 112.41
Cl Cl- 0.0 Cl 35.453
Co Co+3 -1.0 Co 58.9332
Co(2) Co+2 0.0 Co
Co(3) Co+3 -1.0 Co
Cr CrO4-2 1.0 Cr 51.996
Cr(2) Cr+2 0.0 Cr
Cr(3) Cr(OH)2+ 0.0 Cr
Cr(6) CrO4-2 1.0 Cr
Cu Cu+2 0.0 Cu 63.546
Cu(1) Cu+ 0.0 Cu
Cu(2) Cu+2 0.0 Cu
F F- 0.0 F 18.9984
Fe Fe+3 -2.0 Fe 55.847
Fe(2) Fe+2 0.0 Fe
Fe(3) Fe+3 -2.0 Fe
H H+ -1.0 H 1.0079
H(0) H2 0 H
H(1) H+ -1.0 H
Hg Hg(OH)2 0.0 Hg 200.59
Hg(0) Hg 0.0 Hg
Hg(1) Hg2+2 0.0 Hg
Hg(2) Hg(OH)2 0.0 Hg
I I- 0.0 I 126.904
K K+ 0.0 K 39.0983
Li Li+ 0.0 Li 6.941
Mg Mg+2 0.0 Mg 24.305
Mn Mn+3 0.0 Mn 54.938
Mn(2) Mn+2 0.0 Mn
```

```
Mn(3) Mn+3 0.0 Mn
Mn(6) MnO4-2 0.0 Mn
Mn(7) MnO4- 0.0 Mn
Mo MoO4-2 0.0 Mo 95.94
N NO3- 0.0 N 14.0067
N(-3) NH4+ 0.0 N
N(3) NO2- 0.0 N
N(5) NO3- 0.0 N
Na Na+ 0.0 Na 22.9898
Ni Ni+2 0.0 Ni 58.69
P PO4-3 2.0 P 30.9738
Pb Pb+2 0.0 Pb 207.2
S SO4-2 0.0 SO4 32.066
S(-2) HS- 1.0 S
#S(0) S 0.0 S
S(6) SO4-2 0.0 SO4
Sb Sb(OH)6- 0.0 Sb 121.75
Sb(3) Sb(OH)3 0.0 Sb
Sb(5) Sb(OH)6- 0.0 Sb
Se SeO4-2 0.0 Se 78.96
Se(-2) HSe- 0.0 Se
Se(4) HSeO3- 0.0 Se
Se(6) SeO4-2 0.0 Se
Si H4SiO4 0.0 SiO2 28.0843
Sn Sn(OH)6-2 0.0 Sn 118.71
Sn(2) Sn(OH)2 0.0 Sn
Sn(4) Sn(OH)6-2 0.0 Sn
Sr Sr+2 0.0 Sr 87.62
Tl Tl(OH)3 0.0 Tl 204.383
Tl(1) Tl+ 0.0 Tl
Tl(3) Tl(OH)3 0.0 Tl
U UO2+2 0.0 U 238.029
U(3) U+3 0.0 U
U(4) U+4 -4.0 U
U(5) UO2+ 0.0 U
U(6) UO2+2 0.0 U
V VO2+ -2.0 V 50.94
V(2) V+2 0.0 V
V(3) V+3 -3.0 V
V(4) VO+2 0.0 V
V(5) VO2+ -2.0 V
Zn Zn+2 0.0 Zn 65.39
Benzoate Benzoate- 0.0 121.116 121.116
Phenylacetate Phenylacetate- 0.0 135.142 135.142
Isophthalate Isophthalate-2 0.0 164.117 164.117
Diethylamine Diethylamine 1.0 73.138 73.138
Butylamine Butylamine 1.0 73.138 73.138
Methylamine Methylamine 1.0 31.057 31.057
Dimethylamine Dimethylamine 1.0 45.084 45.084
Hexylamine Hexylamine 1.0 101.192 101.192
Ethylenediamine Ethylenediamine 2.0 60.099 60.099
Propylamine Propylamine 1.0 59.111 59.111
Isopropylamine Isopropylamine 1.0 59.111 59.111
Trimethylamine Trimethylamine 1.0 59.111 59.111
```

```
Citrate Citrate-3 2.0 189.102 189.102
Nta Nta-3 1.0 188.117 188.117
Edta Edta-4 2.0 288.214 288.214
Propionate Propionate- 1.0 73.072 73.072
Butyrate Butyrate- 1.0 87.098 87.098
Isobutyrate Isobutyrate- 1.0 87.098 87.098
Two_picoline Two_picoline 1.0 93.128 93.128
Three_picoline Three_picoline 1.0 93.128 93.128
Four_picoline Four_picoline 1.0 93.128 93.128
Formate Formate- 0.0 45.018 45.018
Isovalerate Isovalerate- 1.0 101.125 101.125
Valerate Valerate- 1.0 101.125 101.125
Acetate Acetate- 1.0 59.045 59.045
Tartarate Tartarate-2 0.0 148.072 148.072
Glycine Glycine- 1.0 74.059 74.059
Salicylate Salicylate-2 1.0 136.107 136.107
Glutamate Glutamate-2 1.0 145.115 145.115
Phthalate Phthalate-2 1.0 164.117 164.117
SOLUTION_SPECIES
e- = e-
log_k 0
H2O = H2O
log_k 0
Ag+ = Ag+
log_k 0
Al+3 = Al+3
log_k 0
H3AsO4 = H3AsO4
log_k 0
H3BO3 = H3BO3
log_k 0
Ba+2 = Ba+2
log_k 0
Be+2 = Be+2
log_k 0
Br- = Br-
log_k 0
CO3-2 = CO3-2
log_k 0
Cyanide- = Cyanide-
log_k 0
Dom_a = Dom_a
log_k 0
Dom_b = Dom_b
log_k 0
Dom_c = Dom_c
log_k 0
Ca+2 = Ca+2
log_k 0
Cd+2 = Cd+2
log_k 0
Cl- = Cl-
log_k 0
Co+3 = Co+3
```

log_k 0
CrO4-2 = CrO4-2
log_k 0
Cu+2 = Cu+2
log_k 0
F- = F-
log_k 0
Fe+3 = Fe+3
log_k 0
H+ = H+
log_k 0
Hg(OH)2 = Hg(OH)2
log_k 0
I- = I-
log_k 0
K+ = K+
log_k 0
Li+ = Li+
log_k 0
Mg+2 = Mg+2
log_k 0
Mn+3 = Mn+3
log_k 0
MoO4-2 = MoO4-2
log_k 0
NO3- = NO3-
log_k 0
Na+ = Na+
log_k 0
Ni+2 = Ni+2
log_k 0
PO4-3 = PO4-3
log_k 0
Pb+2 = Pb+2
log_k 0
SO4-2 = SO4-2
log_k 0
Sb(OH)6- = Sb(OH)6-
log_k 0
SeO4-2 = SeO4-2
log_k 0
H4SiO4 = H4SiO4
log_k 0
Sn(OH)6-2 = Sn(OH)6-2
log_k 0
Sr+2 = Sr+2
log_k 0
Tl(OH)3 = Tl(OH)3
log_k 0
UO2+2 = UO2+2
log_k 0
VO2+ = VO2+
log_k 0
Benzoate- = Benzoate-

```
log_k 0
Phenylacetate- = Phenylacetate-
log_k 0
Isophthalate-2 = Isophthalate-2
log_k 0
Zn+2 = Zn+2
log_k 0
Diethylamine = Diethylamine
log_k 0
Butylamine = Butylamine
log_k 0
Methylamine = Methylamine
log_k 0
Dimethylamine = Dimethylamine
log_k 0
Hexylamine = Hexylamine
log_k 0
Ethylenediamine = Ethylenediamine
log_k 0
Propylamine = Propylamine
log_k 0
Isopropylamine = Isopropylamine
log_k 0
Trimethylamine = Trimethylamine
log_k 0
Citrate-3 = Citrate-3
log_k 0
Nta-3 = Nta-3
log_k 0
Edta-4 = Edta-4
log_k 0
Propionate- = Propionate-
log_k 0
Butyrate- = Butyrate-
log_k 0
Isobutyrate- = Isobutyrate-
log_k 0
Two_picoline = Two_picoline
log_k 0
Three_picoline = Three_picoline
log_k 0
Four_picoline = Four_picoline
log_k 0
Formate- = Formate-
log_k 0
Isovalerate- = Isovalerate-
log_k 0
Valerate- = Valerate-
log_k 0
Acetate- = Acetate-
log_k 0
Tartarate-2 = Tartarate-2
log_k 0
Glycine- = Glycine-
```

```
log_k 0
Salicylate-2 = Salicylate-2
log_k 0
Glutamate-2 = Glutamate-2
log_k 0
Phthalate-2 = Phthalate-2
log_k 0
SOLUTION_SPECIES
Fe+3 + e- = Fe+2
log_k 13.032
delta_h -42.7 kJ
-gamma 0 0
# Id: 2802810
# log K source: Bard85
# Delta H source: Bard85
#T and ionic strength:
H3AsO4 + 2e- + 2H+ = H3AsO3 + H2O
log_k 18.898
delta_h -125.6 kJ
-gamma 0 0
# Id: 600610
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Sb(OH)6- + 2e- + 3H+ = Sb(OH)3 + 3H2O
log_k 24.31
delta_h 0 kJ
-gamma 0 0
# Id: 7407410
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + 3e- + 4H+ = U+3 + 2H2O
log_k 0.42
delta_h -42 kJ
-gamma 0 0
# Id: 8908930
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + 2e- + 4H+ = U+4 + 2H2O
log_k 9.216
delta_h -144.1 kJ
-gamma 0 0
# Id: 8918930
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + e- = UO2+
log_k 2.785
delta_h -13.8 kJ
-gamma 0 0
# Id: 8928930
# log K source: MTQ3.11
```

```
# Delta H source: MTQ3.11
#T and ionic strength:
e- + Mn+3 = Mn+2
log_k 25.35
delta_h -107.8 kJ
-gamma 0 0
# Id: 4704710
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Co+3 + e- = Co+2
log_k 32.4
delta_h 0 kJ
-gamma 0 0
# Id: 2002010
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Cu+2 + e- = Cu+
log_k 2.69
delta_h 6.9 kJ
-gamma 0 0
# Id: 2302310
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
V+3 + e- = V+2
log_k -4.31
delta_h 0 kJ
-gamma 0 0
# Id: 9009010
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
VO+2 + e- + 2H+ = V+3 + H2O
log_k 5.696
delta_h 0 kJ
-gamma 0 0
# Id: 9019020
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
VO2+ + e- + 2H+ = VO+2 + H2O
log_k 16.903
delta_h -122.7 kJ
-gamma 0 0
# Id: 9029030
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
SO4-2 + 9H+ + 8e- = HS- + 4H2O
log_k 33.66
delta_h -60.14 kJ
-gamma 0 0
```

```
# Id: 7307320
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Sn(OH)6-2 + 2e- + 4H+ = Sn(OH)2 + 4H2O
log_k 19.2
delta_h 0 kJ
-gamma 0 0
# Id: 7907910
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Tl(OH)3 + 2e- + 3H+ = Tl+ + 3H2O
log_k 45.55
delta_h 0 kJ
-gamma 0 0
# Id: 8708710
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
HSeO3- + 6e- + 6H+ = HSe- + 3H2O
log_k 44.86
delta_h 0 kJ
-gamma 0 0
# Id: 7607610
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
SeO4-2 + 2e- + 3H+ = HSeO3- + H2O
log_k 36.308
delta_h -201.2 kJ
-gamma 0 0
# Id: 7617620
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
0.5Hg2+2 + e- = Hg
log_k 6.5667
delta_h -45.735 kJ
-gamma 0 0
# Id: 3600000
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:

2Hg(OH)2 + 4H+ + 2e- = Hg2+2 + 4H2O
log_k 43.185
delta_h -63.59 kJ
-gamma 0 0
# Id: 3603610
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Cr(OH)2+ + 2H+ + e- = Cr+2 + 2H2O
```

```
log_k 2.947
delta_h 6.36 kJ
-gamma 0 0
# Id: 2102110
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
CrO4-2 + 6H+ + 3e- = Cr(OH)2+ + 2H2O
log_k 67.376
delta_h -103 kJ
-gamma 0 0
# Id: 2112120
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:

2H2O = O2 + 4H+ + 4e-
# Adjusted for equation to aqueous species
log_k -85.9951
-analytic 38.0229 7.99407E-03 -2.7655e+004 -1.4506e+001 199838.45

2 H+ + 2 e- = H2
log_k -3.15
delta_h -1.759 kcal

NO3- + 2 H+ + 2 e- = NO2- + H2O
log_k 28.570
delta_h -43.760 kcal
-gamma 3.0000 0.0000

NO3- + 10 H+ + 8 e- = NH4+ + 3 H2O
log_k 119.077
delta_h -187.055 kcal
-gamma 2.5000 0.0000

Mn+2 + 4H2O = MnO4- + 8H+ + 5e-
log_k -127.794
delta_h 822.67 kJ
-gamma 3 0
# Id: 4700020
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Mn+2 + 4H2O = MnO4-2 + 8H+ + 4e-
log_k -118.422
delta_h 711.07 kJ
-gamma 5 0
# Id: 4700021
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
HS- = S-2 + H+
log_k -17.3
delta_h 49.4 kJ
-gamma 5 0
# Id: 3307301
# log K source: LMa1987
```

```
# Delta H source: NIST2.1.1
#T and ionic strength: 0.00 25.0
HSe- = Se-2 + H+
log_k -15
delta_h 48.116 kJ
-gamma 0 0
# Id: 3307601
# log K source: SCD3.02 (1968 DKa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Tl(OH)3 + 3H+ = Tl+3 + 3H2O
log_k 3.291
delta_h 0 kJ
-gamma 0 0
# Id: 8713300
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
0.5Hg2+2 + e- = Hg
log_k 6.5667
delta_h -45.735 kJ
-gamma 0 0
# Id: 3600000
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Hg(OH)2 + 2H+ = Hg+2 + 2H2O
log_k 6.194
delta_h -39.72 kJ
-gamma 0 0
# Id: 3613300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cr(OH)2+ + 2H+ = Cr+3 + 2H2O
log_k 9.5688
delta_h -129.62 kJ
-gamma 0 0
# Id: 2113300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.10 20.0
H2O = OH- + H+
log_k -13.997
delta_h 55.81 kJ
-gamma 3.5 0
# Id: 3300020
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sn(OH)2 + 2H+ = Sn+2 + 2H2O
log_k 7.094
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 7903301
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Sn(OH)2 + H+ = SnOH+ + H2O
log_k 3.697
delta_h 0 kJ
-gamma 0 0
# Id: 7903302
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Sn(OH)2 + H2O = Sn(OH)3- + H+
log_k -9.497
delta_h 0 kJ
-gamma 0 0
# Id: 7903303
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2Sn(OH)2 + 2H+ = Sn2(OH)2+2 + 2H2O
log_k 9.394
delta_h 0 kJ
-gamma 0 0
# Id: 7903304
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
3Sn(OH)2 + 2H+ = Sn3(OH)4+2 + 2H2O
log_k 14.394
delta_h 0 kJ
-gamma 0 0
# Id: 7903305
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Sn(OH)2 = HSnO2- + H+
log_k -8.9347
delta_h 0 kJ
-gamma 0 0
# Id: 7903306
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Sn(OH)6-2 + 6H+ = Sn+4 + 6H2O
log_k 21.2194
delta_h 0 kJ
-gamma 0 0
# Id: 7913301
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Sn(OH)6-2 = SnO3-2 + 3H2O
log_k -2.2099
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 7913302
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Pb+2 + H2O = PbOH+ + H+
log_k -7.597
delta_h 0 kJ
-gamma 0 0
# Id: 6003300
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Pb+2 + 2H2O = Pb(OH)2 + 2H+
log_k -17.094
delta_h 0 kJ
-gamma 0 0
# Id: 6003301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Pb+2 + 3H2O = Pb(OH)3- + 3H+
log_k -28.091
delta_h 0 kJ
-gamma 0 0
# Id: 6003302
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2Pb+2 + H2O = Pb2OH+3 + H+
log_k -6.397
delta_h 0 kJ
-gamma 0 0
# Id: 6003303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
3Pb+2 + 4H2O = Pb3(OH)4+2 + 4H+
log_k -23.888
delta_h 115.24 kJ
-gamma 0 0
# Id: 6003304
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Pb+2 + 4H2O = Pb(OH)4-2 + 4H+
log_k -39.699
delta_h 0 kJ
-gamma 0 0
# Id: 6003305
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
```

```
4Pb+2 + 4H2O = Pb4(OH)4+4 + 4H+
log_k -19.988
delta_h 88.24 kJ
-gamma 0 0
# Id: 6003306
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
H3BO3 + F- = BF(OH)3-
log_k -0.399
delta_h 7.7404 kJ
-gamma 2.5 0
# Id: 902700
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
H3BO3 + 2F- + H+ = BF2(OH)2- + H2O
log_k 7.63
delta_h 6.8408 kJ
-gamma 2.5 0
# Id: 902701
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
H3BO3 + 3F- + 2H+ = BF3OH- + 2H2O
log_k 13.22
delta_h -20.4897 kJ
-gamma 2.5 0
# Id: 902702
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Al+3 + H2O = AlOH+2 + H+
log_k -4.997
delta_h 47.81 kJ
-gamma 5.4 0
# Id: 303300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Al+3 + 2H2O = Al(OH)2+ + 2H+
log_k -10.094
delta_h 0 kJ
-gamma 5.4 0
# Id: 303301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Al+3 + 3H2O = Al(OH)3 + 3H+
log_k -16.791
delta_h 0 kJ
-gamma 0 0
# Id: 303303
# log K source: NIST46.3
```

```
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Al+3 + 4H2O = Al(OH)4- + 4H+
log_k -22.688
delta_h 173.24 kJ
-gamma 4.5 0
# Id: 303302
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl+ + H2O = TlOH + H+
log_k -13.207
delta_h 56.81 kJ
-gamma 0 0
# Id: 8703300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl(OH)3 + 2H+ = TlOH+2 + 2H2O
log_k 2.694
delta_h 0 kJ
-gamma 0 0
# Id: 8713301
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl(OH)3 + H+ = Tl(OH)2+ + H2O
log_k 1.897
delta_h 0 kJ
-gamma 0 0
# Id: 8713302
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Tl(OH)3 + H2O = Tl(OH)4- + H+
log_k -11.697
delta_h 0 kJ
-gamma 0 0
# Id: 8713303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + H2O = ZnOH+ + H+
log_k -8.997
delta_h 55.81 kJ
-gamma 0 0
# Id: 9503300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Zn+2 + 2H2O = Zn(OH)2 + 2H+
log_k -17.794
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 9503301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + 3H2O = Zn(OH)3- + 3H+
log_k -28.091
delta_h 0 kJ
-gamma 0 0
# Id: 9503302
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + 4H2O = Zn(OH)4-2 + 4H+
log_k -40.488
delta_h 0 kJ
-gamma 0 0
# Id: 9503303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cd+2 + H2O = CdOH+ + H+
log_k -10.097
delta_h 54.81 kJ
-gamma 0 0
# Id: 1603300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + 2H2O = Cd(OH)2 + 2H+
log_k -20.294
delta_h 0 kJ
-gamma 0 0
# Id: 1603301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cd+2 + 3H2O = Cd(OH)3- + 3H+
log_k -32.505
delta_h 0 kJ
-gamma 0 0
# Id: 1603302
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 3.00 25.0
Cd+2 + 4H2O = Cd(OH)4-2 + 4H+
log_k -47.288
delta_h 0 kJ
-gamma 0 0
# Id: 1603303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2Cd+2 + H2O = Cd2OH+3 + H+
log_k -9.397
```

```
delta_h 45.81 kJ
-gamma 0 0
# Id: 1603304
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Hg(OH)2 + H+ = HgOH+ + H2O
log_k 2.797
delta_h -18.91 kJ
-gamma 0 0
# Id: 3613302
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Hg(OH)2 + H2O = Hg(OH)3- + H+
log_k -14.897
delta_h 0 kJ
-gamma 0 0
# Id: 3613303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cu+2 + H2O = CuOH+ + H+
log_k -7.497
delta_h 35.81 kJ
-gamma 4 0
# Id: 2313300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cu+2 + 2H2O = Cu(OH)2 + 2H+
log_k -16.194
delta_h 0 kJ
-gamma 0 0
# Id: 2313301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cu+2 + 3H2O = Cu(OH)3- + 3H+
log_k -26.879
delta_h 0 kJ
-gamma 0 0
# Id: 2313302
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Cu+2 + 4H2O = Cu(OH)4-2 + 4H+
log_k -39.98
delta_h 0 kJ
-gamma 0 0
# Id: 2313303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
```

```
2Cu+2 + 2H2O = Cu2(OH)2+2 + 2H+
log_k -10.594
delta_h 76.62 kJ
-gamma 0 0
# Id: 2313304
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ag+ + H2O = AgOH + H+
log_k -11.997
delta_h 0 kJ
-gamma 0 0
# Id: 203300
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ag+ + 2H2O = Ag(OH)2- + 2H+
log_k -24.004
delta_h 0 kJ
-gamma 0 0
# Id: 203301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ni+2 + H2O = NiOH+ + H+
log_k -9.897
delta_h 51.81 kJ
-gamma 0 0
# Id: 5403300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ni+2 + 2H2O = Ni(OH)2 + 2H+
log_k -18.994
delta_h 0 kJ
-gamma 0 0
# Id: 5403301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ni+2 + 3H2O = Ni(OH)3- + 3H+
log_k -29.991
delta_h 0 kJ
-gamma 0 0
# Id: 5403302
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + H2O = CoOH+ + H+
log_k -9.697
delta_h 0 kJ
-gamma 0 0
# Id: 2003300
# log K source: NIST46.4
```

```
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + 2H2O = Co(OH)2 + 2H+
log_k -18.794
delta_h 0 kJ
-gamma 0 0
# Id: 2003301
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + 3H2O = Co(OH)3- + 3H+
log_k -31.491
delta_h 0 kJ
-gamma 0 0
# Id: 2003302
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + 4H2O = Co(OH)4-2 + 4H+
log_k -46.288
delta_h 0 kJ
-gamma 0 0
# Id: 2003303
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2Co+2 + H2O = Co2OH+3 + H+
log_k -10.997
delta_h 0 kJ
-gamma 0 0
# Id: 2003304
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
4Co+2 + 4H2O = Co4(OH)4+4 + 4H+
log_k -30.488
delta_h 0 kJ
-gamma 0 0
# Id: 2003306
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + 2H2O = CoOOH- + 3H+
log_k -32.0915
delta_h 260.454 kJ
-gamma 0 0
# Id: 2003305
# log K source: NIST2.1.1
# Delta H source: MTQ3.11
#T and ionic strength:
Co+3 + H2O = CoOH+2 + H+
log_k -1.291
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2013300
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 3.00 25.0
Fe+2 + H2O = FeOH+ + H+
log_k -9.397
delta_h 55.81 kJ
-gamma 5 0
# Id: 2803300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Fe+2 + 2H2O = Fe(OH)2 + 2H+
log_k -20.494
delta_h 119.62 kJ
-gamma 0 0
# Id: 2803302
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Fe+2 + 3H2O = Fe(OH)3- + 3H+
log_k -28.991
delta_h 126.43 kJ
-gamma 5 0
# Id: 2803301
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Fe+3 + H2O = FeOH+2 + H+
log_k -2.187
delta_h 41.81 kJ
-gamma 5 0
# Id: 2813300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Fe+3 + 2H2O = Fe(OH)2+ + 2H+
log_k -4.594
delta_h 0 kJ
-gamma 5.4 0
# Id: 2813301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Fe+3 + 3H2O = Fe(OH)3 + 3H+
log_k -12.56
delta_h 103.8 kJ
-gamma 0 0
# Id: 2813302
# log K source: Nord90
# Delta H source: Nord90
#T and ionic strength: 0.00 25.0
Fe+3 + 4H2O = Fe(OH)4- + 4H+
log_k -21.588
```

```
delta_h 0 kJ
-gamma 5.4 0
# Id: 2813303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2Fe+3 + 2H2O = Fe2(OH)2+4 + 2H+
log_k -2.854
delta_h 57.62 kJ
-gamma 0 0
# Id: 2813304
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
3Fe+3 + 4H2O = Fe3(OH)4+5 + 4H+
log_k -6.288
delta_h 65.24 kJ
-gamma 0 0
# Id: 2813305
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Mn+2 + H2O = MnOH+ + H+
log_k -10.597
delta_h 55.81 kJ
-gamma 5 0
# Id: 4703300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Mn+2 + 3H2O = Mn(OH)3- + 3H+
log_k -34.8
delta_h 0 kJ
-gamma 5 0
# Id: 4703301
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Mn+2 + 4H2O = Mn(OH)4-2 + 4H+
log_k -48.288
delta_h 0 kJ
-gamma 5 0
# Id: 4703302
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Mn+2 + 4H2O = MnO4- + 8H+ + 5e-
log_k -127.794
delta_h 822.67 kJ
-gamma 3 0
# Id: 4700020
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
```

```
Mn+2 + 4H2O = MnO4-2 + 8H+ + 4e-
log_k -118.422
delta_h 711.07 kJ
-gamma 5 0
# Id: 4700021
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Cr(OH)2+ + H+ = Cr(OH)+2 + H2O
log_k 5.9118
delta_h -77.91 kJ
-gamma 0 0
# Id: 2113301
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cr(OH)2+ + H2O = Cr(OH)3 + H+
log_k -8.4222
delta_h 0 kJ
-gamma 0 0
# Id: 2113302
# log K source: SCD3.02 (1983 RCa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cr(OH)2+ + 2H2O = Cr(OH)4- + 2H+
log_k -17.8192
delta_h 0 kJ
-gamma 0 0
# Id: 2113303
# log K source: SCD3.02 (1983 RCa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cr(OH)2+ = CrO2- + 2H+
log_k -17.7456
delta_h 0 kJ
-gamma 0 0
# Id: 2113304
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
V+2 + H2O = VOH+ + H+
log_k -6.487
delta_h 59.81 kJ
-gamma 0 0
# Id: 9003300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
V+3 + H2O = VOH+2 + H+
log_k -2.297
delta_h 43.81 kJ
-gamma 0 0
# Id: 9013300
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
V+3 + 2H2O = V(OH)2+ + 2H+
log_k -6.274
delta_h 0 kJ
-gamma 0 0
# Id: 9013301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
V+3 + 3H2O = V(OH)3 + 3H+
log_k -3.0843
delta_h 0 kJ
-gamma 0 0
# Id: 9013302
# log K source: SCD3.02 (1978 TKa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 20.0
2V+3 + 2H2O = V2(OH)2+4 + 2H+
log_k -3.794
delta_h 0 kJ
-gamma 0 0
# Id: 9013304
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2V+3 + 3H2O = V2(OH)3+3 + 3H+
log_k -10.1191
delta_h 0 kJ
-gamma 0 0
# Id: 9013303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 3.00 25.0
VO+2 + 2H2O = V(OH)3+ + H+
log_k -5.697
delta_h 0 kJ
-gamma 0 0
# Id: 9023300
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2VO+2 + 2H2O = H2V2O4+2 + 2H+
log_k -6.694
delta_h 53.62 kJ
-gamma 0 0
# Id: 9023301
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
U+4 + H2O = UOH+3 + H+
log_k -0.597
delta_h 47.81 kJ
-gamma 0 0
```

```
# Id: 8913300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
U+4 + 2H2O = U(OH)2+2 + 2H+
log_k -2.27
delta_h 74.1823 kJ
-gamma 0 0
# Id: 8913301
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + 3H2O = U(OH)3+ + 3H+
log_k -4.935
delta_h 94.7467 kJ
-gamma 0 0
# Id: 8913302
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + 4H2O = U(OH)4 + 4H+
log_k -8.498
delta_h 103.596 kJ
-gamma 0 0
# Id: 8913303
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + 5H2O = U(OH)5- + 5H+
log_k -13.12
delta_h 115.374 kJ
-gamma 0 0
# Id: 8913304
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
6U+4 + 15H2O = U6(OH)15+9 + 15H+
log_k -17.155
delta_h 0 kJ
-gamma 0 0
# Id: 8913305
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
UO2+2 + H2O = UO2OH+ + H+
log_k -5.897
delta_h 47.81 kJ
-gamma 0 0
# Id: 8933300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
2UO2+2 + 2H2O = (UO2)2(OH)2+2 + 2H+
log_k -5.574
```

```
delta_h 41.82 kJ
-gamma 0 0
# Id: 8933301
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
3UO2+2 + 5H2O = (UO2)3(OH)5+ + 5H+
log_k -15.585
delta_h 108.05 kJ
-gamma 0 0
# Id: 8933302
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Be+2 + H2O = BeOH+ + H+
log_k -5.397
delta_h 0 kJ
-gamma 6.5 0
# Id: 1103301
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Be+2 + 2H2O = Be(OH)2 + 2H+
log_k -13.594
delta_h 0 kJ
-gamma 6.5 0
# Id: 1103302
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Be+2 + 3H2O = Be(OH)3- + 3H+
log_k -23.191
delta_h 0 kJ
-gamma 6.5 0
# Id: 1103303
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Be+2 + 4H2O = Be(OH)4-2 + 4H+
log_k -37.388
delta_h 0 kJ
-gamma 6.5 0
# Id: 1103304
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2Be+2 + H2O = Be2OH+3 + H+
log_k -3.177
delta_h 0 kJ
-gamma 6.5 0
# Id: 1103305
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
```

```
3Be+2 + 3H2O = Be3(OH)3+3 + 3H+
log_k -8.8076
delta_h 0 kJ
-gamma 6.5 0
# Id: 1103306
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
Mg+2 + H2O = MgOH+ + H+
log_k -11.397
delta_h 67.81 kJ
-gamma 6.5 0
# Id: 4603300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ca+2 + H2O = CaOH+ + H+
log_k -12.697
delta_h 64.11 kJ
-gamma 6 0
# Id: 1503300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Sr+2 + H2O = SrOH+ + H+
log_k -13.177
delta_h 60.81 kJ
-gamma 5 0
# Id: 8003300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ba+2 + H2O = BaOH+ + H+
log_k -13.357
delta_h 60.81 kJ
-gamma 5 0
# Id: 1003300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
H+ + F- = HF
log_k 3.17
delta_h 13.3 kJ
-gamma 0 0
# Id: 3302700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
H+ + 2F- = HF2-
log_k 3.75
delta_h 17.4 kJ
-gamma 3.5 0
# Id: 3302701
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
2F- + 2H+ = H2F2
log_k 6.768
delta_h 0 kJ
-gamma 0 0
# Id: 3302702
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Sb(OH)3 + F- + H+ = SbOF + 2H2O
log_k 6.1864
delta_h 0 kJ
-gamma 0 0
# Id: 7402700
# log K source: PNL89
# Delta H source: PNL89
#T and ionic strength:
Sb(OH)3 + F- + H+ = Sb(OH)2F + H2O
log_k 6.1937
delta_h 0 kJ
-gamma 0 0
# Id: 7402702
# log K source: PNL89
# Delta H source: PNL89
#T and ionic strength:
H4SiO4 + 4H+ + 6F- = SiF6-2 + 4H2O
log_k 30.18
delta_h -68 kJ
-gamma 5 0
# Id: 7702700
# log K source: Nord90
# Delta H source: Nord90
#T and ionic strength: 0.00 25.0
Sn(OH)2 + 2H+ + F- = SnF+ + 2H2O
log_k 11.582
delta_h 0 kJ
-gamma 0 0
# Id: 7902701
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Sn(OH)2 + 2H+ + 2F- = SnF2 + 2H2O
log_k 14.386
delta_h 0 kJ
-gamma 0 0
# Id: 7902702
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Sn(OH)2 + 2H+ + 3F- = SnF3- + 2H2O
log_k 17.206
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 7902703
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Sn(OH)6-2 + 6H+ + 6F- = SnF6-2 + 6H2O
log_k 33.5844
delta_h 0 kJ
-gamma 0 0
# Id: 7912701
# log K source: Bard85
# Delta H source: MTQ3.11
#T and ionic strength:
Pb+2 + F- = PbF+
log_k 1.848
delta_h 0 kJ
-gamma 0 0
# Id: 6002700
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Pb+2 + 2F- = PbF2
log_k 3.142
delta_h 0 kJ
-gamma 0 0
# Id: 6002701
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Pb+2 + 3F- = PbF3-
log_k 3.42
delta_h 0 kJ
-gamma 0 0
# Id: 6002702
# log K source: SCD3.02 (1956 TKa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Pb+2 + 4F- = PbF4-2
log_k 3.1
delta_h 0 kJ
-gamma 0 0
# Id: 6002703
# log K source: SCD3.02 (1956 TKa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
H3BO3 + 3H+ + 4F- = BF4- + 3H2O
log_k 19.912
delta_h -18.67 kJ
-gamma 2.5 0
# Id: 902703
# log K source: NIST46.3
# Delta H source: NIST2.1.1
#T and ionic strength: 1.00 25.0
Al+3 + F- = AlF+2
log_k 7
```

```
delta_h 4.6 kJ
-gamma 5.4 0
# Id: 302700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Al+3 + 2F- = AlF2+
log_k 12.6
delta_h 8.3 kJ
-gamma 5.4 0
# Id: 302701
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Al+3 + 3F- = AlF3
log_k 16.7
delta_h 8.7 kJ
-gamma 0 0
# Id: 302702
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Al+3 + 4F- = AlF4-
log_k 19.4
delta_h 8.7 kJ
-gamma 4.5 0
# Id: 302703
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl+ + F- = TlF
log_k 0.1
delta_h 0 kJ
-gamma 0 0
# Id: 8702700
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + F- = ZnF+
log_k 1.3
delta_h 11 kJ
-gamma 0 0
# Id: 9502700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + F- = CdF+
log_k 1.2
delta_h 5 kJ
-gamma 0 0
# Id: 1602700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
```

```
Cd+2 + 2F- = CdF2
log_k 1.5
delta_h 0 kJ
-gamma 0 0
# Id: 1602701
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Hg(OH)2 + 2H+ + F- = HgF+ + 2H2O
log_k 7.763
delta_h -35.72 kJ
-gamma 0 0
# Id: 3612701
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.50 25.0
Cu+2 + F- = CuF+
log_k 1.8
delta_h 13 kJ
-gamma 0 0
# Id: 2312700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ag+ + F- = AgF
log_k 0.4
delta_h 12 kJ
-gamma 0 0
# Id: 202700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ni+2 + F- = NiF+
log_k 1.4
delta_h 7.1 kJ
-gamma 0 0
# Id: 5402700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Co+2 + F- = CoF+
log_k 1.5
delta_h 9.2 kJ
-gamma 0 0
# Id: 2002700
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Fe+3 + F- = FeF+2
log_k 6.04
delta_h 10 kJ
-gamma 5 0
# Id: 2812700
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Fe+3 + 2F- = FeF2+
log_k 10.4675
delta_h 17 kJ
-gamma 5 0
# Id: 2812701
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.50 25.0
Fe+3 + 3F- = FeF3
log_k 13.617
delta_h 29 kJ
-gamma 0 0
# Id: 2812702
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.50 25.0
Mn+2 + F- = MnF+
log_k 1.6
delta_h 11 kJ
-gamma 5 0
# Id: 4702700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cr(OH)2+ + 2H+ + F- = CrF+2 + 2H2O
log_k 14.7688
delta_h -70.2452 kJ
-gamma 0 0
# Id: 2112700
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
VO+2 + F- = VOF+
log_k 3.778
delta_h 7.9 kJ
-gamma 0 0
# Id: 9022700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
VO+2 + 2F- = VOF2
log_k 6.352
delta_h 14 kJ
-gamma 0 0
# Id: 9022701
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
VO+2 + 3F- = VOF3-
log_k 7.902
delta_h 20 kJ
-gamma 0 0
```

```
# Id: 9022702
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
VO+2 + 4F- = VOF4-2
log_k 8.508
delta_h 26 kJ
-gamma 0 0
# Id: 9022703
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
VO2+ + F- = VO2F
log_k 3.244
delta_h 0 kJ
-gamma 0 0
# Id: 9032700
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
VO2+ + 2F- = VO2F2-
log_k 5.804
delta_h 0 kJ
-gamma 0 0
# Id: 9032701
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
VO2+ + 3F- = VO2F3-2
log_k 6.9
delta_h 0 kJ
-gamma 0 0
# Id: 9032702
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
VO2+ + 4F- = VO2F4-3
log_k 6.592
delta_h 0 kJ
-gamma 0 0
# Id: 9032703
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
U+4 + F- = UF+3
log_k 9.3
delta_h 21.1292 kJ
-gamma 0 0
# Id: 8912700
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
U+4 + 2F- = UF2+2
log_k 16.4
```

```
delta_h 30.1248 kJ
-gamma 0 0
# Id: 8912701
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
U+4 + 3F- = UF3+
log_k 21.6
delta_h 29.9156 kJ
-gamma 0 0
# Id: 8912702
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
U+4 + 4F- = UF4
log_k 23.64
delta_h 19.2464 kJ
-gamma 0 0
# Id: 8912703
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + 5F- = UF5-
log_k 25.238
delta_h 20.2924 kJ
-gamma 0 0
# Id: 8912704
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + 6F- = UF6-2
log_k 27.718
delta_h 13.8072 kJ
-gamma 0 0
# Id: 8912705
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + F- = UO2F+
log_k 5.14
delta_h 1 kJ
-gamma 0 0
# Id: 8932700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
UO2+2 + 2F- = UO2F2
log_k 8.6
delta_h 2 kJ
-gamma 0 0
# Id: 8932701
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
```

```
UO2+2 + 3F- = UO2F3-
log_k 11
delta_h 2 kJ
-gamma 0 0
# Id: 8932702
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
UO2+2 + 4F- = UO2F4-2
log_k 11.9
delta_h 0.4 kJ
-gamma 0 0
# Id: 8932703
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Be+2 + F- = BeF+
log_k 5.249
delta_h 0 kJ
-gamma 0 0
# Id: 1102701
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Be+2 + 2F- = BeF2
log_k 9.1285
delta_h -4 kJ
-gamma 0 0
# Id: 1102702
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Be+2 + 3F- = BeF3-
log_k 11.9085
delta_h -8 kJ
-gamma 0 0
# Id: 1102703
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Mg+2 + F- = MgF+
log_k 2.05
delta_h 13 kJ
-gamma 4.5 0
# Id: 4602700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ca+2 + F- = CaF+
log_k 1.038
delta_h 14 kJ
-gamma 5 0
# Id: 1502700
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
Sr+2 + F- = SrF+
log_k 0.548
delta_h 16 kJ
-gamma 0 0
# Id: 8002701
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 1.00 25.0
Na+ + F- = NaF
log_k -0.2
delta_h 12 kJ
-gamma 0 0
# Id: 5002700
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Sn(OH)2 + 2H+ + Cl- = SnCl+ + 2H2O
log_k 8.734
delta_h 0 kJ
-gamma 0 0
# Id: 7901801
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sn(OH)2 + 2H+ + 2Cl- = SnCl2 + 2H2O
log_k 9.524
delta_h 0 kJ
-gamma 0 0
# Id: 7901802
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sn(OH)2 + 2H+ + 3Cl- = SnCl3- + 2H2O
log_k 8.3505
delta_h 0 kJ
-gamma 0 0
# Id: 7901803
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 2.00 25.0
Pb+2 + Cl- = PbCl+
log_k 1.55
delta_h 8.7 kJ
-gamma 0 0
# Id: 6001800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Pb+2 + 2Cl- = PbCl2
log_k 2.2
delta_h 12 kJ
-gamma 0 0
```

```
# Id: 6001801
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Pb+2 + 3Cl- = PbCl3-
log_k 1.8
delta_h 4 kJ
-gamma 0 0
# Id: 6001802
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Pb+2 + 4Cl- = PbCl4-2
log_k 1.46
delta_h 14.7695 kJ
-gamma 0 0
# Id: 6001803
# log K source: SCD3.02 (1984 SEa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Tl+ + Cl- = TlCl
log_k 0.51
delta_h -6.2 kJ
-gamma 0 0
# Id: 8701800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl+ + 2Cl- = TlCl2-
log_k 0.28
delta_h 0 kJ
-gamma 0 0
# Id: 8701801
# log K source: SCD3.02 (1992 RAb)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Tl(OH)3 + 3H+ + Cl- = TlCl+2 + 3H2O
log_k 11.011
delta_h 0 kJ
-gamma 0 0
# Id: 8711800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl(OH)3 + 3H+ + 2Cl- = TlCl2+ + 3H2O
log_k 16.771
delta_h 0 kJ
-gamma 0 0
# Id: 8711801
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl(OH)3 + 3H+ + 3Cl- = TlCl3 + 3H2O
log_k 19.791
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 8711802
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl(OH)3 + 3H+ + 4Cl- = TlCl4- + 3H2O
log_k 21.591
delta_h 0 kJ
-gamma 0 0
# Id: 8711803
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl(OH)3 + Cl- + 2H+ = TlOHCl+ + 2H2O
log_k 10.629
delta_h 0 kJ
-gamma 0 0
# Id: 8711804
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Zn+2 + Cl- = ZnCl+
log_k 0.4
delta_h 5.4 kJ
-gamma 4 0
# Id: 9501800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Zn+2 + 2Cl- = ZnCl2
log_k 0.6
delta_h 37 kJ
-gamma 0 0
# Id: 9501801
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Zn+2 + 3Cl- = ZnCl3-
log_k 0.5
delta_h 39.999 kJ
-gamma 4 0
# Id: 9501802
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Zn+2 + 4Cl- = ZnCl4-2
log_k 0.199
delta_h 45.8566 kJ
-gamma 5 0
# Id: 9501803
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
```

```
Zn+2 + H2O + Cl- = ZnOHCl + H+
log_k -7.48
delta_h 0 kJ
-gamma 0 0
# Id: 9501804
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cd+2 + Cl- = CdCl+
log_k 1.98
delta_h 1 kJ
-gamma 0 0
# Id: 1601800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + 2Cl- = CdCl2
log_k 2.6
delta_h 3 kJ
-gamma 0 0
# Id: 1601801
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + 3Cl- = CdCl3-
log_k 2.4
delta_h 10 kJ
-gamma 0 0
# Id: 1601802
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + H2O + Cl- = CdOHCl + H+
log_k -7.404
delta_h 18.2213 kJ
-gamma 0 0
# Id: 1601803
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Hg(OH)2 + 2H+ + Cl- = HgCl+ + 2H2O
log_k 13.494
delta_h -62.72 kJ
-gamma 0 0
# Id: 3611800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + 2Cl- = HgCl2 + 2H2O
log_k 20.194
delta_h -92.42 kJ
-gamma 0 0
# Id: 3611801
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + 3Cl- = HgCl3- + 2H2O
log_k 21.194
delta_h -94.02 kJ
-gamma 0 0
# Id: 3611802
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + 4Cl- = HgCl4-2 + 2H2O
log_k 21.794
delta_h -100.72 kJ
-gamma 0 0
# Id: 3611803
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Hg(OH)2 + Cl- + I- + 2H+ = HgClI + 2H2O
log_k 25.532
delta_h -135.3 kJ
-gamma 0 0
# Id: 3611804
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Hg(OH)2 + H+ + Cl- = HgClOH + H2O
log_k 10.444
delta_h -42.72 kJ
-gamma 0 0
# Id: 3611805
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
Cu+2 + Cl- = CuCl+
log_k 0.2
delta_h 8.3 kJ
-gamma 4 0
# Id: 2311800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cu+2 + 2Cl- = CuCl2
log_k -0.26
delta_h 44.183 kJ
-gamma 0 0
# Id: 2311801
# log K source: SCD3.02 (1989 IPa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cu+2 + 3Cl- = CuCl3-
log_k -2.29
delta_h 57.279 kJ
-gamma 4 0
```

```
# Id: 2311802
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cu+2 + 4Cl- = CuCl4-2
log_k -4.59
delta_h 32.5515 kJ
-gamma 5 0
# Id: 2311803
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cu+ + 2Cl- = CuCl2-
log_k 5.42
delta_h -1.7573 kJ
-gamma 4 0
# Id: 2301800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cu+ + 3Cl- = CuCl3-2
log_k 4.75
delta_h 1.0878 kJ
-gamma 5 0
# Id: 2301801
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cu+ + Cl- = CuCl
log_k 3.1
delta_h 0 kJ
-gamma 0 0
# Id: 2301802
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ag+ + Cl- = AgCl
log_k 3.31
delta_h -12 kJ
-gamma 0 0
# Id: 201800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ag+ + 2Cl- = AgCl2-
log_k 5.25
delta_h -16 kJ
-gamma 0 0
# Id: 201801
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ag+ + 3Cl- = AgCl3-2
log_k 5.2
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 201802
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ag+ + 4Cl- = AgCl4-3
log_k 5.51
delta_h 0 kJ
-gamma 0 0
# Id: 201803
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Ni+2 + Cl- = NiCl+
log_k 0.408
delta_h 2 kJ
-gamma 0 0
# Id: 5401800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
Ni+2 + 2Cl- = NiCl2
log_k -1.89
delta_h 0 kJ
-gamma 0 0
# Id: 5401801
# log K source: SCD3.02 (1989 IPa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + Cl- = CoCl+
log_k 0.539
delta_h 2 kJ
-gamma 0 0
# Id: 2001800
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Co+3 + Cl- = CoCl+2
log_k 2.3085
delta_h 16 kJ
-gamma 0 0
# Id: 2011800
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Fe+3 + Cl- = FeCl+2
log_k 1.48
delta_h 23 kJ
-gamma 5 0
# Id: 2811800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
```

```
Fe+3 + 2Cl- = FeCl2+
log_k 2.13
delta_h 0 kJ
-gamma 5 0
# Id: 2811801
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Fe+3 + 3Cl- = FeCl3
log_k 1.13
delta_h 0 kJ
-gamma 0 0
# Id: 2811802
# log K source: Nord90
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Mn+2 + Cl- = MnCl+
log_k 0.1
delta_h 0 kJ
-gamma 5 0
# Id: 4701800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 20.0
Mn+2 + 2Cl- = MnCl2
log_k 0.25
delta_h 0 kJ
-gamma 0 0
# Id: 4701801
# log K source: Nord90
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Mn+2 + 3Cl- = MnCl3-
log_k -0.31
delta_h 0 kJ
-gamma 5 0
# Id: 4701802
# log K source: Nord90
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cr(OH)2+ + 2H+ + Cl- = CrCl+2 + 2H2O
log_k 9.6808
delta_h -103.62 kJ
-gamma 0 0
# Id: 2111800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
Cr(OH)2+ + 2Cl- + 2H+ = CrCl2+ + 2H2O
log_k 8.658
delta_h -39.2208 kJ
-gamma 0 0
# Id: 2111801
# log K source: MTQ3.11
```

```
# Delta H source: MTQ3.11
#T and ionic strength:
Cr(OH)2+ + 2Cl- + H+ = CrOHCl2 + H2O
log_k 2.9627
delta_h 0 kJ
-gamma 0 0
# Id: 2111802
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
VO+2 + Cl- = VOCl+
log_k 0.448
delta_h 0 kJ
-gamma 0 0
# Id: 9021800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
U+4 + Cl- = UCl+3
log_k 1.7
delta_h -20 kJ
-gamma 0 0
# Id: 8911800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
UO2+2 + Cl- = UO2Cl+
log_k 0.21
delta_h 16 kJ
-gamma 0 0
# Id: 8931800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Be+2 + Cl- = BeCl+
log_k 0.2009
delta_h 0 kJ
-gamma 5 0
# Id: 1101801
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.70 20.0
Sn(OH)2 + 2H+ + Br- = SnBr+ + 2H2O
log_k 8.254
delta_h 0 kJ
-gamma 0 0
# Id: 7901301
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sn(OH)2 + 2H+ + 2Br- = SnBr2 + 2H2O
log_k 8.794
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 7901302
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sn(OH)2 + 2H+ + 3Br- = SnBr3- + 2H2O
log_k 7.48
delta_h 0 kJ
-gamma 0 0
# Id: 7901303
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 3.00 25.0
Pb+2 + Br- = PbBr+
log_k 1.7
delta_h 8 kJ
-gamma 0 0
# Id: 6001300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Pb+2 + 2Br- = PbBr2
log_k 2.6
delta_h -4 kJ
-gamma 0 0
# Id: 6001301
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl+ + Br- = TlBr
log_k 0.91
delta_h -12 kJ
-gamma 0 0
# Id: 8701300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl+ + 2Br- = TlBr2-
log_k -0.384
delta_h 12.36 kJ
-gamma 0 0
# Id: 8701301
# log K source: NIST46.3
# Delta H source: NIST2.1.1
#T and ionic strength: 4.00 25.0
Tl+ + Br- + Cl- = TlBrCl-
log_k 0.8165
delta_h 0 kJ
-gamma 0 0
# Id: 8701302
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Tl+ + I- + Br- = TlIBr-
log_k 2.185
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 8703802
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Tl(OH)3 + 3H+ + Br- = TlBr+2 + 3H2O
log_k 12.803
delta_h 0 kJ
-gamma 0 0
# Id: 8711300
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Tl(OH)3 + 3H+ + 2Br- = TlBr2+ + 3H2O
log_k 20.711
delta_h 0 kJ
-gamma 0 0
# Id: 8711301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Tl(OH)3 + 3Br- + 3H+ = TlBr3 + 3H2O
log_k 27.0244
delta_h 0 kJ
-gamma 0 0
# Id: 8711302
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Tl(OH)3 + 4Br- + 3H+ = TlBr4- + 3H2O
log_k 31.1533
delta_h 0 kJ
-gamma 0 0
# Id: 8711303
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Zn+2 + Br- = ZnBr+
log_k -0.07
delta_h 1 kJ
-gamma 0 0
# Id: 9501300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Zn+2 + 2Br- = ZnBr2
log_k -0.98
delta_h 0 kJ
-gamma 0 0
# Id: 9501301
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
```

```
Cd+2 + Br- = CdBr+
log_k 2.15
delta_h -3 kJ
-gamma 0 0
# Id: 1601300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + 2Br- = CdBr2
log_k 3
delta_h -3 kJ
-gamma 0 0
# Id: 1601301
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + Br- = HgBr+ + 2H2O
log_k 15.803
delta_h -81.92 kJ
-gamma 0 0
# Id: 3611301
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.50 25.0
Hg(OH)2 + 2H+ + 2Br- = HgBr2 + 2H2O
log_k 24.2725
delta_h -127.12 kJ
-gamma 0 0
# Id: 3611302
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.50 25.0
Hg(OH)2 + 2H+ + 3Br- = HgBr3- + 2H2O
log_k 26.7025
delta_h -138.82 kJ
-gamma 0 0
# Id: 3611303
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.50 25.0
Hg(OH)2 + 2H+ + 4Br- = HgBr4-2 + 2H2O
log_k 27.933
delta_h -153.72 kJ
-gamma 0 0
# Id: 3611304
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.50 25.0
Hg(OH)2 + Br- + Cl- + 2H+ = HgBrCl + 2H2O
log_k 22.1811
delta_h -113.77 kJ
-gamma 0 0
# Id: 3611305
# log K source: NIST2.1.1
```

```
# Delta H source: NIST2.1.1
#T and ionic strength:
Hg(OH)2 + Br- + I- + 2H+ = HgBrI + 2H2O
log_k 27.3133
delta_h -151.27 kJ
-gamma 0 0
# Id: 3611306
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Hg(OH)2 + Br- + 3I- + 2H+ = HgBrI3-2 + 2H2O
log_k 34.2135
delta_h 0 kJ
-gamma 0 0
# Id: 3611307
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Hg(OH)2 + 2Br- + 2I- + 2H+ = HgBr2I2-2 + 2H2O
log_k 32.3994
delta_h 0 kJ
-gamma 0 0
# Id: 3611308
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Hg(OH)2 + 3Br- + I- + 2H+ = HgBr3I-2 + 2H2O
log_k 30.1528
delta_h 0 kJ
-gamma 0 0
# Id: 3611309
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Hg(OH)2 + H+ + Br- = HgBrOH + H2O
log_k 12.433
delta_h 0 kJ
-gamma 0 0
# Id: 3613301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Ag+ + Br- = AgBr
log_k 4.6
delta_h 0 kJ
-gamma 0 0
# Id: 201300
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ag+ + 2Br- = AgBr2-
log_k 7.5
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 201301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ag+ + 3Br- = AgBr3-2
log_k 8.1
delta_h 0 kJ
-gamma 0 0
# Id: 201302
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ni+2 + Br- = NiBr+
log_k 0.5
delta_h 0 kJ
-gamma 0 0
# Id: 5401300
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cr(OH)2+ + Br- + 2H+ = CrBr+2 + 2H2O
log_k 7.5519
delta_h -46.9068 kJ
-gamma 0 0
# Id: 2111300
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Be+2 + Br- = BeBr+
log_k 0.1009
delta_h 0 kJ
-gamma 5 0
# Id: 1101301
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.70 20.0
Pb+2 + I- = PbI+
log_k 2
delta_h 0 kJ
-gamma 0 0
# Id: 6003800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Pb+2 + 2I- = PbI2
log_k 3.2
delta_h 0 kJ
-gamma 0 0
# Id: 6003801
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Tl+ + I- = TlI
log_k 1.4279
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 8703800
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Tl+ + 2I- = TlI2-
log_k 1.8588
delta_h 0 kJ
-gamma 0 0
# Id: 8703801
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Tl(OH)3 + 4I- + 3H+ = TlI4- + 3H2O
log_k 34.7596
delta_h 0 kJ
-gamma 0 0
# Id: 8713800
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Zn+2 + I- = ZnI+
log_k -2.0427
delta_h -4 kJ
-gamma 0 0
# Id: 9503800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 3.00 25.0
Zn+2 + 2I- = ZnI2
log_k -1.69
delta_h 0 kJ
-gamma 0 0
# Id: 9503801
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cd+2 + I- = CdI+
log_k 2.28
delta_h -9.6 kJ
-gamma 0 0
# Id: 1603800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + 2I- = CdI2
log_k 3.92
delta_h -12 kJ
-gamma 0 0
# Id: 1603801
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
```

```
Hg(OH)2 + 2H+ + I- = HgI+ + 2H2O
log_k 19.603
delta_h -111.22 kJ
-gamma 0 0
# Id: 3613801
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Hg(OH)2 + 2H+ + 2I- = HgI2 + 2H2O
log_k 30.8225
delta_h -182.72 kJ
-gamma 0 0
# Id: 3613802
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Hg(OH)2 + 2H+ + 3I- = HgI3- + 2H2O
log_k 34.6025
delta_h -194.22 kJ
-gamma 0 0
# Id: 3613803
# log K source: NIST46.4
# Delta H source: NIST2.1.1
#T and ionic strength: 0.50 25.0
Hg(OH)2 + 2H+ + 4I- = HgI4-2 + 2H2O
log_k 36.533
delta_h -220.72 kJ
-gamma 0 0
# Id: 3613804
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Ag+ + I- = AgI
log_k 6.6
delta_h 0 kJ
-gamma 0 0
# Id: 203800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 18.0
Ag+ + 2I- = AgI2-
log_k 11.7
delta_h 0 kJ
-gamma 0 0
# Id: 203801
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 18.0
Ag+ + 3I- = AgI3-2
log_k 12.6
delta_h -122 kJ
-gamma 0 0
# Id: 203802
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ag+ + 4I- = AgI4-3
log_k 14.229
delta_h 0 kJ
-gamma 0 0
# Id: 203803
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 2.00 25.0
Cr(OH)2+ + I- + 2H+ = CrI+2 + 2H2O
log_k 4.8289
delta_h 0 kJ
-gamma 0 0
# Id: 2113800
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
H+ + HS- = H2S
log_k 7.02
delta_h -22 kJ
-gamma 0 0
# Id: 3307300
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Pb+2 + 2HS- = Pb(HS)2
log_k 15.27
delta_h 0 kJ
-gamma 0 0
# Id: 6007300
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Pb+2 + 3HS- = Pb(HS)3-
log_k 16.57
delta_h 0 kJ
-gamma 0 0
# Id: 6007301
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Tl+ + HS- = TlHS
log_k 2.474
delta_h 0 kJ
-gamma 0 0
# Id: 8707300
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
2Tl+ + HS- = Tl2HS+
log_k 5.974
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 8707301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
2Tl+ + 3HS- + H2O = Tl2OH(HS)3-2 + H+
log_k 1.0044
delta_h 0 kJ
-gamma 0 0
# Id: 8707302
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
2Tl+ + 2HS- + 2H2O = Tl2(OH)2(HS)2-2 + 2H+
log_k -11.0681
delta_h 0 kJ
-gamma 0 0
# Id: 8707303
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Zn+2 + 2HS- = Zn(HS)2
log_k 12.82
delta_h 0 kJ
-gamma 0 0
# Id: 9507300
# log K source: DHa1993
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + 3HS- = Zn(HS)3-
log_k 16.1
delta_h 0 kJ
-gamma 0 0
# Id: 9507301
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Zn+2 + 3HS- = ZnS(HS)2-2 + H+
log_k 6.12
delta_h 0 kJ
-gamma 0 0
# Id: 9507302
# log K source: DHa1993
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + 2HS- + 2HS- = Zn(HS)4-2
log_k 14.64
delta_h 0 kJ
-gamma 0 0
# Id: 9507303
# log K source: DHa1993
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + 2HS- = ZnS(HS)- + H+
log_k 6.81
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 9507304
# log K source: DHa1993
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cd+2 + HS- = CdHS+
log_k 8.008
delta_h 0 kJ
-gamma 0 0
# Id: 1607300
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Cd+2 + 2HS- = Cd(HS)2
log_k 15.212
delta_h 0 kJ
-gamma 0 0
# Id: 1607301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Cd+2 + 3HS- = Cd(HS)3-
log_k 17.112
delta_h 0 kJ
-gamma 0 0
# Id: 1607302
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Cd+2 + 4HS- = Cd(HS)4-2
log_k 19.308
delta_h 0 kJ
-gamma 0 0
# Id: 1607303
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Hg(OH)2 + 2HS- = HgS2-2 + 2H2O
log_k 29.414
delta_h 0 kJ
-gamma 0 0
# Id: 3617300
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
Hg(OH)2 + 2H+ + 2HS- = Hg(HS)2 + 2H2O
log_k 44.516
delta_h 0 kJ
-gamma 0 0
# Id: 3617301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
```

```
Hg(OH)2 + H+ + 2HS- = HgHS2- + 2H2O
log_k 38.122
delta_h 0 kJ
-gamma 0 0
# Id: 3617302
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
Cu+2 + 3HS- = Cu(HS)3-
log_k 25.899
delta_h 0 kJ
-gamma 0 0
# Id: 2317300
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Ag+ + HS- = AgHS
log_k 13.8145
delta_h 0 kJ
-gamma 0 0
# Id: 207300
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 20.0
Ag+ + 2HS- = Ag(HS)2-
log_k 17.9145
delta_h 0 kJ
-gamma 0 0
# Id: 207301
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 20.0
Fe+2 + 2HS- = Fe(HS)2
log_k 8.95
delta_h 0 kJ
-gamma 0 0
# Id: 2807300
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Fe+2 + 3HS- = Fe(HS)3-
log_k 10.987
delta_h 0 kJ
-gamma 0 0
# Id: 2807301
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
HS- = S2-2 + H+
log_k -11.7828
delta_h 46.4 kJ
-gamma 0 0
-no_check
# Id: 7317300
```

```
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
HS- = S3-2 + H+
log_k -10.7667
delta_h 42.2 kJ
-gamma 0 0
-no_check
# Id: 7317301
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
HS- = S4-2 + H+
log_k -9.9608
delta_h 39.3 kJ
-gamma 0 0
-no_check
# Id: 7317302
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
HS- = S5-2 + H+
log_k -9.3651
delta_h 37.6 kJ
-gamma 0 0
-no_check
# Id: 7317303
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
HS- = S6-2 + H+
log_k -9.881
delta_h 0 kJ
-gamma 0 0
-no_check
# Id: 7317304
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
2Sb(OH)3 + 4HS- + 2H+ = Sb2S4-2 + 6H2O
log_k 49.3886
delta_h -321.78 kJ
-gamma 0 0
# Id: 7407300
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Cu+ + 2HS- = Cu(S4)2-3 + 2H+
log_k 3.39
delta_h 0 kJ
-gamma 23 0
-no_check
# Id: 2307300
# log K source: MTQ3.11
```

```
# Delta H source: MTQ3.11
#T and ionic strength:
Cu+ + 2HS- = CuS4S5-3 + 2H+
log_k 2.66
delta_h 0 kJ
-gamma 25 0
-no_check
# Id: 2307301
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Ag+ + 2HS- = Ag(S4)2-3 + 2H+
log_k 0.991
delta_h 0 kJ
-gamma 22 0
-no_check
# Id: 207302
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Ag+ + 2HS- = AgS4S5-3 + 2H+
log_k 0.68
delta_h 0 kJ
-gamma 24 0
-no_check
# Id: 207303
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Ag+ + 2HS- = Ag(HS)S4-2 + H+
log_k 10.431
delta_h 0 kJ
-gamma 15 0
-no_check
# Id: 207304
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
H+ + SO4-2 = HSO4-
log_k 1.99
delta_h 22 kJ
-gamma 4.5 0
# Id: 3307320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
NH4+ + SO4-2 = NH4SO4-
log_k 1.03
delta_h 0 kJ
-gamma 5 0
# Id: 4907320
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
```

```
Pb+2 + SO4-2 = PbSO4
log_k 2.69
delta_h 0 kJ
-gamma 0 0
# Id: 6007320
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Pb+2 + 2SO4-2 = Pb(SO4)2-2
log_k 3.47
delta_h 0 kJ
-gamma 0 0
# Id: 6007321
# log K source: SCD3.02 (1960 RKa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Al+3 + SO4-2 = AlSO4+
log_k 3.89
delta_h 28 kJ
-gamma 4.5 0
# Id: 307320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Al+3 + 2SO4-2 = Al(SO4)2-
log_k 4.92
delta_h 11.9 kJ
-gamma 4.5 0
# Id: 307321
# log K source: Nord90
# Delta H source: Nord90
#T and ionic strength: 0.00 25.0
Tl+ + SO4-2 = TlSO4-
log_k 1.37
delta_h -0.8 kJ
-gamma 0 0
# Id: 8707320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Zn+2 + SO4-2 = ZnSO4
log_k 2.34
delta_h 6.2 kJ
-gamma 0 0
# Id: 9507320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Zn+2 + 2SO4-2 = Zn(SO4)2-2
log_k 3.28
delta_h 0 kJ
-gamma 0 0
# Id: 9507321
# log K source: MTQ3.11
```

```
# Delta H source: MTQ3.11
#T and ionic strength:
Cd+2 + SO4-2 = CdSO4
log_k 2.37
delta_h 8.7 kJ
-gamma 0 0
# Id: 1607320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + 2SO4-2 = Cd(SO4)2-2
log_k 3.5
delta_h 0 kJ
-gamma 0 0
# Id: 1607321
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Hg(OH)2 + 2H+ + SO4-2 = HgSO4 + 2H2O
log_k 8.612
delta_h 0 kJ
-gamma 0 0
# Id: 3617320
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Cu+2 + SO4-2 = CuSO4
log_k 2.36
delta_h 8.7 kJ
-gamma 0 0
# Id: 2317320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ag+ + SO4-2 = AgSO4-
log_k 1.3
delta_h 6.2 kJ
-gamma 0 0
# Id: 207320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ni+2 + SO4-2 = NiSO4
log_k 2.3
delta_h 5.8 kJ
-gamma 0 0
# Id: 5407320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ni+2 + 2SO4-2 = Ni(SO4)2-2
log_k 0.82
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 5407321
# log K source: SCD3.02 (1978 BLa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + SO4-2 = CoSO4
log_k 2.3
delta_h 6.2 kJ
-gamma 0 0
# Id: 2007320
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Fe+2 + SO4-2 = FeSO4
log_k 2.39
delta_h 8 kJ
-gamma 0 0
# Id: 2807320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Fe+3 + SO4-2 = FeSO4+
log_k 4.05
delta_h 25 kJ
-gamma 5 0
# Id: 2817320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Fe+3 + 2SO4-2 = Fe(SO4)2-
log_k 5.38
delta_h 19.2 kJ
-gamma 0 0
# Id: 2817321
# log K source: Nord90
# Delta H source: Nord90
#T and ionic strength: 0.00 25.0
Mn+2 + SO4-2 = MnSO4
log_k 2.25
delta_h 8.7 kJ
-gamma 0 0
# Id: 4707320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cr(OH)2+ + 2H+ + SO4-2 = CrSO4+ + 2H2O
log_k 12.9371
delta_h -98.62 kJ
-gamma 0 0
# Id: 2117320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 50.0
Cr(OH)2+ + H+ + SO4-2 = CrOHSO4 + H2O
log_k 8.2871
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 2117321
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
2Cr(OH)2+ + SO4-2 + 2H+ = Cr2(OH)2SO4+2 + 2H2O
log_k 16.155
delta_h 0 kJ
-gamma 0 0
# Id: 2117323
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
2Cr(OH)2+ + 2SO4-2 + 2H+ = Cr2(OH)2(SO4)2 + 2H2O
log_k 17.9288
delta_h 0 kJ
-gamma 0 0
# Id: 2117324
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + SO4-2 = USO4+2
log_k 6.6
delta_h 8 kJ
-gamma 0 0
# Id: 8917320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
U+4 + 2SO4-2 = U(SO4)2
log_k 10.5
delta_h 33 kJ
-gamma 0 0
# Id: 8917321
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
UO2+2 + SO4-2 = UO2SO4
log_k 3.18
delta_h 20 kJ
-gamma 0 0
# Id: 8937320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
UO2+2 + 2SO4-2 = UO2(SO4)2-2
log_k 4.3
delta_h 38 kJ
-gamma 0 0
# Id: 8937321
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
```

```
V+3 + SO4-2 = VSO4+
log_k 2.674
delta_h 0 kJ
-gamma 0 0
# Id: 9017320
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
VO+2 + SO4-2 = VOSO4
log_k 2.44
delta_h 17 kJ
-gamma 0 0
# Id: 9027320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
VO2+ + SO4-2 = VO2SO4-
log_k 1.378
delta_h 0 kJ
-gamma 0 0
# Id: 9037320
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
Be+2 + SO4-2 = BeSO4
log_k 2.19
delta_h 29 kJ
-gamma 0 0
# Id: 1107321
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Be+2 + 2SO4-2 = Be(SO4)2-2
log_k 2.596
delta_h 0 kJ
-gamma 0 0
# Id: 1107322
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Mg+2 + SO4-2 = MgSO4
log_k 2.26
delta_h 5.8 kJ
-gamma 0 0
# Id: 4607320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ca+2 + SO4-2 = CaSO4
log_k 2.36
delta_h 7.1 kJ
-gamma 0 0
# Id: 1507320
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Sr+2 + SO4-2 = SrSO4
log_k 2.3
delta_h 8 kJ
-gamma 0 0
# Id: 8007321
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Li+ + SO4-2 = LiSO4-
log_k 0.64
delta_h 0 kJ
-gamma 5 0
# Id: 4407320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Na+ + SO4-2 = NaSO4-
log_k 0.73
delta_h 1 kJ
-gamma 5.4 0
# Id: 5007320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
K+ + SO4-2 = KSO4-
log_k 0.85
delta_h 4.1 kJ
-gamma 5.4 0
# Id: 4107320
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
HSe- + H+ = H2Se
log_k 3.89
delta_h 3.3 kJ
-gamma 0 0
# Id: 3307600
# log K source: NIST46.3
# Delta H source: NIST2.1.1
#T and ionic strength: 0.00 25.0
2Ag+ + HSe- = Ag2Se + H+
log_k 34.911
delta_h 0 kJ
-gamma 0 0
# Id: 207600
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Ag+ + H2O + 2HSe- = AgOH(Se)2-4 + 3H+
log_k -20.509
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 207601
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Mn+2 + HSe- = MnSe + H+
log_k -5.385
delta_h 0 kJ
-gamma 0 0
# Id: 4707600
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
HSeO3- = SeO3-2 + H+
log_k -8.4
delta_h 5.02 kJ
-gamma 0 0
# Id: 3307611
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
HSeO3- + H+ = H2SeO3
log_k 2.63
delta_h 6.2 kJ
-gamma 0 0
# Id: 3307610
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + 2HSeO3- = Cd(SeO3)2-2 + 2H+
log_k -10.884
delta_h 0 kJ
-gamma 0 0
# Id: 1607610
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Ag+ + HSeO3- = AgSeO3- + H+
log_k -5.592
delta_h 0 kJ
-gamma 0 0
# Id: 207610
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Ag+ + 2HSeO3- = Ag(SeO3)2-3 + 2H+
log_k -13.04
delta_h 0 kJ
-gamma 0 0
# Id: 207611
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Fe+3 + HSeO3- = FeHSeO3+2
log_k 3.422
```

```
delta_h 25 kJ
-gamma 0 0
# Id: 2817610
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
SeO4-2 + H+ = HSeO4-
log_k 1.7
delta_h 23 kJ
-gamma 0 0
# Id: 3307620
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Zn+2 + SeO4-2 = ZnSeO4
log_k 2.19
delta_h 0 kJ
-gamma 0 0
# Id: 9507620
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + 2SeO4-2 = Zn(SeO4)2-2
log_k 2.196
delta_h 0 kJ
-gamma 0 0
# Id: 9507621
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Cd+2 + SeO4-2 = CdSeO4
log_k 2.27
delta_h 0 kJ
-gamma 0 0
# Id: 1607620
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ni+2 + SeO4-2 = NiSeO4
log_k 2.67
delta_h 14 kJ
-gamma 0 0
# Id: 5407620
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Co+2 + SeO4-2 = CoSeO4
log_k 2.7
delta_h 12 kJ
-gamma 0 0
# Id: 2007621
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
```

```
Mn+2 + SeO4-2 = MnSeO4
log_k 2.43
delta_h 14 kJ
-gamma 0 0
# Id: 4707620
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
NH4+ = NH3 + H+
log_k -9.244
delta_h 52 kJ
-gamma 0 0
# Id: 3304900
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ag+ + NH4+ = AgNH3+ + H+
log_k -5.934
delta_h -72 kJ
-gamma 0 0
# Id: 204901
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ag+ + 2NH4+ = Ag(NH3)2+ + 2H+
log_k -11.268
delta_h -160 kJ
-gamma 0 0
# Id: 204902
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Hg(OH)2 + H+ + NH4+ = HgNH3+2 + 2H2O
log_k 5.75
delta_h 0 kJ
-gamma 0 0
# Id: 3614900
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 2.00 22.0
Hg(OH)2 + 2NH4+ = Hg(NH3)2+2 + 2H2O
log_k 5.506
delta_h -246.72 kJ
-gamma 0 0
# Id: 3614901
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 1.00 25.0
Hg(OH)2 + 3NH4+ = Hg(NH3)3+2 + 2H2O + H+
log_k -3.138
delta_h -312.72 kJ
-gamma 0 0
# Id: 3614902
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 2.00 25.0
Hg(OH)2 + 4NH4+ = Hg(NH3)4+2 + 2H2O + 2H+
log_k -11.482
delta_h -379.72 kJ
-gamma 0 0
# Id: 3614903
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.10 25.0
Cu+2 + NH4+ = CuNH3+2 + H+
log_k -5.234
delta_h -72 kJ
-gamma 0 0
# Id: 2314901
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ni+2 + NH4+ = NiNH3+2 + H+
log_k -6.514
delta_h -67 kJ
-gamma 0 0
# Id: 5404901
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Ni+2 + 2NH4+ = Ni(NH3)2+2 + 2H+
log_k -13.598
delta_h -111.6 kJ
-gamma 0 0
# Id: 5404902
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+2 + NH4+ = Co(NH3)+2 + H+
log_k -7.164
delta_h -65 kJ
-gamma 0 0
# Id: 2004900
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+2 + 2NH4+ = Co(NH3)2+2 + 2H+
log_k -14.778
delta_h 0 kJ
-gamma 0 0
# Id: 2004901
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 2.00 25.0
Co+2 + 3NH4+ = Co(NH3)3+2 + 3H+
log_k -22.922
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2004902
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 2.00 25.0
Co+2 + 4NH4+ = Co(NH3)4+2 + 4H+
log_k -31.446
delta_h 0 kJ
-gamma 0 0
# Id: 2004903
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 2.00 30.0
Co+2 + 5NH4+ = Co(NH3)5+2 + 5H+
log_k -40.47
delta_h 0 kJ
-gamma 0 0
# Id: 2004904
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 2.00 30.0
Co+3 + 6NH4+ + H2O = Co(NH3)6OH+2 + 7H+
log_k -43.7148
delta_h 0 kJ
-gamma 0 0
# Id: 2014901
# log K source: NIST2.1.1
# Delta H source: MTQ3.11
#T and ionic strength:
Co+3 + 5NH4+ + Cl- = Co(NH3)5Cl+2 + 5H+
log_k -17.9584
delta_h 113.38 kJ
-gamma 0 0
# Id: 2014902
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Co+3 + 6NH4+ + Cl- = Co(NH3)6Cl+2 + 6H+
log_k -33.9179
delta_h 104.34 kJ
-gamma 0 0
# Id: 2014903
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Co+3 + 6NH4+ + Br- = Co(NH3)6Br+2 + 6H+
log_k -33.8884
delta_h 110.57 kJ
-gamma 0 0
# Id: 2014904
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Co+3 + 6NH4+ + I- = Co(NH3)6I+2 + 6H+
log_k -33.4808
```

```
delta_h 115.44 kJ
-gamma 0 0
# Id: 2014905
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Co+3 + 6NH4+ + SO4-2 = Co(NH3)6SO4+ + 6H+
log_k -28.9926
delta_h 124.5 kJ
-gamma 0 0
# Id: 2014906
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Cr(OH)2+ + 6NH4+ = Cr(NH3)6+3 + 2H2O + 4H+
log_k -32.8952
delta_h 0 kJ
-gamma 0 0
# Id: 2114900
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 4.50 25.0
Cr(OH)2+ + 5NH4+ = Cr(NH3)5OH+2 + 4H+ + H2O
log_k -30.2759
delta_h 0 kJ
-gamma 0 0
# Id: 2114901
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cr(OH)2+ + 6NH4+ + Cl- = Cr(NH3)6Cl+2 + 2H2O + 4H+
log_k -31.7932
delta_h 0 kJ
-gamma 0 0
# Id: 2114904
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cr(OH)2+ + 6NH4+ + Br- = Cr(NH3)6Br+2 + 4H+ + 2H2O
log_k -31.887
delta_h 0 kJ
-gamma 0 0
# Id: 2114905
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cr(OH)2+ + 6NH4+ + I- = Cr(NH3)6I+2 + 4H+ + 2H2O
log_k -32.008
delta_h 0 kJ
-gamma 0 0
# Id: 2114906
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
```

```
#Cr(OH)2+ + 4NH4+ = cis+ + 4H+
# log_k -29.8574
# delta_h 0 kJ
# -gamma 0 0
# # Id: 4902113
# # log K source: MTQ3.11
# # Delta H source: MTQ3.11
# #T and ionic strength:
#Cr(OH)2+ + 4NH4+ = trans+ + 4H+
# log_k -30.5537
# delta_h 0 kJ
# -gamma 0 0
# # Id: 4902114
# # log K source: MTQ3.11
# # Delta H source: MTQ3.11
# #T and ionic strength:
Ca+2 + NH4+ = CaNH3+2 + H+
log_k -9.144
delta_h 0 kJ
-gamma 0 0
# Id: 1504901
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Ca+2 + 2NH4+ = Ca(NH3)2+2 + 2H+
log_k -18.788
delta_h 0 kJ
-gamma 0 0
# Id: 1504902
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Sr+2 + NH4+ = SrNH3+2 + H+
log_k -9.344
delta_h 0 kJ
-gamma 0 0
# Id: 8004901
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Ba+2 + NH4+ = BaNH3+2 + H+
log_k -9.444
delta_h 0 kJ
-gamma 0 0
# Id: 1004901
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Tl+ + NO2- = TlNO2
log_k 0.83
delta_h 0 kJ
-gamma 0 0
# Id: 8704910
# log K source: NIST46.3
```

```
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ag+ + NO2- = AgNO2
log_k 2.32
delta_h -29 kJ
-gamma 0 0
# Id: 204911
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ag+ + 2NO2- = Ag(NO2)2-
log_k 2.51
delta_h -46 kJ
-gamma 0 0
# Id: 204910
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cu+2 + NO2- = CuNO2+
log_k 2.02
delta_h 0 kJ
-gamma 0 0
# Id: 2314911
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cu+2 + 2NO2- = Cu(NO2)2
log_k 3.03
delta_h 0 kJ
-gamma 0 0
# Id: 2314912
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + NO2- = CoNO2+
log_k 0.848
delta_h 0 kJ
-gamma 0 0
# Id: 2004911
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Sn(OH)2 + 2H+ + NO3- = SnNO3+ + 2H2O
log_k 7.942
delta_h 0 kJ
-gamma 0 0
# Id: 7904921
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Pb+2 + NO3- = PbNO3+
log_k 1.17
delta_h 2 kJ
-gamma 0 0
```

```
# Id: 6004920
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Pb+2 + 2NO3- = Pb(NO3)2
log_k 1.4
delta_h -6.6 kJ
-gamma 0 0
# Id: 6004921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Tl+ + NO3- = TlNO3
log_k 0.33
delta_h -2 kJ
-gamma 0 0
# Id: 8704920
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Tl(OH)3 + NO3- + 3H+ = TlNO3+2 + 3H2O
log_k 7.0073
delta_h 0 kJ
-gamma 0 0
# Id: 8714920
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Cd+2 + NO3- = CdNO3+
log_k 0.5
delta_h -21 kJ
-gamma 0 0
# Id: 1604920
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Cd+2 + 2NO3- = Cd(NO3)2
log_k 0.2
delta_h 0 kJ
-gamma 0 0
# Id: 1604921
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + NO3- = HgNO3+ + 2H2O
log_k 5.7613
delta_h 0 kJ
-gamma 0 0
# Id: 3614920
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 3.00 25.0
Hg(OH)2 + 2H+ + 2NO3- = Hg(NO3)2 + 2H2O
log_k 5.38
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 3614921
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 3.00 25.0
Cu+2 + NO3- = CuNO3+
log_k 0.5
delta_h -4.1 kJ
-gamma 0 0
# Id: 2314921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cu+2 + 2NO3- = Cu(NO3)2
log_k -0.4
delta_h 0 kJ
-gamma 0 0
# Id: 2314922
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + NO3- = ZnNO3+
log_k 0.4
delta_h -4.6 kJ
-gamma 0 0
# Id: 9504921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Zn+2 + 2NO3- = Zn(NO3)2
log_k -0.3
delta_h 0 kJ
-gamma 0 0
# Id: 9504922
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ag+ + NO3- = AgNO3
log_k -0.1
delta_h 22.6 kJ
-gamma 0 0
# Id: 204920
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ni+2 + NO3- = NiNO3+
log_k 0.4
delta_h 0 kJ
-gamma 0 0
# Id: 5404921
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
```

```
Co+2 + NO3- = CoNO3+
log_k 0.2
delta_h 0 kJ
-gamma 0 0
# Id: 2004921
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Co+2 + 2NO3- = Co(NO3)2
log_k 0.5085
delta_h 0 kJ
-gamma 0 0
# Id: 2004922
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Fe+3 + NO3- = FeNO3+2
log_k 1
delta_h -37 kJ
-gamma 0 0
# Id: 2814921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Mn+2 + NO3- = MnNO3+
log_k 0.2
delta_h 0 kJ
-gamma 0 0
# Id: 4704921
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Mn+2 + 2NO3- = Mn(NO3)2
log_k 0.6
delta_h -1.6569 kJ
-gamma 0 0
# Id: 4704920
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cr(OH)2+ + NO3- + 2H+ = CrNO3+2 + 2H2O
log_k 8.2094
delta_h -65.4378 kJ
-gamma 0 0
# Id: 2114920
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + NO3- = UO2NO3+
log_k 0.3
delta_h -12 kJ
-gamma 0 0
# Id: 8934921
# log K source: NIST46.4
```

```
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
VO2+ + NO3- = VO2NO3
log_k -0.296
delta_h 0 kJ
-gamma 0 0
# Id: 9034920
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 20.0
Ca+2 + NO3- = CaNO3+
log_k 0.5
delta_h -5.4 kJ
-gamma 0 0
# Id: 1504921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sr+2 + NO3- = SrNO3+
log_k 0.6
delta_h -10 kJ
-gamma 0 0
# Id: 8004921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ba+2 + NO3- = BaNO3+
log_k 0.7
delta_h -13 kJ
-gamma 0 0
# Id: 1004921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
H+ + Cyanide- = HCyanide
log_k 9.21
delta_h -43.63 kJ
-gamma 0 0
# Id: 3301431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cd+2 + Cyanide- = CdCyanide+
log_k 6.01
delta_h -30 kJ
-gamma 0 0
# Id: 1601431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cd+2 + 2Cyanide- = Cd(Cyanide)2
log_k 11.12
delta_h -54.3 kJ
-gamma 0 0
```

```
# Id: 1601432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cd+2 + 3Cyanide- = Cd(Cyanide)3-
log_k 15.65
delta_h -90.3 kJ
-gamma 0 0
# Id: 1601433
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cd+2 + 4Cyanide- = Cd(Cyanide)4-2
log_k 17.92
delta_h -112 kJ
-gamma 0 0
# Id: 1601434
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + Cyanide- = HgCyanide+ + 2H2O
log_k 23.194
delta_h -136.72 kJ
-gamma 0 0
# Id: 3611431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + 2Cyanide- = Hg(Cyanide)2 + 2H2O
log_k 38.944
delta_h 154.28 kJ
-gamma 0 0
# Id: 3611432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + 3Cyanide- = Hg(Cyanide)3- + 2H2O
log_k 42.504
delta_h -262.72 kJ
-gamma 0 0
# Id: 3611433
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + 4Cyanide- = Hg(Cyanide)4-2 + 2H2O
log_k 45.164
delta_h -288.72 kJ
-gamma 0 0
# Id: 3611434
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cu+ + 2Cyanide- = Cu(Cyanide)2-
log_k 21.9145
```

```
delta_h -121 kJ
-gamma 0 0
# Id: 2301432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Cu+ + 3Cyanide- = Cu(Cyanide)3-2
log_k 27.2145
delta_h -167.4 kJ
-gamma 0 0
# Id: 2301433
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cu+ + 4Cyanide- = Cu(Cyanide)4-3
log_k 28.7145
delta_h -214.2 kJ
-gamma 0 0
# Id: 2301431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ag+ + 2Cyanide- = Ag(Cyanide)2-
log_k 20.48
delta_h -137 kJ
-gamma 0 0
# Id: 201432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ag+ + 3Cyanide- = Ag(Cyanide)3-2
log_k 21.7
delta_h -140 kJ
-gamma 0 0
# Id: 201433
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ag+ + H2O + Cyanide- = Ag(Cyanide)OH- + H+
log_k -0.777
delta_h 0 kJ
-gamma 0 0
# Id: 201431
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ni+2 + 4Cyanide- = Ni(Cyanide)4-2
log_k 30.2
delta_h -180 kJ
-gamma 0 0
# Id: 5401431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
```

```
Ni+2 + 4Cyanide- + H+ = NiH(Cyanide)4-
log_k 36.0289
delta_h 0 kJ
-gamma 0 0
# Id: 5401432
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
Ni+2 + 4Cyanide- + 2H+ = NiH2Cyanide4
log_k 40.7434
delta_h 0 kJ
-gamma 0 0
# Id: 5401433
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
Ni+2 + 4Cyanide- + 3H+ = NiH3(Cyanide)4+
log_k 43.3434
delta_h 0 kJ
-gamma 0 0
# Id: 5401434
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
Co+2 + 3Cyanide- = Co(Cyanide)3-
log_k 14.312
delta_h 0 kJ
-gamma 0 0
# Id: 2001431
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 1.00 25.0
Co+2 + 5Cyanide- = Co(Cyanide)5-3
log_k 23
delta_h -257 kJ
-gamma 0 0
# Id: 2001432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 1.00 25.0
Fe+2 + 6Cyanide- = Fe(Cyanide)6-4
log_k 35.4
delta_h -358 kJ
-gamma 0 0
# Id: 2801431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
H+ + Fe+2 + 6Cyanide- = HFe(Cyanide)6-3
log_k 39.71
delta_h -356 kJ
-gamma 0 0
# Id: 2801432
# log K source: NIST46.4
```

```
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
2H+ + Fe+2 + 6Cyanide- = H2Fe(Cyanide)6-2
log_k 42.11
delta_h -352 kJ
-gamma 0 0
# Id: 2801433
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Fe+3 + 6Cyanide- = Fe(Cyanide)6-3
log_k 43.6
delta_h -293 kJ
-gamma 0 0
# Id: 2811431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
2Fe+3 + 6Cyanide- = Fe2(Cyanide)6
log_k 47.6355
delta_h -218 kJ
-gamma 0 0
# Id: 2811432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Sn(OH)2 + Fe+3 + 6Cyanide- + 2H+ = SnFe(Cyanide)6- + 2H2O
log_k 53.54
delta_h 0 kJ
-gamma 0 0
# Id: 7901431
# log K source: Ba1987
# Delta H source:
#T and ionic strength: 0.00 25.0
NH4+ + Fe+2 + 6Cyanide- = NH4Fe(Cyanide)6-3
log_k 37.7
delta_h -354 kJ
-gamma 0 0
# Id: 4901431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Tl+ + Fe+2 + 6Cyanide- = TlFe(Cyanide)6-3
log_k 38.4
delta_h -365.5 kJ
-gamma 0 0
# Id: 8701432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Mg+2 + Fe+3 + 6Cyanide- = MgFe(Cyanide)6-
log_k 46.39
delta_h -290 kJ
-gamma 0 0
```

```
# Id: 4601431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Mg+2 + Fe+2 + 6Cyanide- = MgFe(Cyanide)6-2
log_k 39.21
delta_h -346 kJ
-gamma 0 0
# Id: 4601432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ca+2 + Fe+3 + 6Cyanide- = CaFe(Cyanide)6-
log_k 46.43
delta_h -291 kJ
-gamma 0 0
# Id: 1501431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ca+2 + Fe+2 + 6Cyanide- = CaFe(Cyanide)6-2
log_k 39.1
delta_h -347 kJ
-gamma 0 0
# Id: 1501432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
2Ca+2 + Fe+2 + 6Cyanide- = Ca2Fe(Cyanide)6
log_k 40.6
delta_h -350.201 kJ
-gamma 0 0
# Id: 1501433
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Sr+2 + Fe+3 + 6Cyanide- = SrFe(Cyanide)6-
log_k 46.45
delta_h -292 kJ
-gamma 0 0
# Id: 8001431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sr+2 + Fe+2 + 6Cyanide- = SrFe(Cyanide)6-2
log_k 39.1
delta_h -350 kJ
-gamma 0 0
# Id: 8001432
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ba+2 + Fe+2 + 6Cyanide- = BaFe(Cyanide)6-2
log_k 39.19
```

```
delta_h -342 kJ
-gamma 0 0
# Id: 1001430
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ba+2 + Fe+3 + 6Cyanide- = BaFe(Cyanide)6-
log_k 46.48
delta_h -292 kJ
-gamma 0 0
# Id: 1001431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Na+ + Fe+2 + 6Cyanide- = NaFe(Cyanide)6-3
log_k 37.6
delta_h -354 kJ
-gamma 0 0
# Id: 5001431
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
K+ + Fe+2 + 6Cyanide- = KFe(Cyanide)6-3
log_k 37.75
delta_h -353.9 kJ
-gamma 0 0
# Id: 4101433
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
K+ + Fe+3 + 6Cyanide- = KFe(Cyanide)6-2
log_k 45.04
delta_h -291 kJ
-gamma 0 0
# Id: 4101430
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
H+ + PO4-3 = HPO4-2
log_k 12.375
delta_h -15 kJ
-gamma 5 0
# Id: 3305800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
2H+ + PO4-3 = H2PO4-
log_k 19.573
delta_h -18 kJ
-gamma 5.4 0
# Id: 3305801
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
```

```
3H+ + PO4-3 = H3PO4
log_k 21.721
delta_h -10.1 kJ
-gamma 0 0
# Id: 3305802
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Co+2 + H+ + PO4-3 = CoHPO4
log_k 15.4128
delta_h 0 kJ
-gamma 0 0
# Id: 2005800
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
Fe+2 + 2H+ + PO4-3 = FeH2PO4+
log_k 22.273
delta_h 0 kJ
-gamma 5.4 0
# Id: 2805800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Fe+2 + H+ + PO4-3 = FeHPO4
log_k 15.975
delta_h 0 kJ
-gamma 0 0
# Id: 2805801
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Fe+3 + 2H+ + PO4-3 = FeH2PO4+2
log_k 23.8515
delta_h 0 kJ
-gamma 5.4 0
# Id: 2815801
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Fe+3 + H+ + PO4-3 = FeHPO4+
log_k 22.292
delta_h -30.5432 kJ
-gamma 5.4 0
# Id: 2815800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Cr(OH)2+ + 4H+ + PO4-3 = CrH2PO4+2 + 2H2O
log_k 31.9068
delta_h 0 kJ
-gamma 0 0
# Id: 2115800
# log K source: MTQ3.11
```

```
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + PO4-3 + H+ = UHPO4+2
log_k 24.443
delta_h 31.38 kJ
-gamma 0 0
# Id: 8915800
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + 2PO4-3 + 2H+ = U(HPO4)2
log_k 46.833
delta_h 7.1128 kJ
-gamma 0 0
# Id: 8915801
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + 3PO4-3 + 3H+ = U(HPO4)3-2
log_k 67.564
delta_h -32.6352 kJ
-gamma 0 0
# Id: 8915802
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
U+4 + 4PO4-3 + 4H+ = U(HPO4)4-4
log_k 88.483
delta_h -110.876 kJ
-gamma 0 0
# Id: 8915803
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + H+ + PO4-3 = UO2HPO4
log_k 19.655
delta_h -8.7864 kJ
-gamma 0 0
# Id: 8935800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
UO2+2 + 2PO4-3 + 2H+ = UO2(HPO4)2-2
log_k 42.988
delta_h -47.6934 kJ
-gamma 0 0
# Id: 8935801
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + 2H+ + PO4-3 = UO2H2PO4+
log_k 22.833
delta_h -15.4808 kJ
-gamma 0 0
```

```
# Id: 8935802
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
UO2+2 + 2PO4-3 + 4H+ = UO2(H2PO4)2
log_k 44.7
delta_h -69.036 kJ
-gamma 0 0
# Id: 8935803
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + 3PO4-3 + 6H+ = UO2(H2PO4)3-
log_k 66.245
delta_h -119.662 kJ
-gamma 0 0
# Id: 8935804
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
UO2+2 + PO4-3 = UO2PO4-
log_k 13.25
delta_h 0 kJ
-gamma 0 0
# Id: 8935805
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Mg+2 + PO4-3 = MgPO4-
log_k 4.654
delta_h 12.9704 kJ
-gamma 5.4 0
# Id: 4605800
# log K source: SCD3.02 (1993 GMa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.20 25.0
Mg+2 + 2H+ + PO4-3 = MgH2PO4+
log_k 21.2561
delta_h -4.6861 kJ
-gamma 5.4 0
# Id: 4605801
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 37.0
Mg+2 + H+ + PO4-3 = MgHPO4
log_k 15.175
delta_h -3 kJ
-gamma 0 0
# Id: 4605802
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ca+2 + H+ + PO4-3 = CaHPO4
log_k 15.035
```

```
delta_h -3 kJ
-gamma 0 0
# Id: 1505800
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ca+2 + PO4-3 = CaPO4-
log_k 6.46
delta_h 12.9704 kJ
-gamma 5.4 0
# Id: 1505801
# log K source: SCD3.02 (1993 GMa)
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ca+2 + 2H+ + PO4-3 = CaH2PO4+
log_k 20.923
delta_h -6 kJ
-gamma 5.4 0
# Id: 1505802
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Sr+2 + H+ + PO4-3 = SrHPO4
log_k 14.8728
delta_h 0 kJ
-gamma 0 0
# Id: 8005800
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
Sr+2 + 2H+ + PO4-3 = SrH2PO4+
log_k 20.4019
delta_h 0 kJ
-gamma 0 0
# Id: 8005801
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 20.0
Na+ + H+ + PO4-3 = NaHPO4-
log_k 13.445
delta_h 0 kJ
-gamma 5.4 0
# Id: 5005800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
K+ + H+ + PO4-3 = KHPO4-
log_k 13.255
delta_h 0 kJ
-gamma 5.4 0
# Id: 4105800
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
```

```
H3AsO3 = AsO3-3 + 3H+
log_k -34.744
delta_h 84.726 kJ
-gamma 0 0
# Id: 3300602
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
H3AsO3 = HAsO3-2 + 2H+
log_k -21.33
delta_h 59.4086 kJ
-gamma 0 0
# Id: 3300601
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
H3AsO3 = H2AsO3- + H+
log_k -9.29
delta_h 27.41 kJ
-gamma 0 0
# Id: 3300600
# log K source: NIST46.4
# Delta H source: NIST2.1.1
#T and ionic strength: 0.00 25.0
H3AsO3 + H+ = H4AsO3+
log_k -0.305
delta_h 0 kJ
-gamma 0 0
# Id: 3300603
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
H3AsO4 = AsO4-3 + 3H+
log_k -20.7
delta_h 12.9 kJ
-gamma 0 0
# Id: 3300613
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
H3AsO4 = HAsO4-2 + 2H+
log_k -9.2
delta_h -4.1 kJ
-gamma 0 0
# Id: 3300612
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
H3AsO4 = H2AsO4- + H+
log_k -2.24
delta_h -7.1 kJ
-gamma 0 0
# Id: 3300611
# log K source: NIST46.4
```

```
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sb(OH)3 + H2O = Sb(OH)4- + H+
log_k -12.0429
delta_h 69.8519 kJ
-gamma 0 0
# Id: 7400020
# log K source: PNL89
# Delta H source: PNL89
#T and ionic strength:
Sb(OH)3 + H+ = Sb(OH)2+ + H2O
log_k 1.3853
delta_h 0 kJ
-gamma 0 0
# Id: 7403302
# log K source: PNL89
# Delta H source: PNL89
#T and ionic strength:
Sb(OH)3 = HSbO2 + H2O
log_k -0.0105
delta_h -0.13 kJ
-gamma 0 0
# Id: 7400021
# log K source: NIST2.1.1
# Delta H source: NIST2.1.1
#T and ionic strength:
Sb(OH)3 = SbO2- + H2O + H+
log_k -11.8011
delta_h 70.1866 kJ
-gamma 0 0
# Id: 7403301
# log K source: PNL89
# Delta H source: PNL89
#T and ionic strength:
Sb(OH)3 + H+ = SbO+ + 2H2O
log_k 0.9228
delta_h 8.2425 kJ
-gamma 0 0
# Id: 7403300
# log K source: PNL89
# Delta H source: PNL89
#T and ionic strength:
Sb(OH)6- = SbO3- + 3H2O
log_k 2.9319
delta_h 0 kJ
-gamma 0 0
# Id: 7410021
# log K source: PNL89
# Delta H source: PNL89
#T and ionic strength:
Sb(OH)6- + 2H+ = SbO2+ + 4H2O
log_k 2.3895
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 7413300
# log K source: PNL89
# Delta H source: PNL89
#T and ionic strength:
H+ + CO3-2 = HCO3-
log_k 10.329
delta_h -14.6 kJ
-gamma 5.4 0
# Id: 3301400
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
2H+ + CO3-2 = H2CO3
log_k 16.681
delta_h -23.76 kJ
-gamma 0 0
# Id: 3301401
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Pb+2 + 2CO3-2 = Pb(CO3)2-2
log_k 9.938
delta_h 0 kJ
-gamma 0 0
# Id: 6001400
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Pb+2 + CO3-2 = PbCO3
log_k 6.478
delta_h 0 kJ
-gamma 0 0
# Id: 6001401
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Pb+2 + CO3-2 + H+ = PbHCO3+
log_k 13.2
delta_h 0 kJ
-gamma 0 0
# Id: 6001402
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
Zn+2 + CO3-2 = ZnCO3
log_k 4.76
delta_h 0 kJ
-gamma 0 0
# Id: 9501401
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Zn+2 + H+ + CO3-2 = ZnHCO3+
log_k 11.829
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 9501400
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + CO3-2 = HgCO3 + 2H2O
log_k 18.272
delta_h 0 kJ
-gamma 0 0
# Id: 3611401
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Hg(OH)2 + 2H+ + 2CO3-2 = Hg(CO3)2-2 + 2H2O
log_k 21.772
delta_h 0 kJ
-gamma 0 0
# Id: 3611402
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Hg(OH)2 + 3H+ + CO3-2 = HgHCO3+ + 2H2O
log_k 22.542
delta_h 0 kJ
-gamma 0 0
# Id: 3611403
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Cd+2 + CO3-2 = CdCO3
log_k 4.3578
delta_h 0 kJ
-gamma 0 0
# Id: 1601401
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
Cd+2 + H+ + CO3-2 = CdHCO3+
log_k 10.6863
delta_h 0 kJ
-gamma 0 0
# Id: 1601400
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 3.00 25.0
Cd+2 + 2CO3-2 = Cd(CO3)2-2
log_k 7.2278
delta_h 0 kJ
-gamma 0 0
# Id: 1601403
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 20.0
```

```
Cu+2 + CO3-2 = CuCO3
log_k 6.77
delta_h 0 kJ
-gamma 0 0
# Id: 2311400
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cu+2 + H+ + CO3-2 = CuHCO3+
log_k 12.129
delta_h 0 kJ
-gamma 0 0
# Id: 2311402
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Cu+2 + 2CO3-2 = Cu(CO3)2-2
log_k 10.2
delta_h 0 kJ
-gamma 0 0
# Id: 2311401
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Ni+2 + CO3-2 = NiCO3
log_k 4.5718
delta_h 0 kJ
-gamma 0 0
# Id: 5401401
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.70 25.0
Ni+2 + H+ + CO3-2 = NiHCO3+
log_k 12.4199
delta_h 0 kJ
-gamma 0 0
# Id: 5401400
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.70 25.0
Co+2 + CO3-2 = CoCO3
log_k 4.228
delta_h 0 kJ
-gamma 0 0
# Id: 2001400
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
Co+2 + H+ + CO3-2 = CoHCO3+
log_k 12.2199
delta_h 0 kJ
-gamma 0 0
# Id: 2001401
# log K source: NIST46.4
```

```
# Delta H source: MTQ3.11
#T and ionic strength: 0.70 25.0
Fe+2 + H+ + CO3-2 = FeHCO3+
log_k 11.429
delta_h 0 kJ
-gamma 6 0
# Id: 2801400
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Mn+2 + H+ + CO3-2 = MnHCO3+
log_k 11.629
delta_h -10.6 kJ
-gamma 5 0
# Id: 4701400
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
UO2+2 + CO3-2 = UO2CO3
log_k 9.6
delta_h 4 kJ
-gamma 0 0
# Id: 8931400
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
UO2+2 + 2CO3-2 = UO2(CO3)2-2
log_k 16.9
delta_h 16 kJ
-gamma 0 0
# Id: 8931401
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
UO2+2 + 3CO3-2 = UO2(CO3)3-4
log_k 21.6
delta_h -40 kJ
-gamma 0 0
# Id: 8931402
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Be+2 + CO3-2 = BeCO3
log_k 6.2546
delta_h 0 kJ
-gamma 0 0
# Id: 1101401
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 3.00 25.0
Mg+2 + CO3-2 = MgCO3
log_k 2.92
delta_h 12 kJ
-gamma 0 0
```

```
# Id: 4601400
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Mg+2 + H+ + CO3-2 = MgHCO3+
log_k 11.339
delta_h -10.6 kJ
-gamma 4 0
# Id: 4601401
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Ca+2 + H+ + CO3-2 = CaHCO3+
log_k 11.599
delta_h 5.4 kJ
-gamma 6 0
# Id: 1501400
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
CO3-2 + Ca+2 = CaCO3
log_k 3.2
delta_h 16 kJ
-gamma 0 0
# Id: 1501401
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
Sr+2 + CO3-2 = SrCO3
log_k 2.81
delta_h 20 kJ
-gamma 0 0
# Id: 8001401
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sr+2 + H+ + CO3-2 = SrHCO3+
log_k 11.539
delta_h 10.4 kJ
-gamma 6 0
# Id: 8001400
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ba+2 + CO3-2 = BaCO3
log_k 2.71
delta_h 16 kJ
-gamma 0 0
# Id: 1001401
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ba+2 + H+ + CO3-2 = BaHCO3+
log_k 11.309
```

```
delta_h 10.4 kJ
-gamma 6 0
# Id: 1001400
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Na+ + CO3-2 = NaCO3-
log_k 1.27
delta_h -20.35 kJ
-gamma 5.4 0
# Id: 5001400
# log K source: NIST46.3
# Delta H source: NIST2.1.1
#T and ionic strength: 0.00 25.0
Na+ + H+ + CO3-2 = NaHCO3
log_k 10.079
delta_h -28.3301 kJ
-gamma 0 0
# Id: 5001401
# log K source: NIST46.3
# Delta H source: NIST2.1.1
#T and ionic strength: 0.00 25.0
H4SiO4 = H2SiO4-2 + 2H+
log_k -23.04
delta_h 61 kJ
-gamma 5.4 0
# Id: 3307701
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
H4SiO4 = H3SiO4- + H+
log_k -9.84
delta_h 20 kJ
-gamma 4 0
# Id: 3307700
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
UO2+2 + H4SiO4 = UO2H3SiO4+ + H+
log_k -1.9111
delta_h 0 kJ
-gamma 0 0
# Id: 8937700
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 25.0
H3BO3 = H2BO3- + H+
log_k -9.236
delta_h 13 kJ
-gamma 2.5 0
# Id: 3300900
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
```

```
2H3BO3 = H5(BO3)2- + H+
log_k -9.306
delta_h 8.4 kJ
-gamma 2.5 0
# Id: 3300901
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
3H3BO3 = H8(BO3)3- + H+
log_k -7.306
delta_h 29.4 kJ
-gamma 2.5 0
# Id: 3300902
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ag+ + H3BO3 = AgH2BO3 + H+
log_k -8.036
delta_h 0 kJ
-gamma 2.5 0
# Id: 200901
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Mg+2 + H3BO3 = MgH2BO3+ + H+
log_k -7.696
delta_h 13 kJ
-gamma 2.5 0
# Id: 4600901
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ca+2 + H3BO3 = CaH2BO3+ + H+
log_k -7.476
delta_h 17 kJ
-gamma 2.5 0
# Id: 1500901
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sr+2 + H3BO3 = SrH2BO3+ + H+
log_k -7.686
delta_h 17 kJ
-gamma 2.5 0
# Id: 8000901
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ba+2 + H3BO3 = BaH2BO3+ + H+
log_k -7.746
delta_h 17 kJ
-gamma 2.5 0
# Id: 1000901
# log K source: NIST46.4
```

```
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Na+ + H3BO3 = NaH2BO3 + H+
log_k -9.036
delta_h 0 kJ
-gamma 2.5 0
# Id: 5000901
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
CrO4-2 + H+ = HCrO4-
log_k 6.51
delta_h 2 kJ
-gamma 0 0
# Id: 2123300
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
CrO4-2 + 2H+ = H2CrO4
log_k 6.4188
delta_h 39 kJ
-gamma 0 0
# Id: 2123301
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 20.0
2CrO4-2 + 2H+ = Cr2O7-2 + H2O
log_k 14.56
delta_h -15 kJ
-gamma 0 0
# Id: 2123302
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
CrO4-2 + Cl- + 2H+ = CrO3Cl- + H2O
log_k 7.3086
delta_h 0 kJ
-gamma 0 0
# Id: 2121800
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
CrO4-2 + SO4-2 + 2H+ = CrO3SO4-2 + H2O
log_k 8.9937
delta_h 0 kJ
-gamma 0 0
# Id: 2127320
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
CrO4-2 + 4H+ + PO4-3 = CrO3H2PO4- + H2O
log_k 29.3634
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2125800
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
CrO4-2 + 3H+ + PO4-3 = CrO3HPO4-2 + H2O
log_k 26.6806
delta_h 0 kJ
-gamma 0 0
# Id: 2125801
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
CrO4-2 + Na+ = NaCrO4-
log_k 0.6963
delta_h 0 kJ
-gamma 0 0
# Id: 5002120
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
K+ + CrO4-2 = KCrO4-
log_k 0.57
delta_h 0 kJ
-gamma 0 0
# Id: 4102120
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 18.0
MoO4-2 + H+ = HMoO4-
log_k 4.2988
delta_h 20 kJ
-gamma 0 0
# Id: 3304801
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 20.0
MoO4-2 + 2H+ = H2MoO4
log_k 8.1636
delta_h -26 kJ
-gamma 0 0
# Id: 3304802
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 20.0
7MoO4-2 + 8H+ = Mo7O24-6 + 4H2O
log_k 52.99
delta_h -228 kJ
-gamma 0 0
# Id: 3304803
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
7MoO4-2 + 9H+ = HMo7O24-5 + 4H2O
log_k 59.3768
```

```
delta_h -218 kJ
-gamma 0 0
# Id: 3304804
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
7MoO4-2 + 10H+ = H2Mo7O24-4 + 4H2O
log_k 64.159
delta_h -215 kJ
-gamma 0 0
# Id: 3304805
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
7MoO4-2 + 11H+ = H3Mo7O24-3 + 4H2O
log_k 67.405
delta_h -217 kJ
-gamma 0 0
# Id: 3304806
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 1.00 25.0
6MoO4-2 + Al+3 + 6H+ = AlMo6O21-3 + 3H2O
log_k 54.9925
delta_h 0 kJ
-gamma 0 0
# Id: 304801
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.50 25.0
MoO4-2 + 2Ag+ = Ag2MoO4
log_k -0.4219
delta_h -1.18 kJ
-gamma 0 0
# Id: 204801
# log K source: Bard85
# Delta H source: Bard85
#T and ionic strength:
VO2+ + 2H2O = VO4-3 + 4H+
log_k -30.2
delta_h -25 kJ
-gamma 0 0
# Id: 9033303
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
VO2+ + 2H2O = HVO4-2 + 3H+
log_k -15.9
delta_h 0 kJ
-gamma 0 0
# Id: 9033302
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
```

```
VO2+ + 2H2O = H2VO4- + 2H+
log_k -7.3
delta_h 0 kJ
-gamma 0 0
# Id: 9033301
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
VO2+ + 2H2O = H3VO4 + H+
log_k -3.3
delta_h 44.4759 kJ
-gamma 0 0
# Id: 9033300
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
2VO2+ + 3H2O = V2O7-4 + 6H+
log_k -31.24
delta_h -28 kJ
-gamma 0 0
# Id: 9030020
# log K source: NIST46.3
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
2VO2+ + 3H2O = HV2O7-3 + 5H+
log_k -20.67
delta_h 0 kJ
-gamma 0 0
# Id: 9030021
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
2VO2+ + 3H2O = H3V2O7- + 3H+
log_k -3.79
delta_h 0 kJ
-gamma 0 0
# Id: 9030022
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
3VO2+ + 3H2O = V3O9-3 + 6H+
log_k -15.88
delta_h 0 kJ
-gamma 0 0
# Id: 9030023
# log K source: MTQ3.11
# Delta H source: MTQ3.11
#T and ionic strength:
4VO2+ + 4H2O = V4O12-4 + 8H+
log_k -20.56
delta_h -87 kJ
-gamma 0 0
# Id: 9030024
# log K source: NIST46.3
```

```
# Delta H source: NIST46.3
#T and ionic strength: 0.00 25.0
10VO2+ + 8H2O = V10O28-6 + 16H+
log_k -24.0943
delta_h 0 kJ
-gamma 0 0
# Id: 9030025
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 20.0
10VO2+ + 8H2O = HV10O28-5 + 15H+
log_k -15.9076
delta_h 90.0397 kJ
-gamma 0 0
# Id: 9030026
# log K source: NIST46.4
# Delta H source: MTQ3.11
#T and ionic strength: 0.10 20.0
10VO2+ + 8H2O = H2V10O28-4 + 14H+
log_k -10.7
delta_h 0 kJ
-gamma 0 0
# Id: 9030027
# log K source: NIST46.3
# Delta H source: MTQ3.11
#T and ionic strength: 0.00 25.0
Benzoate- + H+ = H(Benzoate)
log_k 4.202
delta_h -0.4602 kJ
-gamma 0 0
# Id: 3309171
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Benzoate- + Pb+2 = Pb(Benzoate)+
log_k 2.4
delta_h 0 kJ
-gamma 0 0
# Id: 6009171
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Benzoate- + Al+3 = Al(Benzoate)+2
log_k 2.05
delta_h 0 kJ
-gamma 0 0
# Id: 309171
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Benzoate- + Al+3 + H2O = AlOH(Benzoate)+ + H+
log_k -0.56
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 309172
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Benzoate- + Zn+2 = Zn(Benzoate)+
log_k 1.7
delta_h 0 kJ
-gamma 0 0
# Id: 9509171
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Benzoate- + Cd+2 = Cd(Benzoate)+
log_k 1.8
delta_h 0 kJ
-gamma 0 0
# Id: 1609171
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2Benzoate- + Cd+2 = Cd(Benzoate)2
log_k 1.82
delta_h 0 kJ
-gamma 0 0
# Id: 1609172
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Benzoate- + Cu+2 = Cu(Benzoate)+
log_k 2.19
delta_h 0 kJ
-gamma 0 0
# Id: 2319171
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Benzoate- + Ag+ = Ag(Benzoate)
log_k 0.91
delta_h 0 kJ
-gamma 0 0
# Id: 209171
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Benzoate- + Ni+2 = Ni(Benzoate)+
log_k 1.86
delta_h 0 kJ
-gamma 0 0
# Id: 5409171
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Co+2 + Benzoate- = Co(Benzoate)+
log_k 1.0537
```

```
delta_h 12 kJ
-gamma 0 0
# Id: 2009171
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 30.0
Benzoate- + Mn+2 = Mn(Benzoate)+
log_k 2.06
delta_h 0 kJ
-gamma 0 0
# Id: 4709171
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Benzoate- + Mg+2 = Mg(Benzoate)+
log_k 1.26
delta_h 0 kJ
-gamma 0 0
# Id: 4609171
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Benzoate- + Ca+2 = Ca(Benzoate)+
log_k 1.55
delta_h 0 kJ
-gamma 0 0
# Id: 1509171
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Phenylacetate- + H+ = H(Phenylacetate)
log_k 4.31
delta_h 2.1757 kJ
-gamma 0 0
# Id: 3309181
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Phenylacetate- + Zn+2 = Zn(Phenylacetate)+
log_k 1.57
delta_h 0 kJ
-gamma 0 0
# Id: 9509181
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Phenylacetate- + Cu+2 = Cu(Phenylacetate)+
log_k 1.97
delta_h 0 kJ
-gamma 0 0
# Id: 2319181
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Co+2 + Phenylacetate- = Co(Phenylacetate)+
log_k 0.591
delta_h 0 kJ
-gamma 0 0
# Id: 2009181
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 2.00 25.0
Co+2 + 2Phenylacetate- = Co(Phenylacetate)2
log_k 0.4765
delta_h 0 kJ
-gamma 0 0
# Id: 2009182
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 2.00 25.0
Isophthalate-2 + H+ = H(Isophthalate)-
log_k 4.5
delta_h 1.6736 kJ
-gamma 0 0
# Id: 3309201
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Isophthalate-2 + 2H+ = H2(Isophthalate)
log_k 8
delta_h 1.6736 kJ
-gamma 0 0
# Id: 3309202
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Isophthalate-2 + Pb+2 = Pb(Isophthalate)
log_k 2.99
delta_h 0 kJ
-gamma 0 0
# Id: 6009201
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2Isophthalate-2 + Pb+2 = Pb(Isophthalate)2-2
log_k 4.18
delta_h 0 kJ
-gamma 0 0
# Id: 6009202
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Isophthalate-2 + Pb+2 + H+ = PbH(Isophthalate)+
log_k 6.69
delta_h 0 kJ
-gamma 0 0
# Id: 6009203
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Isophthalate-2 + Cd+2 = Cd(Isophthalate)
log_k 2.15
delta_h 0 kJ
-gamma 0 0
# Id: 1609201
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2Isophthalate-2 + Cd+2 = Cd(Isophthalate)2-2
log_k 2.99
delta_h 0 kJ
-gamma 0 0
# Id: 1609202
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Isophthalate-2 + Cd+2 + H+ = CdH(Isophthalate)+
log_k 5.73
delta_h 0 kJ
-gamma 0 0
# Id: 1609203
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Isophthalate-2 + Ca+2 = Ca(Isophthalate)
log_k 2
delta_h 0 kJ
-gamma 0 0
# Id: 1509200
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Isophthalate-2 + Ba+2 = Ba(Isophthalate)
log_k 1.55
delta_h 0 kJ
-gamma 0 0
# Id: 1009201
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Diethylamine = H(Diethylamine)+
log_k 10.933
delta_h -53.1368 kJ
-gamma 0 0
# Id: 3309551
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Diethylamine = Zn(Diethylamine)+2
log_k 2.74
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 9509551
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 2Diethylamine = Zn(Diethylamine)2+2
log_k 5.27
delta_h 0 kJ
-gamma 0 0
# Id: 9509552
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 3Diethylamine = Zn(Diethylamine)3+2
log_k 7.71
delta_h 0 kJ
-gamma 0 0
# Id: 9509553
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 4Diethylamine = Zn(Diethylamine)4+2
log_k 9.84
delta_h 0 kJ
-gamma 0 0
# Id: 9509554
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + Diethylamine = Cd(Diethylamine)+2
log_k 2.73
delta_h 0 kJ
-gamma 0 0
# Id: 1609551
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 2Diethylamine = Cd(Diethylamine)2+2
log_k 4.86
delta_h 0 kJ
-gamma 0 0
# Id: 1609552
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 3Diethylamine = Cd(Diethylamine)3+2
log_k 6.37
delta_h 0 kJ
-gamma 0 0
# Id: 1609553
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 4Diethylamine = Cd(Diethylamine)4+2
log_k 7.32
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 1609554
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ag+ + Diethylamine = Ag(Diethylamine)+
log_k 2.98
delta_h 0 kJ
-gamma 0 0
# Id: 209551
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Diethylamine = Ag(Diethylamine)2+
log_k 6.38
delta_h -44.7688 kJ
-gamma 0 0
# Id: 209552
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Diethylamine = Ni(Diethylamine)+2
log_k 2.78
delta_h 0 kJ
-gamma 0 0
# Id: 5409551
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 2Diethylamine = Ni(Diethylamine)2+2
log_k 4.97
delta_h 0 kJ
-gamma 0 0
# Id: 5409552
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 3Diethylamine = Ni(Diethylamine)3+2
log_k 6.72
delta_h 0 kJ
-gamma 0 0
# Id: 5409553
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 4Diethylamine = Ni(Diethylamine)4+2
log_k 7.93
delta_h 0 kJ
-gamma 0 0
# Id: 5409554
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
```

```
Ni+2 + 5Diethylamine = Ni(Diethylamine)5+2
log_k 8.87
delta_h 0 kJ
-gamma 0 0
# Id: 5409555
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Butylamine = H(Butylamine)+
log_k 10.64
delta_h -58.2831 kJ
-gamma 0 0
# Id: 3309561
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Butylamine + 2H+ = Hg(Butylamine)+2 + 2H2O
log_k 14.84
delta_h 0 kJ
-gamma 0 0
# Id: 3619561
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 2Butylamine + 2H+ = Hg(Butylamine)2+2 + 2H2O
log_k 24.24
delta_h 0 kJ
-gamma 0 0
# Id: 3619562
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 3Butylamine + 2H+ = Hg(Butylamine)3+2 + 2H2O
log_k 25.1
delta_h 0 kJ
-gamma 0 0
# Id: 3619563
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 4Butylamine + 2H+ = Hg(Butylamine)4+2 + 2H2O
log_k 26.1
delta_h 0 kJ
-gamma 0 0
# Id: 3619564
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Butylamine = Ag(Butylamine)+
log_k 3.42
delta_h -16.736 kJ
-gamma 0 0
# Id: 209561
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Butylamine = Ag(Butylamine)2+
log_k 7.47
delta_h -52.7184 kJ
-gamma 0 0
# Id: 209562
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Methylamine = H(Methylamine)+
log_k 10.64
delta_h -55.2288 kJ
-gamma 0 0
# Id: 3309581
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Methylamine = Cd(Methylamine)+2
log_k 2.75
delta_h 0 kJ
-gamma 0 0
# Id: 1609581
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 2Methylamine = Cd(Methylamine)2+2
log_k 4.81
delta_h -29.288 kJ
-gamma 0 0
# Id: 1609582
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 3Methylamine = Cd(Methylamine)3+2
log_k 5.94
delta_h 0 kJ
-gamma 0 0
# Id: 1609583
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 4Methylamine = Cd(Methylamine)4+2
log_k 6.55
delta_h -58.576 kJ
-gamma 0 0
# Id: 1609584
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Methylamine + 2H+ = Hg(Methylamine)+2 + 2H2O
log_k 14.76
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 3619581
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 2Methylamine + 2H+ = Hg(Methylamine)2+2 + 2H2O
log_k 23.96
delta_h 0 kJ
-gamma 0 0
# Id: 3619582
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 3Methylamine + 2H+ = Hg(Methylamine)3+2 + 2H2O
log_k 24.3
delta_h 0 kJ
-gamma 0 0
# Id: 3619583
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 4Methylamine + 2H+ = Hg(Methylamine)4+2 + 2H2O
log_k 24.6
delta_h 0 kJ
-gamma 0 0
# Id: 3619584
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Methylamine = Cu(Methylamine)+2
log_k 4.11
delta_h 0 kJ
-gamma 0 0
# Id: 2319581
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Methylamine = Cu(Methylamine)2+2
log_k 7.51
delta_h 0 kJ
-gamma 0 0
# Id: 2319582
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 3Methylamine = Cu(Methylamine)3+2
log_k 10.21
delta_h 0 kJ
-gamma 0 0
# Id: 2319583
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 4Methylamine = Cu(Methylamine)4+2
log_k 12.08
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 2319584
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Methylamine = Ag(Methylamine)+
log_k 3.07
delta_h -12.552 kJ
-gamma 0 0
# Id: 209581
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Methylamine = Ag(Methylamine)2+
log_k 6.89
delta_h -48.9528 kJ
-gamma 0 0
# Id: 209582
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Methylamine = Ni(Methylamine)+2
log_k 2.23
delta_h 0 kJ
-gamma 0 0
# Id: 5409581
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Dimethylamine = H(Dimethylamine)+
log_k 10.774
delta_h -50.208 kJ
-gamma 0 0
# Id: 3309591
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Dimethylamine = Ag(Dimethylamine)2+
log_k 5.37
delta_h -40.5848 kJ
-gamma 0 0
# Id: 209591
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Dimethylamine = Ni(Dimethylamine)+2
log_k 1.47
delta_h 0 kJ
-gamma 0 0
# Id: 5409591
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
H+ + Hexylamine = H(Hexylamine)+
log_k 10.63
delta_h -58.576 kJ
-gamma 0 0
# Id: 3309611
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Hexylamine = Ag(Hexylamine)+
log_k 3.54
delta_h -25.104 kJ
-gamma 0 0
# Id: 209611
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Hexylamine = Ag(Hexylamine)2+
log_k 7.55
delta_h -53.1368 kJ
-gamma 0 0
# Id: 209612
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Ethylenediamine = H(Ethylenediamine)+
log_k 9.928
delta_h -49.7896 kJ
-gamma 0 0
# Id: 3309631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Ethylenediamine = H2(Ethylenediamine)+2
log_k 16.776
delta_h -95.3952 kJ
-gamma 0 0
# Id: 3309632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Ethylenediamine = Pb(Ethylenediamine)+2
log_k 5.04
delta_h 0 kJ
-gamma 0 0
# Id: 6009631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + 2Ethylenediamine = Pb(Ethylenediamine)2+2
log_k 8.5
delta_h 0 kJ
-gamma 0 0
# Id: 6009632
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Ethylenediamine = Zn(Ethylenediamine)+2
log_k 5.66
delta_h -29.288 kJ
-gamma 0 0
# Id: 9509631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 2Ethylenediamine = Zn(Ethylenediamine)2+2
log_k 10.6
delta_h -48.116 kJ
-gamma 0 0
# Id: 9509632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 3Ethylenediamine = Zn(Ethylenediamine)3+2
log_k 13.9
delta_h -71.5464 kJ
-gamma 0 0
# Id: 9509633
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Ethylenediamine = Cd(Ethylenediamine)+2
log_k 5.41
delta_h -28.4512 kJ
-gamma 0 0
# Id: 1609631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 2Ethylenediamine = Cd(Ethylenediamine)2+2
log_k 9.9
delta_h -55.6472 kJ
-gamma 0 0
# Id: 1609632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 3Ethylenediamine = Cd(Ethylenediamine)3+2
log_k 11.6
delta_h -82.4248 kJ
-gamma 0 0
# Id: 1609633
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Ethylenediamine + 2H+ = Hg(Ethylenediamine)+2 + 2H2O
log_k 20.4
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 3619631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 2Ethylenediamine + 2H+ = Hg(Ethylenediamine)2+2 + 2H2O
log_k 29.3
delta_h -173.218 kJ
-gamma 0 0
# Id: 3619632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 2Ethylenediamine + 3H+ = HgH(Ethylenediamine)2+3 + 2H2O
log_k 34.7
delta_h 0 kJ
-gamma 0 0
# Id: 3619633
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 2Ethylenediamine = Cu(Ethylenediamine)2+
log_k 11.2
delta_h 0 kJ
-gamma 0 0
# Id: 2309631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Ethylenediamine = Cu(Ethylenediamine)+2
log_k 10.5
delta_h -52.7184 kJ
-gamma 0 0
# Id: 2319631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Ethylenediamine = Cu(Ethylenediamine)2+2
log_k 19.6
delta_h -105.437 kJ
-gamma 0 0
# Id: 2319632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Ethylenediamine = Ag(Ethylenediamine)+
log_k 4.6
delta_h -48.9528 kJ
-gamma 0 0
# Id: 209631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Ethylenediamine = Ag(Ethylenediamine)2+
log_k 7.5
```

```
delta_h -52.3 kJ
-gamma 0 0
# Id: 209632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Ethylenediamine + H+ = AgH(Ethylenediamine)+2
log_k 11.99
delta_h -75.312 kJ
-gamma 0 0
# Id: 209633
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2Ag+ + Ethylenediamine = Ag2(Ethylenediamine)+2
log_k 6.5
delta_h 0 kJ
-gamma 0 0
# Id: 209634
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2Ag+ + 2Ethylenediamine = Ag2(Ethylenediamine)2+2
log_k 12.7
delta_h -97.0688 kJ
-gamma 0 0
# Id: 209635
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Ethylenediamine + 2H+ = Ag(HEthylenediamine)2+3
log_k 24
delta_h -150.206 kJ
-gamma 0 0
# Id: 209636
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Ethylenediamine + H+ = AgH(Ethylenediamine)2+2
log_k 8.4
delta_h -47.6976 kJ
-gamma 0 0
# Id: 209637
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Ethylenediamine = Ni(Ethylenediamine)+2
log_k 7.32
delta_h -37.656 kJ
-gamma 0 0
# Id: 5409631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Ni+2 + 2Ethylenediamine = Ni(Ethylenediamine)2+2
log_k 13.5
delta_h -76.5672 kJ
-gamma 0 0
# Id: 5409632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 3Ethylenediamine = Ni(Ethylenediamine)3+2
log_k 17.6
delta_h -117.152 kJ
-gamma 0 0
# Id: 5409633
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Ethylenediamine = Co(Ethylenediamine)+2
log_k 5.5
delta_h -28 kJ
-gamma 0 0
# Id: 2009631
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+2 + 2Ethylenediamine = Co(Ethylenediamine)2+2
log_k 10.1
delta_h -58.5 kJ
-gamma 0 0
# Id: 2009632
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+2 + 3Ethylenediamine = Co(Ethylenediamine)3+2
log_k 13.2
delta_h -92.8 kJ
-gamma 0 0
# Id: 2009633
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+3 + 2Ethylenediamine = Co(Ethylenediamine)2+3
log_k 34.7
delta_h 0 kJ
-gamma 0 0
# Id: 2019631
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 25.0
Co+3 + 3Ethylenediamine = Co(Ethylenediamine)3+3
log_k 48.69
delta_h 0 kJ
-gamma 0 0
# Id: 2019632
# log K source: NIST46.4
```

```
# Delta H source: NIST46.2
#T and ionic strength: 1.50 30.0
Fe+2 + Ethylenediamine = Fe(Ethylenediamine)+2
log_k 4.26
delta_h 0 kJ
-gamma 0 0
# Id: 2809631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + 2Ethylenediamine = Fe(Ethylenediamine)2+2
log_k 7.73
delta_h 0 kJ
-gamma 0 0
# Id: 2809632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + 3Ethylenediamine = Fe(Ethylenediamine)3+2
log_k 10.17
delta_h 0 kJ
-gamma 0 0
# Id: 2809633
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + Ethylenediamine = Mn(Ethylenediamine)+2
log_k 2.74
delta_h -11.7152 kJ
-gamma 0 0
# Id: 4709631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + 2Ethylenediamine = Mn(Ethylenediamine)2+2
log_k 4.8
delta_h -25.104 kJ
-gamma 0 0
# Id: 4709632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cr(OH)2+ + 2Ethylenediamine + 2H+ = Cr(Ethylenediamine)2+3 + 2H2O
log_k 22.57
delta_h 0 kJ
-gamma 0 0
# Id: 2119631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cr(OH)2+ + 3Ethylenediamine + 2H+ = Cr(Ethylenediamine)3+3 + 2H2O
log_k 29
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2119632
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mg+2 + Ethylenediamine = Mg(Ethylenediamine)+2
log_k 0.37
delta_h 0 kJ
-gamma 0 0
# Id: 4609631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Ethylenediamine = Ca(Ethylenediamine)+2
log_k 0.11
delta_h 0 kJ
-gamma 0 0
# Id: 1509631
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Propylamine = H(Propylamine)+
log_k 10.566
delta_h -57.53 kJ
-gamma 0 0
# Id: 3309641
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Propylamine = Zn(Propylamine)+2
log_k 2.42
delta_h 0 kJ
-gamma 0 0
# Id: 9509641
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 2Propylamine = Zn(Propylamine)2+2
log_k 4.85
delta_h 0 kJ
-gamma 0 0
# Id: 9509642
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 3Propylamine = Zn(Propylamine)3+2
log_k 7.38
delta_h 0 kJ
-gamma 0 0
# Id: 9509643
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 4Propylamine = Zn(Propylamine)4+2
log_k 9.49
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 9509644
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + Propylamine = Cd(Propylamine)+2
log_k 2.62
delta_h 0 kJ
-gamma 0 0
# Id: 1609641
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 2Propylamine = Cd(Propylamine)2+2
log_k 4.64
delta_h 0 kJ
-gamma 0 0
# Id: 1609642
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 3Propylamine = Cd(Propylamine)3+2
log_k 6.03
delta_h 0 kJ
-gamma 0 0
# Id: 1609643
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ag+ + Propylamine = Ag(Propylamine)+
log_k 3.45
delta_h -12.552 kJ
-gamma 0 0
# Id: 209641
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Propylamine = Ag(Propylamine)2+
log_k 7.44
delta_h -53.1368 kJ
-gamma 0 0
# Id: 209642
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Propylamine = Ni(Propylamine)+2
log_k 2.81
delta_h 0 kJ
-gamma 0 0
# Id: 5409641
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
```

```
Ni+2 + 2Propylamine = Ni(Propylamine)2+2
log_k 5.02
delta_h 0 kJ
-gamma 0 0
# Id: 5409642
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 3Propylamine = Ni(Propylamine)3+2
log_k 6.79
delta_h 0 kJ
-gamma 0 0
# Id: 5409643
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 4Propylamine = Ni(Propylamine)4+2
log_k 8.31
delta_h 0 kJ
-gamma 0 0
# Id: 5409644
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Isopropylamine = H(Isopropylamine)+
log_k 10.67
delta_h -58.3668 kJ
-gamma 0 0
# Id: 3309651
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Isopropylamine = Zn(Isopropylamine)+2
log_k 2.37
delta_h 0 kJ
-gamma 0 0
# Id: 9509651
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 2Isopropylamine = Zn(Isopropylamine)2+2
log_k 4.67
delta_h 0 kJ
-gamma 0 0
# Id: 9509652
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 3Isopropylamine = Zn(Isopropylamine)3+2
log_k 7.14
delta_h 0 kJ
-gamma 0 0
# Id: 9509653
# log K source: SCD2.62
```

```
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 4Isopropylamine = Zn(Isopropylamine)4+2
log_k 9.44
delta_h 0 kJ
-gamma 0 0
# Id: 9509654
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + Isopropylamine = Cd(Isopropylamine)+2
log_k 2.55
delta_h 0 kJ
-gamma 0 0
# Id: 1609651
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 2Isopropylamine = Cd(Isopropylamine)2+2
log_k 4.57
delta_h 0 kJ
-gamma 0 0
# Id: 1609652
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 3Isopropylamine = Cd(Isopropylamine)3+2
log_k 6.07
delta_h 0 kJ
-gamma 0 0
# Id: 1609653
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 4Isopropylamine = Cd(Isopropylamine)4+2
log_k 6.9
delta_h 0 kJ
-gamma 0 0
# Id: 1609654
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Hg(OH)2 + Isopropylamine + 2H+ = Hg(Isopropylamine)+2 + 2H2O
log_k 14.85
delta_h 0 kJ
-gamma 0 0
# Id: 3619651
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + 2Isopropylamine + 2H+ = Hg(Isopropylamine)2+2 + 2H2O
log_k 24.37
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 3619652
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Isopropylamine = Ag(Isopropylamine)+
log_k 3.67
delta_h -23.8488 kJ
-gamma 0 0
# Id: 209651
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Isopropylamine = Ag(Isopropylamine)2+
log_k 7.77
delta_h -59.8312 kJ
-gamma 0 0
# Id: 209652
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Isopropylamine = Ni(Isopropylamine)+2
log_k 2.71
delta_h 0 kJ
-gamma 0 0
# Id: 5409651
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 2Isopropylamine = Ni(Isopropylamine)2+2
log_k 4.86
delta_h 0 kJ
-gamma 0 0
# Id: 5409652
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 3Isopropylamine = Ni(Isopropylamine)3+2
log_k 6.57
delta_h 0 kJ
-gamma 0 0
# Id: 5409653
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 4Isopropylamine = Ni(Isopropylamine)4+2
log_k 7.83
delta_h 0 kJ
-gamma 0 0
# Id: 5409654
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + 5Isopropylamine = Ni(Isopropylamine)5+2
log_k 8.43
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 5409655
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Trimethylamine = H(Trimethylamine)+
log_k 9.8
delta_h -36.8192 kJ
-gamma 0 0
# Id: 3309661
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Trimethylamine = Ag(Trimethylamine)+
log_k 1.701
delta_h 0 kJ
-gamma 0 0
# Id: 209661
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Citrate-3 = H(Citrate)-2
log_k 6.396
delta_h 3.3472 kJ
-gamma 0 0
# Id: 3309671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Citrate-3 = H2(Citrate)-
log_k 11.157
delta_h 1.297 kJ
-gamma 0 0
# Id: 3309672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
3H+ + Citrate-3 = H3(Citrate)
log_k 14.285
delta_h -2.7614 kJ
-gamma 0 0
# Id: 3309673
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Citrate-3 = Pb(Citrate)-
log_k 7.27
delta_h 0 kJ
-gamma 0 0
# Id: 6009671
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
```

```
Pb+2 + 2Citrate-3 = Pb(Citrate)2-4
log_k 6.53
delta_h 0 kJ
-gamma 0 0
# Id: 6009672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Citrate-3 = Al(Citrate)
log_k 9.97
delta_h 0 kJ
-gamma 0 0
# Id: 309671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + 2Citrate-3 = Al(Citrate)2-3
log_k 14.8
delta_h 0 kJ
-gamma 0 0
# Id: 309672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Citrate-3 + H+ = AlH(Citrate)+
log_k 12.85
delta_h 0 kJ
-gamma 0 0
# Id: 309673
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Tl+ + Citrate-3 = Tl(Citrate)-2
log_k 1.48
delta_h 0 kJ
-gamma 0 0
# Id: 8709671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Citrate-3 = Zn(Citrate)-
log_k 6.21
delta_h 8.368 kJ
-gamma 0 0
# Id: 9509671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 2Citrate-3 = Zn(Citrate)2-4
log_k 7.4
delta_h 25.104 kJ
-gamma 0 0
# Id: 9509672
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Citrate-3 + H+ = ZnH(Citrate)
log_k 10.2
delta_h 3.3472 kJ
-gamma 0 0
# Id: 9509673
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Citrate-3 + 2H+ = ZnH2(Citrate)+
log_k 12.84
delta_h 0 kJ
-gamma 0 0
# Id: 9509674
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + Citrate-3 = Cd(Citrate)-
log_k 4.98
delta_h 8.368 kJ
-gamma 0 0
# Id: 1609671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Citrate-3 + H+ = CdH(Citrate)
log_k 9.44
delta_h 3.3472 kJ
-gamma 0 0
# Id: 1609672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Citrate-3 + 2H+ = CdH2(Citrate)+
log_k 12.9
delta_h 0 kJ
-gamma 0 0
# Id: 1609673
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 2Citrate-3 = Cd(Citrate)2-4
log_k 5.9
delta_h 20.92 kJ
-gamma 0 0
# Id: 1609674
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Citrate-3 + 2H+ = Hg(Citrate)- + 2H2O
log_k 18.3
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 3619671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Citrate-3 = Cu(Citrate)-
log_k 7.57
delta_h 0 kJ
-gamma 0 0
# Id: 2319671
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cu+2 + 2Citrate-3 = Cu(Citrate)2-4
log_k 8.9
delta_h 0 kJ
-gamma 0 0
# Id: 2319672
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cu+2 + Citrate-3 + H+ = CuH(Citrate)
log_k 10.87
delta_h 11.7152 kJ
-gamma 0 0
# Id: 2319673
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Citrate-3 + 2H+ = CuH2(Citrate)+
log_k 13.23
delta_h 0 kJ
-gamma 0 0
# Id: 2319674
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
2Cu+2 + 2Citrate-3 = Cu2(Citrate)2-2
log_k 16.9
delta_h 41.84 kJ
-gamma 0 0
# Id: 2319675
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Citrate-3 = Ni(Citrate)-
log_k 6.59
delta_h 16.736 kJ
-gamma 0 0
# Id: 5409671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Citrate-3 + H+ = NiH(Citrate)
log_k 10.5
```

```
delta_h 15.8992 kJ
-gamma 0 0
# Id: 5409672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Citrate-3 + 2H+ = NiH2(Citrate)+
log_k 13.3
delta_h 0 kJ
-gamma 0 0
# Id: 5409673
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 2Citrate-3 = Ni(Citrate)2-4
log_k 8.77
delta_h 12.552 kJ
-gamma 0 0
# Id: 5409674
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 2Citrate-3 + H+ = NiH(Citrate)2-3
log_k 14.9
delta_h 32.6352 kJ
-gamma 0 0
# Id: 5409675
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Citrate-3 = Co(Citrate)-
log_k 6.1867
delta_h 0 kJ
-gamma 0 0
# Id: 2009671
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Co+2 + H+ + Citrate-3 = CoHCitrate
log_k 10.4438
delta_h 0 kJ
-gamma 0 0
# Id: 2009672
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Co+2 + 2H+ + Citrate-3 = CoH2Citrate+
log_k 12.7859
delta_h 0 kJ
-gamma 0 0
# Id: 2009673
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
```

```
Fe+2 + Citrate-3 = Fe(Citrate)-
log_k 6.1
delta_h 0 kJ
-gamma 0 0
# Id: 2809671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + Citrate-3 + H+ = FeH(Citrate)
log_k 10.2
delta_h 0 kJ
-gamma 0 0
# Id: 2809672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Citrate-3 = Fe(Citrate)
log_k 13.1
delta_h 0 kJ
-gamma 0 0
# Id: 2819671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Citrate-3 + H+ = FeH(Citrate)+
log_k 14.4
delta_h 0 kJ
-gamma 0 0
# Id: 2819672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + Citrate-3 = Mn(Citrate)-
log_k 4.28
delta_h 0 kJ
-gamma 0 0
# Id: 4709671
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Mn+2 + Citrate-3 + H+ = MnH(Citrate)
log_k 9.6
delta_h 0 kJ
-gamma 0 0
# Id: 4709672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Be+2 + Citrate-3 = Be(Citrate)-
log_k 5.534
delta_h 0 kJ
-gamma 0 0
# Id: 1109671
# log K source: NIST46.4
```

```
# Delta H source: NIST46.2
#T and ionic strength: 1.00 25.0
Be+2 + H+ + Citrate-3 = BeH(Citrate)
log_k 9.442
delta_h 0 kJ
-gamma 0 0
# Id: 1109672
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 25.0
Ca+2 + Citrate-3 = Ca(Citrate)-
log_k 4.87
delta_h -8.368 kJ
-gamma 0 0
# Id: 1509671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Citrate-3 + H+ = CaH(Citrate)
log_k 9.26
delta_h -0.8368 kJ
-gamma 0 0
# Id: 1509672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Citrate-3 + 2H+ = CaH2(Citrate)+
log_k 12.257
delta_h 0 kJ
-gamma 0 0
# Id: 1509673
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Mg+2 + Citrate-3 = Mg(Citrate)-
log_k 4.89
delta_h 8.368 kJ
-gamma 0 0
# Id: 4609671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mg+2 + Citrate-3 + H+ = MgH(Citrate)
log_k 8.91
delta_h 3.3472 kJ
-gamma 0 0
# Id: 4609672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mg+2 + Citrate-3 + 2H+ = MgH2(Citrate)+
log_k 12.2
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 4609673
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Sr+2 + Citrate-3 = Sr(Citrate)-
log_k 4.3367
delta_h 0 kJ
-gamma 0 0
# Id: 8009671
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Sr+2 + H+ + Citrate-3 = SrH(Citrate)
log_k 8.9738
delta_h 0 kJ
-gamma 0 0
# Id: 8009672
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Sr+2 + 2H+ + Citrate-3 = SrH2(Citrate)+
log_k 12.4859
delta_h 0 kJ
-gamma 0 0
# Id: 8009673
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Ba+2 + Citrate-3 = Ba(Citrate)-
log_k 4.1
delta_h 0 kJ
-gamma 0 0
# Id: 1009671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ba+2 + Citrate-3 + H+ = BaH(Citrate)
log_k 8.74
delta_h 0 kJ
-gamma 0 0
# Id: 1009672
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ba+2 + Citrate-3 + 2H+ = BaH2(Citrate)+
log_k 12.3
delta_h 0 kJ
-gamma 0 0
# Id: 1009673
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Na+ + Citrate-3 = Na(Citrate)-2
log_k 1.03
```

```
delta_h -2.8033 kJ
-gamma 0 0
# Id: 5009671
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
2Na+ + Citrate-3 = Na2(Citrate)-
log_k 1.5
delta_h -5.1045 kJ
-gamma 0 0
# Id: 5009672
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Na+ + Citrate-3 + H+ = NaH(Citrate)-
log_k 6.45
delta_h -3.5982 kJ
-gamma 0 0
# Id: 5009673
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
K+ + Citrate-3 = K(Citrate)-2
log_k 1.1
delta_h 5.4392 kJ
-gamma 0 0
# Id: 4109671
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Nta-3 = H(Nta)-2
log_k 10.278
delta_h -18.828 kJ
-gamma 0 0
# Id: 3309681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Nta-3 = H2(Nta)-
log_k 13.22
delta_h -17.9912 kJ
-gamma 0 0
# Id: 3309682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
3H+ + Nta-3 = H3(Nta)
log_k 15.22
delta_h -16.3176 kJ
-gamma 0 0
# Id: 3309683
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
4H+ + Nta-3 = H4(Nta)+
log_k 16.22
delta_h -16.3176 kJ
-gamma 0 0
# Id: 3309684
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Nta-3 = Pb(Nta)-
log_k 12.7
delta_h -15.8992 kJ
-gamma 0 0
# Id: 6009681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Nta-3 + H+ = PbH(Nta)
log_k 15.3
delta_h 0 kJ
-gamma 0 0
# Id: 6009682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Nta-3 = Al(Nta)
log_k 13.3
delta_h 0 kJ
-gamma 0 0
# Id: 309681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Nta-3 + H+ = AlH(Nta)+
log_k 15.2
delta_h 0 kJ
-gamma 0 0
# Id: 309682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Nta-3 + H2O = AlOH(Nta)- + H+
log_k 8
delta_h 0 kJ
-gamma 0 0
# Id: 309683
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Tl+ + Nta-3 = Tl(Nta)-2
log_k 5.39
delta_h 0 kJ
-gamma 0 0
# Id: 8709681
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Nta-3 = Zn(Nta)-
log_k 11.95
delta_h -3.7656 kJ
-gamma 0 0
# Id: 9509681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 2Nta-3 = Zn(Nta)2-4
log_k 14.88
delta_h -15.0624 kJ
-gamma 0 0
# Id: 9509682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Nta-3 + H2O = ZnOH(Nta)-2 + H+
log_k 1.46
delta_h 46.4424 kJ
-gamma 0 0
# Id: 9509683
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Nta-3 = Cd(Nta)-
log_k 11.07
delta_h -16.736 kJ
-gamma 0 0
# Id: 1609681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 2Nta-3 = Cd(Nta)2-4
log_k 15.03
delta_h -38.0744 kJ
-gamma 0 0
# Id: 1609682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Nta-3 + H2O = CdOH(Nta)-2 + H+
log_k -0.61
delta_h 29.288 kJ
-gamma 0 0
# Id: 1609683
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Nta-3 + 2H+ = Hg(Nta)- + 2H2O
log_k 21.7
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 3619681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Nta-3 = Cu(Nta)-
log_k 14.4
delta_h -7.9496 kJ
-gamma 0 0
# Id: 2319681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Nta-3 = Cu(Nta)2-4
log_k 18.1
delta_h -37.2376 kJ
-gamma 0 0
# Id: 2319682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Nta-3 + H+ = CuH(Nta)
log_k 16.2
delta_h 0 kJ
-gamma 0 0
# Id: 2319683
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Nta-3 + H2O = CuOH(Nta)-2 + H+
log_k 4.8
delta_h 25.5224 kJ
-gamma 0 0
# Id: 2319684
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Nta-3 = Ag(Nta)-2
log_k 6
delta_h -26.3592 kJ
-gamma 0 0
# Id: 209681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Nta-3 = Ni(Nta)-
log_k 12.79
delta_h -10.0416 kJ
-gamma 0 0
# Id: 5409681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 2Nta-3 = Ni(Nta)2-4
log_k 16.96
```

```
delta_h -32.6352 kJ
-gamma 0 0
# Id: 5409682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Nta-3 + H2O = NiOH(Nta)-2 + H+
log_k 1.5
delta_h 15.0624 kJ
-gamma 0 0
# Id: 5409683
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Nta-3 = Co(Nta)-
log_k 11.6667
delta_h -0.4 kJ
-gamma 0 0
# Id: 2009681
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+2 + 2Nta-3 = Co(Nta)2-4
log_k 14.9734
delta_h -20 kJ
-gamma 0 0
# Id: 2009682
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+2 + Nta-3 + H2O = CoOH(Nta)-2 + H+
log_k 0.4378
delta_h 45.6 kJ
-gamma 0 0
# Id: 2009683
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Fe+2 + Nta-3 = Fe(Nta)-
log_k 10.19
delta_h 0 kJ
-gamma 0 0
# Id: 2809681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + 2Nta-3 = Fe(Nta)2-4
log_k 12.62
delta_h 0 kJ
-gamma 0 0
# Id: 2809682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Fe+2 + Nta-3 + H+ = FeH(Nta)
log_k 12.29
delta_h 0 kJ
-gamma 0 0
# Id: 2809683
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + Nta-3 + H2O = FeOH(Nta)-2 + H+
log_k -1.06
delta_h 0 kJ
-gamma 0 0
# Id: 2809684
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Nta-3 = Fe(Nta)
log_k 17.8
delta_h 13.3888 kJ
-gamma 0 0
# Id: 2819681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + 2Nta-3 = Fe(Nta)2-3
log_k 25.9
delta_h 0 kJ
-gamma 0 0
# Id: 2819682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Nta-3 + H2O = FeOH(Nta)- + H+
log_k 13.23
delta_h 0 kJ
-gamma 0 0
# Id: 2819683
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + Nta-3 = Mn(Nta)-
log_k 8.573
delta_h 5.8576 kJ
-gamma 0 0
# Id: 4709681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + 2Nta-3 = Mn(Nta)2-4
log_k 11.58
delta_h -17.1544 kJ
-gamma 0 0
# Id: 4709682
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Cr(OH)2+ + Nta-3 + 2H+ = Cr(Nta) + 2H2O
log_k 21.2
delta_h 0 kJ
-gamma 0 0
# Id: 2119681
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + 2Nta-3 + 2H+ = Cr(Nta)2-3 + 2H2O
log_k 29.5
delta_h 0 kJ
-gamma 0 0
# Id: 2119682
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
MoO4-2 + 2H+ + Nta-3 = MoO3(Nta)-3 + H2O
log_k 19.5434
delta_h -69 kJ
-gamma 0 0
# Id: 4809681
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
MoO4-2 + 3H+ + Nta-3 = MoO3H(Nta)-2 + H2O
log_k 23.3954
delta_h -71 kJ
-gamma 0 0
# Id: 4809682
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 1.00 25.0
MoO4-2 + 4H+ + Nta-3 = MoO3H2(Nta)- + H2O
log_k 25.3534
delta_h -71 kJ
-gamma 0 0
# Id: 4809683
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 1.00 25.0
Be+2 + Nta-3 = Be(Nta)-
log_k 9.0767
delta_h 25 kJ
-gamma 0 0
# Id: 1109681
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Mg+2 + Nta-3 = Mg(Nta)-
log_k 6.5
delta_h 17.9912 kJ
-gamma 0 0
```

```
# Id: 4609681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Nta-3 = Ca(Nta)-
log_k 7.608
delta_h -5.6902 kJ
-gamma 0 0
# Id: 1509681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + 2Nta-3 = Ca(Nta)2-4
log_k 8.81
delta_h -32.6352 kJ
-gamma 0 0
# Id: 1509682
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Sr+2 + Nta-3 = Sr(Nta)-
log_k 6.2767
delta_h -2.2 kJ
-gamma 0 0
# Id: 8009681
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Ba+2 + Nta-3 = Ba(Nta)-
log_k 5.875
delta_h -6.025 kJ
-gamma 0 0
# Id: 1009681
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Edta-4 = H(Edta)-3
log_k 10.948
delta_h -23.4304 kJ
-gamma 0 0
# Id: 3309691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Edta-4 = H2(Edta)-2
log_k 17.221
delta_h -41.0032 kJ
-gamma 0 0
# Id: 3309692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
3H+ + Edta-4 = H3(Edta)-
log_k 20.34
```

```
delta_h -35.564 kJ
-gamma 0 0
# Id: 3309693
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
4H+ + Edta-4 = H4(Edta)
log_k 22.5
delta_h -34.3088 kJ
-gamma 0 0
# Id: 3309694
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
5H+ + Edta-4 = H5(Edta)+
log_k 24
delta_h -32.2168 kJ
-gamma 0 0
# Id: 3309695
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Sn(OH)2 + 2H+ + Edta-4 = Sn(Edta)-2 + 2H2O
log_k 27.026
delta_h 0 kJ
-gamma 0 0
# Id: 7909691
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 20.0
Sn(OH)2 + 3H+ + Edta-4 = SnH(Edta)- + 2H2O
log_k 29.934
delta_h 0 kJ
-gamma 0 0
# Id: 7909692
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 20.0
Sn(OH)2 + 4H+ + Edta-4 = SnH2(Edta) + 2H2O
log_k 31.638
delta_h 0 kJ
-gamma 0 0
# Id: 7909693
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 20.0
Pb+2 + Edta-4 = Pb(Edta)-2
log_k 19.8
delta_h -54.8104 kJ
-gamma 0 0
# Id: 6009691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Pb+2 + Edta-4 + H+ = PbH(Edta)-
log_k 23
delta_h 0 kJ
-gamma 0 0
# Id: 6009692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Edta-4 + 2H+ = PbH2(Edta)
log_k 24.9
delta_h 0 kJ
-gamma 0 0
# Id: 6009693
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Edta-4 = Al(Edta)-
log_k 19.1
delta_h 52.7184 kJ
-gamma 0 0
# Id: 309690
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Edta-4 + H+ = AlH(Edta)
log_k 21.8
delta_h 36.4008 kJ
-gamma 0 0
# Id: 309691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Edta-4 + H2O = AlOH(Edta)-2 + H+
log_k 12.8
delta_h 73.6384 kJ
-gamma 0 0
# Id: 309692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Tl+ + Edta-4 = Tl(Edta)-3
log_k 7.27
delta_h -43.5136 kJ
-gamma 0 0
# Id: 8709691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Tl+ + Edta-4 + H+ = TlH(Edta)-2
log_k 13.68
delta_h 0 kJ
-gamma 0 0
# Id: 8709692
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Edta-4 = Zn(Edta)-2
log_k 18
delta_h -19.2464 kJ
-gamma 0 0
# Id: 9509691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Edta-4 + H+ = ZnH(Edta)-
log_k 21.4
delta_h -28.4512 kJ
-gamma 0 0
# Id: 9509692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Edta-4 + H2O = ZnOH(Edta)-3 + H+
log_k 5.8
delta_h 0 kJ
-gamma 0 0
# Id: 9509693
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Edta-4 = Cd(Edta)-2
log_k 18.2
delta_h -38.0744 kJ
-gamma 0 0
# Id: 1609691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Edta-4 + H+ = CdH(Edta)-
log_k 21.5
delta_h -39.748 kJ
-gamma 0 0
# Id: 1609692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Edta-4 + 2H+ = Hg(Edta)-2 + 2H2O
log_k 29.3
delta_h -125.102 kJ
-gamma 0 0
# Id: 3619691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Edta-4 + 3H+ = HgH(Edta)- + 2H2O
log_k 32.9
delta_h -128.449 kJ
-gamma 0 0
```

```
# Id: 3619692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Edta-4 = Cu(Edta)-2
log_k 20.5
delta_h -34.7272 kJ
-gamma 0 0
# Id: 2319691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Edta-4 + H+ = CuH(Edta)-
log_k 24
delta_h -43.0952 kJ
-gamma 0 0
# Id: 2319692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Edta-4 + 2H+ = CuH2(Edta)
log_k 26.2
delta_h 0 kJ
-gamma 0 0
# Id: 2319693
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Edta-4 + H2O = CuOH(Edta)-3 + H+
log_k 8.5
delta_h 0 kJ
-gamma 0 0
# Id: 2319694
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Edta-4 = Ag(Edta)-3
log_k 8.08
delta_h -31.38 kJ
-gamma 0 0
# Id: 209691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Edta-4 + H+ = AgH(Edta)-2
log_k 15.21
delta_h 0 kJ
-gamma 0 0
# Id: 209693
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ni+2 + Edta-4 = Ni(Edta)-2
log_k 20.1
```

```
delta_h -30.9616 kJ
-gamma 0 0
# Id: 5409691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Edta-4 + H+ = NiH(Edta)-
log_k 23.6
delta_h -38.4928 kJ
-gamma 0 0
# Id: 5409692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Edta-4 + H2O = NiOH(Edta)-3 + H+
log_k 7.6
delta_h 0 kJ
-gamma 0 0
# Id: 5409693
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Edta-4 = Co(Edta)-2
log_k 18.1657
delta_h -15 kJ
-gamma 0 0
# Id: 2009691
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+2 + Edta-4 + H+ = CoH(Edta)-
log_k 21.5946
delta_h -22.9 kJ
-gamma 0 0
# Id: 2009692
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Co+2 + Edta-4 + 2H+ = CoH2(Edta)
log_k 23.4986
delta_h 0 kJ
-gamma 0 0
# Id: 2009693
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 25.0
Co+3 + Edta-4 = Co(Edta)-
log_k 43.9735
delta_h 0 kJ
-gamma 0 0
# Id: 2019691
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
```

```
Co+3 + Edta-4 + H+ = CoH(Edta)
log_k 47.168
delta_h 0 kJ
-gamma 0 0
# Id: 2019692
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
Fe+2 + Edta-4 = Fe(Edta)-2
log_k 16
delta_h -16.736 kJ
-gamma 0 0
# Id: 2809690
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + Edta-4 + H+ = FeH(Edta)-
log_k 19.06
delta_h -27.6144 kJ
-gamma 0 0
# Id: 2809691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + Edta-4 + H2O = FeOH(Edta)-3 + H+
log_k 6.5
delta_h 0 kJ
-gamma 0 0
# Id: 2809692
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Fe+2 + Edta-4 + 2H2O = Fe(OH)2(Edta)-4 + 2H+
log_k -4
delta_h 0 kJ
-gamma 0 0
# Id: 2809693
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Fe+3 + Edta-4 = Fe(Edta)-
log_k 27.7
delta_h -11.2968 kJ
-gamma 0 0
# Id: 2819690
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Edta-4 + H+ = FeH(Edta)
log_k 29.2
delta_h -11.7152 kJ
-gamma 0 0
# Id: 2819691
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Edta-4 + H2O = FeOH(Edta)-2 + H+
log_k 19.9
delta_h 0 kJ
-gamma 0 0
# Id: 2819692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Edta-4 + 2H2O = Fe(OH)2(Edta)-3 + 2H+
log_k 9.85
delta_h 0 kJ
-gamma 0 0
# Id: 2819693
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Mn+2 + Edta-4 = Mn(Edta)-2
log_k 15.6
delta_h -19.2464 kJ
-gamma 0 0
# Id: 4709691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + Edta-4 + H+ = MnH(Edta)-
log_k 19.1
delta_h -24.2672 kJ
-gamma 0 0
# Id: 4709692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cr+2 + Edta-4 = Cr(Edta)-2
log_k 15.3
delta_h 0 kJ
-gamma 0 0
# Id: 2109691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cr+2 + Edta-4 + H+ = CrH(Edta)-
log_k 19.1
delta_h 0 kJ
-gamma 0 0
# Id: 2109692
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + Edta-4 + 2H+ = Cr(Edta)- + 2H2O
log_k 35.5
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2119691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cr(OH)2+ + Edta-4 + 3H+ = CrH(Edta) + 2H2O
log_k 37.4
delta_h 0 kJ
-gamma 0 0
# Id: 2119692
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cr(OH)2+ + Edta-4 + H+ = CrOH(Edta)-2 + H2O
log_k 27.7
delta_h 0 kJ
-gamma 0 0
# Id: 2119693
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Be+2 + Edta-4 = Be(Edta)-2
log_k 11.4157
delta_h 41 kJ
-gamma 0 0
# Id: 1109691
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Mg+2 + Edta-4 = Mg(Edta)-2
log_k 10.57
delta_h 13.8072 kJ
-gamma 0 0
# Id: 4609690
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mg+2 + Edta-4 + H+ = MgH(Edta)-
log_k 14.97
delta_h 0 kJ
-gamma 0 0
# Id: 4609691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Edta-4 = Ca(Edta)-2
log_k 12.42
delta_h -25.5224 kJ
-gamma 0 0
# Id: 1509690
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Edta-4 + H+ = CaH(Edta)-
log_k 15.9
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 1509691
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Sr+2 + Edta-4 = Sr(Edta)-2
log_k 10.4357
delta_h -17 kJ
-gamma 0 0
# Id: 8009691
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Sr+2 + Edta-4 + H+ = SrH(Edta)-
log_k 14.7946
delta_h 0 kJ
-gamma 0 0
# Id: 8009692
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
Ba+2 + Edta-4 = Ba(Edta)-2
log_k 7.72
delta_h -20.5016 kJ
-gamma 0 0
# Id: 1009691
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Na+ + Edta-4 = Na(Edta)-3
log_k 2.7
delta_h -5.8576 kJ
-gamma 0 0
# Id: 5009690
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
K+ + Edta-4 = K(Edta)-3
log_k 1.7
delta_h 0 kJ
-gamma 0 0
# Id: 4109690
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Propionate- = H(Propionate)
log_k 4.874
delta_h 0.66 kJ
-gamma 0 0
# Id: 3309711
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
```

```
Pb+2 + Propionate- = Pb(Propionate)+
log_k 2.64
delta_h 0 kJ
-gamma 0 0
# Id: 6009711
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.00 35.0
Pb+2 + 2Propionate- = Pb(Propionate)2
log_k 3.1765
delta_h 0 kJ
-gamma 0 0
# Id: 6009712
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 2.00 25.0
Zn+2 + Propionate- = Zn(Propionate)+
log_k 1.4389
delta_h 0 kJ
-gamma 0 0
# Id: 9509711
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Zn+2 + 2Propionate- = Zn(Propionate)2
log_k 1.842
delta_h 0 kJ
-gamma 0 0
# Id: 9509712
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 25.0
Cd+2 + Propionate- = Cd(Propionate)+
log_k 1.598
delta_h 0 kJ
-gamma 0 0
# Id: 1609711
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 25.0
Cd+2 + 2Propionate- = Cd(Propionate)2
log_k 2.472
delta_h 0 kJ
-gamma 0 0
# Id: 1609712
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 25.0
Hg(OH)2 + 2H+ + Propionate- = Hg(Propionate)+ + 2H2O
log_k 10.594
delta_h 0 kJ
-gamma 0 0
# Id: 3619711
# log K source: NIST46.4
```

```
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Cu+2 + Propionate- = Cu(Propionate)+
log_k 2.22
delta_h 4.1 kJ
-gamma 0 0
# Id: 2319711
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cu+2 + 2Propionate- = Cu(Propionate)2
log_k 3.5
delta_h 0 kJ
-gamma 0 0
# Id: 2319712
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Ni+2 + Propionate- = Ni(Propionate)+
log_k 0.908
delta_h 0 kJ
-gamma 0 0
# Id: 5409711
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 1.00 25.0
Co+2 + Propionate- = Co(Propionate)+
log_k 0.671
delta_h 4.6 kJ
-gamma 0 0
# Id: 2009711
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 2.00 25.0
Co+2 + 2Propionate- = Co(Propionate)2
log_k 0.5565
delta_h 16 kJ
-gamma 0 0
# Id: 2009712
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 2.00 25.0
Fe+3 + Propionate- = Fe(Propionate)+2
log_k 4.012
delta_h 0 kJ
-gamma 0 0
# Id: 2819711
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 20.0
Cr(OH)2+ + 2H+ + Propionate- = Cr(Propionate)+2 + 2H2O
log_k 15.0773
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2119711
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.50 25.0
Cr(OH)2+ + 2H+ + 2Propionate- = Cr(Propionate)2+ + 2H2O
log_k 17.9563
delta_h 0 kJ
-gamma 0 0
# Id: 2119712
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.50 25.0
Cr(OH)2+ + 2H+ + 3Propionate- = Cr(Propionate)3 + 2H2O
log_k 20.8858
delta_h 0 kJ
-gamma 0 0
# Id: 2119713
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.50 25.0
Mg+2 + Propionate- = Mg(Propionate)+
log_k 0.9689
delta_h 4.2677 kJ
-gamma 0 0
# Id: 4609710
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.10 25.0
Ca+2 + Propionate- = Ca(Propionate)+
log_k 0.9289
delta_h 3.3472 kJ
-gamma 0 0
# Id: 1509710
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.10 25.0
Sr+2 + Propionate- = Sr(Propionate)+
log_k 0.8589
delta_h 0 kJ
-gamma 0 0
# Id: 8009711
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Ba+2 + Propionate- = Ba(Propionate)+
log_k 0.7689
delta_h 0 kJ
-gamma 0 0
# Id: 1009711
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.10 25.0
Ba+2 + 2Propionate- = Ba(Propionate)2
log_k 0.9834
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 1009712
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.10 25.0
H+ + Butyrate- = H(Butyrate)
log_k 4.819
delta_h 2.8 kJ
-gamma 0 0
# Id: 3309721
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Pb+2 + Butyrate- = Pb(Butyrate)+
log_k 2.101
delta_h 0 kJ
-gamma 0 0
# Id: 6009721
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 2.00 25.0
Zn+2 + Butyrate- = Zn(Butyrate)+
log_k 1.4289
delta_h 0 kJ
-gamma 0 0
# Id: 9509721
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Hg(OH)2 + 2H+ + Butyrate- = Hg(Butyrate)+ + 2H2O
log_k 10.3529
delta_h 0 kJ
-gamma 0 0
# Id: 3619721
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Cu+2 + Butyrate- = Cu(Butyrate)+
log_k 2.14
delta_h 0 kJ
-gamma 0 0
# Id: 2319721
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Ni+2 + Butyrate- = Ni(Butyrate)+
log_k 0.691
delta_h 0 kJ
-gamma 0 0
# Id: 5409721
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 2.00 25.0
```

```
Co+2 + Butyrate- = Co(Butyrate)+
log_k 0.591
delta_h 0 kJ
-gamma 0 0
# Id: 2009721
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 2.00 25.0
Co+2 + 2Butyrate- = Co(Butyrate)2
log_k 0.7765
delta_h 0 kJ
-gamma 0 0
# Id: 2009722
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 2.00 25.0
Mg+2 + Butyrate- = Mg(Butyrate)+
log_k 0.9589
delta_h 0 kJ
-gamma 0 0
# Id: 4609720
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.10 25.0
Ca+2 + Butyrate- = Ca(Butyrate)+
log_k 0.9389
delta_h 3.3472 kJ
-gamma 0 0
# Id: 1509720
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.10 25.0
Sr+2 + Butyrate- = Sr(Butyrate)+
log_k 0.7889
delta_h 0 kJ
-gamma 0 0
# Id: 8009721
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Ba+2 + Butyrate- = Ba(Butyrate)+
log_k 0.7389
delta_h 0 kJ
-gamma 0 0
# Id: 1009721
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 0.10 25.0
Ba+2 + 2Butyrate- = Ba(Butyrate)2
log_k 0.88
delta_h 0 kJ
-gamma 0 0
# Id: 1009722
# log K source: SCD2.62
```

```
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Isobutyrate- = H(Isobutyrate)
log_k 4.849
delta_h 3.2217 kJ
-gamma 0 0
# Id: 3309731
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Isobutyrate- = Zn(Isobutyrate)+
log_k 1.44
delta_h 0 kJ
-gamma 0 0
# Id: 9509731
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Isobutyrate- = Cu(Isobutyrate)+
log_k 2.17
delta_h 0 kJ
-gamma 0 0
# Id: 2319731
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Isobutyrate- = Cu(Isobutyrate)2
log_k 3.3
delta_h 0 kJ
-gamma 0 0
# Id: 2319732
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Isobutyrate- = Fe(Isobutyrate)+2
log_k 4.2
delta_h 0 kJ
-gamma 0 0
# Id: 2819731
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Isobutyrate- = Ca(Isobutyrate)+
log_k 0.51
delta_h 0 kJ
-gamma 0 0
# Id: 1509731
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Two_picoline = H(Two_picoline)+
log_k 5.95
delta_h -25.5224 kJ
-gamma 0 0
```

```
# Id: 3309801
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Two_picoline = Cu(Two_picoline)+2
log_k 1.3
delta_h 0 kJ
-gamma 0 0
# Id: 2319801
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Two_picoline = Cu(Two_picoline)2+2
log_k 2.8
delta_h 0 kJ
-gamma 0 0
# Id: 2319802
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + Two_picoline = Cu(Two_picoline)+
log_k 5.4
delta_h 0 kJ
-gamma 0 0
# Id: 2309801
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 2Two_picoline = Cu(Two_picoline)2+
log_k 7.65
delta_h 0 kJ
-gamma 0 0
# Id: 2309802
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 3Two_picoline = Cu(Two_picoline)3+
log_k 8.5
delta_h 0 kJ
-gamma 0 0
# Id: 2309803
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Two_picoline = Ag(Two_picoline)+
log_k 2.32
delta_h -24.2672 kJ
-gamma 0 0
# Id: 209801
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Two_picoline = Ag(Two_picoline)2+
log_k 4.68
```

```
delta_h -42.6768 kJ
-gamma 0 0
# Id: 209802
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Two_picoline = Ni(Two_picoline)+2
log_k 0.4
delta_h 0 kJ
-gamma 0 0
# Id: 5409801
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Three_picoline = H(Three_picoline)+
log_k 5.7
delta_h -23.8488 kJ
-gamma 0 0
# Id: 3309811
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Three_picoline = Zn(Three_picoline)+2
log_k 1
delta_h 0 kJ
-gamma 0 0
# Id: 9509811
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 2Three_picoline = Zn(Three_picoline)2+2
log_k 2.1
delta_h 0 kJ
-gamma 0 0
# Id: 9509812
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 3Three_picoline = Zn(Three_picoline)3+2
log_k 2.6
delta_h 0 kJ
-gamma 0 0
# Id: 9509813
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 4Three_picoline = Zn(Three_picoline)4+2
log_k 3.7
delta_h 0 kJ
-gamma 0 0
# Id: 9509814
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Cd+2 + Three_picoline = Cd(Three_picoline)+2
log_k 1.42
delta_h 0 kJ
-gamma 0 0
# Id: 1609811
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 2Three_picoline = Cd(Three_picoline)2+2
log_k 2.27
delta_h 0 kJ
-gamma 0 0
# Id: 1609812
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 3Three_picoline = Cd(Three_picoline)3+2
log_k 3.6
delta_h 0 kJ
-gamma 0 0
# Id: 1609813
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 4Three_picoline = Cd(Three_picoline)4+2
log_k 4
delta_h 0 kJ
-gamma 0 0
# Id: 1609814
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + Three_picoline = Cu(Three_picoline)+
log_k 5.6
delta_h 0 kJ
-gamma 0 0
# Id: 2309811
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 2Three_picoline = Cu(Three_picoline)2+
log_k 7.78
delta_h 0 kJ
-gamma 0 0
# Id: 2309812
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 3Three_picoline = Cu(Three_picoline)3+
log_k 8.6
delta_h 0 kJ
-gamma 0 0
# Id: 2309813
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 4Three_picoline = Cu(Three_picoline)4+
log_k 9
delta_h 0 kJ
-gamma 0 0
# Id: 2309814
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Three_picoline = Cu(Three_picoline)+2
log_k 2.77
delta_h 0 kJ
-gamma 0 0
# Id: 2319811
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Three_picoline = Cu(Three_picoline)2+2
log_k 4.8
delta_h 0 kJ
-gamma 0 0
# Id: 2319812
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 3Three_picoline = Cu(Three_picoline)3+2
log_k 6.3
delta_h 0 kJ
-gamma 0 0
# Id: 2319813
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 4Three_picoline = Cu(Three_picoline)4+2
log_k 7.2
delta_h 0 kJ
-gamma 0 0
# Id: 2319814
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Three_picoline = Ag(Three_picoline)+
log_k 2.2
delta_h -21.7568 kJ
-gamma 0 0
# Id: 209811
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Three_picoline = Ag(Three_picoline)2+
log_k 4.46
delta_h -49.7896 kJ
-gamma 0 0
```

```
# Id: 209812
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Three_picoline = Ni(Three_picoline)+2
log_k 1.87
delta_h 0 kJ
-gamma 0 0
# Id: 5409811
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 2Three_picoline = Ni(Three_picoline)2+2
log_k 3.3
delta_h 0 kJ
-gamma 0 0
# Id: 5409812
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 3Three_picoline = Ni(Three_picoline)3+2
log_k 4.1
delta_h 0 kJ
-gamma 0 0
# Id: 5409813
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 4Three_picoline = Ni(Three_picoline)4+2
log_k 4.6
delta_h 0 kJ
-gamma 0 0
# Id: 5409814
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Three_picoline = Co(Three_picoline)+2
log_k 1.4
delta_h 0 kJ
-gamma 0 0
# Id: 2009811
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
Co+2 + 2Three_picoline = Co(Three_picoline)2+2
log_k 2.2
delta_h 0 kJ
-gamma 0 0
# Id: 2009812
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
Co+2 + 3Three_picoline = Co(Three_picoline)3+2
log_k 2.5
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 2009813
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
H+ + Four_picoline = H(Four_picoline)+
log_k 6.03
delta_h -25.3132 kJ
-gamma 0 0
# Id: 3309821
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Four_picoline = Zn(Four_picoline)+2
log_k 1.4
delta_h 0 kJ
-gamma 0 0
# Id: 9509821
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 2Four_picoline = Zn(Four_picoline)2+2
log_k 2.11
delta_h 0 kJ
-gamma 0 0
# Id: 9509822
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 3Four_picoline = Zn(Four_picoline)3+2
log_k 2.85
delta_h 0 kJ
-gamma 0 0
# Id: 9509823
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Four_picoline = Cd(Four_picoline)+2
log_k 1.59
delta_h 0 kJ
-gamma 0 0
# Id: 1609821
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 2Four_picoline = Cd(Four_picoline)2+2
log_k 2.4
delta_h 0 kJ
-gamma 0 0
# Id: 1609822
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
```

```
Cd+2 + 3Four_picoline = Cd(Four_picoline)3+2
log_k 3.18
delta_h 0 kJ
-gamma 0 0
# Id: 1609823
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + 4Four_picoline = Cd(Four_picoline)4+2
log_k 4
delta_h 0 kJ
-gamma 0 0
# Id: 1609824
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + Four_picoline = Cu(Four_picoline)+
log_k 5.65
delta_h 0 kJ
-gamma 0 0
# Id: 2309821
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 2Four_picoline = Cu(Four_picoline)2+
log_k 8.2
delta_h 0 kJ
-gamma 0 0
# Id: 2309822
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 3Four_picoline = Cu(Four_picoline)3+
log_k 8.8
delta_h 0 kJ
-gamma 0 0
# Id: 2309823
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+ + 4Four_picoline = Cu(Four_picoline)4+
log_k 9.2
delta_h 0 kJ
-gamma 0 0
# Id: 2309824
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Four_picoline = Cu(Four_picoline)+2
log_k 2.88
delta_h 0 kJ
-gamma 0 0
# Id: 2319821
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Four_picoline = Cu(Four_picoline)2+2
log_k 5.16
delta_h 0 kJ
-gamma 0 0
# Id: 2319822
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 3Four_picoline = Cu(Four_picoline)3+2
log_k 6.77
delta_h 0 kJ
-gamma 0 0
# Id: 2319823
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 4Four_picoline = Cu(Four_picoline)4+2
log_k 8.08
delta_h 0 kJ
-gamma 0 0
# Id: 2319824
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 5Four_picoline = Cu(Four_picoline)5+2
log_k 8.3
delta_h 0 kJ
-gamma 0 0
# Id: 2319825
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Four_picoline = Ag(Four_picoline)+
log_k 2.03
delta_h -25.5224 kJ
-gamma 0 0
# Id: 209821
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Four_picoline = Ag(Four_picoline)2+
log_k 4.39
delta_h -53.5552 kJ
-gamma 0 0
# Id: 209822
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Four_picoline = Ni(Four_picoline)+2
log_k 2.11
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 5409821
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 2Four_picoline = Ni(Four_picoline)2+2
log_k 3.59
delta_h 0 kJ
-gamma 0 0
# Id: 5409822
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 3Four_picoline = Ni(Four_picoline)3+2
log_k 4.34
delta_h 0 kJ
-gamma 0 0
# Id: 5409823
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 4Four_picoline = Ni(Four_picoline)4+2
log_k 4.7
delta_h 0 kJ
-gamma 0 0
# Id: 5409824
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Four_picoline = Co(Four_picoline)+2
log_k 1.56
delta_h 0 kJ
-gamma 0 0
# Id: 2009821
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
Co+2 + 2Four_picoline = Co(Four_picoline)2+2
log_k 2.51
delta_h 0 kJ
-gamma 0 0
# Id: 2009822
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
Co+2 + 3Four_picoline = Co(Four_picoline)3+2
log_k 2.94
delta_h 0 kJ
-gamma 0 0
# Id: 2009823
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
Co+2 + 4Four_picoline = Co(Four_picoline)4+2
log_k 3.17
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 2009824
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
H+ + Formate- = H(Formate)
log_k 3.745
delta_h 0.1674 kJ
-gamma 0 0
# Id: 3309831
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Formate- = Pb(Formate)+
log_k 2.2
delta_h 0 kJ
-gamma 0 0
# Id: 6009831
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + Formate- = Zn(Formate)+
log_k 1.44
delta_h 0 kJ
-gamma 0 0
# Id: 9509831
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Formate- = Cd(Formate)+
log_k 1.7
delta_h 0 kJ
-gamma 0 0
# Id: 1609831
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Hg(OH)2 + Formate- + 2H+ = Hg(Formate)+ + 2H2O
log_k 9.6
delta_h 0 kJ
-gamma 0 0
# Id: 3619831
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Formate- = Cu(Formate)+
log_k 2
delta_h 0 kJ
-gamma 0 0
# Id: 2319831
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Ni+2 + Formate- = Ni(Formate)+
log_k 1.22
delta_h 0 kJ
-gamma 0 0
# Id: 5409831
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Co+2 + Formate- = Co(Formate)+
log_k 1.209
delta_h 0 kJ
-gamma 0 0
# Id: 2009831
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 30.0
Co+2 + 2Formate- = Co(Formate)2
log_k 1.1365
delta_h 0 kJ
-gamma 0 0
# Id: 2009832
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 2.00 25.0
Cr+2 + Formate- = Cr(Formate)+
log_k 1.07
delta_h 0 kJ
-gamma 0 0
# Id: 2109831
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mg+2 + Formate- = Mg(Formate)+
log_k 1.43
delta_h 0 kJ
-gamma 0 0
# Id: 4609831
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Formate- = Ca(Formate)+
log_k 1.43
delta_h 4.184 kJ
-gamma 0 0
# Id: 1509831
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Sr+2 + Formate- = Sr(Formate)+
log_k 1.39
delta_h 4 kJ
-gamma 0 0
# Id: 8009831
# log K source: NIST46.4
```

```
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ba+2 + Formate- = Ba(Formate)+
log_k 1.38
delta_h 0 kJ
-gamma 0 0
# Id: 1009831
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Isovalerate- = H(Isovalerate)
log_k 4.781
delta_h 4.5606 kJ
-gamma 0 0
# Id: 3309841
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Isovalerate- = Zn(Isovalerate)+
log_k 1.39
delta_h 0 kJ
-gamma 0 0
# Id: 9509841
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Isovalerate- = Cu(Isovalerate)+
log_k 2.08
delta_h 0 kJ
-gamma 0 0
# Id: 2319841
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Isovalerate- = Ca(Isovalerate)+
log_k 0.2
delta_h 0 kJ
-gamma 0 0
# Id: 1509841
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Valerate- = H(Valerate)
log_k 4.843
delta_h 2.887 kJ
-gamma 0 0
# Id: 3309851
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Valerate- = Cu(Valerate)+
log_k 2.12
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2319851
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Valerate- = Ca(Valerate)+
log_k 0.3
delta_h 0 kJ
-gamma 0 0
# Id: 1509851
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ba+2 + Valerate- = Ba(Valerate)+
log_k -0.2
delta_h 0 kJ
-gamma 0 0
# Id: 1009851
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Acetate- = H(Acetate)
log_k 4.757
delta_h 0.41 kJ
-gamma 0 0
# Id: 3309921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sn(OH)2 + 2H+ + Acetate- = Sn(Acetate)+ + 2H2O
log_k 10.0213
delta_h 0 kJ
-gamma 0 0
# Id: 7909921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 3.00 25.0
Sn(OH)2 + 2H+ + 2Acetate- = Sn(Acetate)2 + 2H2O
log_k 12.32
delta_h 0 kJ
-gamma 0 0
# Id: 7909922
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 3.00 25.0
Sn(OH)2 + 2H+ + 3Acetate- = Sn(Acetate)3- + 2H2O
log_k 13.55
delta_h 0 kJ
-gamma 0 0
# Id: 7909923
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 3.00 25.0
Pb+2 + Acetate- = Pb(Acetate)+
log_k 2.68
```

```
delta_h -0.4 kJ
-gamma 0 0
# Id: 6009921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Pb+2 + 2Acetate- = Pb(Acetate)2
log_k 4.08
delta_h -0.8 kJ
-gamma 0 0
# Id: 6009922
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Tl+ + Acetate- = Tl(Acetate)
log_k -0.11
delta_h 0 kJ
-gamma 0 0
# Id: 8709921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Zn+2 + Acetate- = Zn(Acetate)+
log_k 1.58
delta_h 8.3 kJ
-gamma 0 0
# Id: 9509921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Zn+2 + 2Acetate- = Zn(Acetate)2
log_k 2.6434
delta_h 22 kJ
-gamma 0 0
# Id: 9509922
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Cd+2 + Acetate- = Cd(Acetate)+
log_k 1.93
delta_h 9.6 kJ
-gamma 0 0
# Id: 1609921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cd+2 + 2Acetate- = Cd(Acetate)2
log_k 2.86
delta_h 15 kJ
-gamma 0 0
# Id: 1609922
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
```

```
Hg(OH)2 + 2H+ + Acetate- = Hg(Acetate)+ + 2H2O
log_k 10.494
delta_h 0 kJ
-gamma 0 0
# Id: 3619920
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Hg(OH)2 + 2H+ + 2Acetate- = Hg(Acetate)2 + 2H2O
log_k 13.83
delta_h 0 kJ
-gamma 0 0
# Id: 3619921
# log K source: NIST46.4
# Delta H source: SCD2.62
#T and ionic strength: 3.00 25.0
Cu+2 + Acetate- = Cu(Acetate)+
log_k 2.21
delta_h 7.1 kJ
-gamma 0 0
# Id: 2319921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cu+2 + 2Acetate- = Cu(Acetate)2
log_k 3.4
delta_h 12 kJ
-gamma 0 0
# Id: 2319922
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Cu+2 + 3Acetate- = Cu(Acetate)3-
log_k 3.9434
delta_h 6.2 kJ
-gamma 0 0
# Id: 2319923
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Ag+ + Acetate- = Ag(Acetate)
log_k 0.73
delta_h 3 kJ
-gamma 0 0
# Id: 209921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ag+ + 2Acetate- = Ag(Acetate)2-
log_k 0.64
delta_h 3 kJ
-gamma 0 0
# Id: 209922
# log K source: NIST46.4
```

```
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ni+2 + Acetate- = Ni(Acetate)+
log_k 1.37
delta_h 8.7 kJ
-gamma 0 0
# Id: 5409921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Ni+2 + 2Acetate- = Ni(Acetate)2
log_k 2.1
delta_h 10 kJ
-gamma 0 0
# Id: 5409922
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Co+2 + Acetate- = Co(Acetate)+
log_k 1.38
delta_h 0 kJ
-gamma 0 0
# Id: 2009921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Co+2 + 2Acetate- = Co(Acetate)2
log_k 0.7565
delta_h 0 kJ
-gamma 0 0
# Id: 2009922
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 2.00 25.0
Fe+2 + Acetate- = Fe(Acetate)+
log_k 1.4
delta_h 0 kJ
-gamma 0 0
# Id: 2809920
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Fe+3 + Acetate- = Fe(Acetate)+2
log_k 4.0234
delta_h 0 kJ
-gamma 0 0
# Id: 2819920
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
Fe+3 + 2Acetate- = Fe(Acetate)2+
log_k 7.5723
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2819921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
Fe+3 + 3Acetate- = Fe(Acetate)3
log_k 9.5867
delta_h 0 kJ
-gamma 0 0
# Id: 2819922
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
Mn+2 + Acetate- = Mn(Acetate)+
log_k 1.4
delta_h 0 kJ
-gamma 0 0
# Id: 4709920
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Cr+2 + Acetate- = Cr(Acetate)+
log_k 1.8
delta_h 0 kJ
-gamma 0 0
# Id: 2109921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Cr+2 + 2Acetate- = Cr(Acetate)2
log_k 2.92
delta_h 0 kJ
-gamma 0 0
# Id: 2109922
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Cr(OH)2+ + 2H+ + Acetate- = Cr(Acetate)+2 + 2H2O
log_k 15.0073
delta_h -125.62 kJ
-gamma 0 0
# Id: 2119921
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Cr(OH)2+ + 2H+ + 2Acetate- = Cr(Acetate)2+ + 2H2O
log_k 17.9963
delta_h -117.62 kJ
-gamma 0 0
# Id: 2119922
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Cr(OH)2+ + 2H+ + 3Acetate- = Cr(Acetate)3 + 2H2O
log_k 20.7858
```

```
delta_h -96.62 kJ
-gamma 0 0
# Id: 2119923
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.50 25.0
Be+2 + Acetate- = Be(Acetate)+
log_k 2.0489
delta_h 0 kJ
-gamma 0 0
# Id: 1109921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Be+2 + 2Acetate- = Be(Acetate)2
log_k 3.0034
delta_h 0 kJ
-gamma 0 0
# Id: 1109922
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Mg+2 + Acetate- = Mg(Acetate)+
log_k 1.27
delta_h 0 kJ
-gamma 0 0
# Id: 4609920
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Ca+2 + Acetate- = Ca(Acetate)+
log_k 1.18
delta_h 4 kJ
-gamma 0 0
# Id: 1509920
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Sr+2 + Acetate- = Sr(Acetate)+
log_k 1.14
delta_h 0 kJ
-gamma 0 0
# Id: 8009921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Ba+2 + Acetate- = Ba(Acetate)+
log_k 1.07
delta_h 0 kJ
-gamma 0 0
# Id: 1009921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
```

```
Na+ + Acetate- = Na(Acetate)
log_k -0.18
delta_h 12 kJ
-gamma 0 0
# Id: 5009920
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
K+ + Acetate- = K(Acetate)
log_k -0.1955
delta_h 4.184 kJ
-gamma 0 0
# Id: 4109921
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
H+ + Tartarate-2 = H(Tartarate)-
log_k 4.366
delta_h -0.7531 kJ
-gamma 0 0
# Id: 3309931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Tartarate-2 = H2(Tartarate)
log_k 7.402
delta_h -3.6819 kJ
-gamma 0 0
# Id: 3309932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Sn(OH)2 + 2H+ + Tartarate-2 = Sn(Tartarate) + 2H2O
log_k 13.1518
delta_h 0 kJ
-gamma 0 0
# Id: 7909931
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
Pb+2 + Tartarate-2 = Pb(Tartarate)
log_k 3.98
delta_h 0 kJ
-gamma 0 0
# Id: 6009931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + 2Tartarate-2 = Al(Tartarate)2-
log_k 9.37
delta_h 0 kJ
-gamma 0 0
# Id: 309931
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Tl+ + Tartarate-2 = Tl(Tartarate)-
log_k 1.4
delta_h 0 kJ
-gamma 0 0
# Id: 8709931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Tl+ + Tartarate-2 + H+ = TlH(Tartarate)
log_k 4.8
delta_h 0 kJ
-gamma 0 0
# Id: 8709932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Tartarate-2 = Zn(Tartarate)
log_k 3.43
delta_h 0 kJ
-gamma 0 0
# Id: 9509931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 2Tartarate-2 = Zn(Tartarate)2-2
log_k 5.5
delta_h 0 kJ
-gamma 0 0
# Id: 9509932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Tartarate-2 + H+ = ZnH(Tartarate)+
log_k 5.9
delta_h 0 kJ
-gamma 0 0
# Id: 9509933
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Tartarate-2 = Cd(Tartarate)
log_k 2.7
delta_h 0 kJ
-gamma 0 0
# Id: 1609931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 2Tartarate-2 = Cd(Tartarate)2-2
log_k 4.1
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 1609932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Tartarate-2 + 2H+ = Hg(Tartarate) + 2H2O
log_k 14
delta_h 0 kJ
-gamma 0 0
# Id: 3619931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Tartarate-2 = Cu(Tartarate)
log_k 3.97
delta_h 0 kJ
-gamma 0 0
# Id: 2319931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Tartarate-2 + H+ = CuH(Tartarate)+
log_k 6.7
delta_h 0 kJ
-gamma 0 0
# Id: 2319932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Tartarate-2 = Ni(Tartarate)
log_k 3.46
delta_h 0 kJ
-gamma 0 0
# Id: 5409931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Tartarate-2 + H+ = NiH(Tartarate)+
log_k 5.89
delta_h 0 kJ
-gamma 0 0
# Id: 5409932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Tartarate-2 = Co(Tartarate)
log_k 3.05
delta_h 0 kJ
-gamma 0 0
# Id: 2009931
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Co+2 + 2Tartarate-2 = Co(Tartarate)2-2
log_k 4
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 2009932
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Co+2 + H+ + Tartarate-2 = CoH(Tartarate)+
log_k 5.754
delta_h 0 kJ
-gamma 0 0
# Id: 2009933
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 1.00 20.0
Fe+2 + Tartarate-2 = Fe(Tartarate)
log_k 3.1
delta_h 0 kJ
-gamma 0 0
# Id: 2809931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Tartarate-2 = Fe(Tartarate)+
log_k 7.78
delta_h 0 kJ
-gamma 0 0
# Id: 2819931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + Tartarate-2 = Mn(Tartarate)
log_k 3.38
delta_h 0 kJ
-gamma 0 0
# Id: 4709931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + Tartarate-2 + H+ = MnH(Tartarate)+
log_k 6
delta_h 0 kJ
-gamma 0 0
# Id: 4709932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mg+2 + Tartarate-2 = Mg(Tartarate)
log_k 2.3
delta_h 0 kJ
-gamma 0 0
# Id: 4609931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Mg+2 + Tartarate-2 + H+ = MgH(Tartarate)+
log_k 5.75
delta_h 0 kJ
-gamma 0 0
# Id: 4609932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Be+2 + Tartarate-2 = Be(Tartarate)
log_k 2.768
delta_h 0 kJ
-gamma 0 0
# Id: 1109931
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
Be+2 + 2Tartarate-2 = Be(Tartarate)2-2
log_k 4.008
delta_h 0 kJ
-gamma 0 0
# Id: 1109932
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
Ca+2 + Tartarate-2 = Ca(Tartarate)
log_k 2.8
delta_h -8.368 kJ
-gamma 0 0
# Id: 1509931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Tartarate-2 + H+ = CaH(Tartarate)+
log_k 5.86
delta_h -9.1211 kJ
-gamma 0 0
# Id: 1509932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Sr+2 + Tartarate-2 = Sr(Tartarate)
log_k 2.55
delta_h 0 kJ
-gamma 0 0
# Id: 8009931
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 20.0
Sr+2 + H+ + Tartarate-2 = SrH(Tartarate)+
log_k 5.8949
delta_h 0 kJ
-gamma 0 0
# Id: 8009932
# log K source: NIST46.4
```

```
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Ba+2 + Tartarate-2 = Ba(Tartarate)
log_k 2.54
delta_h 0 kJ
-gamma 0 0
# Id: 1009931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ba+2 + Tartarate-2 + H+ = BaH(Tartarate)+
log_k 5.77
delta_h 0 kJ
-gamma 0 0
# Id: 1009932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Na+ + Tartarate-2 = Na(Tartarate)-
log_k 0.9
delta_h -0.8368 kJ
-gamma 0 0
# Id: 5009931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Na+ + Tartarate-2 + H+ = NaH(Tartarate)
log_k 4.58
delta_h -2.8451 kJ
-gamma 0 0
# Id: 5009932
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
K+ + Tartarate-2 = K(Tartarate)-
log_k 0.8
delta_h 0 kJ
-gamma 0 0
# Id: 4109931
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Glycine- = H(Glycine)
log_k 9.778
delta_h -44.3504 kJ
-gamma 0 0
# Id: 3309941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Glycine- = H2(Glycine)+
log_k 12.128
delta_h -48.4507 kJ
-gamma 0 0
```

```
# Id: 3309942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Glycine- = Pb(Glycine)+
log_k 5.47
delta_h 0 kJ
-gamma 0 0
# Id: 6009941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + 2Glycine- = Pb(Glycine)2
log_k 8.86
delta_h 0 kJ
-gamma 0 0
# Id: 6009942
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Tl+ + Glycine- = Tl(Glycine)
log_k 1.72
delta_h 0 kJ
-gamma 0 0
# Id: 8709941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Glycine- = Zn(Glycine)+
log_k 5.38
delta_h -11.7152 kJ
-gamma 0 0
# Id: 9509941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 2Glycine- = Zn(Glycine)2
log_k 9.81
delta_h -24.2672 kJ
-gamma 0 0
# Id: 9509942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 3Glycine- = Zn(Glycine)3-
log_k 12.3
delta_h -39.748 kJ
-gamma 0 0
# Id: 9509943
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Glycine- = Cd(Glycine)+
log_k 4.69
```

```
delta_h -8.7864 kJ
-gamma 0 0
# Id: 1609941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 2Glycine- = Cd(Glycine)2
log_k 8.4
delta_h -22.5936 kJ
-gamma 0 0
# Id: 1609942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 3Glycine- = Cd(Glycine)3-
log_k 10.7
delta_h -35.9824 kJ
-gamma 0 0
# Id: 1609943
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Glycine- + 2H+ = Hg(Glycine)+ + 2H2O
log_k 17
delta_h 0 kJ
-gamma 0 0
# Id: 3619941
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Hg(OH)2 + 2Glycine- + 2H+ = Hg(Glycine)2 + 2H2O
log_k 25.8
delta_h 0 kJ
-gamma 0 0
# Id: 3619942
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cu+ + 2Glycine- = Cu(Glycine)2-
log_k 10.3
delta_h 0 kJ
-gamma 0 0
# Id: 2309941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Glycine- = Cu(Glycine)+
log_k 8.57
delta_h -25.104 kJ
-gamma 0 0
# Id: 2319941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Cu+2 + 2Glycine- = Cu(Glycine)2
log_k 15.7
delta_h -54.8104 kJ
-gamma 0 0
# Id: 2319942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Glycine- = Ag(Glycine)
log_k 3.51
delta_h -19.2464 kJ
-gamma 0 0
# Id: 209941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Glycine- = Ag(Glycine)2-
log_k 6.89
delta_h -48.116 kJ
-gamma 0 0
# Id: 209942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Glycine- = Ni(Glycine)+
log_k 6.15
delta_h -18.828 kJ
-gamma 0 0
# Id: 5409941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 2Glycine- = Ni(Glycine)2
log_k 11.12
delta_h -38.0744 kJ
-gamma 0 0
# Id: 5409942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 3Glycine- = Ni(Glycine)3-
log_k 14.63
delta_h -62.3416 kJ
-gamma 0 0
# Id: 5409943
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Co+2 + Glycine- = Co(Glycine)+
log_k 5.07
delta_h -12 kJ
-gamma 0 0
# Id: 2009941
# log K source: NIST46.4
```

```
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Co+2 + 2Glycine- = Co(Glycine)2
log_k 9.07
delta_h -26 kJ
-gamma 0 0
# Id: 2009942
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Co+2 + 3Glycine- = Co(Glycine)3-
log_k 11.6
delta_h -41 kJ
-gamma 0 0
# Id: 2009943
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Co+2 + Glycine- + H2O = CoOH(Glycine) + H+
log_k -5.02
delta_h 0 kJ
-gamma 0 0
# Id: 2009944
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Fe+2 + Glycine- = Fe(Glycine)+
log_k 4.31
delta_h -15.0624 kJ
-gamma 0 0
# Id: 2809941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + 2Glycine- = Fe(Glycine)2
log_k 8.29
delta_h 0 kJ
-gamma 0 0
# Id: 2809942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Glycine- = Fe(Glycine)+2
log_k 9.38
delta_h 0 kJ
-gamma 0 0
# Id: 2819941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Glycine- + H+ = FeH(Glycine)+3
log_k 11.55
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2819942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + Glycine- = Mn(Glycine)+
log_k 3.19
delta_h -1.2552 kJ
-gamma 0 0
# Id: 4709941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + 2Glycine- = Mn(Glycine)2
log_k 5.4
delta_h 0 kJ
-gamma 0 0
# Id: 4709942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cr(OH)2+ + Glycine- + 2H+ = Cr(Glycine)+2 + 2H2O
log_k 18.7
delta_h 0 kJ
-gamma 0 0
# Id: 2119941
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + 2Glycine- + 2H+ = Cr(Glycine)2+ + 2H2O
log_k 25.6
delta_h 0 kJ
-gamma 0 0
# Id: 2119942
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + 3Glycine- + 2H+ = Cr(Glycine)3 + 2H2O
log_k 31.6
delta_h 0 kJ
-gamma 0 0
# Id: 2119943
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Mg+2 + Glycine- = Mg(Glycine)+
log_k 2.08
delta_h 4.184 kJ
-gamma 0 0
# Id: 4609941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Glycine- = Ca(Glycine)+
log_k 1.39
```

```
delta_h -4.184 kJ
-gamma 0 0
# Id: 1509941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Glycine- + H+ = CaH(Glycine)+2
log_k 10.1
delta_h -35.9824 kJ
-gamma 0 0
# Id: 1509942
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Sr+2 + Glycine- = Sr(Glycine)+
log_k 0.91
delta_h 0 kJ
-gamma 0 0
# Id: 8009941
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.00 25.0
Ba+2 + Glycine- = Ba(Glycine)+
log_k 0.77
delta_h 0 kJ
-gamma 0 0
# Id: 1009941
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Salicylate-2 = H(Salicylate)-
log_k 13.7
delta_h -35.7732 kJ
-gamma 0 0
# Id: 3309951
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Salicylate-2 = H2(Salicylate)
log_k 16.8
delta_h -38.7857 kJ
-gamma 0 0
# Id: 3309952
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Salicylate-2 = Zn(Salicylate)
log_k 7.71
delta_h 0 kJ
-gamma 0 0
# Id: 9509951
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
```

```
Zn+2 + Salicylate-2 + H+ = ZnH(Salicylate)+
log_k 15.5
delta_h 0 kJ
-gamma 0 0
# Id: 9509952
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Salicylate-2 = Cd(Salicylate)
log_k 6.2
delta_h 0 kJ
-gamma 0 0
# Id: 1609951
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Salicylate-2 + H+ = CdH(Salicylate)+
log_k 16
delta_h 0 kJ
-gamma 0 0
# Id: 1609952
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Salicylate-2 = Cu(Salicylate)
log_k 11.3
delta_h -17.9912 kJ
-gamma 0 0
# Id: 2319951
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Salicylate-2 = Cu(Salicylate)2-2
log_k 19.3
delta_h 0 kJ
-gamma 0 0
# Id: 2319952
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Salicylate-2 + H+ = CuH(Salicylate)+
log_k 14.8
delta_h 0 kJ
-gamma 0 0
# Id: 2319953
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Salicylate-2 = Ni(Salicylate)
log_k 8.2
delta_h 0 kJ
-gamma 0 0
# Id: 5409951
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 2Salicylate-2 = Ni(Salicylate)2-2
log_k 12.64
delta_h 0 kJ
-gamma 0 0
# Id: 5409952
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Co+2 + Salicylate-2 = Co(Salicylate)
log_k 7.4289
delta_h 0 kJ
-gamma 0 0
# Id: 2009951
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
Co+2 + 2Salicylate-2 = Co(Salicylate)2-2
log_k 11.8
delta_h 0 kJ
-gamma 0 0
# Id: 2009952
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 20.0
Fe+2 + Salicylate-2 = Fe(Salicylate)
log_k 7.2
delta_h 0 kJ
-gamma 0 0
# Id: 2809951
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+2 + 2Salicylate-2 = Fe(Salicylate)2-2
log_k 11.6
delta_h 0 kJ
-gamma 0 0
# Id: 2809952
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + Salicylate-2 = Fe(Salicylate)+
log_k 17.6
delta_h 0 kJ
-gamma 0 0
# Id: 2819951
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Fe+3 + 2Salicylate-2 = Fe(Salicylate)2-
log_k 29.3
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 2819952
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + Salicylate-2 = Mn(Salicylate)
log_k 6.5
delta_h 0 kJ
-gamma 0 0
# Id: 4709951
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mn+2 + 2Salicylate-2 = Mn(Salicylate)2-2
log_k 10.1
delta_h 0 kJ
-gamma 0 0
# Id: 4709952
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Be+2 + Salicylate-2 = Be(Salicylate)
log_k 13.3889
delta_h -31.7732 kJ
-gamma 0 0
# Id: 1109951
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.10 25.0
Be+2 + 2Salicylate-2 = Be(Salicylate)2-2
log_k 23.25
delta_h 0 kJ
-gamma 0 0
# Id: 1109952
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Mg+2 + Salicylate-2 = Mg(Salicylate)
log_k 5.76
delta_h 0 kJ
-gamma 0 0
# Id: 4609951
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Mg+2 + Salicylate-2 + H+ = MgH(Salicylate)+
log_k 15.3
delta_h 0 kJ
-gamma 0 0
# Id: 4609952
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ca+2 + Salicylate-2 = Ca(Salicylate)
log_k 4.05
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 1509951
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Salicylate-2 + H+ = CaH(Salicylate)+
log_k 14.3
delta_h 0 kJ
-gamma 0 0
# Id: 1509952
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ba+2 + Salicylate-2 + H+ = BaH(Salicylate)+
log_k 13.9
delta_h 0 kJ
-gamma 0 0
# Id: 1009951
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
H+ + Glutamate-2 = H(Glutamate)-
log_k 9.96
delta_h -41.0032 kJ
-gamma 0 0
# Id: 3309961
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Glutamate-2 = H2(Glutamate)
log_k 14.26
delta_h -43.5136 kJ
-gamma 0 0
# Id: 3309962
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
3H+ + Glutamate-2 = H3(Glutamate)+
log_k 16.42
delta_h -46.8608 kJ
-gamma 0 0
# Id: 3309963
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Glutamate-2 = Pb(Glutamate)
log_k 6.43
delta_h 0 kJ
-gamma 0 0
# Id: 6009961
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
```

```
Pb+2 + 2Glutamate-2 = Pb(Glutamate)2-2
log_k 8.61
delta_h 0 kJ
-gamma 0 0
# Id: 6009962
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Pb+2 + Glutamate-2 + H+ = PbH(Glutamate)+
log_k 14.08
delta_h 0 kJ
-gamma 0 0
# Id: 6009963
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Al+3 + Glutamate-2 + H+ = AlH(Glutamate)+2
log_k 13.07
delta_h 0 kJ
-gamma 0 0
# Id: 309961
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Glutamate-2 = Zn(Glutamate)
log_k 6.2
delta_h 0 kJ
-gamma 0 0
# Id: 9509961
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 2Glutamate-2 = Zn(Glutamate)2-2
log_k 9.13
delta_h 0 kJ
-gamma 0 0
# Id: 9509962
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Zn+2 + 3Glutamate-2 = Zn(Glutamate)3-4
log_k 9.8
delta_h 0 kJ
-gamma 0 0
# Id: 9509963
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cd+2 + Glutamate-2 = Cd(Glutamate)
log_k 4.7
delta_h 0 kJ
-gamma 0 0
# Id: 1609961
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 2Glutamate-2 = Cd(Glutamate)2-2
log_k 7.59
delta_h 0 kJ
-gamma 0 0
# Id: 1609962
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Hg(OH)2 + Glutamate-2 + 2H+ = Hg(Glutamate) + 2H2O
log_k 19.8
delta_h 0 kJ
-gamma 0 0
# Id: 3619961
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Hg(OH)2 + 2Glutamate-2 + 2H+ = Hg(Glutamate)2-2 + 2H2O
log_k 26.2
delta_h 0 kJ
-gamma 0 0
# Id: 3619962
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cu+2 + Glutamate-2 = Cu(Glutamate)
log_k 9.17
delta_h -20.92 kJ
-gamma 0 0
# Id: 2319961
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Glutamate-2 = Cu(Glutamate)2-2
log_k 15.78
delta_h -48.116 kJ
-gamma 0 0
# Id: 2319962
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Glutamate-2 + H+ = CuH(Glutamate)+
log_k 13.3
delta_h -28.0328 kJ
-gamma 0 0
# Id: 2319963
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + Glutamate-2 = Ag(Glutamate)-
log_k 4.22
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 209961
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ag+ + 2Glutamate-2 = Ag(Glutamate)2-3
log_k 7.36
delta_h 0 kJ
-gamma 0 0
# Id: 209962
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
2Ag+ + Glutamate-2 = Ag2(Glutamate)
log_k 3.4
delta_h 0 kJ
-gamma 0 0
# Id: 209963
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Glutamate-2 = Ni(Glutamate)
log_k 6.47
delta_h 0 kJ
-gamma 0 0
# Id: 5409961
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + 2Glutamate-2 = Ni(Glutamate)2-2
log_k 10.7
delta_h -30.9616 kJ
-gamma 0 0
# Id: 5409962
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Glutamate-2 = Co(Glutamate)
log_k 5.4178
delta_h 0 kJ
-gamma 0 0
# Id: 2009961
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Co+2 + 2Glutamate-2 = Co(Glutamate)2-2
log_k 8.7178
delta_h 0 kJ
-gamma 0 0
# Id: 2009962
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Mn+2 + Glutamate-2 = Mn(Glutamate)
log_k 4.95
```

```
delta_h 0 kJ
-gamma 0 0
# Id: 4709961
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Mn+2 + 2Glutamate-2 = Mn(Glutamate)2-2
log_k 8.48
delta_h 0 kJ
-gamma 0 0
# Id: 4709962
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + Glutamate-2 + 2H+ = Cr(Glutamate)+ + 2H2O
log_k 22.6
delta_h 0 kJ
-gamma 0 0
# Id: 2119961
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + 2Glutamate-2 + 2H+ = Cr(Glutamate)2- + 2H2O
log_k 30.7
delta_h 0 kJ
-gamma 0 0
# Id: 2119962
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + Glutamate-2 + 3H+ = CrH(Glutamate)+2 + 2H2O
log_k 25.2
delta_h 0 kJ
-gamma 0 0
# Id: 2119963
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Mg+2 + Glutamate-2 = Mg(Glutamate)
log_k 2.8
delta_h 0 kJ
-gamma 0 0
# Id: 4609961
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Glutamate-2 = Ca(Glutamate)
log_k 2.06
delta_h 0 kJ
-gamma 0 0
# Id: 1509961
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
```

```
Ca+2 + Glutamate-2 + H+ = CaH(Glutamate)+
log_k 11.13
delta_h 0 kJ
-gamma 0 0
# Id: 1509962
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Sr+2 + Glutamate-2 = Sr(Glutamate)
log_k 2.2278
delta_h 0 kJ
-gamma 0 0
# Id: 8009961
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Ba+2 + Glutamate-2 = Ba(Glutamate)
log_k 2.14
delta_h 0 kJ
-gamma 0 0
# Id: 1009961
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
H+ + Phthalate-2 = H(Phthalate)-
log_k 5.408
delta_h 2.1757 kJ
-gamma 0 0
# Id: 3309971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
2H+ + Phthalate-2 = H2(Phthalate)
log_k 8.358
delta_h 4.8534 kJ
-gamma 0 0
# Id: 3309972
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Phthalate-2 = Pb(Phthalate)
log_k 4.26
delta_h 0 kJ
-gamma 0 0
# Id: 6009971
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Pb+2 + 2Phthalate-2 = Pb(Phthalate)2-2
log_k 4.83
delta_h 0 kJ
-gamma 0 0
# Id: 6009972
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
Pb+2 + Phthalate-2 + H+ = PbH(Phthalate)+
log_k 6.98
delta_h 0 kJ
-gamma 0 0
# Id: 6009973
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + Phthalate-2 = Al(Phthalate)+
log_k 4.56
delta_h 0 kJ
-gamma 0 0
# Id: 309971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Al+3 + 2Phthalate-2 = Al(Phthalate)2-
log_k 7.2
delta_h 0 kJ
-gamma 0 0
# Id: 309972
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + Phthalate-2 = Zn(Phthalate)
log_k 2.91
delta_h 13.3888 kJ
-gamma 0 0
# Id: 9509971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Zn+2 + 2Phthalate-2 = Zn(Phthalate)2-2
log_k 4.2
delta_h 0 kJ
-gamma 0 0
# Id: 9509972
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Phthalate-2 = Cd(Phthalate)
log_k 3.43
delta_h 0 kJ
-gamma 0 0
# Id: 1609971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + Phthalate-2 + H+ = CdH(Phthalate)+
log_k 6.3
delta_h 0 kJ
-gamma 0 0
```

```
# Id: 1609973
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cd+2 + 2Phthalate-2 = Cd(Phthalate)2-2
log_k 3.7
delta_h 0 kJ
-gamma 0 0
# Id: 1609972
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Phthalate-2 = Cu(Phthalate)
log_k 4.02
delta_h 8.368 kJ
-gamma 0 0
# Id: 2319971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + Phthalate-2 + H+ = CuH(Phthalate)+
log_k 7.1
delta_h 3.8493 kJ
-gamma 0 0
# Id: 2319970
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cu+2 + 2Phthalate-2 = Cu(Phthalate)2-2
log_k 5.3
delta_h 15.8992 kJ
-gamma 0 0
# Id: 2319972
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Phthalate-2 = Ni(Phthalate)
log_k 2.95
delta_h 7.5312 kJ
-gamma 0 0
# Id: 5409971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ni+2 + Phthalate-2 + H+ = NiH(Phthalate)+
log_k 6.6
delta_h 0 kJ
-gamma 0 0
# Id: 5409972
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Co+2 + Phthalate-2 = Co(Phthalate)
log_k 2.83
```

```
delta_h 7.9 kJ
-gamma 0 0
# Id: 2009971
# log K source: NIST46.4
# Delta H source: NIST46.4
#T and ionic strength: 0.00 25.0
Co+2 + H+ + Phthalate-2 = CoH(Phthalate)+
log_k 7.227
delta_h 0 kJ
-gamma 0 0
# Id: 2009972
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.50 25.0
Mn+2 + Phthalate-2 = Mn(Phthalate)
log_k 2.74
delta_h 10.0416 kJ
-gamma 0 0
# Id: 4709971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Cr(OH)2+ + Phthalate-2 + 2H+ = Cr(Phthalate)+ + 2H2O
log_k 16.3
delta_h 0 kJ
-gamma 0 0
# Id: 2119971
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + 2Phthalate-2 + 2H+ = Cr(Phthalate)2- + 2H2O
log_k 21.2
delta_h 0 kJ
-gamma 0 0
# Id: 2119972
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Cr(OH)2+ + 3Phthalate-2 + 2H+ = Cr(Phthalate)3-3 + 2H2O
log_k 23.3
delta_h 0 kJ
-gamma 0 0
# Id: 2119973
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Be+2 + Phthalate-2 = Be(Phthalate)
log_k 4.8278
delta_h 0 kJ
-gamma 0 0
# Id: 1109971
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
```

```
Be+2 + 2Phthalate-2 = Be(Phthalate)2-2
log_k 6.5478
delta_h 0 kJ
-gamma 0 0
# Id: 1109972
# log K source: NIST46.4
# Delta H source: NIST46.2
#T and ionic strength: 0.10 25.0
Mg+2 + Phthalate-2 = Mg(Phthalate)
log_k 2.49
delta_h 0 kJ
-gamma 0 0
# Id: 4609971
# log K source: SCD2.62
# Delta H source: SCD2.62
#T and ionic strength:
Ca+2 + Phthalate-2 = Ca(Phthalate)
log_k 2.45
delta_h 0 kJ
-gamma 0 0
# Id: 1509970
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ca+2 + Phthalate-2 + H+ = CaH(Phthalate)+
log_k 6.43
delta_h 0 kJ
-gamma 0 0
# Id: 1509971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Ba+2 + Phthalate-2 = Ba(Phthalate)
log_k 2.33
delta_h 0 kJ
-gamma 0 0
# Id: 1009971
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
Na+ + Phthalate-2 = Na(Phthalate)-
log_k 0.8
delta_h 4.184 kJ
-gamma 0 0
# Id: 5009970
# log K source: NIST46.2
# Delta H source: NIST46.2
#T and ionic strength:
K+ + Phthalate-2 = K(Phthalate)-
log_k 0.7
delta_h 3.7656 kJ
-gamma 0 0
# Id: 4109971
# log K source: NIST46.2
```

```
# Delta H source: NIST46.2
#T and ionic strength:
PHASES
Sulfur
S + H+ + 2e- = HS-
log_k -2.1449
delta_h -16.3 kJ
Semetal(hex
Se + H+ + 2e- = HSe-
log_k -7.7084
delta_h 15.9 kJ
Semetal(am)
Se + H+ + 2e- = HSe-
log_k -7.1099
delta_h 10.8784 kJ
Sbmetal
Sb + 3H2O = Sb(OH)3 + 3H+ + 3e-
log_k -11.6889
delta_h 83.89 kJ
Snmetal(wht)
Sn + 2H2O = Sn(OH)2 + 2H+ + 2e-
log_k -2.3266
delta_h -0 kJ
Pbmetal
Pb = Pb+2 + 2e-
log_k 4.2462
delta_h 0.92 kJ
Tlmetal
Tl = Tl+ + e-
log_k 5.6762
delta_h 5.36 kJ
Znmetal
Zn = Zn+2 + 2e-
log_k 25.7886
delta_h -153.39 kJ
Cdmetal(alpha)
Cd = Cd+2 + 2e-
log_k 13.5147
delta_h -75.33 kJ
Cdmetal(gamma)
Cd = Cd+2 + 2e-
log_k 13.618
delta_h -75.92 kJ
Hgmetal(l)
Hg = 0.5Hg2+2 + e-
log_k -13.4517
delta_h 83.435 kJ
Cumetal
Cu = Cu+ + e-
log_k -8.756
delta_h 71.67 kJ
Agmetal
Ag = Ag+ + e-
log_k -13.5065
```

```
delta_h 105.79 kJ
Crmetal
Cr = Cr+2 + 2e-
log_k 30.4831
delta_h -172 kJ
Vmetal
V = V+3 + 3e-
log_k 44.0253
delta_h -259 kJ
Stibnite
Sb2S3 + 6H2O = 2Sb(OH)3 + 3H+ + 3HS-
log_k -50.46
delta_h 293.78 kJ
Orpiment
As2S3 + 6H2O = 2H3AsO3 + 3HS- + 3H+
log_k -61.0663
delta_h 350.68 kJ
Realgar
AsS + 3H2O = H3AsO3 + HS- + 2H+ + e-
log_k -19.747
delta_h 127.8 kJ
SnS
SnS + 2H2O = Sn(OH)2 + H+ + HS-
log_k -19.114
delta_h -0 kJ
SnS2
SnS2 + 6H2O = Sn(OH)6-2 + 4H+ + 2HS-
log_k -57.4538
delta_h -0 kJ
Galena
PbS + H+ = Pb+2 + HS-
log_k -13.97
delta_h 80 kJ
Tl2S
Tl2S + H+ = 2Tl+ + HS-
log_k -7.19
delta_h 91.52 kJ
ZnS(am)
ZnS + H+ = Zn+2 + HS-
log_k -9.052
delta_h 15.3553 kJ
Sphalerite
ZnS + H+ = Zn+2 + HS-
log_k -11.45
delta_h 30 kJ
Wurtzite
ZnS + H+ = Zn+2 + HS-
log_k -8.95
delta_h 21.171 kJ
Greenockite
CdS + H+ = Cd+2 + HS-
log_k -14.36
delta_h 55 kJ
Hg2S
```

```
Hg2S + H+ = Hg2+2 + HS-
log_k -11.6765
delta_h 69.7473 kJ
Cinnabar
HgS + 2H2O = Hg(OH)2 + H+ + HS-
log_k -45.694
delta_h 253.76 kJ
Metacinnabar
HgS + 2H2O = Hg(OH)2 + H+ + HS-
log_k -45.094
delta_h 253.72 kJ
Chalcocite
Cu2S + H+ = 2Cu+ + HS-
log_k -34.92
delta_h 168 kJ
Djurleite
Cu0.066Cu1.868S + H+ = 0.066Cu+2 + 1.868Cu+ + HS-
log_k -33.92
delta_h 200.334 kJ
Anilite
Cu0.25Cu1.5S + H+ = 0.25Cu+2 + 1.5Cu+ + HS-
log_k -31.878
delta_h 182.15 kJ
BlaubleiII
Cu0.6Cu0.8S + H+ = 0.6Cu+2 + 0.8Cu+ + HS-
log_k -27.279
delta_h -0 kJ
BlaubleiI
Cu0.9Cu0.2S + H+ = 0.9Cu+2 + 0.2Cu+ + HS-
log_k -24.162
delta_h -0 kJ
Covellite
CuS + H+ = Cu+2 + HS-
log_k -22.3
delta_h 97 kJ
Chalcopyrite
CuFeS2 + 2H+ = Cu+2 + Fe+2 + 2HS-
log_k -35.27
delta_h 148.448 kJ
Acanthite
Ag2S + H+ = 2Ag+ + HS-
log_k -36.22
delta_h 227 kJ
NiS(alpha)
NiS + H+ = Ni+2 + HS-
log_k -5.6
delta_h -0 kJ
NiS(beta)
NiS + H+ = Ni+2 + HS-
log_k -11.1
delta_h -0 kJ
NiS(gamma)
NiS + H+ = Ni+2 + HS-
log_k -12.8
```

```
delta_h -0 kJ
CoS(alpha)
CoS + H+ = Co+2 + HS-
log_k -7.44
delta_h -0 kJ
CoS(beta)
CoS + H+ = Co+2 + HS-
log_k -11.07
delta_h -0 kJ
FeS(ppt)
FeS + H+ = Fe+2 + HS-
log_k -2.95
delta_h -11 kJ
Greigite
Fe3S4 + 4H+ = 2Fe+3 + Fe+2 + 4HS-
log_k -45.035
delta_h -0 kJ
Mackinawite
FeS + H+ = Fe+2 + HS-
log_k -3.6
delta_h -0 kJ
Pyrite
FeS2 + 2H+ + 2e- = Fe+2 + 2HS-
log_k -18.5082
delta_h 49.844 kJ
MnS(grn)
MnS + H+ = Mn+2 + HS-
log_k 0.17
delta_h -32 kJ
MnS(pnk)
MnS + H+ = Mn+2 + HS-
log_k 3.34
delta_h -0 kJ
MoS2
MoS2 + 4H2O = MoO4-2 + 6H+ + 2HS- + 2e-
log_k -70.2596
delta_h 389.02 kJ
BeS
BeS + H+ = Be+2 + HS-
log_k 19.38
delta_h -0 kJ
BaS
BaS + H+ = Ba+2 + HS-
log_k 16.18
delta_h -0 kJ
Hg2(Cyanide)2
Hg2(Cyanide)2 = Hg2+2 + 2Cyanide-
log_k -39.3
delta_h -0 kJ
CuCyanide
CuCyanide = Cu+ + Cyanide-
log_k -19.5
delta_h -19 kJ
AgCyanide
```

```
AgCyanide = Ag+ + Cyanide-
log_k -15.74
delta_h 110.395 kJ
Ag2(Cyanide)2
Ag2(Cyanide)2 = 2Ag+ + 2Cyanide-
log_k -11.3289
delta_h -0 kJ
NaCyanide(cubic)
NaCyanide = Cyanide- + Na+
log_k 1.6012
delta_h 0.969 kJ
KCyanide(cubic)
KCyanide = Cyanide- + K+
log_k 1.4188
delta_h 11.93 kJ
Pb2Fe(Cyanide)6
Pb2Fe(Cyanide)6 = 2Pb+2 + Fe+2 + 6Cyanide-
log_k -53.42
delta_h -0 kJ
Zn2Fe(Cyanide)6
Zn2Fe(Cyanide)6 = 2Zn+2 + Fe+2 + 6Cyanide-
log_k -51.08
delta_h -0 kJ
Cd2Fe(Cyanide)6
Cd2Fe(Cyanide)6 = 2Cd+2 + Fe+2 + 6Cyanide-
log_k -52.78
delta_h -0 kJ
Ag4Fe(Cyanide)6
Ag4Fe(Cyanide)6 = 4Ag+ + Fe+2 + 6Cyanide-
log_k -79.47
delta_h -0 kJ
Ag3Fe(Cyanide)6
Ag3Fe(Cyanide)6 = 3Ag+ + Fe+3 + 6Cyanide-
log_k -72.7867
delta_h -0 kJ
Mn3(Fe(Cyanide)6)2
Mn3(Fe(Cyanide)6)2 = 3Mn+2 + 2Fe+3 + 12Cyanide-
log_k -105.4
delta_h -0 kJ
Sb2Se3
Sb2Se3 + 6H2O = 2Sb(OH)3 + 3HSe- + 3H+
log_k -67.7571
delta_h 343.046 kJ
SnSe
SnSe + 2H2O = Sn(OH)2 + H+ + HSe-
log_k -30.494
delta_h -0 kJ
SnSe2
SnSe2 + 6H2O = Sn(OH)6-2 + 4H+ + 2HSe-
log_k -65.1189
delta_h -0 kJ
Clausthalite
PbSe + H+ = Pb+2 + HSe-
log_k -27.1
```

```
delta_h 119.72 kJ
Tl2Se
Tl2Se + H+ = 2Tl+ + HSe-
log_k -18.1
delta_h 85.62 kJ
ZnSe
ZnSe + H+ = Zn+2 + HSe-
log_k -14.4
delta_h 25.51 kJ
CdSe
CdSe + H+ = Cd+2 + HSe-
log_k -20.2
delta_h 75.9814 kJ
HgSe
HgSe + 2H2O = Hg(OH)2 + H+ + HSe-
log_k -55.694
delta_h -0 kJ
Cu2Se(alpha)
Cu2Se + H+ = 2Cu+ + HSe-
log_k -45.8
delta_h 214.263 kJ
Cu3Se2
Cu3Se2 + 2H+ = 2HSe- + 2Cu+ + Cu+2
log_k -63.4911
delta_h 340.327 kJ
CuSe
CuSe + H+ = Cu+2 + HSe-
log_k -33.1
delta_h 121.127 kJ
CuSe2
CuSe2 + 2H+ + 2e- = 2HSe- + Cu+2
log_k -33.3655
delta_h 140.582 kJ
Ag2Se
Ag2Se + H+ = 2Ag+ + HSe-
log_k -48.7
delta_h 265.48 kJ
NiSe
NiSe + H+ = Ni+2 + HSe-
log_k -17.7
delta_h -0 kJ
CoSe
CoSe + H+ = Co+2 + HSe-
log_k -16.2
delta_h -0 kJ
FeSe
FeSe + H+ = Fe+2 + HSe-
log_k -11
delta_h 2.092 kJ
Ferroselite
FeSe2 + 2H+ + 2e- = 2HSe- + Fe+2
log_k -18.5959
delta_h 47.2792 kJ
MnSe
```

```
MnSe + H+ = Mn+2 + HSe-
log_k 3.5
delta_h -98.15 kJ
AlSb
AlSb + 3H2O = Sb(OH)3 + 6e- + Al+3 + 3H+
log_k 65.6241
delta_h -0 kJ
ZnSb
ZnSb + 3H2O = Sb(OH)3 + 5e- + Zn+2 + 3H+
log_k 11.0138
delta_h -54.8773 kJ
CdSb
CdSb + 3H2O = Sb(OH)3 + 5e- + 3H+ + Cd+2
log_k -0.3501
delta_h 22.36 kJ
Cu2Sb:3H2O
Cu2Sb:3H2O = Sb(OH)3 + 6e- + 3H+ + Cu+ + Cu+2
log_k -34.8827
delta_h 233.237 kJ
Cu3Sb
Cu3Sb + 3H2O = Sb(OH)3 + 6e- + 3H+ + 3Cu+
log_k -42.5937
delta_h 308.131 kJ
#Ag4Sb
# Ag4Sb + 3H2O = Sb(OH)3 + 6e- + 3Ag+ + 3H+
# log_k -56.1818
# delta_h -0 kJ
Breithauptite
NiSb + 3H2O = Sb(OH)3 + 5e- + 3H+ + Ni+2
log_k -18.5225
delta_h 96.0019 kJ
MnSb
MnSb + 3H2O = Mn+3 + Sb(OH)3 + 6e- + 3H+
log_k -2.9099
delta_h 21.1083 kJ
Mn2Sb
Mn2Sb + 3H2O = 2Mn+2 + Sb(OH)3 + 7e- + 3H+
log_k 61.0796
delta_h -0 kJ
USb2
USb2 + 8H2O = UO2+2 + 2Sb(OH)3 + 12e- + 10H+
log_k 29.5771
delta_h -103.56 kJ
U3Sb4
U3Sb4 + 12H2O = 3U+4 + 4Sb(OH)3 + 24e- + 12H+
log_k 152.383
delta_h -986.04 kJ
Mg2Sb3
Mg2Sb3 + 9H2O = 2Mg+2 + 3Sb(OH)3 + 9H+ + 13e-
log_k 74.6838
delta_h -0 kJ
Ca3Sb2
Ca3Sb2 + 6H2O = 3Ca+2 + 2Sb(OH)3 + 6H+ + 12e-
log_k 142.974
```

delta_h -732.744 kJ
NaSb
NaSb + 3H2O = Na+ + Sb(OH)3 + 3H+ + 4e-
log_k 23.1658
delta_h -93.45 kJ
Na3Sb
Na3Sb + 3H2O = 3Na+ + Sb(OH)3 + 3H+ + 6e-
log_k 94.4517
delta_h -432.13 kJ
SeO2
SeO2 + H2O = HSeO3- + H+
log_k 0.1246
delta_h 1.4016 kJ
SeO3
SeO3 + H2O = SeO4-2 + 2H+
log_k 21.044
delta_h -146.377 kJ
Sb2O5
Sb2O5 + 7H2O = 2Sb(OH)6- + 2H+
log_k -9.6674
delta_h -0 kJ
SbO2
SbO2 + 4H2O = Sb(OH)6- + e- + 2H+
log_k -27.8241
delta_h -0 kJ
Sb2O4
Sb2O4 + 2H2O + 2H+ + 2e- = 2Sb(OH)3
log_k 3.4021
delta_h -68.04 kJ
Sb4O6(cubic)
Sb4O6 + 6H2O = 4Sb(OH)3
log_k -18.2612
delta_h 61.1801 kJ
Sb4O6(orth)
Sb4O6 + 6H2O = 4Sb(OH)3
log_k -17.9012
delta_h 37.6801 kJ
Sb(OH)3
Sb(OH)3 = Sb(OH)3
log_k -7.1099
delta_h 30.1248 kJ
Senarmontite
Sb2O3 + 3H2O = 2Sb(OH)3
log_k -12.3654
delta_h 30.6478 kJ
Valentinite
Sb2O3 + 3H2O = 2Sb(OH)3
log_k -8.4806
delta_h 19.0163 kJ
Chalcedony
SiO2 + 2H2O = H4SiO4
log_k -3.55
delta_h 19.7 kJ
Cristobalite

```
SiO2 + 2H2O = H4SiO4
log_k -3.35
delta_h 20.006 kJ
Quartz
SiO2 + 2H2O = H4SiO4
log_k -4
delta_h 22.36 kJ
SiO2(am-gel)
SiO2 + 2H2O = H4SiO4
log_k -2.71
delta_h 14 kJ
SiO2(am-ppt)
SiO2 + 2H2O = H4SiO4
log_k -2.74
delta_h 15.15 kJ
SnO
SnO + H2O = Sn(OH)2
log_k -4.9141
delta_h -0 kJ
SnO2
SnO2 + 4H2O = Sn(OH)6-2 + 2H+
log_k -28.9749
delta_h -0 kJ
Sn(OH)2
Sn(OH)2 = Sn(OH)2
log_k -5.4309
delta_h -0 kJ
Sn(OH)4
Sn(OH)4 + 2H2O = Sn(OH)6-2 + 2H+
log_k -22.2808
delta_h -0 kJ
H2Sn(OH)6
H2Sn(OH)6 = Sn(OH)6-2 + 2H+
log_k -23.5281
delta_h -0 kJ
Massicot
PbO + 2H+ = Pb+2 + H2O
log_k 12.894
delta_h -66.848 kJ
Litharge
PbO + 2H+ = Pb+2 + H2O
log_k 12.694
delta_h -65.501 kJ
PbO:0.3H2O
PbO:0.33H2O + 2H+ = Pb+2 + 1.33H2O
log_k 12.98
delta_h -0 kJ
Plattnerite
PbO2 + 4H+ + 2e- = Pb+2 + 2H2O
log_k 49.6001
delta_h -296.27 kJ
Pb(OH)2
Pb(OH)2 + 2H+ = Pb+2 + 2H2O
log_k 8.15
```

```
delta_h -58.5342 kJ
Pb2O(OH)2
Pb2O(OH)2 + 4H+ = 2Pb+2 + 3H2O
log_k 26.188
delta_h -0 kJ
Al(OH)3(am)
Al(OH)3 + 3H+ = Al+3 + 3H2O
log_k 10.8
delta_h -111 kJ
Boehmite
AlOOH + 3H+ = Al+3 + 2H2O
log_k 8.578
delta_h -117.696 kJ
Diaspore
AlOOH + 3H+ = Al+3 + 2H2O
log_k 6.873
delta_h -103.052 kJ
Gibbsite
Al(OH)3 + 3H+ = Al+3 + 3H2O
log_k 8.291
delta_h -95.3952 kJ
Tl2O
Tl2O + 2H+ = 2Tl+ + H2O
log_k 27.0915
delta_h -96.41 kJ
TlOH
TlOH + H+ = Tl+ + H2O
log_k 12.9186
delta_h -41.57 kJ
Avicennite
Tl2O3 + 3H2O = 2Tl(OH)3
log_k -13
delta_h -0 kJ
Tl(OH)3
Tl(OH)3 = Tl(OH)3
log_k -5.441
delta_h -0 kJ
Zn(OH)2(am)
Zn(OH)2 + 2H+ = Zn+2 + 2H2O
log_k 12.474
delta_h -80.62 kJ
Zn(OH)2
Zn(OH)2 + 2H+ = Zn+2 + 2H2O
log_k 12.2
delta_h -0 kJ
Zn(OH)2(beta)
Zn(OH)2 + 2H+ = Zn+2 + 2H2O
log_k 11.754
delta_h -83.14 kJ
Zn(OH)2(gamma)
Zn(OH)2 + 2H+ = Zn+2 + 2H2O
log_k 11.734
delta_h -0 kJ
Zn(OH)2(epsilon)
```

```
Zn(OH)2 + 2H+ = Zn+2 + 2H2O
log_k 11.534
delta_h -81.8 kJ
ZnO(active)
ZnO + 2H+ = Zn+2 + H2O
log_k 11.1884
delta_h -88.76 kJ
Zincite
ZnO + 2H+ = Zn+2 + H2O
log_k 11.334
delta_h -89.62 kJ
Cd(OH)2(am)
Cd(OH)2 + 2H+ = Cd+2 + 2H2O
log_k 13.73
delta_h -86.9017 kJ
Cd(OH)2
Cd(OH)2 + 2H+ = Cd+2 + 2H2O
log_k 13.644
delta_h -94.62 kJ
Monteponite
CdO + 2H+ = Cd+2 + H2O
log_k 15.1034
delta_h -103.4 kJ
Hg2(OH)2
Hg2(OH)2 + 2H+ = Hg2+2 + 2H2O
log_k 5.2603
delta_h -0 kJ
Montroydite
HgO + H2O = Hg(OH)2
log_k -3.64
delta_h -38.9 kJ
Hg(OH)2
Hg(OH)2 = Hg(OH)2
log_k -3.4963
delta_h -0 kJ
Cuprite
Cu2O + 2H+ = 2Cu+ + H2O
log_k -1.406
delta_h -124.02 kJ
Cu(OH)2
Cu(OH)2 + 2H+ = Cu+2 + 2H2O
log_k 8.674
delta_h -56.42 kJ
Tenorite
CuO + 2H+ = Cu+2 + H2O
log_k 7.644
delta_h -64.867 kJ
Ag2O
Ag2O + 2H+ = 2Ag+ + H2O
log_k 12.574
delta_h -45.62 kJ
Ni(OH)2
Ni(OH)2 + 2H+ = Ni+2 + 2H2O
log_k 12.794
```

```
delta_h -95.96 kJ
Bunsenite
NiO + 2H+ = Ni+2 + H2O
log_k 12.4456
delta_h -100.13 kJ
CoO
CoO + 2H+ = Co+2 + H2O
log_k 13.5864
delta_h -106.295 kJ
Co(OH)2
Co(OH)2 + 2H+ = Co+2 + 2H2O
log_k 13.094
delta_h -0 kJ
Co(OH)3
Co(OH)3 + 3H+ = Co+3 + 3H2O
log_k -2.309
delta_h -92.43 kJ
#Wustite-0.11
# WUSTITE-0.11 + 2H+ = 0.947Fe+2 + H2O
# log_k 11.6879
# delta_h -103.938 kJ
Fe(OH)2
Fe(OH)2 + 2H+ = Fe+2 + 2H2O
log_k 13.564
delta_h -0 kJ
Ferrihydrite
Fe(OH)3 + 3H+ = Fe+3 + 3H2O
log_k 3.191
delta_h -73.374 kJ
Fe3(OH)8
Fe3(OH)8 + 8H+ = 2Fe+3 + Fe+2 + 8H2O
log_k 20.222
delta_h -0 kJ
Goethite
FeOOH + 3H+ = Fe+3 + 2H2O
log_k 0.491
delta_h -60.5843 kJ
Pyrolusite
MnO2 + 4H+ + 2e- = Mn+2 + 2H2O
log_k 41.38
delta_h -272 kJ
Birnessite
MnO2 + 4H+ + e- = Mn+3 + 2H2O
log_k 18.091
delta_h -0 kJ
Nsutite
MnO2 + 4H+ + e- = Mn+3 + 2H2O
log_k 17.504
delta_h -0 kJ
Pyrochroite
Mn(OH)2 + 2H+ = Mn+2 + 2H2O
log_k 15.194
delta_h -97.0099 kJ
Manganite
```

```
MnOOH + 3H+ + e- = Mn+2 + 2H2O
log_k 25.34
delta_h -0 kJ
Cr(OH)2
Cr(OH)2 + 2H+ = Cr+2 + 2H2O
log_k 10.8189
delta_h -35.6058 kJ
Cr(OH)3(am)
Cr(OH)3 + H+ = Cr(OH)2+ + H2O
log_k -0.75
delta_h -0 kJ
Cr(OH)3
Cr(OH)3 + H+ = Cr(OH)2+ + H2O
log_k 1.3355
delta_h -29.7692 kJ
CrO3
CrO3 + H2O = CrO4-2 + 2H+
log_k -3.2105
delta_h -5.2091 kJ
MoO3
MoO3 + H2O = MoO4-2 + 2H+
log_k -8
delta_h -0 kJ
VO
VO + 2H+ = V+3 + H2O + e-
log_k 14.7563
delta_h -113.041 kJ
V(OH)3
V(OH)3 + 3H+ = V+3 + 3H2O
log_k 7.591
delta_h -0 kJ
VO(OH)2
VO(OH)2 + 2H+ = VO+2 + 2H2O
log_k 5.1506
delta_h -0 kJ
Uraninite
UO2 + 4H+ = U+4 + 2H2O
log_k -4.6693
delta_h -77.86 kJ
UO2(am)
UO2 + 4H+ = U+4 + 2H2O
log_k 0.934
delta_h -109.746 kJ
UO3
UO3 + 2H+ = UO2+2 + H2O
log_k 7.7
delta_h -81.0299 kJ
Gummite
UO3 + 2H+ = UO2+2 + H2O
log_k 7.6718
delta_h -81.0299 kJ
UO2(OH)2(beta)
UO2(OH)2 + 2H+ = UO2+2 + 2H2O
log_k 5.6116
```

delta_h -56.7599 kJ
Schoepite
UO2(OH)2:H2O + 2H+ = UO2+2 + 3H2O
log_k 5.994
delta_h -49.79 kJ
Be(OH)2(am)
Be(OH)2 + 2H+ = Be+2 + 2H2O
log_k 7.194
delta_h -0 kJ
Be(OH)2(alpha)
Be(OH)2 + 2H+ = Be+2 + 2H2O
log_k 6.894
delta_h -0 kJ
Be(OH)2(beta)
Be(OH)2 + 2H+ = Be+2 + 2H2O
log_k 6.494
delta_h -0 kJ
Brucite
Mg(OH)2 + 2H+ = Mg+2 + 2H2O
log_k 16.844
delta_h -113.996 kJ
Periclase
MgO + 2H+ = Mg+2 + H2O
log_k 21.5841
delta_h -151.23 kJ
Mg(OH)2(active)
Mg(OH)2 + 2H+ = Mg+2 + 2H2O
log_k 18.794
delta_h -0 kJ
Lime
CaO + 2H+ = Ca+2 + H2O
log_k 32.6993
delta_h -193.91 kJ
Portlandite
Ca(OH)2 + 2H+ = Ca+2 + 2H2O
log_k 22.804
delta_h -128.62 kJ
Ba(OH)2:8H2O
Ba(OH)2:8H2O + 2H+ = Ba+2 + 10H2O
log_k 24.394
delta_h -54.32 kJ
Cu(SbO3)2
Cu(SbO3)2 + 6H+ + 4e- = 2Sb(OH)3 + Cu+2
log_k 45.2105
delta_h -0 kJ
Arsenolite
As4O6 + 6H2O = 4H3AsO3
log_k -2.76
delta_h 59.9567 kJ
Claudetite
As4O6 + 6H2O = 4H3AsO3
log_k -3.065
delta_h 55.6054 kJ
As2O5

```
As2O5 + 3H2O = 2H3AsO4
log_k 6.7061
delta_h -22.64 kJ
Pb2O3
Pb2O3 + 6H+ + 2e- = 2Pb+2 + 3H2O
log_k 61.04
delta_h -0 kJ
Minium
Pb3O4 + 8H+ + 2e- = 3Pb+2 + 4H2O
log_k 73.5219
delta_h -421.874 kJ
Al2O3
Al2O3 + 6H+ = 2Al+3 + 3H2O
log_k 19.6524
delta_h -258.59 kJ
Co3O4
Co3O4 + 8H+ = Co+2 + 2Co+3 + 4H2O
log_k -10.4956
delta_h -107.5 kJ
CoFe2O4
CoFe2O4 + 8H+ = Co+2 + 2Fe+3 + 4H2O
log_k -3.5281
delta_h -158.82 kJ
Magnetite
Fe3O4 + 8H+ = 2Fe+3 + Fe+2 + 4H2O
log_k 3.4028
delta_h -208.526 kJ
Hercynite
FeAl2O4 + 8H+ = Fe+2 + 2Al+3 + 4H2O
log_k 22.893
delta_h -313.92 kJ
Hematite
Fe2O3 + 6H+ = 2Fe+3 + 3H2O
log_k -1.418
delta_h -128.987 kJ
Maghemite
Fe2O3 + 6H+ = 2Fe+3 + 3H2O
log_k 6.386
delta_h -0 kJ
Lepidocrocite
FeOOH + 3H+ = Fe+3 + 2H2O
log_k 1.371
delta_h -0 kJ
Hausmannite
Mn3O4 + 8H+ + 2e- = 3Mn+2 + 4H2O
log_k 61.03
delta_h -421 kJ
Bixbyite
Mn2O3 + 6H+ = 2Mn+3 + 3H2O
log_k -0.6445
delta_h -124.49 kJ
Cr2O3
Cr2O3 + H2O + 2H+ = 2Cr(OH)2+
log_k -2.3576
```

```
delta_h -50.731 kJ
#V2O3
# V2O3 + 3H+ = V+3 + 1.5H2O
# log_k 4.9
# delta_h -82.5085 kJ
V3O5
V3O5 + 4H+ = 3VO+2 + 2H2O + 2e-
log_k 1.8361
delta_h -98.46 kJ
#V2O4
# V2O4 + 2H+ = VO+2 + H2O
# log_k 4.27
# delta_h -58.8689 kJ
V4O7
V4O7 + 6H+ = 4VO+2 + 3H2O + 2e-
log_k 7.1865
delta_h -163.89 kJ
V6O13
V6O13 + 2H+ = 6VO2+ + H2O + 4e-
log_k -60.86
delta_h 271.5 kJ
V2O5
V2O5 + 2H+ = 2VO2+ + H2O
log_k -1.36
delta_h 34 kJ
U4O9
U4O9 + 18H+ + 2e- = 4U+4 + 9H2O
log_k -3.0198
delta_h -426.87 kJ
U3O8
U3O8 + 16H+ + 4e- = 3U+4 + 8H2O
log_k 21.0834
delta_h -485.44 kJ
Spinel
MgAl2O4 + 8H+ = Mg+2 + 2Al+3 + 4H2O
log_k 36.8476
delta_h -388.012 kJ
Magnesioferrite
Fe2MgO4 + 8H+ = Mg+2 + 2Fe+3 + 4H2O
log_k 16.8597
delta_h -278.92 kJ
Natron
Na2CO3:10H2O = 2Na+ + CO3-2 + 10H2O
log_k -1.311
delta_h 65.8771 kJ
Cuprousferrite
CuFeO2 + 4H+ = Cu+ + Fe+3 + 2H2O
log_k -8.9171
delta_h -15.89 kJ
Cupricferrite
CuFe2O4 + 8H+ = Cu+2 + 2Fe+3 + 4H2O
log_k 5.9882
delta_h -210.21 kJ
FeCr2O4
```

FeCr2O4 + 4H+ = 2Cr(OH)2+ + Fe+2
log_k 7.2003
delta_h -140.4 kJ
MgCr2O4
MgCr2O4 + 4H+ = 2Cr(OH)2+ + Mg+2
log_k 16.2007
delta_h -179.4 kJ
SbF3
SbF3 + 3H2O = Sb(OH)3 + 3H+ + 3F-
log_k -10.2251
delta_h -6.7279 kJ
PbF2
PbF2 = Pb+2 + 2F-
log_k -7.44
delta_h 20 kJ
ZnF2
ZnF2 = Zn+2 + 2F-
log_k -0.5343
delta_h -59.69 kJ
CdF2
CdF2 = Cd+2 + 2F-
log_k -1.2124
delta_h -46.22 kJ
Hg2F2
Hg2F2 = Hg2+2 + 2F-
log_k -10.3623
delta_h -18.486 kJ
CuF
CuF = Cu+ + F-
log_k -4.9056
delta_h 16.648 kJ
CuF2
CuF2 = Cu+2 + 2F-
log_k 1.115
delta_h -66.901 kJ
CuF2:2H2O
CuF2:2H2O = Cu+2 + 2F- + 2H2O
log_k -4.55
delta_h -15.2716 kJ
AgF:4H2O
AgF:4H2O = Ag+ + F- + 4H2O
log_k 1.0491
delta_h 15.4202 kJ
CoF2
CoF2 = Co+2 + 2F-
log_k -1.5969
delta_h -57.368 kJ
CoF3
CoF3 = Co+3 + 3F-
log_k -1.4581
delta_h -123.692 kJ
CrF3
CrF3 + 2H2O = Cr(OH)2+ + 3F- + 2H+
log_k -11.3367

```
delta_h -23.3901 kJ
VF4
VF4 + H2O = VO+2 + 4F- + 2H+
log_k 14.93
delta_h -199.117 kJ
UF4
UF4 = U+4 + 4F-
log_k -29.5371
delta_h -79.0776 kJ
UF4:2.5H2O
UF4:2.5H2O = U+4 + 4F- + 2.5H2O
log_k -32.7179
delta_h 24.325 kJ
MgF2
MgF2 = Mg+2 + 2F-
log_k -8.13
delta_h -8 kJ
Fluorite
CaF2 = Ca+2 + 2F-
log_k -10.5
delta_h 8 kJ
SrF2
SrF2 = Sr+2 + 2F-
log_k -8.58
delta_h 4 kJ
BaF2
BaF2 = Ba+2 + 2F-
log_k -5.82
delta_h 4 kJ
Cryolite
Na3AlF6 = 3Na+ + Al+3 + 6F-
log_k -33.84
delta_h 38 kJ
SbCl3
SbCl3 + 3H2O = Sb(OH)3 + 3Cl- + 3H+
log_k 0.5719
delta_h -35.18 kJ
SnCl2
SnCl2 + 2H2O = Sn(OH)2 + 2H+ + 2Cl-
log_k -9.2752
delta_h -0 kJ
Cotunnite
PbCl2 = Pb+2 + 2Cl-
log_k -4.78
delta_h 26.166 kJ
Matlockite
PbClF = Pb+2 + Cl- + F-
log_k -8.9733
delta_h 33.19 kJ
Phosgenite
PbCl2:PbCO3 = 2Pb+2 + 2Cl- + CO3-2
log_k -19.81
delta_h -0 kJ
Laurionite
```

PbOHCl + H+ = Pb+2 + Cl- + H2O
log_k 0.623
delta_h -0 kJ
Pb2(OH)3Cl
Pb2(OH)3Cl + 3H+ = 2Pb+2 + 3H2O + Cl-
log_k 8.793
delta_h -0 kJ
TlCl
TlCl = Tl+ + Cl-
log_k -3.74
delta_h 41 kJ
ZnCl2
ZnCl2 = Zn+2 + 2Cl-
log_k 7.05
delta_h -72.5 kJ
Zn2(OH)3Cl
Zn2(OH)3Cl + 3H+ = 2Zn+2 + 3H2O + Cl-
log_k 15.191
delta_h -0 kJ
Zn5(OH)8Cl2
Zn5(OH)8Cl2 + 8H+ = 5Zn+2 + 8H2O + 2Cl-
log_k 38.5
delta_h -0 kJ
CdCl2
CdCl2 = Cd+2 + 2Cl-
log_k -0.6588
delta_h -18.58 kJ
CdCl2:1H2O
CdCl2:1H2O = Cd+2 + 2Cl- + H2O
log_k -1.6932
delta_h -7.47 kJ
CdCl2:2.5H2O
CdCl2:2.5H2O = Cd+2 + 2Cl- + 2.5H2O
log_k -1.913
delta_h 7.2849 kJ
CdOHCl
CdOHCl + H+ = Cd+2 + H2O + Cl-
log_k 3.5373
delta_h -30.93 kJ
Calomel
Hg2Cl2 = Hg2+2 + 2Cl-
log_k -17.91
delta_h 92 kJ
HgCl2
HgCl2 + 2H2O = Hg(OH)2 + 2Cl- + 2H+
log_k -21.2621
delta_h 107.82 kJ
Nantokite
CuCl = Cu+ + Cl-
log_k -6.73
delta_h 42.662 kJ
Melanothallite
CuCl2 = Cu+2 + 2Cl-
log_k 6.2572

```
delta_h -63.407 kJ
Atacamite
Cu2(OH)3Cl + 3H+ = 2Cu+2 + 3H2O + Cl-
log_k 7.391
delta_h -93.43 kJ
Cerargyrite
AgCl = Ag+ + Cl-
log_k -9.75
delta_h 65.2 kJ
CoCl2
CoCl2 = Co+2 + 2Cl-
log_k 8.2672
delta_h -79.815 kJ
CoCl2:6H2O
CoCl2:6H2O = Co+2 + 2Cl- + 6H2O
log_k 2.5365
delta_h 8.0598 kJ
(Co(NH3)6)Cl3
(Co(NH3)6)Cl3 + 6H+ = Co+3 + 6NH4+ + 3Cl-
log_k 20.0317
delta_h -33.1 kJ
(Co(NH3)5OH2)Cl3
(Co(NH3)5OH2)Cl3 + 5H+ = Co+3 + 5NH4+ + 3Cl- + H2O
log_k 11.7351
delta_h -25.37 kJ
(Co(NH3)5Cl)Cl2
(Co(NH3)5Cl)Cl2 + 5H+ = Co+3 + 5NH4+ + 3Cl-
log_k 4.5102
delta_h -10.74 kJ
Fe(OH)2.7Cl.3
Fe(OH)2.7Cl.3 + 2.7H+ = Fe+3 + 2.7H2O + 0.3Cl-
log_k -3.04
delta_h -0 kJ
MnCl2:4H2O
MnCl2:4H2O = Mn+2 + 2Cl- + 4H2O
log_k 2.7151
delta_h -10.83 kJ
CrCl2
CrCl2 = Cr+2 + 2Cl-
log_k 14.0917
delta_h -110.76 kJ
CrCl3
CrCl3 + 2H2O = Cr(OH)2+ + 3Cl- + 2H+
log_k 15.1145
delta_h -121.08 kJ
VCl2
VCl2 = V+3 + 2Cl- + e-
log_k 18.8744
delta_h -141.16 kJ
VCl3
VCl3 = V+3 + 3Cl-
log_k 23.4326
delta_h -179.54 kJ
VOCl
```

```
VOCl + 2H+ = V+3 + Cl- + H2O
log_k 11.1524
delta_h -104.91 kJ
VOCl2
VOCl2 = VO+2 + 2Cl-
log_k 12.7603
delta_h -117.76 kJ
VO2Cl
VO2Cl = VO2+ + Cl-
log_k 2.8413
delta_h -40.28 kJ
Halite
NaCl = Na+ + Cl-
log_k 1.6025
delta_h 3.7 kJ
SbBr3
SbBr3 + 3H2O = Sb(OH)3 + 3Br- + 3H+
log_k 0.9689
delta_h -20.94 kJ
SnBr2
SnBr2 + 2H2O = Sn(OH)2 + 2H+ + 2Br-
log_k -9.5443
delta_h -0 kJ
SnBr4
SnBr4 + 6H2O = Sn(OH)6-2 + 6H+ + 4Br-
log_k -28.8468
delta_h -0 kJ
PbBr2
PbBr2 = Pb+2 + 2Br-
log_k -5.3
delta_h 35.499 kJ
PbBrF
PbBrF = Pb+2 + Br- + F-
log_k -8.49
delta_h -0 kJ
TlBr
TlBr = Tl+ + Br-
log_k -5.44
delta_h 54 kJ
ZnBr2:2H2O
ZnBr2:2H2O = Zn+2 + 2Br- + 2H2O
log_k 5.2005
delta_h -30.67 kJ
CdBr2:4H2O
CdBr2:4H2O = Cd+2 + 2Br- + 4H2O
log_k -2.425
delta_h 30.5001 kJ
Hg2Br2
Hg2Br2 = Hg2+2 + 2Br-
log_k -22.25
delta_h 133 kJ
HgBr2
HgBr2 + 2H2O = Hg(OH)2 + 2Br- + 2H+
log_k -25.2734
```

```
delta_h 138.492 kJ
CuBr
CuBr = Cu+ + Br-
log_k -8.3
delta_h 54.86 kJ
Cu2(OH)3Br
Cu2(OH)3Br + 3H+ = 2Cu+2 + 3H2O + Br-
log_k 7.9085
delta_h -93.43 kJ
Bromyrite
AgBr = Ag+ + Br-
log_k -12.3
delta_h 84.5 kJ
(Co(NH3)6)Br3
(Co(NH3)6)Br3 + 6H+ = Co+3 + 6NH4+ + 3Br-
log_k 18.3142
delta_h -21.1899 kJ
(Co(NH3)5Cl)Br2
(Co(NH3)5Cl)Br2 + 5H+ = Co+3 + 5NH4+ + Cl- + 2Br-
log_k 5.0295
delta_h -6.4 kJ
CrBr3
CrBr3 + 2H2O = Cr(OH)2+ + 3Br- + 2H+
log_k 19.9086
delta_h -141.323 kJ
AsI3
AsI3 + 3H2O = H3AsO3 + 3I- + 3H+
log_k 4.2307
delta_h 3.15 kJ
SbI3
SbI3 + 3H2O = Sb(OH)3 + 3H+ + 3I-
log_k -0.538
delta_h 13.5896 kJ
PbI2
PbI2 = Pb+2 + 2I-
log_k -8.1
delta_h 62 kJ
TlI
TlI = Tl+ + I-
log_k -7.23
delta_h 75 kJ
ZnI2
ZnI2 = Zn+2 + 2I-
log_k 7.3055
delta_h -58.92 kJ
CdI2
CdI2 = Cd+2 + 2I-
log_k -3.5389
delta_h 13.82 kJ
Hg2I2
Hg2I2 = Hg2+2 + 2I-
log_k -28.34
delta_h 163 kJ
Coccinite
```

```
HgI2 + 2H2O = Hg(OH)2 + 2H+ + 2I-
log_k -34.9525
delta_h 210.72 kJ
HgI2:2NH3
HgI2:2NH3 + 2H2O = Hg(OH)2 + 2I- + 2NH4+
log_k -16.2293
delta_h 132.18 kJ
HgI2:6NH3
HgI2:6NH3 + 2H2O + 4H+ = Hg(OH)2 + 2I- + 6NH4+
log_k 33.7335
delta_h -90.3599 kJ
CuI
CuI = Cu+ + I-
log_k -12
delta_h 82.69 kJ
Iodyrite
AgI = Ag+ + I-
log_k -16.08
delta_h 110 kJ
(Co(NH3)6)I3
(Co(NH3)6)I3 + 6H+ = Co+3 + 6NH4+ + 3I-
log_k 16.5831
delta_h -9.6999 kJ
(Co(NH3)5Cl)I2
(Co(NH3)5Cl)I2 + 5H+ = Co+3 + 5NH4+ + Cl- + 2I-
log_k 5.5981
delta_h 0.66 kJ
CrI3
CrI3 + 2H2O = Cr(OH)2+ + 3I- + 2H+
log_k 20.4767
delta_h -134.419 kJ
Cerussite
PbCO3 = Pb+2 + CO3-2
log_k -13.13
delta_h 24.79 kJ
Pb2OCO3
Pb2OCO3 + 2H+ = 2Pb+2 + H2O + CO3-2
log_k -0.5578
delta_h -40.8199 kJ
Pb3O2CO3
Pb3O2CO3 + 4H+ = 3Pb+2 + CO3-2 + 2H2O
log_k 11.02
delta_h -110.583 kJ
Hydrocerussite
Pb3(OH)2(CO3)2 + 2H+ = 3Pb+2 + 2H2O + 2CO3-2
log_k -18.7705
delta_h -0 kJ
Pb10(OH)6O(CO3)6
Pb10(OH)6O(CO3)6 + 8H+ = 10Pb+2 + 6CO3-2 + 7H2O
log_k -8.76
delta_h -0 kJ
Tl2CO3
Tl2CO3 = 2Tl+ + CO3-2
log_k -3.8367
```

delta_h 35.49 kJ
Smithsonite
ZnCO3 = Zn+2 + CO3-2
log_k -10
delta_h -15.84 kJ
ZnCO3:1H2O
ZnCO3:1H2O = Zn+2 + CO3-2 + H2O
log_k -10.26
delta_h -0 kJ
Otavite
CdCO3 = Cd+2 + CO3-2
log_k -12
delta_h -0.55 kJ
Hg2CO3
Hg2CO3 = Hg2+2 + CO3-2
log_k -16.05
delta_h 45.14 kJ
Hg3O2CO3
Hg3O2CO3 + 4H2O = 3Hg(OH)2 + 2H+ + CO3-2
log_k -29.682
delta_h -0 kJ
CuCO3
CuCO3 = Cu+2 + CO3-2
log_k -11.5
delta_h -0 kJ
Malachite
Cu2(OH)2CO3 + 2H+ = 2Cu+2 + 2H2O + CO3-2
log_k -5.306
delta_h 76.38 kJ
Azurite
Cu3(OH)2(CO3)2 + 2H+ = 3Cu+2 + 2H2O + 2CO3-2
log_k -16.906
delta_h -95.22 kJ
Ag2CO3
Ag2CO3 = 2Ag+ + CO3-2
log_k -11.09
delta_h 42.15 kJ
NiCO3
NiCO3 = Ni+2 + CO3-2
log_k -6.87
delta_h -41.589 kJ
CoCO3
CoCO3 = Co+2 + CO3-2
log_k -9.98
delta_h -12.7612 kJ
Siderite
FeCO3 = Fe+2 + CO3-2
log_k -10.24
delta_h -16 kJ
Rhodochrosite
MnCO3 = Mn+2 + CO3-2
log_k -10.58
delta_h -1.88 kJ
Rutherfordine

```
UO2CO3 = UO2+2 + CO3-2
log_k -14.5
delta_h -3.03 kJ
Artinite
MgCO3:Mg(OH)2:3H2O + 2H+ = 2Mg+2 + CO3-2 + 5H2O
log_k 9.6
delta_h -120.257 kJ
Hydromagnesite
Mg5(CO3)4(OH)2:4H2O + 2H+ = 5Mg+2 + 4CO3-2 + 6H2O
log_k -8.766
delta_h -218.447 kJ
Magnesite
MgCO3 = Mg+2 + CO3-2
log_k -7.46
delta_h 20 kJ
Nesquehonite
MgCO3:3H2O = Mg+2 + CO3-2 + 3H2O
log_k -4.67
delta_h -24.2212 kJ
Aragonite
CaCO3 = Ca+2 + CO3-2
log_k -8.3
delta_h -12 kJ
Calcite
CaCO3 = Ca+2 + CO3-2
log_k -8.48
delta_h -8 kJ
Dolomite(ordered)
CaMg(CO3)2 = Ca+2 + Mg+2 + 2CO3-2
log_k -17.09
delta_h -39.5 kJ
Dolomite(disordered)
CaMg(CO3)2 = Ca+2 + Mg+2 + 2CO3-2
log_k -16.54
delta_h -46.4 kJ
Huntite
CaMg3(CO3)4 = 3Mg+2 + Ca+2 + 4CO3-2
log_k -29.968
delta_h -107.78 kJ
Strontianite
SrCO3 = Sr+2 + CO3-2
log_k -9.27
delta_h -0 kJ
Witherite
BaCO3 = Ba+2 + CO3-2
log_k -8.57
delta_h 4 kJ
Thermonatrite
Na2CO3:H2O = 2Na+ + CO3-2 + H2O
log_k 0.637
delta_h -10.4799 kJ
TlNO3
TlNO3 = Tl+ + NO3-
log_k -1.6127
```

```
delta_h 42.44 kJ
Zn(NO3)2:6H2O
Zn(NO3)2:6H2O = Zn+2 + 2NO3- + 6H2O
log_k 3.3153
delta_h 24.5698 kJ
Cu2(OH)3NO3
Cu2(OH)3NO3 + 3H+ = 2Cu+2 + 3H2O + NO3-
log_k 9.251
delta_h -72.5924 kJ
(Co(NH3)6)(NO3)3
(Co(NH3)6)(NO3)3 + 6H+ = Co+3 + 6NH4+ + 3NO3-
log_k 17.9343
delta_h 1.59 kJ
(Co(NH3)5Cl)(NO3)2
(Co(NH3)5Cl)(NO3)2 + 5H+ = Co+3 + 5NH4+ + Cl- + 2NO3-
log_k 6.2887
delta_h 6.4199 kJ
UO2(NO3)2
UO2(NO3)2 = UO2+2 + 2NO3-
log_k 12.1476
delta_h -83.3999 kJ
UO2(NO3)2:2H2O
UO2(NO3)2:2H2O = UO2+2 + 2NO3- + 2H2O
log_k 4.851
delta_h -25.355 kJ
UO2(NO3)2:3H2O
UO2(NO3)2:3H2O = UO2+2 + 2NO3- + 3H2O
log_k 3.39
delta_h -9.1599 kJ
UO2(NO3)2:6H2O
UO2(NO3)2:6H2O = UO2+2 + 2NO3- + 6H2O
log_k 2.0464
delta_h 20.8201 kJ
Pb(BO2)2
Pb(BO2)2 + 2H2O + 2H+ = Pb+2 + 2H3BO3
log_k 6.5192
delta_h -15.6119 kJ
Zn(BO2)2
Zn(BO2)2 + 2H2O + 2H+ = Zn+2 + 2H3BO3
log_k 8.29
delta_h -0 kJ
Cd(BO2)2
Cd(BO2)2 + 2H2O + 2H+ = Cd+2 + 2H3BO3
log_k 9.84
delta_h -0 kJ
Co(BO2)2
Co(BO2)2 + 2H2O + 2H+ = Co+2 + 2H3BO3
log_k 27.0703
delta_h -0 kJ
SnSO4
SnSO4 + 2H2O = Sn(OH)2 + 2H+ + SO4-2
log_k -56.9747
delta_h -0 kJ
Sn(SO4)2
```

```
Sn(SO4)2 + 6H2O = Sn(OH)6-2 + 6H+ + 2SO4-2
log_k -15.2123
delta_h -0 kJ
Larnakite
PbO:PbSO4 + 2H+ = 2Pb+2 + SO4-2 + H2O
log_k -0.4344
delta_h -21.83 kJ
Pb3O2SO4
Pb3O2SO4 + 4H+ = 3Pb+2 + SO4-2 + 2H2O
log_k 10.6864
delta_h -79.14 kJ
Pb4O3SO4
Pb4O3SO4 + 6H+ = 4Pb+2 + SO4-2 + 3H2O
log_k 21.8772
delta_h -136.45 kJ
Anglesite
PbSO4 = Pb+2 + SO4-2
log_k -7.79
delta_h 12 kJ
Pb4(OH)6SO4
Pb4(OH)6SO4 + 6H+ = 4Pb+2 + SO4-2 + 6H2O
log_k 21.1
delta_h -0 kJ
AlOHSO4
AlOHSO4 + H+ = Al+3 + SO4-2 + H2O
log_k -3.23
delta_h -0 kJ
Al4(OH)10SO4
Al4(OH)10SO4 + 10H+ = 4Al+3 + SO4-2 + 10H2O
log_k 22.7
delta_h -0 kJ
Tl2SO4
Tl2SO4 = 2Tl+ + SO4-2
log_k -3.7868
delta_h 33.1799 kJ
Zn2(OH)2SO4
Zn2(OH)2SO4 + 2H+ = 2Zn+2 + 2H2O + SO4-2
log_k 7.5
delta_h -0 kJ
Zn4(OH)6SO4
Zn4(OH)6SO4 + 6H+ = 4Zn+2 + 6H2O + SO4-2
log_k 28.4
delta_h -0 kJ
Zn3O(SO4)2
Zn3O(SO4)2 + 2H+ = 3Zn+2 + 2SO4-2 + H2O
log_k 18.9135
delta_h -258.08 kJ
Zincosite
ZnSO4 = Zn+2 + SO4-2
log_k 3.9297
delta_h -82.586 kJ
ZnSO4:1H2O
ZnSO4:1H2O = Zn+2 + SO4-2 + H2O
log_k -0.638
```

delta_h -44.0699 kJ
Bianchite
ZnSO4:6H2O = Zn+2 + SO4-2 + 6H2O
log_k -1.765
delta_h -0.6694 kJ
Goslarite
ZnSO4:7H2O = Zn+2 + SO4-2 + 7H2O
log_k -2.0112
delta_h 14.21 kJ
Cd3(OH)4SO4
Cd3(OH)4SO4 + 4H+ = 3Cd+2 + 4H2O + SO4-2
log_k 22.56
delta_h -0 kJ
Cd3(OH)2(SO4)2
Cd3(OH)2(SO4)2 + 2H+ = 3Cd+2 + 2H2O + 2SO4-2
log_k 6.71
delta_h -0 kJ
Cd4(OH)6SO4
Cd4(OH)6SO4 + 6H+ = 4Cd+2 + 6H2O + SO4-2
log_k 28.4
delta_h -0 kJ
CdSO4
CdSO4 = Cd+2 + SO4-2
log_k -0.1722
delta_h -51.98 kJ
CdSO4:1H2O
CdSO4:1H2O = Cd+2 + SO4-2 + H2O
log_k -1.7261
delta_h -31.5399 kJ
CdSO4:2.67H2O
CdSO4:2.67H2O = Cd+2 + SO4-2 + 2.67H2O
log_k -1.873
delta_h -17.9912 kJ
Hg2SO4
Hg2SO4 = Hg2+2 + SO4-2
log_k -6.13
delta_h 5.4 kJ
HgSO4
HgSO4 + 2H2O = Hg(OH)2 + SO4-2 + 2H+
log_k -9.4189
delta_h 14.6858 kJ
Cu2SO4
Cu2SO4 = 2Cu+ + SO4-2
log_k -1.95
delta_h -19.079 kJ
Antlerite
Cu3(OH)4SO4 + 4H+ = 3Cu+2 + 4H2O + SO4-2
log_k 8.788
delta_h -0 kJ
Brochantite
Cu4(OH)6SO4 + 6H+ = 4Cu+2 + 6H2O + SO4-2
log_k 15.222
delta_h -202.86 kJ
Langite

```
Cu4(OH)6SO4:H2O + 6H+ = 4Cu+2 + 7H2O + SO4-2
log_k 17.4886
delta_h -165.55 kJ
CuOCuSO4
CuOCuSO4 + 2H+ = 2Cu+2 + H2O + SO4-2
log_k 10.3032
delta_h -137.777 kJ
CuSO4
CuSO4 = Cu+2 + SO4-2
log_k 2.9395
delta_h -73.04 kJ
Chalcanthite
CuSO4:5H2O = Cu+2 + SO4-2 + 5H2O
log_k -2.64
delta_h 6.025 kJ
Ag2SO4
Ag2SO4 = 2Ag+ + SO4-2
log_k -4.82
delta_h 17 kJ
Ni4(OH)6SO4
Ni4(OH)6SO4 + 6H+ = 4Ni+2 + SO4-2 + 6H2O
log_k 32
delta_h -0 kJ
Retgersite
NiSO4:6H2O = Ni+2 + SO4-2 + 6H2O
log_k -2.04
delta_h 4.6024 kJ
Morenosite
NiSO4:7H2O = Ni+2 + SO4-2 + 7H2O
log_k -2.1449
delta_h 12.1802 kJ
CoSO4
CoSO4 = Co+2 + SO4-2
log_k 2.8024
delta_h -79.277 kJ
CoSO4:6H2O
CoSO4:6H2O = Co+2 + SO4-2 + 6H2O
log_k -2.4726
delta_h 1.0801 kJ
Melanterite
FeSO4:7H2O = Fe+2 + SO4-2 + 7H2O
log_k -2.209
delta_h 20.5 kJ
Fe2(SO4)3
Fe2(SO4)3 = 2Fe+3 + 3SO4-2
log_k -3.7343
delta_h -242.028 kJ
H-Jarosite
(H3O)Fe3(SO4)2(OH)6 + 5H+ = 3Fe+3 + 2SO4-2 + 7H2O
log_k -12.1
delta_h -230.748 kJ
Na-Jarosite
NaFe3(SO4)2(OH)6 + 6H+ = Na+ + 3Fe+3 + 2SO4-2 + 6H2O
log_k -11.2
```

```
delta_h -151.377 kJ
K-Jarosite
KFe3(SO4)2(OH)6 + 6H+ = K+ + 3Fe+3 + 2SO4-2 + 6H2O
log_k -14.8
delta_h -130.875 kJ
MnSO4
MnSO4 = Mn+2 + SO4-2
log_k 2.5831
delta_h -64.8401 kJ
Mn2(SO4)3
Mn2(SO4)3 = 2Mn+3 + 3SO4-2
log_k -5.711
delta_h -163.427 kJ
VOSO4
VOSO4 = VO+2 + SO4-2
log_k 3.6097
delta_h -86.7401 kJ
Epsomite
MgSO4:7H2O = Mg+2 + SO4-2 + 7H2O
log_k -2.1265
delta_h 11.5601 kJ
Anhydrite
CaSO4 = Ca+2 + SO4-2
log_k -4.36
delta_h -7.2 kJ
Gypsum
CaSO4:2H2O = Ca+2 + SO4-2 + 2H2O
log_k -4.61
delta_h 1 kJ
Celestite
SrSO4 = Sr+2 + SO4-2
log_k -6.62
delta_h 2 kJ
Barite
BaSO4 = Ba+2 + SO4-2
log_k -9.98
delta_h 23 kJ
Mirabilite
Na2SO4:10H2O = 2Na+ + SO4-2 + 10H2O
log_k -1.114
delta_h 79.4416 kJ
Thenardite
Na2SO4 = 2Na+ + SO4-2
log_k 0.3217
delta_h -9.121 kJ
K-Alum
KAl(SO4)2:12H2O = K+ + Al+3 + 2SO4-2 + 12H2O
log_k -5.17
delta_h 30.2085 kJ
Alunite
KAl3(SO4)2(OH)6 + 6H+ = K+ + 3Al+3 + 2SO4-2 + 6H2O
log_k -1.4
delta_h -210 kJ
(NH4)2CrO4
```

(NH4)2CrO4 = CrO4-2 + 2NH4+
log_k 0.4046
delta_h 9.163 kJ
PbCrO4
PbCrO4 = Pb+2 + CrO4-2
log_k -12.6
delta_h 44.18 kJ
Tl2CrO4
Tl2CrO4 = 2Tl+ + CrO4-2
log_k -12.01
delta_h 74.27 kJ
Hg2CrO4
Hg2CrO4 = Hg2+2 + CrO4-2
log_k -8.7
delta_h -0 kJ
CuCrO4
CuCrO4 = Cu+2 + CrO4-2
log_k -5.44
delta_h -0 kJ
Ag2CrO4
Ag2CrO4 = 2Ag+ + CrO4-2
log_k -11.59
delta_h 62 kJ
MgCrO4
MgCrO4 = CrO4-2 + Mg+2
log_k 5.3801
delta_h -88.9518 kJ
CaCrO4
CaCrO4 = Ca+2 + CrO4-2
log_k -2.2657
delta_h -26.945 kJ
SrCrO4
SrCrO4 = Sr+2 + CrO4-2
log_k -4.65
delta_h -10.1253 kJ
BaCrO4
BaCrO4 = Ba+2 + CrO4-2
log_k -9.67
delta_h 33 kJ
Li2CrO4
Li2CrO4 = CrO4-2 + 2Li+
log_k 4.8568
delta_h -45.2792 kJ
Na2CrO4
Na2CrO4 = CrO4-2 + 2Na+
log_k 2.9302
delta_h -19.6301 kJ
Na2Cr2O7
Na2Cr2O7 + H2O = 2CrO4-2 + 2Na+ + 2H+
log_k -9.8953
delta_h 22.1961 kJ
K2CrO4
K2CrO4 = CrO4-2 + 2K+
log_k -0.5134

```
delta_h 18.2699 kJ
K2Cr2O7
K2Cr2O7 + H2O = 2CrO4-2 + 2K+ + 2H+
log_k -17.2424
delta_h 80.7499 kJ
Hg2SeO3
Hg2SeO3 + H+ = Hg2+2 + HSeO3-
log_k -4.657
delta_h -0 kJ
HgSeO3
HgSeO3 + 2H2O = Hg(OH)2 + H+ + HSeO3-
log_k -12.43
delta_h -0 kJ
Ag2SeO3
Ag2SeO3 + H+ = 2Ag+ + HSeO3-
log_k -7.15
delta_h 39.68 kJ
CuSeO3:2H2O
CuSeO3:2H2O + H+ = Cu+2 + HSeO3- + 2H2O
log_k 0.5116
delta_h -36.861 kJ
NiSeO3:2H2O
NiSeO3:2H2O + H+ = HSeO3- + Ni+2 + 2H2O
log_k 2.8147
delta_h -31.0034 kJ
CoSeO3
CoSeO3 + H+ = Co+2 + HSeO3-
log_k 1.32
delta_h -0 kJ
Fe2(SeO3)3:2H2O
Fe2(SeO3)3:2H2O + 3H+ = 3HSeO3- + 2Fe+3 + 2H2O
log_k -20.6262
delta_h -0 kJ
Fe2(OH)4SeO3
Fe2(OH)4SeO3 + 5H+ = HSeO3- + 2Fe+3 + 4H2O
log_k 1.5539
delta_h -0 kJ
MnSeO3
MnSeO3 + H+ = Mn+2 + HSeO3-
log_k 1.13
delta_h -0 kJ
MnSeO3:2H2O
MnSeO3:2H2O + H+ = HSeO3- + Mn+2 + 2H2O
log_k 0.9822
delta_h 8.4935 kJ
MgSeO3:6H2O
MgSeO3:6H2O + H+ = Mg+2 + HSeO3- + 6H2O
log_k 3.0554
delta_h 5.23 kJ
CaSeO3:2H2O
CaSeO3:2H2O + H+ = HSeO3- + Ca+2 + 2H2O
log_k 2.8139
delta_h -19.4556 kJ
SrSeO3
```

```
SrSeO3 + H+ = Sr+2 + HSeO3-
log_k 2.3
delta_h -0 kJ
BaSeO3
BaSeO3 + H+ = Ba+2 + HSeO3-
log_k 1.83
delta_h 11.98 kJ
Na2SeO3:5H2O
Na2SeO3:5H2O + H+ = 2Na+ + HSeO3- + 5H2O
log_k 10.3
delta_h -0 kJ
PbSeO4
PbSeO4 = Pb+2 + SeO4-2
log_k -6.84
delta_h 15 kJ
Tl2SeO4
Tl2SeO4 = 2Tl+ + SeO4-2
log_k -4.1
delta_h 43 kJ
ZnSeO4:6H2O
ZnSeO4:6H2O = Zn+2 + SeO4-2 + 6H2O
log_k -1.52
delta_h -0 kJ
CdSeO4:2H2O
CdSeO4:2H2O = Cd+2 + SeO4-2 + 2H2O
log_k -1.85
delta_h -0 kJ
Ag2SeO4
Ag2SeO4 = 2Ag+ + SeO4-2
log_k -8.91
delta_h -43.5 kJ
CuSeO4:5H2O
CuSeO4:5H2O = Cu+2 + SeO4-2 + 5H2O
log_k -2.44
delta_h -0 kJ
NiSeO4:6H2O
NiSeO4:6H2O = Ni+2 + SeO4-2 + 6H2O
log_k -1.52
delta_h -0 kJ
CoSeO4:6H2O
CoSeO4:6H2O = Co+2 + SeO4-2 + 6H2O
log_k -1.53
delta_h -0 kJ
MnSeO4:5H2O
MnSeO4:5H2O = Mn+2 + SeO4-2 + 5H2O
log_k -2.05
delta_h -0 kJ
UO2SeO4:4H2O
UO2SeO4:4H2O = UO2+2 + SeO4-2 + 4H2O
log_k -2.25
delta_h -0 kJ
MgSeO4:6H2O
MgSeO4:6H2O = Mg+2 + SeO4-2 + 6H2O
log_k -1.2
```

```
delta_h -0 kJ
CaSeO4:2H2O
CaSeO4:2H2O = Ca+2 + SeO4-2 + 2H2O
log_k -3.02
delta_h -8.3 kJ
SrSeO4
SrSeO4 = Sr+2 + SeO4-2
log_k -4.4
delta_h 0.4 kJ
BaSeO4
BaSeO4 = Ba+2 + SeO4-2
log_k -7.46
delta_h 22 kJ
BeSeO4:4H2O
BeSeO4:4H2O = Be+2 + SeO4-2 + 4H2O
log_k -2.94
delta_h -0 kJ
Na2SeO4
Na2SeO4 = 2Na+ + SeO4-2
log_k 1.28
delta_h -0 kJ
K2SeO4
K2SeO4 = 2K+ + SeO4-2
log_k -0.73
delta_h -0 kJ
(NH4)2SeO4
(NH4)2SeO4 = 2NH4+ + SeO4-2
log_k 0.45
delta_h -0 kJ
H2MoO4
H2MoO4 = MoO4-2 + 2H+
log_k -12.8765
delta_h 49 kJ
PbMoO4
PbMoO4 = Pb+2 + MoO4-2
log_k -15.62
delta_h 53.93 kJ
Al2(MoO4)3
Al2(MoO4)3 = 3MoO4-2 + 2Al+3
log_k 2.3675
delta_h -260.8 kJ
Tl2MoO4
Tl2MoO4 = MoO4-2 + 2Tl+
log_k -7.9887
delta_h -0 kJ
ZnMoO4
ZnMoO4 = MoO4-2 + Zn+2
log_k -10.1254
delta_h -10.6901 kJ
CdMoO4
CdMoO4 = MoO4-2 + Cd+2
log_k -14.1497
delta_h 19.48 kJ
CuMoO4
```

CuMoO4 = MoO4-2 + Cu+2
log_k -13.0762
delta_h 12.2 kJ
Ag2MoO4
Ag2MoO4 = 2Ag+ + MoO4-2
log_k -11.55
delta_h 52.7 kJ
NiMoO4
NiMoO4 = MoO4-2 + Ni+2
log_k -11.1421
delta_h 1.3 kJ
CoMoO4
CoMoO4 = MoO4-2 + Co+2
log_k -7.7609
delta_h -23.3999 kJ
FeMoO4
FeMoO4 = MoO4-2 + Fe+2
log_k -10.091
delta_h -11.1 kJ
BeMoO4
BeMoO4 = MoO4-2 + Be+2
log_k -1.7817
delta_h -56.4 kJ
MgMoO4
MgMoO4 = Mg+2 + MoO4-2
log_k -1.85
delta_h -0 kJ
CaMoO4
CaMoO4 = Ca+2 + MoO4-2
log_k -7.95
delta_h -2 kJ
BaMoO4
BaMoO4 = MoO4-2 + Ba+2
log_k -6.9603
delta_h 10.96 kJ
Li2MoO4
Li2MoO4 = MoO4-2 + 2Li+
log_k 2.4416
delta_h -33.9399 kJ
Na2MoO4
Na2MoO4 = MoO4-2 + 2Na+
log_k 1.4901
delta_h -9.98 kJ
Na2MoO4:2H2O
Na2MoO4:2H2O = MoO4-2 + 2Na+ + 2H2O
log_k 1.224
delta_h -0 kJ
Na2Mo2O7
Na2Mo2O7 + H2O = 2MoO4-2 + 2Na+ + 2H+
log_k -16.5966
delta_h 56.2502 kJ
K2MoO4
K2MoO4 = MoO4-2 + 2K+
log_k 3.2619

```
delta_h -3.38 kJ
PbHPO4
PbHPO4 = Pb+2 + H+ + PO4-3
log_k -23.805
delta_h -0 kJ
Pb3(PO4)2
Pb3(PO4)2 = 3Pb+2 + 2PO4-3
log_k -43.53
delta_h -0 kJ
Pyromorphite
Pb5(PO4)3Cl = 5Pb+2 + 3PO4-3 + Cl-
log_k -84.43
delta_h -0 kJ
Hydroxylpyromorphite
Pb5(PO4)3OH + H+ = 5Pb+2 + 3PO4-3 + H2O
log_k -62.79
delta_h -0 kJ
Plumbgummite
PbAl3(PO4)2(OH)5:H2O + 5H+ = Pb+2 + 3Al+3 + 2PO4-3 + 6H2O
log_k -32.79
delta_h -0 kJ
Hinsdalite
PbAl3PO4SO4(OH)6 + 6H+ = Pb+2 + 3Al+3 + PO4-3 + SO4-2 + 6H2O
log_k -2.5
delta_h -0 kJ
Tsumebite
Pb2CuPO4(OH)3:3H2O + 3H+ = 2Pb+2 + Cu+2 + PO4-3 + 6H2O
log_k -9.79
delta_h -0 kJ
Zn3(PO4)2:4H2O
Zn3(PO4)2:4H2O = 3Zn+2 + 2PO4-3 + 4H2O
log_k -35.42
delta_h -0 kJ
Cd3(PO4)2
Cd3(PO4)2 = 3Cd+2 + 2PO4-3
log_k -32.6
delta_h -0 kJ
Hg2HPO4
Hg2HPO4 = Hg2+2 + H+ + PO4-3
log_k -24.775
delta_h -0 kJ
Cu3(PO4)2
Cu3(PO4)2 = 3Cu+2 + 2PO4-3
log_k -36.85
delta_h -0 kJ
Cu3(PO4)2:3H2O
Cu3(PO4)2:3H2O = 3Cu+2 + 2PO4-3 + 3H2O
log_k -35.12
delta_h -0 kJ
Ag3PO4
Ag3PO4 = 3Ag+ + PO4-3
log_k -17.59
delta_h -0 kJ
Ni3(PO4)2
```

```
Ni3(PO4)2 = 3Ni+2 + 2PO4-3
log_k -31.3
delta_h -0 kJ
CoHPO4
CoHPO4 = Co+2 + PO4-3 + H+
log_k -19.0607
delta_h -0 kJ
Co3(PO4)2
Co3(PO4)2 = 3Co+2 + 2PO4-3
log_k -34.6877
delta_h -0 kJ
Vivianite
Fe3(PO4)2:8H2O = 3Fe+2 + 2PO4-3 + 8H2O
log_k -36
delta_h -0 kJ
Strengite
FePO4:2H2O = Fe+3 + PO4-3 + 2H2O
log_k -26.4
delta_h -9.3601 kJ
Mn3(PO4)2
Mn3(PO4)2 = 3Mn+2 + 2PO4-3
log_k -23.827
delta_h 8.8701 kJ
MnHPO4
MnHPO4 = Mn+2 + PO4-3 + H+
log_k -25.4
delta_h -0 kJ
(VO)3(PO4)2
(VO)3(PO4)2 = 3VO+2 + 2PO4-3
log_k -25.1
delta_h -0 kJ
Mg3(PO4)2
Mg3(PO4)2 = 3Mg+2 + 2PO4-3
log_k -23.28
delta_h -0 kJ
MgHPO4:3H2O
MgHPO4:3H2O = Mg+2 + H+ + PO4-3 + 3H2O
log_k -18.175
delta_h -0 kJ
FCO3Apatite
Ca9.316Na0.36Mg0.144(PO4)4.8(CO3)1.2F2.48 = 9.316Ca+2 + 0.36Na+ + 0.144Mg+2 + 4.8PO4-3 +
1.2CO3-2 + 2.48F-
log_k -114.4
delta_h 164.808 kJ
Hydroxylapatite
Ca5(PO4)3OH + H+ = 5Ca+2 + 3PO4-3 + H2O
log_k -44.333
delta_h -0 kJ
CaHPO4:2H2O
CaHPO4:2H2O = Ca+2 + H+ + PO4-3 + 2H2O
log_k -18.995
delta_h 23 kJ
CaHPO4
CaHPO4 = Ca+2 + H+ + PO4-3
```

```
log_k -19.275
delta_h 31 kJ
Ca3(PO4)2(beta)
Ca3(PO4)2 = 3Ca+2 + 2PO4-3
log_k -28.92
delta_h 54 kJ
Ca4H(PO4)3:3H2O
Ca4H(PO4)3:3H2O = 4Ca+2 + H+ + 3PO4-3 + 3H2O
log_k -47.08
delta_h -0 kJ
SrHPO4
SrHPO4 = Sr+2 + H+ + PO4-3
log_k -19.295
delta_h -0 kJ
BaHPO4
BaHPO4 = Ba+2 + H+ + PO4-3
log_k -19.775
delta_h -0 kJ
U(HPO4)2:4H2O
U(HPO4)2:4H2O = U+4 + 2PO4-3 + 2H+ + 4H2O
log_k -51.584
delta_h 16.0666 kJ
(UO2)3(PO4)2
(UO2)3(PO4)2 = 3UO2+2 + 2PO4-3
log_k -49.4
delta_h 397.062 kJ
UO2HPO4
UO2HPO4 = UO2+2 + H+ + PO4-3
log_k -24.225
delta_h -0 kJ
Uramphite
(NH4)2(UO2)2(PO4)2 = 2UO2+2 + 2NH4+ + 2PO4-3
log_k -51.749
delta_h 40.5848 kJ
Przhevalskite
Pb(UO2)2(PO4)2 = 2UO2+2 + Pb+2 + 2PO4-3
log_k -44.365
delta_h -46.024 kJ
Torbernite
Cu(UO2)2(PO4)2 = 2UO2+2 + Cu+2 + 2PO4-3
log_k -45.279
delta_h -66.5256 kJ
Bassetite
Fe(UO2)2(PO4)2 = 2UO2+2 + Fe+2 + 2PO4-3
log_k -44.485
delta_h -83.2616 kJ
Saleeite
Mg(UO2)2(PO4)2 = 2UO2+2 + Mg+2 + 2PO4-3
log_k -43.646
delta_h -84.4331 kJ
Ningyoite
CaU(PO4)2:2H2O = U+4 + Ca+2 + 2PO4-3 + 2H2O
log_k -53.906
delta_h -9.4977 kJ
```

H-Autunite
H2(UO2)2(PO4)2 = 2UO2+2 + 2H+ + 2PO4-3
log_k -47.931
delta_h -15.0624 kJ
Autunite
Ca(UO2)2(PO4)2 = 2UO2+2 + Ca+2 + 2PO4-3
log_k -43.927
delta_h -59.9986 kJ
Sr-Autunite
Sr(UO2)2(PO4)2 = 2UO2+2 + Sr+2 + 2PO4-3
log_k -44.457
delta_h -54.6012 kJ
Na-Autunite
Na2(UO2)2(PO4)2 = 2UO2+2 + 2Na+ + 2PO4-3
log_k -47.409
delta_h -1.9246 kJ
K-Autunite
K2(UO2)2(PO4)2 = 2UO2+2 + 2K+ + 2PO4-3
log_k -48.244
delta_h 24.5182 kJ
Uranocircite
Ba(UO2)2(PO4)2 = 2UO2+2 + Ba+2 + 2PO4-3
log_k -44.631
delta_h -42.2584 kJ
Pb3(AsO4)2
Pb3(AsO4)2 + 6H+ = 3Pb+2 + 2H3AsO4
log_k 5.8
delta_h -0 kJ
AlAsO4:2H2O
AlAsO4:2H2O + 3H+ = Al+3 + H3AsO4 + 2H2O
log_k 4.8
delta_h -0 kJ
Zn3(AsO4)2:2.5H2O
Zn3(AsO4)2:2.5H2O + 6H+ = 3Zn+2 + 2H3AsO4 + 2.5H2O
log_k 13.65
delta_h -0 kJ
Cu3(AsO4)2:2H2O
Cu3(AsO4)2:2H2O + 6H+ = 3Cu+2 + 2H3AsO4 + 2H2O
log_k 6.1
delta_h -0 kJ
Ag3AsO3
Ag3AsO3 + 3H+ = 3Ag+ + H3AsO3
log_k 2.1573
delta_h -0 kJ
Ag3AsO4
Ag3AsO4 + 3H+ = 3Ag+ + H3AsO4
log_k -2.7867
delta_h -0 kJ
Ni3(AsO4)2:8H2O
Ni3(AsO4)2:8H2O + 6H+ = 3Ni+2 + 2H3AsO4 + 8H2O
log_k 15.7
delta_h -0 kJ
Co3(AsO4)2
Co3(AsO4)2 + 6H+ = 3Co+2 + 2H3AsO4

```
log_k 13.0341
delta_h -0 kJ
FeAsO4:2H2O
FeAsO4:2H2O + 3H+ = Fe+3 + H3AsO4 + 2H2O
log_k 0.4
delta_h -0 kJ
Mn3(AsO4)2:8H2O
Mn3(AsO4)2:8H2O + 6H+ = 3Mn+2 + 2H3AsO4 + 8H2O
log_k 12.5
delta_h -0 kJ
Ca3(AsO4)2:4H2O
Ca3(AsO4)2:4H2O + 6H+ = 3Ca+2 + 2H3AsO4 + 4H2O
log_k 22.3
delta_h -0 kJ
Ba3(AsO4)2
Ba3(AsO4)2 + 6H+ = 3Ba+2 + 2H3AsO4
log_k -8.91
delta_h 11.0458 kJ
#NH4VO3
# NH4VO3 + 2H+ = 2VO2+ + H2O
# log_k 3.8
# delta_h 30 kJ
Pb3(VO4)2
Pb3(VO4)2 + 8H+ = 3Pb+2 + 2VO2+ + 4H2O
log_k 6.14
delta_h -72.6342 kJ
Pb2V2O7
Pb2V2O7 + 6H+ = 2Pb+2 + 2VO2+ + 3H2O
log_k -1.9
delta_h -26.945 kJ
AgVO3
AgVO3 + 2H+ = Ag+ + VO2+ + H2O
log_k 0.77
delta_h -0 kJ
Ag2HVO4
Ag2HVO4 + 3H+ = 2Ag+ + VO2+ + 2H2O
log_k 1.48
delta_h -0 kJ
Ag3H2VO5
Ag3H2VO5 + 4H+ = 3Ag+ + VO2+ + 3H2O
log_k 5.18
delta_h -0 kJ
Fe(VO3)2
Fe(VO3)2 + 4H+ = Fe+2 + 2VO2+ + 2H2O
log_k -3.72
delta_h -61.6722 kJ
Mn(VO3)2
Mn(VO3)2 + 4H+ = Mn+2 + 2VO2+ + 2H2O
log_k 4.9
delta_h -92.4664 kJ
Mg(VO3)2
Mg(VO3)2 + 4H+ = Mg+2 + 2VO2+ + 2H2O
log_k 11.28
delta_h -136.649 kJ
```

```
Mg2V2O7
Mg2V2O7 + 6H+ = 2Mg+2 + 2VO2+ + 3H2O
log_k 26.36
delta_h -255.224 kJ
Carnotite
KUO2VO4 + 4H+ = K+ + UO2+2 + VO2+ + 2H2O
log_k 0.23
delta_h -36.4008 kJ
Tyuyamunite
Ca(UO2)2(VO4)2 + 8H+ = Ca+2 + 2UO2+2 + 2VO2+ + 4H2O
log_k 4.08
delta_h -153.134 kJ
Ca(VO3)2
Ca(VO3)2 + 4H+ = Ca+2 + 2VO2+ + 2H2O
log_k 5.66
delta_h -84.7678 kJ
Ca3(VO4)2
Ca3(VO4)2 + 8H+ = 3Ca+2 + 2VO2+ + 4H2O
log_k 38.96
delta_h -293.466 kJ
Ca2V2O7
Ca2V2O7 + 6H+ = 2Ca+2 + 2VO2+ + 3H2O
log_k 17.5
delta_h -159.494 kJ
Ca3(VO4)2:4H2O
Ca3(VO4)2:4H2O + 8H+ = 3Ca+2 + 2VO2+ + 8H2O
log_k 39.86
delta_h -0 kJ
Ca2V2O7:2H2O
Ca2V2O7:2H2O + 6H+ = 2Ca+2 + 2VO2+ + 5H2O
log_k 21.552
delta_h -0 kJ
Ba3(VO4)2:4H2O
Ba3(VO4)2:4H2O + 8H+ = 3Ba+2 + 2VO2+ + 8H2O
log_k 32.94
delta_h -0 kJ
Ba2V2O7:2H2O
Ba2V2O7:2H2O + 6H+ = 2Ba+2 + 2VO2+ + 5H2O
log_k 15.872
delta_h -0 kJ
NaVO3
NaVO3 + 2H+ = Na+ + VO2+ + H2O
log_k 3.8582
delta_h -30.1799 kJ
Na3VO4
Na3VO4 + 4H+ = 3Na+ + VO2+ + 2H2O
log_k 36.6812
delta_h -184.61 kJ
Na4V2O7
Na4V2O7 + 6H+ = 4Na+ + 2VO2+ + 3H2O
log_k 37.4
delta_h -201.083 kJ
Halloysite
Al2Si2O5(OH)4 + 6H+ = 2Al+3 + 2H4SiO4 + H2O
```

```
log_k 9.5749
delta_h -181.43 kJ
Kaolinite
Al2Si2O5(OH)4 + 6H+ = 2Al+3 + 2H4SiO4 + H2O
log_k 7.435
delta_h -148 kJ
Greenalite
Fe3Si2O5(OH)4 + 6H+ = 3Fe+2 + 2H4SiO4 + H2O
log_k 20.81
delta_h -0 kJ
Chrysotile
Mg3Si2O5(OH)4 + 6H+ = 3Mg+2 + 2H4SiO4 + H2O
log_k 32.2
delta_h -196 kJ
Sepiolite
Mg2Si3O7.5OH:3H2O + 4H+ + 0.5H2O = 2Mg+2 + 3H4SiO4
log_k 15.76
delta_h -114.089 kJ
Sepiolite(A)
Mg2Si3O7.5OH:3H2O + 0.5H2O + 4H+ = 2Mg+2 + 3H4SiO4
log_k 18.78
delta_h -0 kJ
PHASES
O2(g)
O2 + 4H+ + 4e- = 2H2O
log_k 83.0894
delta_h -571.66 kJ
CH4(g)
CH4 + 3H2O = CO3-2 + 8e- + 10H+
log_k -41.0452
delta_h 257.133 kJ
CO2(g)
CO2 + H2O = 2H+ + CO3-2
log_k -18.147
delta_h 4.06 kJ
H2S(g)
H2S = H+ + HS-
log_k -8.01
delta_h -0 kJ
H2Se(g)
H2Se = HSe- + H+
log_k -4.96
delta_h -15.3 kJ
Hg(g)
Hg = 0.5Hg2+2 + e-
log_k -7.8733
delta_h 22.055 kJ
Hg2(g)
Hg2 = Hg2+2 + 2e-
log_k -14.9554
delta_h 58.07 kJ
Hg(CH3)2(g)
Hg(CH3)2 + 8H2O = Hg(OH)2 + 2CO3-2 + 16e- + 20H+
log_k -73.7066
```

```
delta_h 481.99 kJ
HgF(g)
HgF = 0.5Hg2+2 + F-
log_k 32.6756
delta_h -254.844 kJ
HgF2(g)
HgF2 + 2H2O = Hg(OH)2 + 2F- + 2H+
log_k 12.5652
delta_h -165.186 kJ
HgCl(g)
HgCl = 0.5Hg2+2 + Cl-
log_k 19.4966
delta_h -162.095 kJ
HgBr(g)
HgBr = 0.5Hg2+2 + Br-
log_k 16.7566
delta_h -142.157 kJ
HgBr2(g)
HgBr2 + 2H2O = Hg(OH)2 + 2Br- + 2H+
log_k -18.3881
delta_h 54.494 kJ
HgI(g)
HgI = 0.5Hg2+2 + I-
log_k 11.3322
delta_h -106.815 kJ
HgI2(g)
HgI2 + 2H2O = Hg(OH)2 + 2I- + 2H+
log_k -27.2259
delta_h 114.429 kJ
SURFACE_MASTER_SPECIES
Hfo_s Hfo_sOH
Hfo_w Hfo_wOH
Hao_ Hao_OH #hydrous aluminum oxides - gibbsite
SURFACE_SPECIES
Hfo_wOH = Hfo_wOH
log_k 0.0
Hfo_sOH = Hfo_sOH
log_k 0.0
Hao_OH = Hao_OH
log_k 0.0

Hfo_sOH + H+ = Hfo_sOH2+
log_k 7.29
delta_h 0 kJ
# Id: 8113302
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH = Hfo_sO- + H+
log_k -8.93
delta_h 0 kJ
# Id: 8113301
# log K source:
# Delta H source:
```

```
#T and ionic strength:
Hfo_wOH + H+ = Hfo_wOH2+
log_k 7.29
delta_h 0 kJ
# Id: 8123302
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH = Hfo_wO- + H+
log_k -8.93
delta_h 0 kJ
# Id: 8123301
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Ba+2 = Hfo_sOHBa+2
log_k 5.46
delta_h 0 kJ
# Id: 8111000
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Ba+2 = Hfo_wOBa+ + H+
log_k -7.2
delta_h 0 kJ
# Id: 8121000
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Ca+2 = Hfo_sOHCa+2
log_k 4.97
delta_h 0 kJ
# Id: 8111500
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Ca+2 = Hfo_wOCa+ + H+
log_k -5.85
delta_h 0 kJ
# Id: 8121500
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Mg+2 = Hfo_wOMg+ + H+
log_k -4.6
delta_h 0 kJ
# Id: 8124600
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Ag+ = Hfo_sOAg + H+
log_k -1.72
delta_h 0 kJ
# Id: 8110200
```

```
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Ag+ = Hfo_wOAg + H+
log_k -5.3
delta_h 0 kJ
# Id: 8120200
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Ni+2 = Hfo_sONi+ + H+
log_k 0.37
delta_h 0 kJ
# Id: 8115400
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Ni+2 = Hfo_wONi+ + H+
log_k -2.5
delta_h 0 kJ
# Id: 8125400
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Cd+2 = Hfo_sOCd+ + H+
log_k 0.47
delta_h 0 kJ
# Id: 8111600
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Cd+2 = Hfo_wOCd+ + H+
log_k -2.9
delta_h 0 kJ
# Id: 8121600
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Co+2 = Hfo_sOCo+ + H+
log_k -0.46
delta_h 0 kJ
# Id: 8112000
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Co+2 = Hfo_wOCo+ + H+
log_k -3.01
delta_h 0 kJ
# Id: 8122000
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Zn+2 = Hfo_sOZn+ + H+
log_k 0.99
```

```
delta_h 0 kJ
# Id: 8119500
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Zn+2 = Hfo_wOZn+ + H+
log_k -1.99
delta_h 0 kJ
# Id: 8129500
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Cu+2 = Hfo_sOCu+ + H+
log_k 2.89
delta_h 0 kJ
# Id: 8112310
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Cu+2 = Hfo_wOCu+ + H+
log_k 0.6
delta_h 0 kJ
# Id: 8123100
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Pb+2 = Hfo_sOPb+ + H+
log_k 4.65
delta_h 0 kJ
# Id: 8116000
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Pb+2 = Hfo_wOPb+ + H+
log_k 0.3
delta_h 0 kJ
# Id: 8126000
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Be+2 = Hfo_sOBe+ + H+
log_k 5.7
delta_h 0 kJ
# Id: 8111100
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Be+2 = Hfo_wOBe+ + H+
log_k 3.3
delta_h 0 kJ
# Id: 8121100
# log K source:
# Delta H source:
#T and ionic strength:
```

```
Hfo_sOH + Hg(OH)2 + H+ = Hfo_sOHg+ + 2H2O
log_k 13.95
delta_h 0 kJ
# Id: 8113610
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Hg(OH)2 + H+ = Hfo_wOHg+ + 2H2O
log_k 12.64
delta_h 0 kJ
# Id: 8123610
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Sn(OH)2 + H+ = Hfo_sOSn+ + 2H2O
log_k 15.1
delta_h 0 kJ
# Id: 8117900
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Sn(OH)2 + H+ = Hfo_wOSn+ + 2H2O
log_k 13
delta_h 0 kJ
# Id: 8127900
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Cr(OH)2+ = Hfo_sOCrOH+ + H2O
log_k 11.63
delta_h 0 kJ
# Id: 8112110
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + H3AsO3 = Hfo_sH2AsO3 + H2O
log_k 5.41
delta_h 0 kJ
# Id: 8110600
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + H3AsO3 = Hfo_wH2AsO3 + H2O
log_k 5.41
delta_h 0 kJ
# Id: 8120600
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + H3BO3 = Hfo_sH2BO3 + H2O
log_k 0.62
delta_h 0 kJ
# Id: 8110900
# log K source:
```

```
# Delta H source:
#T and ionic strength:
Hfo_wOH + H3BO3 = Hfo_wH2BO3 + H2O
log_k 0.62
delta_h 0 kJ
# Id: 8120900
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + PO4-3 + 3H+ = Hfo_sH2PO4 + H2O
log_k 31.29
delta_h 0 kJ
# Id: 8115800
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + PO4-3 + 3H+ = Hfo_wH2PO4 + H2O
log_k 31.29
delta_h 0 kJ
# Id: 8125800
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + PO4-3 + 2H+ = Hfo_sHPO4- + H2O
log_k 25.39
delta_h 0 kJ
# Id: 8115801
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + PO4-3 + 2H+ = Hfo_wHPO4- + H2O
log_k 25.39
delta_h 0 kJ
# Id: 8125801
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + PO4-3 + H+ = Hfo_sPO4-2 + H2O
log_k 17.72
delta_h 0 kJ
# Id: 8115802
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + PO4-3 + H+ = Hfo_wPO4-2 + H2O
log_k 17.72
delta_h 0 kJ
# Id: 8125802
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + H3AsO4 = Hfo_sH2AsO4 + H2O
log_k 8.61
delta_h 0 kJ
```

```
# Id: 8110610
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + H3AsO4 = Hfo_wH2AsO4 + H2O
log_k 8.61
delta_h 0 kJ
# Id: 8120610
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + H3AsO4 = Hfo_sHAsO4- + H2O + H+
log_k 2.81
delta_h 0 kJ
# Id: 8110611
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + H3AsO4 = Hfo_wHAsO4- + H2O + H+
log_k 2.81
delta_h 0 kJ
# Id: 8120611
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + H3AsO4 = Hfo_sOHAsO4-3 + 3H+
log_k -10.12
delta_h 0 kJ
# Id: 8110613
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + H3AsO4 = Hfo_wOHAsO4-3 + 3H+
log_k -10.12
delta_h 0 kJ
# Id: 8120613
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + VO2+ + 2H2O = Hfo_sOHVO4-3 + 4H+
log_k -16.63
delta_h 0 kJ
# Id: 8119031
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + VO2+ + 2H2O = Hfo_wOHVO4-3 + 4H+
log_k -16.63
delta_h 0 kJ
# Id: 8129031
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + SO4-2 + H+ = Hfo_sSO4- + H2O
```

```
log_k 7.78
delta_h 0 kJ
# Id: 8117320
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + SO4-2 + H+ = Hfo_wSO4- + H2O
log_k 7.78
delta_h 0 kJ
# Id: 8127320
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + SO4-2 = Hfo_sOHSO4-2
log_k 0.79
delta_h 0 kJ
# Id: 8117321
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + SO4-2 = Hfo_wOHSO4-2
log_k 0.79
delta_h 0 kJ
# Id: 8127321
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + HSeO3- = Hfo_sSeO3- + H2O
log_k 4.29
delta_h 0 kJ
# Id: 8117610
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + HSeO3- = Hfo_wSeO3- + H2O
log_k 4.29
delta_h 0 kJ
# Id: 8127610
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + HSeO3- = Hfo_sOHSeO3-2 + H+
log_k -3.23
delta_h 0 kJ
# Id: 8117611
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + HSeO3- = Hfo_wOHSeO3-2 + H+
log_k -3.23
delta_h 0 kJ
# Id: 8127611
# log K source:
# Delta H source:
```

```
#T and ionic strength:
Hfo_sOH + SeO4-2 + H+ = Hfo_sSeO4- + H2O
log_k 7.73
delta_h 0 kJ
# Id: 8117620
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + SeO4-2 + H+ = Hfo_wSeO4- + H2O
log_k 7.73
delta_h 0 kJ
# Id: 8127620
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + SeO4-2 = Hfo_sOHSeO4-2
log_k 0.8
delta_h 0 kJ
# Id: 8117621
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + SeO4-2 = Hfo_wOHSeO4-2
log_k 0.8
delta_h 0 kJ
# Id: 8127621
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + CrO4-2 + H+ = Hfo_sCrO4- + H2O
log_k 10.85
delta_h 0 kJ
# Id: 8112120
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + CrO4-2 + H+ = Hfo_wCrO4- + H2O
log_k 10.85
delta_h 0 kJ
# Id: 8122120
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + CrO4-2 = Hfo_sOHCrO4-2
log_k 3.9
delta_h 0 kJ
# Id: 8112121
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + CrO4-2 = Hfo_wOHCrO4-2
log_k 3.9
delta_h 0 kJ
# Id: 8122121
```

```
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + MoO4-2 + H+ = Hfo_sMoO4- + H2O
log_k 9.5
delta_h 0 kJ
# Id: 8114800
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + MoO4-2 + H+ = Hfo_wMoO4- + H2O
log_k 9.5
delta_h 0 kJ
# Id: 8124800
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + MoO4-2 = Hfo_sOHMoO4-2
log_k 2.4
delta_h 0 kJ
# Id: 8114801
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + MoO4-2 = Hfo_wOHMoO4-2
log_k 2.4
delta_h 0 kJ
# Id: 8124801
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Sb(OH)6- + H+ = Hfo_sSbO(OH)4 + 2H2O
log_k 8.4
delta_h 0 kJ
# Id: 8117410
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Sb(OH)6- + H+ = Hfo_wSbO(OH)4 + 2H2O
log_k 8.4
delta_h 0 kJ
# Id: 8127410
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Sb(OH)6- = Hfo_sOHSbO(OH)4- + H2O
log_k 1.3
delta_h 0 kJ
# Id: 8117411
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Sb(OH)6- = Hfo_wOHSbO(OH)4- + H2O
log_k 1.3
```

```
delta_h 0 kJ
# Id: 8127411
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Cyanide- + H+ = Hfo_sCyanide + H2O
log_k 13
delta_h 0 kJ
# Id: 8111430
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Cyanide- + H+ = Hfo_wCyanide + H2O
log_k 13
delta_h 0 kJ
# Id: 8121430
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_sOH + Cyanide- = Hfo_sOHCyanide-
log_k 5.7
delta_h 0 kJ
# Id: 8111431
# log K source:
# Delta H source:
#T and ionic strength:
Hfo_wOH + Cyanide- = Hfo_wOHCyanide-
log_k 5.7
delta_h 0 kJ
# Id: 8121431
# log K source:
# Delta H source:
#T and ionic strength:
#Additions from GWB Minteq
Hfo_wOH + H4SiO4 = Hfo_wOSi(OH)3 + H2O
log_k 4.28
delta_h 0 kJ
Hfo_wOH + H4SiO4 = Hfo_wOSiO(OH)2- + H+ + H2O
log_k -3.22
delta_h 0 kJ
Hfo_sOH + H4SiO4 = Hfo_sOSi(OH)3 + H2O
log_k 4.28
delta_h 0
Hfo_sOH + H4SiO4 = Hfo_sOSiO(OH)2- + H+ + H2O
log_k -3.22
delta_h 0
Hfo_wOH + CO3-2 + H+ = Hfo_wCO3- + H2O
log_k 12.56
delta_h 0
Hfo_wOH + CO3-2 + 2H+= Hfo_wHCO3 + H2O
log_k 20.62
delta_h 0
Hfo_sOH + CO3-2 + H+ = Hfo_sCO3- + H2O
log_k 12.56
```

```
delta_h 0
Hfo_sOH + CO3-2 + 2H+= Hfo_sHCO3 + H2O
log_k 20.62
delta_h 0

#Karamalidis and Dzombak sorption to gibbsite (hao) as compiled in Cravotta 2021 (https://doi.org/10.1016/j.apgeochem.2020.104845) Table S4 unless otherwise noted
Hao_OH + Cu+2 = Hao_OCu+ + H+
log_k 0.25
Hao_OH + Pb+2 = Hao_OPb+ + H+
log_k 0.37
Hao_OH + Co+2 = Hao_OCo+ + H+
log_k -2.52
Hao_OH + Cd+2 = Hao_OCd+ + H+
log_k -2.73
Hao_OH + Mn+2 = Hao_OMn+ + H+
log_k -5.49
Hao_OH + Fe+2 = Hao_OFe+ + H+
log_k -3.77
Hao_OH + Ca+2 = Hao_OCa+ + H+
log_k -10.49
Hao_OH + Mg+2 = Hao_OMg+ + H+
log_k -5.93
Hao_OH + Ba+2 = Hao_OBa+ + H+
log_k -8.5
Hao_OH + Sr+2 = Hao_OSr+ + H+
log_k -8.26
Hao_OH + Zn+2 = Hao_OZn+ + H+
log_k -0.96
Hao_OH + PO4-3 + 3 H+ = Hao_H2PO4 + H2O
log_k 26.89
Hao_OH + PO4-3 + 2H+ = Hao_HPO4- + H2O
log_k 19.37
Hao_OH + PO4-3 + H+ = Hao_PO4-2 + H2O
log_k 13.57
#Hao_OH + SO4-2 + H+ = Hao_SO4- + H2O
# log_k -0.45
#Hao_OH + SO4-2 = Hao_OHSO4-2
# log_k 1.19
Hao_OH + F- + H+ = Hao_F + H2O
log_k 8.78
Hao_OH + F- = Hao_OHF-
log_k 2.88
Hao_OH + 2 F- + H+ = Hao_F2- + H2O
log_k 11.94
Hao_OH + H4SiO4 = Hao_OH4SiO4- + H+
log_k -4.16

#Modified value from Goldberg and Glaubig (1985)
Hao_OH + H3BO3 = Hao_H2BO3 + H2O
Log_k 4.83
Hao_OH + H3BO3 = Hao_H3BO4- + H+
Log_k -7.40

#Modified value from Kitadai et al. (2018)
Hao_OH + SO4-2 + H+ = Hao_SO4- + H2O
```

```
log_k 2.4
#Modified value from Kitadai et al. (2018)
Hao_OH + SO4-2 = Hao_OHSO4-2
log_k 7.5

END
```

ATTACHMENT C
Details of Geochemical Model Parameterization

Attachment C. Details of Geochemical Model Parameterization

Introduction

This attachment to the Groundwater Polishing Report for the Joppa East Ash Pond (EAP) provides detailed information regarding geochemical model parameterization. The information provided includes sources of thermodynamic data, sources of data used in model parameterization, summarized values, and calculation methods. All solid-phase data is fully documented in the Nature and Extent Report.[1] All aqueous data have been posted to the facility's operating record in accordance with 35 I.A.C. § 845.800(d)(15).

Solid Phase Inputs

The solid phase inputs to the model included iron (hydr)oxides and aluminum (hydr)oxides. These phases tend to have relatively rapid precipitation kinetics and form an outer layer on the surfaces of aquifer solids, creating surface area for sorption and attenuation of boron. Input concentrations for iron and aluminum (hydr)oxides are ideally derived using sequential extraction procedure (SEP) data. SEP methods are described in the Geochemical Conceptual Site Model (GCSM)[2] and employ chemical extractants to dissolve metals from specific solid-associated phases. SEP methods use progressively stronger reagents to solubilize metals from increasingly recalcitrant phases. Although these procedures do not identify the discrete solid phases in a soil/aquifer matrix, they provide a means to evaluate the characterize the metal binding mechanisms and relative stability of metals in each phase, and to estimate the available mass of the respective attenuating phase(s) (i.e., aluminum and iron [hydr]oxide). However, SEP analyses were not completed for Joppa EAP samples, necessitating alternative means of deriving oxide inputs.

Because SEP analyses for iron and aluminum were not completed for Joppa EAP samples, model input concentrations for ferrihydrite for Joppa EAP were derived using site-specific total metals and mineralogy (X-ray diffraction [XRD]) datasets which were refined using an analogous compiled SEP dataset consisting of samples collected from similar geologic systems at various power generating facilities across Illinois. The geologic similarity (regional geology, similar lithologies and depositional environments, similar mineral assembleges) between the samples comprising this dataset and the Joppa EAP subsurface make this dataset appropriate for estimating the amount and distribution of sorbing solid phases. SEP data for iron and aluminum is available for 25 solid phase samples across six distinct hydrostratigraphic units. Total solid-phase iron was measured in eleven

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[1] The Nature and Extent Report was previously submitted to IEPA on April 3, 2024, and provided with relevant updates as Appendix D of the CAAA to which this report is attached.

[2] Ibid.; the GCSM is an appendix of the Nature and Extent Report.

site-specific UA solids at concentrations ranging from 830 milligrams per kilogram (mg/kg) to 99,000 mg/kg. This total iron was determined to be either crystalline or amorphous ferrihydrite based on XRD results of EAP Uppermost Aquifer solids samples. Of the total solid-phase iron, 5.40% was assumed to be amorphous ferrihydrite based on the 25th percentile of amorphous ferrihydrite distribution in the analogous compiled SEP dataset. The remaining 94.60% of total solid-phase iron was assumed to be crystalline ferrihydrite. The gibbsite component of the models was determined using the average mass of aluminum oxide taken directly from the analogous compiled SEP dataset.

In thermodynamic modeling, the amount of sorbing phase present is typically the dominant control on the concentration of constituents sorbed. Therefore, different amounts of metal oxides were used to test the sensitivity of the model to the amount of sorbing phase present. The amount of metal oxides used were derived from the 25th percentile, median (*i.e.*, 50th percentile), and 75th percentile of the SEP results for the relevant iron and aluminum phases.

Sorption of inorganic constituents to iron (hydr)oxides in the MINTEQ v4 database[3] is represented by the hydrous ferric oxide (HFO) thermodynamic data set presented in Dzombak and Morel (1990). Sorption of inorganic constituents to aluminum (hydr)oxides is represented by the hydrous aluminum oxide (HAO) thermodynamic data presented in Karamalidis and Dzombak (2010), Goldberg and Glaubig (1985) (boron), and Kitadai et al. (2018) (sulfate). These sorption data are based on gibbsite, a nearly ubiquitous crystalline aluminum hydroxide mineral (Karamalidis and Dzombak 2010).

The quantities of HFO and HAO in the model are represented by ferrihydrite ($Fe(OH)_3$) and gibbsite ($Al(OH)_3$), respectively. Ferrihydrite is the most similar naturally occurring iron oxide to HFO (Dzombak and Morel, 1990), and sorption data for HAO was determined using gibbsite (Karamalidis and Dzombak 2010). Metal concentrations are presented in milligrams per kilogram of dry weight (mg/kg dw), whereas ferrihydrite and gibbsite inputs to the model represent moles of solid phase associated with one liter (L) of aqueous phase. The concentrations of iron and aluminum were converted to moles of ferrihydrite and gibbsite (respectively) according to the following:

The mass in kilograms (kg) of solid in the model (i.e., per 1 L of water) was calculated by:

$$Solid\ Mass\ In\ Model\ (kg) = \frac{(1-\phi)}{\phi} \times \frac{1000\ cm^3\ water}{L\ water} \times 1\ L\ water\ \times \rho\ \times \frac{1\ kg\ solid}{1000\ g\ solid}$$

Where:

ϕ = porosity (water volume in cubic centimeters [cm^3] / total volume in cm^3)

ρ = density of the solid (grams [g]/cm^3)

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[3] The default MINTEQ v4 database for PHREEQC does not include sorption data for carbonate and silicate to HFO. Thermodynamic constants for sorption of carbonate and silicate to HFO were added from the MINTEQ database associated with the Geochemist's Workbench software program.

Porosity and density represent the median of measurements each hydrostratigraphic unit as reported in the Hydrogeologic Characterization Report[4].

Moles of ferrihydrite and gibbsite were determined using metals concentrations as described above, the molar mass of iron or aluminum, and the mass of solid phase in the model:

$$\begin{aligned}&Moles\ of\ Metal\ Oxide\\&\qquad= \frac{mg\ Fe\ or\ Al}{kg\ solid} \times \frac{g}{1000\ mg} \times \frac{moles\ Fe\ or\ Al}{g\ Fe\ or\ Al} \times kg\ Solid\ Mass\ in\ Model\end{aligned}$$

The moles of ferrihydrite and gibbsite are represented by moles of Fe or Al (respectively) in a 1:1 ratio mased on the mineral formula. Ferrihydrite and gibbsite were allowed to precipitate or dissolve in the reaction phase of the model to evaluate the impact of source control on sorbing phase availability.

Calcite and dolomite would typically be included as mineral phases in the model because carbonate mineral formation and dissolution are often major controls on groundwater pH. However, neither mineral was detected in XRD analyses of EAP solids samples, so neither mineral was included in the initial input of the speciation modeling effort. However, both calcite and dolomite were allowed to precipitate in the reaction phase of the model.

Aqueous Inputs

In addition to the constituent of concern boron, the following parameters are included in the model and are anticipated to capture the expected attenuation and mobilization mechanisms for reasons detailed below:

- Temperature, pH and pe: pH and pe (a measure of redox potential) are major controls on chemical attenuation and mobility.
- Chloride, potassium, and sodium: Major ions in groundwater typically required for the model to reach charge balance.
- Carbonate ion, calcium, and magnesium: Major ions in groundwater that may also form common minerals, including carbonates. Carbonate mineral formation and dissolution is often a major control on groundwater pH. Bicarbonate and carbonate ions, a major component of groundwater alkalinity, may also compete with sulfate/boron for sorbing sites.
- Silicon and phosphate: Silicate and phosphate are oxyanions that compete with sulfate/boron for sorbing sites.
- Aluminum, iron, and manganese: As discussed above, iron and aluminum form reactive metal (hydr)oxide minerals which have high capacities for sorbing other ions on their surfaces. Although sorption to manganese oxides was not considered in this model, manganese behaves similarly to iron and is included for completeness.

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[4] The Hydrogeologic Characterization Report was previously submitted to IEPA as part of the Closure Permit Application and is provided as Appendix B.3 to the Construction Permit Application.

- Remaining constituents regulated under 35 IAC § 845.600[5]: Although these parameters are not subject to corrective action at NEW PAP, they are included in the model for completeness.

Values for pe and carbonate ion concentrations were derived from values previously reported in the analytical data according to the following methods.

pe is a non-dimension scale of redox potential and is calculated from oxidation reduction potential (ORP). First, the field-measured ORP was converted to Eh (i.e., the redox potential normalized to the standard hydrogen electrode). The following equation provided in the Horiba water quality meter instruction manual[6] was used:

$Eh = ORP + 206 – 0.7*(T – 25)$

Where both Eh and ORP are in volts (V) and T is temperature in degrees Celsius. Eh is then converted to pe:

$pe = (Eh * F) / (2.303 * R * T)$

Where:

F = Faraday constant (96,500 Joules (J) / V-equivalent)

R = Molar gas constant (8.31 J / Kelvin (K)-mole)

T = temperature in Kelvin

Data reported for groundwater at the site include carbonate and bicarbonate alkalinity in units of mg of calcium carbonate per liter (mg $CaCO_3$/L). For use in modeling, it is convenient to convert these values to a single carbonate (CO_3^{2-}) ion concentration. Because carbonate and bicarbonate alkalinity are reported in the same units (i.e., standardized to mg $CaCO_3$) and represent different protonation states of the same inorganic carbon oxyanion, they were summed to represent total alkalinity due to carbonate. This summed alkalinity was converted to concentration of carbonate ion according to the following equation:

$$\frac{mg\ CO_3^{2-}}{L} = \frac{mg\ CaCO_3}{L} \times \frac{mole\ CaCO_3}{100.1\ mg\ CaCO_3} \times \frac{1\ mole\ CO_3^{2-}}{1\ mole\ CaCO_3} \times \frac{60\ mg\ CO_3^{2-}}{mole\ CO_3^{2-}}$$

The full suite of geochemical parameters for this model was measured in Quarter 2 and Quarter 3, 2023. The medians of these results were used in the model to represent average groundwater interacting with the solid phase. For downgradient wells the median for each parameter was calculated for each location individually. For background wells, a single median for each parameter was calculated using data from both background locations.

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[5] Mercury, thallium, total dissolved solids, and radium were not included in the model. Mercury reactions within the environment are highly complex and would require a separate modeling effort. Thallium forms a non-reactive monovalent cation and is rarely detected in the groundwater and is therefore not expected to contribute to model outcomes. Total dissolved solids are not a chemical parameter, but rather the result of other chemical abundances taken together. Radium is not included in most thermodynamic databases.

[6] https://static.horiba.com/fileadmin/Horiba/Products/Process_and_Environmental/Water_Pollution/Instruction_Manuals/U-50/U-50_Manual.pdf

The model was run without charge balancing and with charge balancing on chloride. The results during the reaction modeling did not substantially differ with and without charge balancing on chloride. The results presented in the Groundwater Polishing Report therefore represent the model results using charge balancing on chloride.

References

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Karamalidis A.K. and Dzombak D.A. 2010. Surface Complexation Modeling: Gibbsite. John Wiley & Sons, New York.

Kitadai N., Nishiuchi K, and Tanaka M. 2018. A comprehensive predictive model for sulfate adsorption on oxide minerals. *Geochimica et Cosmochimica Acta* **238**:150-168.

ATTACHMENT D

Complete Geochemical Modeling Outputs

Attachment D. PHREEQC modeling output

Groundwater Polishing Report
East Ash Pond
Joppa Power Plant
Joppa, IL

Location	Location Description	Model	Charge Balance	Solids Summary
G06	C - UA	Initial Soln	TRUE	25p
G07	C - UA	Initial Soln	TRUE	25p
G08	C - UA	Initial Soln	TRUE	25p
G09	C - UA	Initial Soln	TRUE	25p
G10	C - UA	Initial Soln	TRUE	25p
G06	C - UA	Speciation Model	TRUE	25p
G07	C - UA	Speciation Model	TRUE	25p
G08	C - UA	Speciation Model	TRUE	25p
G09	C - UA	Speciation Model	TRUE	25p
G10	C - UA	Speciation Model	TRUE	25p
G06	C - UA	First Reaction	TRUE	25p
G06	C - UA	Second Reaction	TRUE	25p
G07	C - UA	First Reaction	TRUE	25p
G07	C - UA	Second Reaction	TRUE	25p
G08	C - UA	First Reaction	TRUE	25p
G08	C - UA	Second Reaction	TRUE	25p
G09	C - UA	First Reaction	TRUE	25p
G09	C - UA	Second Reaction	TRUE	25p
G10	C - UA	First Reaction	TRUE	25p
G10	C - UA	Second Reaction	TRUE	25p
G06	C - UA	Initial Soln	TRUE	75p
G07	C - UA	Initial Soln	TRUE	75p
G08	C - UA	Initial Soln	TRUE	75p
G09	C - UA	Initial Soln	TRUE	75p
G10	C - UA	Initial Soln	TRUE	75p
G06	C - UA	Speciation Model	TRUE	75p
G07	C - UA	Speciation Model	TRUE	75p
G08	C - UA	Speciation Model	TRUE	75p
G09	C - UA	Speciation Model	TRUE	75p
G10	C - UA	Speciation Model	TRUE	75p
G06	C - UA	First Reaction	TRUE	75p
G06	C - UA	Second Reaction	TRUE	75p
G07	C - UA	First Reaction	TRUE	75p
G07	C - UA	Second Reaction	TRUE	75p
G08	C - UA	First Reaction	TRUE	75p
G08	C - UA	Second Reaction	TRUE	75p
G09	C - UA	First Reaction	TRUE	75p
G09	C - UA	Second Reaction	TRUE	75p
G10	C - UA	First Reaction	TRUE	75p
G10	C - UA	Second Reaction	TRUE	75p
G06	C - UA	Initial Soln	TRUE	median
G07	C - UA	Initial Soln	TRUE	median
G08	C - UA	Initial Soln	TRUE	median

G09	C - UA	Initial Soln	TRUE	median
G10	C - UA	Initial Soln	TRUE	median
G06	C - UA	Speciation Model	TRUE	median
G07	C - UA	Speciation Model	TRUE	median
G08	C - UA	Speciation Model	TRUE	median
G09	C - UA	Speciation Model	TRUE	median
G10	C - UA	Speciation Model	TRUE	median
G06	C - UA	First Reaction	TRUE	median
G06	C - UA	Second Reaction	TRUE	median
G07	C - UA	First Reaction	TRUE	median
G07	C - UA	Second Reaction	TRUE	median
G08	C - UA	First Reaction	TRUE	median
G08	C - UA	Second Reaction	TRUE	median
G09	C - UA	First Reaction	TRUE	median
G09	C - UA	Second Reaction	TRUE	median
G10	C - UA	First Reaction	TRUE	median
G10	C - UA	Second Reaction	TRUE	median
G06	C - UA	Initial Soln	FALSE	25p
G07	C - UA	Initial Soln	FALSE	25p
G08	C - UA	Initial Soln	FALSE	25p
G09	C - UA	Initial Soln	FALSE	25p
G10	C - UA	Initial Soln	FALSE	25p
G06	C - UA	Speciation Model	FALSE	25p
G07	C - UA	Speciation Model	FALSE	25p
G08	C - UA	Speciation Model	FALSE	25p
G09	C - UA	Speciation Model	FALSE	25p
G10	C - UA	Speciation Model	FALSE	25p
G06	C - UA	First Reaction	FALSE	25p
G06	C - UA	Second Reaction	FALSE	25p
G07	C - UA	First Reaction	FALSE	25p
G07	C - UA	Second Reaction	FALSE	25p
G08	C - UA	First Reaction	FALSE	25p
G08	C - UA	Second Reaction	FALSE	25p
G09	C - UA	First Reaction	FALSE	25p
G09	C - UA	Second Reaction	FALSE	25p
G10	C - UA	First Reaction	FALSE	25p
G10	C - UA	Second Reaction	FALSE	25p
G06	C - UA	Initial Soln	FALSE	75p
G07	C - UA	Initial Soln	FALSE	75p
G08	C - UA	Initial Soln	FALSE	75p
G09	C - UA	Initial Soln	FALSE	75p
G10	C - UA	Initial Soln	FALSE	75p
G06	C - UA	Speciation Model	FALSE	75p
G07	C - UA	Speciation Model	FALSE	75p
G08	C - UA	Speciation Model	FALSE	75p
G09	C - UA	Speciation Model	FALSE	75p
G10	C - UA	Speciation Model	FALSE	75p
G06	C - UA	First Reaction	FALSE	75p
G06	C - UA	Second Reaction	FALSE	75p
G07	C - UA	First Reaction	FALSE	75p

G07	C - UA	Second Reaction	FALSE	75p
G08	C - UA	First Reaction	FALSE	75p
G08	C - UA	Second Reaction	FALSE	75p
G09	C - UA	First Reaction	FALSE	75p
G09	C - UA	Second Reaction	FALSE	75p
G10	C - UA	First Reaction	FALSE	75p
G10	C - UA	Second Reaction	FALSE	75p
G06	C - UA	Initial Soln	FALSE	median
G07	C - UA	Initial Soln	FALSE	median
G08	C - UA	Initial Soln	FALSE	median
G09	C - UA	Initial Soln	FALSE	median
G10	C - UA	Initial Soln	FALSE	median
G06	C - UA	Speciation Model	FALSE	median
G07	C - UA	Speciation Model	FALSE	median
G08	C - UA	Speciation Model	FALSE	median
G09	C - UA	Speciation Model	FALSE	median
G10	C - UA	Speciation Model	FALSE	median
G06	C - UA	First Reaction	FALSE	median
G06	C - UA	Second Reaction	FALSE	median
G07	C - UA	First Reaction	FALSE	median
G07	C - UA	Second Reaction	FALSE	median
G08	C - UA	First Reaction	FALSE	median
G08	C - UA	Second Reaction	FALSE	median
G09	C - UA	First Reaction	FALSE	median
G09	C - UA	Second Reaction	FALSE	median
G10	C - UA	First Reaction	FALSE	median
G10	C - UA	Second Reaction	FALSE	median

NOTES:

All model results are in units of moles with the exceptions of:

pH and pe (standard units)

charge (equivalents)

Results beginning with 'd_' (change from prior model step)

Results beginning with 'si_' (saturation index)

pH	pe	charge	pct_err	S(6)
6.59	5.05	-4.50e-13	-2.89e-09	0.00206
6.41	5.38	3.04e-17	1.69e-13	0.00275
6.95	4.00	-1.98e-14	-1.02e-10	0.00356
6.30	4.07	4.11e-17	2.76e-13	0.00245
6.62	5.41	-1.62e-15	-7.11e-12	0.00376
6.59	5.05	-4.50e-13	-2.90e-09	0.00206
6.41	5.38	4.69e-17	2.60e-13	0.00275
6.95	4.00	-1.98e-14	-1.02e-10	0.00356
6.30	4.07	4.11e-17	2.76e-13	0.00245
6.62	5.41	-1.62e-15	-7.11e-12	0.00376
6.45	4.72	-1.21e-05	-1.23e-01	0.000273
6.45	4.76	2.12e-06	0.0216	0.000215
6.31	4.87	7.11e-06	0.0729	0.000328
6.40	4.77	1.67e-05	0.172	0.000231
6.60	2.78	-4.32e-05	-4.35e-01	0.000260
6.51	3.21	-1.49e-05	-1.52e-01	0.000212
6.37	3.18	2.74e-05	0.282	0.000316
6.45	3.21	1.27e-05	0.130	0.000218
6.43	3.97	-1.93e-05	-1.96e-01	0.000292
6.45	4.07	2.78e-06	0.0285	0.000217
6.59	5.05	-4.50e-13	-2.89e-09	0.00206
6.41	5.38	3.04e-17	1.69e-13	0.00275
6.95	4.00	-1.98e-14	-1.02e-10	0.00356
6.30	4.07	4.11e-17	2.76e-13	0.00245
6.62	5.41	-1.62e-15	-7.11e-12	0.00376
6.59	5.05	-4.50e-13	-2.90e-09	0.00206
6.41	5.38	4.69e-17	2.60e-13	0.00275
6.95	4.00	-1.98e-14	-1.02e-10	0.00356
6.30	4.07	4.11e-17	2.76e-13	0.00245
6.62	5.41	-1.62e-15	-7.11e-12	0.00376
6.43	4.70	-8.44e-05	-8.41e-01	0.000469
6.43	4.76	2.41e-05	0.247	0.000322
6.17	5.01	-8.04e-05	-8.16e-01	0.000533
6.18	5.13	3.31e-05	0.343	0.000424
6.77	2.16	-6.44e-05	-6.16e-01	0.000471
6.72	2.39	-2.10e-05	-2.12e-01	0.000272
6.15	3.45	-5.58e-05	-5.66e-01	0.000590
6.20	3.51	0.000104	1.08	0.000428
6.37	3.95	-9.75e-05	-9.59e-01	0.000522
6.37	4.04	1.87e-05	0.192	0.000347
6.59	5.05	-4.50e-13	-2.89e-09	0.00206
6.41	5.38	3.04e-17	1.69e-13	0.00275
6.95	4.00	-1.98e-14	-1.02e-10	0.00356

6.30	4.07	4.11e-17	2.76e-13	0.00245
6.62	5.41	-1.62e-15	-7.11e-12	0.00376
6.59	5.05	-4.50e-13	-2.90e-09	0.00206
6.41	5.38	4.69e-17	2.60e-13	0.00275
6.95	4.00	-1.98e-14	-1.02e-10	0.00356
6.30	4.07	4.11e-17	2.76e-13	0.00245
6.62	5.41	-1.62e-15	-7.11e-12	0.00376
6.44	4.69	-3.79e-05	-3.83e-01	0.000357
6.45	4.71	1.33e-05	0.136	0.000243
6.22	4.96	-2.50e-05	-2.56e-01	0.000439
6.29	4.93	4.42e-05	0.456	0.000312
6.71	2.37	-7.09e-05	-7.00e-01	0.000338
6.62	2.71	-3.24e-05	-3.29e-01	0.000224
6.25	3.29	1.95e-05	0.200	0.000451
6.38	3.16	7.06e-05	0.729	0.000273
6.40	3.92	-5.67e-05	-5.68e-01	0.000399
6.43	3.95	1.57e-05	0.160	0.000255
6.59	5.05	0.00275	21.6	0.00206
6.41	5.38	0.00301	20.1	0.00275
6.95	4.00	0.00246	14.6	0.00356
6.30	4.07	0.00227	18.0	0.00245
6.62	5.41	0.00346	18.0	0.00376
6.59	5.05	0.00275	21.6	0.00206
6.41	5.38	0.00301	20.1	0.00275
6.95	4.00	0.00246	14.6	0.00356
6.30	4.07	0.00227	18.0	0.00245
6.62	5.41	0.00346	18.0	0.00376
6.45	4.70	-1.66e-05	-1.69e-01	0.000273
6.45	4.75	1.68e-06	0.0172	0.000215
6.32	4.84	-8.51e-07	-8.72e-03	0.000330
6.40	4.76	1.62e-05	0.166	0.000230
6.61	2.76	-4.51e-05	-4.53e-01	0.000260
6.51	3.19	-1.52e-05	-1.54e-01	0.000212
6.38	3.16	2.22e-05	0.228	0.000316
6.45	3.19	1.22e-05	0.125	0.000218
6.44	3.95	-2.37e-05	-2.40e-01	0.000292
6.45	4.06	2.29e-06	0.0234	0.000217
6.59	5.05	0.00275	21.6	0.00206
6.41	5.38	0.00301	20.1	0.00275
6.95	4.00	0.00246	14.6	0.00356
6.30	4.07	0.00227	18.0	0.00245
6.62	5.41	0.00346	18.0	0.00376
6.59	5.05	0.00275	21.6	0.00206
6.41	5.38	0.00301	20.1	0.00275
6.95	4.00	0.00246	14.6	0.00356
6.30	4.07	0.00227	18.0	0.00245
6.62	5.41	0.00346	18.0	0.00376
6.44	4.66	-1.22e-04	-1.21e+00	0.000479
6.43	4.73	1.71e-05	0.175	0.000320
6.18	4.97	-1.41e-04	-1.43e+00	0.000556

6.19	5.10	2.14e-05	0.221	0.000427
6.77	2.13	-8.22e-05	-7.85e-01	0.000473
6.73	2.37	-2.47e-05	-2.49e-01	0.000270
6.16	3.41	-9.68e-05	-9.79e-01	0.000606
6.21	3.48	9.77e-05	1.01	0.000428
6.38	3.92	-1.35e-04	-1.33e+00	0.000534
6.38	4.01	1.20e-05	0.123	0.000346
6.59	5.05	0.00275	21.6	0.00206
6.41	5.38	0.00301	20.1	0.00275
6.95	4.00	0.00246	14.6	0.00356
6.30	4.07	0.00227	18.0	0.00245
6.62	5.41	0.00346	18.0	0.00376
6.59	5.05	0.00275	21.6	0.00206
6.41	5.38	0.00301	20.1	0.00275
6.95	4.00	0.00246	14.6	0.00356
6.30	4.07	0.00227	18.0	0.00245
6.62	5.41	0.00346	18.0	0.00376
6.45	4.66	-5.00e-05	-5.05e-01	0.000358
6.46	4.69	1.12e-05	0.115	0.000242
6.23	4.93	-4.65e-05	-4.75e-01	0.000446
6.30	4.90	4.18e-05	0.431	0.000311
6.71	2.34	-7.60e-05	-7.49e-01	0.000337
6.62	2.70	-3.36e-05	-3.41e-01	0.000224
6.26	3.26	5.84e-06	0.0598	0.000454
6.38	3.14	6.86e-05	0.708	0.000272
6.41	3.89	-6.84e-05	-6.84e-01	0.000400
6.43	3.93	1.36e-05	0.139	0.000254

B	Li	As	C(4)	Cl
0.000304	5.95e-07	3.57e-08	0.00170	0.00335
0.000466	8.65e-07	3.37e-08	0.00173	0.00361
0.000543	8.36e-07	1.32e-07	0.00166	0.00288
0.000391	9.15e-07	8.95e-08	0.00114	0.00279
0.000300	9.80e-07	5.38e-08	0.00196	0.00418
0.000304	5.95e-07	3.57e-08	0.00170	0.00335
0.000466	8.65e-07	3.37e-08	0.00173	0.00361
0.000543	8.36e-07	1.32e-07	0.00166	0.00288
0.000391	9.15e-07	8.95e-08	0.00114	0.00279
0.000300	9.80e-07	5.38e-08	0.00196	0.00418
8.47e-05	7.39e-07	2.59e-08	0.00175	0.00347
5.78e-05	7.39e-07	2.84e-08	0.00190	0.00347
9.29e-05	7.39e-07	1.50e-08	0.00173	0.00347
6.09e-05	7.39e-07	1.58e-08	0.00191	0.00347
8.89e-05	7.39e-07	7.55e-08	0.00168	0.00347
5.79e-05	7.39e-07	7.61e-08	0.00184	0.00347
9.00e-05	7.39e-07	6.91e-08	0.00163	0.00347
5.99e-05	7.39e-07	7.23e-08	0.00185	0.00347
7.56e-05	7.39e-07	2.15e-08	0.00175	0.00347
5.37e-05	7.39e-07	2.10e-08	0.00187	0.00347
0.000304	5.95e-07	3.57e-08	0.00170	0.00335
0.000466	8.65e-07	3.37e-08	0.00173	0.00361
0.000543	8.36e-07	1.32e-07	0.00166	0.00288
0.000391	9.15e-07	8.95e-08	0.00114	0.00279
0.000300	9.80e-07	5.38e-08	0.00196	0.00418
0.000304	5.95e-07	3.57e-08	0.00170	0.00335
0.000466	8.65e-07	3.37e-08	0.00173	0.00361
0.000543	8.36e-07	1.32e-07	0.00166	0.00288
0.000391	9.15e-07	8.95e-08	0.00114	0.00279
0.000300	9.80e-07	5.38e-08	0.00196	0.00418
0.000136	7.39e-07	2.00e-08	0.00141	0.00347
0.000102	7.39e-07	2.11e-08	0.00151	0.00347
0.000158	7.39e-07	1.45e-08	0.00139	0.00347
0.000113	7.39e-07	1.40e-08	0.00148	0.00347
0.000163	7.39e-07	6.45e-08	0.00134	0.00347
0.000110	7.39e-07	6.70e-08	0.00145	0.00347
0.000147	7.39e-07	5.14e-08	0.00112	0.00347
0.000107	7.39e-07	5.53e-08	0.00128	0.00347
0.000114	7.39e-07	2.02e-08	0.00145	0.00347
8.88e-05	7.39e-07	1.97e-08	0.00154	0.00347
0.000304	5.95e-07	3.57e-08	0.00170	0.00335
0.000466	8.65e-07	3.37e-08	0.00173	0.00361
0.000543	8.36e-07	1.32e-07	0.00166	0.00288

0.000391	9.15e-07	8.95e-08	0.00114	0.00279
0.000300	9.80e-07	5.38e-08	0.00196	0.00418
0.000304	5.95e-07	3.57e-08	0.00170	0.00335
0.000466	8.65e-07	3.37e-08	0.00173	0.00361
0.000543	8.36e-07	1.32e-07	0.00166	0.00288
0.000391	9.15e-07	8.95e-08	0.00114	0.00279
0.000300	9.80e-07	5.38e-08	0.00196	0.00418
0.000117	7.39e-07	2.27e-08	0.00157	0.00347
8.55e-05	7.39e-07	2.61e-08	0.00176	0.00347
0.000133	7.39e-07	1.45e-08	0.00154	0.00347
9.30e-05	7.39e-07	1.50e-08	0.00173	0.00347
0.000130	7.39e-07	7.11e-08	0.00150	0.00347
8.82e-05	7.39e-07	7.73e-08	0.00168	0.00347
0.000126	7.39e-07	5.95e-08	0.00135	0.00347
8.97e-05	7.39e-07	7.39e-08	0.00167	0.00347
0.000100	7.39e-07	2.12e-08	0.00160	0.00347
7.65e-05	7.39e-07	2.19e-08	0.00176	0.00347
0.000304	5.95e-07	3.57e-08	0.00170	0.000607
0.000466	8.65e-07	3.37e-08	0.00173	0.000607
0.000543	8.36e-07	1.32e-07	0.00166	0.000423
0.000391	9.15e-07	8.95e-08	0.00114	0.000522
0.000300	9.80e-07	5.38e-08	0.00196	0.000720
0.000304	5.95e-07	3.57e-08	0.00170	0.000607
0.000466	8.65e-07	3.37e-08	0.00173	0.000607
0.000543	8.36e-07	1.32e-07	0.00166	0.000423
0.000391	9.15e-07	8.95e-08	0.00114	0.000522
0.000300	9.80e-07	5.38e-08	0.00196	0.000720
8.50e-05	7.39e-07	2.67e-08	0.00176	0.00347
5.78e-05	7.39e-07	2.92e-08	0.00190	0.00347
9.32e-05	7.39e-07	1.55e-08	0.00173	0.00347
6.09e-05	7.39e-07	1.63e-08	0.00191	0.00347
8.90e-05	7.39e-07	7.78e-08	0.00168	0.00347
5.78e-05	7.39e-07	7.83e-08	0.00184	0.00347
9.02e-05	7.39e-07	7.10e-08	0.00163	0.00347
5.98e-05	7.39e-07	7.41e-08	0.00185	0.00347
7.58e-05	7.39e-07	2.23e-08	0.00176	0.00347
5.37e-05	7.39e-07	2.17e-08	0.00187	0.00347
0.000304	5.95e-07	3.57e-08	0.00170	0.000607
0.000466	8.65e-07	3.37e-08	0.00173	0.000607
0.000543	8.36e-07	1.32e-07	0.00166	0.000423
0.000391	9.15e-07	8.95e-08	0.00114	0.000522
0.000300	9.80e-07	5.38e-08	0.00196	0.000720
0.000304	5.95e-07	3.57e-08	0.00170	0.000607
0.000466	8.65e-07	3.37e-08	0.00173	0.000607
0.000543	8.36e-07	1.32e-07	0.00166	0.000423
0.000391	9.15e-07	8.95e-08	0.00114	0.000522
0.000300	9.80e-07	5.38e-08	0.00196	0.000720
0.000138	7.39e-07	2.10e-08	0.00143	0.00347
0.000102	7.39e-07	2.19e-08	0.00152	0.00347
0.000160	7.39e-07	1.52e-08	0.00140	0.00347

0.000113	7.39e-07	1.44e-08	0.00148	0.00347
0.000164	7.39e-07	6.73e-08	0.00135	0.00347
0.000110	7.39e-07	6.94e-08	0.00145	0.00347
0.000148	7.39e-07	5.33e-08	0.00112	0.00347
0.000107	7.39e-07	5.69e-08	0.00128	0.00347
0.000115	7.39e-07	2.12e-08	0.00147	0.00347
8.90e-05	7.39e-07	2.05e-08	0.00154	0.00347
0.000304	5.95e-07	3.57e-08	0.00170	0.000607
0.000466	8.65e-07	3.37e-08	0.00173	0.000607
0.000543	8.36e-07	1.32e-07	0.00166	0.000423
0.000391	9.15e-07	8.95e-08	0.00114	0.000522
0.000300	9.80e-07	5.38e-08	0.00196	0.000720
0.000304	5.95e-07	3.57e-08	0.00170	0.000607
0.000466	8.65e-07	3.37e-08	0.00173	0.000607
0.000543	8.36e-07	1.32e-07	0.00166	0.000423
0.000391	9.15e-07	8.95e-08	0.00114	0.000522
0.000300	9.80e-07	5.38e-08	0.00196	0.000720
0.000117	7.39e-07	2.36e-08	0.00158	0.00347
8.56e-05	7.39e-07	2.69e-08	0.00177	0.00347
0.000134	7.39e-07	1.51e-08	0.00154	0.00347
9.32e-05	7.39e-07	1.55e-08	0.00174	0.00347
0.000130	7.39e-07	7.36e-08	0.00151	0.00347
8.83e-05	7.39e-07	7.95e-08	0.00168	0.00347
0.000127	7.39e-07	6.14e-08	0.00136	0.00347
8.98e-05	7.39e-07	7.60e-08	0.00167	0.00347
0.000101	7.39e-07	2.20e-08	0.00161	0.00347
7.65e-05	7.39e-07	2.27e-08	0.00177	0.00347

F	Ca	Mg	Na	K
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.11e-05	0.000809	0.000398	0.00253	3.04e-05
1.12e-05	0.000809	0.000386	0.00253	3.04e-05
1.11e-05	0.000809	0.000389	0.00253	3.04e-05
1.13e-05	0.000809	0.000385	0.00253	3.04e-05
1.11e-05	0.000812	0.000415	0.00253	3.04e-05
1.12e-05	0.000809	0.000389	0.00253	3.04e-05
1.11e-05	0.000809	0.000387	0.00253	3.04e-05
1.13e-05	0.000809	0.000383	0.00253	3.04e-05
1.11e-05	0.000809	0.000406	0.00253	3.04e-05
1.12e-05	0.000809	0.000386	0.00253	3.04e-05
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.09e-05	0.000815	0.000450	0.00253	3.04e-05
1.11e-05	0.000809	0.000390	0.00253	3.04e-05
1.07e-05	0.000811	0.000408	0.00253	3.04e-05
1.09e-05	0.000809	0.000385	0.00253	3.04e-05
1.11e-05	0.000832	0.000539	0.00253	3.04e-05
1.11e-05	0.000809	0.000411	0.00253	3.04e-05
1.06e-05	0.000810	0.000407	0.00253	3.04e-05
1.10e-05	0.000809	0.000382	0.00253	3.04e-05
1.07e-05	0.000815	0.000484	0.00253	3.04e-05
1.10e-05	0.000809	0.000394	0.00253	3.04e-05
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05

1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.10e-05	0.000811	0.000416	0.00253	3.04e-05
1.12e-05	0.000809	0.000386	0.00253	3.04e-05
1.08e-05	0.000809	0.000395	0.00253	3.04e-05
1.12e-05	0.000809	0.000383	0.00253	3.04e-05
1.11e-05	0.000817	0.000455	0.00253	3.04e-05
1.11e-05	0.000809	0.000395	0.00253	3.04e-05
1.09e-05	0.000809	0.000394	0.00253	3.04e-05
1.13e-05	0.000808	0.000379	0.00253	3.04e-05
1.09e-05	0.000811	0.000437	0.00253	3.04e-05
1.12e-05	0.000809	0.000388	0.00253	3.04e-05
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.11e-05	0.000809	0.000398	0.00253	3.04e-05
1.12e-05	0.000809	0.000386	0.00253	3.04e-05
1.11e-05	0.000809	0.000389	0.00253	3.04e-05
1.12e-05	0.000809	0.000385	0.00253	3.04e-05
1.11e-05	0.000812	0.000415	0.00253	3.04e-05
1.12e-05	0.000809	0.000389	0.00253	3.04e-05
1.11e-05	0.000809	0.000387	0.00253	3.04e-05
1.13e-05	0.000809	0.000383	0.00253	3.04e-05
1.11e-05	0.000809	0.000406	0.00253	3.04e-05
1.12e-05	0.000809	0.000386	0.00253	3.04e-05
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.09e-05	0.000815	0.000451	0.00253	3.04e-05
1.11e-05	0.000809	0.000391	0.00253	3.04e-05
1.07e-05	0.000811	0.000408	0.00253	3.04e-05

1.09e-05	0.000809	0.000385	0.00253	3.04e-05
1.11e-05	0.000832	0.000540	0.00253	3.04e-05
1.11e-05	0.000810	0.000412	0.00253	3.04e-05
1.06e-05	0.000810	0.000408	0.00253	3.04e-05
1.10e-05	0.000809	0.000382	0.00253	3.04e-05
1.07e-05	0.000815	0.000486	0.00253	3.04e-05
1.10e-05	0.000809	0.000395	0.00253	3.04e-05
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.40e-05	0.00221	0.00100	0.00207	6.29e-05
2.19e-05	0.00243	0.000992	0.00302	0.000108
1.58e-05	0.00340	0.00134	0.00174	4.21e-05
1.71e-05	0.00165	0.00105	0.00273	2.45e-05
1.76e-05	0.00305	0.00156	0.00358	0.000197
1.10e-05	0.000811	0.000417	0.00253	3.04e-05
1.11e-05	0.000809	0.000387	0.00253	3.04e-05
1.09e-05	0.000809	0.000396	0.00253	3.04e-05
1.12e-05	0.000809	0.000384	0.00253	3.04e-05
1.11e-05	0.000817	0.000457	0.00253	3.04e-05
1.11e-05	0.000809	0.000396	0.00253	3.04e-05
1.09e-05	0.000809	0.000394	0.00253	3.04e-05
1.13e-05	0.000808	0.000380	0.00253	3.04e-05
1.09e-05	0.000811	0.000438	0.00253	3.04e-05
1.12e-05	0.000809	0.000388	0.00253	3.04e-05

Ba	Si	P	Mn	Fe
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
6.29e-07	0.000123	4.35e-07	3.14e-07	1.36e-07
7.95e-07	0.000128	4.64e-07	3.20e-07	1.28e-07
5.21e-07	0.000140	2.74e-07	8.93e-07	2.30e-07
7.40e-07	0.000132	3.15e-07	3.48e-07	1.64e-07
6.63e-07	0.000146	2.85e-07	1.53e-06	2.91e-06
8.08e-07	0.000165	2.65e-07	4.34e-07	2.10e-06
5.43e-07	0.000237	8.49e-07	5.80e-07	5.64e-06
7.84e-07	0.000212	9.63e-07	3.33e-07	3.02e-06
5.88e-07	0.000190	3.21e-07	3.99e-07	6.42e-07
7.86e-07	0.000180	3.27e-07	3.26e-07	4.50e-07
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
3.71e-07	0.000109	3.54e-07	3.04e-07	1.61e-07
5.32e-07	0.000114	3.69e-07	3.13e-07	1.44e-07
3.24e-07	0.000147	2.15e-07	2.40e-06	4.26e-07
4.03e-07	0.000148	2.21e-07	4.91e-07	3.07e-07
3.78e-07	0.000105	2.97e-07	4.12e-06	3.99e-06
6.34e-07	0.000117	2.92e-07	1.18e-06	3.08e-06
2.94e-07	0.000258	5.32e-07	1.28e-06	1.46e-05
4.00e-07	0.000260	6.02e-07	4.09e-07	8.69e-06
3.36e-07	0.000194	2.79e-07	5.92e-07	1.03e-06
4.94e-07	0.000197	2.79e-07	3.67e-07	8.33e-07
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05

3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
4.83e-07	0.000115	3.94e-07	3.07e-07	1.48e-07
7.04e-07	0.000123	4.40e-07	3.16e-07	1.34e-07
3.91e-07	0.000146	2.36e-07	1.70e-06	3.39e-07
5.48e-07	0.000143	2.70e-07	4.16e-07	2.28e-07
5.16e-07	0.000122	3.01e-07	3.01e-06	3.63e-06
7.65e-07	0.000147	2.94e-07	8.01e-07	2.98e-06
3.82e-07	0.000255	6.66e-07	9.51e-07	1.04e-05
6.24e-07	0.000247	8.93e-07	3.67e-07	5.60e-06
4.35e-07	0.000195	3.03e-07	5.04e-07	8.80e-07
6.71e-07	0.000195	3.24e-07	3.44e-07	6.76e-07
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
6.29e-07	0.000122	4.42e-07	3.14e-07	1.37e-07
7.96e-07	0.000128	4.69e-07	3.20e-07	1.29e-07
5.19e-07	0.000139	2.79e-07	9.10e-07	2.34e-07
7.41e-07	0.000132	3.19e-07	3.49e-07	1.67e-07
6.64e-07	0.000146	2.89e-07	1.56e-06	2.97e-06
8.09e-07	0.000164	2.68e-07	4.37e-07	2.14e-06
5.42e-07	0.000237	8.62e-07	5.87e-07	5.81e-06
7.85e-07	0.000212	9.73e-07	3.34e-07	3.11e-06
5.88e-07	0.000189	3.26e-07	4.03e-07	6.54e-07
7.87e-07	0.000180	3.31e-07	3.27e-07	4.58e-07
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
3.64e-07	0.000108	3.66e-07	3.05e-07	1.61e-07
5.34e-07	0.000113	3.77e-07	3.14e-07	1.46e-07
3.11e-07	0.000146	2.23e-07	2.46e-06	4.26e-07

4.01e-07	0.000147	2.25e-07	4.98e-07	3.10e-07
3.76e-07	0.000105	3.05e-07	4.21e-06	4.05e-06
6.37e-07	0.000117	2.98e-07	1.20e-06	3.14e-06
2.86e-07	0.000257	5.48e-07	1.30e-06	1.48e-05
4.00e-07	0.000259	6.14e-07	4.13e-07	8.92e-06
3.29e-07	0.000193	2.88e-07	6.01e-07	1.03e-06
4.96e-07	0.000196	2.85e-07	3.70e-07	8.46e-07
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
2.57e-07	0.000106	6.30e-07	2.57e-07	4.05e-07
9.17e-07	0.000146	4.68e-07	4.51e-05	1.59e-06
4.76e-07	0.000102	6.30e-07	3.72e-05	1.63e-05
3.03e-07	0.000256	8.56e-07	1.84e-05	3.61e-05
3.50e-07	0.000196	6.95e-07	2.78e-06	7.70e-06
4.81e-07	0.000115	4.03e-07	3.08e-07	1.50e-07
7.07e-07	0.000123	4.46e-07	3.16e-07	1.36e-07
3.85e-07	0.000145	2.41e-07	1.74e-06	3.43e-07
5.50e-07	0.000143	2.74e-07	4.19e-07	2.32e-07
5.17e-07	0.000122	3.06e-07	3.08e-06	3.70e-06
7.66e-07	0.000146	2.98e-07	8.12e-07	3.04e-06
3.79e-07	0.000254	6.81e-07	9.69e-07	1.06e-05
6.27e-07	0.000247	9.07e-07	3.69e-07	5.77e-06
4.33e-07	0.000194	3.09e-07	5.12e-07	8.93e-07
6.74e-07	0.000194	3.29e-07	3.46e-07	6.89e-07

Al	Sb	Be	Cd	Cr
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
5.33e-08	1.64e-09	3.57e-08	7.49e-10	1.63e-07
5.39e-08	1.64e-09	3.72e-08	5.58e-10	1.66e-07
8.58e-08	1.64e-09	1.12e-07	4.29e-10	4.98e-07
6.32e-08	1.64e-09	9.20e-08	2.81e-10	3.71e-07
3.77e-08	1.64e-09	9.00e-08	6.24e-10	2.99e-07
4.56e-08	1.64e-09	1.26e-07	5.24e-10	4.31e-07
6.81e-08	1.64e-09	5.38e-08	3.76e-10	8.86e-08
5.28e-08	1.64e-09	4.38e-08	2.51e-10	6.76e-08
5.55e-08	1.64e-09	7.62e-08	6.83e-10	2.92e-07
5.27e-08	1.64e-09	7.40e-08	5.21e-10	2.73e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
5.61e-08	1.65e-09	3.44e-08	1.13e-09	1.66e-07
5.70e-08	1.64e-09	3.59e-08	9.21e-10	1.69e-07
1.60e-07	1.64e-09	1.48e-07	8.98e-10	7.75e-07
1.51e-07	1.64e-09	1.49e-07	6.28e-10	7.53e-07
3.21e-08	1.64e-09	5.03e-08	7.72e-10	1.60e-07
3.29e-08	1.64e-09	5.94e-08	6.36e-10	1.89e-07
1.73e-07	1.65e-09	9.15e-08	8.48e-10	1.84e-07
1.40e-07	1.64e-09	8.34e-08	5.71e-10	1.57e-07
6.62e-08	1.64e-09	8.25e-08	1.02e-09	3.43e-07
6.82e-08	1.64e-09	8.68e-08	8.73e-10	3.53e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07

3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
5.38e-08	1.64e-09	3.46e-08	9.84e-10	1.63e-07
5.27e-08	1.64e-09	3.54e-08	7.77e-10	1.62e-07
1.26e-07	1.64e-09	1.37e-07	6.87e-10	6.72e-07
9.28e-08	1.64e-09	1.19e-07	4.43e-10	5.35e-07
3.33e-08	1.64e-09	6.26e-08	7.07e-10	2.01e-07
3.68e-08	1.64e-09	8.61e-08	6.31e-10	2.85e-07
1.10e-07	1.65e-09	7.30e-08	6.16e-10	1.33e-07
6.73e-08	1.64e-09	5.37e-08	3.80e-10	8.78e-08
6.03e-08	1.64e-09	7.96e-08	8.86e-10	3.18e-07
5.63e-08	1.64e-09	7.76e-08	7.25e-10	2.98e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
5.27e-08	1.64e-09	3.53e-08	8.78e-10	1.62e-07
5.37e-08	1.64e-09	3.71e-08	6.51e-10	1.67e-07
8.44e-08	1.64e-09	1.10e-07	4.99e-10	4.95e-07
6.29e-08	1.64e-09	9.13e-08	3.23e-10	3.73e-07
3.76e-08	1.64e-09	8.92e-08	7.07e-10	2.97e-07
4.56e-08	1.64e-09	1.26e-07	5.92e-10	4.30e-07
6.72e-08	1.64e-09	5.32e-08	4.25e-10	8.83e-08
5.26e-08	1.64e-09	4.37e-08	2.81e-10	6.80e-08
5.49e-08	1.64e-09	7.53e-08	8.08e-10	2.91e-07
5.25e-08	1.64e-09	7.36e-08	6.13e-10	2.74e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
5.43e-08	1.65e-09	3.34e-08	1.31e-09	1.62e-07
5.58e-08	1.64e-09	3.52e-08	1.08e-09	1.67e-07
1.50e-07	1.64e-09	1.42e-07	1.03e-09	7.47e-07

1.46e-07	1.64e-09	1.46e-07	7.31e-10	7.42e-07
3.20e-08	1.64e-09	4.93e-08	8.71e-10	1.57e-07
3.28e-08	1.64e-09	5.85e-08	7.20e-10	1.87e-07
1.65e-07	1.65e-09	8.87e-08	9.53e-10	1.78e-07
1.35e-07	1.64e-09	8.16e-08	6.46e-10	1.55e-07
6.38e-08	1.64e-09	7.99e-08	1.19e-09	3.33e-07
6.64e-08	1.64e-09	8.49e-08	1.03e-09	3.47e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
3.03e-07	6.99e-09	2.22e-08	1.56e-09	1.08e-07
3.03e-07	3.29e-09	8.33e-08	1.56e-09	3.77e-07
3.03e-07	1.64e-09	3.33e-08	1.56e-09	1.09e-07
3.03e-07	1.60e-08	6.11e-08	1.56e-09	1.01e-07
3.03e-07	1.64e-09	4.44e-08	1.56e-09	1.62e-07
5.28e-08	1.64e-09	3.39e-08	1.15e-09	1.60e-07
5.22e-08	1.64e-09	3.50e-08	9.14e-10	1.61e-07
1.22e-07	1.64e-09	1.33e-07	8.02e-10	6.60e-07
9.12e-08	1.64e-09	1.17e-07	5.18e-10	5.32e-07
3.32e-08	1.64e-09	6.16e-08	8.01e-10	1.98e-07
3.66e-08	1.64e-09	8.52e-08	7.15e-10	2.83e-07
1.07e-07	1.65e-09	7.15e-08	6.97e-10	1.31e-07
6.63e-08	1.64e-09	5.31e-08	4.30e-10	8.74e-08
5.90e-08	1.64e-09	7.79e-08	1.05e-09	3.13e-07
5.56e-08	1.64e-09	7.65e-08	8.59e-10	2.97e-07

Co	Pb	Mo	Se	Hfo_s
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0.000145
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0.000145
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0.000145
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0.000145
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0.000145
1.80e-08	2.36e-09	7.73e-09	3.41e-09	0.000145
1.30e-08	1.75e-09	9.46e-09	3.99e-09	0.000145
1.78e-08	3.48e-09	6.92e-09	2.66e-09	0.000145
1.06e-08	2.23e-09	9.80e-09	3.20e-09	0.000145
4.42e-08	1.68e-09	8.59e-09	3.04e-09	0.000145
3.57e-08	1.31e-09	8.57e-09	3.38e-09	0.000145
2.12e-08	1.26e-09	1.19e-08	4.15e-09	0.000145
1.30e-08	8.44e-10	1.47e-08	5.03e-09	0.000145
2.70e-08	2.02e-09	7.23e-09	2.45e-09	0.000145
1.98e-08	1.55e-09	8.80e-09	2.80e-09	0.000145
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0.00115
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0.00115
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0.00115
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0.00115
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0.00115
2.76e-08	3.44e-09	4.96e-09	2.55e-09	0.00115
2.22e-08	2.83e-09	5.40e-09	2.71e-09	0.00115
3.98e-08	7.15e-09	3.83e-09	2.04e-09	0.00115
2.71e-08	4.97e-09	4.11e-09	2.10e-09	0.00115
5.56e-08	2.26e-09	8.70e-09	2.46e-09	0.00115
4.50e-08	1.85e-09	8.46e-09	2.59e-09	0.00115
5.06e-08	2.64e-09	4.98e-09	2.54e-09	0.00115
3.33e-08	1.81e-09	6.36e-09	2.88e-09	0.00115
4.10e-08	2.87e-09	4.69e-09	1.93e-09	0.00115
3.47e-08	2.46e-09	4.86e-09	1.98e-09	0.00115
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0

1.03e-07	5.55e-09	1.12e-08	3.80e-09	0
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0.000410
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0.000410
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0.000410
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0.000410
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0.000410
2.40e-08	3.05e-09	6.08e-09	2.89e-09	0.000410
1.88e-08	2.49e-09	7.57e-09	3.35e-09	0.000410
3.02e-08	5.54e-09	4.75e-09	2.24e-09	0.000410
1.87e-08	3.66e-09	6.48e-09	2.56e-09	0.000410
5.12e-08	2.02e-09	8.78e-09	2.72e-09	0.000410
4.49e-08	1.73e-09	8.45e-09	3.00e-09	0.000410
3.65e-08	1.98e-09	7.71e-09	3.17e-09	0.000410
2.19e-08	1.32e-09	1.30e-08	4.22e-09	0.000410
3.56e-08	2.56e-09	5.71e-09	2.14e-09	0.000410
2.88e-08	2.16e-09	6.97e-09	2.39e-09	0.000410
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0.000145
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0.000145
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0.000145
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0.000145
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0.000145
1.88e-08	2.49e-09	7.94e-09	3.46e-09	0.000145
1.36e-08	1.84e-09	9.59e-09	4.03e-09	0.000145
1.85e-08	3.68e-09	7.17e-09	2.70e-09	0.000145
1.11e-08	2.36e-09	1.00e-08	3.24e-09	0.000145
4.56e-08	1.73e-09	8.76e-09	3.08e-09	0.000145
3.69e-08	1.36e-09	8.65e-09	3.41e-09	0.000145
2.20e-08	1.33e-09	1.22e-08	4.22e-09	0.000145
1.35e-08	8.86e-10	1.48e-08	5.09e-09	0.000145
2.81e-08	2.13e-09	7.44e-09	2.49e-09	0.000145
2.08e-08	1.63e-09	8.93e-09	2.83e-09	0.000145
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0.00115
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0.00115
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0.00115
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0.00115
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0.00115
2.84e-08	3.59e-09	5.31e-09	2.63e-09	0.00115
2.31e-08	2.97e-09	5.65e-09	2.76e-09	0.00115
4.07e-08	7.43e-09	4.14e-09	2.11e-09	0.00115

2.81e-08	5.22e-09	4.31e-09	2.14e-09	0.00115
5.69e-08	2.33e-09	9.13e-09	2.52e-09	0.00115
4.63e-08	1.91e-09	8.76e-09	2.63e-09	0.00115
5.17e-08	2.74e-09	5.31e-09	2.62e-09	0.00115
3.43e-08	1.89e-09	6.66e-09	2.94e-09	0.00115
4.21e-08	2.99e-09	5.02e-09	1.99e-09	0.00115
3.60e-08	2.58e-09	5.10e-09	2.02e-09	0.00115
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0
4.07e-08	5.55e-09	1.12e-08	3.80e-09	0.000410
7.56e-08	1.52e-08	1.33e-08	3.80e-09	0.000410
1.27e-07	5.55e-09	2.16e-08	3.80e-09	0.000410
1.03e-07	5.55e-09	1.12e-08	3.80e-09	0.000410
6.71e-08	5.55e-09	1.80e-08	3.80e-09	0.000410
2.50e-08	3.21e-09	6.37e-09	2.96e-09	0.000410
1.97e-08	2.63e-09	7.78e-09	3.40e-09	0.000410
3.13e-08	5.83e-09	5.01e-09	2.29e-09	0.000410
1.96e-08	3.88e-09	6.71e-09	2.61e-09	0.000410
5.27e-08	2.08e-09	9.08e-09	2.77e-09	0.000410
4.63e-08	1.79e-09	8.61e-09	3.04e-09	0.000410
3.77e-08	2.07e-09	8.07e-09	3.24e-09	0.000410
2.27e-08	1.39e-09	1.34e-08	4.29e-09	0.000410
3.70e-08	2.69e-09	5.99e-09	2.19e-09	0.000410
3.01e-08	2.28e-09	7.18e-09	2.42e-09	0.000410

Hfo_w	Hao_	m_Hfo_wOH	m_Hfo_wOH2+	m_Hfo_wOHSO4-2
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.00580	0.00106	0.000440	0.000585	4.03e-05
0.00580	0.00106	0.000314	0.000414	9.06e-05
0.00580	0.00106	0.000412	0.000336	3.12e-05
0.00580	0.00106	0.000288	0.000580	5.36e-05
0.00580	0.00106	0.000314	0.000384	4.79e-05
0.00580	0.00106	0.000379	0.000512	1.07e-05
0.00580	0.00106	0.000360	0.000494	7.87e-06
0.00580	0.00106	0.000303	0.000339	2.84e-05
0.00580	0.00106	0.000309	0.000325	1.55e-05
0.00580	0.00106	0.000295	0.000274	8.24e-06
0.00580	0.00106	0.000257	0.000252	8.16e-06
0.00580	0.00106	0.000279	0.000482	7.90e-06
0.00580	0.00106	0.000289	0.000473	4.33e-06
0.00580	0.00106	0.000300	0.000338	1.40e-05
0.00580	0.00106	0.000301	0.000329	1.01e-05
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.0460	0.00396	0.00349	0.00464	0.000320
0.0460	0.00396	0.00249	0.00329	0.000719
0.0460	0.00396	0.00327	0.00266	0.000248
0.0460	0.00396	0.00228	0.00460	0.000425
0.0460	0.00396	0.00249	0.00305	0.000380
0.0460	0.00396	0.00339	0.00447	0.000191
0.0460	0.00396	0.00325	0.00429	0.000126
0.0460	0.00396	0.00245	0.00311	0.000558
0.0460	0.00396	0.00239	0.00294	0.000432
0.0460	0.00396	0.00316	0.00256	9.65e-05
0.0460	0.00396	0.00288	0.00242	5.92e-05
0.0460	0.00396	0.00223	0.00432	0.000261
0.0460	0.00396	0.00217	0.00407	0.000156
0.0460	0.00396	0.00247	0.00293	0.000245
0.0460	0.00396	0.00240	0.00280	0.000166
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0.0164	0.00261	0.00124	0.00165	0.000114
0.0164	0.00261	0.000887	0.00117	0.000256
0.0164	0.00261	0.00117	0.000949	8.83e-05
0.0164	0.00261	0.000813	0.00164	0.000151
0.0164	0.00261	0.000887	0.00109	0.000135
0.0164	0.00261	0.00114	0.00152	4.51e-05
0.0164	0.00261	0.00107	0.00144	2.66e-05
0.0164	0.00261	0.000855	0.00103	0.000141
0.0164	0.00261	0.000843	0.000951	7.96e-05
0.0164	0.00261	0.000989	0.000850	2.57e-05
0.0164	0.00261	0.000841	0.000775	1.91e-05
0.0164	0.00261	0.000777	0.00143	4.87e-05
0.0164	0.00261	0.000771	0.00134	1.81e-05
0.0164	0.00261	0.000858	0.000994	5.92e-05
0.0164	0.00261	0.000837	0.000946	3.43e-05
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.00580	0.00106	0.000439	0.000583	4.10e-05
0.00580	0.00106	0.000313	0.000412	9.21e-05
0.00580	0.00106	0.000411	0.000335	3.14e-05
0.00580	0.00106	0.000287	0.000578	5.43e-05
0.00580	0.00106	0.000313	0.000383	4.86e-05
0.00580	0.00106	0.000379	0.000513	1.05e-05
0.00580	0.00106	0.000360	0.000495	7.79e-06
0.00580	0.00106	0.000304	0.000340	2.80e-05
0.00580	0.00106	0.000309	0.000326	1.53e-05
0.00580	0.00106	0.000295	0.000275	8.06e-06
0.00580	0.00106	0.000257	0.000254	8.04e-06
0.00580	0.00106	0.000279	0.000483	7.76e-06
0.00580	0.00106	0.000289	0.000474	4.29e-06
0.00580	0.00106	0.000300	0.000339	1.37e-05
0.00580	0.00106	0.000301	0.000331	9.95e-06
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.0460	0.00396	0.00348	0.00462	0.000325
0.0460	0.00396	0.00248	0.00327	0.000731
0.0460	0.00396	0.00326	0.00266	0.000249
0.0460	0.00396	0.00228	0.00458	0.000431
0.0460	0.00396	0.00248	0.00304	0.000386
0.0460	0.00396	0.00340	0.00447	0.000186
0.0460	0.00396	0.00325	0.00430	0.000122
0.0460	0.00396	0.00246	0.00311	0.000551

0.0460	0.00396	0.00240	0.00295	0.000424
0.0460	0.00396	0.00316	0.00257	9.32e-05
0.0460	0.00396	0.00288	0.00243	5.71e-05
0.0460	0.00396	0.00223	0.00432	0.000256
0.0460	0.00396	0.00217	0.00407	0.000151
0.0460	0.00396	0.00248	0.00294	0.000239
0.0460	0.00396	0.00241	0.00281	0.000160
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.0164	0.00261	0.00124	0.00165	0.000116
0.0164	0.00261	0.000884	0.00117	0.000260
0.0164	0.00261	0.00116	0.000947	8.88e-05
0.0164	0.00261	0.000811	0.00163	0.000154
0.0164	0.00261	0.000884	0.00108	0.000137
0.0164	0.00261	0.00114	0.00152	4.38e-05
0.0164	0.00261	0.00107	0.00145	2.60e-05
0.0164	0.00261	0.000858	0.00103	0.000139
0.0164	0.00261	0.000845	0.000955	7.78e-05
0.0164	0.00261	0.000990	0.000853	2.49e-05
0.0164	0.00261	0.000842	0.000779	1.87e-05
0.0164	0.00261	0.000779	0.00143	4.76e-05
0.0164	0.00261	0.000771	0.00135	1.76e-05
0.0164	0.00261	0.000861	0.000997	5.76e-05
0.0164	0.00261	0.000838	0.000950	3.35e-05

m_Hfo_wSO4-	m_Hfo_wOSi(OH)3	m_Hfo_wOSiO(OH)2-	m_Hfo_wHCO3	m_Hfo_wCO3-
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2.69e-05	0.000891	0.000413	0.00173	0.000221
6.00e-05	0.000878	0.000410	0.00162	0.000208
1.27e-05	0.000800	0.000606	0.000897	0.000187
5.41e-05	0.00141	0.000431	0.00115	9.71e-05
2.94e-05	0.00117	0.000590	0.00138	0.000192
7.27e-06	0.000886	0.000404	0.00192	0.000241
5.41e-06	0.000877	0.000394	0.00198	0.000245
1.59e-05	0.000810	0.000447	0.00178	0.000271
8.18e-06	0.000778	0.000456	0.00181	0.000293
3.83e-06	0.000823	0.000547	0.00116	0.000212
4.02e-06	0.000807	0.000507	0.00127	0.000219
6.85e-06	0.00126	0.000450	0.00144	0.000141
3.56e-06	0.00117	0.000440	0.00153	0.000159
7.91e-06	0.00109	0.000595	0.00155	0.000233
5.53e-06	0.00103	0.000581	0.00162	0.000251
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000213	0.00706	0.00328	0.0137	0.00175
0.000476	0.00696	0.00325	0.0128	0.00165
0.000101	0.00635	0.00481	0.00712	0.00149
0.000429	0.0112	0.00342	0.00914	0.000770
0.000233	0.00931	0.00468	0.0110	0.00152
0.000126	0.00704	0.00330	0.0142	0.00183
8.34e-05	0.00705	0.00329	0.0146	0.00188
0.000355	0.00685	0.00333	0.0133	0.00178
0.000266	0.00675	0.00339	0.0136	0.00189
3.93e-05	0.00635	0.00482	0.00763	0.00159
2.49e-05	0.00643	0.00472	0.00810	0.00164
0.000254	0.0110	0.00349	0.00989	0.000866
0.000146	0.0108	0.00353	0.0105	0.000949
0.000145	0.00915	0.00476	0.0114	0.00163
9.69e-05	0.00904	0.00478	0.0117	0.00171
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
7.60e-05	0.00252	0.00117	0.00489	0.000626
0.000170	0.00248	0.00116	0.00457	0.000588
3.60e-05	0.00226	0.00171	0.00254	0.000529
0.000153	0.00398	0.00122	0.00326	0.000275
8.32e-05	0.00332	0.00167	0.00391	0.000542
3.00e-05	0.00251	0.00117	0.00524	0.000670
1.79e-05	0.00252	0.00115	0.00542	0.000683
8.52e-05	0.00238	0.00122	0.00489	0.000691
4.50e-05	0.00231	0.00126	0.00505	0.000760
1.11e-05	0.00231	0.00166	0.00295	0.000582
8.81e-06	0.00235	0.00157	0.00322	0.000593
4.50e-05	0.00379	0.00127	0.00379	0.000350
1.58e-05	0.00363	0.00128	0.00404	0.000393
3.44e-05	0.00320	0.00170	0.00420	0.000616
1.94e-05	0.00312	0.00170	0.00436	0.000654
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2.72e-05	0.000888	0.000413	0.00173	0.000222
6.09e-05	0.000875	0.000409	0.00162	0.000208
1.28e-05	0.000798	0.000604	0.000897	0.000187
5.48e-05	0.00141	0.000431	0.00115	9.72e-05
2.98e-05	0.00117	0.000589	0.00139	0.000192
7.15e-06	0.000884	0.000403	0.00192	0.000240
5.37e-06	0.000876	0.000392	0.00198	0.000244
1.57e-05	0.000808	0.000445	0.00178	0.000270
8.09e-06	0.000777	0.000454	0.00181	0.000291
3.76e-06	0.000821	0.000543	0.00115	0.000210
3.98e-06	0.000806	0.000503	0.00126	0.000218
6.74e-06	0.00126	0.000449	0.00144	0.000141
3.53e-06	0.00117	0.000438	0.00153	0.000158
7.76e-06	0.00109	0.000593	0.00155	0.000233
5.48e-06	0.00103	0.000578	0.00162	0.000250
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000216	0.00704	0.00327	0.0137	0.00176
0.000483	0.00694	0.00325	0.0128	0.00165
0.000102	0.00633	0.00479	0.00711	0.00148
0.000435	0.0111	0.00341	0.00914	0.000771
0.000237	0.00928	0.00467	0.0110	0.00152
0.000122	0.00702	0.00329	0.0142	0.00183
8.06e-05	0.00703	0.00328	0.0146	0.00187
0.000350	0.00683	0.00332	0.0133	0.00178

0.000261	0.00673	0.00338	0.0136	0.00189
3.80e-05	0.00633	0.00479	0.00762	0.00159
2.41e-05	0.00642	0.00469	0.00808	0.00163
0.000249	0.0109	0.00348	0.00988	0.000867
0.000142	0.0107	0.00353	0.0105	0.000949
0.000142	0.00912	0.00475	0.0114	0.00163
9.38e-05	0.00902	0.00477	0.0117	0.00170
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
7.70e-05	0.00251	0.00117	0.00490	0.000627
0.000172	0.00247	0.00116	0.00457	0.000589
3.63e-05	0.00226	0.00171	0.00254	0.000529
0.000155	0.00397	0.00122	0.00326	0.000275
8.43e-05	0.00331	0.00167	0.00392	0.000543
2.92e-05	0.00251	0.00116	0.00523	0.000669
1.76e-05	0.00251	0.00115	0.00541	0.000681
8.37e-05	0.00238	0.00122	0.00489	0.000690
4.41e-05	0.00230	0.00126	0.00504	0.000758
1.07e-05	0.00230	0.00165	0.00294	0.000580
8.66e-06	0.00235	0.00156	0.00321	0.000589
4.39e-05	0.00378	0.00127	0.00379	0.000349
1.54e-05	0.00363	0.00128	0.00403	0.000392
3.34e-05	0.00319	0.00170	0.00419	0.000615
1.90e-05	0.00311	0.00169	0.00435	0.000652

m_Hfo_wPO4-2	m_Hfo_wHPO4-	m_Hfo_wH2PO4	m_Hfo_sCO3-	m_Hfo_sHCO3
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
9.79e-05	0.000312	1.69e-05	1.14e-08	8.93e-08
9.08e-05	0.000288	1.55e-05	8.72e-09	6.78e-08
7.31e-05	0.000143	4.73e-06	5.54e-09	2.65e-08
9.09e-05	0.000440	3.61e-05	1.18e-08	1.40e-07
7.90e-05	0.000232	1.16e-05	9.07e-09	6.55e-08
9.66e-05	0.000313	1.72e-05	1.40e-08	1.11e-07
9.53e-05	0.000314	1.75e-05	1.45e-08	1.17e-07
0.000104	0.000278	1.26e-05	1.26e-08	8.26e-08
0.000108	0.000274	1.17e-05	1.39e-08	8.59e-08
6.66e-05	0.000148	5.60e-06	7.28e-09	3.98e-08
6.39e-05	0.000151	6.02e-06	7.77e-09	4.49e-08
0.000104	0.000432	3.04e-05	1.77e-08	1.80e-07
0.000109	0.000428	2.86e-05	1.99e-08	1.92e-07
8.45e-05	0.000228	1.05e-05	1.19e-08	7.87e-08
8.63e-05	0.000227	1.01e-05	1.30e-08	8.36e-08
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000777	0.00248	0.000134	9.05e-08	7.08e-07
0.000720	0.00228	0.000123	6.91e-08	5.38e-07
0.000580	0.00113	3.75e-05	4.39e-08	2.11e-07
0.000721	0.00349	0.000286	9.35e-08	1.11e-06
0.000627	0.00184	9.21e-05	7.19e-08	5.19e-07
0.000783	0.00247	0.000133	1.04e-07	8.03e-07
0.000780	0.00247	0.000133	1.07e-07	8.36e-07
0.000743	0.00226	0.000117	8.00e-08	5.98e-07
0.000764	0.00225	0.000112	8.60e-08	6.22e-07
0.000580	0.00113	3.74e-05	5.26e-08	2.52e-07
0.000567	0.00114	3.91e-05	5.48e-08	2.71e-07
0.000747	0.00347	0.000274	1.08e-07	1.24e-06
0.000769	0.00346	0.000265	1.19e-07	1.32e-06
0.000644	0.00183	8.84e-05	8.16e-08	5.69e-07
0.000652	0.00182	8.67e-05	8.58e-08	5.90e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0.000277	0.000883	4.78e-05	3.23e-08	2.52e-07
0.000257	0.000814	4.38e-05	2.46e-08	1.92e-07
0.000207	0.000403	1.34e-05	1.57e-08	7.51e-08
0.000257	0.00124	0.000102	3.33e-08	3.96e-07
0.000223	0.000657	3.28e-05	2.56e-08	1.85e-07
0.000277	0.000882	4.77e-05	3.82e-08	2.98e-07
0.000274	0.000885	4.86e-05	3.94e-08	3.13e-07
0.000276	0.000798	3.92e-05	3.14e-08	2.23e-07
0.000291	0.000787	3.62e-05	3.51e-08	2.33e-07
0.000199	0.000410	1.43e-05	1.95e-08	9.88e-08
0.000189	0.000418	1.57e-05	2.02e-08	1.10e-07
0.000279	0.00123	9.23e-05	4.38e-08	4.75e-07
0.000292	0.00122	8.69e-05	4.92e-08	5.05e-07
0.000234	0.000649	3.06e-05	3.09e-08	2.11e-07
0.000238	0.000646	2.98e-05	3.31e-08	2.20e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
9.85e-05	0.000313	1.69e-05	1.13e-08	8.82e-08
9.14e-05	0.000289	1.55e-05	8.61e-09	6.69e-08
7.30e-05	0.000143	4.74e-06	5.49e-09	2.63e-08
9.14e-05	0.000441	3.62e-05	1.17e-08	1.39e-07
7.95e-05	0.000233	1.16e-05	8.98e-09	6.48e-08
9.69e-05	0.000314	1.73e-05	1.38e-08	1.10e-07
9.55e-05	0.000315	1.77e-05	1.43e-08	1.16e-07
0.000104	0.000279	1.27e-05	1.24e-08	8.15e-08
0.000109	0.000275	1.18e-05	1.36e-08	8.49e-08
6.64e-05	0.000148	5.63e-06	7.20e-09	3.95e-08
6.37e-05	0.000151	6.06e-06	7.67e-09	4.46e-08
0.000104	0.000433	3.06e-05	1.75e-08	1.78e-07
0.000109	0.000430	2.88e-05	1.96e-08	1.90e-07
8.47e-05	0.000229	1.05e-05	1.17e-08	7.78e-08
8.64e-05	0.000228	1.02e-05	1.28e-08	8.27e-08
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000781	0.00249	0.000134	8.95e-08	7.00e-07
0.000725	0.00229	0.000123	6.83e-08	5.30e-07
0.000579	0.00113	3.76e-05	4.36e-08	2.09e-07
0.000725	0.00350	0.000287	9.27e-08	1.10e-06
0.000630	0.00185	9.23e-05	7.13e-08	5.14e-07
0.000787	0.00248	0.000133	1.02e-07	7.92e-07
0.000783	0.00248	0.000134	1.06e-07	8.25e-07
0.000748	0.00227	0.000117	7.90e-08	5.90e-07

0.000768	0.00226	0.000113	8.49e-08	6.14e-07
0.000579	0.00113	3.75e-05	5.20e-08	2.49e-07
0.000566	0.00114	3.92e-05	5.42e-08	2.69e-07
0.000751	0.00349	0.000275	1.07e-07	1.23e-06
0.000772	0.00347	0.000265	1.18e-07	1.30e-06
0.000647	0.00184	8.86e-05	8.07e-08	5.62e-07
0.000655	0.00183	8.71e-05	8.48e-08	5.83e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000278	0.000886	4.79e-05	3.19e-08	2.49e-07
0.000258	0.000817	4.39e-05	2.44e-08	1.89e-07
0.000206	0.000403	1.34e-05	1.55e-08	7.45e-08
0.000258	0.00125	0.000102	3.30e-08	3.92e-07
0.000225	0.000660	3.29e-05	2.54e-08	1.83e-07
0.000278	0.000886	4.79e-05	3.77e-08	2.94e-07
0.000275	0.000889	4.89e-05	3.89e-08	3.09e-07
0.000278	0.000802	3.93e-05	3.10e-08	2.20e-07
0.000292	0.000791	3.64e-05	3.46e-08	2.30e-07
0.000199	0.000410	1.44e-05	1.93e-08	9.79e-08
0.000189	0.000419	1.58e-05	2.00e-08	1.09e-07
0.000280	0.00124	9.27e-05	4.33e-08	4.69e-07
0.000293	0.00123	8.74e-05	4.85e-08	4.99e-07
0.000235	0.000652	3.08e-05	3.06e-08	2.08e-07
0.000239	0.000649	3.00e-05	3.27e-08	2.18e-07

m_Hfo_sHPO4-	m_Hfo_sH2BO3	m_Hfo_sH2PO4	m_Hfo_sOSi(OH)3	m_Hfo_sOSiO(OH)2-
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.61e-08	2.88e-11	8.71e-10	4.59e-08	2.13e-08
1.21e-08	2.56e-11	6.49e-10	3.68e-08	1.72e-08
4.22e-09	2.76e-11	1.40e-10	2.37e-08	1.79e-08
5.34e-08	5.70e-11	4.38e-09	1.71e-07	5.23e-08
1.10e-08	1.86e-11	5.49e-10	5.55e-08	2.79e-08
1.82e-08	7.77e-12	9.99e-10	5.14e-08	2.35e-08
1.86e-08	5.13e-12	1.04e-09	5.19e-08	2.33e-08
1.29e-08	5.45e-12	5.85e-10	3.75e-08	2.07e-08
1.30e-08	3.72e-12	5.56e-10	3.69e-08	2.16e-08
5.10e-09	3.76e-12	1.93e-10	2.83e-08	1.88e-08
5.34e-09	2.20e-12	2.14e-10	2.86e-08	1.80e-08
5.40e-08	1.31e-11	3.80e-09	1.58e-07	5.63e-08
5.36e-08	9.03e-12	3.58e-09	1.46e-07	5.51e-08
1.16e-08	4.81e-12	5.32e-10	5.53e-08	3.03e-08
1.17e-08	3.48e-12	5.23e-10	5.33e-08	3.00e-08
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.28e-07	2.28e-10	6.91e-09	3.64e-07	1.69e-07
9.56e-08	2.03e-10	5.15e-09	2.92e-07	1.36e-07
3.35e-08	2.19e-10	1.11e-09	1.88e-07	1.42e-07
4.23e-07	4.52e-10	3.48e-08	1.36e-06	4.15e-07
8.72e-08	1.48e-10	4.36e-09	4.40e-07	2.21e-07
1.40e-07	1.09e-10	7.49e-09	3.98e-07	1.87e-07
1.42e-07	7.92e-11	7.63e-09	4.04e-07	1.88e-07
1.02e-07	7.27e-11	5.27e-09	3.09e-07	1.50e-07
1.02e-07	5.14e-11	5.13e-09	3.07e-07	1.54e-07
3.73e-08	7.06e-11	1.23e-09	2.09e-07	1.59e-07
3.83e-08	4.41e-11	1.31e-09	2.15e-07	1.58e-07
4.35e-07	1.71e-10	3.44e-08	1.37e-06	4.37e-07
4.35e-07	1.21e-10	3.32e-08	1.35e-06	4.44e-07
9.16e-08	5.87e-11	4.42e-09	4.58e-07	2.38e-07
9.18e-08	4.47e-11	4.36e-09	4.55e-07	2.40e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
4.55e-08	8.14e-11	2.46e-09	1.30e-07	6.03e-08
3.41e-08	7.24e-11	1.83e-09	1.04e-07	4.86e-08
1.19e-08	7.79e-11	3.96e-10	6.70e-08	5.07e-08
1.51e-07	1.61e-10	1.24e-08	4.84e-07	1.48e-07
3.11e-08	5.26e-11	1.55e-09	1.57e-07	7.89e-08
5.03e-08	3.17e-11	2.72e-09	1.43e-07	6.65e-08
5.11e-08	2.20e-11	2.80e-09	1.45e-07	6.64e-08
3.63e-08	2.16e-11	1.78e-09	1.09e-07	5.56e-08
3.63e-08	1.51e-11	1.67e-09	1.07e-07	5.83e-08
1.38e-08	1.79e-11	4.81e-10	7.74e-08	5.56e-08
1.43e-08	1.05e-11	5.36e-10	8.03e-08	5.37e-08
1.54e-07	5.13e-11	1.16e-08	4.74e-07	1.59e-07
1.53e-07	3.60e-11	1.09e-08	4.54e-07	1.61e-07
3.26e-08	1.80e-11	1.54e-09	1.61e-07	8.56e-08
3.27e-08	1.35e-11	1.51e-09	1.58e-07	8.60e-08
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.60e-08	2.84e-11	8.63e-10	4.52e-08	2.10e-08
1.20e-08	2.52e-11	6.42e-10	3.62e-08	1.69e-08
4.19e-09	2.73e-11	1.39e-10	2.34e-08	1.77e-08
5.30e-08	5.62e-11	4.35e-09	1.69e-07	5.17e-08
1.09e-08	1.83e-11	5.44e-10	5.47e-08	2.76e-08
1.80e-08	7.71e-12	9.95e-10	5.08e-08	2.31e-08
1.85e-08	5.08e-12	1.04e-09	5.13e-08	2.30e-08
1.28e-08	5.41e-12	5.83e-10	3.70e-08	2.04e-08
1.29e-08	3.67e-12	5.56e-10	3.64e-08	2.13e-08
5.08e-09	3.74e-12	1.93e-10	2.81e-08	1.86e-08
5.31e-09	2.18e-12	2.14e-10	2.84e-08	1.78e-08
5.37e-08	1.30e-11	3.79e-09	1.56e-07	5.56e-08
5.33e-08	8.93e-12	3.57e-09	1.45e-07	5.44e-08
1.15e-08	4.78e-12	5.30e-10	5.46e-08	2.98e-08
1.17e-08	3.45e-12	5.22e-10	5.27e-08	2.96e-08
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.27e-07	2.25e-10	6.84e-09	3.59e-07	1.67e-07
9.48e-08	2.00e-10	5.09e-09	2.87e-07	1.34e-07
3.32e-08	2.16e-10	1.10e-09	1.86e-07	1.41e-07
4.21e-07	4.46e-10	3.45e-08	1.34e-06	4.10e-07
8.66e-08	1.45e-10	4.32e-09	4.34e-07	2.19e-07
1.39e-07	1.09e-10	7.42e-09	3.92e-07	1.84e-07
1.41e-07	7.86e-11	7.57e-09	3.98e-07	1.86e-07
1.01e-07	7.29e-11	5.22e-09	3.04e-07	1.48e-07

1.02e-07	5.12e-11	5.08e-09	3.03e-07	1.52e-07
3.70e-08	7.05e-11	1.23e-09	2.07e-07	1.57e-07
3.80e-08	4.39e-11	1.31e-09	2.13e-07	1.56e-07
4.32e-07	1.71e-10	3.41e-08	1.36e-06	4.32e-07
4.32e-07	1.20e-10	3.30e-08	1.33e-06	4.39e-07
9.09e-08	5.87e-11	4.39e-09	4.51e-07	2.35e-07
9.12e-08	4.45e-11	4.33e-09	4.49e-07	2.37e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
4.51e-08	8.02e-11	2.44e-09	1.28e-07	5.94e-08
3.38e-08	7.12e-11	1.81e-09	1.02e-07	4.79e-08
1.18e-08	7.71e-11	3.93e-10	6.62e-08	5.01e-08
1.50e-07	1.59e-10	1.23e-08	4.78e-07	1.46e-07
3.09e-08	5.18e-11	1.54e-09	1.55e-07	7.79e-08
4.99e-08	3.15e-11	2.70e-09	1.41e-07	6.56e-08
5.08e-08	2.18e-11	2.79e-09	1.43e-07	6.55e-08
3.61e-08	2.16e-11	1.77e-09	1.07e-07	5.48e-08
3.61e-08	1.50e-11	1.66e-09	1.05e-07	5.74e-08
1.37e-08	1.79e-11	4.80e-10	7.67e-08	5.49e-08
1.42e-08	1.05e-11	5.36e-10	7.97e-08	5.31e-08
1.53e-07	5.11e-11	1.15e-08	4.68e-07	1.57e-07
1.52e-07	3.58e-11	1.08e-08	4.49e-07	1.59e-07
3.24e-08	1.79e-11	1.53e-09	1.59e-07	8.44e-08
3.25e-08	1.34e-11	1.50e-09	1.56e-07	8.48e-08

m_Hfo_sOHSO4-2	m_Hfo_sSO4-	m_Hao_SO4-	m_Hao_OHSO4-2	m_Hao_H2BO3
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2.08e-09	1.39e-09	2.11e-14	7.91e-05	0.000839
3.80e-09	2.52e-09	3.05e-14	8.04e-05	0.000851
9.24e-10	3.77e-10	9.22e-15	8.68e-05	0.000840
6.50e-09	6.57e-09	3.88e-14	7.06e-05	0.000873
2.26e-09	1.39e-09	2.72e-14	9.46e-05	0.000813
6.23e-10	4.22e-10	1.99e-14	6.82e-05	0.000758
4.66e-10	3.20e-10	2.11e-14	7.06e-05	0.000703
1.32e-09	7.38e-10	2.92e-14	7.07e-05	0.000762
7.35e-10	3.88e-10	2.43e-14	7.33e-05	0.000704
2.84e-10	1.32e-10	1.35e-14	7.11e-05	0.000755
2.89e-10	1.42e-10	1.83e-14	7.19e-05	0.000700
9.89e-10	8.57e-10	2.37e-14	6.04e-05	0.000786
5.43e-10	4.46e-10	1.96e-14	6.21e-05	0.000729
7.12e-10	4.02e-10	2.27e-14	7.04e-05	0.000740
5.21e-10	2.86e-10	2.16e-14	7.20e-05	0.000689
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.65e-08	1.10e-08	7.91e-14	0.000297	0.00315
3.01e-08	1.99e-08	1.14e-13	0.000301	0.00319
7.33e-09	2.99e-09	3.46e-14	0.000325	0.00315
5.16e-08	5.21e-08	1.45e-13	0.000265	0.00327
1.80e-08	1.10e-08	1.02e-13	0.000355	0.00305
1.08e-08	7.12e-09	8.34e-14	0.000257	0.00302
7.20e-09	4.77e-09	7.88e-14	0.000255	0.00292
2.51e-08	1.60e-08	1.53e-13	0.000262	0.00304
1.97e-08	1.21e-08	1.54e-13	0.000266	0.00293
3.18e-09	1.30e-09	3.62e-14	0.000280	0.00299
1.98e-09	8.35e-10	3.62e-14	0.000272	0.00289
3.27e-08	3.18e-08	1.63e-13	0.000226	0.00313
1.95e-08	1.84e-08	1.42e-13	0.000224	0.00303
1.22e-08	7.27e-09	1.10e-13	0.000268	0.00294
8.33e-09	4.87e-09	9.96e-14	0.000261	0.00285
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
5.88e-09	3.92e-09	5.21e-14	0.000195	0.00207
1.07e-08	7.11e-09	7.53e-14	0.000198	0.00210
2.61e-09	1.07e-09	2.28e-14	0.000214	0.00207
1.84e-08	1.86e-08	9.57e-14	0.000174	0.00216
6.40e-09	3.94e-09	6.71e-14	0.000234	0.00201
2.57e-09	1.71e-09	4.93e-14	0.000165	0.00196
1.53e-09	1.04e-09	4.55e-14	0.000166	0.00188
6.43e-09	3.88e-09	8.74e-14	0.000171	0.00197
3.68e-09	2.08e-09	7.29e-14	0.000173	0.00188
8.61e-10	3.71e-10	2.53e-14	0.000176	0.00195
6.51e-10	3.01e-10	2.98e-14	0.000173	0.00186
6.10e-09	5.63e-09	7.95e-14	0.000147	0.00203
2.26e-09	1.98e-09	5.33e-14	0.000146	0.00195
2.97e-09	1.73e-09	6.19e-14	0.000172	0.00191
1.73e-09	9.83e-10	5.19e-14	0.000170	0.00184
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2.09e-09	1.39e-09	2.12e-14	7.91e-05	0.000836
3.81e-09	2.52e-09	3.07e-14	8.05e-05	0.000848
9.22e-10	3.77e-10	9.25e-15	8.66e-05	0.000838
6.53e-09	6.59e-09	3.89e-14	7.04e-05	0.000871
2.27e-09	1.39e-09	2.73e-14	9.44e-05	0.000809
6.05e-10	4.10e-10	1.99e-14	6.96e-05	0.000754
4.56e-10	3.15e-10	2.12e-14	7.20e-05	0.000699
1.28e-09	7.18e-10	2.92e-14	7.24e-05	0.000758
7.16e-10	3.79e-10	2.45e-14	7.49e-05	0.000700
2.76e-10	1.29e-10	1.35e-14	7.19e-05	0.000753
2.84e-10	1.40e-10	1.84e-14	7.27e-05	0.000698
9.62e-10	8.35e-10	2.37e-14	6.15e-05	0.000784
5.32e-10	4.38e-10	1.97e-14	6.31e-05	0.000727
6.91e-10	3.91e-10	2.26e-14	7.17e-05	0.000737
5.10e-10	2.81e-10	2.17e-14	7.33e-05	0.000686
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.65e-08	1.10e-08	7.95e-14	0.000297	0.00314
3.02e-08	2.00e-08	1.15e-13	0.000302	0.00318
7.31e-09	2.99e-09	3.47e-14	0.000325	0.00314
5.18e-08	5.23e-08	1.46e-13	0.000264	0.00327
1.80e-08	1.11e-08	1.02e-13	0.000354	0.00304
1.04e-08	6.83e-09	8.26e-14	0.000262	0.00300
6.88e-09	4.56e-09	7.80e-14	0.000260	0.00290
2.45e-08	1.56e-08	1.52e-13	0.000269	0.00302

1.91e-08	1.17e-08	1.53e-13	0.000272	0.00291
3.05e-09	1.24e-09	3.57e-14	0.000283	0.00299
1.90e-09	8.03e-10	3.58e-14	0.000276	0.00288
3.18e-08	3.09e-08	1.62e-13	0.000231	0.00312
1.88e-08	1.76e-08	1.41e-13	0.000228	0.00302
1.18e-08	7.00e-09	1.09e-13	0.000274	0.00293
7.98e-09	4.67e-09	9.85e-14	0.000266	0.00284
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
5.90e-09	3.92e-09	5.23e-14	0.000195	0.00206
1.08e-08	7.12e-09	7.58e-14	0.000199	0.00209
2.61e-09	1.06e-09	2.28e-14	0.000214	0.00207
1.85e-08	1.86e-08	9.61e-14	0.000174	0.00215
6.43e-09	3.94e-09	6.74e-14	0.000233	0.00200
2.47e-09	1.64e-09	4.89e-14	0.000169	0.00195
1.49e-09	1.00e-09	4.54e-14	0.000169	0.00187
6.24e-09	3.76e-09	8.70e-14	0.000175	0.00196
3.55e-09	2.01e-09	7.26e-14	0.000178	0.00187
8.29e-10	3.58e-10	2.50e-14	0.000178	0.00194
6.34e-10	2.94e-10	2.97e-14	0.000175	0.00186
5.90e-09	5.44e-09	7.89e-14	0.000150	0.00203
2.18e-09	1.91e-09	5.31e-14	0.000148	0.00194
2.86e-09	1.66e-09	6.13e-14	0.000176	0.00190
1.68e-09	9.52e-10	5.17e-14	0.000174	0.00183

m_Hao_H3BO4-	Ferrihydrite	d_Ferrihydrite	Gibbsite	d_Gibbsite
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.47e-11	0.0291	0	0.0317	0
1.05e-11	0.0291	0	0.0317	0
3.70e-11	0.0291	0	0.0317	0
7.44e-12	0.0291	0	0.0317	0
1.32e-11	0.0291	0	0.0317	0
1.21e-11	0.0290	5.03e-07	0.0320	2.50e-07
1.10e-11	0.0290	5.03e-07	0.0320	2.49e-07
8.63e-12	0.0290	4.89e-07	0.0320	2.17e-07
9.91e-12	0.0290	4.98e-07	0.0320	2.40e-07
1.86e-11	0.0290	5.17e-07	0.0320	2.65e-07
1.29e-11	0.0290	5.07e-07	0.0320	2.57e-07
9.37e-12	0.0290	4.97e-07	0.0320	2.35e-07
1.08e-11	0.0290	5.03e-07	0.0320	2.50e-07
1.08e-11	0.0290	5.02e-07	0.0320	2.48e-07
1.07e-11	0.0290	5.04e-07	0.0320	2.50e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
5.52e-11	0.226	0	0.120	0
3.93e-11	0.226	0	0.120	0
1.39e-10	0.226	0	0.120	0
2.79e-11	0.226	0	0.120	0
4.96e-11	0.226	0	0.120	0
4.34e-11	0.230	5.01e-07	0.120	2.47e-07
4.42e-11	0.230	5.01e-07	0.120	2.46e-07
2.44e-11	0.230	4.67e-07	0.120	1.43e-07
2.37e-11	0.230	4.70e-07	0.120	1.52e-07
1.08e-10	0.230	6.01e-07	0.120	2.71e-07
1.02e-10	0.230	4.80e-07	0.120	2.70e-07
2.03e-11	0.230	4.77e-07	0.120	1.30e-07
2.23e-11	0.230	4.68e-07	0.120	1.63e-07
3.35e-11	0.230	4.96e-07	0.120	2.37e-07
3.50e-11	0.230	4.96e-07	0.120	2.35e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
3.64e-11	0.0822	0	0.0795	0
2.59e-11	0.0822	0	0.0795	0
9.13e-11	0.0822	0	0.0795	0
1.84e-11	0.0822	0	0.0795	0
3.27e-11	0.0822	0	0.0795	0
3.08e-11	0.0820	5.03e-07	0.0790	2.49e-07
3.20e-11	0.0820	5.04e-07	0.0790	2.50e-07
1.81e-11	0.0820	4.76e-07	0.0790	1.77e-07
2.10e-11	0.0820	4.87e-07	0.0790	2.10e-07
6.35e-11	0.0820	5.37e-07	0.0790	2.70e-07
5.07e-11	0.0820	5.06e-07	0.0790	2.66e-07
1.76e-11	0.0820	4.86e-07	0.0790	1.93e-07
2.49e-11	0.0820	4.96e-07	0.0790	2.36e-07
2.49e-11	0.0820	4.99e-07	0.0790	2.43e-07
2.81e-11	0.0820	5.02e-07	0.0790	2.47e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.46e-11	0.0291	0	0.0317	0
1.04e-11	0.0291	0	0.0317	0
3.67e-11	0.0291	0	0.0317	0
7.37e-12	0.0291	0	0.0317	0
1.31e-11	0.0291	0	0.0317	0
1.23e-11	0.0290	5.04e-07	0.0320	2.50e-07
1.11e-11	0.0290	5.03e-07	0.0320	2.49e-07
8.78e-12	0.0290	4.89e-07	0.0320	2.19e-07
1.00e-11	0.0290	4.98e-07	0.0320	2.40e-07
1.88e-11	0.0290	5.17e-07	0.0320	2.65e-07
1.29e-11	0.0290	5.07e-07	0.0320	2.57e-07
9.51e-12	0.0290	4.98e-07	0.0320	2.36e-07
1.09e-11	0.0290	5.03e-07	0.0320	2.50e-07
1.09e-11	0.0290	5.02e-07	0.0320	2.48e-07
1.08e-11	0.0290	5.04e-07	0.0320	2.51e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
5.47e-11	0.226	0	0.120	0
3.90e-11	0.226	0	0.120	0
1.38e-10	0.226	0	0.120	0
2.76e-11	0.226	0	0.120	0
4.91e-11	0.226	0	0.120	0
4.46e-11	0.230	5.02e-07	0.120	2.49e-07
4.54e-11	0.230	5.02e-07	0.120	2.47e-07
2.51e-11	0.230	4.70e-07	0.120	1.53e-07

2.43e-11	0.230	4.71e-07	0.120	1.57e-07
1.11e-10	0.230	6.11e-07	0.120	2.71e-07
1.04e-10	0.230	4.75e-07	0.120	2.70e-07
2.08e-11	0.230	4.80e-07	0.120	1.38e-07
2.29e-11	0.230	4.68e-07	0.120	1.68e-07
3.44e-11	0.230	4.97e-07	0.120	2.39e-07
3.59e-11	0.230	4.96e-07	0.120	2.37e-07
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
3.60e-11	0.0822	0	0.0795	0
2.57e-11	0.0822	0	0.0795	0
9.06e-11	0.0822	0	0.0795	0
1.82e-11	0.0822	0	0.0795	0
3.23e-11	0.0822	0	0.0795	0
3.16e-11	0.0820	5.03e-07	0.0790	2.50e-07
3.26e-11	0.0820	5.04e-07	0.0790	2.51e-07
1.85e-11	0.0820	4.77e-07	0.0790	1.81e-07
2.14e-11	0.0820	4.87e-07	0.0790	2.12e-07
6.48e-11	0.0820	5.40e-07	0.0790	2.70e-07
5.13e-11	0.0820	5.05e-07	0.0790	2.66e-07
1.80e-11	0.0820	4.87e-07	0.0790	1.96e-07
2.54e-11	0.0820	4.96e-07	0.0790	2.37e-07
2.55e-11	0.0820	5.00e-07	0.0790	2.44e-07
2.87e-11	0.0820	5.02e-07	0.0790	2.47e-07

Barite	d_Barite	Calcite	d_Calcite	Dolomite(ordered)
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
9.11e-07	9.11e-07	0	0	0
1.66e-06	7.45e-07	0	0	0
1.02e-06	1.02e-06	0	0	0
1.82e-06	8.00e-07	0	0	0
8.78e-07	8.78e-07	0	0	0
1.61e-06	7.32e-07	0	0	0
9.98e-07	9.98e-07	0	0	0
1.75e-06	7.56e-07	0	0	0
9.52e-07	9.52e-07	0	0	0
1.71e-06	7.54e-07	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.17e-06	1.17e-06	0	0	0
2.18e-06	1.01e-06	0	0	0
1.22e-06	1.22e-06	0	0	0
2.35e-06	1.14e-06	0	0	0
1.16e-06	1.16e-06	0	0	0
2.07e-06	9.07e-07	0	0	0
1.25e-06	1.25e-06	0	0	0
2.39e-06	1.14e-06	0	0	0
1.20e-06	1.20e-06	0	0	0
2.25e-06	1.05e-06	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.06e-06	1.06e-06	0	0	0
1.89e-06	8.36e-07	0	0	0
1.15e-06	1.15e-06	0	0	0
2.14e-06	9.92e-07	0	0	0
1.03e-06	1.03e-06	0	0	0
1.80e-06	7.76e-07	0	0	0
1.16e-06	1.16e-06	0	0	0
2.07e-06	9.16e-07	0	0	0
1.11e-06	1.11e-06	0	0	0
1.97e-06	8.69e-07	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
9.11e-07	9.11e-07	0	0	0
1.66e-06	7.45e-07	0	0	0
1.02e-06	1.02e-06	0	0	0
1.82e-06	7.99e-07	0	0	0
8.76e-07	8.76e-07	0	0	0
1.61e-06	7.32e-07	0	0	0
9.99e-07	9.99e-07	0	0	0
1.75e-06	7.56e-07	0	0	0
9.52e-07	9.52e-07	0	0	0
1.71e-06	7.53e-07	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.18e-06	1.18e-06	0	0	0
2.18e-06	1.01e-06	0	0	0
1.23e-06	1.23e-06	0	0	0

2.37e-06	1.14e-06	0	0	0
1.16e-06	1.16e-06	0	0	0
2.07e-06	9.03e-07	0	0	0
1.25e-06	1.25e-06	0	0	0
2.39e-06	1.14e-06	0	0	0
1.21e-06	1.21e-06	0	0	0
2.26e-06	1.04e-06	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1.06e-06	1.06e-06	0	0	0
1.89e-06	8.33e-07	0	0	0
1.16e-06	1.16e-06	0	0	0
2.15e-06	9.91e-07	0	0	0
1.02e-06	1.02e-06	0	0	0
1.80e-06	7.74e-07	0	0	0
1.16e-06	1.16e-06	0	0	0
2.07e-06	9.13e-07	0	0	0
1.11e-06	1.11e-06	0	0	0
1.97e-06	8.66e-07	0	0	0

d_Dolomite(ordered)	Gypsum	d_Gypsum	si_Ferrihydrite	si_Gibbsite
0	0	0	0.920	0.872
0	0	0	1.28	0.427
0	0	0	2.73	0.968
0	0	0	1.47	0.428
0	0	0	2.40	0.905
0	0	0	0.920	0.872
0	0	0	1.28	0.427
0	0	0	2.73	0.968
0	0	0	1.47	0.428
0	0	0	2.40	0.905
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0.920	0.872
0	0	0	1.28	0.427
0	0	0	2.73	0.968
0	0	0	1.47	0.428
0	0	0	2.40	0.905
0	0	0	0.920	0.872
0	0	0	1.28	0.427
0	0	0	2.73	0.968
0	0	0	1.47	0.428
0	0	0	2.40	0.905
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0.920	0.872
0	0	0	1.28	0.427
0	0	0	2.73	0.968

0	0	0	1.47	0.428
0	0	0	2.40	0.905
0	0	0	0.920	0.872
0	0	0	1.28	0.427
0	0	0	2.73	0.968
0	0	0	1.47	0.428
0	0	0	2.40	0.905
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0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0.926	0.873
0	0	0	1.28	0.427
0	0	0	2.74	0.970
0	0	0	1.48	0.429
0	0	0	2.41	0.906
0	0	0	0.926	0.873
0	0	0	1.28	0.427
0	0	0	2.74	0.970
0	0	0	1.48	0.429
0	0	0	2.41	0.906
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
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0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0.926	0.873
0	0	0	1.28	0.427
0	0	0	2.74	0.970
0	0	0	1.48	0.429
0	0	0	2.41	0.906
0	0	0	0.926	0.873
0	0	0	1.28	0.427
0	0	0	2.74	0.970
0	0	0	1.48	0.429
0	0	0	2.41	0.906
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

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0	0	0	0	0
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0	0	0	0	0
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0	0	0	0	0
0	0	0	0.926	0.873
0	0	0	1.28	0.427
0	0	0	2.74	0.970
0	0	0	1.48	0.429
0	0	0	2.41	0.906
0	0	0	0.926	0.873
0	0	0	1.28	0.427
0	0	0	2.74	0.970
0	0	0	1.48	0.429
0	0	0	2.41	0.906
0	0	0	0	0
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0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

si_Barite	si_Calcite	si_Dolomite(ordered)	si_Gypsum
0.350	-1.31e+00	-2.95e+00	-1.27e+00
1.01	-1.56e+00	-3.49e+00	-1.14e+00
0.764	-7.26e-01	-1.82e+00	-9.41e-01
0.495	-2.01e+00	-4.19e+00	-1.31e+00
0.641	-1.12e+00	-2.49e+00	-9.79e-01
0.350	-1.31e+00	-2.95e+00	-1.27e+00
1.01	-1.56e+00	-3.49e+00	-1.14e+00
0.764	-7.26e-01	-1.82e+00	-9.41e-01
0.495	-2.01e+00	-4.19e+00	-1.31e+00
0.641	-1.12e+00	-2.49e+00	-9.79e-01
0	-1.84e+00	-3.98e+00	-2.40e+00
0	-1.80e+00	-3.92e+00	-2.50e+00
0	-2.05e+00	-4.41e+00	-2.32e+00
0	-1.87e+00	-4.07e+00	-2.47e+00
0	-1.64e+00	-3.56e+00	-2.42e+00
0	-1.73e+00	-3.77e+00	-2.50e+00
0	-1.98e+00	-4.28e+00	-2.33e+00
0	-1.80e+00	-3.93e+00	-2.49e+00
0	-1.86e+00	-4.01e+00	-2.37e+00
0	-1.80e+00	-3.91e+00	-2.49e+00
0.350	-1.31e+00	-2.95e+00	-1.27e+00
1.01	-1.56e+00	-3.49e+00	-1.14e+00
0.764	-7.26e-01	-1.82e+00	-9.41e-01
0.495	-2.01e+00	-4.19e+00	-1.31e+00
0.641	-1.12e+00	-2.49e+00	-9.79e-01
0.350	-1.31e+00	-2.95e+00	-1.27e+00
1.01	-1.56e+00	-3.49e+00	-1.14e+00
0.764	-7.26e-01	-1.82e+00	-9.41e-01
0.495	-2.01e+00	-4.19e+00	-1.31e+00
0.641	-1.12e+00	-2.49e+00	-9.79e-01
0	-1.97e+00	-4.19e+00	-2.17e+00
0	-1.93e+00	-4.18e+00	-2.33e+00
0	-2.38e+00	-5.05e+00	-2.12e+00
0	-2.32e+00	-4.96e+00	-2.21e+00
0	-1.52e+00	-3.23e+00	-2.17e+00
0	-1.54e+00	-3.38e+00	-2.40e+00
0	-2.50e+00	-5.30e+00	-2.08e+00
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0	-2.04e+00	-4.30e+00	-2.13e+00
0	-2.01e+00	-4.33e+00	-2.29e+00
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1.01	-1.56e+00	-3.49e+00	-1.14e+00
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0	-1.86e+00	-4.03e+00	-2.42e+00
0.366	-1.30e+00	-2.93e+00	-1.25e+00
1.02	-1.55e+00	-3.47e+00	-1.12e+00
0.776	-7.19e-01	-1.80e+00	-9.31e-01
0.510	-2.00e+00	-4.17e+00	-1.30e+00
0.657	-1.11e+00	-2.47e+00	-9.66e-01
0.366	-1.30e+00	-2.93e+00	-1.25e+00
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1.02	-1.55e+00	-3.47e+00	-1.12e+00
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0.366	-1.30e+00	-2.93e+00	-1.25e+00
1.02	-1.55e+00	-3.47e+00	-1.12e+00
0.776	-7.19e-01	-1.80e+00	-9.31e-01
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0.657	-1.11e+00	-2.47e+00	-9.66e-01
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0.366	-1.30e+00	-2.93e+00	-1.25e+00
1.02	-1.55e+00	-3.47e+00	-1.12e+00
0.776	-7.19e-01	-1.80e+00	-9.31e-01
0.510	-2.00e+00	-4.17e+00	-1.30e+00
0.657	-1.11e+00	-2.47e+00	-9.66e-01
0	-1.88e+00	-4.05e+00	-2.28e+00
0	-1.82e+00	-3.96e+00	-2.45e+00
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0	-2.24e+00	-4.79e+00	-2.18e+00
0	-1.95e+00	-4.23e+00	-2.40e+00
0	-1.93e+00	-4.13e+00	-2.24e+00
0	-1.85e+00	-4.02e+00	-2.43e+00

APPENDIX B
DRAWINGS AND MATERIALS SPECIFICATIONS FOR SELECTED REMEDY

SAVED: 2/13/25 4:09 PM

C:\DC\ACCDOCS\RAMBOLL GRUPPEN AS\RUS-1940102417 VISTRA ENERGY JOP-EAP\PROJECT FILES\4 DELIVERY\40 WIP\401 CIVIL\DRAWINGS\G-000_JOP-EAP.DWG

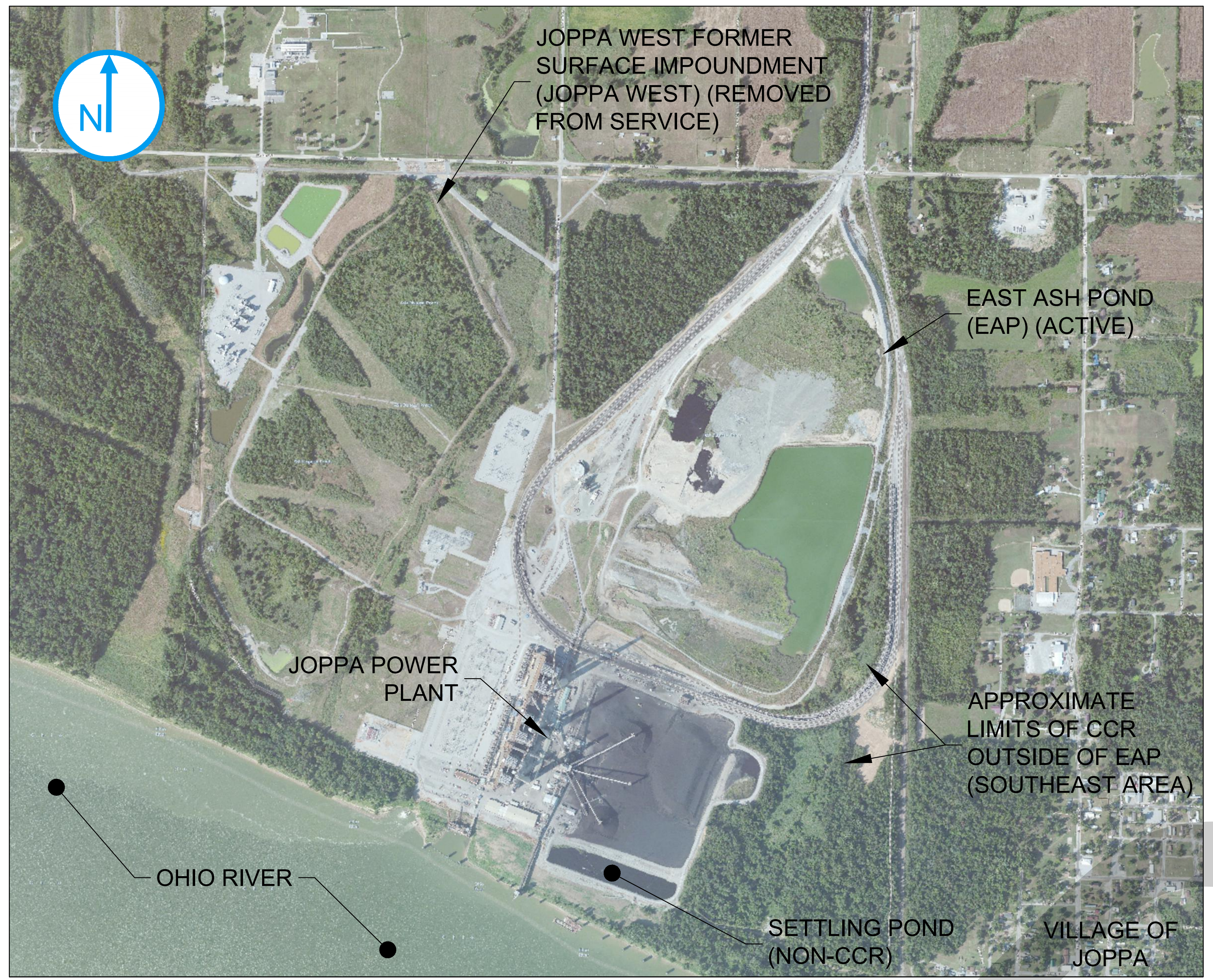
CORRECTIVE ACTION PERMIT-LEVEL DESIGN

Joppa East Ash Pond

Preliminary Corrective Action (PCA)

Joppa Power Plant, Joppa, IL

GROUNDWATER EXTRACTION SYSTEM

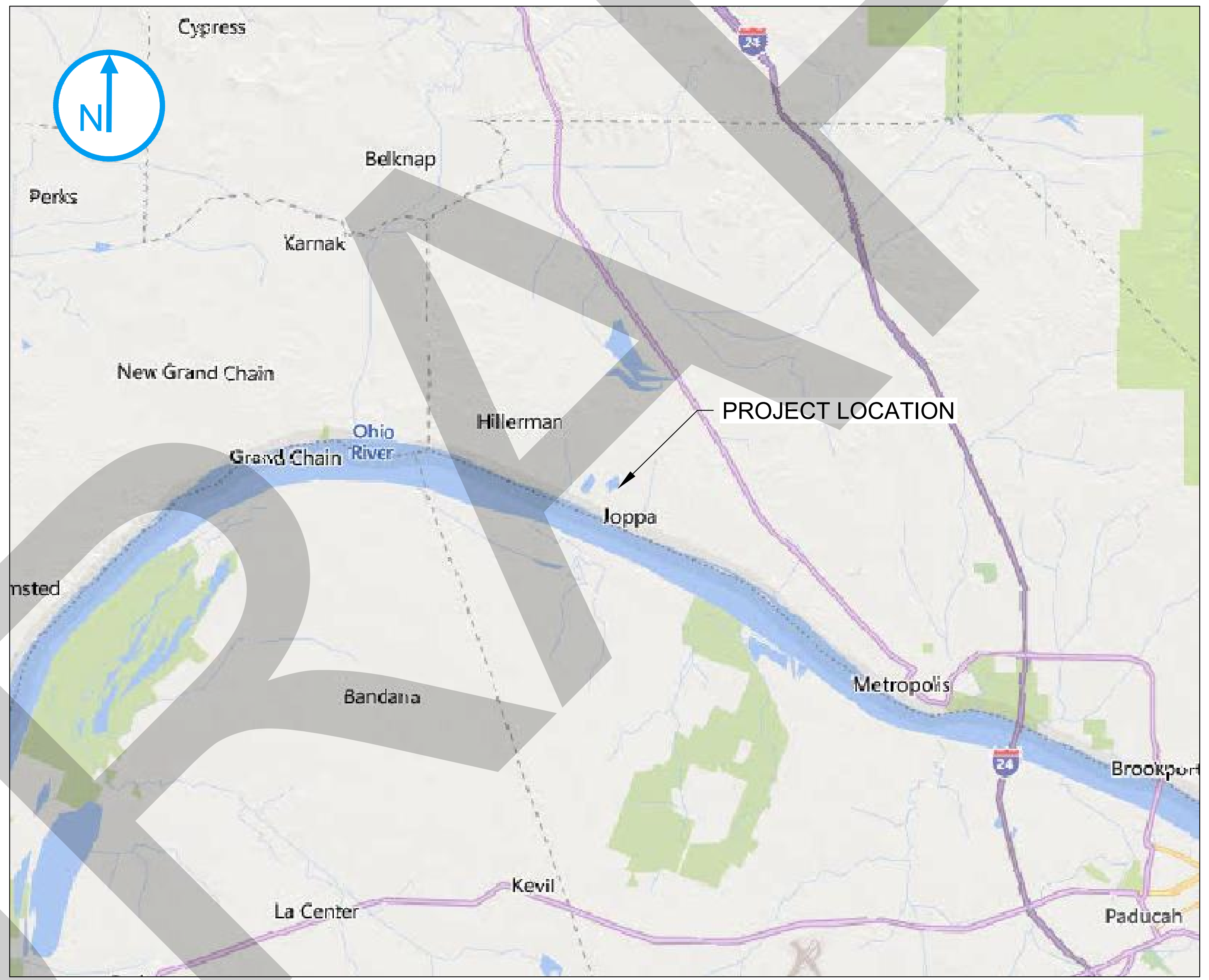


AERIAL IMAGERY: GOOGLE EARTH PRO®.

VICINITY MAP

1000' 0 1000'

SCALE: 1"=1000'



SOURCE: BING MAPS

LOCATION MAP

3 mi 0 3 mi

SCALE: 1"=3 mi

INDEX OF DRAWINGS	
SHEET INDEX NO.	**SHEET TITLE**
	GENERAL
G-000	Cover Sheet
	CIVIL
C-101	Site Plan
C-102	GWE System Conveyance Piping - Enlarged Plan and Profile 1
C-103	GWE System Conveyance Piping - Enlarged Plan and Profile 2
C-104	GWE System Conveyance Piping - Enlarged Plan and Profile 3
C-401	GWE System Compound Layout
C-501	GWE System Extraction Well Detail
	PROCESS
P-001	GWE System Process Flow Diagram

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

April 2025

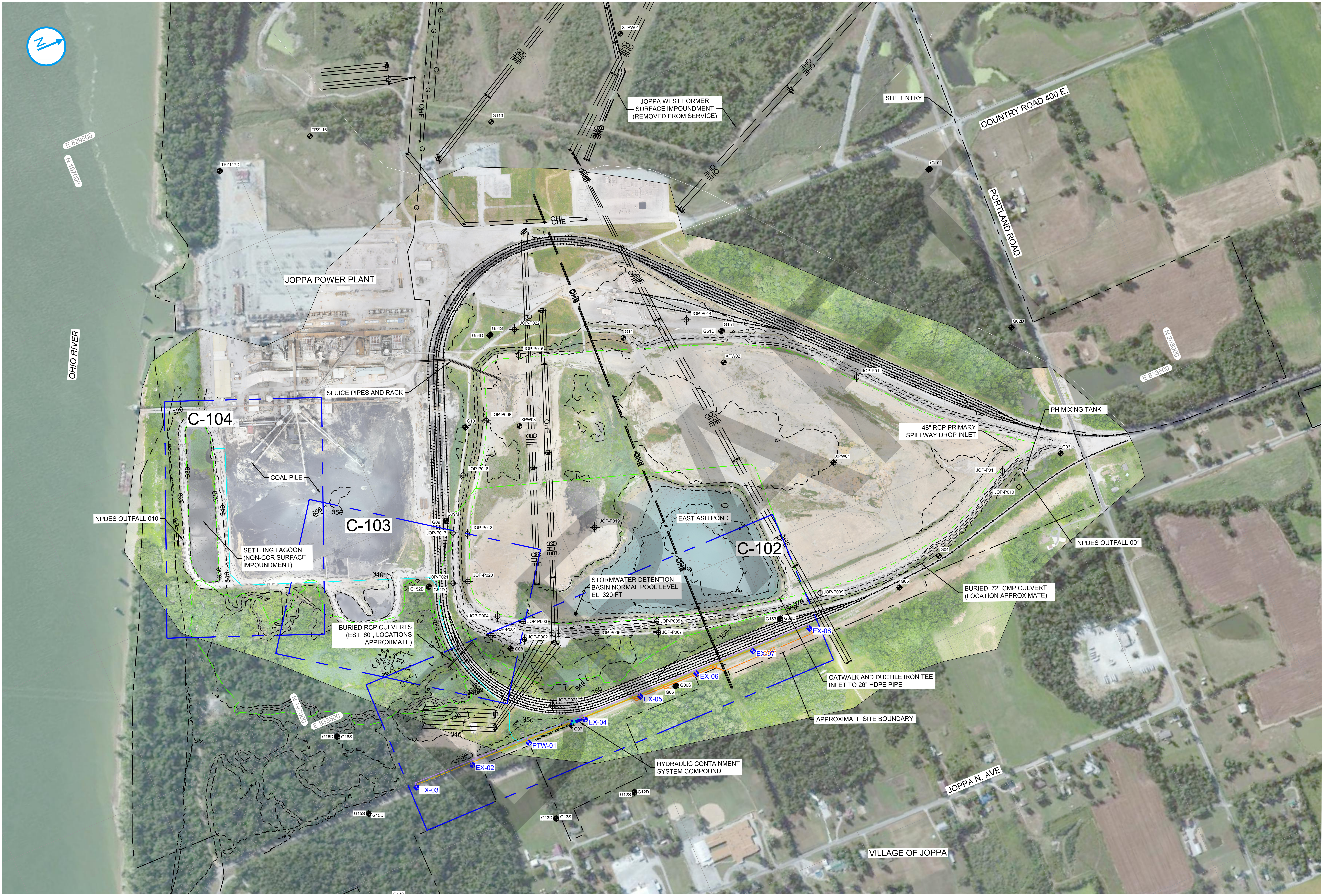
RAMBOLL

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

1940102417

SAVED: 4/1/24 11:11 AM

C:\DC\ACCDOCS\RAMBOLL GRUPPEN AS\RUS-1940102417 VISTRA ENERGY JOP-EAP\PROJECT FILES\4 DELIVERY\40 WIP\401 CIVIL\DRAWINGS\C-101_JOP-EAP.DWG



LEGEND

EXISTING

– – 360 – –	MAJOR CONTOUR
- - - - - -	MINOR CONTOUR
—-—-—	APPROXIMATE SITE BOUNDARY
—— OHE ——	OVERHEAD ELECTRICAL
∅	UTILITY POLE
— — —	EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
+++++++	RAILROAD
⌖ JOP-P017	PIEZOMETER
● G09	MONITORING WELL
—— G ——	NATURAL GAS CONVEYANCE PIPING
—·—·—	APPROXIMATE LIMITS OF CCR UNITS AND NON-CCR SURFACE IMPOUNDMENTS

PROPOSED

● EW-04	EXTRACTION WELL
——	GROUNDWATER EXTRACTION CONVEYANCE PIPING
——	COMBINED GROUNDWATER EXTRACTION CONVEYANCE PIPING, 480/277VAC POWER, AND MULTI-MODE OPTICAL FIBER
■	STRUCTURE
—— OHE ——	OVERHEAD ELECTRICAL
∅	UTILITY POLE

300 0 300 600
SCALE IN FEET

IT IS A VIOLATION OF LAW FOR ANY PERSON, UNLESS ACTING UNDER THE DIRECTION OF A LICENSED ENGINEER, TO ALTER THIS DOCUMENT.

THIS DRAWING WAS PREPARED AT THE SCALE INDICATED. INACCURACIES IN THE STATED SCALE MAY BE INTRODUCED WHEN DRAWINGS ARE REPRODUCED BY ANY MEANS. USE THE GRAPHIC SCALE BAR TO DETERMINE THE ACTUAL SIZE. DRAWING IS NOT SCALABLE IF NO SCALE BAR IS PRESENT.

ISSUED
FOR BID
DATE: 4/1/2024

CLIENT
VISTRA CORP

NO.	DATE	REVISION	INT.
0	4/1/2024	Issued for Bid	JAB

DESIGNER / PROFESSIONAL ENGINEER RESPONSIBLE
J. BOND
DESIGNED BY
C. GLIDDEN
CHECKED BY
J. BOND
DRAWN BY
B. LEMMON
PROJECT NO.
1940102417
DATE
April 2024

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

PROJECT
JOPPA EAST ASH POND

ADDRESS
ELECTRIC ENERGY, INC.
JOPPA POWER PLANT
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

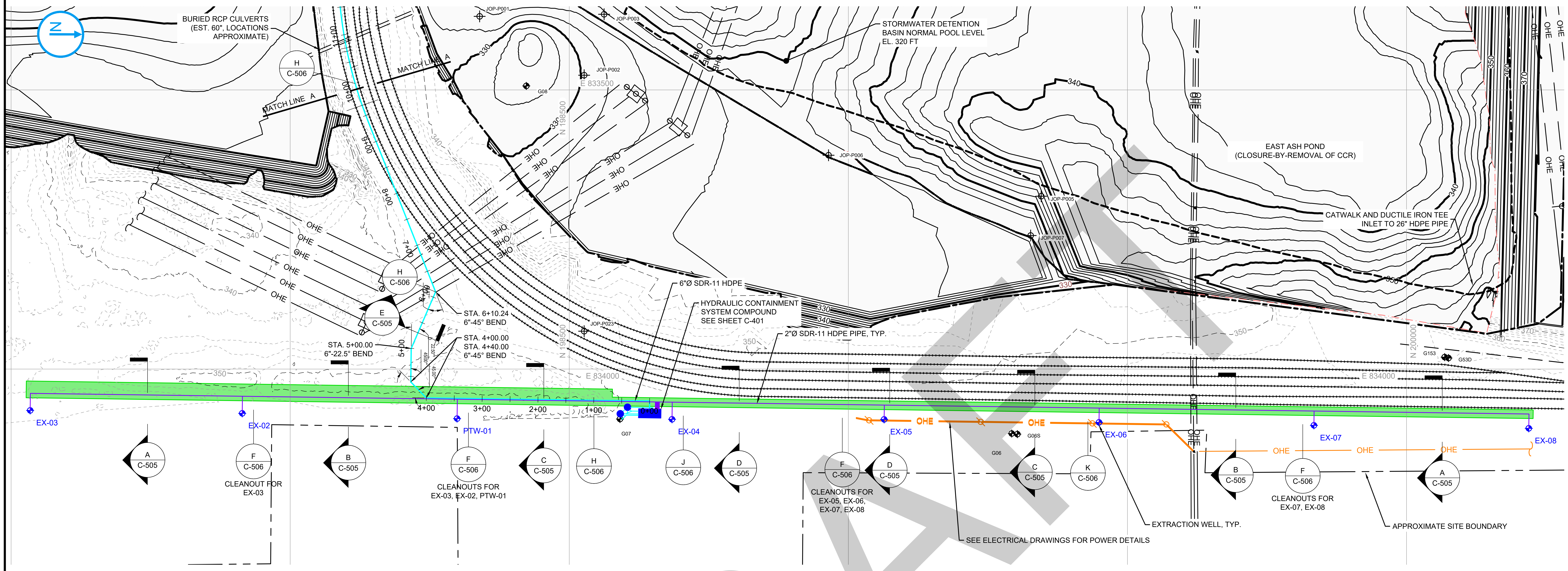
SHEET DESCRIPTION
SITE PLAN

DRAWING LOCATION

C-101

SAVED: 4/1/24 11:40 AM

C:\DC\ACCDOCS\RAMBOLL GRUPPEN AS\RUS-1940102417 VISTRA ENERGY JOP-EAP\PROJECT FILES\4 DELIVERY\40 WIP\401 CIVIL\DRAWINGS\C-201_JOP-EAP.DWG



SYSTEM CONVEYANCE PIPING - ENLARGED PLAN 1

100 0 100

SCALE: 1"=100'

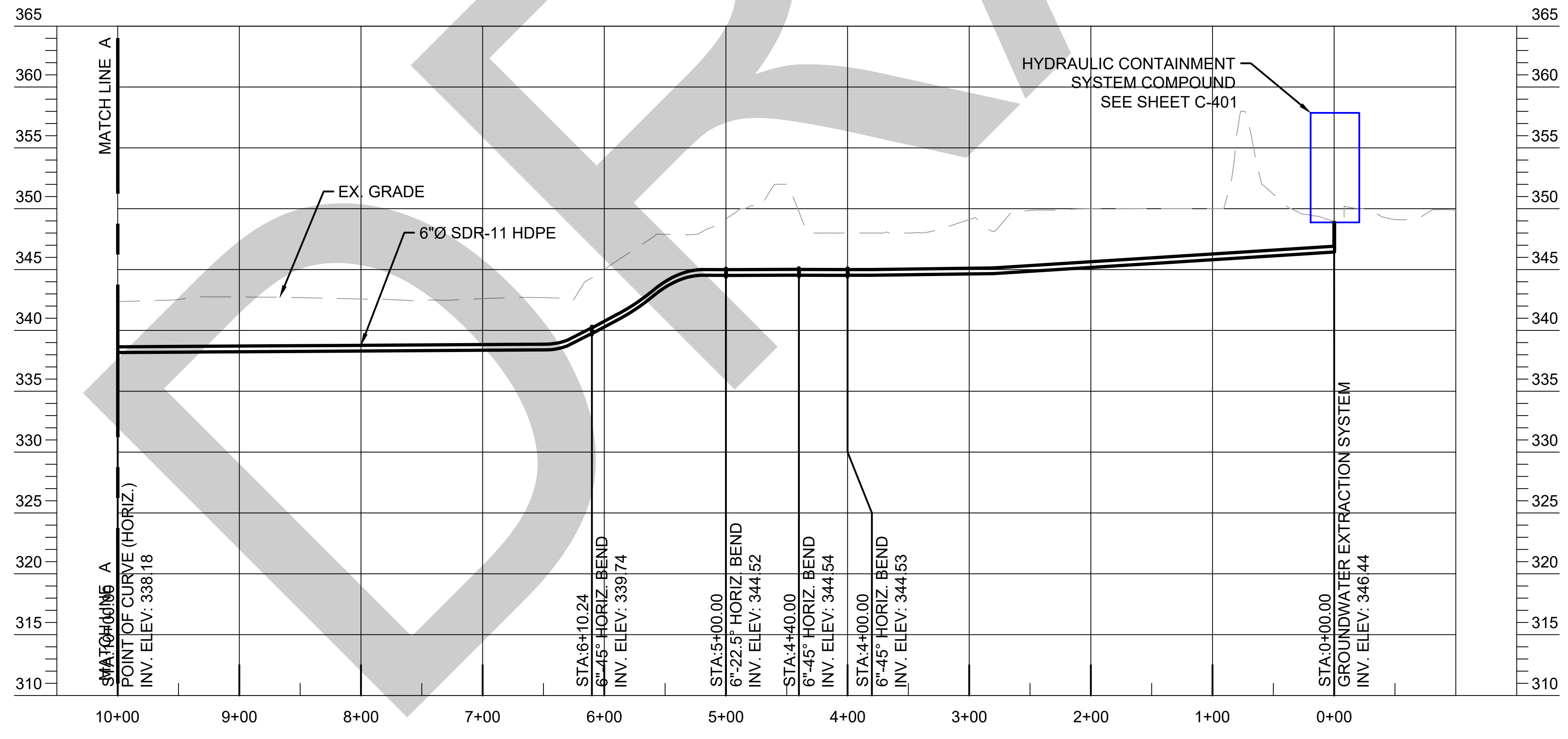
LEGEND

EXISTING

360	MAJOR CONTOUR
	MINOR CONTOUR
	APPROXIMATE SITE BOUNDARY
OHE	OVERHEAD ELECTRICAL
⌀	UTILITY POLE
	EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
	RAILROAD
JOP-P017	PIEZOMETER
G09	MONITORING WELL
G	NATURAL GAS CONVEYANCE PIPING
	APPROXIMATE LIMITS OF CCR UNITS AND NON-CCR SURFACE IMPOUNDMENTS
	APPROXIMATE LIMITS OF CCR OUTSIDE OF EAP
	LIMITS OF BATHYMETRIC SURVEY

PROPOSED

360	(POST-CLOSURE) MAJOR CONTOUR
	(POST-CLOSURE) MINOR CONTOUR
EW-04	EXTRACTION WELL
	GROUNDWATER EXTRACTION CONVEYANCE PIPING
▭	STRUCTURE
OHE	OVERHEAD ELECTRICAL
⌀	UTILITY POLE
🟩	LIMITS OF CLEARING



PROFILE STATION 0+00 TO 10+00

100 0 100

SCALE HORZ. 1" = 100'

x' 0 10'

SCALE: VERT. 1"=10'

IT IS A VIOLATION OF LAW FOR ANY PERSON, UNLESS ACTING UNDER THE DIRECTION OF A LICENSED ENGINEER, TO ALTER THIS DOCUMENT.

THIS DRAWING WAS PREPARED AT THE SCALE INDICATED. INACCURACIES IN THE STATED SCALE MAY BE INTRODUCED WHEN DRAWINGS ARE REPRODUCED BY ANY MEANS. USE THE GRAPHIC SCALE BAR TO DETERMINE THE ACTUAL SIZE. DRAWING IS NOT SCALABLE IF NO SCALE BAR IS PRESENT.

ISSUED
FOR BID

DATE: 4/1/2024

CLIENT
VISTRA CORP

NO.	DATE	REVISION	INT.
0	4/1/2024	Issued for Bid	JAB

DESIGNER / PROFESSIONAL ENGINEER RESPONSIBLE
J. BOND

DESIGNED BY
C. GLIDDEN
CHECKED BY
J. BOND
DRAWN BY
B. LEMMON

PROJECT NO.
1940102417
DATE
April 2024

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

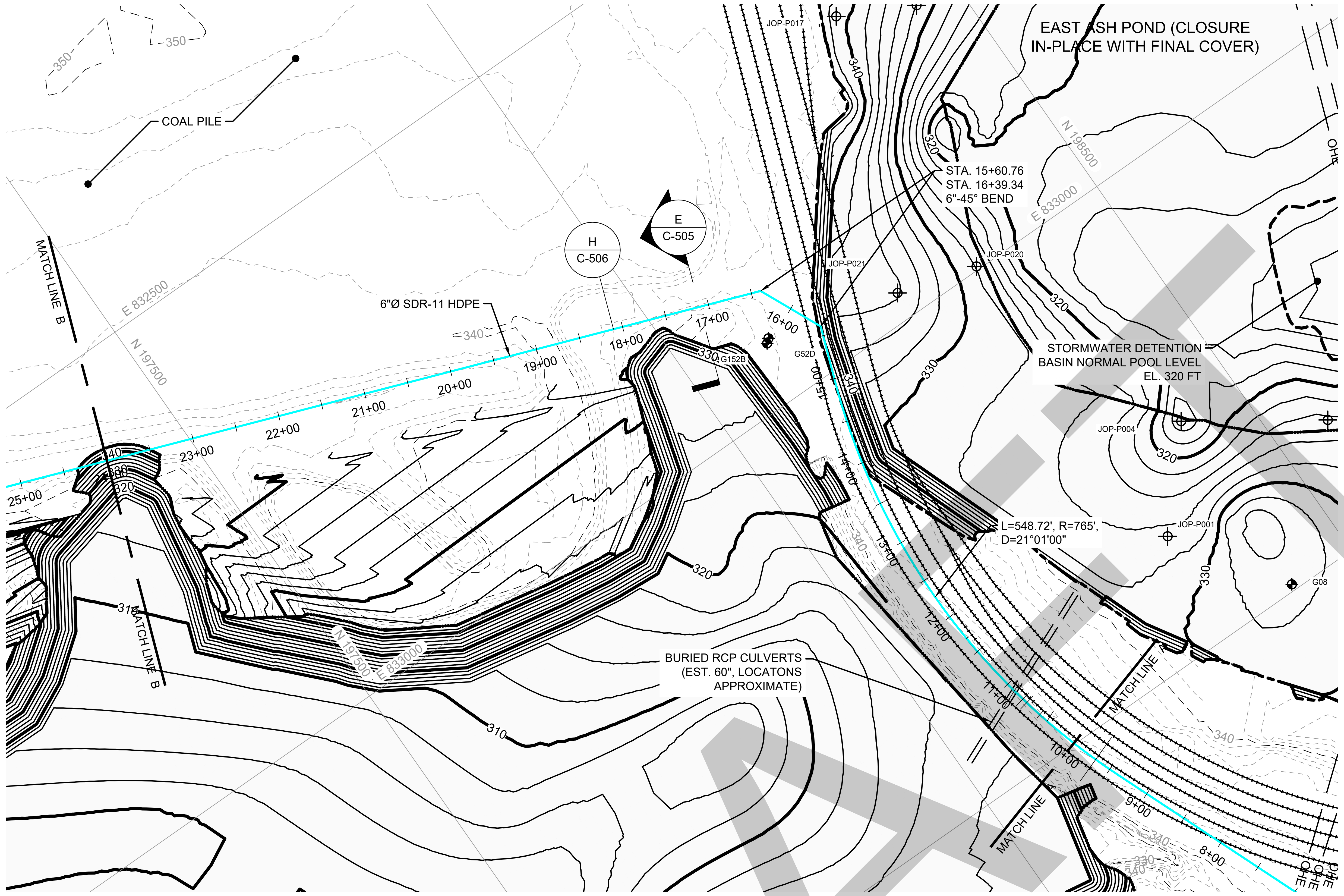
RAMBOLL

PROJECT
JOPPA EAST ASH POND

ADDRESS
ELECTRIC ENERGY, INC.
JOPPA POWER PLANT
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

SHEET DESCRIPTION
GWE SYSTEM CONVEYANCE PIPING - ENLARGED PLAN AND PROFILE 1
DRAWING LOCATION

C-102



SYSTEM CONVEYANCE PIPING - ENLARGED PLAN 2

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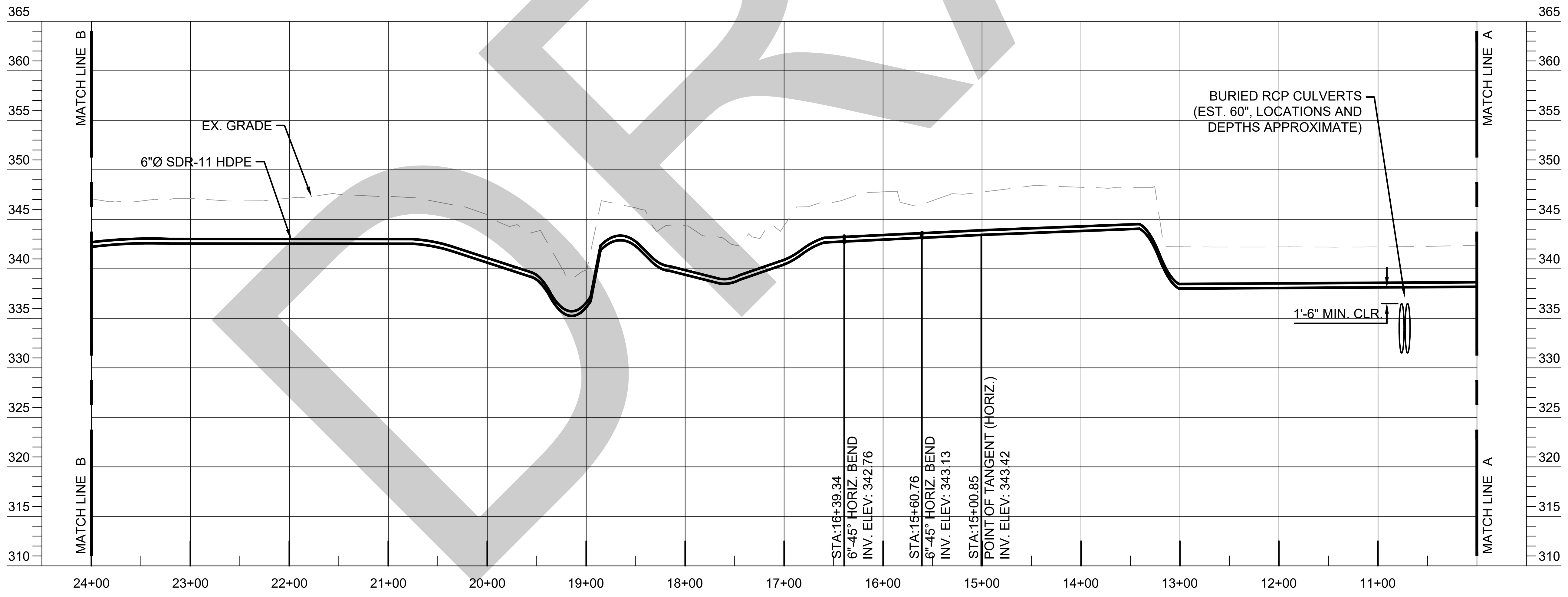
SCALE: 1"=100'



PROFILE STATION 10+00 TO 24+00

100 0 100
SCALE HORZ. 1" = 100'

10' 0 10'
SCALE: VERT. 1"=10'

LEGEND

EXISTING

360	MAJOR CONTOUR
	MINOR CONTOUR
	APPROXIMATE SITE BOUNDARY
OHE	OVERHEAD ELECTRICAL
⌀	UTILITY POLE
	EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
	RAILROAD
JOP-P017	PIEZOMETER
G09	MONITORING WELL
G	NATURAL GAS CONVEYANCE PIPING
	APPROXIMATE LIMITS OF CCR UNITS AND NON-CCR SURFACE IMPOUNDMENTS
	APPROXIMATE LIMITS OF CCR OUTSIDE OF EAP
	LIMITS OF BATHYMETRIC SURVEY

PROPOSED

360	(POST-CLOSURE) MAJOR CONTOUR
	(POST-CLOSURE) MINOR CONTOUR
EW-04	EXTRACTION WELL
	GROUNDWATER EXTRACTION CONVEYANCE PIPING
▭	STRUCTURE
OHE	OVERHEAD ELECTRICAL
⌀	UTILITY POLE

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ISSUED
FOR BID
DATE: 4/1/2024

CLIENT
VISTRA CORP

NO.	DATE	REVISION	INT.
0	4/1/2024	Issued for Bid	JAB

DESIGNER / PROFESSIONAL ENGINEER RESPONSIBLE
J. BOND
DESIGNED BY
C. GLIDDEN
CHECKED BY
J. BOND
DRAWN BY
B. LEMMON
PROJECT NO.
1940102417
DATE
April 2024

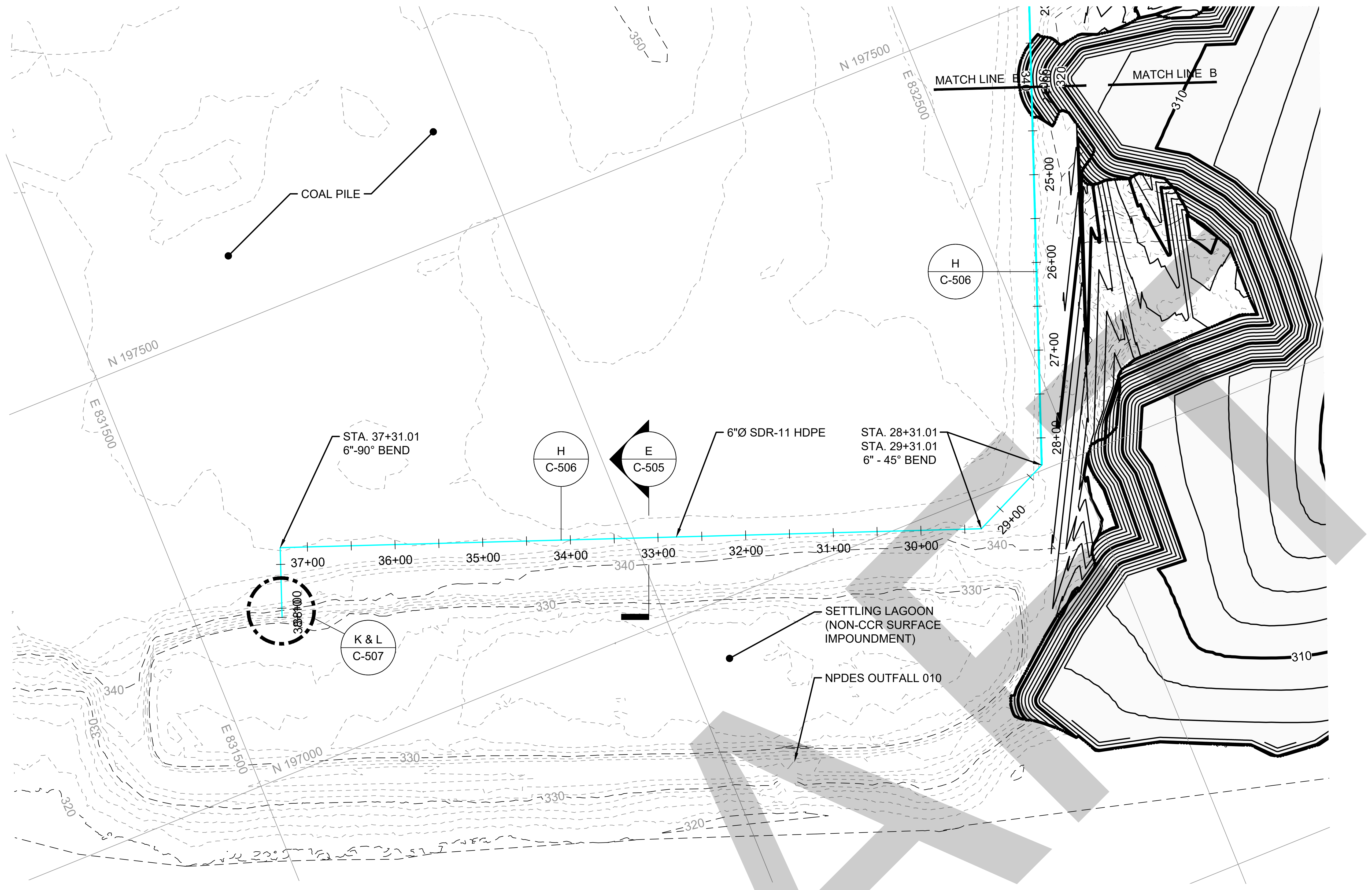
RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

PROJECT
JOPPA EAST ASH POND

ADDRESS
ELECTRIC ENERGY, INC.
JOPPA POWER PLANT
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

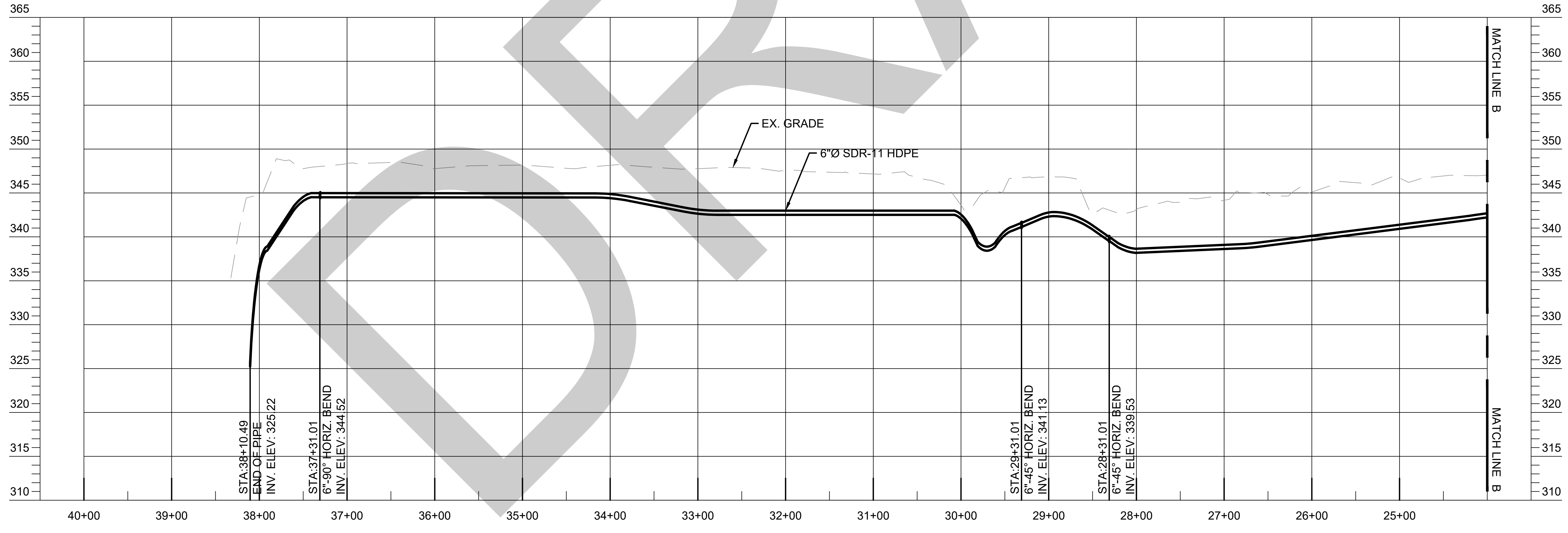
SHEET DESCRIPTION
GWE SYSTEM CONVEYANCE PIPING - ENLARGED PLAN AND PROFILE 2
DRAWING LOCATION

C-103



SYSTEM CONVEYANCE PIPING - ENLARGED PLAN 3

100 0 100
SCALE: 1"=100'



PROFILE STATION 28+00 TO 42+20.52

100 0 100
SCALE HORZ. 1" = 100'

10' 0 10'
SCALE: VERT. 1"=10'

LEGEND

EXISTING

- - - 360 - - -	MAJOR CONTOUR
- - - - - -	MINOR CONTOUR
—·—··—·—	APPROXIMATE SITE BOUNDARY
—— OHE ——	OVERHEAD ELECTRICAL
⌀	UTILITY POLE
— — — —	EXISTING BURIED CULVERT (LOCATION APPROXIMATE)
┼┼┼┼┼┼	RAILROAD
⌖ JOP-P017	PIEZOMETER
◈ G09	MONITORING WELL
—— G ——	NATURAL GAS CONVEYANCE PIPING
—·—·—·—	APPROXIMATE LIMITS OF CCR UNITS AND NON-CCR SURFACE IMPOUNDMENTS
—···—···—	APPROXIMATE LIMITS OF CCR OUTSIDE OF EAP
— — — —	LIMITS OF BATHYMETRIC SURVEY

PROPOSED

—— 360 ——	(POST-CLOSURE) MAJOR CONTOUR
————	(POST-CLOSURE) MINOR CONTOUR
◈ EW-04	EXTRACTION WELL
————	GROUNDWATER EXTRACTION CONVEYANCE PIPING
▭	STRUCTURE
—— OHE ——	OVERHEAD ELECTRICAL
⌀	UTILITY POLE

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April 2024

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ELECTRIC ENERGY, INC.
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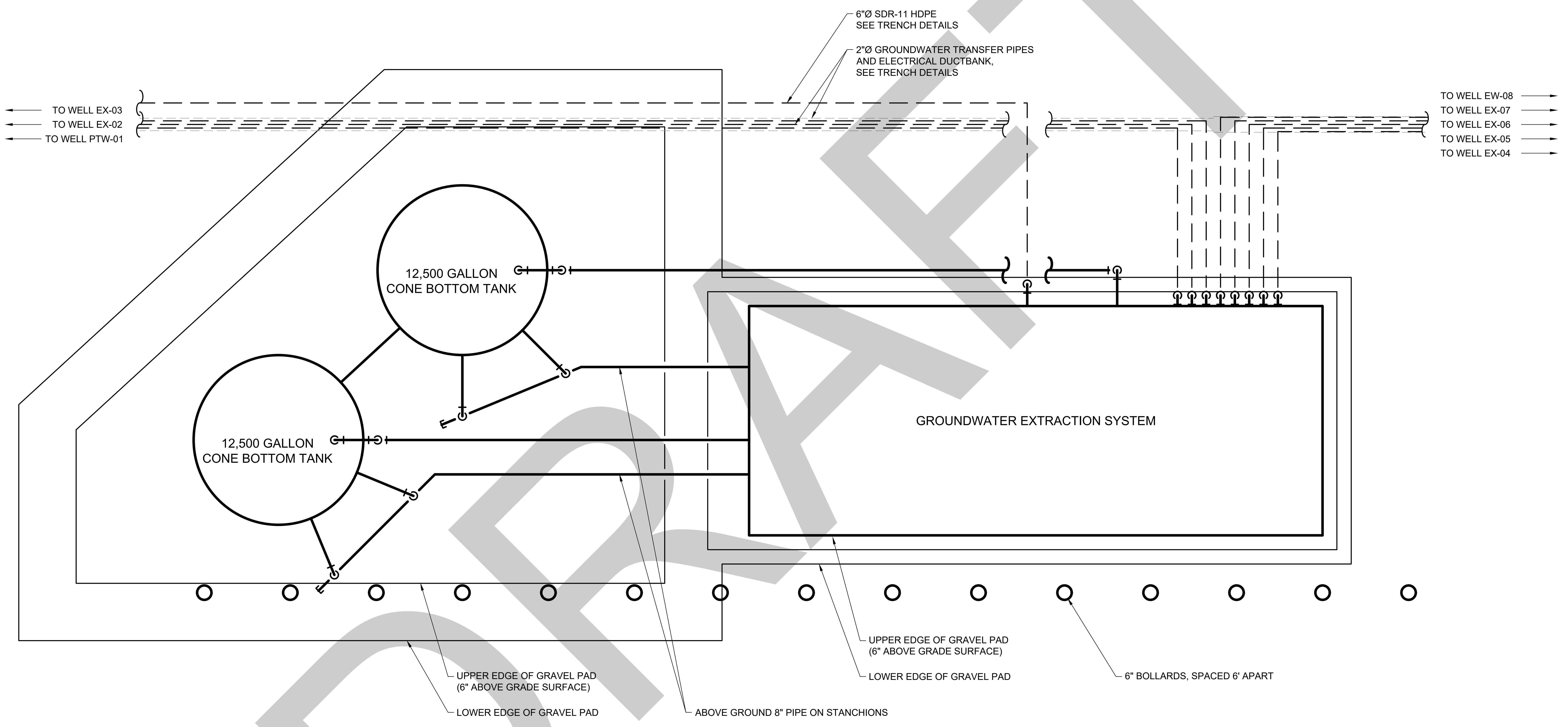
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

SHEET DESCRIPTION
GWE SYSTEM CONVEYANCE PIPING - ENLARGED PLAN AND PROFILE 3
DRAWING LOCATION

C-104



5 0 5 10
SCALE IN FEET

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FOR BID
DATE: 4/1/2024

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VISTRA CORP

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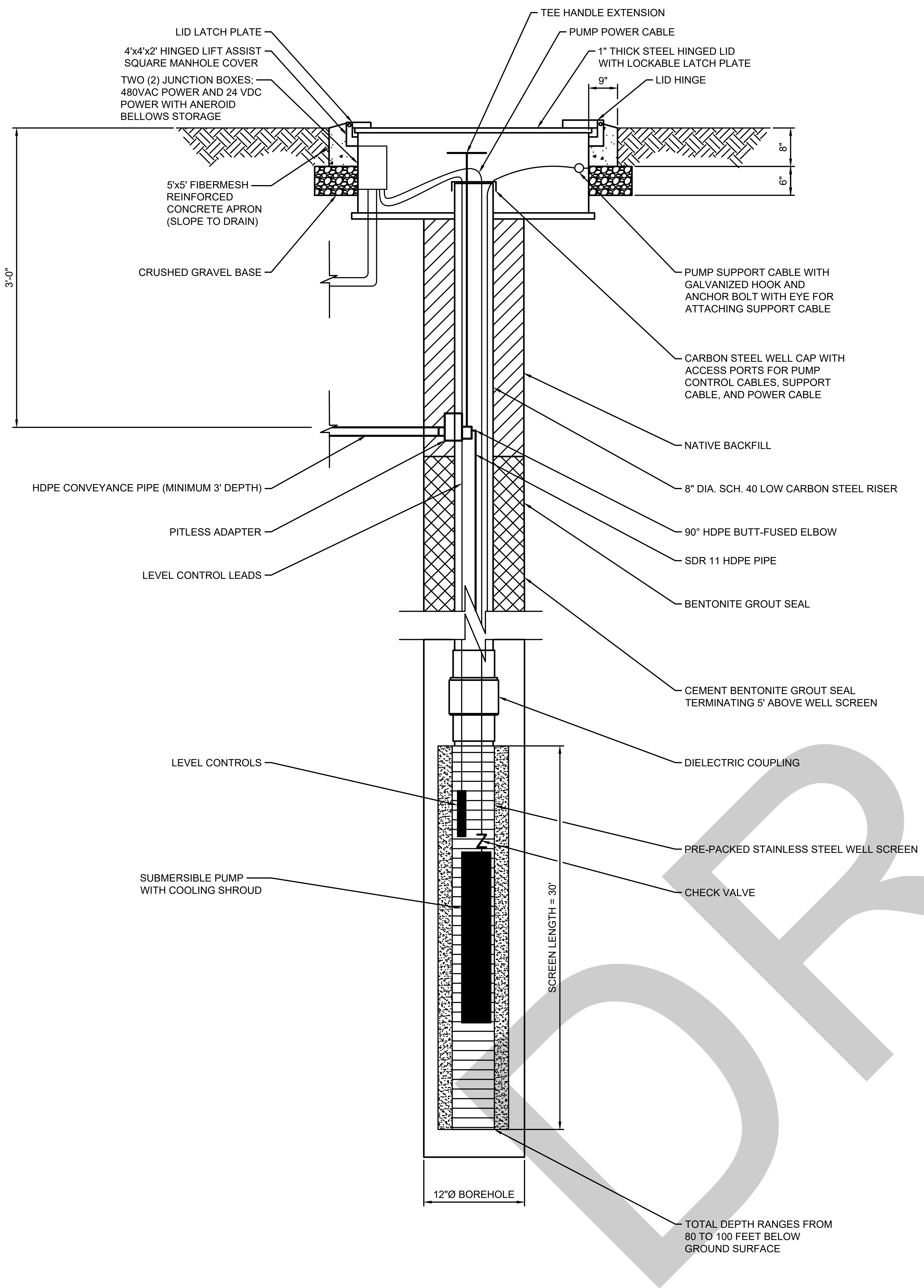
JOPPA POWER PLANT
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

SHEET DESCRIPTION
GWE SYSTEM COMPOUND
LAYOUT
DRAWING LOCATION

C-401

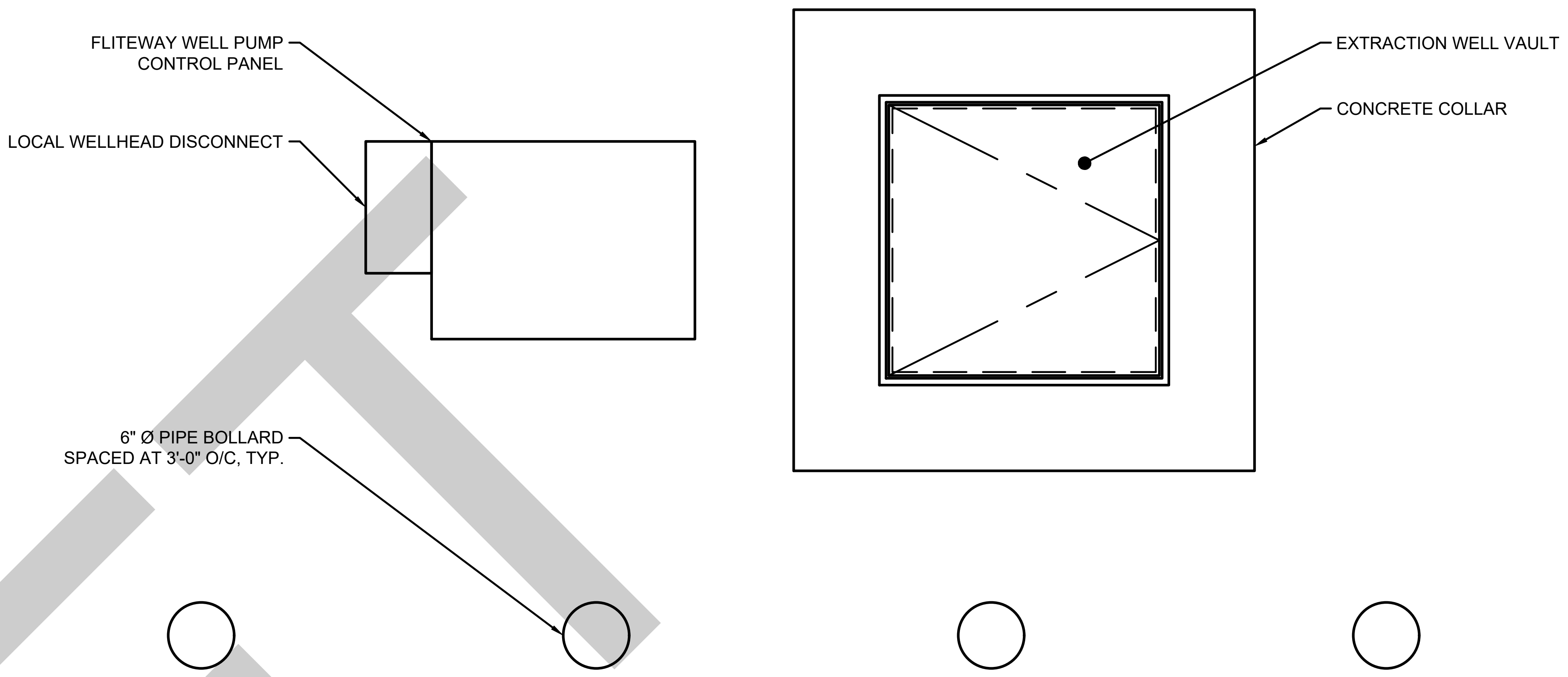
SAVED: 4/1/24 12:05 PM

C:\DC\ACCDOCS\RAMBOLL GRUPPEN AS\RUS-1940102417 VISTRA ENERGY JOP-EAP\PROJECT FILES\4 DELIVERY\40 WIP\401 CIVIL\DRAWINGS\C-411_JOP-EAP.DWG

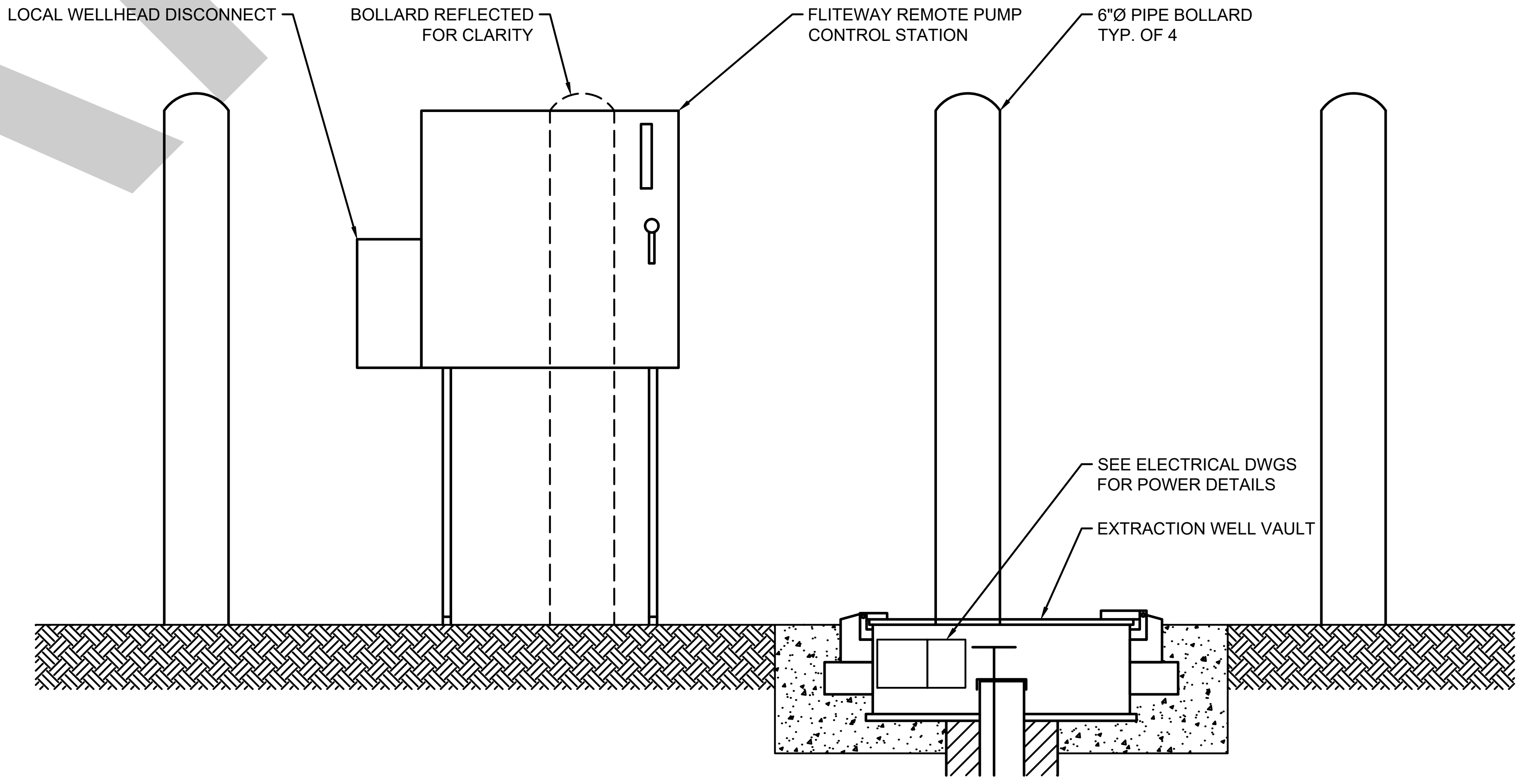


EXTRACTION WELL DETAIL

NOT TO SCALE



TOP PLAN



FRONT ELEVATION

WELLHEAD DETAIL

NOT TO SCALE

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April 2024

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2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

SHEET DESCRIPTION
GWE SYSTEM EXTRACTION WELL DETAIL

DRAWING LOCATION

C-501

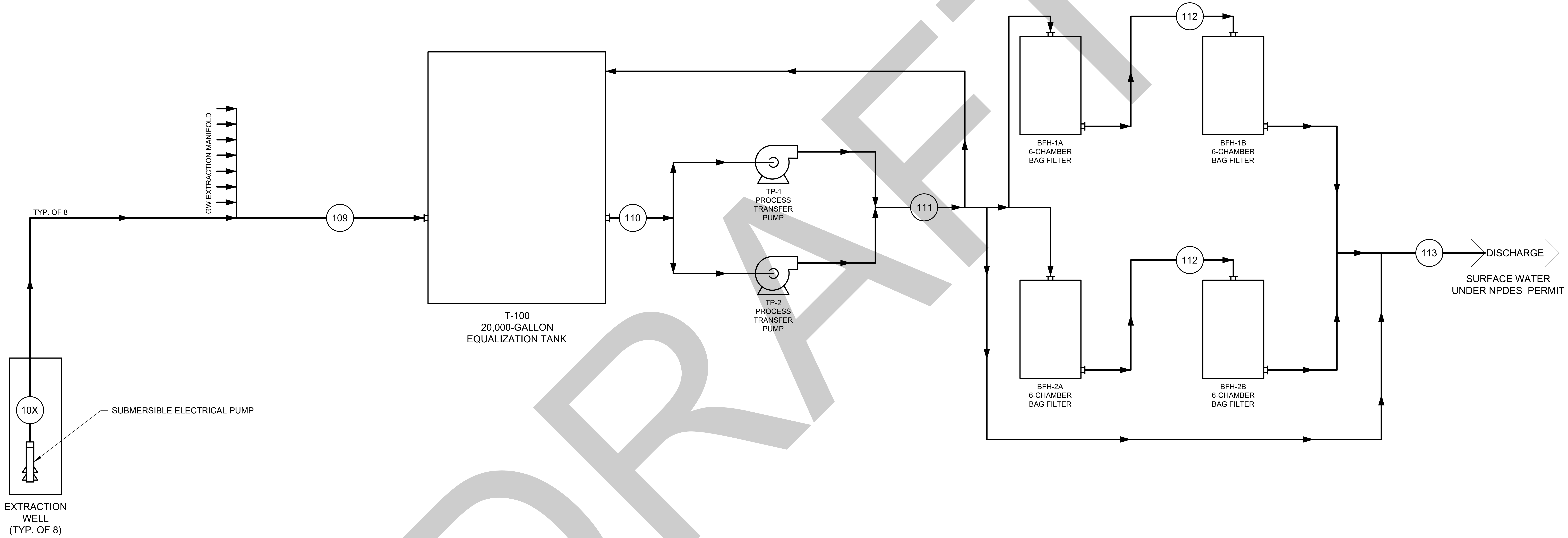
SAVED: 4/1/24 10:58 AM

C:\DC\ACCDOCS\RAMBOLL GRUPPEN AS\RUS-1940102417 VISTRA ENERGY JOP-EAP\PROJECT FILES\4 DELIVERY\40 WIP\401 CIVIL\DRAWINGS\P-001_JOP-EAP.DWG

NOTE:

SYSTEM EQUIPMENT CONFIGURATION, FLOW RATE, AND OTHER DETAILS MAY CHANGE ONCE THE HYDRAULIC MODEL IS UPDATED.

GPM = GALLONS PER MINUTE
GW = GROUNDWATER



STREAM ID	10X	109	110	111	112	113
DESIGN FLOW (GPM)	40-70	320-560	320-560	320-560	160-280	320-560

ISSUED
FOR BID
DATE: 4/1/2024

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RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

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JOPPA EAST ASH POND

ADDRESS
ELECTRIC ENERGY, INC.
JOPPA POWER PLANT
2100 PORTLAND ROAD
JOPPA, ILLINOIS 62953

SHEET DESCRIPTION
GWE SYSTEM PROCESS FLOW DIAGRAM

DRAWING LOCATION

P-001